Digital transformation of risk management for natural-industrial systems while climate change

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Abstract. We consider results of development digital transformation technologies for risk management in natural-industrial systems within environmental economy while climate change. In research, we used: Foresight technologies, theory of decision making under uncertainties, risk management approach, methods of data bases constructing in case of digital risk management platforms. Analysis shows that the ways of risk management for natural-industrial systems while climate change within environmental economy have distinct features of digital transformation, due to new concepts of obtaining and presenting data. Preference is given to the use of digital risk management platforms, which integrate heterogeneous hardware and software resources with the use of web-technologies in distributed networks and wide application of cloud services. As base model for risk management, we proposed to use block diagram of geo-information support decision within in environmental economy while climate change. The proposed basic model allows direct assessment of the environmental monitoring cost impact on the overall business profit. We consider examples of different digital risk management platforms for natural-industrial systems that authors constructed. While research, we used platform https://www.researchgate.net/profile/Valery_Abramov2/ for preliminary data exchange and discussion.

Introduction
Recently, the global economy is developing in a digital transformation, dubbed Industry 4.0, during which the trends of widespread introduction of information technologies are planned and implemented [1-4]. The rapid development of information technologies leads to serious structural changes in established business processes in various industries [5-8], which requires the development of digital transformation technologies for risk management (RM) in industrial area.

In the article, we describe the development results of digital transformation technologies for risk management (RM) in geo-information management area [9-14] in large natural-industrial systems (NIS) [15-17] within environmental economy [18-20], including marine pipelines construction, for example, Nord Stream 2 [21, 22]. Significant attention in the implementation of such NIS should be paid to geo-information support of natural risk management [23-27] in the context of climate change [28-32], including the issues of information collection [16, 30, 31] and data processing [15-17]. The RM technologies discussed in this article take these factors into account.

Methods and data
In research, we used: Foresight technologies, theory of decision making under uncertainties, risk management approach, methods of data bases (DB) constructing in case of digital risk management platforms (DRMP), web-technologies and virtual reality tools. From the point of view on geo-information management, we structured geo-space to allocate the interconnected components of the solution space [9-14].

Results

Our analysis of the state of RM for NIS shows that in the last years the ways of RM for NIS in have distinct features of digital transformation, due to new concepts of obtaining, presenting, archiving and dissemination of data. Preference is given to the use of digital risk management platforms (DRMP), that integrate heterogeneous hardware and software resources with the use of web-technologies in distributed networks and wide application of cloud services. The advantages of DRMP for NIS are economic benefits and additional conveniences for users. Essential expenses necessary while DRMP creating and timely updating of data within its, are generated by a small group of highly skilled professionals, while life support (technical support, system checks commissioned works, maintaining records and issuing of certificates) may be less well-paid employees, which significantly reduces the cost of the business organizations. For users, DRMP for NIS allow to work with the platform at any time and from any device (personal computers, tablets, smartphones) and combine it with other activities. Moreover, the activities within DRMP for NIS can be held simultaneously by hundreds and even thousands of users without the need to provide the flow with the necessary technical means and building spaces, which also significantly reduces costs.

As base model to DRMP for NIS, we proposed to use block diagram of geo-information support decision within in environmental economy while climate change (Fig. 1)

**Figure 1.** Block diagram of geo-information and geo-ecological support decision model for environmental planning and management: 1 – block of distribution of resources; 2 – block of formation of resources; 3 - block of formation of private income; 4 - block of formation of total income; 5 – block of formation of the investment share of resources; 6 - block of comparison with the permissible level of risk; 7-block of formation changing in time set of natural risks, including climate risks; 8 – block of environmental monitoring for geo-information decision support in environmental economy while climate change

The proposed basic model allows to use DRMP for NIS to a direct assessment of the impact of environmental monitoring cost on the overall business profit within NIS. This is very important for large projects in the environmental economy, when the planned marginality of the business can be
significantly worsened due to the cost of environmental monitoring, which will be implemented within NIS. As an example of DRM for NIS, we can point out our decision support systems within environmental economy [18, 20-22, 26].

An important task of DRMP for NIS is to collect data from measurement networks as part of the environmental monitoring block. While studying, we examined samples of measuring equipment from most known but not too expensive companies, as MicroStep-mis and Campbell Scientific. These systems consist of a control unit and a set of connected sensors, information from which is received, processed and sent via the Internet to the database. In our opinion, at high quality of execution of the device and sensors, these tools differ rather high cost, and their modernization and repair are connected with the address to representatives of the companies.

For low-cost measurement networks, we proposed to use Internet of things (IoT) technology as the basic one [16], where it is possible by law and circumstances. We considered Arduino boards and Raspberry Pi Single-Board computers as a controller responsible for collecting, processing and uploading data to the cloud, and a set of sensors that recorded the observed parameters of the environment. Having determined the goals and objectives of the designed system, you can select the sensors, capable of fixing the necessary parameters of the environment.

After connecting the sensors to controller, you should determine how the device will work. In the case of Arduino, we used the C++ programming language, while the MATLAB environment is more suitable for developing software for the Raspberry Pi, which includes sets of blocks that simplify the process of creating a project. We used the ThingSpeak portal as a repository of measured parameters, which is a cloud storage available to any device using the HTTP. With Simulink support package for Raspberry Pi Hardware, we implemented the unit, which automatically sends the received data to the channel ThingSpeak, where they are available for analysis without the need to connect directly to the measuring device.

In Fig. 2, we show an example of ultrafine particles measurement by low-cost Shinyei PPD42NS sensor with usage of Raspberry Pi and ThingSpeak portal as a repository of measured parameters.

![Figure 2](image)

Figure 2. Example of ultrafine particle count measurement by Shinyei PPD42NS sensor with usage of Raspberry Pi and ThingSpeak portal as a repository of measured parameters.

Ease of use and low cost of sensors allow you to create measuring network with IoT technology to cover vast areas. These properties are especially important in the conditions of hard-to-reach areas.

**Discussion**

Significant prospects for the use of DRMP for NIS are in the field of hydrological risks management for large industrial-urban agglomerations developing during climate change. The basis of such DRMP for NIS are digital maps. In Fig. 3, we present an example of a digital map for a large industrial-urban agglomeration in the city of Barnaul within the catchment area of the Ob river. We made this map with QGIS and Global Mapper.
Figure 3. Two-dimensional digital cartographic image of industrial-urban agglomeration in the city of Barnaul within the catchment area of the Ob river

The most important characteristic that determines the strategy of hydrological risks management is the three-dimensional digital topographic model (DTM). In Fig. 4, we present the three-dimensional DTM for the same industrial-urban agglomeration as in Fig. 3.

Figure 4. Three-dimensional DTM for the same industrial-urban agglomeration as in Fig. 3

According to these models, they determine the average height of the catchment, slope, volume of water bodies, etc. Also, longitudinal and transverse topographic sections are constructed. This information is used in the tasks of operational management of hydrological risks (floods,
floodings, violations of shipping conditions, deterioration of water intake conditions, etc.) for the entire industrial-urban agglomeration.

**Conclusion**

We present development results in digital transformation technologies for risk management in natural-industrial systems change within environmental economy while climate. In research, we used: Foresight technologies, theory of decision making under uncertainties, risk management approach, methods of data bases constructing in case of digital risk management platforms. Analysis shows that the ways of risk management for natural-industrial systems within environmental economy while climate change have distinct features of digital transformation, due to new concepts of obtaining and presenting data. Preference is given to DRMP for NIS, which integrate heterogeneous hardware and software resources with the use of web-technologies in distributed networks and wide application of cloud services. As base model for risk management, we proposed to use block diagram of geo-information support decision within in environmental economy while climate change. The proposed basic model allows direct assessment of the environmental monitoring cost impact on the overall business profit. We consider examples of different digital risk management platforms for natural-industrial systems that authors constructed. Significant prospects for the use of DRMP for NIS are in the field of hydrological risks management for large industrial-urban agglomerations developing during climate change.

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**References**

[1] Bril A R Kalinina O V Ilin I V Dubgorn A S and Iliashenko O Y 2017 Forecasting the turnover growth in the risk management system as management decisions support Proc. of 2017 20th IEEE International Conference on Soft Computing and Measurements, SCM 2017 7970692 p 692

[2] Bril A R Kalinina O V and Ilin I V 2017 Financial and economic aspects of IT project management (2017) Proc. of the 30th International Business Information Management Association Conference, IBIMA 2017 - Vision 2020: Sustainable Economic development, Innovation Management, and Global Growth, 2017, January p 2972

[3] Ilin I V Levin A I and Lepekhin A A 2017 The complexity of requirements engineering approach as a potential critical-success factor of software project Proceedings of the 30th International Business Information Management Association Conference, IBIMA 2017 p 2578

[4] Saurenko T Anisimov V Anisimov E and Levin A 2018 Comparing investment projects of innovative developing strategies of municipalities, based on a set of indicators MATEC Web of Conferences, vol. 170 01038

[5] Zaychenko I M Ilin I V and Lyovina A I 2018 Enterprise architecture as a means of digital transformation of mining enterprises in the Arctic Proc. of the 31st International Business Information Management Association Conference, IBIMA 2018: Innovation Management and Education Excellence through Vision 2020 p 4652

[6] Borremans A Dubgorn A Grashenko N and Iliashenko O 2019 Formation of requirements to telemedicine system services taking into account specifics of the Arctic Zone of RF IOP Conference Series: Materials Science and Engineering vol. 497 (1) 012025

[7] Dubgorn A S Ilin I V and Lepekhin A A 2018 Towards telemedicine services for the Arctic regions of the Russian Federation Proc. of the 31st International Business Information Management Association Conference, IBIMA 2018: Innovation Management and Education Excellence through Vision 2020 p 4634
[8] Kozlov A Gutman S Rytova E and Zaychenko I 2017 Human and economic factors of long-distance commuting technology: Analysis of Arctic practices Advances in Intelligent Systems and Computing vol. 487 p 409

[9] Gogoberidze G G, Istomin E P, Sokolov A G, Abramov V M and Fokicheva A A 2015 Methods for external factors assessing within geoinformation management of territories Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 1 issue 2 p 729

[10] Fokicheva A A, Burlov V G, Sokolov A G, Abramov V M and Istomin E P 2018 The methodological basis for the strategic management of territory development Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 18 (2.2) p 483

[11] Fokicheva A A, Sokolov A G, Istomin E P and Popov N N 2018 Multiparameter models in the management of the development of territories, taking into account the influence of hydrometeorological factors IOP Conference Series: Earth and Environmental Science 107(1):012030

[12] Gogoberidze G, Ershova A, Abramov V M, Popov N and Lednova J 2017 The concept and methodology of integrated assessment of coastal systems and coastal infrastructure sustainability Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. (17.52) p 951

[13] Gogoberidze G, Karlin L, Abramov V M and Lednova J 2014 Indicator method of estimation of human impact assessment for coastal local municipalities Proc. IEEE/OSE Baltic International Symposium, BALTIC 2014, Measuring and Modeling of Multi-Scale Interactions in the Marine Environment (Estonia) DOI: 10.1109/BALTIC.2014.6887840

[14] Gogoberidze G, Rumyantseva E, Abramov V M, Rodin N and Vladimirova G 2017 Priorities and challenges of the state policy of the russian federation in arctic Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 17(52) p 921

[15] Popova A N, Abramov V M, Istomin E P, Sokolov A G, Popov N N and Levina A I 2019 Blockchain and Big Data technologies within geo-information support for Arctic projects Proc. of 33rd IBIMA Conference: 10-11 April 2019 (Granada)

[16] Popova A N, Abramov V M, Istomin E P, Sokolov A G, Popov N N and Levina A I 2019 Internet of Things and Big Data technologies within geo-information support for control black carbon in Arctic Proc. of 33rd IBIMA Conference: 10-11 April 2019 (Granada)

[17] Golosovskaya E P, Abramov V M, Istomin E P, Sokolov A G, Fokicheva A A and Levina A I. 2019 Machine Learning with digital generators for training sets including proteins modeling in the context of Big Data and blockchain technologies Proc. of 33rd IBIMA Conference: 10-11 April 2019 (Granada)

[18] Shilin M B, Abramov V M, Aleshin I V, Burlov V G, Chusov A, Istomin E P and Sokolov A G 2019 Geo-Information and Geo-Ecological Support Tools Development for Environmental Economics Proc. of 33rd IBIMA Conference: 10-11 April 2019, (Granada, Spain) p7046

[19] Burlov V G, Istomin E P, Abramov V M, Sokolov A G and Bidenko S I 2019 Decision support model within environmental economics Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 19 (5.3) p 139 DOI: 10.5593/sgem2019/5.3/S21.018

[20] Lepeshkin O M, Istomin E P, Abramov V M, Baikov E A and Bidenko S I 2019 Web-based tools for natural risk management while large environmental projects Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 19 (5.3) p 953 DOI: 10.5593/sgem2019/5.3/S21.120

[21] Shilin M B, Ershova A A, Zhigulsky V A and Abramov V M 2018 Geo-ecological support of optimization for the route of the nordstream-2 marine gas pipeline Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 18 (5.1) p 423
[22] Shilin M, Ershova A, Zhigulsky V, Chusov A, Abramov V, Bagrova T and Popov N 2018 Environmental Safety of the Nord Stream 2 Marine Gas Pipeline (Russian Section) 2018 IEEE/OES Baltic International Symposium DOI: 10.1109/BALTIC.2018.8634858

[23] Fokicheva A A, Istomin E P, Abramov V M, Burlov V G and Sokolov A G 2017 New approach to the assessment of geohazard in the management of the territories Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) DOI: 10.5593/sgem2017/21/S08.127

[24] Burlov V G, Istomin E P, Abramov V M, Fokicheva A A and Sokolov A G 2018 Risk management method in parametric geosystems Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 18 (2.2) p 377

[25] Slesareva L S, Istomin E P, Abramov V M, Sokolov A G and Burlov V G 2017 Knowledge database in geoinformation management of the territory development Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol.17(21) p 951

[26] Garcia J A, Abramov V M and Istomin E P 2018 Innovative geoinformation technologies within management of natural risks in Venezuela Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 18 (2.2) p 261

[27] Karlin L N, Abramov V M, Ovsiannikov A A 2009 The temporal structure of the iceberg hazard in the central part of the Barents Sea Oceanology vol. 49 (USA) p 327

[28] Vekshina T V, Abramov V M, Bolshakov V A, Veretennikov V N and Korinet E M 2019 Geoinformation technologies for assessing arctic and subarctic riverbeds throughput while climate change Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol.19 (2.1) p 903 DOI: 10.5593/sgem2019/2.1/S08.117

[29] Novikov V V, Abramov V M, Istomin E P, Mikheev V L and Palkin I I 2019 Model of geoinformation support for decision-making while natural risk management Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 19 (2.1) p 951 DOI: 10.5593/sgem2019/2.1/S08.123

[30] Gogoberidze G, Lednova J, Karlin L, Abramov V M, Isaev A and Khaimita O 2014 Main results of summer oceanographic surveys in the eastern Gulf of Finland in the framework of the Topcons project Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 3 issue 5 p 253

[31] Alexandrova L V, Popov N N, Abramov V M, Gogoberidze G G and Karlin L N 2015 Water exchange between the Pacific and the Bering sea with impact on climate change in the Arctic and Subarctic Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria) vol. 2(3) p 701

[32] Gogoberidze G G, Popov N N, Isaev A V, Abramov V M and Berboushi S V 2015 Method of assessment for black carbon random fields within Russia for climate management in the Arctic Proc. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, (Bulgaria), vol. 1, issue 4 p 953