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A Limping Giant

Russian Military Space in the First Half of the 2020s

Anatoly Zak

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Abstract

This paper provides an overview of the Russian military space program from 2019 to 2023. We connect ongoing activities and known plans with overall Russian military doctrine. We also offer predictions for the general direction and prospects for Russian military activities for the rest of the 2020s. We discuss major challenges faced by Russia's space industry in current geopolitical conditions and touch on key space assets in active use by the Russian military or in the process of being deployed in orbit, such as the space segment of the early warning system, reconnaissance and electric intelligence satellites, space communications and navigation systems, geodesic systems, ASAT weapons, and key ground assets. We also cover newly emerging systems, such as orbital inspectors, space-to-space eavesdropping systems, and orbital space planes.

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Cover image: Launch of Soyuz-2 rocket from Plesetsk cosmodrome. Russian Ministry of Defense.

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Colleen McCue, PhD, Acting Research Program Director
Countering Threats and Challenges Program
Strategy, Policy, Plans, and Programs Division

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INTRODUCTION

This paper provides an overview of the Russian military space program from 2019 to 2023, including ongoing activities and known plans, in connection to current military space activities and overall Russian military doctrine. It also provides an outlook of the general direction and prospects for Russian military activities for the remainder of the decade (2020s). This paper is intended as an update to CNA's 2019 report on Russia's military space program.[1]

It is obvious that for the rest of this decade, the Russian space program will continue to be shaped by the invasion of Ukraine and Moscow's confrontation with the West. The Kremlin has been on a path it has characterized as the creation of the "multi-polar world" and strategic realignment to the Global South for almost two decades; however, after the annexation of Crimea in 2014, this process accelerated, and it supercharged following the February 24, 2022, full-scale invasion of Ukraine.

The new geopolitical situation has profoundly affected Russian military space policy and Roscosmos, the main developer of military and dual-use spacecraft. In April 2022, then head of Roscosmos, Dmitry Rogozin, stated that "in the current situation, Roscosmos has to become a much rigid structure *[sic]*, working first of all for the benefit of defense and security of the country."[2] To achieve these new tasks and goals, Roscosmos would have to change its financial model, according to Yuri Borisov, who replaced Rogozin as head of Roscosmos in July 2022.[3]

At first sight, the overall militarization of the Russian economy and society, accompanied by major investments into the defense sector, could be seen as beneficial to any industry connected to the military, including space. However, it is unclear how much of that financial windfall has gone toward the army's basic and immediate needs (e.g., boots and artillery shells) or what share is available for high-end long-term projects, including spacecraft. A bigger question is whether the Russian high-tech sector is capable of significant progress under conditions of isolation from the West.

On the surface, Russian military and space officials have pursued the proclaimed goal of refocusing their efforts on the affiliate BRICS countries (i.e., Brazil, India, China, and South Africa) and beyond; however, they have made little progress thus far. Moscow tried to expand already established civilian and military space cooperation with new partners such as Egypt and South Africa, which both had previously ordered Russian dual-use spacecraft with very mixed results. During 2023, Borisov visited Algeria and Egypt, and Minister of Defense Sergei Shoigu visited North Korea at the end of July. These meetings were followed by the summit between Kim Jong Un and Vladimir Putin in September 2023, which began with a highly advertised tour of Russia's new

1 Anatoly Zak, *Russian Military and Dual-Purpose Spacecraft: Latest Status and Operational Overview,* CNA Occasional Paper, June 2019, https://www.cna.org/reports/2019/06/IOP-2019-U-020191-Final.pdf.

2 Natalia Yachmennikova, "Dmitry Rogozin; Our Priority Today Is an Orbital Grouping for Surveillance and Communications" [Дмитрий Рогозин: Наш приоритет сегодня — орбитальная группировка наблюдения и связи], *Rossiiskaya Gazeta,* Apr. 11, 2022.

3 "Yuri Borisov's Interview with Vedomosti," *Novosti Kosmonavtiki*, Dec. 21, 2022, https://novosti-kosmonavtiki.ru/news/85388/.

Vostochny spaceport by the North Korean dictator. However, by its own admission, the Kremlin reached no agreements with North Korea.

In this context, Russia's military space cooperation with Iran was notable. For the first time, Russia began preparing a launch of a geostationary communications satellite for Iran on a Proton rocket, which would be a rare but potentially important foreign assignment for Roscosmos after decades and billions of dollars' worth of commercial cooperation with the West. In 2022, Russia launched a reconnaissance satellite for Iran, which was the only foreign customer for its spacecraft at the time.

GENERAL INDUSTRY ISSUES

The Russian military space program entered the 2020s in a near-crisis mode caused primarily by its inability to lessen its dependence on foreign supplies or to stem the "brain drain" of workers in this industry leaving the country for opportunities elsewhere. In 2019, Yuri Borisov, then deputy prime minister for defense and space, formed a special commission tasked with reporting to Putin on possible measures to resolve the deficit of foreign components.[4]

Around the same time, Borisov and Rogozin appealed to the government to stem an avalanche of mandatory lawsuits and fines from the military and Roscosmos against companies in their own industry because of widespread failures to deliver hardware according to schedule.[5] Roscosmos lost 31 billion rubles in 2021, according to Borisov, and was projected to be more than 50 billion rubles in debt in 2022.[6]

Constraints on mass production of avionics

The public records from these legal cases provide plenty of evidence that the Russian military space program has been suffering from the very same problems experienced by its civilian counterparts. The primary obstacle has been the lack of imported electronic components for high-tech products in aerospace after the West began choking off supplies, such as hardened computer chips graded "military" and "space." These components are particularly difficult to obtain through illicit schemes, and all attempts since 2014 to organize their domestic production have apparently yielded limited results.

In one respect, the supply line issues were self-inflicted because only in the 1990s did the Russian space industry begin mass import of avionics to replace often bulky and failure-prone domestic systems that had been almost exclusively employed in Soviet spacecraft. In May 2022, Borisov stated, "To some extent, we have lost competencies, lost a tempo in the development of our own solutions."[7] At that time, he still served as deputy prime minister and would soon take a position at the helm of Roscosmos.

According to Borisov, the annexation of Crimea in 2014 was a wakeup call for Roscosmos, when "supplies of all necessary components, first of all, radiation-hardened electronics were simultaneously cut....We had to take some serious efforts and they gave some results today."[8]

However, severe delays with practically every major spacecraft project and continuous legal disputes

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4 "Borisov Announced the Disruption of Work on the Development of the Russian Military Satellite Constellation" [Борисов сообщил о срыве работ по развитию российской военной спутниковой группировки], TASS, Dec. 27, 2019, https://tass.ru/armiya-i-opk/7434275.

5 Igor Russak, "Roskosmos Is Preparing a Project to Protect Enterprises under Western Sanctions" [Роскосмос готовит проект о защите предприятий в условиях западных санкций], RIA Novosti, Nov. 18, 2019, https://ria.ru/20191118/1561059633.html.

6 "Yuri Borisov's Interview," *Novosti Kosmonavtiki*.

7 "Borisov: Roscosmos Found Itself in a Better Situation in Terms of Import Substitution than Other Industries" [Борисов: Роскосмос оказался в лучшей ситуации по импортозамещению, чем другие отрасли], TASS, May 26, 2022, tass.ru/ekonomika/14733249.

8 "Borisov: Roscosmos," TASS.

between the military and the industry indicate that fundamental issues have never gone away. Multiple official reports and statements by Russian space officials, including by Rogozin as late as June 2021, confirmed that problems with advanced electronics supplies had resulted in years-long or even decades-long delays to the deployment of dozens of spacecraft,[9] including military and dual-use vehicles (e.g., GLONASS navigation satellites and Kondor radar imagers).

In December 2022, Borisov told *Vedomosti* newspaper that Roscosmos and the Ministry of Defense analyzed reasons for missed deadlines in state procurement orders by Roscosmos companies and developed schedules for making up the orders.[10] Along with including well-publicized stories about illegal smuggling and cannibalizing chips from imported consumer products such as refrigerators and washing machines (which might not bode well for the future of space), the article claimed that Russia was using Chinese exports as substitutes for Western components.[11]

According to industry sources, immediately after the annexation of Crimea, Roscosmos officials discussed possible imports of electronics with visiting Chinese officials, but the Russians were reportedly disappointed with the offered assortment. On February 26, 2022, just two days after starting a full-scale war with Ukraine, Rogozin again said that Roscosmos would be able to buy components for its satellites from China, but a year later, it remains unclear to what extent Beijing is willing or able to help Roscosmos in high-end fields such as space and defense.[12] In fact, available statistics indicated some drop in electronics exports from China to Russia from 2021 to 2022, as shown in Figure 1. The graph indicates a significant drop in electronics exports from Europe and also shows some decrease in exports from China between 2021 and 2022. (In the graph, pink represents a decrease from 2021 to 2022, whereas green represents an increase.) Starting on September 1, 2023, China reportedly imposed restrictions on drone technology supplies to Russia,[13] which could be indicative of Beijing's overall policy.

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9 Dmitry Rogozin, interview with *Rossiya 24* TV Channel, June 16, 2021.

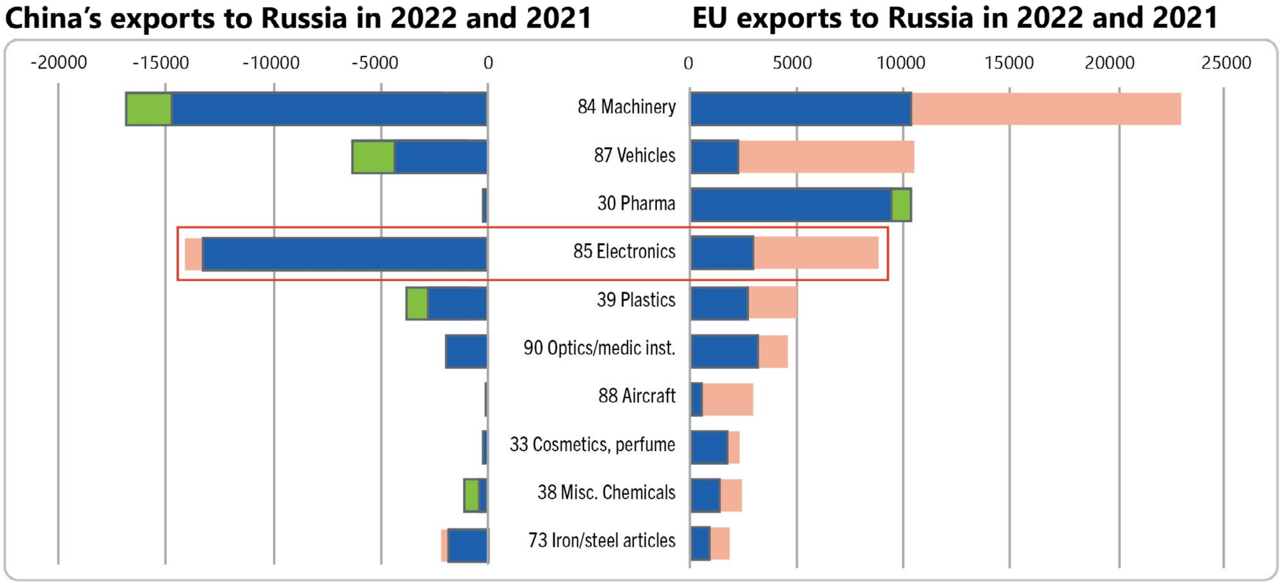
10 "Yuri Borisov's Interview," *Novosti Kosmonavtiki*.

11 "Roskosmos Head Rogozin Proposes Nationalizing Space Microelectronics," Interfax, July 5, 2022, http://www.interfax.com/newsroom/top-stories/80974/; Sergei Karasev, "Import Substitution of Semiconductors in Russia Will Take 15 Years" [На импортозамещение полупроводников в России потребуется 15 лет.], 3dnews.ru, May 11, 2022.

12 "Roskosmos Head Rogozin," Interfax.

13 "Drones Do Not Reach Russia; Chinese Restrictions Have Led to Disruptions in the Supply of Drones and Components" [Беспилотники не долетают до России, Ограничения Китая привели к перебоям с поставками дронов и комплектующих], *Kommersant,* Sept. 18, 2023, https://www.kommersant.ru/doc/6223010.

Figure 1. Chinese and EU exports to Russia, 2021–2022



Source: Twitter, Janis (@jakluge) Kluge, July 13, 2023, twitter.com/jakluge/status/1679459784842510336, based on data found at Comtrade (comtradeplus.un.org).

Note: Pink represents a decrease from 2021 to 2022, whereas green represents an increase.

According to unofficial industry sources, the latest Western restrictions after 2022 have greatly exacerbated the problem, adding at least two years to the already delayed construction of multiple military satellites. In the meantime, according to some unofficial rumors, the Russian Ministry of Defense has barred all foreign-made computer processors from its spacecraft as of 2023, and it has mandated that all Russian satellites developed in the next two years must have domestically built avionics. Since 2014, the Russian government has advertised a wide program of domestically produced substitutions for imports, which was intended to fulfill 95 percent of the space industry's needs by 2021.[14]

By most accounts, domestic development of computer chips seemed to be the only real solution to this chronic problem, but it would also mean additional delays—plus increases in mass and power consumption—as well as reduced reliability, life span, and functionality of the end product given the backward state of the Russian electronics industry.

The company AO Mikron was advertised to be at the forefront of the Russian effort to develop space-rated electronics. A new factory intended to miniaturize Russian-produced computer chips was founded in Zelenograd. Characteristically, in May 2022, the entire Russian space industry leadership, led by Rogozin, visited Mikron's headquarters in Zelenograd to discuss stable supplies of electronics for the Russian spacecraft.

At the same time, Russia's Rostec Corporation, a state-owned defense conglomerate, promised a 30 percent increase in production for aerospace in

[14] Dmitry Ignatev, "New Technology Policy" [Новая технологическая политика], *Izvestiya,* July 28, 2015, https://iz.ru/news/589278.

2023.[15] However, according to one Russian source at the time, it would take Moscow 15 years to organize mass production of necessary semiconductors and microchips.[16] One expert familiar with the matter claimed that Russia simply did not have the necessary capacity to mass-produce cutting-edge electronics.[17]

In July 2022, Rogozin proposed that the Kremlin nationalize companies that produce electronics for satellites and cited Roscosmos and Rosatom's lack of access to radiation-hardened avionics as the main reason for the move.[18] Three months earlier, Roscosmos bought a stake in the Yaroslavl Radio Plant, a leading producer of radio equipment for aerospace, and integrated it into its RKS Corporation, which is responsible for flight control systems within Roscosmos.[19]

At the same time, ISS Reshetnev, the leading producer of Russian military satellites, formed a special group on electronic components within its Chief Designer Council, which is responsible for engineering developments at the company. Reshetnev claimed that the share of domestically built electronics aboard GLONASS navigation satellites (then under construction) had been higher than on those operating in orbit. The company also said that (military) communications satellites intended for operation in highly elliptical orbit (apparently referring to the Meridian, Sfera, and Repei spacecraft[20]) are slated to employ Russian-built electronics.

However, in addition to electronics, the Russian space industry was also lacking several new materials used in spacecraft. In May 2022, ISS Reshetnev reported a continuous effort to find new foreign suppliers or to organize domestic production for nearly 40 items, including materials for honeycomb panels and carbon fiber used in satellite structures. Reshetnev boasted its successful development of domestically produced antennas and transponder equipment, including communications payloads for a quartet of Blagovest military communications satellites, which were launched in the late 2010s. The company also reported the new development of high-frequency radio equipment and digital processing units.[21]

Still, there were indications that the Russian aerospace industry would long depend on Western suppliers. In 2021, Rogozin admitted that even after the planned completion of the Roscosmos imports–replacing effort in the GLONASS program (then promised in 2025), the substitution of foreign components would not be absolute "because even the USA does not produce everything domestically."[22]

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15 Roman Kamanin, "Rostekh Will Increase Supplies of Components for Space Industry by 30 Percent" ["Ростех" увеличит поставки компонентов для космической отрасли на 30% в 2022 г], MK.ru, Apr. 17, 2022, https://www.mk.ru/science/space/2022/04/17/rostekh-uvelichit-postavki-komponentov-dlya-kosmicheskoy-otrasli-na-30-v-2022-godu.html.

16 Karasev, "Import Substitution of Semiconductors in Russia."

17 RiddleRider, "Future of the Russian Microelectronics" [Будущее российской микроэлетроники], *Habr,* Apr. 18, 2022, habr.com/ru/articles/661637/.

18 "Roskosmos Head Rogozin," Interfax.

19 "Roskosmos Head Rogozin," Interfax.

20 Meridian, Sfera, and Repei satellites (detailed below) are designed to operate in a highly elliptical (egg-shaped) orbit with an apogee (the highest point) positioned over the Northern Hemisphere, which is more suitable for communications and electronic intelligence over the high-latitude regions of the planet than traditional equatorial orbits.

21 "ISS Collective Is Ready to Give Adequate Answer to Challenges of the Time" [Коллектив ИСС готов дать достойный ответ на вызовы времени], Roscosmos.ru Press Release, May 1, 2022, https://www.roscosmos.ru/102/.

22 "Supplies of Native Electronics for Space Grew 2.5 Times in 3 Years" [Поставки отечественной электроники для космоса выросли за 3 года в 2,5 раза], Roscosmos.ru Press Release, June 10, 2021, http://www.roscosmos.ru/31403/.

In July 2023, *Le Parisien*, a French newspaper, reported the arrest of nine French and Chinese managers of the Ommic semiconductor producer for illegally transferring secret technologies to Russia and China. According to court documents, Russian military producers bought dual-use semiconductors from the company worth 11.8 million euro as late as March 2023.[23]

Personnel and salaries

Aging personnel and challenges in hiring new recruits into the industry had remained problems throughout the post-Soviet period, but the issue appeared to be getting worse. After the mass emigration of 2022, in the wake of full-scale invasion of Ukraine and subsequent mobilization, the Russian defense industry was officially reported to be short of 16,000 key specialists.[24] In addition, according to the vice president of the Russian Academy of Sciences (RAN), Russia had lost 50,000 scientists in the past five years.[25]

[23] John Leicester, "France Is Investigating Suspected Smuggling to China and Russia of Advanced Chip Technology," Associated Press, July 27, 2023, https://abcnews.go.com/Technology/wireStory/france-investigating-suspected-smuggling-china-russia-advanced-chip-101713344.

[24] "Military-Industrial Complex Needs More Than 16 Thousand New Specialists, Says Manturov" [ОПК необходимо свыше 16 тысяч новых специалистов, заявил Мантуров], RIA Novosti, July 24, 2023, ria.ru/20230724/opk-1885974170.html.

[25] "Vice-President of RAS Reported Loss of 50 Thousand Employees Over Five Years" [Вице-президент РАН сообщил о потере страной 50 тысяч сотрудников за пять лет], Interfax, May 18, 2023, http://interfax.ru/russia/902007.

RUSSIA'S ORBITAL ASSETS

In the 2020s, Russia has occupied a distant third place in space after—the United States and China—when counting the number of annual launches and the amount of mass delivered to orbit.[26] Still, the Russian military has pursued a wide range of space projects that is comparable (but not equal) in scope to the projects of the US and China, continuing along the lines established during the Soviet period. The projects included satellites for optical and electronic intelligence, early warning about ballistic missile launches, and dedicated or dual-use support systems for communications, navigation, and weather forecasting on the battlefield for strategic command and control purposes. In addition, new types of systems—inspector satellites, new generation antisatellite systems, and in-orbit communications intelligence satellites—had been introduced into the Russian arsenal or tested in orbit. Some exotic technologies, such as a nuclear-powered, electrically propelled space tug, were also in the works for military applications. At the same time, practically all ongoing and prospective programs were bogged down by technical delays associated with Western sanctions and by the lack of experienced personnel or adequate production and testing infrastructure.[27]

The total number of active Russian satellites in orbit varies in different official accounts, but the most recent summaries hover under 200 spacecraft. According to the Industry and Trade Minister Denis Manturov, Russia operated 192 satellites as of April 12, 2023. In October 2022, the head of Titov Chief Test Center, Major General Sergei Marchuk, reported around 170 satellites within the Russian orbital grouping.[28] In comparison, in December 2019, the Russian orbital assets (military and civilian) were reported to include 162 satellites.[29] In September 2023, ISS Reshetnev planned to produce 24 "state-ordered" (hence military) spacecraft from 2024 to 2030.[30]

As of May 14, 2019, Russian orbital assets managed by Roscosmos included 91 spacecraft (see Figure 2), most of them dual-purpose satellites relevant to military activities. In December 2019, Roscosmos stated that Russian orbital assets included 92 civilian, scientific, and navigation satellites. According to Rogozin, the Russian civilian satellite constellation included 89 spacecraft in 2021.

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[26] See Anatoly Zak, "Russian Space Program in 2023," Russian Space Web, RussianSpaceWeb.com/2023.html.

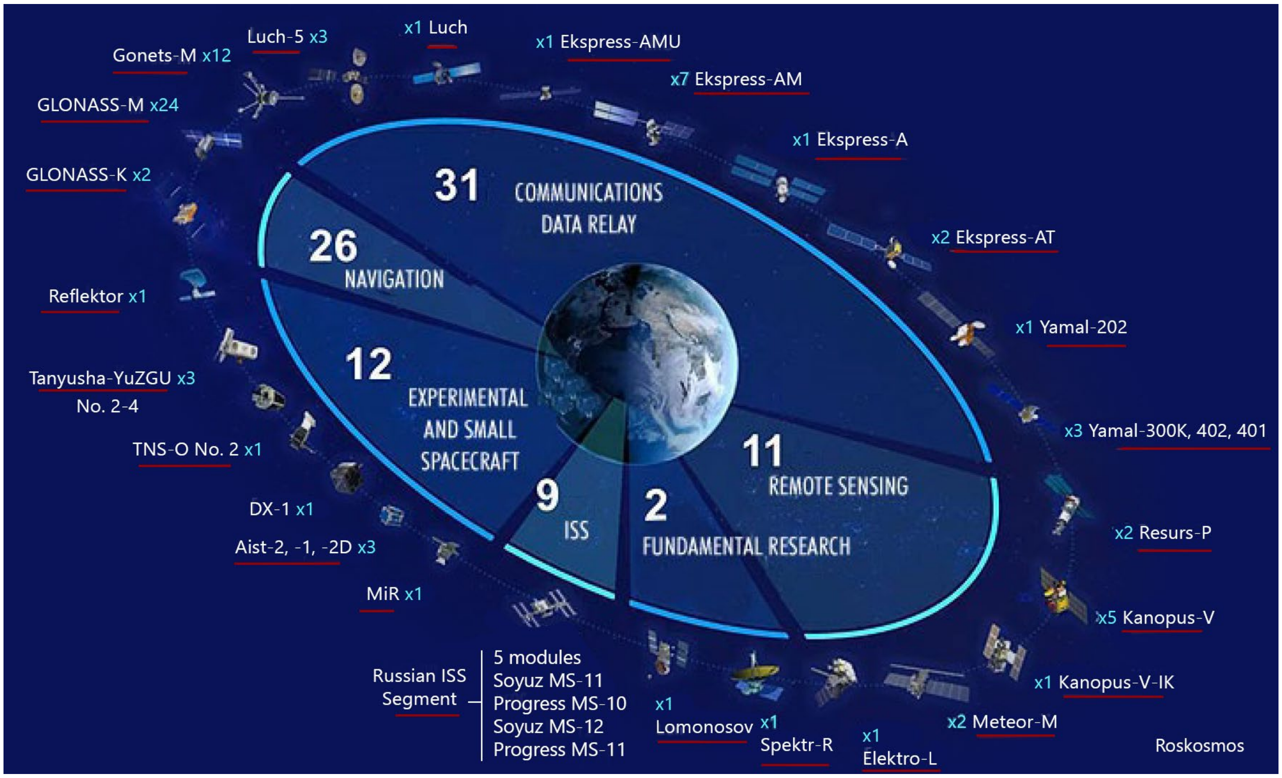
[27] Anatoly Zak, "Russian Space Program in 2023."

[28] "Titov MTSC Will Provide 10 Launches of the Latest Satellites in the Near Future" [ГИКЦ им. Титова обеспечит 10 запусков новейших спутников в ближайшее время], *Novosti Kosmonavtiki,* Oct. 4, 2022, https://www.novosti-kosmonavtiki.ru/news/84795/.

[29] "Orbital Grouping Included 162 Satellites As of End of 2019" [Орбитальная группировка на конец 2019 года включала 162 космических аппарата], *VPK News*, Sept. 9, 2020, https://vpk.name/news/442703_orbitalnaya_gruppirovka_na_konec_2019_goda_vklyuchala_162_kocmicheskih_apparata.html.

[30] "Reshetnev Is Planning to Build 377 Communication and Navigation Satellites in 2024–2030" ["Решетнев" планирует создать 377 космических аппаратов связи и навигации в 2024-2030гг], Interfax-AVN, Sept. 28, 2023, http://www.militarynews.ru/story.asp?rid=1&nid=602973&lang=RU.

Figure 2. Russian orbital assets



Source: Roscosmos transformation [Трансформация Роскосмоса], Roscosmos TV, May 24, 2019, https://www.youtube.com/watch?v=T1e6zAYZvRA.

MILITARY AND DUAL-USE SATELLITE SYSTEMS

With a general reversal of democratic reforms in Russia, the Russian military also drifted toward less transparency in its space operations, even though vestiges of relatively open post-Soviet policies had largely survived. Even so, the proliferation of the internet in Russia provided access to extensive legal and procurement documentation. In addition, increasingly sophisticated wide-spectrum satellite tracking became available. These two developments offered new insight into the murky world of the Russian military space. As a result, an informal small group of Western satellite watchers and historians, including Robert Christy, Bart Hendrickx, Nico Janssen, Marco Langbroek, Jonathan McDowell, and Scott Tilley, were able to track Russian space activities in unprecedented detail.

Imaging intelligence

In the early 2020s, Russia continued attempts to modernize its lagging capabilities in imaging reconnaissance from space and to develop new generation systems. In 2015, the Russian Chief Intelligence Directorate (GRU) finally stopped using Kobalt-M imaging satellites, which were delivering film back to Earth.[31] From that point, the Russian military had to rely entirely on remote transmission of high-resolution imagery.

Around that time, the Russian Ministry of Defense operated two Persona high-resolution reconnaissance satellites, and it was also presumed to have access to optical imaging data from less powerful Resurs, Kanopus, and Aist satellites, which are officially under civilian management. It also possibly had access to products from the Russian-built EgyptSat-A spacecraft, launched for the Egyptian government in 2019. With a mass of just 1,150 kilograms, Egyptsat-A was reported to be capable of seeing details as small as 0.7 meters in panchromatic mode and of operating in orbit up to 25 years, which, if achieved, would be the best capabilities for a Russian-built satellite.[32]

In 2022, Russia used a similar partnership with Iran to introduce a similar class of spacecraft known as Project 505 or Khayam. Roscosmos said little about the project besides admitting to the involvement of its companies in its development, but some of the Russian contractors advertised their contributions.[33] This new generation satellite was developed at the Moscow-based VNIIEM enterprise, previously known for the Kanopus series of satellites. Moscow-based NPK Barl provided ground systems, while ONPP Tekhnologiya, based in Obninsk, Kaluga Region, stated it had developed ultralight composite-based structures for the spacecraft, including solar panels

[31] A. Yu Kovtun et al., “70th Anniversary of Frunze AO KB Arsenal” [Акционерное общество “Конструкторское бюро «Арсенал” имени Фрунзе 70 лет], Roscosmos, 2019.

[32] RKK Energia Presentation at MAKS-2013 Air and Space Show, Zhukovsky, Russia, Aug. 2014.

[33] “Russia Will Build Remote-Sensing Satellite for Iran” [Россия создаст для Ирана спутник дистанционного зондирования земли], TASS, Aug. 25, 2015, https://tass.ru/kosmos/2210115.

and radiators, which doubled as the satellite's body.[34] In total, Iran promised a joint production of four Khayam satellites.[35]

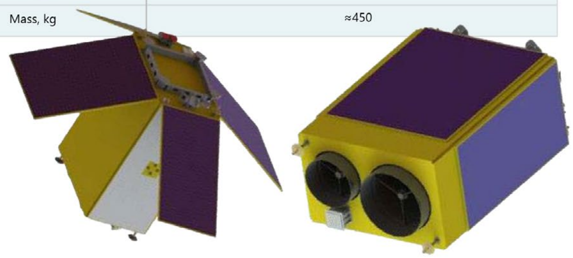
When the first satellite launched, the *Washington Post* reported that the Russian military would initially use the Khayam satellite to produce imagery with a resolution of 1.2 meters in support of its invasion of Ukraine.[36] This proposed arrangement indicated that Russia lacked its own imaging assets in orbit and needed to fund its military projects with the help of foreign partnerships. Interestingly, it is known that VNIIEM relied heavily on Western components to build the Kanopus series, including critical hardware supplied by British-based Surrey Satellite Technologies. The natural question, then, is whether Khayam could be replicated in the near future, which would confirm that Western components had been successfully substituted or obtained despite restrictions. Previously, the launch of the first Khayam satellite had reportedly been planned for the second quarter of 2021, and the delay may indicate issues with the satellite's completion.

VNIIEM was also known for working on the Razbeg imaging satellite, which could be related to Khayyam or be a more advanced project. The company published specifications for a "prospective super-high resolution" satellite with a mass of around 450 kilograms, which could improve optical resolution down to 0.7 meters, as shown in Figure 3. VNIIEM was apparently considering cooperation with Belarus to develop a relatively compact satellite with a much more powerful telescope.

Figure 3. Razbeg imaging satellite specifications

Design architecture of a super-high-resolution spacecraft (VNIIEM Corporation)

Характеристики	Значение		
Image type	Panchromatic	Multispectral	Infrared
Resolution, m	0,7	2,0	3-5
Spectral range, MKM			3-5
Temperature variation equivalent to noise, K			0,05
Observation swath, km	500		500
Coverage swath, km	16		40
Altitude, km	500		
Launch vehicle	All vehicle classes, including air-launched, hitchhiker and cluster		
Angular attitude control	Three-axis, electromechanical		
Attitude control accuracy	No worse than 3 degrees		
Attitude control measurement accuracy	No worse than 10 seconds		
Stabilization accuracy	No worse than 0.0004 degrees per sec.		
Spacecraft rotation	Each axis up to 2 degrees per sec.		
Command radio line	S-band		
Data transmission rate	8.2 GHz; up to 300 Mbit/sec.		
Average power consumption per orbit	Up to 650 Watts		
Life span	No less than 5 years		
Mass, kg	≈450		



Source: VNIIEM.

In June 2019, VNIIEM unveiled a scale model of the RBKA satellite at the Paris Air Show in Le Bourget, France. The accompanying information showed that the 1,825-kilogram spacecraft would be able to deliver images with a resolution of 35 centimeters per pixel during its seven-year life span. Interestingly, even the general architecture of RBKA resembled advanced Western spacecraft more than the traditional Soviet designs often inherited by Russian satellites, such as Resurs-P or Meteor-M.

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[34] "Developments of Kaluga Enterprise Used in Iranian Satellite" [Разработки Калужского предприятия применили в иранском спутнике], TASS, Aug. 15, 2022, https://tass.ru/kosmos/15477343.

[35] Ahmet Dursun, "Iran Announced Plans to Organize Joint Production of Satellites with Russia" [Иран объявил о планах наладить производство спутников с РФ], AA News Agency, Aug. 10, 2022, https://www.aa.com.tr/ru/иран-объявил-о-планах-наладить-производство-спутников-с-рф/2658216.

[36] Joby Warrick and Ellen Nakashima, "Russia to Launch Spy Satellite for Iran but Use It First over Ukraine," *Washington Post,* Aug. 4, 2022.

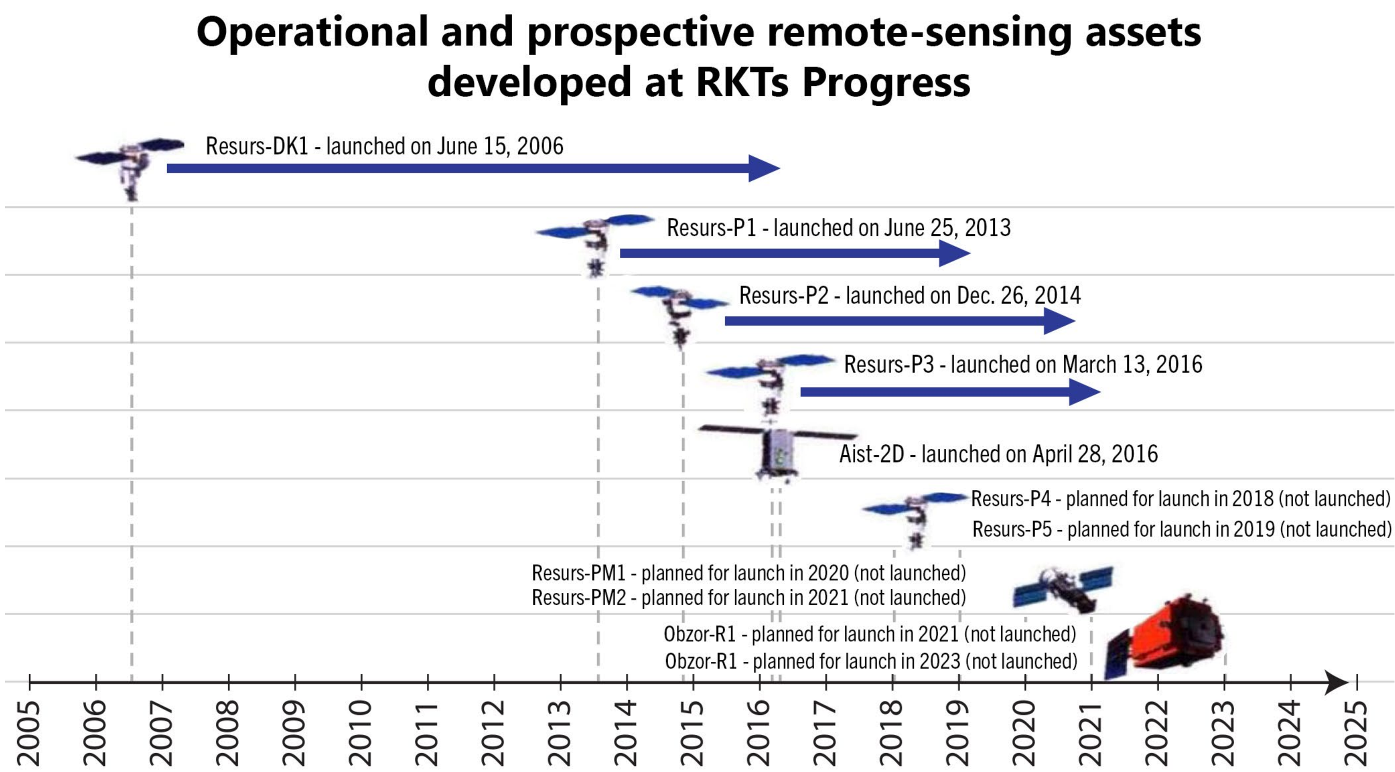
Three RBKA satellites had been promised, but as of 2023, the first launch in the series is not expected before 2028 because of sanctions.[37]

Resurs-P series

RKTs Progress in Samara, the most prolific developer of the Soviet reconnaissance satellites, also struggled to upgrade its line of spacecraft. As shown in Figure 4, the first three "civilian" Resurs-P satellites, launched in 2013, 2014, and 2016, were plagued by in-orbit failures, and their upgraded versions had been continuously delayed.[38]

According to plans made in the 2010s, the fourth and fifth Resur-P satellites were scheduled for launch in 2018 and 2019, but they have yet to fly as of 2023, once again illustrating the profound effect of the Western sanctions. According to the same schedule, the new generation Resurs-PM imagers were promised in 2020 and 2021, but they had to be postponed years beyond those dates.[39]

Figure 4. Planned launch schedule for imaging satellites developed at RKTs Progress as of the mid-2010s



Source: RKTs Progress.

[37] "Belarus Develops Satellite That Can Become a Part of Russian Orbital Grouping" [Белоруссия разрабатывает спутник, который может войти в состав орбитальной группировки РФ], TASS, Apr. 11, 2023, https://tass.ru/kosmos/17496725.

[38] RKTs Progress, "Resurs-P No. 1 Five Years in Orbit" [РКЦ Прогресс. Ресурс-П №1 - 5 лет на орбите], Roscosmos Press Release, June 25, 2018, https://www.roscosmos.ru/25233/.

[39] Anatoly Zak, "Resurs-P Earth-Watching Satellites," Russian Space Web, https://www.russianspaceweb.com/resurs_p.html.

New trend: a small satellite imaging constellation

Until recently, most Russian reconnaissance satellites were one-of-kind, multi-ton machines, which took many years and many millions of rubles to build. But in the early 2020s, the Russian space industry appeared to desire to catch up with the worldwide trend of miniaturizing optics and electronics in order to develop imaging satellite constellations with large numbers of small satellites, which could provide near instantaneous global coverage with little loss in quality and detail.

One early attempt was apparently the Razdan (MKA) project at VNIIEM,[40] which began orbital flight tests with the launch of the EMKA No. 1 satellite in March 2018, but the program appeared to be moving slowly. In August 2023, RKTs Progress announced plans to develop the Small Operative High-Detail Observation Spacecraft, MKA-OVN, capable of delivering panchromatic images with a resolution of 0.4 meters and multispectral images with a resolution of 1.2 meters along a 14-kilometer swath. A complete network would consist of 32 spacecraft, deployed in eight launches of four satellites (probably on a Soyuz rocket, also produced at RKTs Progress). According to the company, the preliminary project design was completed and offered to "various organizations and agencies," but it was obvious that the project was primarily intended for the Ministry of Defense. It would take up to 10 years to fully develop the project after the start of funding, according to the company.[41] The MKA-OVN project likely grew from RKTs Progress' experience with developing the Aist series of compact imaging satellites, the latest of which—Aist-2T No. 1 and No. 2, followed by Aist-ST—are planned for launch sometime in 2024.[42]

In 2019, ISS Reshetnev, which had previously had no major involvement in developing imaging satellites, also bid for the construction of a serial production line for prospective imaging satellites developed within the Sfera project.[43]

Radar imagers

In the early 2020s, the Russian space industry finally appeared to be mastering a long elusive goal of building all-weather, day-and-night radar imaging satellites. Notably, several types of radar-carrying satellites either entered orbit, including Neitron, Kondor-FKA, Pion-NKS, and Meteor-M, or were reported to be in advanced stages of development, including Obzor-R and Araks-R.

On May 27, 2023, after a dual false start nearly a decade earlier and at least four years behind schedule, Roscosmos launched the first of four planned "civilian" versions of the Kondor radar-imaging satellites, originally developed under contracts with the Russian Ministry of Defense and the South African government. Despite its open status, the Kondor-FKA mission was advertised as a great asset for the Russian military and a significant tool for the war in Ukraine. A more advanced version

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[40] Bart Hendrickx, "Upgrading Russia's Fleet of Optical Reconnaissance Satellites," *Space Review,* Aug. 10, 2020, http://www.thespacereview.com/article/4006/1.

[41] "RKTs Progress Proposed Launching 32 High-Resolution Observation Satellites" [РКЦ "Прогресс" предложил запустить 32 спутника высокодетального наблюдения], TASS, Aug. 24, 2023, https://tass.ru/kosmos/18584389.

[42] Aviation Explorer, "Satellites for Development of the 3D Model of the Earth Will Be Launched on Soyuz" [Спутники для создания 3Д-модели Земли "Аист-2Т" запустят на Союзе], May 22, 2023, aex.ru/news/2023/5/22/257499/.

[43] "Sphere of Perspectives" [Сфера" перспектив], *Sibirsky Sputnik* 23, no. 480 (2019), https://www.iss-reshetnev.ru/media/newspaper-2019/newspaper-480.pdf.

of the satellite, designated Kondor-FKA-M, was also promised and would be equipped with the so-called hybrid mirror antenna.[44]

There were also indications that Kondor-FKA was preceded into orbit by its military cousin, code-named Neitron. The Russian military launched a semiclassified spacecraft from Plesetsk on February 5, 2022, just three weeks before the full-scale invasion of Ukraine and between three and four years later than originally expected.[45] Surprisingly, the satellite, officially designated Kosmos-2553, was inserted into a much higher orbit than that of Kondor-FKA, which might indicate that the former was intended for a wide-theater observation role. There were also rumors that additional Neitron satellites had been planned.

At the same time, the Russian military was still waiting for the Araks-R satellite system, which would be capable of obtaining more detailed radar images than those provided by Kondor and Neitron. The initial Araks constellation was expected to have two satellites, to be joined later by three additional spacecraft. Although the Araks program has its roots in the 1970s, the development of the latest radar-carrying incarnation of the spacecraft started around 2012—before the annexation of Crimea—when the Russian industry apparently hoped to obtain critical technology for the project from the West. European companies such as Thales Alenia Space, EADS Astrium (now Airbus), and Israeli IAI were known to bid for participation in the project. Viktor Khartov, head of NPO Lavochkin, which won the prime contractor role in the project, said that one key condition of the agreement with Western suppliers had to be the transfer of necessary know-how to Russia.[46]

All these plans were likely derailed by the Kremlin's annexation of Crimea in 2014, and the Araks-R satellite remained grounded until 2023, even though there were indications as late as 2019 that NPO Lavochkin was trying to move the project forward.[47] The service module of the Araks-R satellite was expected to derive from the company's standard Navigator bus, which had proved its capabilities in multiple civilian, dual-use, and scientific missions, such as Elektro-L and Arktika-M.

However, it appeared that the radar payload was the main stumbling block for the Araks-R project. Official legal records indicate that in 2015, the Ministry of Defense sued NPO Lavochkin over its December 24, 2012, contract to develop the Araks-R satellite. In the court proceedings, NPO Lavochkin argued that their failure to complete the work by November 23, 2013, had been due to changes in both the spacecraft concept after the completion of the preliminary design and the technical assignment for the project's next development phase, known in Russia as OKR (for *Opytno-Konstruktorskaya Rabota).*[48]

Interestingly, the litigation between NPO Lavochkin and the Russian military over the Araks-R

[44] A. M. Alekseeva et al., "Active Transponder with a Function of Simulating Complex and Surface-Distributed Targets for Testing, Calibration and Validation of Space-Based Radar at Different Phases of Its Life Span" [Активный транспондер с функцией имитации сложных и поверхностно-распределённых целей для испытаний, калибровки и валидации космических РСА на различных этапах их жизненного цикла], Vega, Murom 2020 Remote-Sensing Conference, https://elibraryru/item.asp?id=43884559.

[45] "Third launch from Vostochny" [Третий пуск с Восточного], Novator, no. 2, Feb. 2018, p. 2.

[46] Ivan Cheberko, "Ministry of Defense Will Spend 70 Billion Rubles for Spy Satellites" [Минобороны потратит 70 млрд рублей на спутники-шпионы], *Izvestiya,* Apr. 10, 2013, https://iz.ru/news/548372.

[47] OVOS: Obshchestvennye Slushaniia, "Reconstruction and Technical Re-Equipment of Production of Product 14F155" [Реконструкция и техническое перевооружение производства изделия 14Ф155], Dec. 6, 2019, http://o-v-o-s.ru/50/4882.

[48] Moscow Arbitration Court Decision No. A40-124789/2015, Dec. 24, 2015, sudact.ru/arbitral/doc/MQJ3LKDnVegl/.

development coincided with the events in Crimea, even though the resulting sanctions probably hit the project further down the road.

Dual-use radar imagers

Within weeks after Kondor-FKA entered orbit in 2023, Roscosmos also launched its fifth spacecraft in the Meteor-M series. Notably, the satellite carried a radar-imaging antenna for the first time in the Meteor-M series, which was obvious from the available photos of the spacecraft.[49] The most sophisticated "civilian" radar imager, called Obzor-R, was also reported to be undergoing finishing touches in 2023 at RKTs Progress in Samara, after many years of delays.[50]

The Russian industry outlined a general direction for future efforts to build radar-imaging systems. In 2020, a group of specialists from the Vega company, the prime supplier of imaging radar in Russia, delivered a report at the remote-sensing conference. According to the paper, Obzor-R, Araks-R, and Kondor-FKA satellites were all using synthetic aperture radar operating in X- and S-band, in which the scanning signal swath does not exceed 600 megahertz. At the same time, developers were conducting research into the onboard radar for the geosynchronous satellite system and working on a multiband Earth-observation system operating in X-, L-, and P-bands. In addition, the Sfera project called for the development of a 23-satellite constellation of small radar imagers that would operate in X-band.[51]

Electronic intelligence from space

In the 2020s, Russia continued to actively develop and deploy orbital assets for radio eavesdropping from space. At the forefront of the effort remained the Liana system, consisting of Lotos and Pion spacecraft. After the first three launches of Lotos-S variants in the 2010s, three more satellites in the series were put into orbit in 2021 and 2022. These satellites were intended for tracking radio signatures of ground-based targets. At least two more Lotos-S satellites were in development, based on published documentation.

More importantly, the first Pion-NKS spacecraft, customized for guiding Navy missiles to their targets based on radar imagery, was finally launched on June 25, 2021. The completion of the satellite had been delayed by the breakdown of industrial ties with Ukraine in 2014 and by Western sanctions. As the next step, on April 28, 2014, the Ministry of Defense signed a contract with ISS Reshetnev in Zheleznogorsk for the preliminary design of the low-orbital Akvarel space system, which would presumably replace Pion-NKS. In parallel, on September 1, 2014, work began on the Repei-V spacecraft, which was intended to provide electronic intelligence from a highly elliptical orbit, covering polar areas of the Earth, and work also began on the Repei-S satellite in the geostationary orbit to focus on lower latitudes of the planet.[52]

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[49] Anatoly Zak, "Soyuz Launches a Meteor Weather Satellite and Hitchhikers," Russian Space Web, RussianSpaceWeb.com/meteor-m2-3.html.

[50] "Obzor-R Radar Satellite Is Scheduled for Launch in 2023" [Радиолокационный космический аппарат Обзор-Р планируется вывсети на орбиту в 2023], Roscosmos Press Release, Apr. 30, 2022.

[51] Alekseeva et al., "Active Transponder."

[52] Zheleznogorsk City Court Decision No. 12-40/2016, Mar. 17, 2016, https://sudact.ru/regular/doc/M8an8de4SFWQ/.

The completion of the preliminary design for Akvarel was scheduled in 2015. In turn, on July 15, 2014, ISS Reshetnev subcontracted the development of the payload for the Akvarel spacecraft to the Berg Institute, TsNIRTI. Reshetnev delegated the development of the ground control complex for the two Repei subsystems to RKS Corporation on September 1, 2014. In addition, Reshetnev tasked NTTs KIUS Effes with assessing the "battlefield stability and survivability" of the Repei system. Interestingly, the same company also had to formulate a concept and specifications for the "onboard means and methods of defense" of the Repei orbital grouping, apparently pointing to some kind of antisatellite action.[53]

Possibly hinting at a related development, in an interview with the journal *Radioelektronnye Tekhnologii* at the beginning of 2020, Deputy Minister of Defense Aleksei Krivoruchko said that the Russian Armament Program, GPV-2027, which would cover military procurements up to 2027, would also fund the development of self-defense systems for various types of attacks on Russian satellites.[54]

The Akvarel and Repei projects were frequently complicated by litigation between the Ministry of Defense and ISS Reshetnev. Within this litigation, both sides accused the other of delaying the start of work and coordinating poorly. For example, in 2015, the leading ISS Reshetnev managers in the Akvarel and Repei projects, S. V. Vysotsky and A. L. Ivlev, were accused of administrative violations and of failing to complete the preliminary design of their respective systems by June 30, 2015, as required by the contracts.[55] In 2017, the *Izvestiya* daily newspaper promised the launch of the Repei satellite in 2018.[56] However, as of early 2023, the satellites for Akvarel and Repei systems still remained on the ground. By that time, Ukrainian intelligence reported that the first launch of the Repei satellite had been postponed from 2022 to 2024 because of sanctions against ISS Reshetnev.[57]

In-space radio intercepts (communications intelligence)

In March 2023, Russia launched the second Olymp-K satellite, which was thinly disguised as a part of the Luch data relay series but widely believed to be configured for eavesdropping on Western satellite communications, like its predecessor launched in 2014. By March 23, 2023, the satellite slowed down its drift positioning at 79 east longitude in the geostationary orbit; however, in the following days, the satellite climbed above the geostationary altitude, causing an accelerating westerly drift during the rest of the month. In the second half of May 2023, Olymp-K "parked" itself over 8.9 degrees west longitude, not far from Eutelsat KA-SAT-9A and Eutelsat-9B.[58]

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[53] Zheleznogorsk City Court Decision.

[54] Alex Krivoruchko, "Path into the New Decade" [Путь в новое десятилетие], *Radioelectronnye Tekhnologii*, no. 1 (2020), http://bmpd.livejournal.com/3921645.html.

[55] Zheleznogorsk City Court Decision.

[56] "New Russian Repei Reconnaissance Satellites Will Be Launched in 2018" [Новый российский спутник-разведчик «Репей» запустят в 2018 году], *Izvestiya*, Nov. 13, 2017, https://iz.ru/670137/2017-11-13/novyi-rossiiskii-sputnik-razvedchik-repei-zapustiat-v-2018-godu.

[57] Main Directorate of Intelligence at the Ministry of Defense of Ukraine, "Russian Space Intelligence Is Collapsing under the Influence of International Sanctions" [Космічна розвідка рф колапсує під впливом міжнародних санкцій], Jan. 24, 2023, t.me/DIUkraine/1904.

[58] Marco (@Marco_Langbroek) Langbroek, "Image from last night: geosynchronous Russian SIGINT #Spy satellite #Luch/Olymp 2 (2023-031A) launched in March," Tweet, X, Aug. 22, 2023, 2:24 p.m. https://twitter.com/Marco_Langbroek/status/1694052972982850036.

EKS early warning constellation

In the early 2020s, Russian space forces continued slowly deploying the new generation satellite system called EKS, which was intended to provide early warning of launches of ballistic missiles. Since the first introduction of the Tundra/Kupol satellite for the EKS system in 2015, six spacecraft of this type have been launched into the constellation on Soyuz rockets.[59] From 2019 to 2022, the Ministry of Defense launched one EKS satellite per year. However, no additions have been made so far in 2023, and the constellation never reached the promised number of 10 satellites in orbit. Until the time of this writing, all satellites had been inserted in elliptical orbits, while an expected version of the satellites intended for deployment in the geostationary orbit has never arrived.

The latest break in deploying the EKS constellation coincided with the rumored transition of the Kupol launches from the Soyuz-2 to the Angara-5 rocket, which was expected to take place at the end of 2022 or in early 2023. But the EKS has not so far materialized, even though the Angara-5 launch vehicle, assigned to carry its first EKS payload, was reportedly shipped from Moscow to its launch site in Plesetsk on May 13, 2022.

Military communications

The Russian military was also behind schedule on upgrading its critical communications capabilities, represented by the Sfera-S and Sfera-V constellations comprising the integrated third generation communications network, ESSS-3. Despite numerous reports about the development of the satellites in the previous years and about their delay from 2018 to 2021, none of them had flown yet as of 2023.[60] By that time, Ukrainian intelligence reported that the deployment of the system had been postponed from 2025 to 2027.

The Gerakl-KV data-relay project, which was known to be in preliminary design since 2014, was in slightly better condition.[61] The spacecraft, intended for transmitting data and images from other military satellites to ground control, was to be launched on the Angara-5 rocket from Plesetsk. As of 2023, its first launch had been postponed from 2023 to 2025.[62]

Various Russian sources also mentioned such ongoing projects at ISS Reshetnev as Yenisei-2 and Ispolin, which appeared to be related to military or classified communications, presumably based in the geostationary orbit.[63]

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[59] Vladimir Misnik, "Deployment of the Unified Space System Is Going According to Plan" [Развертывание Единой Космической Системы идет по плану], *Vozduzhno–Kosmicheskiy Rubezh* (Aug. 2017), p. 39, http://bvpa.ru/wp-content/uploads/2017/08/VKR-01_2017.pdf.

[60] Ivan Safronov, "Billions Will Get in Touch" [Миллиарды выйдут на связь], *Kommersant*, Feb. 11, 2016, http://www.kommersant.ru/doc/2913130.

[61] Nikolay Balkovoy, "Development and Research of a Control System for the Dynamic Torque of the Engine-Flywheel of the Spacecraft Orientation and Stabilization System" [Разработка и исследование системы управления динамическим моментом двигателя-маховика системы ориентации и стабилизации космического аппарата], (Tomsk State University Dissertation, 2019), нгту.рф/files/dissertations/avtoreferat_v.15_154720194086.pdf.

[62] Main Directorate of Intelligence, "Russian Space Intelligence."

[63] Channel 1HD Russian TV, *New Processing Building Is Under Construction at Plesetsk Spaceport* [На косомдроме Плесецк строится новый монтажно-испытательный корпус], Channel 1HD Russian TV, Dec. 29, 2021, television program.

On the low orbit front, Russia continued deploying the Rodnik secret communications system and planned future launches. According to available public documents, at least two upgraded trios of Rodnik satellites were slated for launch in 2023 or later.

With the Rodnik program scheduled to last from 2015 to 2020, the Ministry of Defense funded the Klyuch R&D project to develop the 14F161 variant of the previous 14F132 version of the Rodnik satellite. The primary goal of the upgrades was to replace imported components. The Rodnik system was also set to switch to the newly introduced Angara-1.2 rocket, replacing the Rockot booster that had been used in the Ukrainian flight control system, and switch from the Soyuz rocket, which was oversized for the task. Based on public records of litigation between the Ministry of Defense and the prime developer ISS Reshetnev, the Klyuch project experienced delays due to lack of coordination of technical assignments for the system, which is probably "legal speak" for bureaucratic problems.[64]

The GLONASS navigation system

In the 2020s, the Russian military and Roscosmos continued the operation and replenishment of the dual-use GLONASS navigation network. One major step forward for the program was the introduction of the GLONASS-K2 spacecraft variant in August 2023, which reached orbit a decade later than the original 2010 promise. Substituting imported components with domestically built hardware was the primary reason for the delay.[65]

The K2 variant was advertised to feature an unpressurized satellite bus and a new type of navigation signal with the so-called code-protected selection. The spacecraft was expected to transmit three types of signals, two of which in L1 and L2 range would be designed for specialized users, such as the military, and one channel in L1 range that would be available to everyone else. The K2 was also designed to use a new generation thermal control system based on electrically powered thermal panels complemented with optical thermal coating, replacing traditional fluid-based systems. The new thermal control method (first tested on GLONASS-K satellites) made it possible to maintain temperature of some critical avionics on the spacecraft within 0.1 degrees, according to its manufacturer, ISS Reshetnev. With all these upgrades, the K2 variant would improve navigation accuracy down to 30 centimeters, according to the designer general of the GLONASS system, Sergei Karutin.[66] As of 2022, the accuracy of the GLONASS system for civilian users was reported to be 1.32 meters.

However, ISS Reshetnev later disclosed that the first pair of K2 variants would be built in a different configuration than the follow-on spacecraft in the series, probably indicating that only some planned upgrades could be initially implemented, whereas other changes had to be left until better times.[67]

In the meantime, the replenishment of the GLONASS constellation was expected to continue. According to a presentation from ISS Reshetnev made in early 2022, up to 15 GLONASS-K satellites were slated for launch by 2030. The company also stated in 2021 that a newly approved GLONASS development

[64] *Ministry of Defense v. ISS Reshetnev, (*Appellate Court of Moscow District 2020), https://kad.arbitr.ru/Card/f17c2eaa-941e-4f21-8161-0154193014a4.

[65] "Two Blagovest Military Satellites Will Be Launched in December 2018" [Два военных спутника "Благовест" запустят в декаблре 2018 года], TASS, July 2, 2018, http://tass.ru/kosmos/5340171.

[66] "The First Launch of the GLONASS-K2 Navigation Satellite Was Scheduled for August 7, 2023" [Первый запуск навигационного аппарата "Глонасс-К2" с Плесецка запланировали на 7 августа], TASS, July 31, 2023, https://tass.ru/kosmos/18416221.

[67] "Refreshment of the System" [Обновление системы], *Sibirsky Sputnik* 9, no. 517 (2021), p. 3.

program called for the launch of 13 satellites in the K2 series by the end of the decade.[68]

Until the middle of the 2020s, the K2 variant would operate with older satellites, which would be eventually phased out. At least eight GLONASS-K1 satellites were planned for launch by 2024, but these missions are likely to continue well into the second half of the 2020s. In 2022, four K2 variants and eight K1 variants were in production at ISS Reshetnev for the GLONASS constellation.[69]

Low-orbit communications constellations

In 2022, the Russian invasion of Ukraine demonstrated the military significance of the fledgling Starlink constellation, which provided near-instantaneous broadband internet access thanks to hundreds of satellites in low orbit. Among various applications, it reportedly allowed commands and video communications with aerial drones guiding and correcting artillery fire or surface and sea drones heading out on suicide missions.

Not coincidentally, around the same time, a Russian startup called Buro-1440 advertised its commitment to building a similar network, even though the economic feasibility of the whole concept remained unclear. It appeared that factors beyond pure commerce were at play given the sorry state of space business in Russia.[70] In 2023, Buro-1440 emerged on the scene with a state-of-the-art mission control facility in Moscow, clearly modeled after the SpaceX facility in Hawthorne, California. The company also reportedly offered its prospective hires double the salary offered at Roscosmos.[71] The company launched its first experimental satellite in 2023 and promised to begin deploying the actual constellation in 2025 by launching between 10 and 12 rockets per year with 15 satellites onboard. The constellation is expected to be completed in 2035 with around 900 satellites in orbit.[72]

The development of Starlink and other low-orbital networks, which required hundreds or even thousands of satellites, was tied to two other challenges facing the Russian space industry—scaling up production and cutting costs of individual satellites. In the early 2020s, Russian officials continuously stressed that organizing spacecraft conveyor belts was a key task for the industry.

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68 "GLONASS Perspectives" [Перспектива ГЛОНАСС], *Sibirsky Sputnik* 25, no. 533 (2021), p. 2.

69 Vestnik GLONASS, "Around 15 Newest GLONASS Satellites Will Be Launched Before 2030" [До 2030 года будут запущены около 15 новейших навигационных спутников "Глонасс-К2"], Apr. 17, 2022, http://vestnik-glonass.ru/news/tech/do-2030-goda-budut-zapushcheny-okolo-15-navigatsionnykh-sputnikov-glonassk2/.

70 "IKS Holding Company Will Launch 900 Low-Orbit Satellites by 2035" [Компания "ИКС холдинга" к 2035 году запустит на орбиту 900 низкоорбитальных спутников], TASS, July 7, 2022, https://tass.ru/kosmos/18216983.

71 Zakrytyi Kosmos Telegram Channel, "A Few More Answers about 'Buro 1440'" [Еще несколько ответов про "Бюро 1440"], Feb. 8, 2023, http://t.me/roscosmos_press/819.

72 "IKS Holding Company," TASS.

ASAT WEAPONS

On November 15, 2021, as the mass buildup of troops and armor on the Ukrainian border was becoming increasingly evident to the public, the Russian military stunned the world with a reckless antisatellite test, destroying the defunct Kosmos-1408 (Tselina-D) spacecraft, originally built in the Soviet Ukraine. The resulting cloud of some 1,500 debris posed a direct and long-term threat to the International Space Station (ISS), which is permanently inhabited by a crew—including Russian cosmonauts. Kosmos-1408 was apparently destroyed by a direct-ascent missile, developed under the Nudol project and based in Plesetsk. The system apparently uses a mobile launcher with two missiles encapsulated into individual containers.

In addition to the Nudol complex, Russia advertised the development of several other ASAT systems. According to multiple Russian sources, work continued on both the new version of the Soviet-era Kontakt 76M6 antisatellite missile intended for a mid-air launch from the MiG-31 aircraft[73] and on the A-60 Sokol-Eshelon laser system based on the Il-76 aircraft.[74]

In 2018, photos of a MiG-31 with a full-scale mockup of an antisatellite missile began circulating on the internet. At the time, US intelligence officials were quoted as saying that the system was expected to be operational by 2022.[75]

In 2021, Russian sources linked the 14K168 Burevestnik project to the latest effort to build an aircraft-launched antisatellite system.[76] The two-stage solid-propellant missile, intended to be dropped from a MiG-31, was designed to carry a conventional or nuclear warhead and could attack low-orbiting satellites at altitudes of up to 500 kilometers.[77]

Laser systems

In addition to antisatellite missiles, Russia also jump-started the Soviet effort to build lasers powerful and accurate enough to temporarily dazzle or even completely blind sensitive equipment on orbiting satellites.

In May 2022, Deputy Prime Minister Borisov said the Russian armed forces were in the process of being equipped with the Peresvet laser system, which was reportedly capable of blinding enemy satellites in orbit up to an altitude of 1,500 kilometers. Borisov also promised the emergence of weapons using "new physical principles" in the following decade, including electromagnetic systems.[78]

Bart Hendrickx also identified the OKR Kalina project, conducted by the corporation Precision Instruments Systems, NPK SPP, with the goal of building the 30Zh6MK optical laser facility in the mountains of Northern Caucuses, where it would be capable of

[73] "Russia Is Developing the Burevestnik Complex to Combat Satellites" [Россия разрабатывает комплекс «Буревестник» для борьбы со спутниками], *Novosti Kosmonavtiki*, Jan. 4, 2021, https://novosti-kosmonavtiki.ru/news/78181/.

[74] *Annual Report of OAO KBKhA Design Bureau for 2011* [Годовой Отчет ОАО КБХА за 2011 г.], May 15, 2012, p. 20.

[75] "Russian Missile Identified as Anti-Satellite Weapon to Be Ready by 2022," NCBC, Oct. 25, 2018, https://www.ncbc.com/2018/10/25/russian-missile-identified-as-anti-satellite-weapon-ready-by-2022.

[76] "Russia Is Developing the Burevestnik Complex," *Novosti Kosmonavtiki*.

[77] Military Russia, "Complex 14K168 Burevestnik, Rocket 14A045," Apr. 22, 2020, http://www.militaryrussia.ru/blog/topic-914.html.

[78] "Borisov: The Peresvet Laser Complex Allows You to Blind Satellites at an Altitude of Up to 1,500 Km" [Борисов: лазерный комплекс "Пересвет" позволяет ослеплять спутники на высоте до 1 500 км], TASS, May 18, 2022, https://tass.ru/armiya-i-opk/14655039.

affecting optical systems of satellites. The project appeared to be ongoing for much of the 2010s.

Russian sources also advertised a far-fetched concept of installing the Sokol-Eshelon laser system on a spacecraft powered by a nuclear reactor to form an orbital antisatellite platform.[79]

Notably, in October 2022, the unannounced antisatellite weapons race escalated into a diplomatic duel between Russia and the United States. First, Konstantin Vorontsov, deputy director for Non-Proliferation and Arms Control at the Russian Foreign Ministry, said that Russia could legitimately target US satellites helping the Ukrainian military.[80] The statement coincided with high-profile stories in the Western media about the use of Starlink satellites by the Ukrainian military. Unlike the usual endless stream of threats and innuendo in the Russian propaganda channels, Vorontsov's statement was taken seriously enough in the US to warrant a reminder to Moscow from John Kirby, the national security coordinator for strategic communications at the White House, that no attack on US infrastructure would go unanswered.[81] As of 2023, no intercepts had taken place, and Starlink could continue business as usual in Ukraine.

Co-orbital ASAT system and inspector satellites

In the 2010s, the Russian arsenal of antisatellite projects diversified even further with the 21st-century reincarnation of the co-orbital satellite killer. The new type of maneuverable satellite, intended for suicide missions in orbit, was brought on the scene by a newcomer to the Russian spacecraft development field. As researched by Bart Hendrickx, the Moscow-based TsNIIKhM organization led the development of a plethora of relatively small but sophisticated spacecraft, such as Burevestnik, Nivelir, Napryazhenie, and Numizmat. Burevestnik (not to be confused with an ASAT weapon with the same name) turned out to be a prospective maneuverable orbiter designed to knock out enemy spacecraft.[82]

At the same time, TsNIIKhM's Nivelir project relied on a similar miniature satellite platform to develop an inspector satellite, perhaps the most intriguing project in the Russian military space program, which appeared in the 2010s and continued in the 2020s.[83]

Starting in 2013, routine Russian military launches were delivering mysterious extra payloads, which were displaying increasingly complex orbital maneuvers. Soon after the first missions, identified as Kosmos-2491 and -2499, attracted public attention, the Russian government tried to deny the military nature of the effort. Speaking at a year-end press conference on December 15, 2014, the head of Roscosmos, Oleg Ostapenko, said that maneuverable satellites had been developed through cooperation between Roscosmos and the Russian Academy of Sciences and that they had been intended for peaceful purposes, including unspecified research by educational institutions.

As the missions continued to evolve, more credible explanations were needed. In 2017, a new "mothership," later linked to a project at NPO

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79 "MAKS Aviasalon" [Авиасалон МАКС], MAKS-2023 Press Release, Apr. 10, 2023, t.me/aviasalonmaks/6796.

80 "Closed Cosmos" [Закрытый космос], TASS, Oct. 27, 2022, http://www.t.me/roscosmos_press/488.

81 Stan Pribylov, "The Kremlin Tries to Scare the US and the West with 'Star Wars'" [Кремль попытался напугать США и Запад «звездными войнами»], Golos Ameriki, Oct. 28, 2022, https://www.golosameriki.com/a/russian--diplomat-star-wars-threat/6809550.html.

82 Bart Hendrickx, Postings on the Novosti Kosmonavtiki eb Forum (2017–2023), http://forum.novosti-kosmonavtiki.ru.

83 "Means of Space Control" [Космицческие средства контроля], GNTs RF FGUP "TsNIIKhM," accessed Oct. 16, 2022, http://cniihm.ru/о-фгуп-цниихм/научные-направления/космические-средства-контроля/.

Lavochkin, went into orbit and released its own maneuvering objects. On August 23, 2017, the Russian Ministry of Defense announced that a miniature vehicle designed to inspect other satellites in orbit had been released from a military spacecraft launched with the Kosmos-2519 mission.[84] The official statement from the Ministry of Defense read as follows:

> On June 23 of this year, a spacecraft developed for the Russian Ministry of Defense was launched from Plesetsk Cosmodrome. That spacecraft represents a space platform, which can carry different variants of payloads. Today, from that platform, took place the separation of a small spacecraft intended for the inspection of the condition of a Russian satellite. Later on, a scientific experiment is being planned to study that satellite's external appearance with the small (inspector) spacecraft.[85]

In the meantime, tracking data indicated that at the beginning of August 2017, that very spacecraft had synchronized its orbital inclination with that of the Kosmos-2486 (Persona) reconnaissance satellite launched on June 7, 2013. It was the apparent target of the inspection referenced in the Ministry of Defense's official statement.[86]

In its official registration to the United Nations, Russia reported that the satellite separating from Kosmos-2519 on August 23, 2017, had received the official designation of Kosmos-2521.[87] Then, on October 30, 2017, Kosmos-2521 also released a subsatellite, which was officially named Kosmos-2523. According to tracking data from the US Space Force, Kosmos-2521 reentered the Earth's atmosphere on September 12, 2019, after its orbit decayed to an altitude between 126 and 113 kilometers.

On July 10, 2019, a Soyuz-2-1v/Volga rocket launched four payloads officially identified as Kosmos-2535, Kosmos-2536, Kosmos-2537, and Kosmos-2538. According to the Ministry of Defense, the satellites were intended to study the artificial and natural effects of space on the Russian spacecraft and to calibrate the radar systems of Russia's Air and Space Forces (VKS).

Press releases followed the launch. On August 1, 2019, the official TASS news agency quoted the Russian Ministry of Defense as saying that a Russian military satellite inspector had conducted orbital servicing of a Russian "registrar" satellite: "The inspection of the condition and the orbital servicing of the registrar satellite had been performed with the use of the inspector satellite. The transmission of instrument and telemetry data about the condition of the registrar satellite had also been conducted."[88]

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[84] Department of Information and Mass Communications of the Russian Ministry of Defense, "A Spacecraft Developed for the Ministry of Defense Was Launched on June 23, 2017" [23 июня текущего года с космодрома Плесецк был осуществлен запуск космического аппарата в интересах Минообороны России.], Aug. 23, 2017, http://function.mil.ru/news_page/country/more.htm?id=12139523@egNews.

[85] "Experimental Spacecraft-Inspector Developed for Ministry of Defense Separates from Satellite" [Созданный для Минобороны РФ экспериментальный аппарат-инспектор отделился от спутника], TASS, Oct. 30, 2017, http://www.tass.ru/armiya-i-opk/4686774.

[86] "Experimental Spacecraft-Inspector," TASS.

[87] Official notes to the Secretary General of the United Nations, Russian Ministry of Foreign Affairs, MID, Oct. 11 and Nov. 12, 2017, ST/SG/SER.E/824, V.18-01128 and ST/SG/SER.E/826, V.18-01122.

[88] Russian Ministry of Defense Statement, *Ministry of Defense Continues Flight Tests of Spacecraft Kosmos-2535 and Kosmos-2536* [Минобороны РФ продолжает летные испытания космических аппаратор Космос-2535 и Космос-2536], Aug. 1, 2019, https://function.mil.ru/news_page/country/more.htm?id=12244103@egNews.

According to the report, the inspection was performed during tests of Kosmos-2535 and Kosmos-2536 satellites. During the test on August 1, the military also gathered and processed orbital parameters of these satellites, performed checks of operational modes, and assessed payload parameters. The Ministry of Defense said that the "equipment records the influence on the spacecraft-registrar of space junk, electron and proton emissions from the external natural radiation belt of the Earth, protons and heavy charged particles, [and] solar and galactic space rays."[89]

In the meantime, available orbital elements indicated that newly formed fragments, originating from one of the satellites, appeared to be heading toward another object associated with the launch, hinting that the antisatellite weapon had been tested. Dockings between Kosmos-2535 and Kosmos-2536 were also suspected.[90]

Russian "inspectors" begin chasing US satellites

After a series of test flights in the 2010s, the Russian "inspector" program appeared to transition to "operational" status, which manifested itself in bold attempts to "chase" American satellites.

On November 25, 2019, a Soyuz-2-1v rocket launched the Kosmos-2542 satellite that, according to the Russian military, was based on a standard platform capable of monitoring the condition of Russian satellites. Interfax quoted the Ministry of Defense as saying, "The optical equipment also allows the spacecraft to conduct imaging of the Earth's surface."[91]

On December 6, 2019, the Russian Ministry of Defense announced that a small subsatellite had separated from the multifunctional platform in orbit. The announcement also said, "In the course of the experiment, visual information is being transmitted to the ground processing facilities in order to assess the technical status of the spacecraft under observation."[92]

By December 9 of that same year, the US radar detected the first maneuver of the new satellite, designated 2019-079D in the US and Kosmos-2543 in Russia, which boosted its perigee by 4 kilometers. By mid-December 2019, the subsatellite boosted its perigee by 55 kilometers. Because the mother vehicle entered orbit within 1 degree of inclination from the USA-245 classified satellite, observers immediately suspected an attempt by the Russian pair to intercept and inspect the American spacecraft.[93] Interestingly, according to satellite observer Nico Janssen, between December 9 and December 10, USA-245 left its 272-by-985-kilometer orbit and maneuvered somewhere else, possibly attempting to prevent a close encounter with the newly released Kosmos-2543, which climbed to a 590-by-859-kilometer orbit.[94]

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89 Russian Ministry of Defense Statement, *Ministry of Defense Continues Flight Tests*.

90 Nico Janssen, "Kosmos 2535/2536/2543 Operations," message via SeeSat-l at seesat@satobs.org, Sept. 19, 2020.

91 "Russian Military Began Controlling New Satellite Which Is Capable of Monitoring Other Satellites and of Watching the Earth" [Российские военные взяли под контроль новый спутник, способный инспектировать другие и космические аппараты и наблюдать Землю], Interfax, Nov. 26, 2023, https://www.militarynews.ru/story.asp?rid=1&nid=522436.

92 "Ministry of Defense Tested Satellite-Inspector" [Минобороны испытало спутник-инспектор], RIA Novosti, Dec. 6, 2019, https://www.ria.ru/20191206/1562069408.html.

93 Tim Collins, "Kosmos 2542/2543 vs. USA 245?," message via SeeSat-l at seesat@satobs.org, Dec. 26, 2019.

94 Janssen, "Kosmos 2542/2543 vs. USA 245?," message via SeeSat-l at seesat@satobs.org, Dec. 26, 2019.

It took almost two years for another presumed inspector to launch on August 1, 2022.[95] This time, the spacecraft designated Kosmos-2558 was launched into a proximity orbit with the American USA-326 satellite.[96]

In the following months, Kosmos-2558 continued performing orbit corrections two or three times per month to keep its orbital altitude between 441 and 444 kilometers, apparently to maintain its orbital plane close to that of USA-326, according to tracking by Janssen. But by the middle of March 2023, the Russian satellite climbed even closer to its apparent US target, making possible periodic passes. Janssen estimated that Kosmos-2558 would pass around 44.6 kilometers from USA-326 on March 18, 2023. Once again, the American satellite was detected performing a last-minute evasive maneuver right before a close encounter attempt as close as 31 kilometers around April 7, 2023.

The final known "inspector" mission was simultaneously launched with Kosmos-2561 and Kosmos-2562 on October 21, 2022. This time, the orbital maneuvers of the Kosmos-2562 satellite appeared to be synchronized with those of a "civilian" Resurs-P No. 3 remote-sensing satellite.[97]

In recent years, fragmentary official information hinted that the orbital inspector program had continued into the 2020s. For example, in 2021, ISS Reshetnev reported that its specialists had developed a mechanism for multiple deployment and folding of solar panels in orbit, which could increase on-demand maneuverability of the spacecraft.[98] For more data on inspector satellites, see Table 1.

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95 Langbroek, "New blogpost: 'Kosmos 2558, a Russian inspector satellite targetting the US IMMINT satellite USA 326?,'" Tweet, X, Aug. 2, 2022, https://twitter.com/Marco_Langbroek/status/1554491449017831424.

96 Nico Janssen, "Re: Russian Launch—Aug 1," message via SeeSat-1 at seesat@satobs.org, Aug. 2022, http://www.satobs.org/seesat/Aug-2022/0010.html.

97 Jonathan (@planet4589) McDowell, "The Kosmos-2562 satellite, launched in Oct 2022, appears to have a mission to carry out proximity operations with the retired Resurs-P3 satellite," Tweet, X, May 9, 2023, https://twitter.com/planet4589/status/1656145400426790912.

98 "The Art of Mechanics" [Искусство механики], *Sibirsky Sputnik* 23, no. 531 (2021), p. 8.

Table 1. Summary of "inspector satellite" launches

Launch date	Launch vehicle	Spacecraft	Details
Dec. 25, 2013	Rockot/Briz-KM	Kosmos-2488, -2489, -2490, -2491	Kosmos-2491 not announced at the time of the launch; made orbital maneuvers; disintegrated in Dec. 2019
May 23, 2014	Rockot/Briz-KM	Kosmos-2496, -2497, -2498, -2499	Object E (Kosmos-2499 not announced at the time of the launch) made orbital maneuvers, performed rendezvous with Briz-KM; disintegrated on Oct. 23, 2021
Mar. 31, 2015	Rockot/Briz-KM	Three Gonets-M, Kosmos-2504	Kosmos-2504 maneuvered in orbit, multiple rendezvous with Briz-KM stage in 2015, maneuvered again in 2017, passed near a Chinese satellite debris. Made simultaneous maneuvers with Kosmos-2499 in 2017 and with Kosmos-2542/-2543 pair in 2019
June 23, 2017	Soyuz-2-1v/Volga	Kosmos-2519	Released multiple subsatellites, Kosmos-2521, -2523. Performed in-orbit maneuvering
Nov. 30, 2018	Rockot/Briz-KM	Kosmos-2530, -2531, -2532	Object E was detected in orbit in addition to identified satellites and an upper stage
July 10, 2019	Soyuz-2-1v/Volga	Kosmos-2535, -2536, -2537, -2538	Launched into a co-planar orbit with Kosmos-2486 (Persona). Maneuvered in orbit, released multiple fragments
Nov. 25, 2019	Soyuz-2-1v/Volga	Kosmos-2542, -2543	Announced as based on a standard platform that can monitor the condition of Russian satellites. Made attempts to approach USA-245 satellite, which maneuvered to a different orbit. Kosmos-2543 performed rendezvous with Kosmos-2535. Kosmos-2543 released an unidentified object
Dec. 3, 2020	Soyuz-2-1b/Fregat	Kosmos-2548	Unidentified 5th satellite (Object E) was detected around Dec. 14, 2020
Aug. 1, 2020	Soyuz-2-1v/Volga	Kosmos-2558	Attempted to chase USA-326 in 2023
Oct. 21, 2022	Soyuz-2-1v/Volga	Kosmos-2561, -2562	Kosmos-2562 maneuvered near Resurs-P No. 3

Source: Compiled by Anatoly Zak based on information from RussianSpaceWeb.com.

NEW GENERATION OF GEODESIC SATELLITES?

Mysterious missions were associated with four Russian military launches from Plesetsk between 2021 and 2023. Despite being delivered into orbit by two types of vehicles—Soyuz-2-1v and Angara-1.2—their commonality was hinted at by similar orbital parameters and initially by their behavior, or rather lack of behavior. All of these lightweight satellites were inserted into a slightly elliptical orbit around 300 kilometers in altitude and inclined 96.4 degrees toward the equator. The first three payloads, designated Kosmos-2551, Kosmos-2555, and Kosmos-2560, made no discernable orbital maneuvers and remained in orbit from a few weeks to a couple of months waiting for the third spacecraft.

Then, the apparent fourth member of the same family was launched on March 29, 2023, into a similar orbit. Initially, it showed no detectable propulsive activity, even though it was seemingly in a stable flight. As expected, the satellite was slowly losing altitude as a result of atmospheric drag until summer 2023, when US Space Force tracking data indicated small but noticeable "bumps" in apogee and perigee, suggesting that the satellite had finally activated some kind of low-thrust propulsion system, counteracting its natural decay.[99]

From the outset, these launches were associated with the EO-MKA experimental project at TsNIIKhM, which also produced orbital inspectors. A credible report also appeared on the Russian *Novosti Kosmonavtiki* forum stating that the satellites were used as targets for testing ground–based Peresvet antisatellite lasers.

However, Western researcher Bart Hendrickx unearthed extensive evidence linking these types of launches to the Geovysota project, which also originated at TsNIIKhM. Multiple contract documentation and litigation records indicated that the Geovysota project had called for the development of an exotic geodesic satellite using an aerodynamic shape pioneered by the European GOCE satellite, except that its Russian copycat would be propelled by an innovative electric ramjet, which had never been used in space before.[100] These new thrusters apparently suck particles from the rarified air in the upper atmosphere through a special inlet and direct them into an electric ionizing chamber that produces low but constant thrust. A gradual trial-and-error testing of the new propulsion system on Geovysota satellites could explain the lack of discernable maneuvers during their earlier missions.

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99 Russian Space Web, "Soyuz-2-1v Rocket Launches Military Payload," N.D., https://www.russianspaceweb.com/eo_mka4.html.

100 Bart Hendrickx, "NIR Geovysota," *Novosti Kosmonavtiki* Forum, May 25, 2022, https://forum.novosti-kosmonavtiki.ru/index.php?topic=20844.0.

Table 2. Summary of EO-MKA (Geovysota) launches

Launch date	Launch-vehicle	Spacecraft	Details
Sept. 9, 2021	Soyuz-2-1v	Kosmos-2551	Inserted into 295-by-307-kilometer orbit with the inclination 96.35 degrees
Apr. 29, 2022	Angara-1.2	Kosmos-2555	Inserted into 279-by-294-kilometer orbit with the inclination 96.5 degrees
Oct. 15, 2022	Angara-1.2	Kosmos-2560	Inserted into 329-by-344-kilometer orbit with the inclination 96.4 degrees
Mar. 28, 2023	Soyuz-2-1v	Kosmos-2568	Inserted into 329-by-345-kilometer orbit with the inclination 96.4 degrees. Conducted orbital maneuvers

Source: Robert Christy, Orbital Focus, http://orbitalfocus.uk/Diaries/Launches/.

ORBITAL SPACE PLANE

In addition to developing antisatellite weapons and orbital inspections, there were signs that Russia was interested in developing an orbital mini-shuttle similar to the American X-37 orbiter and its Chinese equivalent. On October 2, 2020, Roscosmos State Corporation solicited bids for a preliminary study code-named Avangard-Pilot-MMKK, worth 238.75 million rubles ($3.07 million). The study was a part of the wider Avangard research project intended to propose civilian and dual-purpose spacecraft for future development.[101]

The Pilot-MMKK study was tasked with drawing up a technical and economic justification for a reusable multipurpose space vehicle, abbreviated in Russian as MMKK. Starting in 2020, the project would continue for around two years and would have to be completed by August 30, 2022. In the course of the work, the contract winner would have to formulate the design concept of the space plane, assess the feasibility of its development, catalog critical technologies required for the implementation of the project, and list its practical missions, including the delivery, servicing, and return of cargo from orbit.

As its outcome, the study would have to produce a draft of a technical assignment for the preliminary development, OKR, of a reusable spacecraft. The OKR is the Russian equivalent of the preliminary development in the Western aerospace industry. Therefore, the Pilot-MMKK study would be limited to a pre-preliminary level, which could eventually lead to the preliminary design and full-scale development of the spacecraft.

The tender documentation[102] for the Pilot-MMKK project said that the planned vehicle would be used for transport operations and technical support of low-orbiting piloted and automated systems and that the architecture of the ship would serve as the basis for a piloted version. However, the lack of wider public information about the project and the absence of a clear link between the work and the current Russian strategy in human space flight indicated that the Ministry of Defense would most likely be the customer for the proposed vehicle.

The tender documentation for the Pilot-MMKK project required that officials working on the project hold a secret clearance and that all the work and subcontracts associated with the project have special arrangements designed to preserve state secrets.

Both the secrecy level around the Pilot-MMKK project and the available information indicated that in its conceived form, the spacecraft resembled the X-37 project in the United States, as well as its recently launched Chinese equivalent. Neither country detailed the exact mission of their minishuttles, but these vehicles were believed to be used for long-duration military experiments, including tests of equipment for future spy satellites. As of 2023, the exact status of the MMKK project remains unclear.

[101] RTS Tender No. 0995000000220000061, "Avangard (Pilot)-MMKK Systems Research" [Системные исследования "Авангард (Пилот)-ММКК"], Oct. 6, 2020, https://www.rts-tender.ru (not accessible outside Russia as of Oct. 9, 2023).

[102] RTS Tender No. 0995000000220000061, "Avangard."

POST-ISS SPACE STATION

At the turn of the 2020s, the Kremlin officially committed to building an Earth-orbiting space station of its own by the retirement of the ISS around 2030. A simultaneous decision to assemble its future space base on a near-polar orbit was widely advertised as an effort to finally observe the entire Russian territory, instead of the southern-most sliver of the country visible from the ISS. However, behind the scenes, the developers' attention could actually have been outside the Russian territory.

On October 2, 2020, Vladimir Soloviev, first deputy director general at RKK Energia, outlined the intention for the Russian Orbital Station (ROS) to supersede the ISS.[103] Soloviev named the following key priorities of the Russian space program regarding the operation of a habitable base in low Earth orbit:

- National security
- Monitoring natural and human-made disasters
- Early warning about threats from space
- Acceleration of technical development in Russia by creating scientific and technical potential for future large-scale projects
- Fast introduction of digital technologies

Not coincidentally, national security was listed first, and practically all secondary applications had a military dimension. The statement was clearly intended for those audiences.

Proponents of the ROS project also advocated for the revival of long abandoned or unrealized applications of space stations, such as military and dual-purpose surveillance activities, as well as semi-industrial production of unnamed biomaterials, semiconductors, and optics.

Within the station's military role, proponents advocated such applications as radar scanning of the Earth and space, the assembly of large-scale structures, including those for the calibration of ground-based early warning radar, and testing elements for the control system of the assets operated by VKS.

In any case, the transition of Russian cosmonauts from the ISS to a national space station could theoretically be attractive to the Ministry of Defense, if the developers could overcome a traditional skepticism of the military toward human space flight. It is also unclear whether military activities could be reconciled with tourism and other commercial business proposed for the future station.

[103] Vladimir Soloviev, "A Presentation at the Day of Space Science," The Space Research Institute of the Russian Academy of Sciences, RAN, Oct. 2, 2020.

GROUND INFRASTRUCTURE DEVELOPMENT

The long planned introduction of new families of military satellites was accompanied by the development of new processing and support infrastructure at the main military launch center in Plesetsk, north of Moscow.

In the early 2020s, VKS completed the construction of a large new facility identified as UNTK, which is the Russian abbreviation of Unifitsirovanny Tekhnicheskiy Kompleks (Integrated Technical Complex). The facility also has the code name 500/645-UNTK-14272. The heart of the center is Facility No. 250, which consists of a large building for preparing the new generation spacecraft for integration with the launch vehicle. It houses at least three work sites for nearly simultaneous processing of different types of satellites and space tugs compatible with the Angara-5 rocket.[104]

Each preparation bay covered an area of 27 by 16 meters and was reported to feature a vertical processing rig. Work Site No. 1 was intended for future satellites built by ISS Reshetnev in Zheleznogorsk, including Repei, Gerakl-KV, Sfera, Ispolin, and Ekspress. Because the company specialized in heavy communications and electronic-intelligence spacecraft, the facility was probably equipped with installation and testing hardware for spacecraft heading to geostationary orbit.

The room next door, identified as Work Site No. 2, was dedicated to the EKS early-warning satellites built at RKK Energia and intended for tracking enemy missile launches from highly elliptical or geostationary orbits. Finally, Work Site No. 3 was custom-built to process the Briz-M space tug, which served as the third stage of the Angara-5 rocket.

All three spacecraft processing work sites opened into the 16-meter-wide Work Site No. 4, which was intended for processing payload fairing, launching vehicle adapters, and finalizing assembly of the payload sections ahead of their integration with the rocket. The new facility was estimated to have a general length of 200 meters, a width of 80 meters, and a height of 44 meters. The overall volume was 657,676 cubic meters, providing a working area of 19,294 square meters.

Along with the development of military spacecraft, the industrial base was also noticeably upgraded. For example, in 2020, ISS Reshetnev reported the construction of the new thermal vacuum chamber, which would be the largest in the country, hinting at the increase in the size of the future Russian satellites.[105] In the same year, the company also reported major reconstruction of its production facilities, where composite materials would be produced, galvanization processes would take place, and mechanical shops would be located. ISS Reshetnev also reported the construction of new facilities for the production of waveguide devices and antenna feeders, and it reported that it had installed new equipment for manufacturing circuit boards and other components.

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[104] Channel 1HD Russian TV, "New Processing Building Is Under Construction."

[105] *Complex of Thermal and Vacuum Testing Will Be the Largest in the Country*, [Комплекс термовакуумных испытаний Решетнёвской фирмы станет самым крупным в стране], Posted by Razvitie TV Channel (YouTube, Sept. 4, 2020), Video, https://www.youtube.com/watch?v=plT7q5FYsxU.

Ground tracking component

The growing number of satellites in orbit and the increasing complexity of military activities in orbit and in the upper atmosphere prompted Russia to expand its space command and control capabilities on the ground, known in Russian as SKKP, which stands for Система Контроля Космического Пространства, or Control System of Cosmic Space.

The system included a diverse network of sensors spread across Russia and increasingly overseas as well. Official Russian sources listed the Razvyazka radar, optical telescopes in the Caucus Mountains, the radar of the Krona system, the Okno facility in the Pamir Mountains, and an observatory in the Buryat Republic among the components of the SKKP network.

In 2022, Roscosmos launched a new program called Mlechny Put ("Milky Way"). The program was advertised as an international system in which each partner could contribute its tracking assets in exchange for access to the resulting database of space objects and their paths in space. The official goal of the program was monitoring space objects and providing early warning about comet and asteroid threats. At the time, the program was also expected to have an orbital component, with the first satellite scheduled for launch in 2027.

On July 24, 2023, after more than a decade of negotiations, Roscosmos finally inaugurated its ground tracking facility in Hartebeesthoek, South Africa. Not coincidentally, South Africa was one of the few countries that took an unapologetically pro-Russian position in the Russian invasion of Ukraine. Officially, the Roscosmos facility in South Africa was intended to detect and track space junk, but practically, it provided Russia with a unique vantage point for tracking any space object passing over the Southern Hemisphere, which was very difficult to do from Russian territory. For example, the Russian ISON ground network, formally controlled by the "civilian" Academy of Sciences, was known to track US satellites from the GSSAP system in the geostationary orbit.[106] In 2017, the same site in South Africa was already employed for the deployment of equipment designed to improve the accuracy of Russia's GLONASS dual-use navigation system.

The South African optical tracking site became the second of four facilities for Russia's Automated Warning System of Threatening Situations in Near-Earth Space, ASPOS OKP, which was designed to detect objects at altitudes from 120 to 40,000 kilometers with three types of telescopes.[107]

Starting in 2018, RAN also began construction of seven facilities for the National Helio-Physics Center in the Sayan Mountains of Buryatia and in the Irkutsk Region, officially intended for studying the upper atmosphere and near-Earth space. The instruments planned were reported to include a solar telescope, a radar network, Light Detection and Ranging (LIDAR), and optical sensors. Their completion was scheduled for no later than 2030.[108]

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[106] "American Space Satellites Were Conducting Rendezvous with Russian Satellites" [Американские спутники-шпионы сближались с российскими аппаратами], RIA Novosti, Mar. 3, 2020, https://ria.ru/20190406/1552437817.html.

[107] "Yuri Borisov Participated in the Opening of the Russian Detection and Space Control Complex in South Africa," Roscosmos Press Release, July 23, 2023, http://www.roscosmos.ru/39518/.

[108] "The Construction of the Largest Solar Telescope in Eurasia Started Near Lake Baikal" [Рядом с Байкалом началось строительство крупнейшего в Евразии солнечного телескопа], TASS, Aug. 5, 2023, https://nauka.tass.ru/nauka/18450693.

CONCLUSION

During the early 2000s, the Russian space industry was able to restore some of its potential lost in the 1990s and to modernize its obsolete manufacturing and testing infrastructure inherited from the USSR. In addition, thanks to open trade and many joint commercial projects with the West, Roscosmos enjoyed healthy budgets, and its companies had many opportunities to obtain cutting-edge technologies from the West. During this time, Russia was able to build an industrial foundation for a wide range of military and civilian projects that might still yield results in the coming years.

However, given the worsening economic picture and increasing technological isolation, the industry will likely struggle for the rest of the 2020s. Despite new emphasis on defense and security and an increase in subsidies to the defense and space sector in the 2020s, many signs already hint at a deepening crisis in the space industry, inevitably affecting its military component.

Russia's unprecedented isolation from Western technologies and accelerating brain drain, triggered by the war, will likely exacerbate slow but steady degradation of the Russian technological prowess in space, including its already deficient command and control component, which likely contributed to Russia's disastrous performance in Ukraine.

In June 2022, former chief of Roscosmos Dmitry Rogozin posted on X (formerly known as Twitter) about Russia's inadequate space budget and the overwhelming superiority of NATO's command and control structure, supported by space assets:

> I have to remind that just on the budget side, we allocated $2.5 billion (for Roskosmos, while) the civilian budget of NASA is $25 billion and the civilian budget at SpaceX is equal to that at Roskosmos, and that is not counting tens of billions of dollars allocated annually for feverishly deploying US system for the control of the entire planet. In two-three years, we will have orders of magnitude more dense US command, control and targeting system. The US not simply just see our troops on the ground, they see our air force, UAVs, probe radar coverage areas, they assess time for Kalibr (cruise) missiles approach, they provide real-time target guidance to Ukrainian generals from an operational control center in Poland.[109]

Although such outcries can be dismissed as a "doom posting," they still accurately reflect general anxiety of the Russian leadership over the inferiority of the Russian military command and control system, in which satellites play a crucial role. In September 2023, even Russian Foreign Minister Sergei Lavrov added proverbial American spy satellites to the essential list of excuses for Russia losing the war in Ukraine: "No matter what the US says, they are leading this war, they are putting up weapons, ammunition, intelligence, data from satellites."[110]

[109] Igor (@JerkinGirkin) Girkin, "анализаторы анализатора анализируют," Tweet, X, June 4, 2022, http://twitter.com/GirkinGirkin/status/1532922260088045568.

[110] NOELReports (@NOELReports), "Minister of Foreign Affairs of Russia, Sergei Lavrov commented on the role of the US in the war," Tweet, X, Sept. 23, 2023, http://twitter.com/NOELreports/status/1703356748164186213.

The available information suggests that despite considerable investments and efforts along multiple directions, many of the components of the Russian military space grouping remain unfinished and far behind schedule. It includes the Russian early-warning system EKSOiBU, the new generation communications system, an electronic-intelligence system, and (perhaps most problematic for today's Russian military) the deficient imaging reconnaissance component. Moreover, the new generation of low-orbital communications systems, which are already operating in the West, are now barely on the drawing board in Russia. In the meantime, the inertia left over from the progress Russia made in previous years has manifested in recent successes, such as the introduction of the orbital radar, even as a number of critical directions within the Russian military space program appear to be stalling.

On January 24, 2023, Ukrainian intelligence issued an unusually detailed statement to the effect that the Russia space reconnaissance system was on the brink of collapse because of Western sanctions.[111] At the same time, Russian propaganda cultivated the notion that some non-Western countries or groups of countries, such as BRICS, Iran, or North Korea, could help Russia out of its technological black hole. However, so far, little available evidence has supported that idea.

For example, depending on the particular area of space technology, China, let alone any other country, has so far been either unable or unwilling to help Russia with any of its space projects, despite a continuous broad public campaign promising Sino-Russian cooperation in space. Moreover, China and India have so far flatly rejected any sizeable participation in Russian space projects, and they have equally denied Russia any significant involvement in their national projects, beyond procurement of some off-the-shelf hardware and services.

In theory, space programs in Iran and North Korea, which operated under sanctions for many decades, could be presented as a recipe for future Russian resilience in space. However, this argument more likely proves the opposite point to the one it is usually employed to make: the examples of Iran and North Korea only illustrate how backward and limited in scope the Russian space program could become if Russia remains on its present course.

Looking forward, we see a few possible scenarios for Russian military space developments. The North Korean model, deriving from a protracted war in Ukraine, will likely bring some (though not unlimited) funding into the military space sector, but it would not necessarily produce stellar results. Overall, it would likely further widen an already immense gap in space capabilities between Russia and the West.

Even if relations normalize between Moscow and the rest of the world, it is doubtful that the West would lift restrictions on the supply of dual-use technologies to Russia any time soon. But, at the very least, the Russian space industry could see less bleeding of its human talent and have some prospects for upgrading its technological capabilities in dual-use fields, such as communications and remote sensing.

If the history of the USSR is any guide, the prospects for the Russian space program, including its military component, are bleak.

[111] Main Directorate of Intelligence at the Ministry of Defense of Ukraine, "Russian Space Intelligence."

APPENDIX A: SUMMARY OF RUSSIAN MILITARY SPACECRAFT PROJECTS

Spacecraft	Mission	Status
Akvarel	Low-orbit electronic intelligence (ELINT)	Delayed/Cancelled?
Araks-R	Radar imaging	Delayed
Bars	Cartography	In operation
Blagovest	Communications	Operational
Burevestnik	ASAT	In development
Egyptsat	Imaging	Flight testing
Ekvator	Communications	In development
Geovysota	Geodesy	In development
Gerakl-KV	Data-relay	Delayed
GLONASS	Navigation	In operation
Ispolin	Communications	Delayed
Khayam	Imaging	Flight testing
Klyuch	Low-orbit communications	In development
Kupol (Tundra EKS)	Early warning	Flight testing
Labirint	ELINT	Cancelled
Lotos-S	Low-orbit ELINT	In operation
Meridian	Communications	In operation
Neitron	Radar imaging	Flight testing
Nivelir/Numizmat	Inspector/ASAT	Flight testing
Olymp	ELINT	In operation
Persona	Imaging	In operation
Pion-NKS	Low-orbit ELINT	Flight testing
Razbeg	Imaging	Flight testing
Razdan	Imaging (optical reconnaissance)	In development (?)
Repei-V, -S	ELINT	Delayed
Rodnik	Communications	In operation
Romashka	Mobile communications	Cancelled
Sfera-V, -S	Communications	Delayed
Yenisei-2	Communications	In development

Source: RussianSpaceWeb.com.

APPENDIX B: KEY RUSSIAN CONTRACTORS INVOLVED IN MILITARY SPACECRAFT DEVELOPMENT

Company	Field
ISS Reshetnev, Zheleznogorsk	Prime developer, system integrator: GLONASS, Repei, Blagovest, Gerakl, Sfera, Rodnik
OKB Fakel, Kaliningrad (Kenigsberg)	Electric propulsion systems
RKK Energia, Korolev	Prime developer, system integrator: EKSOiBU, EgyptSat
RKS Corporation, Moscow	Avionics
RKTs Progress, Samara	Prime developer, system integrator: Persona, Resurs-P, Obzor-R
NPO Lavochkin, Moscow	Prime developer, system integrator: Araks-R
NPO Mashinostroenia, Reutov	Prime developer, system integrator: Kondor-FKA, Neitron
Vega, Moscow	Radar systems
KB Arsenal, St. Petersburg	Prime developer, system integrator: Lotos-S, Pion-NKS
TsNIIKhM, Moscow	Prime developer, system integrator: Geovysota, Nivelir
VNIIEM, Moscow	Prime developer, system integrator: Khayam, Kanopus, Meteor-M, Razbeg
NPK Barl, Moscow	Optical systems

Source: RussianSpaceWeb.com.

APPENDIX C: RUSSIAN LAUNCH STATISTICS IN THE 21ST CENTURY

Year	Total Russian launches*	Total Russian spacecraft…	…including military satellites
2000	36	31	13
2001	24	30	13
2002	25	19	12
2003	21	22	12
2004	23	19	11
2005	26	20	8
2006	25	18	8
2007	26	16	9
2008	27	21	13
2009	32	29	11
2010	31	26	16
2011	34	27	11
2012	26	23	4
2013	34	31	16
2014	36	37	13
2015	29	27	11
2016	19	15	4
2017	21	20	7
2018	20	20	9
2019	25	27	12
2020	17	17	5
2021	25	15	4
2022	22	25	14
2023**	15**	15**	6**

Source: RussianSpaceWeb.com.

Note: *GLONASS is counted as military spacecraft; university cubesats and other small satellites are not included; sea launch missions are not included; Tsyklon and Dnepr launches included; dummy payloads included; Kosmos-1 solar sail suborbital payload is counted as a spacecraft. Soyuz launches from Kourou are included.

**As of Nov. 27, 2023.

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