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CONCEPTUAL FRAMEWORK FOR THE AUTOMATION OF THE MONITORING SYSTEM OF NATURAL EMERGENCIES SYNTHESIS

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The system of emergency monitoring is considered. Decomposition of emergency monitoring system is proposed, which allows to define a set of tasks for synthesis of emergency monitoring system at each level in a typical emergency monitoring system. A conceptual model of emergency monitoring system in the form of a «black box» is developed. A system concept of interaction of tasks of synthesis of emergency monitoring system is proposed.

Introduction

To combat natural disasters in Ukraine operates the Unified State System of Civil Protection (USSCP), which consists of functional and territorial units. The activities of the USSCP are aimed at solving the issues of ensuring the necessary level of safety of life of the territory of the state only in conditions where an emergency (ES) has arisen [1].

The territory of Ukraine is characterized by the occurrence of almost the entire spectrum of dangerous natural phenomena and processes of geological, hydrogeological and meteorological origin, which are the sources of natural disasters [2].

Every year there are many reports of natural emergencies causing millions of dollars of damage. By means of new technologies, there are more and more opportunities to respond to changes in the environmental situation on the territory of Ukraine [2–3].

Effective management of life safety of the territory of Ukraine at different levels of administrative-territorial distribution should be based on regular environmental monitoring [3–4].

The issues of development and implementation of ES monitoring system and its integration into the USSCP today remain unsolved.

Analysis of recent publications

Environmental security is given a great deal of attention around the world. There are universally accepted approaches, enshrined in the UN’s 17 global Sustainable Development Goals. However, each country has its own laws that regulate the norms of environmental impact and set environmental standards for production enterprises.

Environmental monitoring of territories plays an important role in improving the environmental security of Ukraine.

Environmental engineers, consultants, regional authorities, as well as corporations in the field of mining and processing of minerals, mining, and agriculture use the data obtained by monitoring.

Analysis of scientific literature [3–5] shows that when solving the problem of formation of ES monitoring system of different nature there is a need to study the features of manifestation of non-linear interrelations between the components of life processes in Ukraine in modes of daily functioning and state of emergency.

Nowadays, innovative solutions based on end-to-end digital technologies are increasingly being used for ES monitoring. These are, for example, platform solutions and online services whose data sources can be drones and other equipment with special observation sensors. Such systems can be local, within a specific area of the district, or global - on the scale of one region or the country as a whole [6].

Innovations are becoming particularly in demand as the volume of data collected as part of ES monitoring is growing, and more technological solutions are required for their processing and analysis – including machine learning, artificial intelligence and big data analytics.

In Ukraine, it is necessary to develop an ES monitoring system that should collect information on the state of the environment by combining several existing surveillance and automatic control systems.

In work [2] the integrated functional scheme of information-analytical subsystem of management of ES prevention and elimination processes in the Unified State System of Civil Protection, which has four levels: object, local, regional, state. The realization of complex inclusion in the operating USSCP system vertically from object to state levels of various functional elements of the territorial ES monitoring subsystem and constituent subsystems of situational centers is considered.

However, so far the task of synthesis of ES monitoring and warning system has not been solved.

Main part

According to [2, 7], monitoring is a continuous complex observation of potentially dangerous objects, measurement of parameters of the state of such objects, analysis of their functioning and identification of natural and man-made factors of ES formation. Thus, implementation of the monitoring process is the solution of two tasks: measurement of parameters of the state of potentially dangerous object and analysis of its functioning, identification of natural and man-made factors of ES formation.

The measurement task requires answers to the questions:

– What potentially hazardous objects are we observing, i.e., where are we measuring?

– To define the control points of measurement;

– What do we measure? Define the indicators and units of measurement.

– How do we measure? Define measurement methods and techniques.

– What is the frequency (step) of measurements? Define at what intervals (in what steps) should be made measurements.

In the proposed hierarchical decomposition structure of the ES monitoring system at each level $Urv = \{Urv_E\}$, where $E = \overline{1,4}$, 4 is a number of levels for which it is necessary to monitor, allocate a certain number of MSES sites $Uch = \{Uch_{En}\}$, $n = \overline{1, n^E}$ where n is a site number of each level of the monitoring system, with each of the sites having control points $PKUch = \{PKUch_{Enj}\}$, $j = \overline{1, j'}$ where j' is the number of the control unit (CU) of each MSES section where at least one switching device (SD) is installed – $KUUch = \{KUUch_{Enjq}\}$, $q = \overline{1, q^j}$ where q^j – the number of SDs installed in the control point, in the simplest case the number of CUs and the number of SDs installed in the corresponding CUs coincides with the number of sites.

In this case, each CU will be connected to the data collection and transmission devices (DCTD), which, in turn, will be installed at the points of collection and transmission of information. $TSIUch = \{TSIUch_{Enjqi}\}$, where $i = \overline{1, i'}$, i' – number of the data collection and transmission point at each section of the monitoring system. DCTDs are devices with modules and a programmable logic controller (PLC), which are designed to take readings from measuring instruments $USIUch = \{USIUch_{Enjqim}\}$, $m = \overline{1, m^i}$, m^i – DCTD number.

The exact number of DCTDs will be determined by the list of control points $TKUUch = \{TKUUch_{Enjqimg}\}$. $g = \overline{1, g'}$; g' – control point (CP) number, and the connected measuring devices (MDs) installed in them $SI = \{SI_{Enjqimgpv}\}$,

$v = \overline{1, v^p}$; v^p – the number of measuring devices, by means of which the monitoring indicators are measured at the control points $PKTKUUch = \{PKTKUUch_{Enjqimgp}\}$, $p = \overline{1, p^g}$, p^g – number of the indicator measured in the control point.

The software tool BpWin and IDEF0 were used to develop a conceptual model of MSES. IDEF0 methodology allows to find bottlenecks of business processes, which can be subsequently eliminated [8–10].

A schematic representation of the ES monitoring process can be represented as follows (fig. 1) in the form of a black box, characterized by inputs (source information) and outputs (MSES result), information and resource support (arrows at the bottom) and methodological support (arrows at the top).

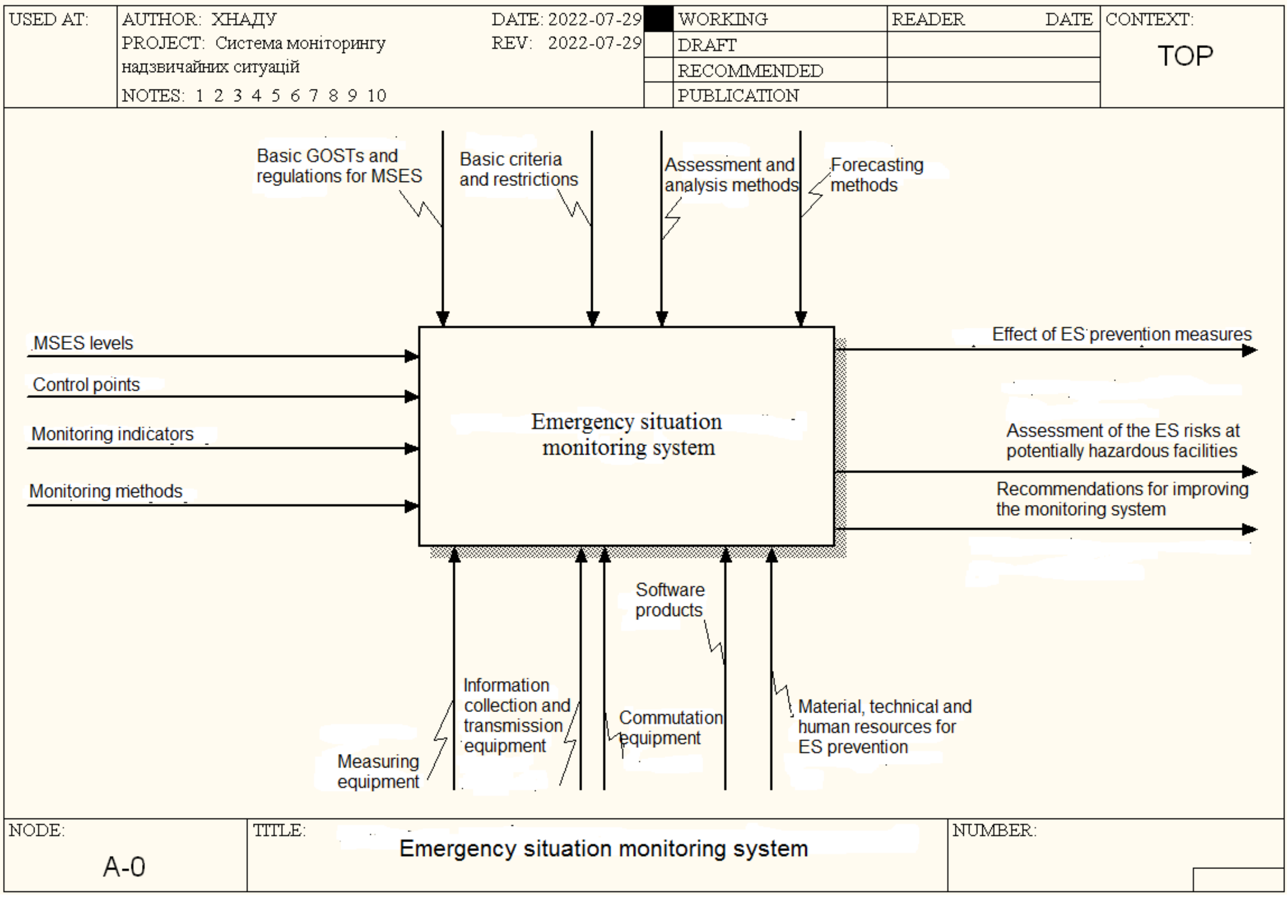

Fig. 1. Conceptual model of MSES in the form of a «black box»

At the same time, the structure of the ES monitoring system synthesis tasks is reduced to solving the following main tasks: definition of control points; selection of monitoring indicators at control points; selection of measuring devices; definition of locations of data collection and transmission devices; definition of the list of control points for each of the DCTD; selection of DCTD in each of their locations; definition of locations of control points and switching devices; definition of the list of served DCTD for each of the control units; selection of control devices for each of the control units.

The system concept of ES monitoring task interaction is presented in fig. 2. 3 presents the interaction of MSES synthesis tasks and input data for them.

The essence of tasks of structural and topological synthesis can be constructed as follows: considering sets of ordinary parts, their functions and properties, find the number of levels of the system, the set of parts on each level and their interrelations.

The task of parametric synthesis is to select the functional characteristics of elements, subsystems and links. The task is solved for specific structural, topological and technological features of the system. The results of the solution form the basis for the synthesis of elements, subsystems and links or the selection of their types and types from a given set of devices.

The MSES synthesis procedure includes a stage of analysis of the monitoring results and examination of the current situation. After that, it is possible to proceed to the selection of recommendations for the further functioning and operation of MSES.

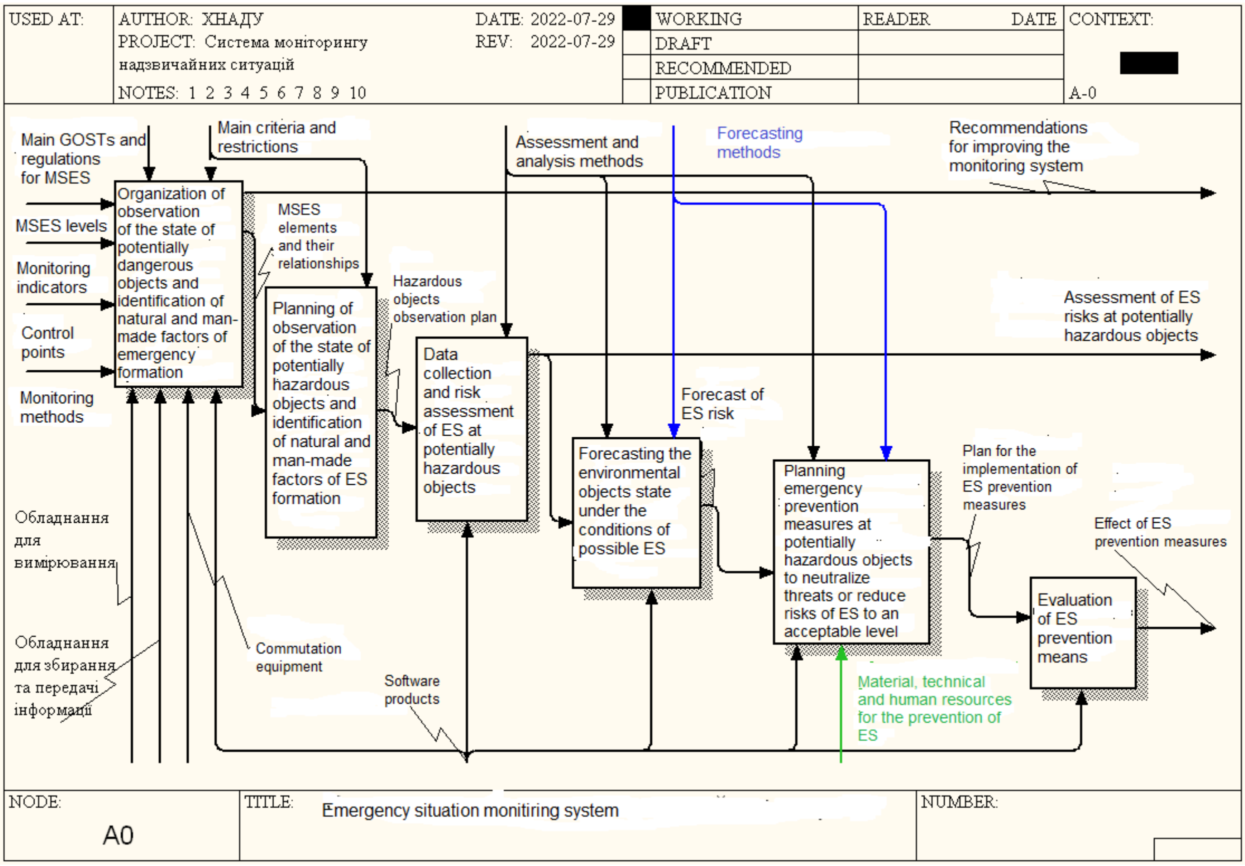

Fig. 2. System concept of interaction of ES monitoring tasks

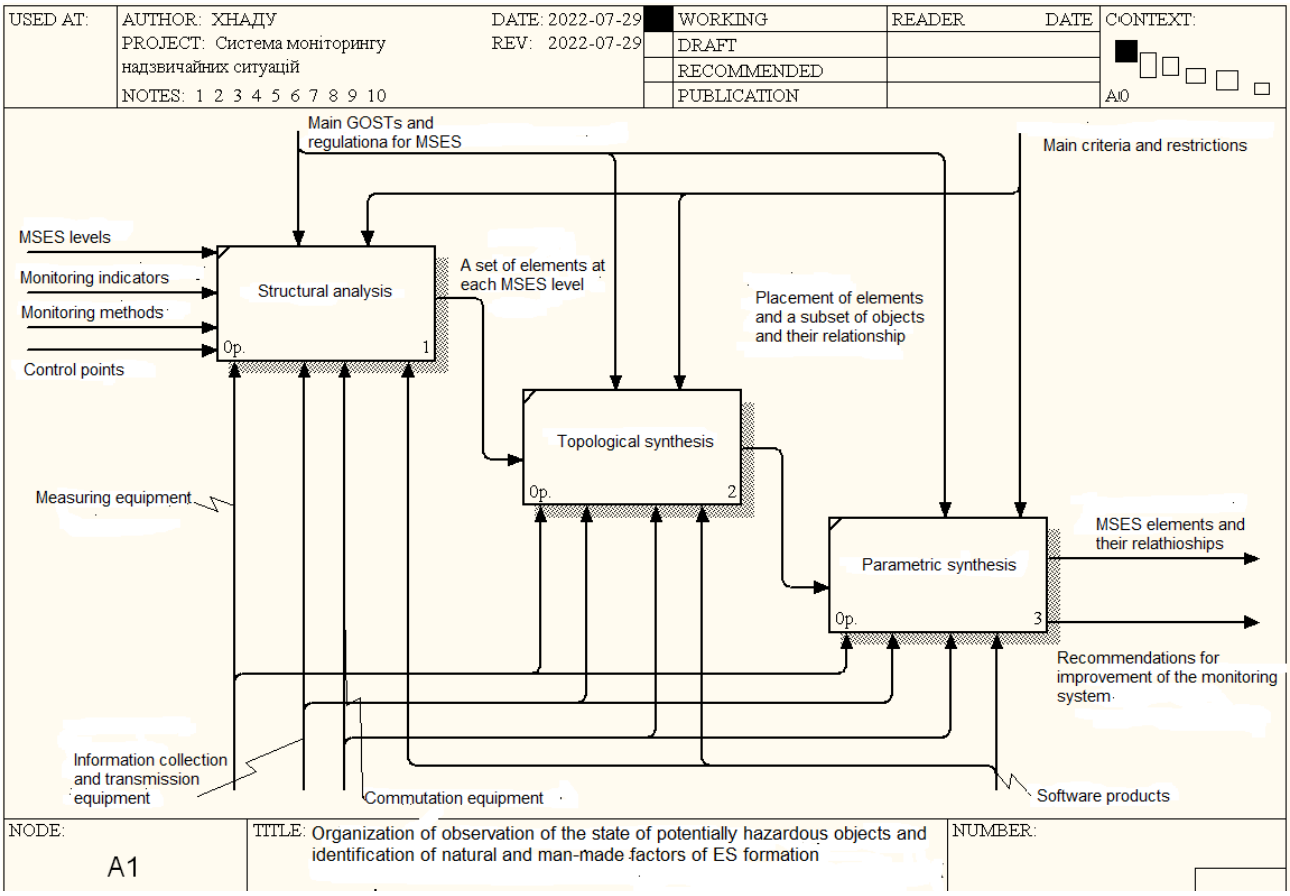

Fig. 3. Interaction of MSES synthesis tasks

Conclusion

Thus, a hierarchical structure of ES monitoring system is developed in this paper. Decomposition of ES monitoring system is proposed, which allows to define a set of tasks of MSES synthesis for each of the levels in a typical MSES. Developed a conceptual model of MSES in the form of a «black box», reflecting the interaction of input information, information, resource and methodological support to obtain initial information about the effect, the current state of the monitoring system, based on expertise, as well as receive recommendations to improve MSES. System concept of interaction tasks synthesis of ES monitoring system, which, unlike known approaches, allows to develop MSES from unified system positions. The next stage of research is to develop appropriate multi-criteria models that take into account all the features of the synthesized system.

References

1. Pro zatverdzhennia Polozhennia pro yedynu derzhavnu system tsyvilnoho zakhystu: Postanova Kabinetu Ministriv Ukrayiny vid 5 sichnia 2014 roku [On the approval of the

Regulationon the unified state system of civil protection: Resolution of the Cabinet of Ministers of Ukraine dated January 5, 2014] [In Ukrainian].

2. Liashenko, O., Kyryichuk, D., Krugla, N., Lozhkin, R. Development of a decision support system formitigation and elimination the consequences of natural disasters in Ukraine. In International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2019. Vol. 19.pp. 825–832. **DOI**: https://doi.org/10.5593/sgem2019/2.1/s08.107

3. Kuljeshov M. M., Sadkovyj V. P., Tiutiunyk V. V. Derzhavna systema cyviljnogho zakhystu [State system of civil protection]. Kharkiv: Nacionaljnyj universytet cyviljnogho zakhystu Ukrajiny, 2020. 232 s. [In Ukrainian].

4. Andronov V. A., Divizinjuk M. M., Kalughin V. D., Tjutjunyk V. V. Naukovo-konstruktorsjki osnovy stvorennja kompleksnoji systemy monitorynghu nadzvychajnykh sytuacij v Ukrajini [Scientific and design basis for thecreation of a comprehensive system for monitoring emergencies in Ukraine]. Kharkiv: Nacionaljnyj universyte tcyviljnogho zakhystu Ukrajiny, 2016. 319 s. [In Ukrainian].

5. V. Tiutiunyk, O. Tiutiunyk, M. Udianskyi, O. Yashchenko, «Regions of Ukraine clustering level of risk and ways to improve the efficiency of a unified state civil defense system under uncertainty input information about emergencies», NVCZ, no. 1(11), pp. 75–84, Jul. 2021.

6. Yachishin A. V., Popov O. O., Artemchuk V. O. (2014) Methods of environmental parameters measurements. *Proceedings of the National Technical University «KhPI» Collection of scientific papers. Series: Mechanical and technological systems and complexes*. №40 (1083) pp. 130–137. [In Ukrainian].

7. Nefedov L. I., Shevchenko M. V. (2015) System concept synthesis monitoring system of regional gas supply. *Scientific Bulletin Kherson State Maritime Academy*, №1 (12). pp. 275–285. http://nbuv.gov.ua/UJRN/Nvkhdmi_2015_1_34 [In Russian].

8. Tomashevsky, O. M., Tsigelik, G. G., Viter, M. B., Duduk, V. I. (2012). Informaciyni tehnologiyi ta modelyuvannya bizness-processiv: navch. posib. K.: Centr uchbovoy literatury, 296.

9. Fil, N. (2016). A functional model of the information technology for management of natural emergency situations on trunk roads. *Automation of Technological and Business Processes*, 8(2). **DOI**: https://doi.org/10.15673/atbp.v8i2.172

10. National Institute of Standards and Technology. Integration Definition For Function Modeling (IDEF0). – Washington: Draft Federal Information, 1993. – 116 p.