Concept and mechanism for managing the digital transformation of Arctic target subspaces and spheres of vital activity

N I Didenko1
1 Peter the Great St. Petersburg Polytechnic University, Polytechnicheskaya, 29, 195251, St. Petersburg, Russian Federation
1E-mail corresponding author didenko.nikolay@mail.ru

Abstract. The present article considers a concept and mechanism for managing the digital transformation of Arctic target subspaces and spheres of vital activity. The necessary and sufficient conditions for choosing the concept and mechanism for managing the digital transformation of the development of the Arctic target subspaces and spheres of life are considered. The necessary conditions for the innovative and technological development of the Arctic territory, as well as the choice of concept and management mechanism, stem from the requirements of a set of measures that sustain human activity under the extreme conditions of the Arctic. Sufficient conditions for innovative technological development are determined by technological capabilities combined with a sufficient volume of investment in the global economy. The conceptual provisions of digital transformation are based on two main areas: (a) Industry 4.0 strategies adopted in various countries; (b) the main technological trends in the field of digital transformation of industry in the global economy. A schematic infrastructure for digital transformation of the technology-product life cycle of target subspaces and spheres of vital activity is presented along with a mechanism for managing the digital developmental transformation of Arctic target subspaces and spheres of life.

Keywords: Arctic regions, digital transformation, concept of digital transformation, digital transformation management

1. Introduction

The Arctic territories comprise a veritable storehouse of mineral resources. Significant hydrocarbon reserves located in this region are capable of satisfying the growing demand for energy both within Russia and on the global market. The mainland part of the Russian Arctic also disposes a huge quantity of mineral ores. Mineral resources are located mainly in the northern part.

The current state of the Arctic territories is characterised by the process of global warming. In this context, global warming manifests itself as the gradual thawing of permafrost under the influence of ongoing climate change. The contemporary phenomenon of warming is attributable to an increase in the greenhouse effect. In terms of natural environment, the Arctic is highly sensitive to human impact, taking a long time to recover following ill-considered human intervention.

Against this background, the Northern Sea Route (NSR) is currently of great importance in the development of the Arctic. The NSR forms an important part of the infrastructure of the economic complex of the sparsely populated areas of the Far North, providing a connecting thread between the western and eastern regions of the Russian Arctic. The NSR has the potential to unite river arteries
across 70% of the territory of the Russian Federation into a common transport network. At present, essential goods are being delivered along the NSR to the cities along the Arctic coast of twenty-nine Russian regions. The territories on which human life-sustaining activity takes place in the Arctic are referred to here in terms of target subspaces. These include: base cities, mobile shift camps, development support zones (territories of mineral resource extraction and infrastructure development), recreational areas (nature reserves and national parks), fisheries, reindeer herding territories, the Northern Sea Route and security infrastructure.

Within the target subspaces, a person may be defined in terms of engaging in certain spheres of life-sustaining activity: production and economic, innovation and technology, social, political, spiritual, environmental management and demographic.

Given the importance of the Arctic territories for Russia and the world community, the aim of the present article is to develop a concept and mechanism for managing the digital transformation of the development of the Arctic target subspaces and spheres of vital activity.

2. Methods

2.1. General theoretical research methods
The following theoretical methods were used: analysis, synthesis, classification, abstraction, formalization, analogy, modeling, idealization, deduction, induction.

2.2. Analysis of the problem knowledge - one of the main research methods
As a consequence of its rapid spread, the digital economy has quickly become an integral part of people's daily lives. Contemporary economic science pays special attention to the development of the digital economy, manifested in terms of the effect of digitalisation on the economic growth of the country and the world. In the period following the 2008 financial crisis, the digital economy came under renewed interest as the search for factors of sustainable economic growth intensified. The new paradox of the digital economy is the subject of an article by Chihiro Watanabe, Yuji Touc, Pekka Neitaaanmäki [1]. Here the authors identify structural sources of productivity decline in the digital economy and determine the limitations of GDP in measuring the progress of the digital economy. In 2015, the World Economic Forum [2] in collaboration with Accenture launched the Digital Transformation Initiative, which aims at forming a central hub for new opportunities arising from the latest developments in the field of digitalisation of business and society. Since its inception, the Initiative has analysed the impact of digital transformation in 13 industries and across five interdisciplinary themes to identify what business and society as a whole are gaining from the process of digitalisation. Peterson K. Ozili [3] discusses some issues related to digital finance, an area that has yet to be critically reviewed in the literature.

Rajive Joshi, Paul Didier, Jaime Jimenez, Timothy Carey [4] argue that CIOs can deliver tangible benefits using technologies such as Oracle Java Embedded, Big Data management systems and Oracle Engineered Systems powered by Intel and Xeon processors. In 2015, the Chinese Prime Minister announced a seven percent increase in GDP growth [5] due to the digital economy. Tomi and Mikko Dufva [6] argue that the reason that the degree of digitalisation and its consequences are difficult to understand is because most people lack direct experience of what digitalisation actually is. General approaches to digital transformation are presented by S.A. Dyatlov et al. [7], A.V. Gudkov et al. [8], S.A. Atroshenko et al. [9], D.F. Skripnuk et al. [10], K.V. Kireev et al. [11].

A considerable amount of work is devoted to the difficulties of life in the Arctic and the need to use modern technologies to improve living conditions [12], [13], [14], [15]. Some works describe economic activity in the Arctic regions along with an analysis of the state of the environment [16], [17], [18]. Almost all studies on the digitalisation of the economy to one degree or another invoke the statement of Nobel Prize winner Robert Solow: “We see computers everywhere but in the productivity statistics”. We will note only one study by Brynjolfsson and Yang [19]; in this work, there is little connection made between investments in information and communication technologies and an increase in production productivity. This study covered the decade from 1980 to 1990. It is worth noting that, as a consequences of the difficulty involved in carefully and accurately examining the
cause-effect relationships due to insufficient information and elementary analytical research methods, the study cannot be considered to be a complete statement of the problem.

3. Results

3.1. Conceptual principles of the digital transformation of the Arctic target subspaces and spheres of vital activity

The conceptual principles of the digital transformation of the Arctic target subspaces and spheres of vital activity in the target subspaces follow from the following provisions [20], [21], [22]:

A. Industry 4.0 strategies adopted in various countries.
B. Analysis of the main technological trends in the digital transformation of industry in the global economy.

In Germany, a strategy referred to as Industrie 4.0, based on the concept of the Internet of Things (IoT), has been adopted. This new development strategy for German industry aims to create Cyber-Physical Systems (CPS), in which computing resources are integrated into physical processes. Similar strategies adopted by other European economies include the High Value Manufacturing Catapult in the UK, Usine du Futur in France, Fabbrica del Futuro in Italy, Smart Factory in the Netherlands and Made Different in Belgium. Meanwhile, the Industrial Internet Consortium (IIC) was created in the USA in 2014. In 2017, the Consortium published The IIoT Connectivity Framework (IICF), aimed at helping practitioners reveal data in isolated systems, enable data exchange and interaction between previously closed components and subsystems, as well as accelerating the development of new industrial and cross-industrial applications. In China, in 2015, the concept of “Internet +” was adopted; this brought together the best initiatives of the leading countries of the world. The concept consists of a number of areas: “Internet + Manufacturing Industry”, “Internet + Finance”, “Internet + Medicine”, “Internet + Government”, “Internet + AIC”. According to this concept, information and communication technology (ICT) should be used in industrial enterprises to transform the existing mode of production. In Russia, the Digital Economy Development Programme was adopted on July 6, 2017. The state undertakes to create all the technical and financial conditions to ensure rapid progress in emerging industrial sectors. Particular attention is paid to the development of computer and telecommunication equipment. One of the results of this strategy will be the creation of 50 “smart cities” in which 50,000,000 people will live. The state undertakes to create special technological medical centres equipped with the latest technology, in which qualified assistance will be provided. The deadline for the implementation of the large-scale project is set for 2025.

An analysis of the main technological trends shows that today the world economy has entered a phase of rapid development of digital information and communication technologies and their convergence with technologies of industrial production. In accordance with the strategies discussed above, the essence of convergence is that manufacturers of technical systems and household appliances will integrate hardware and software into their products in such a way as to implement remote control functions, as well as provide for automatic data collection and analysis. Within the digital economy, the majority of the life cycle of products and services will be implemented in digital form: marketing analysis; calculation of technical and economic characteristics; construction design; engineering analysis; virtual tests; digital integration of all nodes and components with the subsequent withdrawal of the obtained digital model into the physical world in specialised production centres for collective use; its assembly, delivery to the customer and after-sales service.

Summarising the main approaches to digital transformation of industry abroad, the following scheme of digital transformation of the life cycle of technology products for target subspaces and spheres of life in target subspaces is proposed. (Figure 1).
Figure 1. Schematic infrastructure of the digital transformation of the technology-product life cycle.

Figure 1 shows a system of interconnection of matrices of “target-means”, which clarify the sequence of applying the principles of digital transformation of the technology-product life cycle.

The matrix system translates into digital production based on cloud technologies. Standards and classifiers comprise the “framework” for the interaction of digital production centres along the stages of the product life cycle.

In the context of digital production in a single virtual information environment, a 3D model of the product structure is generated, strength and physico-chemical characteristics are calculated and engineering analysis is carried out to permit the design of production processes, as well as to inform interaction with suppliers, co-contractors, service and operating companies etc.

3.2. Structure of mechanism for managing the digital transformation of the Arctic target subspaces and spheres of vital activity

Figure 2 presents the structure of the mechanism for managing the digital transformation of Arctic target subspaces and spheres of vital activity.

Figure 2. Structure of mechanism for managing the digital transformation of the Arctic target subspaces and spheres of vital activity.
Actions when implementing the concept of managing the digital transformation of the development of the Arctic target subspaces and spheres of life in the target subspaces.

a) Integration of target subspaces and spheres of vital activity therein into one information network based on a network-centric principle.

b) The use of the network-centric management approach, which deploys modern information and network technologies to integrate geographically dispersed controls into a highly adaptive global system.

c) Exchange of information between target subspaces and life spheres in target subspaces, which should increase the development efficiency of both the Arctic territory overall, as well as each target subspace and life-sustaining activity in target subspaces.

4. Discussion

The choice of the concept and mechanism for managing the digital transformation of the development of the Arctic target subspaces is carried out considering the necessary and sufficient conditions. The selection criteria for the concept of innovative technological development and the implementation of the selected concept of digital transformation of the development of the Arctic target subspaces consist in the geopolitical / geo-economic / scientific-technical / socio-economic efficiency of technological solutions. In order to correctly assess whether a particular solution is effective, it is necessary to select performance criteria and evaluation methods, as well as to evaluate the expected effects and possible losses. Since, in order to perform these tasks out correctly, it is necessary to have knowledge of specific technical solutions, therefore the types of technical solutions must first be determined.

The necessary conditions for the innovative and technological development of the Arctic territory, as well as the choice of concept and mechanism for the management of digital development, stem from the requirements of a set of measures that sustain human activity under the extreme conditions of the Arctic. Life in the Arctic is truly extreme [23], [24], [25], [26], [27]. Today, average life expectancy in the Arctic and subarctic space is 6-7 years less than the average for Russia. The mortality rate is 9 times higher. Among the factors that tend to result in a shorter life, there is a deficiency of ultraviolet radiation, especially in terms of immunity, delayed regenerative functions and other aspects. Under such conditions, the importance of technology in human life is constantly increasing. In this regard, the issue arises not only of having technical means for providing protection against adverse conditions, but also the possibility of replacing a human worker with a technological solution.

There are several areas of human activity in the Arctic in which a worker can be replaced by technology. By way of an example, we cite one of these areas, namely mapping. Currently, only about 5% of the Arctic has been mapped in accordance with the standards of the 21st century. Therefore, in order not to engage in this work in extremely harsh conditions, unmanned vehicles can be used to solve this problem. Other technologies, including autonomous ships, can be used as reconnaissance platforms, as well as for research and monitoring of the Arctic natural environment.

Sufficient conditions consist of means and opportunities for innovative technological development and the implementation of the selected concept of managing the digital transformation of the development of the target subspaces of the Russian Arctic.

Sufficient conditions are determined by technological capabilities combined with a sufficient volume of investment in the global economy.

Technological opportunities in the global economy are determined by the currently dominant so-called fifth industrial revolution or Industry 5.0. In the most developed countries, the productive forces attributable to Industry 5.0 is approximately 60 percent; those attributable to Industry 4.0 comprise percent, while those pertaining to nascent Industry 6.0 technologies are currently around five percent.

In many respects, the real investment volume [24] depends on the possibility of implementing various transformations, acquiring more modern equipment and attracting more experienced specialists. As a consequence of this, several steady trends have developed in the global investment
market. Some of them are already capable of generating profits of more than 25% per annum. These are responsible investments, e.g. in new types of healthcare and artificial intelligence.

Such responsible investment vehicles are referred to as Environmental, Social and Governance (ESG) and Socially Responsible Investment (SRI). In fact, this includes all types of business that can positively affect the life of society, as well as companies that pay increased attention to environmental and social aspects. In 2016, the World Bank calculated that investments in the ESG sector had reached $10.4 trillion.

In terms of new types of healthcare, we may refer to the active introduction of technologies based on Big Data and machine learning. In 2015, the volume of venture investments in the healthcare sector reached $7.5 billion in the United States alone. By 2016, this figure had already surpassed $7.7 billion. New opportunities in this area are based on the analysis of huge amounts of historical data derived from a comprehensive study of the systems and cells of the body, which ultimately allows risks to the health of every person to be individually calculated and prevented. For a long time, investments in the Artificial Intelligence sector were carried out in two main directions – either through small start-ups or within large corporations. In 2017, investments in artificial intelligence entered a new phase consisting primarily of mergers and acquisitions. This consisted mainly of the active purchasing of small profile companies by the market-leaders. In 2016, Google, Apple, Intel, Microsoft and Salesforce absorbed over 40 companies involved in machine learning, data science, natural language processing and computer vision. In 2016, for the first time in the history of the information technology market, the non-tech sector invested more in private technology start-ups than the IT sector. Over the past few years, an entire range of industries has developed that are actively investing in the technological component. These consist, first and foremost, in the form of financiers (Goldman Sachs, Citigroup, American Express), mediators (Disney, Time Warner, Discovery), industrialists (General Electric, Caterpillar), healthcare providers (Anthem, Humana) and business service providers (MasterCard, Western Union).

5. Conclusion
The example of the convergence of production with ICT in the Arctic oil industry is presented (Figure 3). An analysis of the technologies and convergence of production with ICT in the Arctic oil industry allowed us to formulate possible directions of digital transformation in this area.

Figure 3. Digitalization trends in the Arctic oil industry.
References

[1] Watanabeab C, Touc Y and Neittaanmäkia P 2018 A new paradox of the digital economy - Structural sources of the limitation of GDP statistics Technology in Society 55 pp 9-23

[2] Introducing the Digital Transformation Initiative World Economic Forum Available from: http://reports.weforum.org/digital-transformation/introducing-the-digital-transformation-initiative [Accessed 20 March 2019]

[3] Ozili P K 2018 Impact of digital finance on financial inclusion and stability Borsa Istanbul Review 18(4) pp 329-340

[4] Joshi R, Didier P, Jimenez J and Carey T 2019 The industrial internet of things connectivity framework Industrial Internet Consortium Available from: https://www.iiconsortium.org/IICF.htm [Accessed 20 March 2019]

[5] China unveils targets for 2015: Li Keqiang’s speech as it happened South China Morning Post. March 5 Available from: http://www.scmp.com/news/china/article/1729846/live-li-keqiang-unveils-chinas-annual-work-report [Accessed 10 March 2019]

[6] Dufva T and Dufva M 2019 Grasping the future of the digital society Futures 107 pp 17-28

[7] Dyatlov S A, Didenko N I, Lobanov O S and Kulik S V 2019 Digital transformation and convergence effect as factors of achieving sustainable development IOP Conf. Series: Earth and Environmental Science 302(1) 012102

[8] Gudkov A V, Dadonov D N, Krotkov E A, Krasulina O and Akobiya N 2018 Research features of voltage static load characteristics in the electric system of Russia Int. Conf. on Reliability, Infocom Technologies and Optimization: Trends and Future Directions (Amity Univ Uttar Pradesh Noida INDIA/Publisher: IEEE) pp 295-300

[9] Atroshenko S A, Korolyov I A and Didenko N 2016 Evaluation of physico-mechanical properties of high-chromium tool steels modified with harrington method Materials Phys. and Mechanics 26(1) pp 26-29

[10] Skripnuk D, Kikkas K N, Safonova A S and Volodarskaya E B 2019 Comparison of international transport corridors in the Arctic based on the autoregressive distributed lag model IOP Conf. Series: Earth and Environmental Science (Institute of Phys. Publishing Press) 302(1) 01209

[11] Kireev K V, Ermakov V V, Kikkas K, Gasyuk D P and Rodionova U 2018 Mathematical modeling of Arc extinction process in devices with liquid-metal contact Int. Conf. on Infocom Technologies and Unmanned Systems: Trends and Future Directions (Amity Univ. Dubai U ARAB EMIRATES/Publisher: IEEE) pp 273-277

[12] Rudenko D Y, Pogodavea T V and Didenko N I 2015 Poverty alleviation strategies in the russian arctic regions Mediterranean J. of Social Sciences 6(1) pp 32-39

[13] Afonichkina E A and Afonichkin A I 2018 Synergies of the Economic Development of the Arctic Cluster System IOP Conf. Series: Earth and Environmental Science (Institute of Phys. Publishing Press) 180(1) 012011

[14] Skripnuk D 2019 Analysis of the regional modernization processes in a global context with an example of the Russian northern regions Int. J. of System Assurance Engineering and Management pp 1–11

[15] Skripnuk D and Ulitin V V 2016 Technical and economic substantiation of permafrost thermal stabilization technology under global warming conditions Materials Physics and Mechanics 26 (1) pp 85-88

[16] Skripnuk D, Kikkas K and Romashkina E 2019 Sustainable development and environmental security in the countries of the circumpolar north E3S Web of Conf. 110 02037

[17] Klochkov Y, Klochkova E, Kiyatkina E, Skripnuk D and Aydarov D 2018 Development of methods for business modeling Int. Conf. on Infocom Technologies and Unmanned Systems: Trends and Future Directions pp 366-369
[18] Kikkas K N, Kulik S V, Krepkaia T N and Mokhorov D A 2019 Analysis of the economic relations of the circumpolar countries IOP Conf. Series: Earth and Environmental Science 302(1) 012093

[19] Brynjolfsson E, Hitt L M and Yang S 2002 Intangible Assets: Computers and Organizational Capital Forthcoming in Brookings Papers on Economic Activity 138 p 52

[20] Antipov S 2018 Neural network model as a way of processing complex systems of econometric equations characterizing the interaction of the Russian Arctic MATEC Web of Conf. (Publisher: EDP Sciences) 170 01025

[21] Kikkas K 2018 Territorial-sectoral modelling of the automotive industry in the Russian Federation IOP Conf. Series: Earth and Environmental Science (Institute of Phys. Publishing Press) 180(1) 012015

[22] Gazizulina A Y, Mirolyubova O V, Konakhina N A, Grigorieva A A and Danilova S Y 2018 Problems of forming requirements to training of specialists for industrial and economic complex Int. Conf. on Reliability, Infocom Technologies and Optimization: Trends and Future Directions (Amity Univ Uttar Pradesh Noida INDIA/Publisher: IEEE) pp 196-198

[23] Kikkas K, Chagina E, Garbuzyuk I and Mazzaccaro J L 2019 The experience of increasing labor productivity in the Arctic nations Int. J. of Systems Assurance Engineering and Management pp 1-7

[24] Popkova A, Kostko N and Skripnuk D 2017 The quality of social space mapping: The case of Tyumen, Russia Int. Multidisciplinary Scientific GeoConf. Surveying Geology and Mining Ecology Management 17(23) pp 753-760

[25] Konakhina N A 2018 Evaluation of Russian Arctic Foreign Trade Activity IOP Conf. Series: Earth and Environmental Science (Institute of Phys. Publishing Press) 180(1) 012018

[26] Silkina G 2019 From analogue to digital tools of business control: Succession and transformation IOP Conf. Series: Materials Science and Engineering 497(1) 012018

[27] Kozmenko S, Teslya A and Fedoseev S 2018 Maritime economics of the Arctic: Legal regulation of environmental monitoring IOP Conf. Series: Earth and Environmental Science (Institute of Phys. Publishing Press) 180(1) 012009