DYNAMIC VISUALIZATION IN EMERGENCY MANAGEMENT

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Abstract

Support for an emergency management is one of important role of contemporary cartography. Map use during emergency situations is demanding high flexibility according to situation dynamic, scope of decision making and various user involved. Electronic maps are offering more flexible possibilities then traditional analogue maps without debate, but nowadays, despite main data sources for emergency management are GIS based, many cartographic interfaces are even less efficient copies of former analogue maps.

In our paper we would like to make an overview of contemporary situation of cartographic support for emergency management in the Czech Republic. At the base of this analysis we focus on possibilities of dynamic cartographic visualization involvement in these processes. The main topics to mention are adaptive cartographic representations for operators, dispatchers and decision makers over shared geodatabases with continuous update. Possibilities of small display cartography in mobile environment will be discussed with emphasis of operators. Cognitive and perception abilities of operational staff will be evaluated.

INTRODUCTION

The use of GIS in a wide range of applications has been practical and successful for the last years. The enormous possibilities of these systems are thoroughly appreciated and have been established as decision supporting tools in many areas of human activities. Today's GIS are usually static and often used in long-term planning and administration processes. The technological development in the IT as well as telecommunication sector shows a clear trend towards mobile applications. Such mobile use would also be desirable in the GI/GIS sector and would broaden the possible fields of applications for those, who are in a need for quick decision in the field.

Natural hazards and other emergency issues are usually related to a specific location and other spatial information (address, river, chemical plant, and road). In emergency management, a better analysis of the situation, the planning of resources, the prognosis or the damage relief are demanding for a useful combination of topographic and thematic spatial data.

Existing geospatial solutions are not covering all possible field applications exhaustively and are often used in the traditional pre- and post-disaster activities. During the emergency events an appropriate GI based emergency management supportive tool is lacking. Disaster and risk management needs to ensure interoperability of emergency services, to provide appropriate information at the right place and in the right moment and to ensure high-quality care for citizens. An extended cooperation is needed across different sectors involved in risk management such as the Health Sector, Police, Fire Brigade, municipality and civil protection, which is beyond their specific services and communications.

The importance of the standard procedures for communication were recognized by the Open Geospatial Consortium (OGC) which is currently addressing an extensive set of interoperability initiatives and standards (WMS, WFS, SWE) and the OGC Working group on disaster management became again active dealing with the emergency management relevant geospatial issues (critical infrastructure - CICE, emergency management symbols – EMS). Parallel to

developing new technologies and approaches for data access and sharing, the process of decision making has to be improved and facilitating tools must be further developed.

Despite several successful studies both on the field of mobile interoperable emergency management (Urbánek, 2005), decision support systems (Zlatanova, 2005), and wearable GIS (Baldegger, Giger, 2003) the problem of dynamic geovizualization is still viable and unsolved on broader application level.

CONTEMPORARY SITUATION OF INFORMATION SYSTEMS AND CARTOGRAPHIC SUPPORT FOR EMERGENCY MANAGEMENT IN THE CZECH REPUBLIC

The central organ of public administration dealing with the matter of civil protection in the Czech Republic is the Ministry of Interior. Execution of public administration in civil protection that is enacted in organisational structure of the Ministry of Interior is secured by General Directorate of the Czech Fire Rescue Service.

General Directorate of the Czech Fire Rescue Service (below CFRS) co-ordinates activities in the area of civil protection in a close cooperation with central and other bodies of public administration. Further, according to the transferred force, it co-operates with self-administration organs, corporations and selected individuals, that run a business on the base of law and whose activity is important for security of civil protection tasks.

General Directorate of CFRS manages 14 fire rescue brigades and also establishes educational, technical and purpose-built institutions.

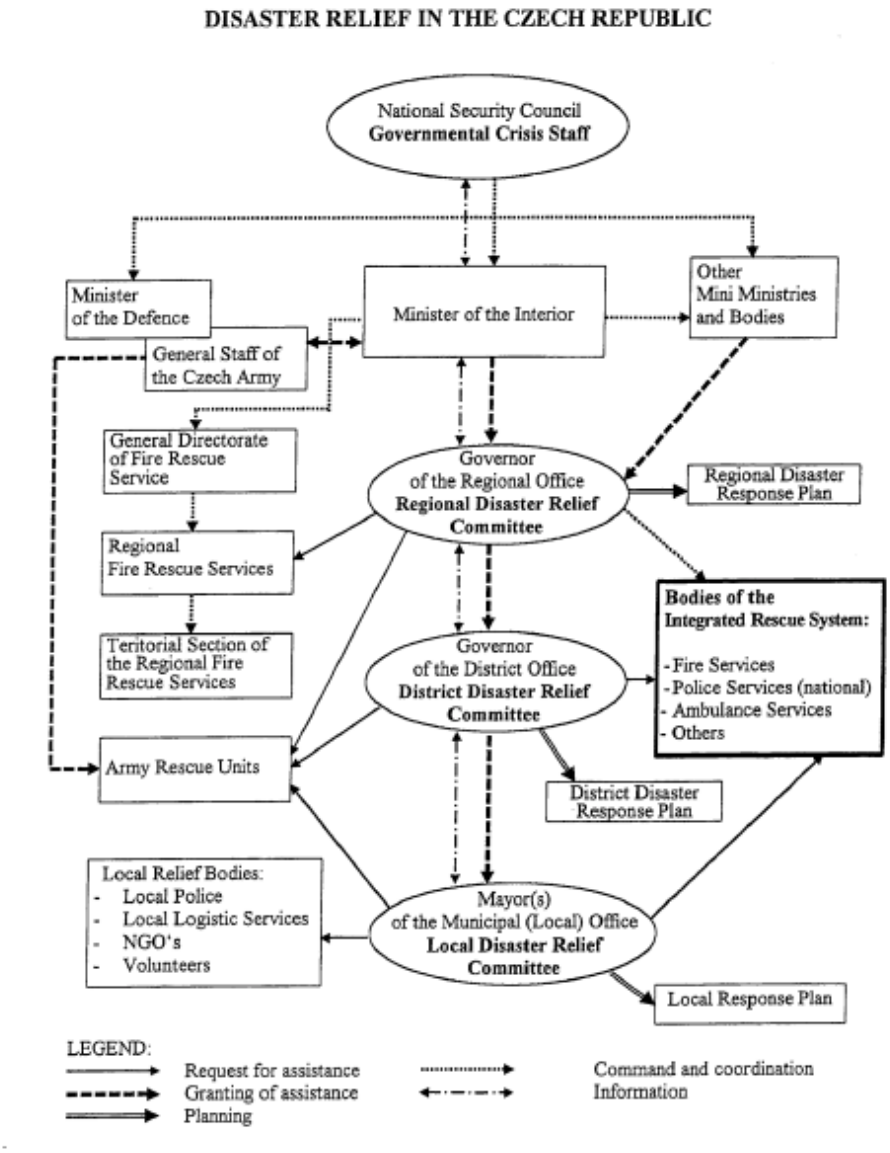


Figure 1. Structure of disaster relief in the Czech Republic (Obrusník, 205)

The Czech Republic has a relatively new policy of crisis management, which includes especially early warning, dissemination of warnings with precisely specified responsibilities and competencies of all main "players" like the above mentioned CFRS, army, various state institutions (ministries), and also regional institutions (regional administrations, regional FRS, and others). Similarly the system goes down to communities and their administrations. The Crisis Management system together with Integrated Rescue System has been defined by a new legislation package valid since January 1, 2001. The whole system has been used during the 2002 August catastrophic Flood in the Czech Republic (and Central Europe). The government in January 2000 approved General Strategy for flood prevention. Some other precaution related more to prevention of disasters (mainly floods) in future are solved in harmony with the legal transposition of Water Framework or other specific EU based norms.

Hazard mapping has been done on sectoral bases by several institutions. Recently, the Ministry of environment launched a project for mapping in GIS various kinds of hazards and also risks (Seveso chemicals, land slides, floods waste and combined hazards have also been considered e.g. flooding of waste etc). These databases and GIS will be available for ministries, regional administration and institutions supplying data. However, an access will be limited. On the other hand, some hazard mapping has also been carried out by insurance companies.

More detailed risk monitoring and mapping is under development as a part of the overall crisis management and will be finished within the next 2 years according to the official statement (Obrusník, 2005).

Relatively well developed is risk information management system for floods (flood prevention plans and management) – on all levels of state, regional and community administration. For other kinds of disasters it is not so developed due to low frequency of such events in comparison with floods.

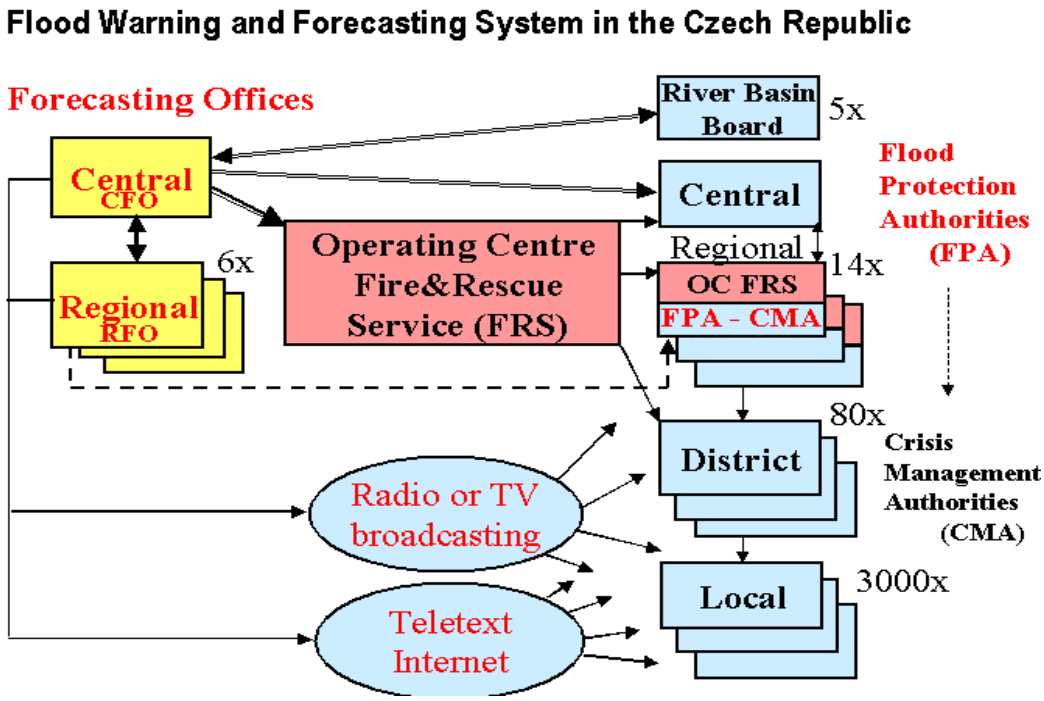


Fig. 2: Connection of Warning and Forecasting Service to the State Crisis Management System (SCMS) (Obrusník, 2005).

The responsible bodies for flood warning in the Czech Republic are the Czech Hydrometeorological Institute (CHMI), which fulfils tasks of national meteorological and hydrological service (NMHS), and River Basin Boards responsible for water management including manipulation of dams. Since the disastrous 1997 Flood CHMI has started to re-built and re-organize its forecasting and warning service by creating a mutually inter-connected system of a Central Forecasting Office (CFO) in Prague-Komořany and six regional forecasting offices (RFOs) at the Institute's regional branches. All RFOs include a hydrological and a meteorological sections forming a fully integrated forecasting and warning system, based on a multi-sensor observation input (precipitation, river flow, data from the WMO Global Telecommunication System (GTS), which uses also modern remote sensing devices like weather radars and satellites (especially for nowcasting). Moreover, the system also routinely uses data from numerical weather models for heavy precipitation forecast and permits flood forecasts with a longer lead-time. Since 2002 year, hydrologists both at CFO and RFOs calculate operationally hydrological models derived and calibrated in the past for the basins of the major rivers in the country and pass and disseminate hydrological forecasts and warnings together with meteorological information via the State Crisis Management System –SCMS and, when necessary also via media, to the public (Fig. 2).

During the 2002 flood the CFO's hydrologists routinely issued summary reports (60 such reports during the whole event) about water stream levels with flood warnings and alerts distributed together with the meteorological part, in the state emergency system by Fire and Rescue Services and also in media (TV, radio). CFO also issued 15 special reports for the country's Central Crisis Management Staff (CCMS) and the RFOs cooperated similarly with regional staffs. CHMI distributed information and forecasts from the Czech part of the Labe river basin to the crisis management authorities in Germany, what could serve as an example of cross-border cooperation within the central European region.

The feasibility study of Emergency Management Information System (EMIS) was formulated in the early 2005 (Nesrsta, Jindra, Horák, 2005). Information system is assessed from different viewpoints including:

- Hierarchy – there exist 3 main levels of EMIS – central, regional, and local with different roles in emergency situations.

- Organisation – processes, methods, and scenarios are analysed. It is also an important integration component for bridging the EMIS with other systems.

- Data and technology – describes EMIS on the conceptual level and technologies used. The main building stones of the proposed architecture are secured communication infrastructure and service oriented architecture (SOA) based on the web services concept.

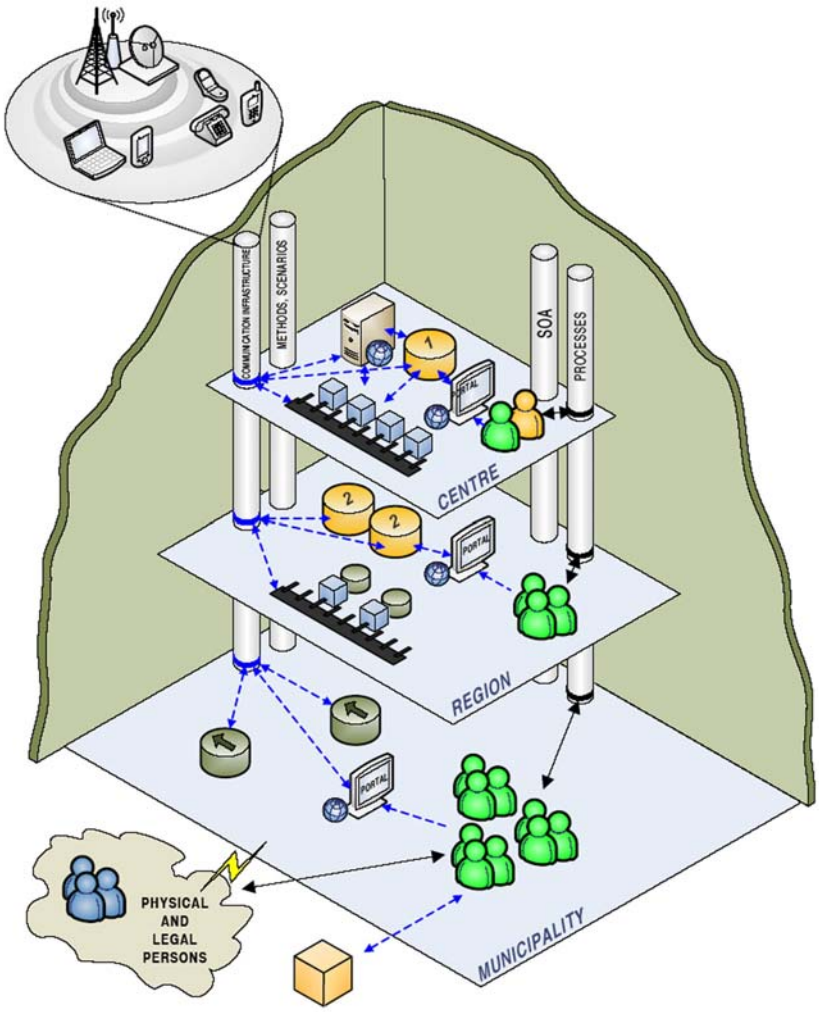
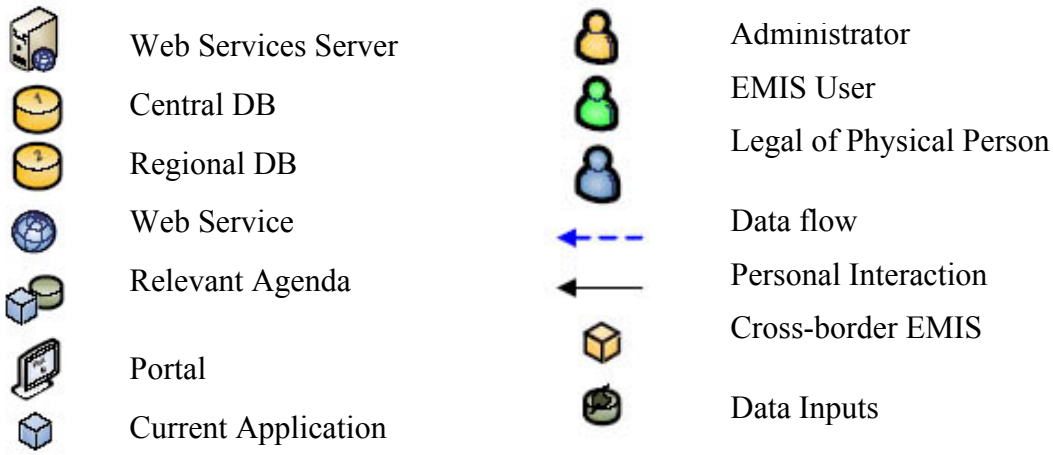


Fig. 3 – Proposed general architecture of EMIS (adapted from: Nesrsta, Jindra, Horák, 2005)



General architecture of EMIS is shown on figure 3. EMIS is proposed as a modular system based on interrelated modules. One of the 3 main subsystems is the GIS and navigation system consisting of maps, digital orthophotos and relevant registries (without detail specification).

Since the feasibility study did not explicitly defined the geospatial component of emergency management support, there was initiated another study focused specifically geospatial issues. The study analyses current legislative and organisational structure of the Fire Rescue Brigades – the de facto entity in charge of emergency management. It also describes the basic users' tasks, personal background, and defines the simplified conceptual model of processes. GIS data sets and current technology are examined together with existing hardware and basic communication infrastructure. The second part of the study drafts and proposes the possible future solution – basic reference data sets, thematic data sets, technical background including back-up, and architecture as well as the main application of the future system. Integration with other systems in both directions is only sketched (see fig. 4) and some basic interoperability principles are mentioned (NSDI, INSPIRE principles, Open Geospatial Consortium web services).

The above mentioned top-down attitudes are implemented on the central level, however there exist also activities on the regional level building the emergency management information system bottom-up (Macko 2005).

POSSIBILITIES OF DYNAMIC CARTOGRAPHIC VISUALIZATION

Contemporary cartographic support of emergency management is either copy of ordinary analogue maps as a base map background or simple static visualization of features stored in geodatabases. Technology nowadays offers much wider possibilities how to make cartographic representation. In our project we are focusing on maximal involvement of electronic maps abilities in order to reach efficient decision support in emergency situations. The main idea is to create real-time individual cartographic representation from common data source that is continuously updated. Cartographic visualization of relevant real world phenomenon represent very effective way to explore spatially related data and necessary decision can be accelerated. Dynamic visualization also overcomes the main bottleneck of analogue maps - its inflexibility; they simply cannot reflect all possible information that is useful for topical situation. On the other hand

analogue maps are usually overloaded with information; hardly legible for ordinary people and only staff trained in particular map reading is fully able to use all the information available. GIS client software allows symbolizing geodata according to attributes, but creation of a sensible visual representation takes time and needs cartographically skilled staff. In this context we need to establish processes which will automatically generate cartographic representation on demand and ease the reading for dedicated persons or user's group. Several partial tasks must be accomplished to reach aforementioned goals:

- To establish common data source – in this task it is necessary to create uniform interface to various resources which are necessary for emergency management. Nowadays exist databases and geodatabases with a lot of useful information for emergency situation, but their software and model environment is heterogeneous. In the time of emergency situation it is difficult to combine data and almost impossible to create appropriate map. It is necessary to ensure existence of some information hub which will generate, combine, and provide maps to operational units. For functionality of such hub there must be all involved data sources equipped with rich and uniform metadata and appropriate thesauri multilingual must be prepared. In the case of geodatabases we need both geometric thesaurus and attribute thesauri. As objects geometric thesauri we can consider gazetteers and various cartographic or geodata models. Some of attempts already exist, but usually are incomplete and are regionally or thematically limited.

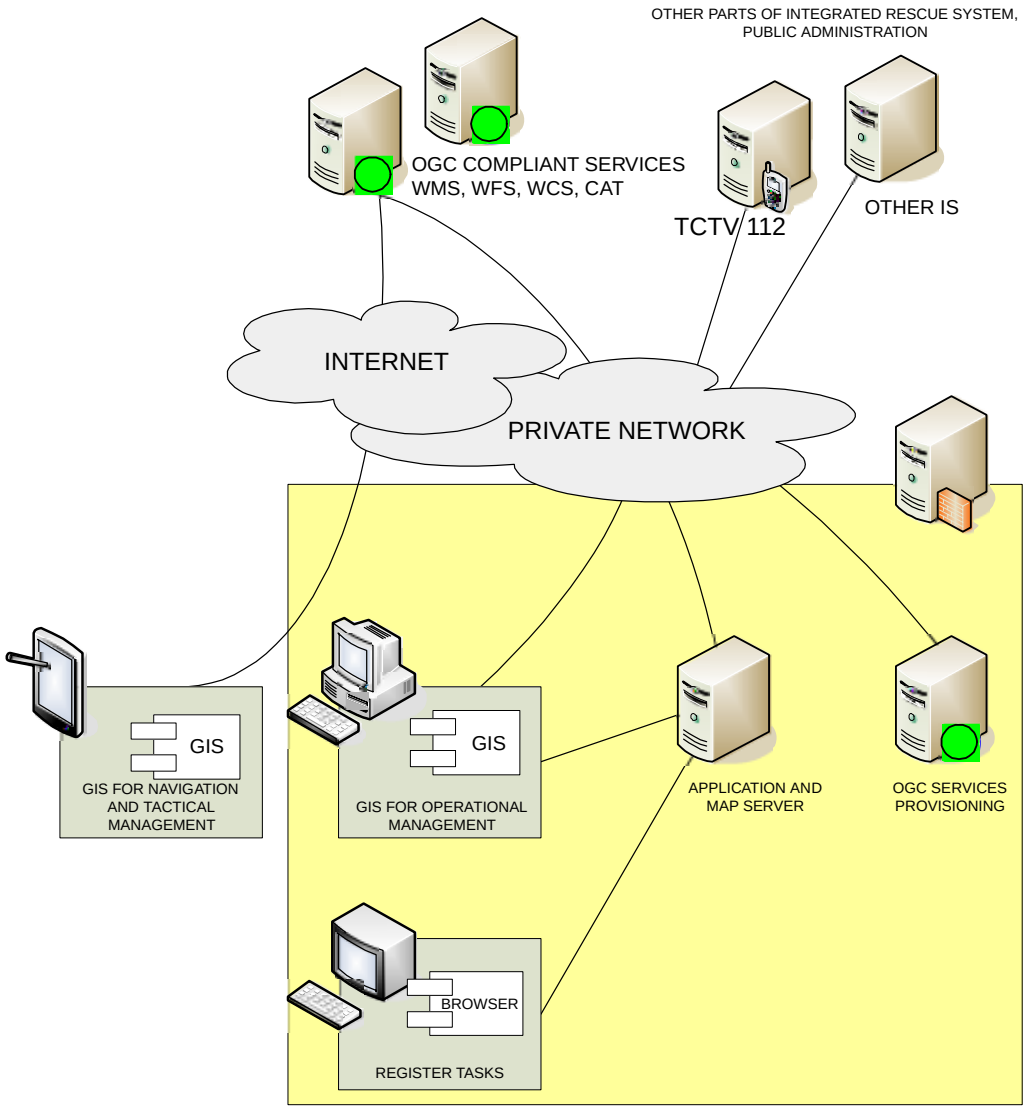


Fig 4. Integration of GIS system with other integrated rescue system services (adapted from: T-maps, 2004)

- To ensure adaptability of cartographic representation – adaptability extends cartographic generalisation with involvement of user status. In the case of emergency management we can consider following occurrences of map adaptation:

1. User level – operational units, dispatching units and stakeholders need different scales, themes and map extent, but over the same data because of understatement.
2. User background – people involved in emergency management have different educational and map use bias.
3. Theme importance – different features are necessary in map content and features have also variable significance with changing emergency situation.
4. New phenomena – new features reflecting the emergency status need to be inserted into map consistently.
5. Interaction between device and environment – various electronic visualization devices are used and they are also in interaction with environment which is influencing visibility and amount of information used.

- To ensure real-time reclassification of phenomenon – if map plays role of database mining and decision support tool than the key process is distribution of data sets to classes for easy understanding of phenomenon nature and importance. Phenomenon has many attributes and weight of attributes is changing according to situation – quick classification algorithms are necessary.
- To solve cartographic visualization on devices with limited size of display – at the lowest level mobile device are usually used, such devices have displays which cannot be regularly used for traditional maps. There is necessary to design symbolic non-geodetic cartographic representation with multiscale capabilities and irregular movement over map space.
- To design symbol sets which will take into account device capabilities and user psychic status – symbology plays important role in perception of features in map and strongly supports cognition of spatial patterns. In case of emergency situations we need to consider stressful situations of all involved persons that lead to errors in perception. Symbols must reflect such situation, but also need to respect customs in particular thematic area. In symbology domain there exist standardizing activities from the side of OGC. Standard proposal is named EMS-1.This activity has wider background focused on general delivery of web mapping services during emergency situations. According to symbols they are related to FGDC symbol sets for emergency mapping (ERMS) but standard is extensible and supports variable symbolisation.
- To involve dynamics into cartographic representation – temporarily unstable and changing conditions play important role in emergency management. What happens if …, and what is the extent of moving phenomena are the most obvious questions to be answered. All these aspects must be expressed in proper cartographic representation through involvement of animation and time stamps.

Cartographic visualization in emergency management can play a key role like an instant decision support tool. For such task it is necessary to encourage and support general standardisation activities in emergency management area. But even more important is involvement of new technologies of electronic and mobile mapping. Future maps for emergency management must be more schematic and individual then contemporary maps. According to user environment it is necessary to provide deep research in area of usability (both map content and map controls must be focused) to improve intuitiveness of usage. Maps need to be tailored to user not user to map especially in this domain.

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