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Sanctions Against the Russian Rocket and Space Industry: Strategic Risks and Countermeasures

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ABSTRACT

The relevance of the research is determined by current situation of the long-term targeted sanctions impact on the technological sectors of the Russian economy and strategic importance of ensuring sustainable development of the national space industry. **The purpose** of the research is to review the external sanctions measures and to examine the possible extent of their influence on the development of the industry, to identify strategic risks and to propose priority goals and tools to achieve them within the framework of managing the task of maintaining the competitiveness of the Russian space sector. **Methods:** the study was carried out on the basis of actual foreign legal framework analysis with the application of abstract-logical methods. **Scientific novelty:** the author proposed comprehensive measures to support the sustainable development of the rocket and space industry under conditions of significant external restrictions. **Research results:** the article systematizes the main current sanctions measures against the domestic space industry and puts forward mechanisms to counteract their negative impact. **Practical significance:** the outcomes can be useful both for the scientific community and for decision-makers, who participate in the processes of strategic planning for the development of the national rocket and space industry.

Keywords: sanctions; rocket and space industry; risks; strategic management; technological sovereignty; sustainable development

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INTRODUCTION

Starting from 2014, the Russian economy has been subjected to large-scale sanctions pressure from the Western countries led by the US. In the modern world, economic sanctions have become one of the main tools of hybrid wars aimed at undermining the power of the state without direct armed intervention [1, 2]. New economic restrictions against Russia, despite their wide coverage, have a pronounced targeting nature: they are largely aimed at undermining the military power and technological development of the country. At the same time, when implementing the plan to cut off access to advanced technologies in strategic industries, the rocket and space sector is one of the key targets. In February 2022, U.S. President Joe Biden stated bluntly: "We estimate that we will cut off more than half of Russia's high-tech imports, and it will strike a blow to their ability to continue to modernize their military. It will degrade their aerospace industry, including their space program".[1]

Science-intensive high-tech rocket and space industry (RSI) is able to act as a locomotive of innovative development, it promotes the country's involvement in international scientific and technological cooperation, ensures the sovereignty of the information and telecommunication infrastructure environment, plays a fundamentally important role in ensuring national security, creates the prestige of the state in the international arena [3]. In addition, since the end of the Cold War, the products of RSI and related space services have become a serious source of commercial revenue. According to some expert estimates, the global space sector exceeded $ 600 billion in 2023, with a forecast to reach $ 1.8 trillion by 2035.[2]

For Russia, the rocket and space sector is one of the priority areas of development.[3] Historically, the country has been at the forefront of space exploration, and the domestic RSI retains a high potential at the international level. A developed space sector ensures Russia's parity among the leading space powers and geopolitical status, creates conditions for a higher standard of living for the population by providing services based on complex space systems, generates economic profit and serves as the engine of scientific and technological progress. All this makes it necessary to implement competent strategic management of the industry in order to ensure its sustainable development in the context of organised sanctions restrictions imposed by Western countries and their allies.

SANCTIONS AGAINST THE RUSSIAN ROCKET AND SPACE INDUSTRY

The sanctions measures that affect the Russian RSI can be summarised and classified as follows:

1. Restrictions on the supply of military and dual-use goods and technologies.

2. Targeted sectoral sanctions imposed through the export control system aimed at restricting the supply of know-how, components, finished goods and services in the rocket and space sector.

3. Targeted sanctions in the form of inclusion of individuals and organisations of RSI in sanctions blocking lists.

4. Sanctions against other high-tech industries that are related to RSI [towards electronic industry, creation of sensor equipment, software, etc.].

5. Secondary sanctions.

A separate factor of sanctions influence can be called the refusal to participate in joint scientific and technical projects in the field of space exploration and research. For example, in spring 2022, the German Aerospace Center announced the termination of bilateral cooperation with Russian space institutions (including the shutdown of the eROSITA telescope on board the Spektr-RG orbital astrophysical observatory, which was carrying out research in tandem with the Russian ART-XC telescope). In July 2022, it was announced that the European Space Agency (ESA) would withdraw from the joint Russian-European multi-year Mars exploration mission. The planned co-operation

[1] URL: https://spacenews.com/biden-sanctions-will-degrade-russian-space-program/

[2] URL: https://www3.weforum.org/docs/WEF_Space_2024.pdf

[3] URL: http://government.ru/news/48570/

between State Space Corporation "Roscosmos" and NASA on Venus exploration was also cancelled [4].

The leading role in the process of initiating and implementing anti-Russian sanctions belongs to the US, which began to pursue a policy of restrictions against the Russian rocket and space sector even before the military crisis in Ukraine.

UNITED STATES SANCTIONS

US sanctions are comprehensive and are imposed mainly by the U.S. Department of State, the Bureau of Industry and Security (BIS) of the U.S. Department of Commerce and the Office of Foreign Assets Control (OFAC) of the U.S. Department of the Treasury (see *Figure* below).

In the summer of 2013, the US began blocking the supplies of electronic components in the "military" and "space" categories (radiation-resistant components) for the production of rocket and space technology (RST) in Russia [5]. These products fall under the supervision of the International Traffic in Arms Regulations (ITAR), a national regime for controlling the circulation of military and defence technology, administered by the US Department of State.

In 2018, the U.S. Department of Defence established a ban on contracting for its needs with certain foreign commercial satellite service providers if there is a national security risk in doing so.[4] As of 2019, Russia is included in the list of such suppliers along with China, North Korea, Iran, Sudan and Syria.[5] As of 1 January 2023, the prohibition on the purchase of such services also applies if spacecraft or launch vehicles (LV) developed or manufactured in these countries (or by an enterprise with full or partial participation of these states) are used for their implementation. In essence, this measure means the refusal of US military units from 2023 onwards to purchase satellite services provided by satellites launched by Russian LV outside the US, as well as those created with Russian participation.

In March 2021, the U.S. State Department's decision to include Russia on the list of countries subject to the ITAR restrictions of subsection 126.1, "Prohibited Exports, Imports, and Sales to or from Certain Countries", took effect.[6] In fact, this means that the country falls under an embargo on military trade with the US and, in the specific case of Russia, a general "policy of denial" of licences and other permits to export military and dual-use products and services to the country, including RST and related items and equipment listed in the U.S. Munitions List (USML).[7]

The US sanctions imposed immediately after Russia's announcement of a special military operation in Ukraine are multidimensional and wide-ranging.

Firstly, starting from April 2022 many Russian RSI enterprises — among which part of State Space Corporation "Roscosmos" framework JSC "Russian Space Systems", JSC "Academician M.F. Reshetnev Information Satellite Systems", JSC "Lavochkin Assosiation", JSC "Center for Operation of Space Ground Based Infrastructure" ("TSENKI"), JSC "TerraTech", JSC "Makeyev State Rocket Center", JSC "Scientific and Production Corporation "Precision Instrument Engineering Systems", JSC "Salavat Chemical Plant", JSC "Federal Research and Production Centre "Titan-Barrikady", JSC "Arsenal Design Bureau named after M.V. Frunze" — are included in the sanctions list of the Specially Designated Nationals and Blocked Persons List (SDN List) of the US Treasury Department's OFAC.[8] It also contains many other scientific and manufacturing organisations directly or indirectly related

[4] URL: https://www.govinfo.gov/content/pkg/USCODE-2022-title10/pdf/USCODE-2022-title10-subtitleA-partIV-chap135-sec2279.pdf

[5] URL: https://www.federalregister.gov/documents/2019/05/31/2019–11306/defense-federal-acquisition-regulation-supplement-foreign-commercial-satellite-services-and-certain

[6] URL: https://www.federalregister.gov/documents/2021/03/18/2021–05530/international-traffic-in-arms-regulations-addition-of-russia

[7] URL: https://www.ecfr.gov/current/title-22/part-121; https://www.ecfr.gov/current/title-22/chapter-I/subchapter-M/part-126

[8] URL: https://sanctionslist.ofac.treas.gov/Home/SdnList

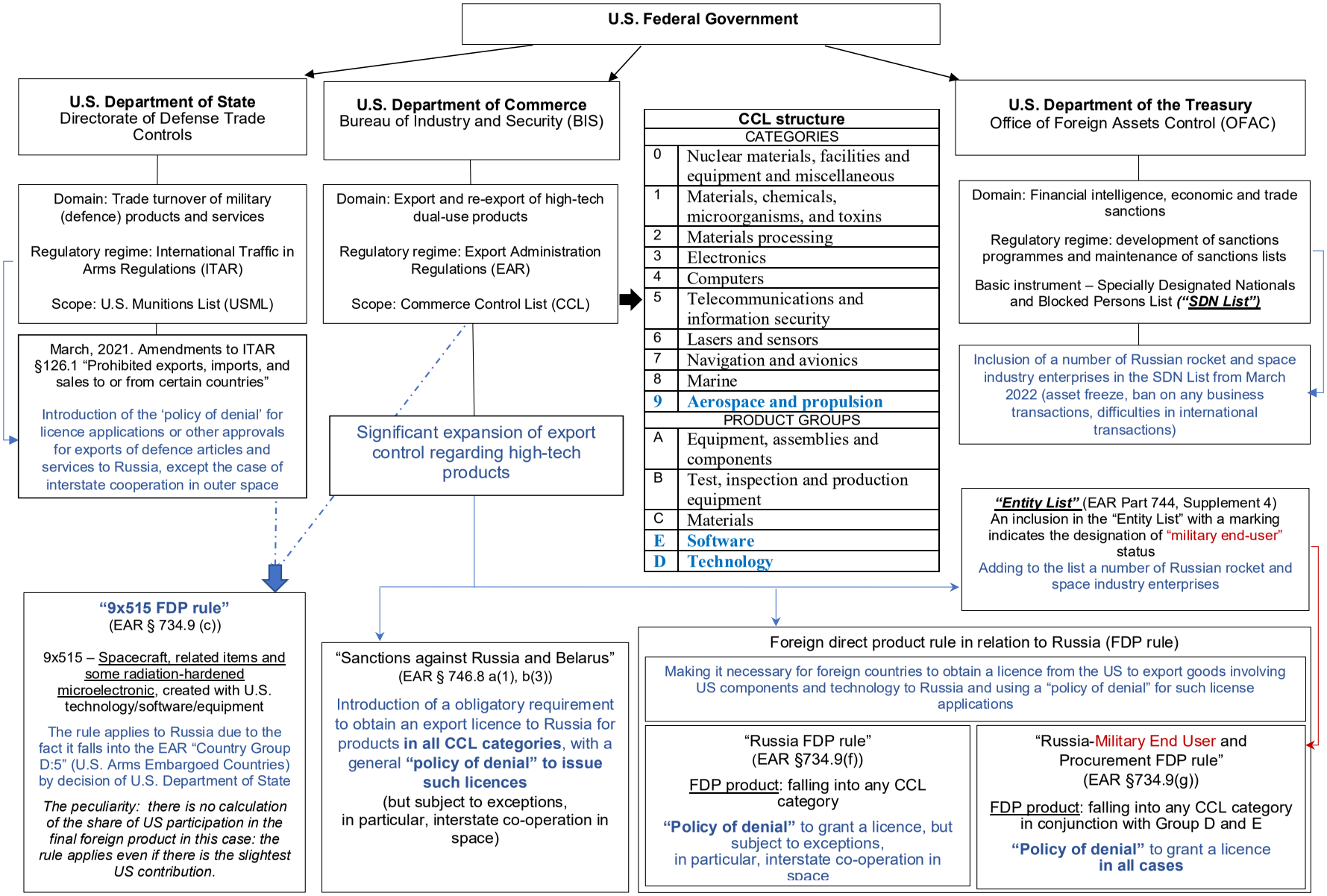

Fig. **Schematic representation of US sanction restrictions on the Russian rocket and space sector**

Source: compiled by the author based on a study of the U.S. regulatory framework.

to the development of RST, including electronics. Economic transactions with these organisations are prohibited for US residents and on US territory. In addition, it potentially implies difficulties in international transactions participation, as the U.S. financial system identifies SDN List participants through automated screening.

Secondly, BIS of the U.S. Department of Commerce has included some aerospace companies and of related industries in the list of foreign entities that are subject to special licensing requirements of the Export Administration Regulations (EAR) — so-called "U.S. Entity List".[9] The list mentions more than 10 Russian entities subject to an a priori "policy of denial" when issuing an export licence, but a licence may be approved if it relates to the US government's support for the use of the International Space Station.

Third, BIS published a number of amendments to the EAR that tighten export controls on Russia in general:

• licensing requirements for exports and re-exports for dealing with Russia for all items on the Commerce Control List (CCL) were introduced, where no licence was previously required. CCL is a list of high-tech goods with dual-use potential, in which category 9 "Aerospace and Propulsion" includes space products (spacecraft, LV, payloads, onboard systems, various components, ground-based space equipment, rocket propulsion systems, software etc.). With a few exceptions (including intergovernmental cooperation in space), the licence, which has become mandatory, is issued using a "policy of denial".[10] According to BIS, the measure is being taken to "significantly limit Russia's ability to obtain items it is not able to produce itself"[11];

• two new Foreign Direct Product Rules (FDP) — Russia FDP rule / Russia-Military End User and Procurement FDP rule — were introduced, requiring foreign suppliers that use U.S. technology, software or equipment in the creation of their finished goods to obtain a licence from the US for their planned shipments to Russia.[12] These rules apply to products pertaining to any item in CCL list.[13] Applications for these licences should be processed by the US using the "policy of denial". In the case of the "Russia-Military End User FDP rule" (i.e., where it is known that the purchaser/intermediary in transfer to the last recipient/end user of the above products is a person with a designated "military end user" status), the "policy of denial" for licences does not provide for an exemption.[14] Belonging to mentioned consumer status under this rule is determined by a special mark on the Entity List, where many Russian defence and aerospace organisations are listed from 2022. FDPs against Russia create significant restrictions on imports of space products from other countries, as it is common to find certain components, parts or technologies of U.S. origin in their manufacture.

The U.S. general foreign export control regulations have a section "9x515 FDP rule" that relates specifically to the space sector.[15] "9x515" is the so-called Export Control Classification Numbers (ECCNs) of EAR that were formerly covered under ITAR (USML, Category XV "Spacecraft and Related Articles"). In the ECCN "9x515" "x" denotes any of the product groups A, B, C, D or E of the CCL list (*Table 1*).

Under the "9x515 FDP rule", a foreign space industry end-item is subject to U.S. export control if it was created using U.S. software or technology

[9] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-744/supplement-no-4-part-744-entity-list

[10] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-746/ss-7468-sanctions-against-russia-and

[11] URL: https://www.federalregister.gov/documents/2022/03/03/2022–04300/implementation-of-sanctions-against-russia-under-the-export-administration-regulations-ear

[12] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-734/ss-7349-foreign-direct-product-fdp-rules

[13] In the case of the "Russia-Military End User FDP rule" all CCL items in conjunction with product groups D (software) and E (technology) are considered

[14] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-746/ss-7468-sanctions-against-russia-and

[15] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-734/ss-7349-foreign-direct-product-fdp-rules

Table 1

ECCNs of "9x515 FDP rule"

ECCN	Description of the meaning
9A515	Spacecraft and related commodities
9B515	Test, inspection, and production equipment "specially designed" for spacecraft and related commodities
9C515	None (-)
9D515	Software "specially designed" for the development, production, operation, installation, maintenance, repair, overhaul, or refurbishing of spacecraft and related commodities
9E515	Technology required for the development, production, operation, installation, repair, overhaul, or refurbishing of spacecraft and related commodities

Source: compiled by the author based on the analysis of category 9 "Aerospace and Propulsion" of the CCL.

designated in ECCN 9D 515 or 9E 515 and is covered by any ECCN 9x515, coupled with the condition that its export destination be certain groups of countries. Russia is affected by the "9x515 FDP rule" due to its inclusion, as of 2021, in the EAR section "Country Group D:5" (countries, which are subject to US arms embargo).[16] Since ITAR is superior to the EAR regime, ECCN 9x515 positions are also more controlled than other ECCNs in the CCL. Accordingly, a foreign enterprise applying for a U.S. licence to export such space products to Russia will receive a refusal with the utmost degree of probability. It is important that, unlike other FDP rules, which prevalently become active when identified share of U.S. participation in a foreign product in excess of 10 or 25% (so-called "de minimis level" accounting), the "9x515 FDP rule" does not involve such calculations — it applies always, even when the U.S. contribution to the creation of products matching with these ECCNs is negligible.[17]

EUROPEAN UNION SANCTIONS (EU)

The most significant restrictions for the Russian RSI are contained in "Council Regulation (EU) 2022/328 of 25 February 2022 amending Regulation (EU) No 833/2014 concerning restrictive measures in view of Russia's actions destabilising the situation in Ukraine".[18]

Firstly, the EU has imposed targeted restrictions — a ban on the sale, supply, transfer, or export to Russia of goods and technologies suitable for use in the RSI (namely spacecraft and their components), whether or not they originate from the EU. The provision of insurance, reinsurance, maintenance, financing, and material assistance services in relation to space technologies and products is also prohibited. Later, a ban was added on the transit through Russian territory of these technologies exported from the EU to third countries.

Secondly, the EU has imposed a ban on the export to Russia of all dual-use products and technologies and those which "might contribute to Russia's military and technological enhancement, or the development of the defence and security sector". The provision of all kinds of support services and financing in relation to them is prohibited. The list of dual-use items is defined in Annex I of "Regulation (EU) 2021/821 of the European Parliament and of the Council", where category 9 "Aerospace and Propulsion" includes

[16] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-740/supplement-no-1-part-740-country-groups

[17] URL: https://www.bis.gov/ear/title-15/subtitle-b/chapter-vii/subchapter-c/part-734/ss-7344-de-minimis-us-content

[18] URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R 0328 (there is currently an updated version of the document).

many diverse items from the space technology sector.[19] An exception is possible in certain cases, in particular if the purpose is intergovernmental cooperation on space programmes, but even in this situation a licence may not be granted or may be subsequently suspended/cancelled at the discretion of the competent authorities.

It is legally prohibited to knowingly or intentionally engage in activities that have the purpose or effect of circumventing the above prohibitions.

The EU also maintains its own list of end-users of military products, which includes among others JSC "Space Rocket Centre "Progress", JSC "Central Research Institute of Machine Building" ("TsNIIMash"), JSC "Russian Space Systems", JSC "Lavochkin Assosiation", JSC "Yaroslav Radio Factory", JSC "Afanasyev Technomac". List provides for a strict targeted ban on transactions in dual-use goods and technologies with the above organisations.[20]

SANCTIONS IMPOSED BY OTHER COUNTRIES

Japan, Canada, the United Kingdom (the UK), Taiwan, Singapore and South Korea joined the anti-Russian sanctions.

The UK and Canada added JSC "TsNIIMash", JSC "Space Rocket Centre "Progress", JSC "Makeyev State Rocket Center" and some other organisations of the Russian RSI to their national sanctions lists.[21] Both countries have banned insurance and reinsurance services for space products and technologies which owned, controlled or operated by Russia.[22]

Any person under the national jurisdiction of Canada is prohibited from exporting/supplying to Russia items noted in the "Special Economic Measures (Russia) Regulations" under the "arms production" list, which includes satellites, sub-orbital and space LV (exception — items for use in connection with International Space Station activities).[23]

In addition to the established ban on imports and exports of military goods, dual-use goods and critical technologies, in March 2022, the UK imposed a targeted ban on exports and transfers to Russia of RST (as well as technology and software for their design, development or use) and on the provision of technical assistance, brokerage and financial services in support of space technologies.[24]

In March 2022, *Japan* imposed sanctions against JSC "Space Rocket Centre "Progress", JSC "Russian Space Systems" and JSC "TsNIIMash", as well as against many enterprises of the Russian radio-electronic industry and restricted the supply of high-tech products related to the production of semiconductors and microchips. In April 2023, the country imposed a targeted ban on the export of spacecraft, their parts, and components to Russia.[25]

Taiwan has imposed export controls on many items of high-tech goods (including aerospace) similar to those of the US and the EU.[26] Supplies of equipment for the production of semiconductor components, microchips and microprocessors are prohibited to Russia. Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest semiconductor manufacturer, announced its intention to fully comply with export control rules in relation to Russia.[27]

Singapore in March 2022 imposed a ban on the transfer to Russia of all items from the "Military

[19] URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R 0821&qid=1697278574468

[20] URL: https://eur-lex.europa.eu/eli/reg/2024/745

[21] URL: https://www.gov.uk/government/publications/the-uk-sanctions-list; https://www.international.gc.ca/world-monde/international_relations-relations_internationales/sanctions/consolidated-consolide.aspx?lang=eng

[22] URL: https://www.legislation.gov.uk/uksi/2019/855/regulation/29A; https://gazette.gc.ca/rp-pr/p2/2022/2022–04–27/html/sor-dors74-eng.html

[23] URL: https://laws.justice.gc.ca/eng/regulations/SOR-2014–58/FullText.html

[24] URL: https://www.gov.uk/government/publications/russia-sanctions-guidance/russia-sanctions-guidance

[25] URL: https://www.meti.go.jp/press/2022/03/20230331001/20230331001.html

[26] URL: https://www.moea.gov.tw/Mns/english/news/News.aspx?kind=6&menu_id=176&news_id=104215

[27] URL: https://sputnikglobe.com/20220227/taiwanese-semiconductor-producer-reportedly-suspends-supplies-to-russia-due-to-sanctions-1093426167.html

Goods List" and all items in the "electronics" category from the "Dual-Use Goods List" as presented in the national legal document "Strategic Goods (Control) Order 2021".[28]

South Korea is actively cooperating with the US under the FDP rule to block Russia's access to global high-tech products such as electronics, semiconductors, and RST. Under the 2022 amendments to the national export control regulation "Public Notice on Trade of Strategic Items", such items must receive special authorisation from the Korean Ministry of Trade, Industry and Energy to be shipped to Russia — each case will be reviewed separately, and export authorisation will be granted on an exceptional basis.[29]

CAN THE SANCTIONS BE EFFECTIVE?

In the short term, the main consequences of the sanctions impact on the domestic rocket and space sector are as follows:

- reduction or termination of scientific and technical co-operation with "traditional" competent space actors (US, European countries, ESA);
- loss of export revenues (in particular, termination of sales of RD-180/RD-181 engines to the US and termination of co-operation with OneWeb to organise a series of launches to deploy a satellite constellation of the same name);
- displacement (loss of position) from the international market of commercial launch services (in particular, the breakdown of relations with ESA and Russia's cessation of launches from the Guiana Space Centre);
- delay in the implementation of domestic satellite constellation deployment programmes due to the stoppage of supplies of Western electronic components (before the sanctions began, many civilian communications satellites were manufactured on the principle "Russian platform — imported payload"[30]);
- exposure of the heavy dependence on foreign Earth remote sensing (ERS) data: operators Maxar (US), Capella Space (US), Airbus D&S (France), SIIS (South Korea), Deimos Imaging (Spain) and a number of others have stopped supplying data, and Russia has entered into an agreement on the supply of ERS information with Chinese companies;
- termination by some foreign partners of maintenance of their software used by the Russian space infrastructure;
- reduction of supplies and maintenance of ground equipment in the sphere of satellite communication services implementation;
- reduction in the share of foreign satellite service operators, increase in revenue of domestic suppliers in this segment.

Since Russia is not widely represented in commercial segments of the global space industry, the main impact of the imposed sanctions is more of a technological nature. The most vulnerable area of the Russian RSI is radiation-resistant microelectronics that remain functional in outer space. Despite the fact the import substitution programme has been underway in the industry since 2014, the dependence of the national RSI on imported supplies of electronics for spacecraft production remains significant [6].

It is worth noting that the so-called extraterritorial secondary sanctions pose a certain threat to the economic dynamics of Russia's space sector. In this case, it implies the imposition of strict measures by the West against companies from other countries not under their jurisdiction which do not adhere to the sanctions policy against Russia. For example, in February 2023, Chinese companies HEAD Aerospace and Spacety were placed on the Entity List for co-operating with Russia in the supply of commercial ERS data contrary to US policy and were labelled as "Russian military end-users" with all the resulting restrictions on international

[28] URL: https://www.mfa.gov.sg/Newsroom/Press-Statements-Transcripts-and-Photos/2022/03/20220305-sanctions

[29] URL: https://www.kimchang.com/en/insights/detail.kc?sch_section=4&idx=24881

[30] URL: https://www.rscc.ru/news/1234/

transactions. Companies from Armenia, Belarus, Uzbekistan, and Canada, among which there are many manufacturers and suppliers of electronic components, have also received similar status for co-operation with Russia. Extraterritorial secondary sanctions can also be imposed in the situation of import of products of the Russian RSI by third countries. For example, JSC Rosoboronexport has the right to conduct foreign trade activities in relation to military products, under which some types of competitive RST products fall. However, the organisation is enrolled in the US SDN List and Entity List, which discourages some foreign customers, as they risk being included in these blocking lists if the US proves or even suspects such cooperation. The reluctance of foreign third-country companies to lose contact with the US and EU markets and to allow increase their commercial risks due to the threat of being subject to secondary sanctions may strengthen the economic isolation of the Russian RSI in the future.

In general, the consequences of the impact of the "sanctions siege" in the long term are difficult to predict. The presumption of its effectiveness is based on the concept that these measures can have a significant negative impact on the global competitiveness of the target state's industries. US authorities state: "Some of the most powerful impacts of our actions will come over time as we squeeze Russia's access to finance and technology for strategic sectors of its economy and degrade its industrial capacity for years to come".[31] Various works devoted to this issue confirm that restrictive measures in the form of technological sanctions have an effect on the technological development of the country [7–12]. In particular, the rupture of established chains of production of high-tech products with foreign participants, withdrawal from joint projects of scientific and technological cooperation, decline in investment attractiveness, capital outflow have a negative impact on the ability of the sub-sanctioned economy to generate innovations. Moreover, according to studies, the accumulation and strengthening of negative consequences of technological sanctions is observed in the next 5 years after their introduction [7]. Under such conditions, the internal anti-crisis policy pursued by the target state comes to the forefront.

In this context, China's long experience of being under sanctions since 1989, aimed at slowing down the country's development and maximising US economic benefits, is noteworthy. Nevertheless, China has made a tremendous leap forward in economic, technological, and military-political terms: having realised the difficulty of importing technological products from Western countries, the country focused on its independent research and development, including the field of space technologies [13]. According to official government data, China's R&D expenditures in the "spacecraft manufacturing" segment soared from $ 22.6 million in 2000 (10 patents) to $ 386.6 million in 2016 (632 patents).[32] At present, China's achievements in space sphere are more than significant — the country has become a full-fledged space power comparable to the US. China's success in overcoming the consequences of technological sanctions was ensured due to the implementation of a systematic economic, scientific, and technological policy [14].

Thus, the sanctions imposed by Western countries can have a short- and medium-term negative impact on the Russian rocket and space sector, but in the long term the outcome of the situation will largely depend on the state's strategic course of managing its development in the new emerging conditions.

COUNTERACTING STRATEGIC RISKS

The scale, segmental "point" targeting approach together with the long-term and escalating feature of foreign sanctions imposed on the Russian economy from the beginning of 2022 are a

[31] URL: https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/02/24/remarks-by-president-biden-on-russias-unprovoked-and-unjustified-attack-on-ukraine/

[32] URL: https://chinapower.csis.org/china-space-launch/#:~:text=In%20pursuit%20of%20this%20goal%2C, to%20632%20applications%20in%202016

Table 2

Main types of strategic risks for the Russian rocket and space sector in the context of sanctions and countermeasures

Type of risk	Counter measures
Risk of industry stagnation due to the general crisis and possible structural deformation of the economy	• Competent state policy • (understanding of the strategic importance of the RSI, provision of necessary support measures)
Risk of delay in the industry's development due to isolation from supplies of high-tech space products	• Search for alternative suppliers (in particular, strengthening co-operation with China); • parallel import; • import substitution policy: localisation of production, concentration on development of own solutions, technologies, and competences
Risk of loss of export revenues due to termination of actual and potential commercial space projects	• Search for new partners in the international space market; • introduction into the RSI practice of turning the created useful item/service into a product and bringing it to the end consumer; • development of the domestic market (in particular, by facilitating the integration of services based on spacecraft systems into the everyday life of the population), creation of conditions close to market self-reproduction in the RSI; • developing competences in promising commercial space activities (e.g., providing enhanced space situational awareness services); • performing marketing analyses of the global market and conducting campaigns to promote national competences abroad; • improving mechanisms for increasing and maintaining the competitiveness of the RSI, its products, and services
Risk of organising cooperation with new space partners	• Comprehensive assessment of a potential partner: the level of development of its space technologies, political will and financial readiness to invest resources in the development of space programmes, consideration of the history of political and economic relations with Russia; • taking into account the extent of the partner's political ties with Western countries and economic exposure to secondary sanctions; • assessing and controlling own role and position in the planned co-operation project
The risk of a complex technological lag of the rocket and space industry due to external restrictive measures and a certain degree of isolation.	• The general course of state policy towards the fourth industrial revolution, development and implementation of technologies of the sixth technological mode, striving to put in practise the concept of digital transformation in the RSI; • implementation of government measures to support innovation and stimulate innovative development in the RSI; • development of related industries (in particular, radio-electronics) and cross-cutting technologies, introduction of technological road maps and development of effective mechanisms to control their implementation; • organising scientific and technical interstate space projects with new partners; • utilising the potential of private business in the development of the domestic RSI; • prioritising long-term strategic goals over short- and medium-term benefits (e.g., creating in-house developments and technologies as opposed to profitable technological purchases from new suppliers); • searching for ways to reform the institutional structure of the RSI (in particular, developing mechanisms and encouraging the development of public-private partnerships); • managing the risk of integration into international value chains of space products and services creation; • monitoring global technological trends, strategies for the development of space industries and emerging product, technological or organisational innovations; • search for mechanisms to attract extra-budgetary sources of investment in R&D, innovation and support for RSI-projects with a long time horizon for the development, testing and commissioning of new domestic knowledge-intensive products

Table 2 (continued)

Type of risk	Counter measures
Risk of non-achievement/ inadequacy of the embedded strategy	• Revision of the current planned strategy for the long-term development of the national space sector, taking into account current geopolitical and economic conditions and the need for the RSI to comply with modern technological trends and patterns in order to maintain its competitiveness and ensure national security, sovereignty and status in the international arena; • Introduction of medium-term threshold "reconciliation points" on the way to the long-term goal to monitor both the efficiency of the implementation of planned tasks and the changing conditions of the external and internal environment in order to flexibly make the necessary adjustments and overall assessment of the relevance of the initially set development trajectory

Source: compiled by the author.

source of strategic risks for the Russian RSI [15]. Such risks in relation to the rocket and space sector in the current conditions are presented in *Table 2*.

As part of the anti-crisis course of counteracting strategic risks, at the first stages the focus of the RSI development should be the policy of import substitution and achievement of technological sovereignty [16]. This is consistent with the national document "Concept of Technological Development for the period until 2030" approved in May 2023, which has the primary goal of ensuring national control over the reproduction of critical and cross-cutting technologies, including microelectronics and advanced space systems and services.[33] First of all, the Russian RSI needs to overcome its critical dependence on imported microelectronics, as well as to solve the problem of insufficient provision of domestic needs in applied space services: satellite communications and ERS services. A strategic priority in the near future should be the qualitative and quantitative growth of the domestic satellite constellation aimed at meeting the country's socio-economic needs and improving the quality of life of the population — this is a national security issue.

Government support plays a key role in regulating the situation in the RSI under sanctions restrictions. In addition to direct budget financing, one of the current measures of assistance is a programme approved by the government to identify priority areas for technological sovereignty projects (includes the development of spacecraft and new rocket systems) and for structural adaptation of the Russian economy (includes space transport services).[34] The above-mentioned projects will be able to receive a reduced rate of loan approval from the banking sector and more active support from development institutions.

A strategy of complete self-sufficiency in the RSI will contribute to its sustainability, but it is important to avoid a model of complete autarky, which could lead to self-isolation in the long term and carry the risk of technological conservation. In order to avoid this situation, Russia needs to establish co-operation in space exploration with new partners, in the light of breakdown of its long-standing scientific and technological co-operation with the West. In March 2022, the Russian government approved a list of countries and territories unfriendly to Russia.[35] Organising scientific and technological alliances in the rocket and space sector with the above-mentioned states is associated with a high strategic risk, at least because it implies potential instability of ties. The most promising option is the implementation of such projects with the BRICS countries, which would also be an element of strategic partnership. Under current conditions, the importance of the long-

[33] URL: http://government.ru/docs/all/147621/

[34] URL: http://government.ru/docs/48272/

[35] URL: http://government.ru/docs/44745/

standing Russian-Belarusian cooperation in the space sector under the programmes of the Union State of Russia and Belarus is also increasing.

As the RSI reaches the required level of self-sufficiency, it is advisable to develop a plan-strategy for further development of the space sector, taking into account current conditions and global trends, and using the standpoint of a systemic approach as well: coherence, integrity, acceptability and continuity [17, 18].

In general, the concept of development of the domestic RSI needs to be similar to the business model in order to meet global realities. The government should create conditions for effective (networking) interaction between participants of cooperation in the space sector, including representatives of the private sector, as this is an important factor in the formation of a more innovative and dynamically developing industry environment. Attention should be paid to updating the legal framework in order to ensure comfortable regulatory conditions for the development of private companies and more elaborated legislative coverage of commercial activities in the space sector.

The functioning model of the national space sector should provide for active export development. In this respect, Russia's space competences have obvious potential: domestic space products include, among others, LV for launching satellites into various types of Earth orbits, proven manned spacecraft, universal upper stages, various types of satellite platforms, and advanced rocket engines. However, it is necessary to develop attractive diversified commercial offers and raise awareness of them among potential foreign partners (in particular, countries with emerging space sector). For example, African States are very interested in the creation of turn-key ERS complexes with launch of orbital segments by reliable LV and training of personnel, which would allow them to solve various local economic tasks.[36] Under current conditions, it is worth considering the possibility of shifting the geography of space commercial activities to the markets of the SCO (The Shanghai Cooperation Organization) and ASEAN (Association of South East Asian Nations) countries, African and Latin American countries, the Middle East, and South-West Asia [19]. At the same time, it is necessary to implement an anticipatory policy of offers, as these regions are attractive potential markets for other participants of space activities. The search for new commercial partners and entrance into foreign markets is necessary to realise in order to maintain funding of the domestic space sector, strengthen geopolitical strategic ties, and provision incentives for continuous modernisation of space technologies and services to meet market needs in an increasingly competitive environment.

When entering new markets, Russian RSI enterprises will have to reckon with the growing number of foreign private space companies that reduce the cost of products and services through mobility and innovation. The problem of competitiveness of the Russian rocket and space sector is a subject of study for many researchers and requires a comprehensive system approach, since the Russian RSI is characterised by a significant degree of inertia, primarily non-market nature of functioning under the conditions of predominant government ordering [20]. However, the global space industry is approaching the "Space 4.0" paradigm, which is closely intertwined with the fourth industrial revolution and digital transformation. This implies the transition to fundamentally new technologies in the design, production, and testing of RST, as well as in the organisation of interaction between participants in this activity (use of augmented and virtual reality, digital twins, robots, additive manufacturing, quantum technologies, the Internet of Things, the concept of blockchain, cloud computing, artificial intelligence, etc.). [21]. The introduction of such technologies into the industry and their convergence carry the potential for disruptive innovations that can significantly improve the quality and shorten the timeframe

[36] URL: https://www.roscosmos.ru/39545/; https://globalaffairs.ru/articles/kosmicheskie-razvilki/

for RST development, reduce operating costs, which simplifies its production and makes this process and the final product itself more marketable. Digital transformation may become the new leading strategic direction of reforming the Russian RSI, which, if properly elaborated, will make it possible to resolve to a large extent its long-term systemic organisational, structural and conceptual problems, and lead it out of the situation of growing technological backwardness, highlighted by the sanctions impact. The implementation of this task requires a comprehensive multi-level policy of the state to enhance innovation development and create favourable conditions for the formation of competitive advantages of high-tech industries.

An important element in the development and subsequent implementation of the RSI development strategy could be the introduction of a mandatory procedure for identifying, accounting for, and assessing the impact of potential economic and political risks of medium and high threat level, as well as a mechanism for their management.

The proposed measures will serve to maintain long-term sustainability of the Russian RSI in the conditions of external constraints, as well as to form a vector of its development aimed at ensuring technological and economic global competitiveness.

CONCLUSIONS

The large-scale sanctions imposed by Western countries are a source of strategic risks for the domestic RSI and the space sector as a whole and can have a negative impact on its sustainable development.

Maintaining strategic autonomy in space for Russia will largely depend on its ability to create domestic electronic components for the RSI or to import them steadily from alternative sources. However, reliance on parallel imports and Chinese components should not be excessive in order to avoid maintaining and increasing the technological dependence of the Russian RSI. Also, a factor in ensuring national security is the build-up of its own orbital constellation of satellites.

In order to prevent undermining the global competitiveness of the domestic RSI in the context of long-term sanctions, it is necessary to strategically manage the development of the space sector by introducing mechanisms of comprehensive support, permanent forecasting and risk assessment, as well as to increase incentives for its innovative development.

Strategic management implies the possibility of transforming the industry's sanctions restrictions into an impetus for the growth of its technological sovereignty, and can lead to a shift in the focus of co-operation from competent but unreliable Western countries to new friendly partners with significant interest and potential market demand for space technologies and services.

If a well-developed, flexible but consistent anti-crisis policy is implemented, the national space industry can emerge from the current detrimental situation renewed, self-sufficient and more sustainable, capable of solving complex tasks of a new level.

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