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RESEARCH ON THE APPLICABLITY OF VIRTUAL REALITY IN DISASTER RISK REDUCTION

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Risk is ubiquitous in all areas of life and the context of risk differs in different areas: economics, business, health, IT etc. Concepts of risk and situation are tightly coupled.

Situation management is considered "as a framework of concepts, models and enabling technologies for recognizing, reasoning about, affecting on, and predicting situations that are happening or might happen in dynamic systems during pre-defined operational time" [1]. Risk management is the specific field of situational management. Risk management is a process based on the set of principles, realized by the appropriate framework. Relationships between the risk management principles, framework and process are depicted on fig.1 [2].

ISO Guide 73:2009 and other ISO standards concerned with risk management are proposing general definition of *risk* concept as "effect of uncertainty on objectives" [3].

In addition, the meaning of the definition of risk is disclosed in comments to it:

"Note 1: An effect is a deviation from the expected — positive and/or negative.

Note 2: Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).

Note 3: Risk is often characterized by reference to potential *events* and *consequences*, or a combination of these.

Note 4: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated *likelihood* of occurrence.

Note 5: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood."

Total risk R_{total} may be defined as the sum over individual risks R_i, which can be computed as the product of potential losses L_i, and their probabilities, $p(L_i)$.

In mathematical sense this means that the total *risk* R_{total} *is the expected value of loss function* $\mathrm{E}(L)$:

$$R_{total} = \mathrm{E}(L) = \Sigma_i L_i \times p(L_i). \quad (1)$$

Disaster risk analysis of associated with the analysis of situations that arise or may arise in the target environment. Understanding and explaining situations (situational awareness), that arise or may arise during natural disasters, allows to some extent predict their development and effects from taking certain actions. Consequently, risk management can be considered as a separate type of situation management. Risk reduction main goal is minimizing of total risk R_{total} (1) of system from current situation point of view.

Disaster risk reduction is the objective of risk management in the area of disaster management. Disaster management aims to reduce, or avoid the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The United Nations International Strategy for Disaster Reduction (UNISDR) Terminology defines *disaster* as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources." [4]. Concerned definitions are:

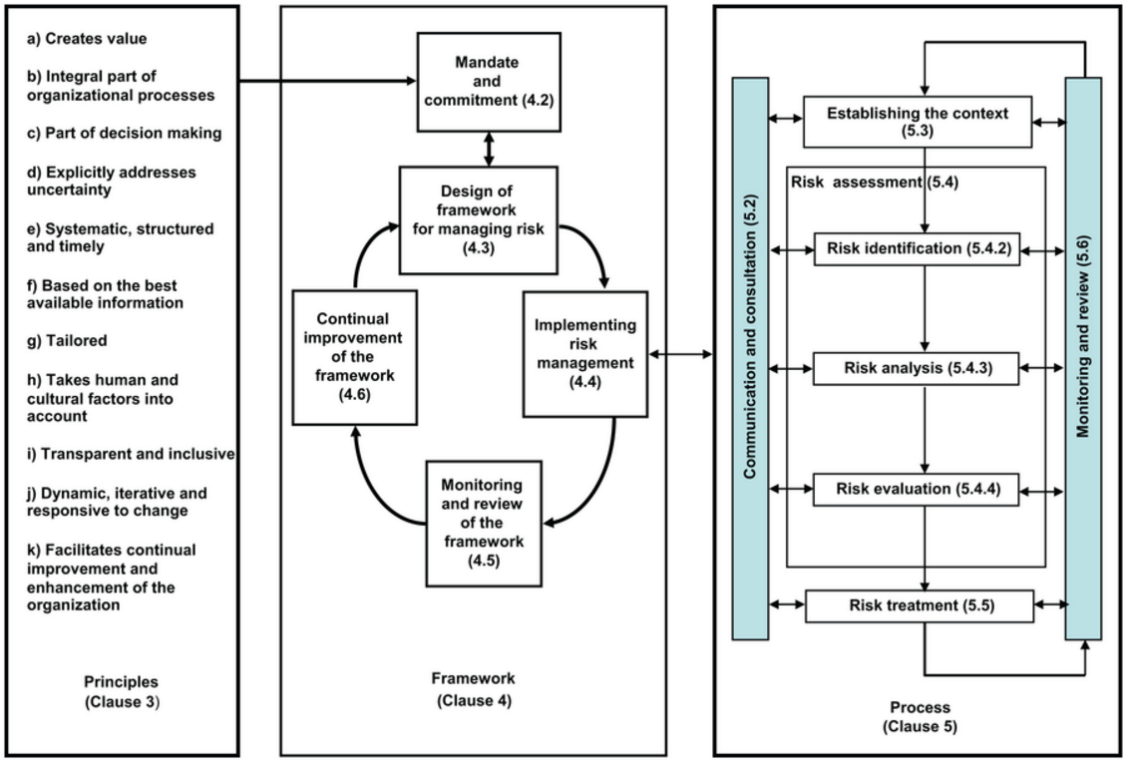

Figure 1. Relationships between the risk management principles, framework and process [2]

- *disaster risk* – the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period;
- *disaster risk management* (DRM) – the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster;
- *disaster risk reduction* (DRR) – the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

The Red Cross and Red Crescent societies define *disaster management* as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters.

The Disaster Risk Management Systems Analysis Guide Book [5] provides a set of tools and methods to assess existing structures and capacities of national, district and local institutions with responsibilities for Disaster Risk Management (DRM) in order to improve their effectiveness and the integration of DRM concerns into development planning, with particular reference to disaster-prone areas, vulnerable sectors and population groups.

DRR refers to the conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development (Sustainable development is defined as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [6]).

DRM includes but goes beyond DRR by adding a management perspective that combines prevention, mitigation and preparedness with response.

Modern information technologies (IT) are widely used in different aspects of disaster management [7, 8]. Virtual reality (VR) is a subdomain of computer-mediated reality (CMR) domain of IT (fig.2). VR is a technology that enables the creation of computer generated virtual worlds with which the user can interact and immerse in. When creating a virtual world, it is important to be able to *emulate the human perception process* or in other words the key to VR is trying to trick. (Perception is known as the process of receiving information via the senses and then interpreting the information via the brain).

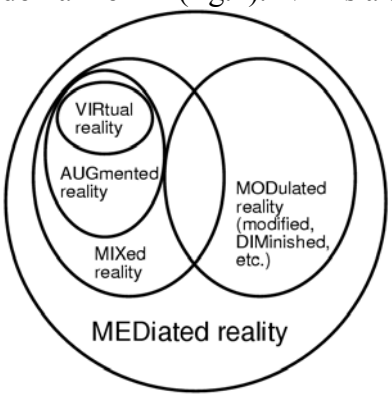

Figure 2. Subdomains of computer-mediated reality domain

Michael R. Heim in his famous book he Metaphysics of Virtual Reality has identified seven different concepts of VR – simulation, interaction, artificiality, immersion, telepresence, full-body immersion, and network communication [9, 10]. Perfect feeling of immersion in a virtual world means that the major senses have to be stimulated, including of course an awareness of where we are within the virtual world. Virtual reality tools allow you to simulate hypothetical situations set, their development and effects on them in a modeling environment. The use of virtual reality in assessing the situational risk of catastrophic events allows more deeply understand their impact on individual subjects, adding to simulations subjective emotional component. Key difference of VR from other types of CMR is simulating a user's physical presence in a virtual or imaginary environment. Thus, VR aimed to create 'situational immersive environments'.

In [11] were listed specifics of VR applications and was pointed, that VR will require professional skills for content generation, full immersion, interaction, programming and implementation. Also in [11] was pointed the value of VR in DRR domain. VR is composite technology of other specific technologies. The main components of the VR environment are subsystems of:

- environment simulation;
- sensing (sensitive);
- affecting (influencing);
- monitoring;
- integration.

Implementation and content of these subsystems are specific for DRM. Risk assessment is the core item of risk management process (fig.1) and DRM (DRR) context. In turn risk assessment includes risk identification, risk analysis and risk evaluation. Application of VR in risk management need additional component – *consultative and communication system* (CCS).

Environmental simulation of disaster shall provide representation of a composite object with controlled properties, that describe different states of environment. Simulated states of environment should meet the disasters classification.

Disaster risk identification, analysis and evaluation should be realized as complex functional components of VR inside the CCS. The result of disaster risk identification function shall be pointing at the built, natural, and community assets susceptible at risk from various hazards. The result of disaster risk analysis function shall be assess the likelihood and the consequence of identified disasters risks and estimation of overall level of risk. The result of disaster risk evaluation function shall be the determination of tolerable level of risk and the placement and readiness of means of control/mitigating of risks.

These components work should be based on the use of relevant knowledge. Therefore, conventional way is to implement components of CCS as agent based systems. cooperation and

coordination of agents in the agent environment can be organized using a behavioral model proposed in [12].

Conclusions

The popularity of VR applications and services will grow in the next years to come and industry will begin to find new ways to take full advantage of the technology. One of the way of using VR is a risk management in general and disaster risk management in particularly. The use of VR in assessing the situational risk of catastrophic events allows more deeply understand their impact on individual subjects, adding to simulations subjective emotional component. The peculiarity of VR application in disaster risk management and disaster risk reduction is the necessity of analytical processing for risk assessment. Several components of analytical system, called consultative and communication system, should perform risks identification, estimation of risks level and determination of tolerable level of risk, and also displaying its results in immersive environment of VR. Situational immersive environments of VR may be organized as agents systems with agents' coordination on the base of common behavioral model of agents.

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