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MOBILE AND ADAPTABLE CARTOGRAPHY AND GEOINFORMATICS IN EARLY WARNING AND CRISES MANAGEMENT

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Mobile and Adaptable Cartography and Geoinformatics in Early Warning and Crises Management

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I. Introduction

From time to time, we can read even in papers of influential specialist that we are now "beyond cartography" and live only in the world of geoinformatics. These authors probably want to stress the fact that nowadays cartography is not a discipline producing only analogue maps by traditional means. On the contrary, it is very significantly influenced by geoinformatics and Information and Communication Technologies (ICT) in general. But it also true that cartography is "still" here. It is able to adapt new technological methods and design new scientific approaches, and moreover, it is able to enrich many processes of map creation and also play an integrative role in common use of many approaches in GI fields. Cartography is offering new types of maps based on spatial DB; it is using the Internet and creates new kinds of maps for it. Today we are talking about ubiquitous mapping, mapping for everywhere, everytime and everything. In some countries, there is significant development in the fields of Mobile and Adaptable Cartography.

All these parts of cartography together with geoinformatics should be used in situations critical for human decisions aiming at harm reduction and often also saving human lives. These are the Early Warning and Crises Management. It is a fact that in key U.N. and EU documents we can find reference to GIS, remote sensing and sometimes geographic information. It is also a fact that after disasters like serious floods or tsunami the rescue works are supported with the use of GIS (e.g. ESRI products in Sri Lanka or Intergraph products in New Orleans). However, these GI technologies are so far not a natural, internal part of operations performed in EW and/or crises management situations.

II. How are Contemporary World Community requests in Early Warning and Crises Management?

Many responses for this question we can find in the materials and Conclusions of the EW III, The Third International Conference on Early Warning , From concept to action which was held on March 27-29 March, 2006 in Bonn, Germany. *Early warning is a major element of disaster risk reduction. It helps prevent loss of life and reduces the potential economic impact of disasters. To be effective, early warning systems need to actively involve the communities at risk, facilitate public education and awareness; communicate and disseminate warnings and messages, and ensure there is a constant state of preparedness.*
Some of the problems connected with cartography and geoinformatics have been highlighted by UN Special Envoy for Tsunami Recovery *President Bill Clinton*.

Talking about practical steps that we can take for EW benefit, he said: "We know *that hazard and vulnerability mapping can give vital advance knowledge of potential risks and information on where best to invest to reduce suffering in the future.* But awareness and knowledge do little if there is no actual implementation of the *preparedness measures."* (Clinton, 2006).

After conference discussions and meetings the participants of the EW III conference agreed necessary future activities:

- Reiterated that effective *early warning systems must be an integral part of disaster risk reduction strategies in national development frameworks* and requires *cooperation amongst many actors.* Emphasis was placed on the important role of local communities, of increased regional cooperation, as well as of training, education and awareness-raising;

- Welcomed the *Global Survey of Early Warning Systems* requested by the UN Secretary-General and encouraged all partners to act upon its recommendations;

- Encouraged national governments, local communities and agencies to utilise the Early Warning Checklist when developing and evaluating their early warning systems;

- Underlined the need for further scientific research to better address early warnings and future risks, developing multi-hazard approaches, with a *special focus on people at risk, their vulnerability and their socio-cultural context;*

- Recognized the need to further *mobilize political commitment*, to expand the dialogue on early warning and to fill identified gaps in early warning capacities, and therefore encouraged the strengthening of the International Early Warning Programme (IEWP) and its Platform for the Promotion of Early Warning, as part of the reformed ISDR system and to facilitate the implementation of the Hyogo Framework for Action; and

- Encouraged the wide dissemination of the outcomes of the conference.

Key issues of conference contained important signals for cartographic and geoinformatics community:

"Issues Identified on Risk Knowledge
The Key points have been raised by participants in relation to risk knowledge, such as the *systematic collection of data* and the processes of undertaking risk assessments, included:
The importance of undertaking hazard mapping and risk assessment with the involvement of the community. This is critical to help raise awareness and knowledge, maintain momentum on disaster risk reduction, and to improve relationships between local and national organizations.

Issues Raised on Monitoring and Warning Services
Reliable monitoring and warning services lie at the core of effective early warning systems. Some improvements could be made in this area:

- Technical monitoring and warning systems must account for the needs of recipients, include *local knowledge, and be coupled with effective communication systems to ensure warnings are understood and acted upon.*
-Better education of local people and communities regarding warning and forecasting systems is required.
- There is a need to better interconnect existing monitoring and forecasting systems to *develop an efficient global early warning system.*
- It is important *to identify ways* in which technical specialists and scientists *can interact more effectively with the local communities in the development of early warning systems.*
- Better use should be made of existing monitoring and forecasting technologies, such as *satellite and spatial data and equipment for early warning purposes.*

Issues Raised on Dissemination and Communication

There were highlighted ways in which warnings could better get to those at risk, and contain clear and useful information that enables proper responses:

- A one-size fits all approach will not take the message the critical 'last mile'. The individual needs of each community must be considered.
- Volunteers and their network are vital to both disseminating warnings and *building community capacity.*
- Building and maintaining trust in the authorities that issue and disseminate warning is critical.
- Disseminating information and warnings to remote areas remains a challenge and reinforces the need to use both technical and non-technical dissemination methods and technologies.

Issues Raised on Response Capability

Communities must understand their risks and warning messages must contain clear useful information to enable proper responses. Key issues include:
- *Building local and national capacities* through involving and empowering people.
- *The critical role of education and public awareness in building understanding of hazards, vulnerabilities and response mechanisms.*
- Focused training to ensure people know how to respond to warnings, *understand how to use equipment and interpret data,* and feel empowered and motivated to maintain early warning systems.
- Better understanding is required in relation to *how people behave and respond to warnings.*
- Maintaining trust and credibility in early warning systems remains a challenge, particularly if false alarms are common.
- Learning from previous disasters is critical to enhance education and awareness and to improve existing early warning systems.

Key Overarching Issues Discussed

A number of important cross-cutting issues were also raised throughout the conference by participants:

- There was clear consensus that a multi-hazard approach to early warning systems is the best way to move forward, while recognizing that different hazards often require individual preparedness and response strategies.
- The need for involvement and empowerment of local communities, or *a 'bottom-up approach'* consistently emerged. Utilizing existing community structures and systems was stressed, along with the need for *active involvement of people most likely to be exposed to hazards in all aspects of the early warning chain*.
- Gender and cultural diversity issues require further consideration when implementing effective *people-centred early warning systems*.
- The importance of effective legal frameworks for disaster risk reduction and early warning was highlighted; the role of local authorities in early warning was stressed; and the importance of mainstreaming disaster risk reduction into development and poverty reduction strategies was reiterated. Coordination of international systems, such as the proposed global early warning system, and national systems was also emphasised.
- Access to adequate funds for disaster risk reduction and early warning remains a concern and challenge for governments, especially in the developing world."

From the point of view of cartography and geoinformatics there area many of approaches linked by one aspect together– by their *location* on the ground or in space. It is very convenient and effective to use maps - analogue or digital, gegraphic information systems (GIS), GPS, remote sensing, etc. for partly or complex solutions of above mentioned problems. Cartographical approaches and its language can help to communicate between scientists, politicians, decision makers and inhabitants in all part of the World by standardized way. Cartography commonly with geoinformatics are rapidly developing research and application fields based on modern information and communication technologies which all together are used or could be used in near future for solving of many above mentioned tasks..

It is a fact and big challenge for ICA that in so high level documents are formulated topics solved by our GI community for many years. Why it is not working? We have Global mapping project covering by digital information almost all world, we are testing how are people reacting and understanding maps in critical situations, we are developing and standardizing information coming to the children through mobile equipment, we are creating new methods of dynamic visualization based on data bases but as well as on so called "sensor cartography", we are able to create multimedia, smart or internet maps. Perhaps the gap exists because our GI fields results are not enough known and deeply included into wide ICT development. Another reason is that we are too much involved to technological approaches but question of context is sometimes on the side.

III. What is new in contemporary cartography?

In compare with the past contemporary cartography became to be different in many aspects. Intelligent access to databases and interactive user support can be used not only for the location of suitable maps on the Internet, but also for map creation and modification according to *specific and individual requirements*. Instead of just *using maps* created by someone else in advance (former role of National Mapping Civil or

Military Organizations), these new research technologies allow individuals to use cartography *interactively, on the basis of individual user's requirement*, to study and present spatial information. It means that nowadays, maps can be adjusted according to requirements of individual users so that the decision making process based on information acquired from the map is facilitated as much as possible. The set of characteristics related to the user, the environment and purpose of map is called **context** and maps that are able to dynamically react to context are called **adaptable maps**.

Because the development of standardized tools (frameworks) for creation of electronic maps is relatively recent, adaptable cartography is so far mostly in the experimental phase. Moreover, because of its commercial use, attention is paid mostly to the area of tourist cartography. **Mobile cartography** is more enhancing the technological part of the realization of the cartographical ideas, the term adaptable cartography is more related to the context of the maps. A good example of new cartographical trends is the GiMoDig Project (http://gimodig.fgi.fi). However, another promising area that could utilize this approach is the area of spatial decision-making concerning specialists from different disciplines and with different educational and cultural backgrounds.

For many years ICA is investigating cartographic education of children. Many tasks were solved in school cartography (maps and atlases), new questions are answered inside mobile cartography. Mobile equipment is a powerfull , especially between children very popular tool which can assist also in the situations of early warning and crises management.

III.1. Context and cartography

In a certain sense, adaptability to context is an extension of cartographic generalization, because extent, scale, character of displayed area and purpose of map is contextual information. In adaptable cartography we have to take into account variability of extent of displayed area related to differences in displays of used equipment (e.g. PDA vs. 19“ LCD monitor). Related to extent is **scale**, transformed to the term **level of detail**. It also becomes a variable characteristic reflecting the necessary amount of information required for taking a decision.

Purpose of map is highly specialized, same as characteristics of the user. Purpose specialization is related directly to the involved situation – e.g. tourist map changes its appearance when we plan a bicycle trip, hiking tour or search for attractive views. The user (who was previously only partly considered in the map purpose) is now much more specific – we can consider his level of education, age, cartographic experience and also his individual tastes and preferences.

The aim is to adjust map to the user’s cognitive abilities and shorten time necessary to extract required information from the map.

Besides specialization of existing contexts, new contexts related to environments of use are created. This includes hardware characteristics of visualization environment (e.g. size of pixel) influencing size of symbols, number of distinguishable colors or transmission characteristics indicating amount of available data in certain time, etc. They also take into account external environment – time, season of the year, location of user, visibility and many other environmental characteristics *(Friedmanova, Stanek, Konecny 2006)*.

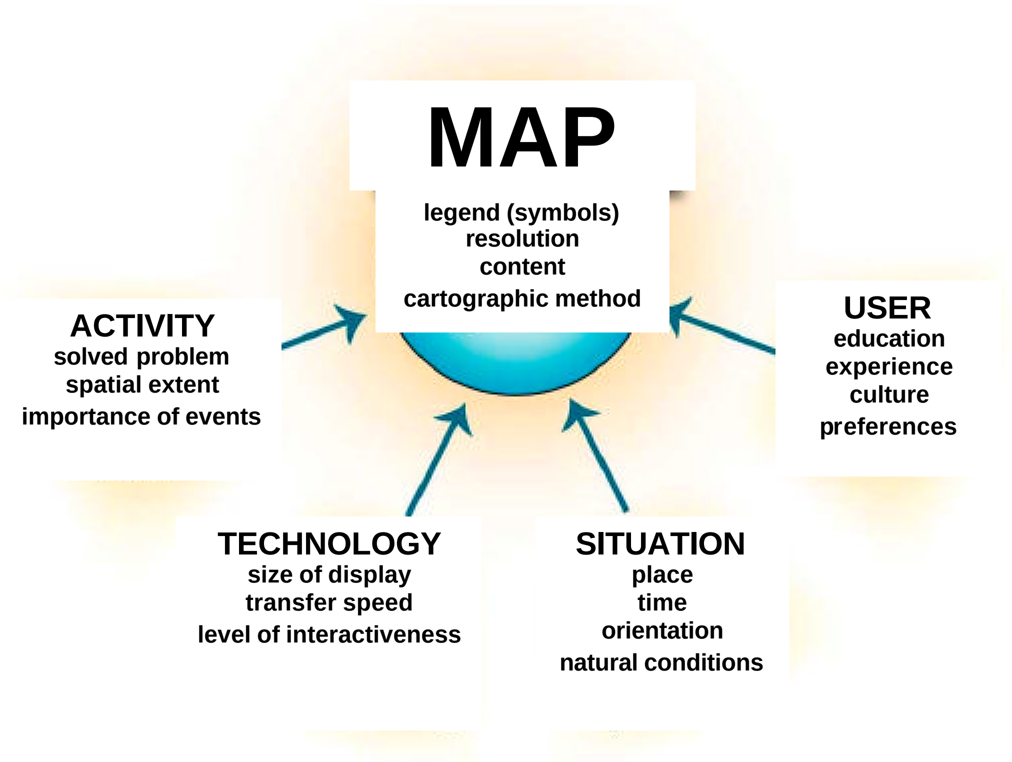

***Fig.3**.: Examples of changes in visualization according to change of context (Friedmanova, Stanek, Konecny 2006)*

III.2. User profiles and situation diagrams

All combinations of the above mentioned contexts create a large number of potential types of cartographic visualizations of geodata. In real life situations, processing such information is limited by time. In order to be able to generate variable content of map in real-time, we have to limit number of alternatives while preserving all substantial advantages of adaptable cartography. The method leading to required selection of alternatives is **the definition of generic user profiles**, together with determination of individually adjustable parameters. Similarly, it is possible to determine several typical situations related to map content; such content can be reduced in individual situations.

In order to create profiles and situation diagrams, it is necessary to analyze decision-making processes for which the maps are used – what are the situations like, what are the roles of users, what **Types of users** will probably take part in dealing with the situation. Dependence between user profile and situation diagram is apparent when a certain type of user can only face a specific, determined situation.

III.3. Others

There are also some others important items which should be solved for good functioning of mobile and adaptable cartography, such as creation of thesaurus, data mining,. etc. (see Friedmannová, Stanek, Konecný, 2006).

IV. Role of cartography in Early Warning and Crisis Management

Many questions asked during management of a crisis situation begin with the word WHERE – WHERE did something happen, WHERE are the rescue units, WHERE are the sources of danger, WHERE should the threatened people be relocated, etc. It is clear, that a natural answer to these questions is a map. The role of cartography in crisis management is therefore clear – simplify and well-arrange required spatial data. That makes the decision-making process quicker and better and leads to minimization of damage.

Members of crisis management and integrated rescue system include the Fire Service, the Rescue Service (Ambulance), the Police, Ministry of Environment, Ministry of Industry and Trade, Ministry of Transportation, Ministry of Defense, Administration of the State Material Reserves, State Office for Nuclear Safety, local authorities, etc. For many (often historic) reasons, these institutions are equipped with a varied set of referential databases Moreover, they build their own thematic databases according to their individual internal needs (database of settlements, maps of flood areas, database of sources of hazards, maps of land-use, ortho-photos of selected areas). Variety of used software corresponds to used databases. E.g. most frequent are ESRI platforms supplemented with different application software developed individually for the users.

The key role for many solutions is nowdays delegated to so called Spatial Data Infrastructures (SDI). E.g. in Europe in the EU member countries and in the accession countries, several large-scale data/information infrastructures are being created (INSPIRE, GMES). They are built in order to support management and decision-making processes, and they are also used for solving a wide range of problems, including crisis management. These solutions require updated, precise, interoperable and integrative spatial data and information equipped with metadata. There is significant public demand for integrated participation of several scientific disciplines in provision of early warning and crisis management. Up-to-date information, their suitable structuring, and easy access to them are necessary for supporting timely and correct decision-making in emergency/crisis situations. Most of such information is area-bound. Their important component is geographical localization; in dynamically changing situation time is also an attribute.

Spatially localized systems can be organized in Geographic Information Systems (GIS). These systems are often the core of the entire management systems that solves not just basic localization tasks, but can also be used for planning and solving complex crisis scenarios and applying their results into practice. An integral part is also visualization of all used information both in static and in dynamic modes and also transfer and processing of all updating information.

V. Early Warning, Crises Management and Mobile and Adaptable Geovizualization Potentilas

Geoinformation and their visualized display are nowadays used not only in stationary systems; they are also becoming an integral part of mobile workstations. Mobile workstations have two basic functions from the point of view of GIS – collection of updating data and communication with higher levels of management. These tools are currently represented mainly by GPS receivers, often equipped with a display unit with various technical and technological quality that allows visualization of basic topographic and additional thematic data. Also used are modern cellular phones – latest models are also equipped with relatively large displays.

Mobile workstations have to be equipped with tools for processing geoinformation and also with corresponding communication tools and channels (communication infrastructure), which are used for providing continuous connection to stationary, usually controlling systems; mobile stations and controlling systems exchange updating information on the dynamically changing situation. Mobile workstations are usually located directly in crisis areas and their operating crews are under significant psychological pressure. Therefore, mobile workstations have to use the latest data and visualize it in such a way, that their users can perceive it clearly and correctly. This is provided with the use of *dynamic cartographic visualization* tools. (Konecný, Kubícek, Talhofer, 2006).

Dynamic cartographic geovisualization is variable visualization of geographic data with cartographic means; it is adapted to scale, range, and context of visualized data (the term „context“ refers to combination of displayed data, hardware and also user's requirements, socio-cultural background, and environment).

An important user of the above-mentioned approaches is crisis management. From the point of view of geoinformatics, crisis management units utilize both spatial data infrastructures including systems for collection, processing, storing, and transfer of updating, usually dynamically changing data, and methods of cartographic visualization, which communicate data and information to user's consciousness. Decisions of users - especially of those in mobile workstations operating directly in the field - are based on visual perception of the given information. This perception is influenced by specific situation of the user. The resulting effect of communicated information is determined by the following:

- characteristics of geoinformation (content, resolution level, quality, timeliness, etc.),
- suitability of cartographic visualization for the used terminal device,
- quality of updating including application of stable transfer systems especially for updating data,
- psychological condition of end user given by their personal character and situation and psychological condition of rescued persons.

The above-mentioned problems are dealt with in the project *Dynamic visualization in crisis management* solved in 2005 – 2011 as a research plan of the Ministry of

Education, Youth, and Sports of Czech Republic (project code MSM0021622418) leaded by the author of this paper. The basic objective of the research plan is creation of a standard digital cartographic infrastructure for dynamic visualization of geospatial data for provision of mobile services (on basis of mobile Internet, mobile telephony, etc.) in crisis management.

The first point is development, formulation, formalization, and algorithmization of procedure for implementation to programming support of crisis management leading to creation of such digital products, which help the user make correct decisions.

Another objective is an analysis of the entire system of geoinformation infrastructure from the point of view of its functionality for cartographic visualization oriented on dynamic visualization, analysis of methods and approaches of dynamic cartographic visualization, concept design, concept validation on testing samples, and elaboration of a pilot project. The objective also includes designing a communication system providing maximum possible speed and stability of data transfer, independence on potential crisis situations, and functioning under all circumstances.

VI. SPATIAL LOCALIZATION IN CRISIS MANAGEMENT

In GIS databases used for early warning and crisis management it is necessary to have explicit definition of location of all objects and events. This explicitness is provided also by standardized geodesic referential system, and also the used cartographic projection.
It is necessary for crisis management to have a continuous system of localization service, especially in the field. Requirements on availability, coverage, accuracy and reliability of localization (including exact time) are best met by Global Navigation Satellite Systems (GNSS), which include:

- GPS – NAVSTAR (Global Positioning System) managed by US Administration; in full operation since 1996 – the only system of all those listed that meets all requirements on full operation;
- GLONASS (Globalnaja Navigacionnaja Sputnikovaja Sistema) is a Russian localization system. In the long term, it doesn't meet requirement of full operation; currently (September 2005) only 14 out of planned 24 satellites are active;
- GALILEO should be the European counterpart to GPS. After it is put into operation, it will be a suitable and much more perfect alternative to GPS – NAVSTAR, because it will offer a much broader use of its results in practice. The GALILEO System should be in operation since 2008.

Besides satellite navigation systems, localization in real time can also be done with the use of inertial or „quasi-inertial“ measuring systems, and also networks of GSM operators.
Inertial measuring systems are relatively complicated and are characteristic with significant accumulation of measurement inaccuracies in results. Accuracy of results quickly drops with time of autonomous operation. Inertial systems – as opposed to satellite systems – provide beside localization also prompt information on orientation

(direction) not only in open terrain, but also underground and/or inside buildings. The future of inertial systems certainly lies in their use together with satellite data – this combination is already in use at present.

Networks of mobile operators allow localization of user with an accuracy of 50 to 300 m. Elevation data can be obtained either indirectly or with a small accuracy. Determination of location with the above-mentioned accuracy is possible in case the user is within reach of three GSM cells. Therefore, this method of localization can only be considered an auxiliary method to satellite navigation systems.

Besides technical means, we should also consider *use of maps*. Map of appropriate scale with a system of coordinates is easily available, cheap, light and small, etc. It also doesn't require supply of electrical energy (Konecný, Kubícek, Talhofer, 2006).

VII. Conclusion remarks and directions for future work

The tasks of all organizations caring for early warning and crises management are to reduce them and - when they occur – ensure safety of human lives. The ICA and many cartographers work in this field of mapping phenomena connected with nature risks and disasters. Showing the way how to draw and read the maps, they are included in the processes of standardization. The way for data capture, collection, classification and visualization is proposed and many different ways for management with cartographic presented data are known.

All efforts could be direct to the international standardization process: it could be started from data standards in some aspects:

- data classification;
- data content;
- *data symbology or presentation;*
- data transfer;
- data usability (Batuk at al 2004, Konecný , Bandrova, 2006b)

According to the same authors process standards could be considers in the following directions:

- general (specific) data transfer procedures;
- existing data access procedures;
- *classification methodology;*
- data collection;
- storage procedures;
- presentation standards;
- data analyzing procedures;
- data integration;
- quality control and quality assurance.

There are also many possibilities for development the mobile and adaptable cartography for aid, dissemination of information, dissemination of maps and consultations through mobile devices which should be develop in near future.

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