THE GIS SUPPORT OF EMERGENCY MANAGEMENT

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Abstract
Almost every information related to the emergencies can be equipped with meaningful entry specifying its position on
the earth surface. Owing to this fact, the GIS can provide substantial support for every effort concerning to the
emergencies. The first part of the article demonstrates the GIS support of strategic decisions. As an example serves the preparations
of the maps for strategic decisions, which concerns to the aerial firefighting of forest fires on the area of the Czech Republic.
The second part of the contribution deals with GIS support of the management of large scale emergencies. As an illustration serves the information support of exercise ZÓNA 2015. The exercise was focused on the simulated severe event on Nuclear Power Plant Temelín. Finally, some ideas to GIS support of the management of emergencies are presented.

Keywords: GIS, emergency, support, forest fires, nuclear power plant event

INTRODUCTION
Almost every information related to the management of emergencies can be equipped with meaningful entry specifying
its position on the earth surface. Owing to this fact, the geographical information systems (GIS) can provide substantial
support for every effort concerning to the emergencies. Because of that, this article is focused on the GIS support of
emergency management on tactical, operational and strategic level.

The first part of the article demonstrates the GIS support of strategic decisions. As an example serves the preparations
of the maps for strategic decisions, which concerns to the aerial firefighting of forest fires on the area of the Czech Republic.
This topic is very important because of the climate change and increasing number of such fires during past year. The statistical data collected during past years on the regional operational centers of Fire and Rescue Service of the Czech Republic were main source for preparation of these maps.

The next part of the contribution deals with GIS support of the management of large scale emergencies on tactical,
operational and strategic level. As an illustration of the support, the information support of the exercise ZÓNA 2015 is
presented. This exercise was focused on the simulated severe event on Nuclear Power Plant Temelín. The printed maps
for the exercise participants and for workgroups were prepared. The special, web based thin map client was prepared for
displaying the simulated situation development during the exercise. This web application, together with direct display of
various layer in ArcMap, was also used for direct information support of various crisis staffs.

During the exercise, the practical deployment of the prepared tools was carefully tested. The stress was given on the
creation of one unified information space, which can be accessed by various subject, involved in management
emergencies, starting from highest level of commands and ending with firefighters on the spot of the event, endangered
people and mass media.

Finally, some ideas to GIS support of the management of emergencies are presented.
FOREST FIRES IN THE CZECH REPUBLIC

The GIS support of strategic decisions of Fire and Rescue Service of the Czech Republic is demonstrated on the demarcation of zones of forest fires aerial firefighting on the area of the Czech Republic. During past years, the Czech Republic faces the very hot and dry weather in the summer. Such weather was crucial for development of many forest and field fires including the large scale fires (from central European point of view).

Owing to this situation, the various GIS analysis was carried out in order to optimize the coverage of the area of the Czech Republic with the aerial firefighting assets.

For the analysis two basic datasets were used. The fires dataset contains a referential data containing territorial units of the Czech Republic, starting from the municipalities through the cluster of municipalities to the counties, the places where the air bases of the Police of the Czech Republic Flying Squad are placed and its operational areas. The second dataset consist from a data concerning to the forest fires on the area of the Czech Republic, which was collected on the operational centers of the Fire and Rescue Service of the Czech Republic during 2006 – 2015 period.

Before the analysis was carried out, the careful review of above mentioned datasets was carried out. During this review was find out, that the data must be cleared before they will be used as the inputs for the analysis.

The main problem of the datasets containing the territorial units was the fact, that some of the area of municipalities, clusters of municipalities and counties consists from more than one polygon and the polygons are a separate entry in the data table. This fact prevents the direct computing of the area density of the forest fires on the area of the territorial units (number of fires per square kilometer of the territorial unit), because the number of the fires for the territorial units will be in this case divided not by the area of the units, but by the various areas of the polygons from which the units is constituted. This problem was even more serious because of the fact, that if the territorial units consists from two or more polygons, there was usually one large polygon and one or more small polygons. Because of that, the whole number of the forest fires on the area of territorial units was also divided by the area of small polygons. This leads to the unusually high density of the forest fires and provides false image on the fire danger on the territorial units and prevents the proper classification of the territorial units, according its forest fire area density, in to the categories. In order to prevent this problems, if the territorial units consist form various polygons, these polygons were dissolved before further usage of dataset into one multipolygon, which was one entry in the data table, characterized by sum of the areas of constituent polygons.

The situation of the datasets, which contains the entries concerning to the forest fires, was even more complicated. The main reasons of this fact was a change of the methodology of the classification of the fires as the forest fires and misclassification of the forest fires, which leads to the negative and positive errors in the summary of the forest fires on the area of the territorial units. There were also the changes in the methodology of the collection of the data on the operational centers. Even the coordinates of the places of the fire were corrupted in many cases. The X and Y coordinates were interchanged, the coordinates have a wrong sign and the various combinations of these errors were presented. Sometimes the coordinates fully missed. Only the entries for last years were without such errors because of the substantial improvement of the software used on the operational centers.

Before the further processing of the forest fires data, the entries without the coordinates, with one or two zero coordinates or with one or two meaningless coordinate was rejected from the dataset. After that the entries with interchanged X and Y coordinate or with coordinate with wrong sign was repaired. The data used the Czech Republic national grid S-JTSK with mathematical orientation of the axes. Because of that, the reparation was easy. It was only necessary to change the order of the coordinates and its sign, to be meaningful for u area of the Czech Republic.

In order to minimize the effect of the misclassification and change of the methodology of classification of fire as a forest fire, the layer of forests was used for a spatial analysis. This layer was a combination of the layer of various forest types (ordinary forest, mountain pine forest and bush). If the fire was on the area of the forest it was taken into further analysis, if not, it was rejected from further processing.

After the preparation of the datasets, the calculation of the forest fires densities on the area of territorial units was carried out. First, the number of the forest fires on the area of territorial unit were counted together with unit area. Finally, the density was calculated by dividing the number of the forest fires with area of the territorial unit. The obtained density of the forest fires was chosen as a criterion for assessment of the forest fire danger on the territorial unit area.

After this analysis, the map output was carefully prepared, which serves for further discussion, with another involved governmental bodies, focused on the coverage of area of the Czech Republic with assets for aerial firefighting of forest fires (figure 1).
Figure 1. The forest fires on the area of the Czech Republic in the years 2006-2015 together with the airports, air bases of the Police of the Czech Republic Flying Squad and its operational areas. The small maps bellow the large map depict the forest fire area densities on the territory of various territorial units of the Czech Republic.

The output of this discussion was a proposal for the establishment of the sectors, the areas which are not at the present time substantially covered by the assets for aerial firefighting of forest fires (figure2).

The forest fire dataset was obtained as an excel file via the export form central Oracle database, which contains the information about all events solved by the Fire and Rescue Service of the Czech Republic. Other data was obtained from Central Data Warehouse of Fire and Rescue Service of the Czech Republic. The above mentioned correction of coordinates was made in excel file. The consequent analysis was carried out with wit ArcPy scripts and the data was stored in ESRI File Geodatabase. The final visualization of the outputs from analysis was made in ArcMap.
Figure 2. One of the proposals of the sectors for aerial firefighting of forest fires. The air bases of the Police of the Czech Republic Flying Squad together with the sector centroids are also presented.

EXERCISE ZÓNA 2015

The exercise ZÓNA 2015 was focused on the management of a simulated emergency caused by severe event at the Nuclear Power Plant Temelín. This exercise provides a possibility to test the various approaches and tools prepared for information support of emergency management, on the Crisis Staff of the General Directorate of Fire and Rescue Service of the Czech Republic and Central Crisis Staff, with GIS. The information support consists from three main parts:

1. Pre-exercise preparation of printed maps for orientation on the area of emergency event. These maps were for disposal on both crisis staffs. In case of need, the maps were for disposal in the electronic form as a pdf or raster files and they can be send to other bodies involved in exercise together with markings depicting the development of the situation.

2. The visualization of current situation and other related layers on the wall screens in crisis staff briefing rooms. The screens were connected to the laptop with running ArcMap (floating license), with an access to the all spatial data in Central Data Warehouse of Fire and Rescue Service of the Czech Republic. The picture of situation was arranged after the direct instructions of the Officer in Charge of the Fire and Rescue Service of the Czech Republic or another person chairing the meeting. In the case of necessity, the screenshots of the situation were administered to the other persons involved in exercise as a raster images.

3. The visualization of current situation and other related layers in web based thin map client. This solution provides the unique opportunity to share the information across wide range of users in the same time. Via the client, the information was available, after the approval of the Officer in Charge, to the all authorized users, starting form high level of commands to the regional crisis staffs an even to the mass media and common public. This enables the creation of the one unified information space in which each authorized user can find the desired information.

Before any steps toward to preparation of the map products for information support of the Exercise was taken, the careful review and preparation of the relevant datasets was done.

Two types of map were prepared for the exercise, the large map for crisis staffs briefing rooms (figure 3) and small map for the personal remarks of the participants of the exercise (figure 4). Both maps depict the emergency planning zone.
centered around the Nuclear Power Plant Temelin. They contain the numbering of the sectors of emergency planning zone and other related data, like evacuation routes, checkpoints, roadblocks, decontamination posts, municipality administrative borders, ... . It is worthy to mention the facts, that these maps prepared for the Exercise can be used also in case of real emergency on the Nuclear Power Plant Temelin.

The visualization of the current situation during the Exercise in the crisis staff briefing room according the instruction of the Officer in Charge of the Fire and Rescue Service of the Czech Republic provides a unique opportunity of the direct support of the decision process with GIS (figure 5). It enables the testing of the relevant datasets, proposed procedures for workout the datasets, and hardware and software assets. It also enables direct review of the data by the Officer in Charge before its publication via web based thin map client for other authorized users. If the data are proposed for publishing via this client, the preferred way of its storage is geodatabase running on Oracle database server with ArcSDE (ESRI server-software sub-system that aims to enable the usage of Relational Database Management Systems for spatial data). This kind of storage enables easy publication of the data as a REST web service of ArcGIS for Server.

If the data are published as a REST web services, they can be easily consumed by various web applications. Publishing a data trough web application enables various users to access the data and the immediately information spread through various levels of the chain of command and various public authorities and even mass media and common public.

Figure 3. The large map of emergency planning zone Nuclear Power Plant Temelin for crisis staffs briefing rooms.
Figure 4. The small map of emergency planning zone Nuclear Power Plant Temelín for personal usage of the participants of the Exercise.

Figure 5. The visualization of the current situation during the Exercise depicting the municipalities proposed for simulated evacuation and the predefined evacuation routes.

For the purpose of the exercise, the web based thin map client, developed on General Directorate of Fire and Rescue Service of the Czech Republic, was slightly customized to satisfy the needs of the Exercise. This customization consists from adding of the new entries to the main menu which enables displaying of:
1. various layers connected with population protection and nuclear power plant emergency event,

2. the layers depicting the current situation and the development of the situation on the place of emergency (figure 6).

The web based thin map client uses the JavaScript, HTML5, CSS3 and ArcGIS API for JavaScript and jQuery JavaScript libraries. It consumes the ArcGIS for Server REST services. The data of the services was stored in Oracle database and ArcSDE (Spatial Database Engine) was used as a layer between the database and ArcGIS for Server.

Figure 6. The web based thin map client with current situation during the Exercise and various layers related to the emergency on Nuclear Power Plant Temelín. The current situation shows the proposed measures for population protection and the number of people (with permanent and temporary address) affected by these measures. The standard layers of the railroads crossings and places where units of Integrated Rescue System reside are also shown. As a background map serves the standard map used on the operational centers of Fire and Rescue System of the Czech Republic.

CONCLUSIONS

The above mentioned examples demonstrated the successful information support of emergency management with GIS systems. Its usage for information support of emergency management can substantially leverage the level of the support and contribute to the successful fulfilling of the missions of Fire and Rescue Service of the Czech Republic.

The chain of the various tools provided by ESRI company, ArcMap, ArcSDE and ArcGIS API for JavaScript provides a unique platform for creation, visualization and publication of information used for information support during the emergencies. It constitutes unique platform, covering whole life of the spatial information, starting from its creation, through its storage, to its publication. This enables a creation of one unified information space covering the whole activities concerning to the emergencies, in which each authorized user can find the desired information.

The above mentioned examples enables the formulation of some advices concerning the usage of the GIS for the information support during the emergencies:

1. Each exercise should be used for testing of information support of the emergency management with GIS. If the GIS assets are regularly tested during the exercises, there is a high probability, that they will not fail during the real emergency.
2. The spatial data can contain various errors and mistakes and even the meaning of the data can change during the time if methodology of its collection change. Owing to this fact each spatial data used for information support of the management of the emergencies have to be carefully revived, and repaired if necessary, before its usage.

3. As much as possible data, tools, hardware and software should be prepared before the real emergency. The exercise can provide guidelines what to be prepared.

4. All tools used for data treatment (preparation, visualization and publishing) must provide seamless platform in order to avoid useless transformation between noncompatible tools. There is no time during emergency for useless work.

5. The used tools must form a platform covering whole life of the spatial information starting from its creation, through its storage to its publication.

6. The same assets should be used for regular daily work as well as for information support with GIS during emergencies. If the assets are regularly used by the users, there is a high probability that user will be familiar with these assets and your work with it will be quick and reliable.

BIOGRAPHY

Capt. Pavel Špulák

I was born in Prague on the 7th July of 1973. In 1991 I have finished Chemical Industrial College and in 1997 I have finished The Institute of Chemical Technology, Prague and obtained the title chemical engineer. After that I work in various research institutions and universities. Since 2005 I have become a member of the Fire and Rescue Service of the Czech Republic and I am working on Directorate General. At present time I am a member of Department of Information and Communication Technologies. My work is focused on various ICT, GIS and programming issues. My favorite programming technologies are Python (both 2.X and 3.X), ArcPy, Oracle, JavaScript, jQuery, ArcGIS API for JavaScript. CSS3 and HTML.

Col. Jan Brothánek

I was born in Ostrava on the 12th April of 1983. I have finished the College of Civil Engineering in 2002 and in 2008 I have finished the Technical University of Ostrava and obtained the title engineer. My studies there were specialized on GIS. After finishing of the University I worked as implementation specialist in software development center of PPF group. Since 2010 I am member of the Fire and Rescue Service of the Czech Republic and I am working on Directorate General as a GIS specialist. I am focusing on coordination of GIS issues in the scope of Czech Fire and Rescue service and project management.