Sustainable development as a prerequisite of digital transformation of enterprises in rocket and space industry

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Abstract. **The article considers key aspects of Russian rocket and space industry digital transformation and justifies the appropriateness of using the principles that underlie a concept of a digital enterprise in order to maintain Russian space industry leadership in terms of the increased competition. It is shown that Russian rocket and space industry is losing the competition in the world market, owing to continuing stagnation of industrial enterprises, as well as existing obstacles to innovative development and technological re-equipment of enterprises. The article focuses on the prospects of using key innovations created in the convergence of digital and space technologies at rocket and space industry enterprises and introduction of modern automation equipment, which shall result in development of a digital enterprise model and make space business more effective. It is also justified that sustainable development of rocket and space industry enterprises is a necessary prerequisite for shifting towards digital transformation in order to boost competitiveness and maintain leadership in the market of space-based technologies and services.**

Keywords: economy, rocket and space industry, enterprise, digital transformation.

I. INTRODUCTION

According to the Strategy for the Development of the Information Society in the Russian Federation 2017–2030, one of the priority areas is the establishment of necessary conditions for the development of a digital economy. The digital economy is a communication environment of economic activity on the internet, as well as its implementation models, methods, instruments, and results [1]. Information and communication technology in the form of the internet and personal computer devices have not only changed business models and consumer behaviour in terms of modern economy but also provided the foundation for the transformation of such social processes as economic activity and the provision of financial and educational services [2]. The main reason for the rapid development of the digital segment is the growth of a transaction sector reaching 70 percent of GDP in economically developed countries. In the Russian Federation, digital economy contributes 2.8 percent or $75 billion to GDP which large proportion accounts for the consumption activity (e-commerce, services, online search) [3]. State administration, consulting and information support, financial accounting, wholesale and retail distribution, as well as the provision of different public, private and social services refer to this sector [4].

The digital economy is becoming a new gradient of the world economy based on electronic interaction and digital technologies. In this regard, the government is implementing the programme «Digital economy of the Russian Federation» [5], which implementation shall result in the establishment of no less than 10 national leader companies: high-technology enterprises developing cross-cutting technologies and managing digital platforms, which operate in the global market and shape the system of start-ups, research groups and industry-specific enterprises providing digital economy development.

Rocket and space industry is one of the leading fields that has been ensuring Russia's competitiveness and might become the leader of the digital transformation of economy. It is represented by Roscosmos State Corporation in the Russian Federation. Digital transformation is necessary for rocket and space industry as well as for other branches of industry to facilitate the introduction of new products into the market, cut production costs and enhance the quality together with the competitiveness of all production

II. MATERIALS AND METHODS (MODEL)

To date, there is no accepted theoretical and methodological basis for investigating the problems of transition to a digital economy. Fundamental economic theory has seriously lagged behind the practice. The peculiarity of the new global problems and challenges associated with the digitalization of the economy and society is that they cannot be studied only by the methods of classical and non-classical science. A fundamentally new class of problems requires the use of interdisciplinary approach, ideas of non-linearity, non-equilibrium and self-organization.

The analysis of scientific research on the problems of digital economy has revealed the immaturity of methodological issues of the formation of prerequisites, conditions and models for the transition of Russian regions to the digital economy. The objective factors hampering the development of these issues are the intensive development of digital technologies, the dynamic changes in the IT sphere, the absence of promising strategic concepts and the positive experience of the transition of regional economic systems to the use of digital technologies.

To achieve the goals of the research, we used the main provisions of the economic development theory, the theory of self-organization, institutional evolutionary theory, the theory of state economy regulation, which together allow us to explore and solve an important scientific and applied problem of creating conditions for the transition of the economy to a digital model of development.

The realization of goals and objectives of the research is achieved by using an interdisciplinary approach, in which we rely on the works of researchers in the field of synergies, the theory of non-linear dynamics, bifurcation and systems theory.

Within the framework of the above-mentioned theoretical approaches, the following research methods are used in the research: methods of economic and statistical analysis, forecasting, system approach, situational analysis, expert assessments.

III. Results and Discussion

Currently, the situation considering the competitiveness of rocket and space industry enterprises is unsatisfactory. Thus, for example, all American, European and Japanese rockets are designed with hydrogen and methane propulsion engines. The creation of rocket engines using different types of fuel is a new challenge of rocket propulsion engineering. Russia is the only spacefaring nation that does not use hydrogen as a rocket engine fuel. It is just beginning the development of such engines with the help of brand new design tools according to the specified requirements. It is to be implemented with the use of a PLM platform (3D PLM-technologies). Unfortunately, Roscosmos does not have a unified corporate system of Product Lifecycle Management (PLM), in terms of which any product can be unfolded so that dozen and hundreds of thousands of its components could be shown in detail.

The other serious problem is that the number of satellite launches decreased five times in 2017 compared with the 1987 figures. The changes in the number of satellite launches over the past 7 years can be seen in Figure 1.

By the number of space vehicles in operation, Russia is in the second place, after the USA [7]. In 2016, labour productivity in Roscosmos State Corporation decreased by 3.7 percent and there was an increase in the number of contingencies produced during space launches of launch vehicles and cargo spacecraft.

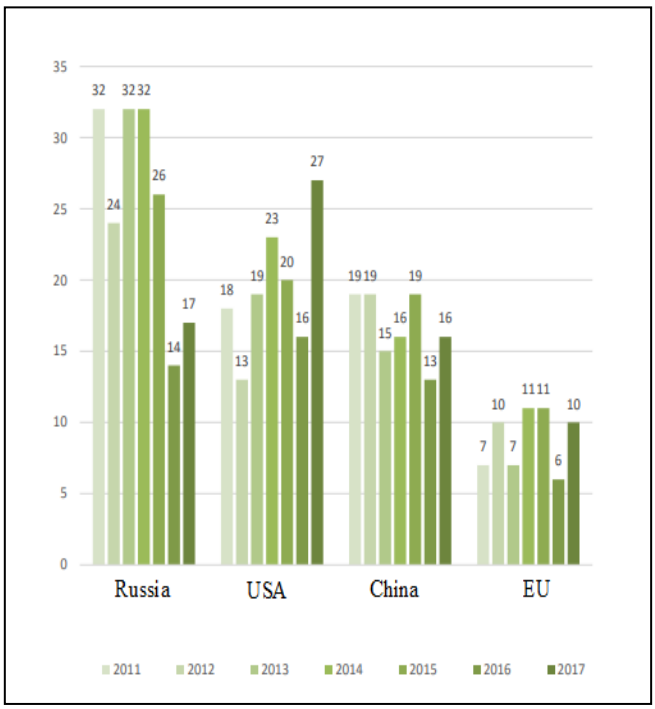

Fig. 1. Number of space launches [6]

In terms of public funding, space activities of the Russian Federation significantly differ from the other leading countries. The levels of space programme public funding are presented in Figure 2.

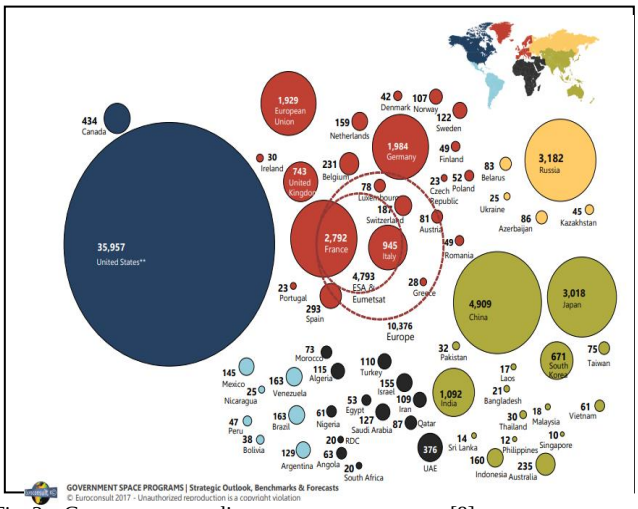

Fig. 2. Government spending on space programmes [8]

There are a number of serious challenges in production and technical, economic and human resource fields of the state corporation activity. Within the industry, the share of equipment with the age under 10 years does not exceed 20 percent, while the extent of wear of productive, process, and test equipment reaches 80%. In 2017, the SpaceX company alone outperformed Russia by the total number of launches; moreover, the Falcon Heavy launch prices per one tonne of cargo are twice as low as the Proton launch prices and one third as much as the Angara A5 ones ($1.4 million against $2.8 million and $3.9 million, respectively) [9].

All the afore-mentioned shows the need for the establishment of a sustainable development strategy at rocket and space industry enterprises, their adaptation to market volatility and the intensive competitive environment under the conditions of the adopted strategy of economy digitalization. What makes rocket and space industry special is that it cannot become totally digital and online (as, for example, it is implemented in the bank sector) due to the fact that within the industry, safety rules and regulations, which have been established for many decades, play a major role and it is not easy to digitalize their requirements. However, it is possible to digitalize business processes in many fields. And it is not just automatization but the creation of new business processes that cannot be implemented without digitalization. Thus, for example, NPO Energomash, which is a part of the Roscosmos State Corporation and the main supplier of launch vehicle rocket engines produced not only in Russia but also abroad, is planning to introduce digital manufacturing at its enterprise by 2020. This means full digital development, product design and manufacturing. For this purpose, at present, machinery automatization is performed as much as possible and control over the execution of technological processes is organized. Another important task being solved by the enterprise within digital transformation is creation of a digital counterpart of a product. With creation of a 3D model at the design stage, each rocket engine has its own digital counterpart, which collects all information about it throughout its life cycle, including operation. This is done to have absolutely all the parameters for modelling and analyzing deviations in digital form. Thus, a rocket engine is completely transferred to the «matrix» [10].

At present, a certain number of rocket and space industry enterprises are creating their accelerators, or «digital laboratories», which aim at mobilizing resources to find and implement the best ideas within and outside the enterprises in collaboration with start-ups and universities.

The major difficulties of digital transformation faced by rocket and space industry enterprises lie in the non-digital culture of enterprises, people's conservatism and their desire to maintain the status quo. This makes it much more difficult to organize work on dissemination and use of innovations. Therefore, the key task today is transition of enterprises to digitalization principles by revising the basic management algorithms, reformatting the corporate culture, as well as reorganizing business processes and forming new technological regulations. Without this, it is impossible to carry out digital reorganization of rocket and space industry enterprises and integration of IT and business processes into a single complex. When this happens, the leading enterprises within the industry such as Russian Space Systems and NPO Energomash can be described as digital enterprises. In other words, digital transformation is a way that will allow the Russian Federation to maintain its leadership in the market of space technologies and ensure sustainable development of entire rocket and space industry in the near and distant future.

In terms of the necessity to ensure sustainable development of rocket and space industry, it should be noted that the first document that laid the foundation for understanding sustainable development of economic systems was the Concept of sustainable development, which was first presented under the name «Our common future» at the conference of the United Nations in the report of the World Commission on Environment and Development (WC\ED) in 1987. It was an attempt to form a new perception of reality in society and find ways of development. The basic meaning of this concept [11] is the idea that sustainable development, as such, not only addresses present-day needs but also should not pose a threat to future generations as related to the satisfaction of their own needs.

In order to promote the idea of sustainable development, a simplified interpretation of the concept principles and provisions is set out in the World Bank publication «Business Strategy for Sustainable Development: Leadership and Accountability» [12]. Under sustainable development, it is offered to understand formation and implementation of an appropriate strategy that contributes to achieving the stated goals of an enterprise and its stakeholders in the context of preservation and increase in value of human and natural resources that will be necessary for the enterprise and society in the future.

Thus, in order to maintain a leading position in the field of space technology within economy digitalization, rocket and space industry enterprises shall ensure the stability of three main components, that is, economic, environmental and social.

A significant step for digital economy in establishing information infrastructure was the development of a programme aimed at building the capacity of remote sensing satellites and creation of an updated digital model of the entire surface of our planet. The implementation of this large-scale project based on the developments of the Russian Space Systems holding, which is part of the Roscosmos State Corporation, stimulates national economy development [13].

Creating a digital model of the Earth is the next stage within the long-term strategy for the creation of a modern geographical information support system of Russian economy development. The importance of improving the satellite remote sensing system and the need for using it for economy and social sphere development are emphasized by the top leadership of the country [14]. The project implementation provides qualitatively new opportunities and objective information regarding agriculture and forestry management, land registry, cartography, region management, control and prevention of emergencies, natural disasters and man-made accidents [15]. The market of satellite remote sensing and geographical information systems (GIS) has been growing steadily (Fig. 3 and Table I). Therefore, this project will bring economic results in the future among other things.

Digital economy is not identified with a separate industry; it is a new way of life, a new basis for business sector functioning, public administration system and society as a whole.

It is associated with an opportunity to achieve a technological breakthrough, as it is focused on high technology and innovations, which, in its turn, are prerequisites for economic growth and competitiveness of Russian economy.

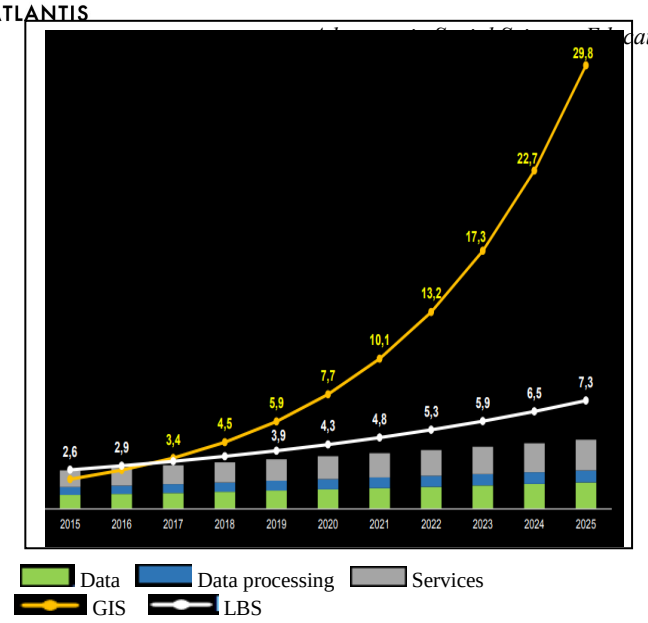

Fig. 3. Satellite Remote Sensing (SRS) and GIS global market volume (billion dollars) [16]

TABLE I. ASSESSMENT OF GLOBAL MARKET OF DATA AND SERVICES SRS[A], GIS[B], AND LBS[C,D]

Description	SRS	GIS and LBS
Market volume (2016), billion $	2.75	5.5
Forecast for 2025, billion $	4.64	37.1
Compound annual growth rate, %	4.64	16.25

[a.] NSR: Satellite-Based Earth Observation (EO) Report, 8th edition. September 2016

[b.] GIS — geoinformation services (web-services providing access to spatial data, ensuring their processing, analysis, search, and visualization)

[c.] LBS — local-based service (software service using location data).

[d.] Markets and Markets Global Forecast data, August 2017

IV. CONCLUSION

In conclusion, it should be noted that with regard to global trends in the field, determining the directions of space activity development in the near and distant future, on the one hand, will enable large state space industry enterprises to make maximum use of existing developments in the field of digitalization and formation of domestic PLM platforms. On the other hand, it will allow private companies to engage in the creation of a new electronic component base for the space industry with greater efficiency. This will allow Russian space industry to ensure sustainable development in the distant future and take a leading place in the global market of digital space services.

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