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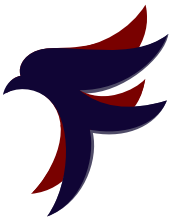

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July 2024

About the Author

Pavel Luzin holds a doctorate in international relations from the Institute of World Economy and International Relations (IMEMO). He is an expert on Russia's politics, defense affairs, and global security. Dr. Luzin studies these fields for Riddle media. Previously, he covered these issues for the presidential campaign of Alexei Navalny in Russia (2017-2018), "Nations in Transit" project at Freedom House (2016-2018), and Center for Polish-Russian Dialogue and Understanding (2015-2018). He has worked for Russian think tanks IMEMO and PIR-Center, and taught at Perm State University and at Higher School of Economics (Perm campus).

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Key Findings

Russia's space program suffers from a deficit of financial resources, limited access to advanced machine tools and space-grade electronics, a shrinking workforce, and low workforce productivity.

These challenges force Russia to focus efforts on the military space activity and leave manned spaceflights and space exploration only to maintain its international status as a space superpower and sense of domestic legitimacy of authoritarian governance without any sustainable outcomes of the civil space activity itself.

Russia's military space program is becoming more and more asymmetric. Russia—unable to develop advanced communication, navigation, and reconnaissance military space capabilities—is trying to rely on a horde of small, short-living but relatively cheap satellites mostly made from consumer and industrial-grade imported electronic components and on technologies of nuclear power to increase its counter-satellite electronic warfare capabilities.

Roscosmos

Introduction

Since 2022, Russia's space program has been in a state of turbulence and uncertainty. However, the deterioration started in 2014 when Russia annexed Crimea and began the first round of the war against Ukraine. Multiple factors have made the sustainable development of the Russian space program impossible: sanctions, an embargo on advanced industrial equipment, workforce shortages, limited financial resources spread among too many projects, cancellation of space cooperation with Western partners except operations on the International Space Station (ISS), and the economic inefficiency of the Russian space industry.

The Russian government and Roscosmos are struggling to increase space expenditures, but monetary inflation, cost-plus inflation within the space industry, and devaluation of the ruble do not allow them to reverse the negative trends. Despite these factors, Russia will keep manned spaceflights and the military space program at any cost.

Consequently, Russia has two main priorities by the 2030s. First, it must maintain the presence of Russian astronauts in outer space even after the ISS era and without any significant scientific outcomes. Second, it must switch satellite manufacturing from space-grade electronics to relatively simple and cheap consumer-grade electronics. This preference for quantity over quality of satellites would allow Russia to boost its manufacturing of short-lived satellites, which will be replaced quickly and provide the armed forces with communication and intelligence capabilities.

In the area of satellite navigation, Russia will struggle to maintain the current architecture of Global'naya Navigatsionnaya Sputnikovaya Sistema, or Global Navigation Satellite System (GLONASS), and the development of new architecture with less satellites is also questionable. The optimistic scenario is that Russia's satellite navigation system with new architecture will cover only the Russian and neighboring territories. However, the Russian armed forces use the consumer-grade GPS and BeiDou trackers, so the deteriorating GLONASS is not a crucial problem for them.

Financial Base of Russia's Space Activity: Limits and Obstacles

Russia funds its space activity through the state program "Space activity of Russia by 2030," which is the prolonged version of the state program "Space activity of Russia in 2013 to 2020."[1] This program consists of subprograms and federal targeted programs for both civil and military space activities. This allows comparison between the current period and the previous period.

A decade ago, there were three federal targeted programs:

1) Federal space program for 2015 to 2016 followed by the federal space program for 2016 to 2025.

2) GLONASS federal targeted program for 2012 to 2020 followed by the GLONASS federal project for 2021 to 2030 (in Russia's budgetary planning, money of federal targeted programs could not be transferred anywhere else, but money of federal projects within one specific state program can be transferred from one to another—that's why there is a transition to federal projects in Russia's space activity which will be completed by 2026).

3) Program of development of launch sites for 2006 to 2015 followed by the program of development of launch sites for 2017 to 2025.

Simply speaking, the state program integrated federal targeted programs related to space to improve the management of Russian space activity.

Also, the state program had two subprograms:

1) Priority innovation projects of the space industry, and

2) Ensuring implementation of "Space activity of Russia in 2013 to 2020."

These two subprograms covered the military space program besides the program for development of satellite navigation system GLONASS, which has mostly military applications, and the program of development of the Plesetsk launch site, the main facility for military orbital launches.

The total funding of the Russian space activity in 2013 to 2020 was planned as 1.8 trillion rubles (about $50 billion according to the projected exchange rates). However, annual budgetary planning and annual budget execution together with devaluation of the ruble after the annexation of Crimea and the beginning of war against Ukraine in 2014 have significantly changed the original state program. Moreover, because of these factors, Russia was not able to develop a new version of the program after its formal end in 2020 and just prolonged its term until 2030 (see Table 1).[2]

Russia's actual space expenditures appeared to be almost ₽260 billion less than what was approved in the federal budget and almost ₽410 billion less than the original version of the state program. Moreover, it was just $25.7 billion against the approved $30 billion and originally planned $50 billion. For the space industry—which has been completely dependent on imported components, industrial equipment, and cooperation ties with the United States, Europe, Japan, and Canada since 1992—it was a crucial underfunding.

Table 1

The planned and actual expenditures of "Space activity of Russia in 2013 to 2022," in Russian rubles (₽) and in US dollars ($) counted according to the average annual exchange rates.

	Budgeted, (₽) million	Actual, (₽)million	Budgeted, $ million	Actual, $ million
2013	166,200.0	164.600.0	5,218.2	5,168.0
2014	175,682.7	151,469.4	4,566.7	3,937.3
2015	184,660.4	169,781.7	3,012.9	2,770.1
2016	199,468.7	192,406.1	2,968.7	2,863.6
2017	185,025.7	153,214.4	3,173.7	2,628.0
2018	216,617.3	161,273.2	3,455.4	2,572.6
2019	257.206.6	183,163.0	3,977.8	2,832.7
2020	261,355.1	214,249.6	3,623.4	2,970.3
Total	1,646,216.5	1,390,157.4	29,996.9	25,742.7

Ministry of Finance of the Russian Federation, Исполнение ... 2013 год (Execution ... 2013); Ministry of Finance of the Russian Federation, Исполнение ... 2014 год (Execution ... for 2014); Ministry of Finance of the Russian Federation, ... 2015 год (предварительные итоги) (Extended Collegium ... 2015 [preliminary results]); Ministry of Finance of the Russian Federation, ... 2016 год (предварительные итоги) (Extended Collegium ... for 2016); Ministry of Finance of the Russian Federation, Исполнение ... 2017 год (Execution ... Russian Federation); Ministry of Finance of the Russian Federation, Исполнение ... 2019 год (Execution ... for 2019); Ministry of Finance of the Russian Federation, ... 2020 год (предварительные итоги) (Extended Collegium ... for 2020); Ministry of Finance of the Russian Federation, Исполнение ... 2021 год (Execution ... for 2021).

Nevertheless, this underfunding also had an objective cause: Russia's space industry was incapable of working according to the plan and delays in many projects meant delays in funding. The Western sanctions, implemented since 2014, were one of the main factors here.

The actual expenditures on the federal targeted programs give a more detailed picture (see Table 2).

The difference between ₽1,390,157.4 million ($25,742.7 million) spent on the whole space activity and ₽1,168,762.6 million ($22,127.3 million) spent on the three federal targeted programs, is ₽221,394.8 million ($3,614.4 million). This number may be considered as an assessment of expenditures on military space activity besides GLONASS and the Plesetsk launch site, and the average annual assessment of military space expenditures is ₽27,674.4 million ($451.8 million) during the period.

All this gives a basis for understanding the Russian space activity in the 2020s considering that a significant amount of data has been classified since 2022. Despite the efforts toward increasing space expenditures, Russia was incapable of achieving the annual level of 2014 in 2021 to 2023and will be hardly able to do this in the coming years (see Table 3).

Since 2021, the structure of the state program "Space activity of Russia" has become much more complicated: Now it involves two remaining federal targeted programs, the federal space program for 2016 to 2025, and development of launch sites program for 2017 to 2025, federal projects (including GLONASS) and other activities. Moreover, some of these

Table 2

The actual space expenditures on the federal targeted programs related to the state program "Space Activity of Russia": federal space program, GLONASS program, and launch sites development program in 2013 to 2020

	₽ million				$ million			
	Federal space program	GLONASS	Launch sites	Total	Federal space program	GLONASS	Launch sites	Total
2013	125,805.9	20,962.2	19,381.4	**166,149.5**	3,949.9	658.2	608.5	**5,216.6**
2014	97,513.0	20,749.8	11,556.2	**129,819.0**	2,534.8	539.4	300.4	**3,374.6**
2015	95,877.7	40,248.4	12,417.2	**148,543.4**	1,564.3	656.7	202.6	**2,423.6**
2016	104,116.8	46,938.9	3,553.6	**154,609.3**	1,549.6	698.6	52.9	**2,301.1**
2017	92,015.1	32,926.7	7,080.3	**132,022.1**	1,578.3	564.8	121.4	**2,264.5**
2018	73,059.1	32,779.1	17,166.5	**123,004.7**	1,165.4	522.9	273.8	**1,962.1**
2019	88,885.0	27,216.9	23,132.8	**139,234.6**	1,374.7	420.9	357.8	**2,153.3**
2020	103,432.0	26,107.3	45,840.7	**175,380.0**	1,434.0	361.9	635.5	**2,431.4**
Total	**780,704.7**	**247,929.2**	**140,128.7 1,168,762.6**	**1,168,762.6**	**15,151.0**	**4,423.3**	**2,553.0**	**22,127.3**

Department of State Target Programs and Capital Investments of the Ministry of Economic Development of Russia, "Перечень федеральных целевых программ, предусмотренных к финансированию из федерального бюджета на 2020 год (List of Federal Target Programs ... for 2020)."

programs, projects, and activities overlap with each other, but they are financed separately for unclear reasons. The main problem here is that it is much harder to identify the Russian military space program among all these fragments.

Nevertheless, Russia's planned expenditures on the federal space program, GLONASS, and development of launch sites are still available for analysis (see Table 4).

GLONASS seems to be crucially underfunded even in rubles. It was officially planned that the navigation system would get ₽484 billion ($6.7 billion) during 2021 to 2030.[3] This amount would allow Russia to complete developing a new generation of navigation satellites GLONASS-K (GLONASS-K2) and to orbit them instead of satellites of the previous generation, GLONASS-M, which either have exceeded the warranted operational lifetime already or will do so in coming years.

However, Russia is going to invest just ₽158 billion ($1.9 billion) in GLONASS by the end of 2026. It is not clear whether the Russian government is going to provide GLONASS with adequate financial sources in 2027 to

Table 3

The planned and actual expenditures of "Space activity of Russia" in 2021 and planned expenditures on this program 2022 to 2026 in Russian rubles (₽) and in US dollars ($) counted according to the average annual exchange rates.

	Budgeted, (₽) million	Actual, (₽)million	Budgeted, $ million	Actual, $ million
2021	267,216.7	239,434.6	3,626.7	3,249.7
2022	264,167.1	236,901.8	3,857.0	3459.0
2023	287,595.4	n/a	3,393.5	n/a
2024	285,953.5	n/a	3,173.7	n/a
2025	271,908.5	n/a	2,984.7	n/a
2026	258,077.6	n/a	2,796.1	n/a
Total	**1,634,918.8**	**n/a**	**19,831.7**	**n/a**

Ministry of Finance of the Russian Federation, Исполнение ... 2021 год (Execution ... for 2021); State Duma of the Federal Assembly of the Russian Federation, "О федеральном бюджете на 2023 год и на плановый период 2024 и 2025 годов (System for ... "Lawmaking"),"; State Duma of the Federal Assembly of the Russian Federation, "Система ... «Законотворчество» [СОЗД ГАС «Законотворчество»] (System ... [SOZD GAS «Lawmaking»])."

Table 4

Russia's planned expenditures on federal space program, development of launch sites program, and GLONASS federal project 2021 to 2026.

	₽ million				$ million			
	Federal space program	**GLONASS**	**Launch sites**	**Total**	**Federal space program**	**GLONASS**	**Launch sites**	**Total**
2021	130,497.8*	24,879.0	56,114.9*	**211,491.7**	1,771.1	337.7	761.6	**2,870.4**
2022	111,816.7	26,963.9	72,730.9	**211,511.5**	1,632.6	393.7	1,061.9	**3,088.2**
2023	133,126.4	26,509.0	60,375.7	**220,011.1**	1,570.8	312.8	712.4	**2,596.0**
2024	138,205.8	24,357.2	49,091.1	**211,654.1**	1,533.9	270.3	544.9	**2,349.1**
2025	145,436.0	27,762.5	48,832.5	**222,031.0**	1,596.4	304.7	536.0	**2,437.2**
2026	148,483.0**	27,860.4	43,946.5**	**220,289.9**	1,608.7	301.8	476.1	**2,386.7**
Total	**807,565.7**	**158,332.0**	**331,091.6**	**1,296,989.3**	**9,713.5**	**1,921.1**	**4,093**	**15,727.6**

Roscosmos, "Годовой отчет Госкорпорации «Роскосмос» (Annual report of the State Corporation «Roscosmos"),"; Alexey Nikosky and Inna Sidorkova, "Убытки «Роскосмоса» выросли в 2022 году примерно на 60% до 50 млрд рублей (Roscosmos' Losses Increased in 2022 by About 60% to 50 billion Rubles)."

2030, but it looks to be almost impossible. For comparison, the actual funding of GLONASS program for 2002 to 2011 was almost ₽114 billion ($3.9 billion) and the actual funding of GLONASS program for 2012 to 2020 was ₽268 billion ($5.1 billion).

Therefore, the planned level of spending is not enough for maintenance and modernization of the current architecture of the Russian satellite navigation system which needs at least eighteen satellites on medium orbit (20,000 to 22,000 km) for sustainable coverage of the Russian territory and at least twenty-four satellites for global coverage.

The financial base of Russia's space activity is limited and does not promise any significant advance.

Russia is trying to develop new GLONASS architecture relying on satellites GLONASS-VKK deployed in high-elliptical orbit. This architecture would allow Russia to cover its territory with just six satellites of this type. However, the first GLONASS-VKK satellite will appear no earlier than 2028, creating even more uncertainty for the whole navigation system.

Additionally, there is an evident and very unusual increase of expenditures on the development of launch sites in 2021 to 2026: ₽331.1 billion ($4.1 billion) compared to ₽140.1 billion ($2.6 billion) in 2013 to 2020. Excluding the budgetary forecast for 2026, the total expenditures on the Russian launch sites would be ₽272.6 billion ($3.4 billion) in 2021 to 2025 including ₽237 billion ($3 billion) on the federal targeted program and almost ₽36 billion ($444 million) on the two separate budgetary projects for maintaining Baikonur and Vostochny respectively.

However, as of 2020, the budgetary plan for the federal targeted program of development of launch sites was ₽225 billion ($3.1 billion) in 2021 to 2025, and there were no additional projects related to the launch sites.[4] As a result, the planned amount of the federal targeted program itself increased by ₽12 billion, and the total plan of expenditures on launch sites increased by ₽48 billion. There are neither significant changes in the development of the Vostochny launch site and modernization of the Plesetsk and Baikonur launch sites, nor a visible cost-plus inflation which requires this increase of expenditures in contrast to the federal space program and GLONASS program. Therefore, this planned increase hypothetically covers part of the Russian military space activity, besides spending on the launch sites themselves.

Nevertheless, the financial base of Russia's space activity is limited and does not promise any significant advance. Despite this fact, the Russian government and Roscosmos declare that they will be able to develop new manned spacecraft and a manned orbital station, launch vehicles of different types, manufacture hundreds of small satellites of different types, and continue the moon exploration program. The imbalance between actual financial capabilities and intentions predetermines fragmentation of Russia's civil space activity in contrast to the progressive and systemic one.

Space Industrial Base of Russia: Challenges of Machine Tools, Components, and Shrinking Human Capital

Russia's state-owned corporation Roscosmos was established in 2015. It has combined the responsibilities of an industrial company and the federal space agency. Some other Russian state-owned military-industrial corporations like Rostec, Tactical Missile Corp., and Almaz-Antey are also engaged in space activity, but they are mostly subcontractors of Roscosmos. Russia also has a policy for development of private space companies and startups, and Roscosmos is responsible for realization of this policy. However, the private space sector in Russia has a mostly imitative nature and has few sustainable prospects within current Russian political and economic circumstances.

Roscosmos has combined the responsibilities of an industrial company and the federal space agency.

Russia's space industry—as a part of military-industrial complex—counts about 170,500 employees, and more than 90 percent of them work in Roscosmos. Since 2015, the number of employees has decreased by more than 65,000 people, from 235,700 people. At least 20,000 employees of Roscosmos produce focus on intercontinental ballistic missiles, submarine-launched ballistic missiles, and tactical ballistic missiles. Russian space industry employment outpaces the American space industry's 152,000 employees and far surpasses the European space industry's 50,000 employees.[5] Comparatively, China Aerospace Science and Technology Corp., the major space corporation in China, employs more than 180,000 people.[6]

The organizational specifics of the Russian space industry with its overregulation, rigid hierarchy of people and entities, and much lower workforce productivity, combined with the decreasing number of employees make it ill-equipped to compete with the United States, Europe, and China. Russia spreads limited human resources among too many programs and projects, both civil and military.

One of the main indicators of low economic efficiency of Roscosmos is its financial statement (see Table 5).

The cumulative net loss of Roscosmos in 2015 to 2023 exceeded ₽110 billion (almost $1.6 billion). This net loss, especially after 2021, has been partly covered by additional government expenditures.[7] However, the projected space budget for the coming years does not promise any significant improvement in the financial position of Roscosmos.

Other indicators of the poor economic efficiency of Roscosmos and the whole Russian space industry are delays in all significant space projects and technical failures. For example, Russia has been developing the Angara family of launch vehicles since 1995, yet these rockets are still in a trial stage. For almost twenty years, Russia has been trying to develop a new manned spacecraft to replace the outdated Soyuz, but there is no chance that the new spacecraft will become operational before the 2030s. Russia was not able to complete construction of its segment on the ISS. Now, it plans to develop and deploy its national

Table 5

Roscosmos consolidated revenue and net profit (net loss) in 2015 to 2023

	Revenue, (₽) million	Net-profit (net-loss) ₽ million	Revenue, $ million	Net-profit (net-loss), $ million
2015	n/a	1,800.0	n/a	29.4
2016	n/a	3,200.0	n/a	47.6
2017	304,000.0	-16,000.0	5,214.0	-274.4
2018	352,100.0	2,500.0	5,616.5	40.0
2019	370,200.0	-1,800.0	5,725.3	-27.8
2020	337,100.0	-4,400.0	4,673.5	-61.0
2021	n/a	-31,000.0	n/a	-420.7
2022	n/a	-50,000.0	n/a	-730.0
2023	n/a	-15,000.0	n/a	-176.1

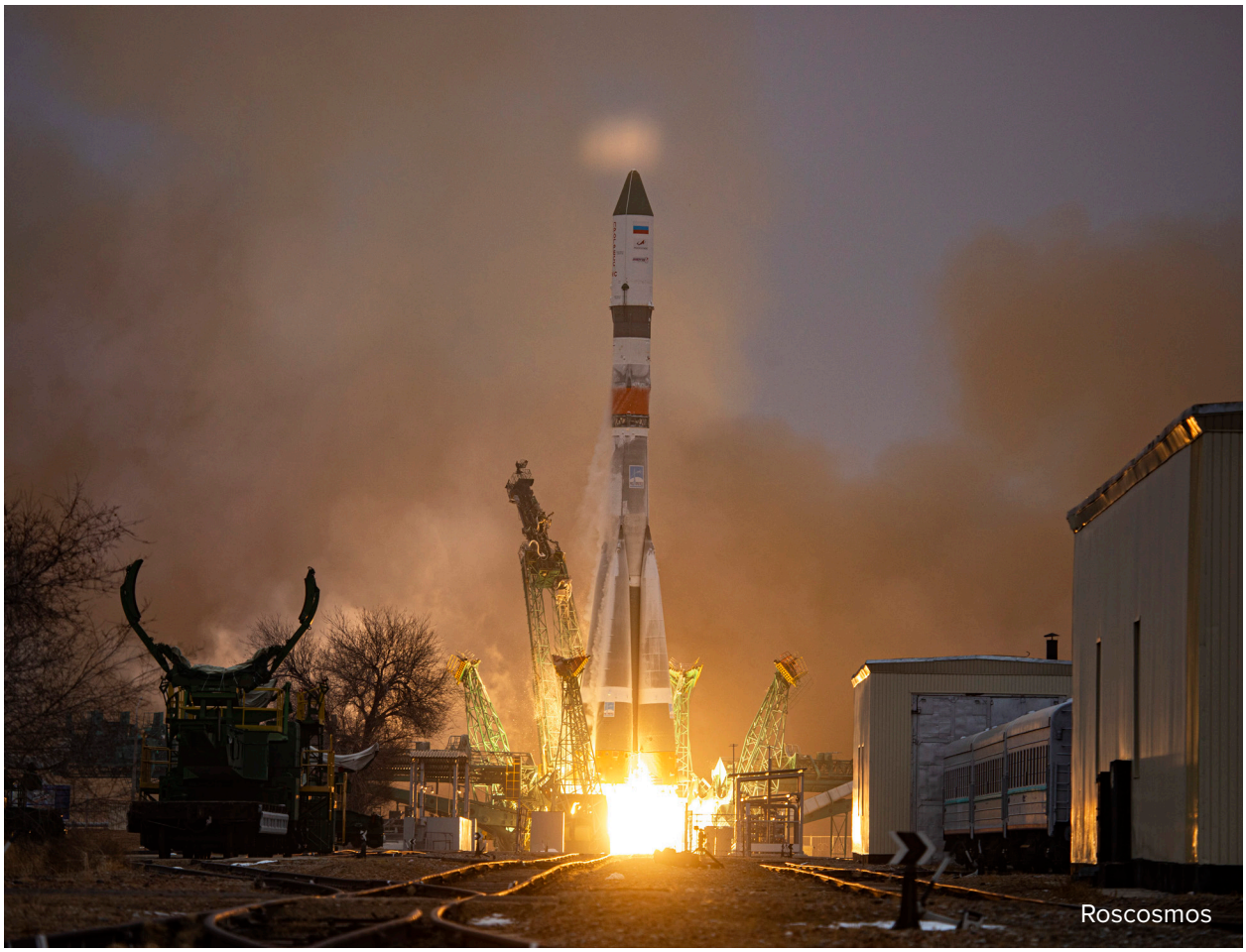
Roscosmos, "Годовой отчет Госкорпорации «Роскосмос» (Annual report of the State Corporation «Roscosmos"),"; Alexey Nikosky and Inna Sidorkova, "Убытки «Роскосмоса» выросли в 2022 году примерно на 60% до 50 млрд рублей (Roscosmos' Losses Increased in 2022 by About 60% to 50 billion Rubles)."

orbital station in the 2030s using the science and energy module, which was scheduled as the last module of the ISS. Also, the replacement of GLONASS-M navigation satellites with GLONASS-K generation was scheduled for the 2010s, but Roscosmos was able to produce and orbit only six satellites of the new generation 2011 to 2023 and one of them was lost.[8]

A series of emergencies with Russian manned spacecraft and orbital modules in 2018 to 2023 further reveals the economic inefficiencies of Roscosmos. Finally, in August 2023, Russia lost its moon probe Luna-25, which was a technical demonstrator for further moon exploration missions, Luna-26 and Luna-27. The first probe was delayed for several years because of technical and financial problems. This failure questions the viability of the Russian moon program which is scheduled for the 2020s.

Roscosmos and the whole Russian space industry are dependent on space-grade electronics imported from the United States and Europe, and industrial equipment imported from the United States, Europe, Japan, Taiwan, and South Korea (including the equipment for producing liquid and solid rocket fuels). Moreover, it has been dependent on space cooperation with the West since 1992.

Russia has long relied on cooperation with and support from other countries to sustain its space industry. In the 1990s, US support was critical in preventing the Russian space industry from deterioration. Russia also got $3.9 billion of revenue for seventy seats in Soyuz spacecrafts for American, European, Japanese, and Canadian astronauts 2006 to 2020 and approximately $1.5–2 billion of revenue for about 150 rocket engines RD-180 and RD-181 supplied to the United States from 1999 to 2021. Also, Russia got several


Roscosmos

billion dollars of revenue for commercial launches of foreign satellites, mostly European and American, in 1996 to 2021.[9]

These contracts provided significant support for the Russian space industry. Even if they did not allow Roscosmos to become a profitable corporation, they compensated for its losses. Consequently, without such contracts, Roscosmos will inevitably face further financial troubles.

To summarize, Roscosmos has three systemic problems: a) the deficit of financial sources, b) limited or absent access to advanced machine tools (industrial equipment) and space-grade electronics, and c) a shrinking workforce and low workforce productivity. These problems prompt Russia's leadership toward focusing efforts on some priorities and sacrificing others. In this way, the military space activity will almost inevitably be the only field where Russia will try to get a sustainable outcome. However, the asymmetric approach is predetermined here.

However, complete refusal from the manned spaceflights and space explorations would be unacceptable in terms of Russia's domestic politics and its foreign policy. Consequently, mostly demonstrative but infrequent manned expeditions on the low-Earth orbit to keep a periodic presence there after the ISS era and further attempts to send probes on the moon to confirm Russia's status of space power instead of long-term space exploration programs will be the only optimistic scenario without fundamental political economy changes in Russia in the foreseeable future.

Prospects and Challenges for Russia's Space Activity

Despite these limitations, Russia is still determined to realize an ambitious space program. It will likely not succeed. When forced to choose, Russia will focus on two main priorities: 1) the manned program in order to demonstrate flag on the Earth orbit and 2) the military program. In this way, the space exploration program is going to be sacrificed.

Manned Spaceflights

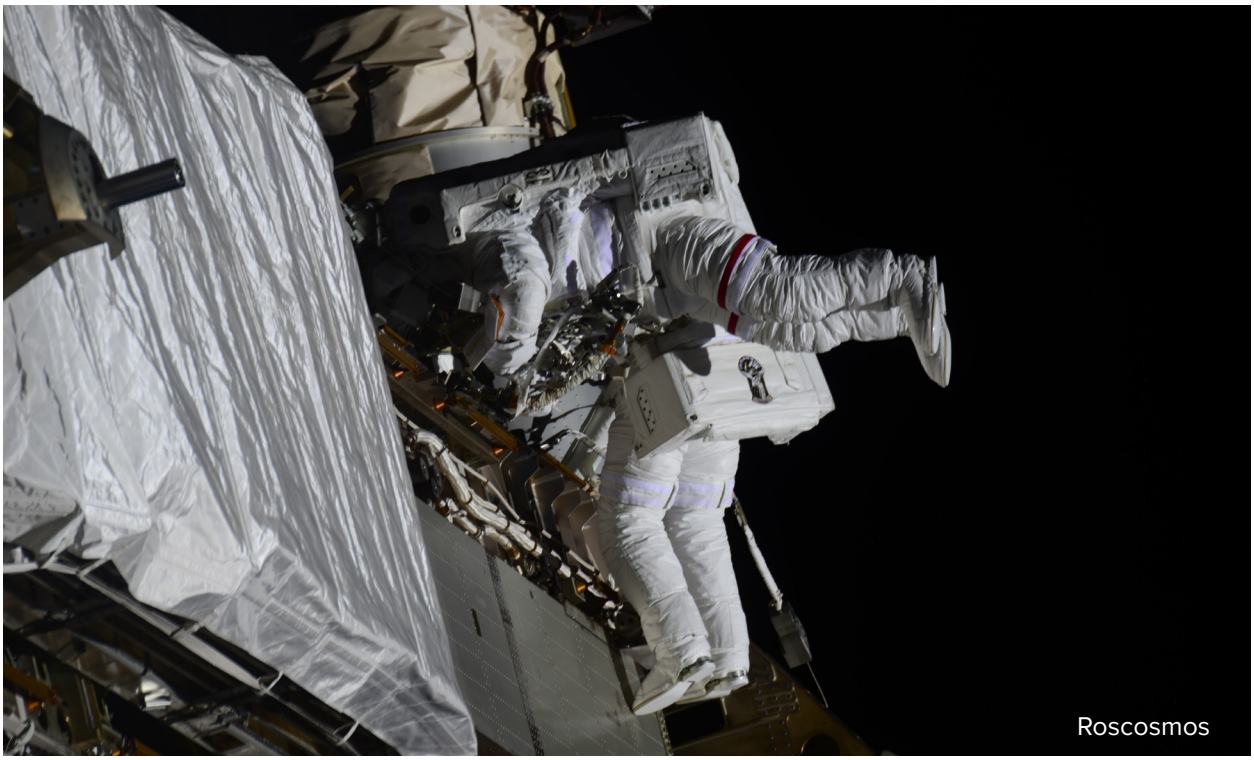
The manned space program plays a political and even ideological role for Russia: Along with its nuclear arsenal and its permanent seat on the UN Security Council, Russia's manned spaceflights help to maintain its great power status. They also maintain Russia's ties and interdependence with the West and demonstrate to Russian society the achievements of decades of authoritarian governance and thus justifies the current authoritarian system.

Before 2022, Russia was planning to continue its manned spaceflights together with its ISS partners. In this way, Russia's essential interest was participation in the US lunar program and especially in the Gateway lunar orbit station. However, Roscosmos was unable to meet American technical requirements and was therefore excluded from the project. Roscosmos insisted on the same model of relations as in the ISS, meaning an equal partnership and the priority of the political purposes of cooperation over contractual obligations.

Russia's negotiation efforts were unsuccessful, and its position was crucially worsened by the annexation of Crimea, the first round of war against Ukraine, election interference in the United States, and Russia's entire foreign policy from 2014 to 2021. Since 2022, Russia's strategy toward the manned spaceflights collapsed. Russia hoped for continuation of partnership with the United States and other partners after the end of the ISS. Russia was going to participate in the manned moon exploration program without its own spacecraft, proper launch vehicle, or big modules. However, there are still no new manned spacecraft, operational launch vehicles, or modules. Even the heavy-class launch rocket "Angara-A5," which has been under development since the mid-1990s and passed another trial flight in April 2024, is officially considered outdated before getting to operational status.[10]

> **Russia's manned spaceflights help to maintain its great power status.**

Trying to keep the manned space program, Russia's leadership changed Roscosmos leadership in 2022 and chose the only remaining option: It launched the project of a national multi-module orbital station on high-inclination orbit. However, all Russian modules orbited in 1992 to 2021 were made using Soviet-era storage of module bodies and some other parts. Roscosmos was not able to build the last module of the ISS on time. The science and energy module also


Roscosmos

known as NEM would be the first module made by Russia itself. This module depends on imported electronics. Even if Russia will be able to complete it, the prospect for the next modules is completely uncertain.

Moreover, the uncertainty of a new manned spacecraft and launch vehicle for it limits Russia's planning because the existing capabilities of the Soyuz spacecraft will not allow Russia to use the orbital station efficiently even if this station is finally developed and deployed. Paradoxically, but in the absence of enough capabilities for advanced manned space program in the post-ISS era, the management of Roscosmos was demonstrating hopes of reconciliation with the West even in December 2022.[11] Roscosmos leadership probably still hopes for this now.

Nevertheless, it would be hard for Russia to keep its manned space program after the end of the ISS program in the late 2020s.The current annual cost of manned spaceflights is ₽35 billion (about $500 million), about one-third or one-fourth of the federal space program.[12] This amount covers spacecraft, launch vehicles, and the permanent presence of Russian astronauts onboard the ISS where their main tasks are related to the technical maintenance of the Russian segment itself. The new station and advanced scientific program for it will need much more effort and money and will entail more risks.

As a result, the conservative assessment of the prospect of the Russian manned space program is the following: Russia will continue to send its astronauts to orbit using Soyuz capsules, but the main purpose will be demonstration of the flag without any tangible results. However, it is not clear if Russia will be able to realize the project of the national multi-module orbital station. Even the prospect of the NEM module is unclear because it must be redesigned for use outside of the Russian ISS segment.

Space Explorations

Space science is becoming a victim of the transforming Russia's space activity. The collapse of cooperation with the European Space Agency, European research centers and universities and NASA together with the failure of Luna-25 probe in August 2023 set a clear prospect of further degradation of space science and technologies in Russia. That means Russia cannot play a significant role in global space explorations in the long term.

Military Program

The military space activity which includes the GLONASS satellite navigation system and ground-based space tracking systems will remain another priority of Russia. It will try to maintain and develop satellite constellations for all purposes: early warning, communication, navigation, space surveillance, optical and radar imaging, civil communication, and optical and radar satellites. As Russia tries to work within all space systems, it spreads limited resources on too many projects.

This spreading derives from the fact that the Russian armed forces face several crucial challenges: the weakness of the GLONASS system, limits in satellite communications, and lack of high-resolution optical and radar imaging capabilities. Moreover, the Russian military realizes that the gaps in satellite communications and reconnaissance cannot be closed soon.[13]

Even though the current weakness of GLONASS is compensated for by the use of civil signals from GPS and BeiDou, Roscosmos is trying to develop a new architecture of the system for the long term. To cover Russia, this architecture will need six satellites in high-elliptical orbit instead of eighteen satellites in medium orbit. However, this R&D program has delays, and the first satellite is not scheduled for orbit until 2030.[14] Moreover, it is hard to say whether Russia will be able to do this at all considering the lack of access to imported advanced space-grade electronics.

Russia will struggle to maintain the current architecture of GLONASS, and the development of new architecture with less satellites is also questionable. The optimistic scenario is that Russia's satellite navigation system with new architecture will cover only Russia and neighboring territories. Russian armed forces use consumer-grade GPS and BeiDou trackers, so the deteriorating GLONASS is not a crucial problem for them.

Russia is severely deficient in advanced optical and radar imaging satellites, and it has so far been unsuccessful in developing and deploying robust systems in this field.

Russia is severely deficient in advanced optical and radar imaging satellites, and it has so far been unsuccessful in developing and deploying robust systems in this field. Nevertheless, Russia's leadership is trying to change the industrial paradigm. The strategic purpose now is massively increasing the production rate of satellites from fifteen satellites a year, which is considered low, to about 200 satellites a year by 2026, and up to 400 satellites a year by 2030.[15] Also, Russia plans to increase its satellite constellation from approximately 160 satellites in 2023 to 1000 satellites in 2030.[16] These targeted numbers mean a significant simplification of satellites and priority of quantity over quality. These numbers also mean that mass manufacturing of micro- and nanosatellites for low-Earth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orbit is becoming the main purpose. Russia is betting on the CubeSat standard.

This also means extended use of consumer- and industrial-grade electronic components within the satellites, which are still available for Russia on the global market, instead of space-grade and military-grade electronics. As a result, the lifetime of such satellites will be short, no more than three to four years or even shorter, but the high production rate would allow Roscosmos to replace them on time.

Moreover, the Russian small space companies like Sputnix (established in 2011 like a private startup and now is a subsidiary of AFK Sistema) has already tested this approach on their educational satellites. They take consumer- and industrial-grade electronics from all over the world, from China to the United States and use it on board their short-lived microsatellites.

At the same time, Russia sees a crucial military threat in the superiority of the United States and its allies in military satellite systems and commercial space systems developed by SpaceX, Planet Labs, Maxar Technologies, and other companies. Moscow sees what combat advantages these systems provide for the Ukrainian armed forces. Moreover, Russia suspects that the American and European private space systems may be used as a cover for the US anti-satellite systems and proclaims such systems as potential combat targets for Russia.[17]

This vision of threats combines with the fact that the Russian leadership feels a lack of confidence in Russia's space industrial base. For instance, Russian-made satellites still depend on imported electronic components and the overall economic state of the space industry is inefficient. Moreover, even the number of launch vehicles available for the Russian military would be very limited in the long-term prospect.[18] For example, the planned production rate of the mentioned Angara-A5 heavy-class launch vehicle is eight rockets a year.[19]

Therefore, Moscow realizes that it is incapable of competing with the West in space and cannot achieve parity in military space capabilities despite all its efforts.


Roscosmos

As a result, Russia will inevitably rely on the asymmetric approach in military space affairs.

In this way, there are at least two options. The first option is Russian efforts toward developing a nuclear-powered spacecraft powerful enough for the massive electronic jamming of satellites. Russia realizes a long-term R&D program here regardless of the technical, organizational, and financial difficulties.[20]

Another option is an orbital nuclear explosion which will cause deterioration of satellite communication and Earth observation constellations through a massive destruction of satellites at one time. As a result, the number of destroyed satellites must be higher than the capabilities of companies to restore these constellations during the acceptable period of time.[21]This option—or at least the threat of it—may look attractive for the Kremlin both in political and technical aspects despite the fact that the Russian authorities officially deny such plans.

As a result, Russia's military space program will probably develop in the same way as Russian drones on the battlefields of Ukraine: a horde of simple and relatively cheap and short-lived vehicles with consumer- and industrial-grade components instead of advanced, sophisticated but expensive and difficult to manufacture ones. That means the significant part of the Russian space industry may become just a group of small engineering design bureaus with manual final assembly lines that will work with kits and sets of components from abroad. Despite the fact that this approach does not promise any advance in the military space program, it may allow Russia's military to keep some space communication, intelligence, and even counter-satellite (interference and jamming) capabilities. Nevertheless, Russia will probably try to compensate for its objective weaknesses through the asymmetric approach based on nuclear power technologies and a horde of small, short living but relatively cheap satellites.

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