

Principles of Information Integration of the Mono-profile Situational Centers for Effective Disaster Management

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Abstract

Article is focused on a problem of information integration of the mono-profile situational centers for increasing of the overall disaster management efficiency. Calamity 9/11 case is used as a demonstration of unacceptable consequences due to absence of information integration. Special role of Common Operational Picture is demonstrated for provision of the effective disaster management decisions. It is proposed to use a Shared Situational Awareness as a one of key performance indicators for development and maintenance of united disaster management "system-of-systems" for Moscow megalopolis. Four basic principles, which can form foundation of integrated disaster management system of Moscow, are described

Keywords: disaster management, common operation picture, resilience, system-of-systems, information integration, mono-profile situational centers, risk-informed

1. Introduction

In recent decades intensity and frequency of the man-made accidents and natural catastrophes are permanently

growing. For restriction of the calamity scale and/or mitigation of the unacceptable consequences, the enormous resources are required and the multiple different systems (federal agencies and municipal organizations - Ministry of Emergency, ambulance, police, fire brigades, etc.) are involved. Each of disaster-management-dedicated system has its own tasks, resources and responsibilities.

In case of any severe accident, a problem of effective management of the multiple heterogeneous systems appeared. Pivotal questions are - how to provide 1) effective interaction of the different municipal services, and collaboration of the federal and urban organizations, 2) just-in-time, accurate and targeted information on current situation, 3) rational allocation of the resources?

Detailed analysis of current state-of-affairs in Moscow shows, that now the different federal agencies and municipal organizations have their own Situational Centers (SC) inside of Moscow megalopolis - for example, in Ministry of Emergency of RF, in Ministry of Natural Resources of RF, in State Corporation RosAtom, etc.. These mono-profile (or mono-disciplinary) SCs are acting in their own interests in first turn [1]. On belief of the mono-profile SCs owners, the most important results of launching of the Situational Centers are improvements in

quality of decision making and reducing of the reaction time for the revealed threats or hazards.

However, collection even multiple mono-profile SCs with weak interaction and collaboration is unable, in principle, to provide comprehensive, integrated and effective disaster management. It is especially true in case of large-scale severe accidents or catastrophes. Requested level of safety and security can be obtained via information integration of the different mono-profile Situational Centers, belonging now for different agencies and organizations. In fact, it is a matter of formation of "system-of-systems" (SoS), where each separate mono-profile SC is a "sub-system", which interact with the other "sub-system" according to the unified operational protocols and data formats.

Necessity in, at least, information integration for effective disaster management is under discussion for a long time in professional communities [2] in Russia. Topical nature of mentioned problem at governmental level is fixed in item 107 of National Security Strategy of Russian Federation [3].

In this article, the problem of information integration of the mono-profile situational centers in Moscow megalopolis into unified (network-enabled) system ("system-of-systems") is considered from viewpoint of methodology of integration. Main goal of current work is to answer - on what methodological principles it will be worthwhile to integrate the different mono-profile situational centers? For development and maintenance of a really comprehensive and dynamic disaster management SoS, four keystone principles are proposed.

In Section 2, the calamity 9/11 case is used as a demonstration of unacceptable consequences due to absence of information integration. Special role of Common Operational Picture (COP) is

demonstrated for provision of the effective disaster management decisions. It is proposed to use a Shared Situational Awareness (SSA) as a one of key performance indicators for development and maintenance of united disaster management "system-of-systems" for Moscow megalopolis. In Section 3 four basic principles, which can form foundation of integrated disaster management system of Moscow, are described. Section 4 summarizes the conclusions of our study

2. Shared Situation Awareness as a prerequisite and performance indicator for effective decision making

Absence of a direct and reliable information channel between New York Police Department and Fire Brigades at downstream level (between the pilots of police helicopters and the fire-fighters inside of building) during 9/11 calamity at World Trade Center in New York results in groundless deaths of the fire-fighters during building collapse [4]. Information on threat of building collapse was distributed along police radio channel to all policemen at 21 minute ahead of collapse. Critically important information was not transmitted to fire-fighters due to inconsistency of the police and the fire brigades radio channels and operational procedures. Eventually, the 121 fire-fighters were cutted-off from vital information and perished.

Absence, incompleteness or ill-timed formation of Shared Situational Awareness (shared between disaster stakeholders) is one of the main factor, which results unacceptable losses (in man-made accidents in off-shore and chemical industries [5], in aviation [6], in military operations [7]).

In summary, inevitability of interagency and inter-organizational information integration is defined by direct danger of unjustifiable losses in case of usage of a

mono-profile approach during and before severe accident. Shared Situation Awareness is absolutely necessary for generation of right decision under severe accident conditions and, consequently, for successful implementation of mitigation and rescue operations.

In united disaster management "System-of-systems", the Shared Situation Awareness is, from one side - one of the main governing parameter, which influence on decision making, and, on the other hand, it can be used as 1) performance indicator for development of SoS and 2) as maturity criterion for currently available mono-profile Situational Centers (sub-systems) form viewpoint of efficiency of their interaction (information exchange and cooperation within framework of the obtained command, synchronization of actions, etc.).

3. Four Basic Principles of Information Integration for Effective Disaster Management from Resilience Perspective

Electronic and procedural integration of the information systems of the different disaster management stakeholders (federal agencies, municipal organizations) can be organized using different frameworks. Here, we delineate two aspects of integration - 1) for what goal integration will be made (SoS's objective function viewpoint)?, 2) on what kind of information semantics an integration will be made (SSA model viewpoint)?

In contrast to the risk-informed frameworks, which are dominating now [8]-[13], thereafter in this paper we will discuss problem of information integration from viewpoint of an innovative resilience-based paradigm for built environment [14]. From SSA model viewpoint, our treatment will be based on works of Endsley and their co-workers [15], where three basic levels of SSA are considered:

level 1 - comprehension of environment in unified space-time representation, level 2 - awareness of the elements and links, level 3 - projection of the state into nearest future.

3.1. Principle 1. Network-enabled Situation Awareness Sharing

For sharing of a unified Situation Awareness across a whole "System-of Systems" it will be reasonable to use the all capabilities of the wide-band, high-throughput electronic networks, including wireless ones. Sharing shall be made, at least, over three channels, which correspond to three basic level of Situation Awareness in Endsley model [15].

3.2. Principle 2. Multi-Scale Monitoring of Pre-cursors and Misshapes

In order to provide information interaction of the different sub-systems at level 1 of Endsley's model (comprehension of environment), the primary data (measurable or computed), which characterize the assets-at-risk, shall be represented in multi-scale view. This multi-scale view shall provide collection/storage/use/reuse of the accident scene, hazards/threats and assets-at-risk.

3.3. Principle 3. Model-based Assessment of Performance/State-of-Health of System-at-Risk and Threats/Hazards

In order to provide information exchange between the different sub-systems at level 2 of Endsley's model, in SoS should be the unified tools and appropriate infrastructure for quantitative description of the threats/hazards and performance of the System-at-Risk and its State-of-Health [16]. Performance indexes can be obtained either from processing of the primary data from sensors or derives on the base of simulations by computational

models, reproducing behavior of real objects (threat carriers or asset at-risk) [17].

3.4. Principle 4. Risk-informed Decision Support

In order to provide information interaction of the different sub-systems at level 3 of Endsley's model, the Sos under development shall be capable to support risk-informed decision making [17]. Risk assessment, performed on the base of permanent monitoring of threat/hazards, is used for searching of the vulnerable or "weak" points in system-at-risk. Maps of risks is used for development of the countermeasures, targeted on vulnerabilities with highest rank.

4. Conclusions

1. Methodological problem of information integration of the mono-profile federal and municipal situational centers for effective disaster management in Moscow megalopolis.
2. Calamity 9/11 case was used as a demonstration of unacceptable consequences due to absence of information integration. Special role of Common Operational Picture (COP) is demonstrated for provision of the effective disaster management decisions.
3. It is proposed to use a Shared Situational Awareness (SSA) as a one of key performance indicators for development and maintenance of united disaster management "system-of-systems" (SoS) for Moscow megalopolis.
4. On the base paradigm for resilience of built environment and Endsley's model for Shared Situation Awareness, the four basic principles, which can form foundation of integrated disaster management system of Moscow, are described.
5. Integration of the existing mono-profile Situational Centers in Moscow it

will be reasonable to perform using stage approach. At first stage to provide network-enabled framework (Principle 1 and 2). At second stage to introduce model-based capabilities (Principle 3). At third stage to provide compliance with risk-informed decision making (Principle 4).

5. Acknowledgement

Authors are grateful to the Russian Foundation of Basic Research for support of the grants, targeted on the development of the risk-informed technologies (11-07-00329-a) and advanced visualization systems (11-07-13166-ofi-m-2011_RZD) for crisis management.

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