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Implementation of the Outputs of Computer Simulation to Support Decision-Making Processes

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***Abstract*—**At the present time, awareness, education, computer simulation and information systems protection are very serious and relevant topics. The article deals with perspectives and possibilities of implementation of emergence or natural hazard threats into the system which is developed for communication among members of crisis management staffs. The Czech Hydro-Meteorological Institute with its System of Integrated Warning Service resents the largest usable base of information.

National information systems are connected to foreign systems, especially to flooding emergency systems of neighboring countries, systems of European Union and international organizations where the Czech Republic is a member. Use of outputs of particular information systems and computer simulations on a single communication interface of information system for communication among members of crisis management staff and setting the site interoperability in the net will lead to time savings in decision-making processes in solving extraordinary events and crisis situations. Faster managing of an extraordinary event or a crisis situation will bring positive effects and minimize the impact of negative effects on the environment.

***Keywords*—**Computer simulation, communication, continuity, critical infrastructure, information systems, safety.

I. Introduction

THE objective of this paper is to describe the implementation process of environmental data and computer simulations in order to information crisis staff members at national and international level. Implementing environmental data proceeds through the communication interfaces among various information systems. Communication interface is aimed at promotion of processes and effective decision-making during the security environment and crisis management analysis.

Currently, the issue of information systems interoperability is very topical in the critical infrastructure area, and newly in the European Critical Infrastructure area [1]. The paper deals with the perspectives and possibilities of new approaches and new communication interface to the protection of the critical infrastructure subjects, their information and communication systems and computer support of decision-making during the crisis situations. It equally includes comprehensive evaluation of interface output for information system. This aim is based on detailed analysis of the current state [2]-[4] and also reflects the experts' requirements in the field of emergency management [5].

The paper is divided into three parts. The introduction describes approaches and methods of process management, which have been selected to create the communication platform of crisis workplace. Further, the development of process communication interface for implementation of computer **s**imulation and information systems outputs is described in terms of the different phases of chosen methodology and in parallel the software architecture is presented. The final part of the paper presents the output of the research and possibilities of created computer **s**imulation system at implementation of information of environmental data to support decision-making processes of the Crisis Staff and other stakeholders.

The number of emergency situations, which are solved at the level of Crisis Staff, is increasing. The aim of the research is to develop a comprehensive information and communication system that will cover these crisis situations. For this reason, an iterative approach, that allows implementation of the data by different external systems, was selected. Design of the communication interface is illustrated at chosen situation, which is the crisis situation of natural origin.

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II. Problem Definition

The issue of crisis management is focused on the actual problem of computer **s**imulation, communication and information changes in crisis situations. Large-scale crisis situations and accidents caused by natural disasters and some hazardous chemical substances are known as extraordinary events. These events are manifested by uncontrolled flows of energy (fire, explosion), leaks of toxic substances and extensive damages [6], [7]. These events are partially or totally uncontrollable. Time and space-bounded event, which has occurred, or which is imminent may lead to immediate or delayed serious damage or threatens life and health of people, livestock, environment or damage to property [8], [6].

Information systems, computer simulations and new technologies can be used either in public administration or the private sector. They can support successful solutions of crisis situations. One of the areas, where these technologies are used, is preventing, preparing for and dealing with emergencies and crisis situations. The emphasis is set on systems that support analyzing, planning and solving emergency and crisis situations. One of these research projects is dealing with interoperability of specialized centers of crisis management. This project uses the outputs from modeling programs and implements these outputs to the process of crisis management and environmental protection.

Improvements to the effectiveness of crisis management processes using of computer simulation.

A major problem in defining requirements for information and communication interfaces is caused by legislation of the Czech Republic [7], [9], [10]. Disunity and lack of unification of concepts of information systems eliminates simple and efficient functioning of the interface. The law of cyber security [11] and newly prepared regulation about major information systems and their criteria, which is preparing for the year 2015, bring necessary changes.

A. Approaches and Methods

Process Management is a field of combining management and technology focused on aligning organizations with regard to the requirements and needs of clients [8], [12]. It is a complex management approach that promotes business effectiveness and efficiency while management strives for innovation, flexibility, and integration with technology. Process Management attempts to improve processes continuously. Therefore, it could be described as a process optimization.

The DYVELOP (Dynamic Vector Logistics of Processes) method was chosen to process support in the research project [12], [13]. The DYVELOP is friendly computer assisted language for the analysis, evaluation, heuristics, modelling, simulation, scenarios and engineering of any entity´s relationships in a Blazon on a scene [14]. It is created for the purpose of better understanding of issues that are connected with process deployment in the specific area of interest (e.g. emergency management, education). The general purpose of the model is given by three main views, which are the Environment, the participating Entities and the Processes (see Fig. 1).

B. Risks in the Environment

Topicality, reliability and accuracy of information about the environment are essential for computer simulation, rapid and effective decision-making in the preparation of solutions and elimination of consequences of emergencies or crisis situations. The monitoring and information tools play a key role in obtaining this information. Information about natural and anthropogenic hazards represent data, statistics and other quantitative or qualitative data, which are used by authorities, especially the emergency management authorities, individuals, households, NGOs, companies, scientific and research institutions. The same figure may present different information for different entities at the same time.

The basic information scheme about sources of danger and their transmission is consistent with other information systems. Main components consist of a source of information, the information in relation to their content, form and manner of transmission and recipient of information. Prediction, origin and course of specific natural hazards are recorded with monitoring tools of individual environmental components that are managed by public authorities. In most cases, information systems in the Czech Republic are focused on natural disasters caused by atmospheric changes, which effects are the most intense, the longest and the most carefully monitored.

For the risk analysis, it is recommended to use qualitative, semi-quantitative or quantitative methods (What-if method, FTA, ETA, FMEA, HAZOP, HRA, etc.) A special method RAMCAP Plus All Hazards Risk and Resilience Prioritizing Critical Infrastructures using RAMCAP Plus Approach was developed in the area of the critical infrastructure. Software applications such as Security Risk Scorecard, Property Security Risk Survey, SFERA- ENERGY enable risk analysis. In the context of the published information, the data about climate, soil and hydrological drought are provided [15], [16].

C. The Current Solution

The Interoperability Workplaces to Support Teaching of Security Management in a Computer Network project should develop decision support system of communication interface, for crisis management evaluation, action improvement and preparedness. The research project Interoperability Workplaces to Support uses existing structures and systems of communication. The key idea was to connect existing heterogeneous information systems and other relevant organizations to the area of management. Thus these individual management entities will be able to exchange information and experiences. A common set of communication interfaces for support of crisis management simulation and optimization provided by modelling system shall enable decision makers and crisis managers to:

- know possible crisis scenarios;
- assess the consequences and range of an incident;
- simulate possible impacts;
- support strategic decisions;
- optimize the resources dedicated to crisis response;
- and check crisis scenarios.

The computer simulations are important for simulate possible impacts and support strategic decisions. This should improve action plans for preparedness and response phases of the crisis management. The similar objectives at European level are addressed within an international research project CRISMA [17]. They can use selected simulation programs and information systems of other entities connected to the network. Therefore, this will enable the sharing of information and practical experience across the whole spectrum of management and crisis management [2], [14]. Illustrative diagram of flexible communication platform architecture to the protection of communication systems for crisis management can be seen at Fig. 1. It presents the initial architecture Crisis Workplace with ties to computer simulation. This expert system connects all the important channels of communication and information flows. The crisis workplace works at a good level, but basic information about the situation for computer simulations were missing. To meet the project objectives, it is necessary to identify the needs of individual stakeholders on mutual communication, the type of outputs and data and level of information of crisis situation exchange.

The relevant information and data may be via computer simulation to improve decision-making crisis management during a crisis.

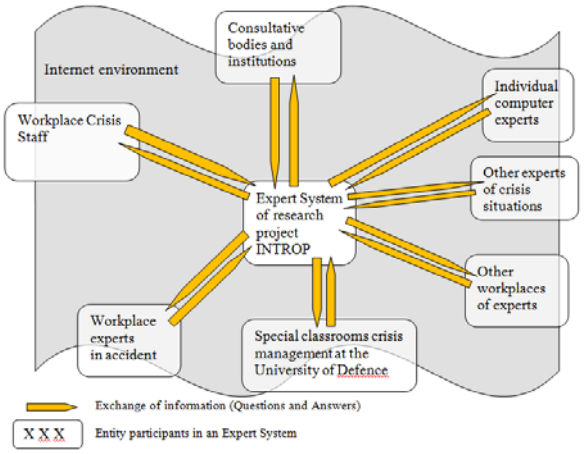

Fig. 1 Communication architecture scheme for Communication Platform Crisis Staff

III. The Possibility of Developing a System

This part deals with perspectives and possibilities of implementation of relevant information to computer simulation. Information about the origin or threat of natural hazards occurrence in the system that is being developed for the communication of the emergency staffs and putting on institutions interoperability working in the network to support decision-making processes of security management. The most usable information basis is presented by the Czech Hydrometeorological Institute with its Integrated Warning System services which deals with dangerous meteorological and hydrological elements and phenomena in a particular territory.

The system of Integrated Warning Service issues warning information for 32 dangerous phenomena. This are divided into 8 groups (temperature, wind, snow, frost, storm, rain, floods and fires). Alerts of storms, rains and floods are issued in cooperation with the flood forecasting and warning service. Other key sources of information are attached to the danger of flooding – the VODA portal provides information about water conditions and flow rates in rivers, water levels in reservoirs, rainfall and water quality. The information inserted into The VODA portal is also provided by river basin authorities. The information system POVIS (Flood Information System) is designed for flood protection and flood authorities, where digital flood plans and books are contained. The Hydro-ecological Information System VÚV TGM (HEIS VÚV) completes the whole flood issue.

The National Information systems are connected with the foreign systems, especially the neighboring countries for the danger of flooding, the European Union (MeteoAlarm, Floods Portal EFAS), and international organizations, in which the Czech Republic is a member. These systems can be used in phase of preparation and solution of emergency or crisis situations, and important information from these systems, that are integrated in one place, make decision making in dealing with these events much easier. The outputs of these information systems are the basic inputs for a computer model of a crisis situation.

The identical information on the situation is important for critical infrastructure entities to ensure the security of critical infrastructure elements and their preparedness of employees to manage and minimize environmental damage. The designed communication interface will also have to use this information in order to plan efficiently in a critical and catastrophic emergencies environment. The system of Crisis Workplace is also applicable to normal activities. This will provide education, practical training and computer simulation of various emergencies in an environment very similar to the reality. This ensures better training of critical infrastructure emergency staffs.

Using of the outputs from the individual information systems and computer simulators on one communications interface of information system for communication of the crisis staffs, and deployment sites interoperability in the network will save time in decision making process in solving emergency and crisis situations. This allows make more important decisions with relevant and verified information in the same time.

IV. Results

In definition of communication interface, there was defined broad spectrum of information and monitoring systems for technological and natural risks that could be used for information support of decision-making processes of the Crisis Workplace. Processed analysis of options and data provided by various information and monitoring systems in the area of environment implies that wise interface of Crisis Workplace will use information and data from Czech Hydrometeorological institute and the Water Information System entitled “VODA.

Practical use has been verified during simulation of an emergency in the Center of Simulation and Training Technologies in Brno in October 2014. By the simulation type CAX (Computer Assisted Exercise) reactions of Crisis Staff were investigated in response to the situation.

The next phase of the research is modelling phase. It represents a detailed analysis of initially identified processes. The processes have been described in terms of individual activities and tasks and also their sequence is clearly defined. The DYVELOP was used for the graphical representation of the processes. In the expert system (Fig. 1) the communication interface with Czech Hydrometeorological Institute was added on basis of XML interface that mediate the transfer of the necessary information.

The project aim is to select information support or computer simulator of environment for the crisis staff. This utility will significantly contribute to reliability, portability and interoperability increase in real action with a view to reducing environmental impacts, loss of human lives and damage to property.

V. Conclusion

The usage of interactive interface for implementation of outputs from external environmental information systems was

designed on basis of experience from arrived extraordinary events and from analogous simulations of extraordinary events and emergency crisis situations solutions for crisis management training with the help of constructive simulation. These outcomes and information included in such outcomes are fundamental parameters for crisis staff improvement and for increase in efficiency in real time.

The computer simulator and interface, which was designed for implementation of information systems outcomes into decision-making processes of extraordinary events, was discussed with experts and it is prepared to be integrated into expert system Crisis Workplace. The solution of an extraordinary event with the use of information included in environment information systems is user-friendly, faster and it brings great benefits for extraordinary events solution. This fact unambiguously results from comparison the utility properties of systems for extraordinary events solutions with possibilities of integration of interface for data implementation and information included in environment information systems.

Faster mastering of emergency or crisis situation will have a positive effect on the course event solutions and it will minimize the impact of negative effects on the environment. The result of this technology implementation will be validated in the practical test simulator at real subject of critical infrastructure.

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