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IMPACT OF MACROECONOMIC AND FINANCIAL FACTORS ON THE MANAGEMENT OF SCIENCE-INTENSIVE ENTERPRISES IN RUSSIA

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ABSTRACT

Objective: The study aims at substantiating new approaches to the management of science-intensive enterprises of rocket and space engineering through analyzing the existing problems and global challenges to their development. **Methods:** To achieve this objective, the authors used a wide range of methodological tools, including systemic and comparative analysis, modeling, economic and statistical methods of group comparison. The study comprised the economic analysis of 62 rocket and space engineering enterprises in the Russian Federation. **Results:** According to the study results, the current economy and economic relations make science-intensive enterprises of rocket and space engineering adapt to global growth trends and search for effective management solutions under the conditions of a state monopoly on their structuring, technological inflation, low capitalization and an increase in returns from R&D through the systemic integration and accumulation of innovations in production.

Keywords: Development management; Rocket and space engineering; Science-intensive enterprises.

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IMPACTO DE FACTORES MACROECONÓMICOS E FINANCEIROS NA GESTÃO DE EMPRESAS COM UTILIZAÇÃO INTENSIVA DE CIÊNCIA NA RÚSSIA

RESUMO

Objetivo: O estudo visa substanciar novas abordagens à gestão de empresas de engenharia de foguetes e espaciais de uso intensivo da ciência, através da análise dos problemas existentes e dos desafios globais ao seu desenvolvimento. **Métodos:** Para alcançar este objetivo, os autores utilizaram uma vasta gama de ferramentas metodológicas, incluindo análise sistémica e comparativa, modelação, métodos económicos e estatísticos de comparação de grupos. O estudo incluiu a análise económica de 62 empresas de foguetões e engenharia espacial na Federação Russa. **Resultados:** De acordo com os resultados do estudo, a economia e as relações económicas actuais fazem com que as empresas de engenharia espacial e de foguetões intensivas em ciência se adaptem às tendências de crescimento global e procurem soluções de gestão eficazes nas condições de monopólio estatal sobre a sua estruturação, inflação tecnológica, baixa capitalização e aumento dos retornos da I&D através da integração sistémica e acumulação de inovações na produção.

Palavras-chave: Gestão do desenvolvimento; Engenharia de foguetes e espacial; Empresas com uso intensivo de ciência.

1 INTRODUCTION

Rocket and space engineering is an industry that produces various devices and equipment for ground-based and spaceflight. It is part of space vehicle and missile manufacturing that embraces a set of enterprises, research institutions and development agencies producing, repairing and updating combat missile systems, space-based missile systems, ground-based equipment for space systems and space equipment samples for civil and military purposes.

Being the initial component of space vehicle and missile manufacturing, rocket and space engineering plays the leading role in ensuring national security. In addition, it has a significant impact on the military, economic and scientific potential of Russia since the competitiveness of such products determines the state and development of the space-related economy.

The recent trends indicate that the Russian presence in space has been decreasing. Thus, it had to gradually reduce its spending from $9.75 billion in 2013 to $4.2 billion in 2018 (Shiryaeva & Rozhanskaia, 2020). Considering the unstable position of the Russian Federation on the global space launch services market, it is necessary to introduce new approaches to the management of rocket and space engineering enterprises and increase the competitiveness of their products.

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The study aims at substantiating new approaches to the management of science-intensive enterprises of rocket and space engineering through analyzing the existing problems and global challenges to their development. To attain this end, we set and solved the following interrelated tasks: 1) to substantiate the current financial and economic state of rocket and space engineering companies and their research intensity; 2) to identify global trends in economic growth that affect the development of such enterprises; 3) to develop new approaches to the management and organization of rocket and space engineering companies.

We became the first to select science-intensive enterprises of rocket and space engineering as the research object and set the above-mentioned objective in Russian science since many scientists did not single out the field of rocket and space engineering as a separate area of scientific knowledge and considered it in conjunction with other rocket and space engineering companies, for example, organizations not directly involved in the production of rocket and space technology, enterprises manufacturing parachutes or building space-launch complexes, as well as organizations of financial, logistics, material and technical support. At the same time, scientific research in the field of missile and space defense became the basis for this study: works on the formation of industrial space policy (Harrington, 2020; Pollpeter, 2011; Sagath et al., 2019), the management and innovative development of rocket and space industry (Makarenko, 2017; Patsuk & Korshakevich, 2017; Payson & Davidian, 2015; van Burg et al., 2017), and the economics of space (Crawford, 2016; Shiryaeva & Rozhanskaia, 2020; Weinzierl, 2018; Yazıcı & Darıcı, 2019). These studies consider certain provisions for managing rocket and space companies. However, they do not adequately reflect the management of research intensity as the main component of their development and the methodological basis of this article. Some scientists highlighted this applied nature in their works (Batkovskii et al., 2019, 2020; Payson & Frolov, 2020). Nevertheless, rocket and space engineering companies do not use such functions on a large-scale basis. Major theories of management and economics consider certain provisions of research intensity from the standpoint of establishing relationships of innovations, the efficiency of R&D management, global economic challenges conditioned by scientific and technological progress, and the economic results of such activities. However, the corresponding studies did not mention research intensity as a separate research object. Therefore, this study is based on theoretical and empirical methods of managing the science intensity of enterprises. The latter is regarded as an activity to use R&D results in production processes to increase their

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efficiency. The topic and methods are substantiated by selected provisions in the field of circular economy (Murray et al., 2017; Weigend Rodríguez et al., 2020), innovation (McCausland, 2021; Xiong et al., 2020), knowledge economy (Szunomár, 2020), new production technologies (Schaffer & Spilker, 2019; Wang et al., 2017), ecosystems (Brand et al., 2020; Brugger et al., 2021; Lugo-Morin, 2021) and globalization (Hrubec & Uhde, 2019). They allowed clarifying the parameters of innovation, the components of R&D management and their effectiveness.

The theoretical conclusions assess the current state of rocket and space engineering companies, clarify the environmental factors that have the greatest impact on their activities and provide recommendations for improving the management and organization of these enterprises, which meets the practice-oriented criterion. This helps the administration change the concept of enterprise management, the core function of managing research intensity and innovation in increasing the efficiency and commercial success of their activities.

2 METHODS

The study is based on theoretical and practical materials describing the economics and management of rocket and space engineering, as well as the related fields of science to substantiate macro-trends and economic challenges for this industry.

The research objective assumed a hypothesis that the current economy and economic relations make science-intensive enterprises of rocket and space engineering adapt to global growth trends and search for effective management solutions under the conditions of a state monopoly on their structuring, technological inflation, low capitalization and an increase in returns from R&D through the systemic integration and accumulation of innovations in production.

To achieve this goal, we analyzed enterprises of rocket and space engineering. They are located in Russia and include 62 enterprises. Within the framework of this research, the sample comprises 51 companies, which amounts to 82% of the total number. We compiled the list of homogeneous enterprises. Their activities were considered from 2013 to 2020. Due to insufficient information and restricted data about such enterprises, some indicators were analyzed for the general totality (i.e. the analysis of organizational and legal forms, enterprises by business size), while the others were considered according to the sample (the analysis of financial and economic indicators, as well as the research intensity of enterprises).

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The analysis of financial and economic indicators included the distribution of rocket and space engineering enterprises according to absolute, quick and current liquidity ratios, the overall solvency ratio, the coefficient of autonomy, equity and leverage ratios, the maneuverability coefficient, the coefficient of financial stability. This analysis allowed to determine the effectiveness of these enterprises and their management.

The management of rocket and space engineering companies was preliminarily systematized in cooperation with five basic departments of the Technological University named after Twice Hero of the Soviet Union, a pilot-cosmonaut of the USSR A.A. Leonov. These are located at large enterprises of rocket and space engineering in the town of Korolev, a cradle of science and an industrial city in Moscow Oblast, Russia. The final formalization of these issues was made in publications of the Russian scientists (Makarenko, 2017; Patsuk & Korshakevich, 2017; Shiryaeva & Rozhanskaia, 2020).

The objectivity and reliability of our provisions and conclusions are provided by a set of tools and scientific methods (dialectical materialism, systems analysis, comparative analysis and synthesis, economic and statistical methods of group comparison). The consistency of the obtained results is ensured by similar intermediate results of other scientists (Payson & Frolov, 2020; Shiryaeva & Rozhanskaia, 2020) of the studied area of knowledge.

3 RESULTS

3.1 Assessing the current financial and economic state of rocket and space engineering companies

Rocket and space engineering enterprises develop rocket and space technologies and process metals for the production of machines, i.e. the creation of metal structures and products. These companies include R&D departments for producing, repairing and updating space rocket complexes, as well as creating space equipment samples for civil and military purposes. Rocket and space engineering enterprises are part of the rocket and space industry involved in launching space flights, training astronauts and providing space services.

Rocket and space engineering companies have several organizational and economic features, including:

1) A large number of R&D projects in the process of creating unique products that

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can be produced as single prototypes or limited editions;

2) The narrow specialization of research institutes and design engineering bureaus at these enterprises, the limitedness of their experimental and serial production, experimental and operating complexes;

3) The limited production of products (single prototypes) and the need to make significant changes to their design, which reduces the life cycle of manufactured products;

4) The high technology (in terms of structure, composition of elements and tasks to be solved, parameters of the created and used technical means) of many projects and programs, and the associated high level of technological and technical risk during their implementation;

5) Long development cycles of new technical means, implementation of large programs, production of prototypes and stock products.

The largest space company in Russia is PAO "RKK Energia". It is the main contractor and leading developer of spacecraft (Soyuz MS and Progress) and the Russian participant in the International Space Station program. It provides products and services in four main areas: manned space complexes; automatic space complexes and systems, including special spacecraft; rocket and space complexes and launch vehicles; R&D projects and other space services (Shiryaeva & Rozhanskaia, 2020).

In total, 62 enterprises should be attributed to rocket and space engineering companies. 58% of them are classified as large, with more than 1,000 employees. 42% of enterprises are medium-sized and employ from 250 to 1,000 people. There are no small enterprises since this industry is characterized by science-intensive and precise mechanical engineering that implies a large number of production personnel and R&D departments (Figure 1).

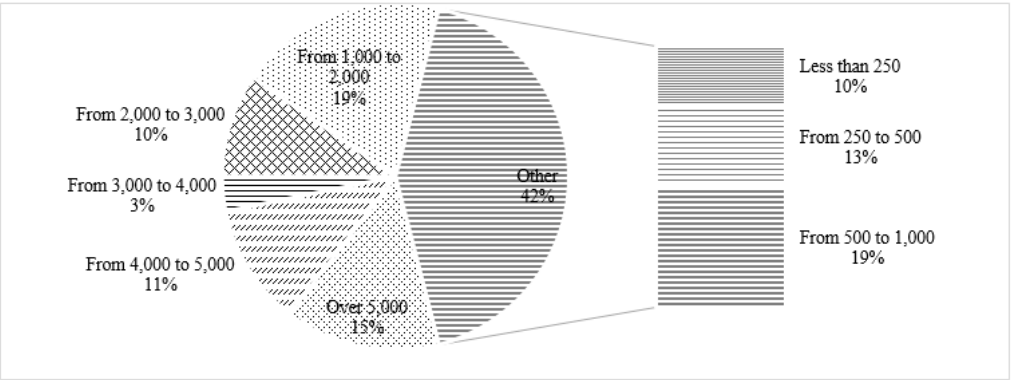

Figure 1. The headcount in rocket and space engineering enterprises

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Due to the distribution of rocket and space engineering enterprises by their organizational and legal forms, we revealed that the share of joint-stock companies increased from 79% to 92% from 2013 to 2020 (Figure 2). Initially, such companies were established as federal state unitary enterprises, i.e. not available for commercial investors due to the fulfillment of state orders, but today their economic growth is mostly based on a market economy. Nevertheless, their main owner is still the state which holds controlling stakes due to the issues of national security, the priority implementation of the state space program and the important social role of these enterprises providing employment opportunities and social infrastructure.

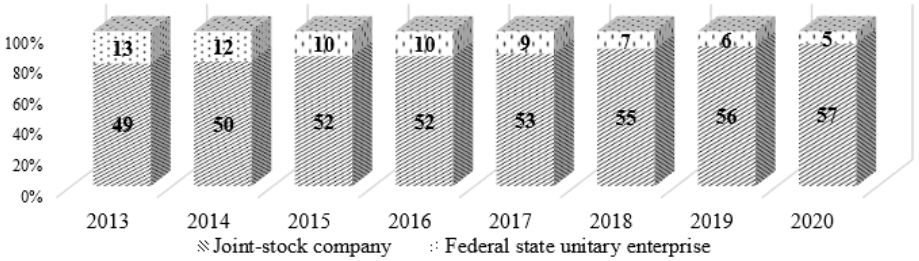

Figure 2. The distribution of rocket and space engineering enterprises by their organizational and legal forms

The enterprises of rocket and space engineering founded during the Soviet period have not fully adapted to a market economy, retaining several organizational and managerial forms of a planned economy. We analyzed the financial and economic indicators of these enterprises. 2019-2020 data were fragmentary and the sample of enterprises for which financial information was publicly available was not representative enough. Therefore, the analyzed period was from 2013 to 2018. In total, 51 enterprises were selected from the total number of 62 enterprises that had the organizational and legal form of a joint-stock company. After analyzing a number of indicators, we established as follows: a) the distribution of enterprises according to the absolute liquidity ratio showed that from 20% to 33% of them had this indicator at 0.5 and higher, which indicates an exceeding amount of free cash that can be used for production development; b) the distribution of enterprises according to the quick liquidity ratio demonstrated that over 37% of them had a sub-standard indicator and imbalance between income and expenses from their ongoing activities; c) the distribution of enterprises according to the current liquidity ratio indicated that 63% of them had normal indicators, 12% of them experienced high financial risks associated

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with the inability to pay the current accounts and 25% of them had an irrational capital structure; d) the distribution of enterprises according to the overall solvency ratio established that 72% of them had a high probability of a solvency crisis; e) the distribution of enterprises by the coefficient of autonomy showed that 39% of them had an adequate ratio of equity capital and reserves to the total amount of assets; f) the distribution of enterprises according to the equity ratios and borrowed funds revealed disproportions in the supply of borrowed capital with private equity funds in 45 enterprises; g) the distribution of enterprises according to the maneuverability coefficient established that, despite the lack of equity capital, 41 enterprises could maintain and replenish the level of their working capital, if needed, on the basis of their own sources; h) the distribution of enterprises according to the coefficient of financial stability showed that only 25% of enterprises could be characterized as financially unstable (Figure 3).

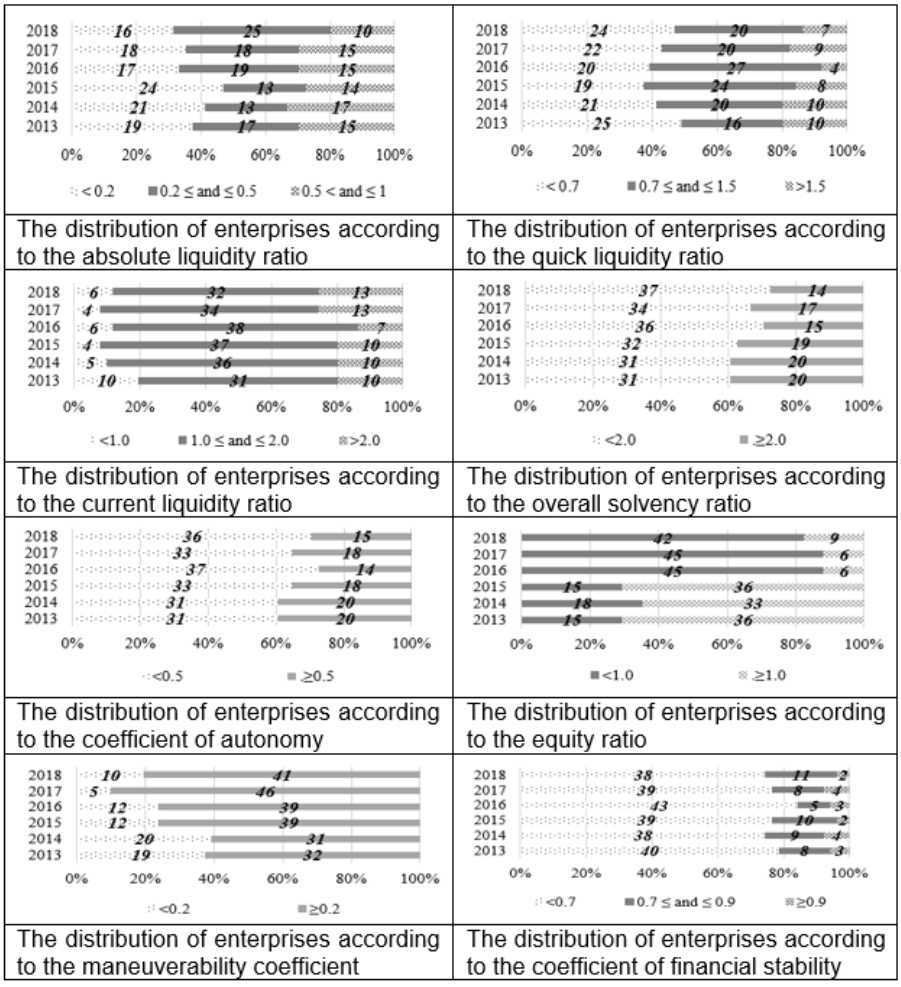

Figure 3. The financial and economic state of rocket and space engineering companies in Russia

A typical feature of the Russian rocket and space engineering enterprises is their

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high research intensity. After analyzing the R&D expenditures of 51 enterprises (Figure 4), we revealed that their involvement in innovation activity increased on an annual basis. In 2020, about 31% of the selected enterprises did not conduct R&D projects, which negatively affected the entire industry. The latter has a reference value for innovation in other sectors of the national economy. Furthermore, the shortage of R&D and lack of involvement in their results hinder the creation of added value for high-tech products in rocket and space engineering.

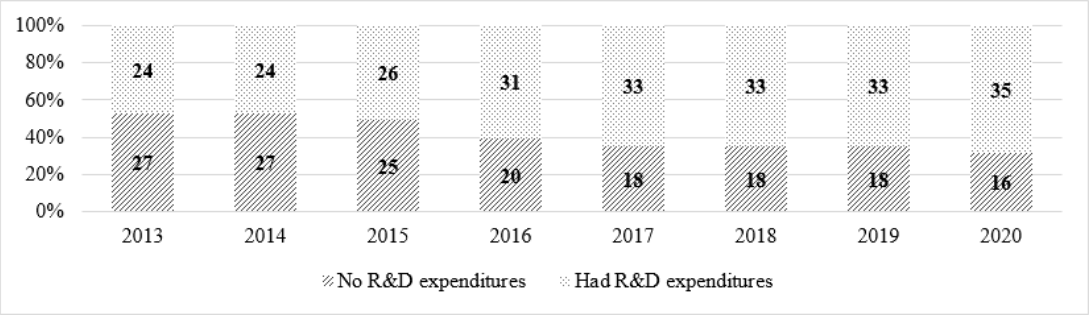

Figure 4. The distribution of rocket and space engineering enterprises by their R&D expenditures

Rocket and space engineering companies have unstable financial and economic indicators due to several challenges, namely, excessive state participation in the management of these enterprises, insufficient adaptability of these enterprises to external changes, low R&D results that can be further used in production. To solve these problems, it is necessary to improve the existing management mechanisms, realize the internal potential and adapt such companies to global macroeconomic trends.

3.2 The impact of global macroeconomic trends on the development of rocket and space engineering enterprises

The specifics of rocket and space engineering enterprises manifested in the high scientific and technical added value of manufactured products, innovative properties and accumulation of scientific and technological achievements increase the role of direct and indirect environmental factors on enterprises as dominants of their development and counteraction to economic turbulence. A circular economy is a model in which plans, resources, procurement, production and waste management are controlled as both processes and results (Murray et al., 2017). It aims at maintaining a healthy ecosystem and improving social well-being. Rocket and space engineering

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enterprises as conductors of space development should be integrated into the globalization model with due regard to environmental, ethical and social constraints of their activities.

Global macro-trends and economic challenges force rocket and space engineering enterprises to search for new, more effective organizational and management solutions. While the algorithms for developing the internal environment of these enterprises were developed back in the USSR and still have not been transformed to market conditions, the algorithms for managing stability in the external environment are still adapting to modern conditions. Most of Russia's rocket and space engineering enterprises are fully or predominantly owned by the state. In other countries, there is an increase in the role of commercial companies and private capital in this area (Weinzierl, 2018). Viable structures differ from those in the United States and Europe when there is a conflict between the traditional perception of industry participants and their revolutionary expectations (Payson & Davidian, 2015). In this regard, market approaches to their management are substituted with administrative ones, and the main goals change from commercial to military and social ones. According to the analysis of balance sheets from 2013 to 2020, from 10% to 20% of them were found unprofitable (Figure 5). Even facing certain losses, enterprises do not liquidate non-core assets and social infrastructure (for example, housing and communal services, recovery centers, health resorts, etc.).

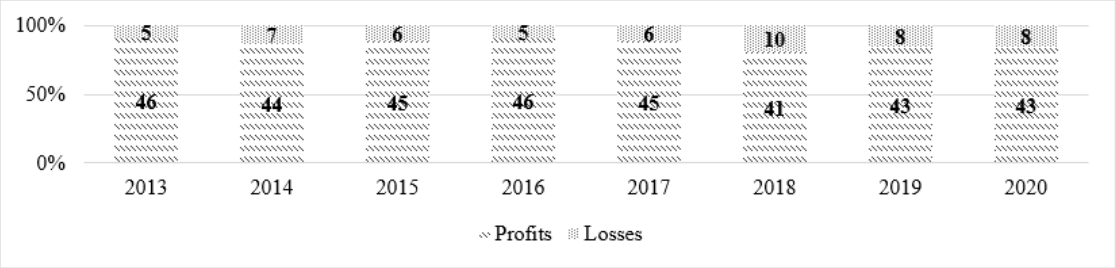

Figure 5. The distribution of rocket and space engineering enterprises by their financial results

The instability of the world economy and aggressive strategies for redistributing the market for missile launch and space services pose a macro challenge for the Russian enterprises and require new incentives for ensuring growth and overcoming crises. The goal-setting of rocket and space engineering includes national economic, scientific and technical, or military objectives. The systemic integration of production and innovation at such enterprises contributes to their solution. The intermediate (R&D activities,

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patents and developments) and final results (science-intensive products) help form competitive national markets for equipment and technologies.

The transformation of the economic world picture affects labor productivity in the missile launch and space industry, the spatial combination of used or potential resources, its share in the country's GDP and an increase in the overall efficiency of corporate and public administration, which is especially important in market conditions.

Nowadays the level of economy is influenced by the development and diffusion of innovations, as well as the formation of innovative infrastructure. The development of industrial sectors calls for reforming the R&D sphere since it generates innovations and should become the core of the new economy. At the macro level, there should be a stable priority of R&D growth rates over GDP growth rates.

As the experience of the leading countries shows, national economies need long-term strategies for increasing their research intensity and rechannel them towards the production of new, technically complex products (Batkovskii et al., 2019). These trends are quite stable. They will lead to the expansion of the R&D sphere and science-intensive rocket and space engineering as the main manufacturer of science-intensive products in the Russian Federation. The future of the industry depends on its rapid adaptation and the rational use of opportunities. The development of space infrastructure will pave the way for various scientific activities, including the construction of large space telescopes, complex space missions to the outer solar system and research stations on the surface of Mars and Moon (Crawford, 2016).

Based on several information sources, we systematized global economic trends and prospects for scientific and technological development, which affects the science-intensive enterprises of rocket and space engineering. These are as follows:

1. Changing environment. The most significant are climate changes, an increase in anthropogenic load and resource depletion. They influence the social globalization and development of trade and industrial relations. As noted by (Sagath et al., 2019), space can serve as an important multiplier of six resilience domains due to its transverse nature: security, environment, energy, resource, knowledge and transport. These trends are typical of all economic sectors, especially rocket and space engineering that explores space. According to D.R. Lugo-Morin (2021), it is the Anthropocene, i.e. an era with a high level of human activity affecting wildlife and playing a significant role in the Earth's ecosystem, increasing demand for energy (Brugger et al., 2021) and space resources (Crawford, 2016), the 'green' phase of capitalism (Brand et al., 2020), which drives the early exploration of outer space. The development of space resources has

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a high potential. It is assumed that the first trillionaire of the Earth will be an asteroid miner (Weinzierl, 2018).

2. Demographic and social changes. According to numerous sources, there is an increase in the rates of urbanization, migration, gerontology and cooperation. The present days are characterized by changes in social values, the continuity of education and its inclusiveness, widespread digitalization, and a radical improvement in living standards (Schaffer & Spilker, 2019), which affects people's preferences, and labor resources at rocket and space engineering companies and their management. The main incentives for developing the economics of space are industrial competitiveness and the creation of new benefits outside the national borders of one state, therefore the full potential of social benefits is still underestimated (Sagath et al., 2019).

3. The development of the knowledge economy and global transformation of production factors with an emphasis on knowledge capital. Indeed, innovations are one of the main drivers of economic growth (Xiong et al., 2020), and their continuous use in production ensures the transition from a low-cost economy to a high-value-added economy (Szunomár, 2020). The share of intellectual products will increase in the conditions of lower costs for material resources, their flexibility and short life cycle based on the mass individualization of demand. The creation of new values will be connected with centers of new knowledge focused on pre-competitive cooperation, active sale of technologies, replication of innovations (Batkovskii et al., 2020) and provision of virtual services. Involvement in the creation of "space elevators" and the development of next-generation transport systems becomes an indicator of innovation in space activities.

4. Changing geopolitical situation. These include the growing multipolarity of economic links and spheres of state influence that determine the instability of local centers. The flows of capital, innovation, production and trade, as well as military escalations, wars and poverty, change the existing situation (Hrubec & Uhde, 2019). Thus, Asian and South American countries become new centers of economic growth. Their competitiveness leads to measures of state and interstate protectionism of the world economy outsiders. This fact hinders the Russian rocket and space engineering since this trend increases the number of space powers and, as a result, decreases the interest of other countries in the missile launch and space industry of the Russian Federation. The situation is aggravated by unresolved issues in the field of space law and the delimitation of national space boundaries (Wortman, 2020).

5. New stages of scientific and technological development. Those require a new

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industrial revolution based on digitalization, artificial intelligence, robotics, new materials, microelectronics and new energy sources, for example, the launch of 5G technology and low-earth orbit ultra-small satellites (McCausland, 2021). New nanomaterials influence the creation of new spaceships. Their main advantages are associated with reduced vehicle weight, improved functionality and durability of space systems (Tsisarskii, 2014). The further scientific and technological progress moves in the creation of new nanomaterials, the faster space programs will be implemented. It is worth mentioning that the speed of creating new technologies is quite high. The current technologies turn obsolete, i.e. the inflation of technologies. Enterprises need to combat these processes to introduce new technologies systemically.

6. The personalization of manufactured products (Wang et al., 2017) based on the logic of globalized liberal markets deeply rooted in everyday life. This simplifies access to cheap and unsustainable goods and labor (Brand et al., 2020).

7. The formation of a circular economy. This assumes a closed-loop economy aimed at resource conservation, regenerative environment-friendly production and responsible consumption (Weigend Rodríguez et al., 2020), involvement of space resources, whose extraction makes the leading space countries fight for (Crawford, 2016). Such factors will transform the existing economic, social and economic ties on the Earth.

Global trends affect the development of rocket and space engineering enterprises. They condition economic (the competitiveness of products and enterprises, transformation of sales markets), technological (approaches to the production of brand-new products), marketing (changing the needs and conditions of product use), social (the changing composition and structure of labor resources, their motivation) and spatial development. Rocket and space engineering enterprises differ in terms of their technical and economic organization but have similar forms and development potentials in the context of changing global economic trends. The rocket and space engineering companies inherited from a planned economy were adapted to market conditions in the 1990s. These adaptation processes have not been completed yet. Rocket and space engineering enterprises are still subject to systemic restructuring.

In general, the state of rocket and space engineering companies is determined by the overall state of the rocket and space industry itself. Historically, this industry has been one of the most science-intensive sectors of the national economy. Since 1957, the rocket and space industry of the Russian Federation has launched more than 1,800 R-7 missiles. Together with the United States and China, Russia is among three

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leaders in successful orbital launches. However, the current space age destroys the strategic monopoly of these countries (Yazıcı & Darıcı, 2019). The United States is the leader in spacecraft production, followed by Russia and Europe. The development of rocket and space engineering depends on the degree of rocket and space technology. At the same time, there is an increase in China's production capacity in the field of space exploration, whose commercial space sector is diversified and aimed at the production of civilian products. This strategy could turn China into a major space conqueror on par with the United States, Russia and Europe (Pollpeter, 2011).

The most promising areas for developing rocket and space technology based on global macroeconomic trends are as follows: 1) new launch vehicles and infrastructure; 2) engine building for rocket and space equipment; 3) orbital stations; 4) manned spacecraft. The current trend in the rocket and space industry is the growing competition among alternative "ground-based" products. The largest increase in demand is common to services in the field of satellite communications and broadcasting from geostationary orbit. They still meet the investment attractiveness criterion. Despite positive scientific and technical indicators, the share of the Russian Federation in the world market of space services has remained practically unchanged over the past five years and amounts to 11%.

High innovation rates are typical of rocket and space engineering enterprises. The R&D effectiveness is determined by the effectiveness of their structures, processes and projects. There is a decrease in competitive advantages if compared to NASA and ESA which managed to achieve success in the research of liquid propulsion systems for rocket spacecraft and systems for their testing, the creation of vacuum coating technology, the building of service stations for producing rocket space vehicles, etc. (Gorlacheva & Ivannikova, 2019). NASA's budget is gradually growing and will have amounted to $19,592.2 million by 2022, with 25% of it spent directly on science (Yazıcı & Darıcı, 2019). It is advisable to implement R&D projects and innovation activities at rocket and space engineering enterprises in the form of project management. However, the appropriate culture has not been formed and there are limitations to the creation of "open" innovations. There is a potential to increase the efficiency of R&D projects by reducing unit costs in the use of space and diversified products, including civilian use and space tourism (Shiryaeva & Rozhanskaia, 2020).

Considering the national security of the Russian Federation and the strategic priorities of space exploration, public authorities participate in the activity and development of rocket and space engineering enterprises. The state is greatly

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interested in the effectiveness of space activities due to the wide applicability of space services in other sectors of the national economy. In this regard, support mechanisms are reduced to four components: preferences, infrastructure, motivation and guarantees. The current industry does not meet the criterion of self-sufficiency since it is not characterized by complete economic reproduction for several reasons, including gaps in the reproduction chain of rocket and space technologies after the collapse of the USSR and the loss of some strategic enterprises, low rates of import substitution and sanctions pressure. It is necessary to form rocket and space engineering facilities that can compete with foreign suppliers. According to A. Yazıcı and S. Darıcı (2019), there will be a bipolar geopolitical force in space exploration in the next 20 years: cooperation between the United States and Europe and cooperation between Russia and China.

Thus, the results of space activities are crucial for developing the Russian economy. Since the 1990s, its rocket and space engineering has been functioning in the context of low competitive advantages. There was a decrease in the reliability and quality of rocket and space technologies, while the industry became more dependent on imports. The current situation in the industry makes its enterprises adapt to global macroeconomic trends. One needs to prioritize the existing issues and, on their basis, develop new approaches to improving internal organization and public administration.

3.3 The impact of global macroeconomic trends on the development of rocket and space engineering enterprises

The need to improve the economic results of many science-intensive enterprises of rocket and space engineering is realized through the insufficient use of accumulated theory and management practice. The basic principles of management at science-intensive enterprises of rocket and space engineering do not meet the criterion of sufficiency due to various control systems with the preserved properties of the Soviet planned economy and global macro trends of the modern market economy. This instability changes depending on the turnover of middle- and top-level management, and state involvement in the functioning of these enterprises. The situation is aggravated by the inconsistency of management concerned with the functioning of such enterprises and their development. Therefore, it is necessary to specify problems in this area and tools for their solution as a factor satisfying organizational needs in the development of rocket and space engineering companies.

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A new approach to managing the development of the Russian science-intensive enterprises of rocket and space engineering includes three components. The first component includes the solution of system-wide issues related to the functioning of administrated objects, i.e. science-intensive enterprises of rocket and space engineering. It involves the identification of the current tasks that impede their sustainable functioning. The second component refers to increasing the effectiveness of the activities conducted by management subjects. These can include both the management of the above-mentioned enterprises and public authorities involved in corporate management. The third component consists in solving the issues associated with management processes and decision-making. It involves the identification of methods and tools for the effective impact of controlling subjects on enterprises.

The system-wide issues related to the functioning of administrated objects

Being objects under management, science-intensive enterprises of rocket and space engineering are research and production organizations aimed at creating rocket and space technologies for various purposes. The prevailing macro trends negatively affect the sustainability of such enterprises. The situation is aggravated by a decrease in the orbital grouping of spacecraft, the reliability of space technology and the presence of the Russian Federation in the market for rocket and space services. To make a strategic maneuver and take a course towards leadership in the international market of rocket and space technology, these enterprises should solve several issues associated with the effectiveness of management, personnel, organization and state monopoly.

Some studies (Makarenko, 2017; Patsuk & Korshakevich, 2017) claim that the efficient use of resources and capacities acquires the greatest relevance. The enterprises of rocket and space engineering were established back in the USSR. Since that time, requirements for resources and models optimizing their costs have changed. Such enterprises occupy excess areas and use obsolete equipment in production activities. The inadequacy of production assets to advanced technologies requires their modernization. Currently, 20% of equipment has a service life of up to 10 years. The general deterioration of production facilities is over 70%. Their loading level varies within 30% (Makarenko, 2017). No rationality in using production facilities and their underutilization leads to an increase in the cost of products. Considering the high innovative properties of the products manufactured by rocket and space engineering

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companies and the high rate of technology changeover, the industry requires systemic re-equipment and renewal of machines. This applies not only to the products themselves but also to the materials, parts and components used in their production. Rocket and space engineering cannot be competitive without innovations that affect its quality and performance (Patsuk & Korshakevich, 2017), the formation and transfer of knowledge and technology. The latter limit the innovative potential of the industry (van Burg et al., 2017). The ineffective management of resources and capacities leads to a decrease in the quality and demand for manufactured products.

The quality of their products is determined by the quality of resources, materials and semi-finished products used in manufacturing. Unscrupulous suppliers, counterfeits and the breakdown of ties established in the USSR indicate the need to solve strategic issues of contractual obligations, import independence and downward diversification of production, as well as tactical problems of incoming quality control. The discrepancy between design and technological requirements for these processes calls for increasing the quality control of products and employees. It is possible to conduct additional tests to improve the quality of design documentation. There is also a need to increase the reliability of control and measuring equipment, including through the use of computers, to encourage flawless work and to update the existing machines. Product quality management is based on ineffective approaches. The imperfection of metrological support and its expertise, the testing of products and the performance of control operations affect the detection of hidden defects in products. Among the other problems, there are also insufficient attention to labor management, workplace discipline and a decrease in the management's demands on compliance with design and technological documentation.

To ensure the efficient use of resources, it is necessary to solve the issue of staffing shortages. First of all, it is the lack of qualified personnel and their aging. The average age of workers in the industry is 46 years old, while highly qualified personnel and scientists are 64 years old (Patsuk & Korshakevich, 2017). Currently, scientists and specialists are not motivated to work at such enterprises. The incentive package in the industry does not meet the sufficiency criterion. Rocket and space engineering enterprises are characterized by low labor productivity (Payson & Frolov, 2020). The average level of wages is higher than the average salary in the Russian Federation and the average wages for the engineering industry, but lower than in other industries where staff with similar or lower qualifications are employed. The anti-incentive is excessive bureaucracy and declaration of labor processes inherited from the Soviet

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planned economy.

The issues related to the effectiveness of management subjects

The subjects controlling rocket and space engineering enterprises are their managers who implement their functions directly or indirectly through public authorities. The effectiveness of their activities is associated with the inconsistency of goal-setting. On the one hand, they should provide enterprises with profits. On the other hand, they need to satisfy public needs and maintain national security. The state objectives in financing and managing rocket and space engineering enterprises can be put as follows. Firstly, the industry produces goods, most of which fall under the category of public goods and in the production of which the market economy is not interested due to high risks and capital intensity. Secondly, such enterprises have a high social significance since they employ over 150,000 people. Thirdly, the industry is of strategic importance for national security and requires constant state control. Fourthly, this industry is a monopoly on the Russian market of rocket and space engineering, and the state as its main owner has the largest profit from its activities. Fifthly, the informal goal of public officials to become members of the supervisory boards and boards of directors of these enterprises is to receive benefits and profits. In Russia, a decision-making algorithm has not been developed for state-run enterprises. However, some other countries have such experience, for example, Korea and Turkey. They develop programs that are subsequently approved by legislative and executive bodies of state power. The control model for rocket and space engineering adopted in the Russian Federation is too centralized. The EU in this matter relies on the decentralization of management functions and decision-making, for instance, the delineation of transport and (tele-) communications, environment, energy or defense issues (Sagath et al., 2019).

One of the most positive ways of state participation in the activities of state-owned enterprises is the use of a contract system. This involves concluding an agreement with each enterprise on certain terms and brings budget financing only if the initial goals are achieved. There are some issues with the participation of the state-owner in the management of a rocket and space engineering enterprise. The executive branch should manage state-owned enterprises, while the legislature should develop the strategy of these enterprises. Within the executive authorities, it is also necessary to form a list of functions assigned to specific ministries. Today most enterprises of rocket

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and space engineering are owned by the Federal Agency for State Property Management which is part of the Ministry of Finance of the Russian Federation. The division of powers between the Ministry of Industry and Trade of the Russian Federation and the Federal Agency for State Property Management seems to be logical. The board of directors of rocket and space engineering enterprises does not differ from similar structures in private companies. The supervisory board of rocket and space engineering enterprises exercises control functions over the activities of their management. The relevant tasks are as follows: 1) to improve control of the state as the main shareholder of enterprises over the activities of managers; 2) to increase the independence and efficiency of the board of directors; 3) to encourage the activities of managers to achieve specific indicators.

Currently, representatives of public authorities are members of the supervisory board. There is potential for increasing the independence and efficiency of the board of directors by involving independent experts. As a rule, representatives of public authorities work in those bodies that act as the owner of these enterprises. The procedure for nominating members to the supervisory board is quite bureaucratic. It is assumed that these representatives should meet certain qualification requirements common to officials working in organizations that manage rocket and space engineering enterprises. It is difficult to transit from a bureaucratic system of electing members to the supervisory board to a democratic one when these decisions will be made with the involvement of representative government bodies.

The primary task of the state is to concentrate resources on fulfilling its main purpose, i.e. to regulate the competitiveness of rocket and space engineering, especially in connection with the imposition of sanctions against the Russian Federation. On the contrary, the state monopoly on organizations represented by the model of the Roscosmos State Corporation for Space Activities can only have medium-term efficiency since it leaves rocket and space engineering enterprises indifferent to increasing competitiveness. State orders are assigned by directives, the competitive procedures are formal and the management of enterprises is not motivated to increase their competitive features. In this case, there is a high probability that the innovative properties of manufactured products will decrease and the ineffective use of budget funds increase. Internal structures are organized in the conditions of strict state control since this simplifies control over their activities and the mechanisms for distributing state orders, which are based on the specialization of rocket and space engineering enterprises. There are also government agents in the rocket and space industry that

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change the existing procedures, such as the Skolkovo Foundation (Payson & Davidian, 2015).

Nowadays the viability of rocket and space engineering enterprises is presented only in the model of opportunities for obtaining state orders. Otherwise, its existence is called into question. Structures in the form of Roscosmos are malfunctioning and do not ensure the achievement of strategic goals for the development of this industry. These facts have a negative effect on the financial position of rocket and space engineering enterprises. Research funding in the field of rocket and space engineering is mainly provided at the expense of the federal budget of the Russian Federation. It is difficult to attract private investment since the risks and terms of project implementation reduce the motivation of potential investors (Harrington, 2020), along with the lack of reserve funds to ensure the implementation of plans for releasing high-tech products with high-risk case insurance (Harrington, 2020). Thus, the investment and financial management of rocket and space engineering are conducted at an unacceptably high level of state participation and budgetary regulation. It is worth mentioning that the total financial dependence of such enterprises on budget funds has been formed. The possibilities for attracting private investment are limited. The current situation of limiting the financing sources hinders the development of the industry.

The issues of management processes and decision-making in management

A planned economy had a drastic impact on the formation of management processes at rocket and space engineering enterprises and laid down the fundamental principles of centralized management with a high degree of absolutism. These properties have survived to this day. Currently, the center of competence and decision-making is the top management and the owner represented by public authorities. The delegation of authority and responsibility from the highest level of management to the lowest is disproportionate due to the rigid centralization of power. The authoritarian leadership opposes the low motivation of employees. Democratic management is practically not implemented at rocket and space engineering enterprises. The specifics of control processes consist in the focus not on potency but rather on efficiency. The criterion for the optimal use of resources is not set but such enterprises function in the conditions of their deficit. The trend of achieving results at any cost prevails.

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4 CONCLUSION

Decision-making tools used at rocket and space engineering enterprises have several problems. Firstly, there is a high time delay between the analysis of the initial situation and the corresponding management result. This fact is associated with the redundancy of procedures for aligning the management hierarchy. Secondly, the analysis of the current situation is not effective since it is poorly adapted to rapidly changing information. Thirdly, there are no initiatives to adjust such results to new data about the object of management. Disinterest is associated with an ineffective motivation system.

Thus, we considered the management of science-intensive R&D enterprises and revealed some scientific, technical, production, financial, organizational and corporate issues. In addition, an imbalance of state and corporate interests in strategic management has been established. The development of science-intensive enterprises is crucial and caused by state involvement, the lack of financial resources and ineffective management.

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