CNA

OCTOBER 2024

Crafting the Russian War Economy:

The Effects of Export Controls on Russia's Defense Industrial Production

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DRM-2024-U-038857-1Rev

Abstract

The Russian military has greatly increased its demand for weapons and equipment since its 2022 invasion of Ukraine. As the Russian defense industry has sought to ramp up production to meet this increased demand, it has had to cope with other nations' export controls on key components, including microprocessors and machine tools, which have the potential to cripple its production capacity. This report examines one aspect of the Russian military industry's shift to a war footing—the extent to which it has been able to shift supply chains to maintain weapons production in the face of export controls. The report highlights three compensation strategies used by the Russian defense industry: import substitution, parallel imports, and foreign cooperation. Case studies demonstrate how these strategies are used to maintain military production. The report concludes with a brief discussion of how to further constrain Russia's military industrial production.

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This work was created in the performance of Federal Government Contract Number N00014-22-D-7001.

Cover image: Uralvagonzavod Research and Production Corporation, Ramil Sitdikov, RIA Novosti. Kremlin.ru.

Approved by:  **October 2024**

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This publication was funded by the Russia Strategic Initiative, U.S. European Command. The views expressed in this publication do not necessarily represent the views of the Department of Defense or the United States government.

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EXECUTIVE SUMMARY

Russia's 2022 invasion of Ukraine came as a surprise to the world. What many analysts thought before the invasion was a grand bluff has two years on become a full-blown conflict with seemingly no end in sight. It is increasingly evident that Russia was not prepared for a protracted war. The Russian government was also caught off guard initially by the scale of the sanctions and export controls that the United States and its allies imposed on Russia. The Russian defense industry was cut off from supplies of a range of critical components required to produce various platforms and munitions, just as demand for these weapons increased to replenish stocks depleted by wartime use. Beginning in 2022, Russia's defense industry went into overdrive to ramp up production, with requirements significantly exceeding initial expectations because of the scale of the Russian military's losses on the battlefield in Ukraine.

This report examines one aspect of the military industry's shift to a war footing—the extent to which it has been able to shift supply chains to maintain the production of weapons in the face of its most significant prewar foreign suppliers introducing export controls on critical components. The report focuses on three strategies that the Russian government and defense industry have used to alleviate the effects of export controls on Russian military production. These strategies include the following:

- Import substitution, which encompasses efforts by the Russian defense industry to replace sanctioned Western products with domestic counterparts
- Parallel import, which involves the import of sanctioned Western products through third countries that have not implemented sanctions against Russia
- Foreign cooperation, which entails imports of foreign military and dual-use technology produced in friendly countries and, in some cases, joint projects with those countries' defense industries

How these three strategies have been implemented by Russian defense industry can be seen through an in-depth examination of how Russia is compensating for export controls on two types of components that are critical for the continued functioning of Russia's military industrial complex: microprocessors and machine tools. The report concludes with an examination of how the combination of constraints and compensation strategies has worked in two key sectors of Russian military production. In the case of precision-guided missiles, export controls have served to constrain production but not curtail it entirely. In the case of uncrewed aerial vehicles (UAVs), Russia has been able to use a combination of parallel import and foreign cooperation to increase the rate of production while setting up its domestic industry for potential import substitution in the future.

Key findings

In the aftermath of Russia's invasion of Ukraine in early 2022, the Russian defense industrial complex initially faced serious disruptions because of the imposition of strict Western sanctions and export controls, in addition to underlying structural problems such as a labor shortage, outdated equipment, and inadequate financing. However, the government's decision to transition to a full war footing in the second half of 2022 mitigated some of the problems caused by structural issues and led Russia to focus on ways to circumvent or blunt the effects of sanctions and export controls. On the structural side, the Russian government vastly increased funding for

the defense industry and other military expenses, doubling the share of the gross domestic product devoted to military expenses in the overall budget. It increased salaries to try to reduce the defense industry's labor shortage, even as it shifted the industry to round-the-clock production. It also made plans to build new factories for military production, resulting in a rapid expansion in production capacity in both high-tech fields such as UAVs and air defense missiles and low-tech areas such as artillery shells.

Over time, the Russian government has found ways to circumvent export controls, primarily through a combination of direct import of weapons and critical components from friendly countries and parallel import of Western-produced components through a range of countries that are either supporting Russia or looking to maintain neutrality in its conflict with the West. Cooperation with foreign partners was critical in shifting the balance in fighting to Russia's advantage in 2023. North Korean ammunition supplies were key to alleviating Russia's shell hunger, allowing Russia to regain advantage in artillery fires during the fall of 2023. Licensed production of Iranian Shahed drones, combined with rapid adoption and adaptation of commercial drones, has largely negated the earlier Ukrainian advantage in the UAV sphere as well. Meanwhile, Russia has rapidly ramped up domestic production of various weapons systems and ammunition. As a result of these compensating actions, Russia's defense industrial complex is well positioned to provide its military with sufficient armaments to sustain the war effort over the next one to two years.

That said, much of the equipment that is being brought into service is refurbished existing stocks, especially tanks and armored vehicles. There is little evidence to date of expansion of new production other than in low-tech areas such as ammunition. Meanwhile, in the longer term, the technological gap between Russia and the West will likely widen. Although Russia has found ways to import the components that it needs to produce its existing military platforms and weapons, it has had more difficulty importing the most advanced microelectronics and other components necessary for future generations of military hardware. When combined with Russia's failure to develop a domestic capability to produce advanced microchips and machine tools, this import gap may lead to a gradual stagnation in Russia's ability to build advanced weaponry.

Implications

Because of the direct and indirect long-term effects of sanctions and export controls, Russia will find it more difficult to build advanced weapons that depend on advanced microchips and high-end machine tools. It will be able to maintain production of its existing designs, but as Western machine tools wear out and adequate numbers of replacement tools fail to arrive, production of advanced weapons will likely slow as well.

The key vulnerabilities remain in microelectronics and high-end machine tools. Although Russia has for the moment been able to maintain its supply of these types of components, its defense industry would be highly vulnerable if supply were cut off. Current export control policies apply only to the most precise machine tools and to higher end electronic components. Although these policies may ensure that the technological gap between Russia and the West grows in the long run, they allow Russia to import the types of components that its military industry uses currently, which in turn allows Russia to build weapons for its ongoing military campaign in Ukraine. Given Russia's defense industry's vulnerability in these sectors and the difficulty in a priori distinguishing between potentially legitimate and illegitimate uses of imported machine tools and microprocessors, one benefit of a blanket ban on the export of machine tools and microprocessors is that

it would potentially play a major role in damaging Russian military production in the immediate term.

A second benefit of a blanket ban would be to simplify the enforcement of export controls. Currently, ambiguity regarding the specific types of components being exported to Russia allows importers to evade export controls. Expanding the extent of the ban on exports would close this loophole. In addition, coordination among all countries involved in the export control regime to synchronize their restrictions would further eliminate potential loopholes. Finally, increasing the capacity of relevant national enforcement bodies by increasing funding and personnel dedicated to sanctions enforcement would heighten the risk to companies looking to violate the export control regime and thereby lead to increased compliance.

Although a blanket ban would address some of the problems associated with ongoing permitted transfers of advanced Western technologies to Russia, Western countries should consider additional measures to combat Russia's parallel import programs. For one, the West should explore using secondary sanctions against countries that permit transshipment hubs to operate unabated within their territories. Current Western efforts to target individual persons or entities participating in illicit transshipments to Russia have been largely ineffective because of these companies' ability to rapidly change names, adopt new forms, and otherwise evade enforcement actions. By targeting the host countries themselves, Western states can raise the costs associated with allowing this kind of activity while encouraging local enforcement action.

Likewise, another measure Western states can pursue is to target their enforcement actions at the most critical supply chains to magnify the effects of their limited enforcement resources. Russia's warfighting ability in Ukraine is more dependent on certain kinds of weapon systems than on others. For example, production of the most advanced Russian electronic warfare systems requires high-end microchips and specialized materials largely supplied by the West. The same is likely to be true of the production of certain advanced Russian air defense systems, fourth-generation combat aircraft, and advanced missile systems. Moreover, the most advanced Western technologies are less readily available on global markets and thus harder for Russia to obtain through parallel import channels. In some cases, denying Russia access to just a few critical components could potentially disrupt production of a key weapon system.

Finally, Western policy-makers should consider ways to better coordinate sanctions activities with military assistance programs. For example, increasing the attrition rates for key Russian weapons systems would exacerbate the Russian defense production challenges. An obvious example would be to further strengthen Ukraine's air defenses to allow it to intercept a higher percentage of Russian cruise missiles and drones. This effort in turn would put even more pressure on Russian missile manufacturers that are already struggling to keep up production because of Western sanctions.

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TABLE OF CONTENTS

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INTRODUCTION

Russia's 2022 invasion of Ukraine came as a surprise to the world. What many analysts thought before the invasion was a grand bluff has two years on become a full-blown conflict with seemingly no end in sight. It is increasingly evident that Russia was not prepared for a protracted war. Because Russian leaders believed that the war would last only a few weeks and sought to maintain almost complete secrecy before the invasion, the Russian government had not taken steps to put its military industry on a war footing. As a result, the Russian defense industry was initially unprepared for the increased demand for armaments from the military.

The Russian government was also caught off guard initially by the scale of the sanctions and export controls that the United States and its allies imposed on Russia. Although Russian leaders had expected and prepared for serious sanctions from the United States and its North Atlantic Treaty Organization (NATO) allies, as well as from key Asian states such as Japan and Australia, they were somewhat surprised that important Russian economic partners in Asia that had not previously enacted sanctions against Russia, such as South Korea, Taiwan, and Singapore, also chose to participate in the sanctions regime.[1] Russian leaders were also surprised by some of the specific sanctions that were imposed against Russia, particularly the unprecedented freeze on Russian Central Bank assets held abroad.[2] Although the initial effect on Russia's financial stability was severe, quick action by the Russian Central Bank and senior economic ministers stabilized the macroeconomic situation. The Russian defense industry, however, was cut off from supplies of a range of critical components required to produce various platforms and munitions just as demand for these weapons increased to replenish stocks depleted by wartime use.

This report examines one aspect of the military industry's shift to a war footing—the extent to which it has been able to shift supply chains to maintain the production of weapons in the face of its most significant prewar foreign suppliers introducing export controls on critical components.

Beginning in 2022, Russia's defense industry went into overdrive to ramp up production, with requirements significantly exceeding initial expectations because of the scale of the Russian military's losses on the battlefield in Ukraine. This report examines one aspect of the military industry's shift to a war footing—the extent to which it has been able to shift supply chains to maintain the production of weapons in the face of its most significant prewar foreign suppliers introducing export controls on critical components.

[1] Valentin Golovachev and Vera Perminova, "Taiwan's Reaction to the Russian Special Military Operation in Ukraine [Реакция Тайваня на специальную военную операцию РФ на Украине]," *Vostochnaia Analitika* 2 (2022), pp. 22–31, https://cyberleninka.ru/article/n/reaktsiya-tayvanya-na-spetsialnuyu-voennuyu-operatsiyu-rf-na-ukraine-kratkiy-obzor.

[2] Alan Rappeport, "U.S. Escalates Sanctions with a Freeze on Russian Central Bank Assets," *New York Times*, Feb. 28, 2022, https://www.nytimes.com/2022/02/28/us/politics/us-sanctions-russia-central-bank.html.

Report structure

The first part of this report examines four types of constraints under which the Russian defense industry has been operating. The first three—manpower, industrial, and budgetary—explain the prevailing economic environment when strict Western sanctions and export controls, the fourth constraint, were introduced after Russia's invasion of Ukraine in February 2022 (see Figure 1). The second part of this report considers how the Russian government and defense industry have worked to mitigate the effect of export controls on Russian military production. It focuses on three strategies:

1. Import substitution, which encompasses efforts by the Russian defense industry to replace sanctioned Western products with domestic counterparts

Figure 1. Russian defense industry constraints and strategies

Source: CNA.

2. Parallel import, which involves the import of sanctioned Western products through third countries that have not implemented sanctions against Russia

3. Foreign cooperation, which entails imports of foreign military and dual-use technology produced in friendly countries and, in some cases, joint projects with those countries' defense industries

General discussion of each of these three strategies, including where and how they are being used, is followed by in-depth case studies of how Russia is compensating for export controls on two types of components that are critical for the continued functioning of Russia's military industrial complex: microprocessors and machine tools.[3] The third part of the report examines how the combination of constraints and compensation strategies has worked in two key sectors of Russian military production. In the case of precision-guided missiles, export controls have served to constrain production but not curtail it entirely. In the case of uncrewed aerial vehicles (UAVs), Russia has used a combination of parallel import and foreign cooperation to increase the rate of production while setting up its domestic industry for potential import substitution in the future. The report concludes with a brief discussion of implications and recommendations for how to further constrain Russia's military industrial production.

Methodology

The first part, which provides an overview of the constraints under which the Russian defense industry is operating, is based primarily on secondary sources. The goal of the section is largely to set the scene for the detailed analysis of compensation strategies that follows. The analysis in this part is largely empirical. For example, in our analysis of budgetary constraints, we examine whether the Russian government is planning to devote adequate financial resources to maintain defense industrial production at the levels needed to keep the military supplied and whether it has the financial reserves to finance those plans. Similarly, we summarize existing discussions of labor shortages and the dilemmas those shortages pose for Russia's defense industry.

The second part addresses the three compensation strategies used by Russia's defense industry. The discussion of import substitution uses Russian production statistics and official and media reporting to examine Russian efforts to build domestic production and the extent to which these efforts have succeeded in replacing imported components. The discussion of parallel import and foreign cooperation is focused on key bilateral relationships, using trade statistics and open-source reporting in multiple languages to analyze the extent to which countries that have not implemented export controls are providing Russia with key components and weapons.

[3] Machine tools are defined as machines that are used to cut or shape metal or other rigid materials. Basic types of machine tools include lathes, drills, shapers, milling machines, grinding machines, power saws, and presses. "Basic Machine Tools," *Britannica*, www.britannica.com/technology/machine-tool.

Similar types of sources, especially trade statistics, are used in the two case studies that focus on two critical sets of inputs: microprocessors and machine tools. In these case studies, we begin with a discussion of the extent of Russian dependence on Western sources followed by a review of the compensation strategies used in that sector. For example, the stockpiling of microchips before the 2022 invasion of Ukraine suggests that preparations for likely repercussions were underway before the attack was launched. We look at production data to analyze the extent to which import substitution has helped to compensate for gaps in import of Western components, finding that this strategy has been largely inadequate. Trade data, on the other hand, show that parallel import of Western semiconductors through third-party countries have played the key role in plugging gaps in legitimate imports. Furthermore, a review of discussions in the Russian press and official government statements suggests that in the long term, Russia is betting on cooperation with China to advance its own production of critical components.

The final part addresses the effect of the combination of constraints and compensation strategies on Russian defense industrial production in two key sectors: missiles and UAVs. We again use production statistics and open-source reporting to discuss how constraints and compensation strategies have affected production of precision-guided missiles and UAVs.

LIMITATIONS ON RUSSIAN DEFENSE INDUSTRY

The Russian defense industrial complex's ability to provide weapons and equipment for the Russian military is subject to four constraining factors: manpower constraints, industrial constraints, budget constraints, and, now, Western sanctions and export controls. The first three have long served as limitations on Russian defense industrial capacity. In effect, they explain the underlying structural environment to which sanctions have been added.

This part of the report thus provides the necessary background for the subsequent discussion of the steps that the Russian government and defense industry have taken to ensure that the Russian military can continue to prosecute its war against Ukraine. As such, we do not provide detailed discussion of the four constraining factors but rather summaries of each to frame the subsequent discussion.

Manpower constraints

As the war in Ukraine continues, the Kremlin has committed the defense industry to working around the clock to keep up with the demand for new equipment and resources to support fighting on the battlefield. But it is becoming clear that structural problems embedded in the defense industrial complex will make domestic manufacturing increasingly challenging. The most important constraint is manpower. There is now a massive deficit of qualified manpower in the Russian arms industry. Manufacturers are facing serious problems finding more workers and engineers despite increasing salaries and other bonuses.

Labor shortage growing

The war economy is driving manpower issues across the board in Russia. The precise extent of war-related increases in production and the resultant increase in the required number of defense sector workers are difficult to estimate from the available data, but, according to some sources, a 30 to 40 percent surge in military-related industries has occurred since January 2023 at the expense of the civilian sector. Consequently, Russia's unemployment rate has fallen to 3 percent, its lowest level in 30 years, leaving businesses struggling to find workers for the labor-intensive industries that dominate the country's economy. The Russian labor market and the whole economy are working at their limit and simply cannot produce more.[4]

According to the Russian Academy of Science's Institute of Economics, the number of total workforce vacancies rose to 6.8 percent by the middle of 2023, jumping from 5.8 percent a year prior. This figure represents a labor shortage of nearly 5

[4] Unemployment in Russia fell to just 3 percent in August 2023, when 60 percent of companies reported a shortage of workers. In today's Russia, there are no unemployed people to put back to work and no factories to reopen through massive government spending. The Central Bank and the Ministry of Finance are aware of this situation and are warning that the economy is overheating because of a combination of fiscal stimulus and a lack of spare productive capacity. Overheating can lead to inflation and erode the value of increased wages and social spending, which has prompted the Central Bank to tighten monetary policy. Solutions to the labor shortage such as inviting immigration, using teenage or prison labor, and outsourcing military production to allied states have already been attempted or discussed. But if they do not work, the effects of the current spending spree are far from certain. See Volodymyr Ishchenko, Ilya Matveev, and Oleg Zhuravlev, "Russian Military Keynesianism: Who Benefits from the War in Ukraine?," Russia Matters, Dec. 5, 2023.

million people.[5] The war in Ukraine alone has led to a shortage of approximately 1 million people in Russia's labor market, including between 300,000 and 500,000 people who were recruited to the army through mobilization and at least half a million more who have left the country since Russia's invasion of Ukraine.[6] A poll by Russia's Yegor Gaidar Institute for Economic Policy, which surveys managers at around 1,000 industrial enterprises in the country each month, found in April 2023 that 35 percent of enterprises lacked workers.

The shortage was partly due to Russia's "partial mobilization" of its population starting in September 2022—a generation of skilled workers are now fighting on the front or have fled the country.[7] Roughly a third of the economic sectors tracked by the statistics service showed a decline in employment, with military recruitment being largely responsible. Moreover, conscription and the recruitment of contractors, compounded by the exodus of Russians from the country, led to a decrease in the male labor pool and a shortage in many industries.[8]

Hundreds of thousands of Russians fled across the border to neighboring countries, including Georgia, Finland, Kazakhstan, and Mongolia, to avoid being conscripted. In May 2023, the vice president of the Russian Academy of Sciences, Valentin Parmon, was cited by state news agency Interfax as saying that Russia had lost around 50,000 scientists over the past five years. *Novaya Gazeta*, an independent Russian newspaper, identified at least 270 academic staff members of Moscow's and St. Petersburg's high-ranking universities who had left the country since the Russia-Ukraine war began. This figure includes 195 Russian scientists; the rest are of other nationalities.[9]

Effect on defense industry

Staff shortages have had several deleterious effects on the economy. Foremost is the inability to produce the required volume of goods and services, which is reflected in a decrease in gross domestic product (GDP) growth rates and an increase in inflation. Labor shortages also caused a sharp increase in wages, especially in industries related to government orders. Enterprises are trying to lure specialists by offering salaries above the market rate. In general, the shortage of personnel makes rebuilding the economy under sanction restrictions difficult.

Analysts have expressed concern that the problem could exacerbate inflation in the country while also wrecking Russia's economic potential in the long term as college-educated workers continue to emigrate. According to one study, Russia is falling into the

5 Maria Stroiteleva, "How Can We Be Without Hands: The Shortage of Workers in 2023 Amounted to 4.8 Million [Как же без рук: дефицит работников в 2023 году составил 4,8 млн]," *Izvestiia*, Dec. 24, 2023, https://iz.ru/1624816/mariia-stroiteleva/kak-zhe-bez-ruk-defitcit-rabotnikov-v-2023-godu-sostavil-48-mln.

6 By April 2023, the mass exodus of Russians out of the country was estimated at 1 million. That same month, a Russian Central Bank survey found that worker availability had hit its lowest level since 1998. See Filip De Mott, "Russia's War in Ukraine Has Drained It of Labor—It Lacks Nearly 5 Million Workers This Year, Report Says," Business Insider, Dec. 25, 2023, https://www.businessinsider.com/russia-lacks-workers-ukraine-war-labor-crisis-worker-shortage-2023-12.

7 Anna Galcheva, "Business Survey Shows Record Level of Staff Shortages Since 1996 [Опрос бизнеса показал рекордный с 1996 года уровень кадрового голода]," *RBK*, May 18, 2023, https://www.rbc.ru/economics/18/05/2023/64649bbd9a79470db02e0730.

8 "Putin's War Is Intensifying Russian Economy's Labor Shortage," Bloomberg News, Mar. 29, 2023.

9 Daria Talanova, "The Great Russian Brain Drain," *Novaya Gazeta*, Aug. 19, 2023, https://novayagazeta.eu/articles/2023/08/19/the-great-russian-brain-drain-en. Half of the Russian scientists who left the country publicly opposed the invasion of Ukraine; they posted online and signed an open letter against the war.

trap of long-term war depletion. If men go to war or emigrate en masse, the effect on the labor market will be severe: conscription at such a productive age leeches the labor force out of an economy that is already expected to lose 3 to 4 million people aged 20 to 40 by 2030 (compared to 2020) for objective demographic reasons.[10]

The regular economy is not alone in being negatively affected by the labor shortage. According to some estimates, Russia's defense industrial complex, which encompasses a workforce of about 2 million, fell short by at least 50,000 highly skilled workers such as machine operators, information technology (IT) specialists, ship builders, and welders by the beginning of 2023.[11] Even though Russia's army and its weapons factories are employing a growing number of workers as Moscow braces itself for a long war, leaving civilian sectors with painful labor shortages and destabilizing the broader economy, it is not enough.[12] Former Deputy Prime Minister and head of Roscosmos Yuri Borisov predicts a shortage of 400,000 people for defense industry enterprises in the future, including 120,000 people with higher education.[13] Russian Technologies (Rostec), the vast state-owned umbrella company that encompasses the country's main arms producers and employs nearly 600,000 people, is looking for new recruits. According to Rostec's chief, Sergei Chemezov, the company needs to hire 25,000 to 30,000 people.[14]

Reasons for the shortfall vary, ranging from lack of a sufficient labor pool to noncompetitive salaries. Although companies in certain parts of the country, especially around Moscow, attract people with high salaries, these salaries are not characteristic across the defense industrial complex. Despite the government's emphasis on the defense industry, some companies have failed to offer competitive salaries. Altai FNPC in Biysk, which produces explosives and is part of Roscosmos, offers 37,250 rubles per year for some skilled jobs. Altai Krai is not a rich region, but even there the average salary was 40,319 rubles in October 2022.[15] JSC Corporation Comet, which specializes in space information and reconnaissance systems, offers underwhelming salaries on its website. Engineers are offered 60,000 rubles, and a leading design engineer is offered 80,000 rubles. This company is based in Moscow, where the average salary in 2022 was 102,210 rubles.[16]

[10] Andrei Kolesnikov, "Russia's Second, Silent War Against Its Human Capital," Carnegie Politika, Feb. 8, 2023.

[11] "Russian Defense Plants Face Record Shortage of Qualified Personnel," Charter 97, Jan. 18, 2023.

[12] The labor shortage in the defense sector is a decades-old problem. Since the early 2010s, the deficit has worsened. In an effort to solve the problem, the government launched an educational and training program, but the planned number of people who will go through the program is just 12,000. This number of trainees will not solve the problem in the foreseeable future. See "On May 13, a Round Table Was Held in the State Duma on the Problems of Training Personnel for the Military-Industrial Complex [13 мая в Госдуме состоялся «круглый стол», посвященный проблемам подготовки кадров для оборонно-промышленного комплекса]," State Duma, May 14, 2013, http://duma.gov.ru/news/8057/.

[13] "Borisov: Shortage of Personnel at Defense Industry Enterprises in the Russian Federation Will Be About 400 Thousand People," VPK.name, June 30, 2022, https://vpk.name/en/613140_borisov-the-shortage-of-personnel-at-defense-industry-enterprises-in-the-russian-federation-will-be-about-400-thousand-people.html.

[14] Anastasia Stognei, "Russia's War Economy Leaves Businesses Starved of Labor," *Financial Times*, Nov. 9, 2023.

[15] Victoria Pavlova, "Out of Competition: How Much Do the Workers of Military Factories Receive in Russia and Abroad," *Novye Izvestia*, Jan. 25, 2023, https://en.newizv.ru/news/2023-01-25/out-of-competition-how-much-do-the-workers-of-military-factories-receive-in-russia-and-abroad-394992.

[16] Pavlova, "Out of Competition."

Factories where wages are rising and a sufficient labor force exists often face other manpower issues, namely burnout. Some plants that produce military equipment have introduced 12-hour working days and 6-day working weeks.[17] Forced overtime is not uncommon.[18] That said, if the labor is unavailable, there is little that companies can do. For example, representatives of manufacturers of the main battle tanks and armored vehicles, Uralvagonzavod and Kurganmashzavod, respectively, have claimed that they just cannot find more workers and engineers despite increasing salaries and other bonuses.[19] They have been hard-pressed to maintain a three-shift work schedule on a permanent basis. In 2022, the Kremlin had to "place" 250 prisoners into Uralvagonzavod to make up the shortfall needed for round-the-clock tank repair. Similar problems can be found at most arms manufacturers in Russia.

Industrial constraints

The Russian defense industry also faces significant challenges in the form of persistent industrial constraints. These include structural problems associated with the defense industry's current organization, technological backwardness, shortages of modern plants and equipment, and endemic corruption. Collectively, these problems continue to impose serious constraints on Russian military research and development (R&D) and defense production.

Structural problems

The defense industry has undergone major restructuring since Vladimir Putin's first presidency in 2000, an initiative that has solved some problems while creating or perpetuating others. In the 1990s, the defense industry endured years of underfunding and neglect. In addition, efforts at defense privatization were only partially successful, having been limited by entrenched interests. As a result, the defense industry that emerged from the chaos of the 1990s was depleted, inefficient, highly fragmented, and poorly structured, comprising a patchwork of state-owned companies and private enterprises that often had differing incentives and overlapping activities. Defense enterprises also lacked the economies of scale needed to operate efficiently, invest in innovation, and compete effectively on global markets. By the end of the 1990s, loss-making companies abounded in the Russian defense industry, often sustained by a continuous cycle of state subsidies. As a result, the government was unable to sustain defense production at affordable levels.

When Putin first came to power, he launched a major industry consolidation program designed to address the industry's most pressing structural problems. Over the next two decades, defense enterprises across Russia were gradually consolidated into large state-owned vertical holding companies organized by major weapons categories, each

[17] Azamat Ismailov, "'Everything for the Front!' How War Is Changing Russia's Labor Market," *Moscow Times*, Dec. 4, 2023, https://www.themoscowtimes.com/2023/12/04/everything-for-the-front-how-war-is-changing-russias-labor-market-a83311.

[18] In 2023, defense companies reduced the number of weekends, holidays, and vacations to keep up with the increasingly demanding schedules for output. See "Chemezov: Rostec Factories Involved in the Implementation of the State Defense Order Work on New Year Holidays [Чемезов: задействованные в выполнении ГОЗ заводы Ростеха работают в новогодние праздники]," TASS, Jan. 2, 2023, https://tass.ru/ekonomika/16732727.

[19] "Old Men Go into Battle: The Country's Defense Plants Cannot Recruit Workers [В бой идут старики: оборонные заводы страны не могут набрать рабочих]," *Novye Izvestia*, Jan. 19, 2023, https://newizv.ru/news/2023-01-19/v-boy-idut-stariki-oboronnye-zavody-strany-ne-mogut-nabrat-rabochih-394312.

controlling multiple defense enterprises.[20] Examples include United Aircraft Corporation, which controls production of Russian fixed-wing combat aircraft, and Almaz-Antei, which is the dominant manufacturer of Russian air defense systems. Later, most of these holding companies were themselves placed under the control of Rostec, which has developed into an industry giant, controlling nearly 700 enterprises while accounting for roughly 75 percent of total Russian defense production.[21]

Industry consolidation was designed to achieve three major objectives. First, establishment of large vertical holding companies was intended to create national champions in key defense sectors by giving them the resources and economies of scale needed to compete effectively in both domestic and global markets.[22] Second, by combining defense enterprises under a single corporate structure, defense planners sought to rationalize defense production by merging constituent enterprises, eliminating duplication, and shutting down failing enterprises to gain "greater efficiency and competitiveness amongst their [remaining] constituent enterprises."[23] Third, industry consolidation was intended to renationalize the defense industry by placing most defense production under state-owned or controlled entities. This rationale has a certain logic. Because the state continued to subsidize the defense industry, it was only fitting for the state to take control of managing the industry.[24]

Industry consolidation has helped to some degree in creating national champions, at least in certain sectors. Six Russian defense holding companies were listed among the top 100 companies on the Stockholm International Peace Research Institute's 2021 annual list of the world's largest defense enterprises.[25] As of 2022, Russia remained the world's second-largest arms exporter, although exports have been declining because of sanctions.[26] In some cases, Russian holding companies have also had success in developing and producing innovative weapon systems and technologies. For example, Russia's Tactical Missile Corporation has been an industry leader in the development of hypersonic weapons, in part by coordinating a large-scale national effort involving multiple firms across the defense industry.[27]

It is not clear, however, that industry consolidation has helped to achieve the efficiencies and economies of scale required to make these large holding

[20] Aleksi Päiväläinen and Karoliina Rajala, *Competitiveness of Russia's Defence Industry: Weak but Steady: Analysis of Economic Indicators*, National Defence University of Finland, 2020, p. 20, https://www.doria.fi/handle/10024/177052.

[21] Richard Connolly, *The Kalashnikov Economy: Russia's National Champions: Economic Means for Political Ends*, Eastern Advisory Group, 2021, p. 12.

[22] Connolly, *The Kalashnikov Economy*, p. 4; Johan Engvall, *Russia's Military R&D Infrastructure: A Primer*, Swedish Defense Research Agency, FOI-R--5124--SE, Apr. 2021, p. 17, https://foi.se/rest-api/report/FOI-R--5124--SE.

[23] Connolly, *The Kalashnikov Economy*, p. 12; Polina Beliakova and Sam Perlo-Freeman, *Corruption in the Russian Defense Sector*, World Peace Foundation, May 11, 2018, p. 5, https://worldpeacefoundation.org/wp-content/uploads/2024/03/Russian-Defense-Corruption-Report-Beliakova-Perlo-Freeman-20180502-final.pdf.

[24] Engvall, *Russia's Military R&D Infrastructure*; Beliakova and Perlo-Freeman, *Corruption in the Russian Defense Sector*.

[25] Lucie Béraud-Sudreau et al., *The SIPRI Top 100 Arms-Producing and Military Services Companies, 2021*, Stockholm International Peace Research Institute, Dec. 2022, pp. 9–11, https://www.sipri.org/publications/2022/sipri-fact-sheets/sipri-top-100-arms-producing-and-military-services-companies-2021.

[26] Pieter D. Wezeman, Justine Gadon, and Siemon T. Wezeman, *Trends in International Arms Transfers, 2022*, Stockholm International Peace Research Institute, Mar. 2023, pp. 2, 5, https://www.sipri.org/publications/2023/sipri-fact-sheets/trends-international-arms-transfers-2022.

[27] "Top Russian Missile Producer Keeps Finger on Pulse to Create New Hypersonic Weapons," TASS, Jan. 26, 2023, https://tass.com/defense/1567525; Julian Cooper, *Russia's Invincible Weapons: Today, Tomorrow, Sometime, Never?*, Changing Character of War Centre, Pembroke College, University of Oxford, May 2018, p. 3, https://www.ccw.ox.ac.uk/blog/2018/4/30/russias-invincible-weapons-today-tomorrow-sometime-never.

companies more innovative and more competitive. Although Russian defense enterprises have been aggregated into vertical holding companies, most of the subsidiaries continue to operate as separate enterprises subject to their own inefficiencies and limitations on scalability. There are a few examples of successful consolidation, however. For example, in the mid-2000s, Russian air defense manufacturer Almaz-Antei combined five separate defense enterprises to form the Northwest Regional Center, a fully integrated engineering and production center located in St. Petersburg.[28] In too many cases, however, consolidation has simply created large groupings of poorly integrated companies exhibiting great variation in performance, with profitable enterprises often compensating for loss-making companies.[29]

Finally, industry consolidation has helped to stifle competition by reducing the number of defense contractors able to compete for new procurement contracts. According to one leading expert, in 2017, "The ten largest Russian military suppliers received no less than 82 percent of all defense budget allocations, and, most notably, government funding accounted for 86 percent of their total revenue."[30] As the latter figure indicates, high industry concentration has also hindered the development of small and medium defense enterprises, which are central to producing innovative technologies in the most advanced Western countries.

Technological backwardness

The Russian defense industry also faces challenges in overcoming persistent technological backwardness, which has plagued military R&D and defense production for the past three decades. Although the defense industry remains Russia's most important high-tech sector and Russian defense industry "is one of the few technology-intensive areas of the economy that has proven to be globally competitive,"[31] Russian defense industry remains several decades behind leading Western arms producers in areas such as factory automation and quality control. As a result, many buyers of Russian weapons and military systems find that they are ineffective or of poor quality. For example, the Indian military found significant production defects in MiG-29 aircraft that it purchased from Russia in the mid-2010s. These defects affected the airframes, engines, and control systems.[32] India has also described Russian-made T-90 tanks as useless because of their inability to function in mountainous terrain.[33] The Azerbaijani military has likewise criticized the reliability of a

[28] These include the Obukhov Plant, the Radio Equipment Plant, the Design Bureau of Special Mechanical Engineering, the All-Russian Research Institute of Radio Equipment, and the Russian Institute of Radio Navigation and Time. "Almaz-Antey: Keys to the Sky [Алмаз-Антей: Ключи от Неба]," *Kryl'ia Rodiny*, Aug. 31, 2018, p. 45; Alisa Alova, "Almaz-Antey Straightened Its Shoulders [Алмаз-Антей Расправил Плечи]," *St. Petersburg Vedomosti*, July 13, 2017, https://spbvedomosti.ru/news/nauka/almaz_antey_raspravil_plechi/.

[29] Connolly, *The Kalashnikov Economy*, p. 12.

[30] Vladislav Inozemtsev, *Russia's Defense Sector: An Economic Perspective*, Swedish Institute of International Affairs, Mar. 2019, p. 5, https://www.ui.se/globalassets/ui.se-eng/publications/ui-publications/2019/ui-brief-no.-3-2019.pdf.

[31] Richard Connolly and Cecilie Sendstad, "Russian Rearmament: An Assessment of Defence-Industrial Performance," *Problems of Post-Communism* 65, no. 3 (2018), p. 1, https://www.ffi.no/en/publications-archive/russian-rearmament-an-assessment-of-defense-industrial-performance.

[32] Paul Iddon, "The Indian Navy's Carrier MiG-29s Keep Crashing. Will New Delhi Seek a Replacement Fighter?," *Forbes*, Dec. 28, 2020, https://www.forbes.com/sites/pauliddon/2021/12/28/the-indian-navys-mig-29s-keep-crashing-will-new-delhi-seek-a-replacement-fighter/.

[33] "India Criticized Russian T-90 Tanks for Poor Performance," Global Defense Corp, Sept. 2, 2020, https://www.globaldefensecorp.com/2020/09/02/india-criticized-russian-t-90-tanks-for-poor-performance/.

variety of Russian weapons systems, including missiles, helicopters, and even machine guns.[34] That said, Russia is one of the few countries able to produce the full range of military equipment, including ground combat systems, naval platforms, air superiority fighters, strategic weapons, and many other systems.

Overall, Russia has had far more success in incrementally upgrading existing weapon systems based on Soviet-era designs than it has in developing wholly new systems, as repeatedly evidenced during the two most recent state armament programs.[35] For example, Russia has successfully developed and produced hundreds of fourth-generation combat aircraft derived from the Soviet-era Su-27 design. These include the Su-30, Su-34, and Su-35 Flanker series. Likewise, Russia has produced upgraded variants of Soviet-era main battle tanks and conventional submarines in relatively large numbers, such as the T-72B3 and the Project 636.3 Kilo-class submarine. However, more advanced systems such as the Su-57 Flanker, the Armata tank, and the Severodvinsk-class submarine took many years to develop, and Russia is still struggling to achieve serial production of these systems.[36] The primary source of problems with Russian weapons production appears to be a high rate of manufacturing defects due to outdated production facilities and poor quality control rather than design problems.[37]

Aging plants and equipment

Russia's defense industry continues to suffer from shortages of modern manufacturing plants and equipment. In 2011, when Russia first launched the 2020 State Armament Program (GPV 2020), the percentage of modern manufacturing equipment in the defense industry had fallen to just 20 percent, according to one estimate.[38] At the time, most of the remaining equipment was more than 20 years old.[39] This situation was the result of a persistent lack of capital investment caused by the serious budget constraints during the 1990s.[40] Thus, when the defense industry commenced large-scale rearmament in 2011, it started from a very low production baseline.

To address this problem, Russia launched GPV 2020 in 2011 to provide supplementary funding for the defense industry. Under this program, the Kremlin dedicated 3 trillion rubles in funding for defense industry modernization.[41] Most of it was provided in the form of state-guaranteed loans to selected defense enterprises across the country. The program was widely adopted by defense enterprises across

[34] "Regular Criticisms of Russian Weapon Systems Quality Shows How Much Its Military Conventional Potential Is Exaggerated," Lansing Institute, Apr. 27, 2021, https://lansinginstitute.org/2021/04/27/regular-criticisms-of-russian-weapon-systems-quality-shows-how-much-its-military-conventional-potential-is-exaggerated/.

[35] Connolly and Sendstad, "Russian Rearmament."

[36] Richard Connolly and Mathieu Boulegue, *Russia's New State Armament Programme: Implications for the Russian Armed Forces and Military Capabilities to 2027*, Chatham House, May 2018, p. 31. See generally Inozemtsev, *Russia's Defense Sector*.

[37] Andrew S. Bowen, *Russian Arms Sales and Defense Industry*, Congressional Research Service, Oct. 14, 2021, https://crsreports.congress.gov/product/pdf/R/R46937.

[38] Päiväläinen and Rajala, *Competitiveness of Russia's Defence Industry*, p. 8. *Modernized equipment* was defined as equipment that was no more than 10 years old at the time.

[39] Tor Bukkvol, *The Russian Defence Industry: Status, Reforms, and Prospects*, Norwegian Defence Research Establishment, pp. 16–17, https://www.ffi.no/en/publications-archive/the-russian-defence-industry-status-reforms-and-prospects.

[40] Päiväläinen and Rajala, *Competitiveness of Russia's Defence Industry*, p. 8.

[41] Fredrik Westerlund, "The Defence Industry," in *Russian Military Capability in a Ten-Year Perspective—2011*, ed. Carolina Vendil Pallin (Swedish Defence Research Agency, 2012), p. 71, https://www.foi.se/rest-api/report/FOI-R--3474--SE. This equated to approximately $100 billion in additional funding at then-current exchange rates.

Russia, providing a significant boost for industry modernization across large swathes of the Russian defense industrial base.[42] As GPV 2020 proceeded, industry modernization received a further boost from the massive infusion of new procurement funding, which has allowed defense enterprises to maintain a higher level of capital expenditure and use their retained earnings for military R&D.[43]

Because of the magnitude of the problem, even with these large infusions of new funding, the defense industry was able to make only partial progress toward fully recapitalizing. Although precise numbers are difficult to obtain, according to one source, the defense industry was able to modernize only about 1 percent of its total equipment base each year.[44] Moreover, the pace of modernization started to slow in 2017 as the Kremlin began to cut defense spending to a more sustainable level.[45]

Since the 2022 invasion of Ukraine, sanctions are posing a fresh challenge for Russian defense industry modernization, in this case because of the growing restrictions on the acquisition of advanced Western machine tools. This limitation, and the extent to which Russia has been able to circumvent it, will be discussed in detail later in this report.

Corruption

The Russian defense industry continues to be plagued by endemic corruption, yet another significant constraint on defense production. Although precisely gauging the extent of corruption in the military industrial complex is difficult because of the secretive nature of defense procurement and the lack of transparency regarding enforcement actions, in 2010, then Russian president Dmitry Medvedev estimated that 20 percent of the funds distributed each year through the state procurement system (around $33 billion) had been misappropriated.[46] In 2018, Chief Military Prosecutor Valery Petrov reported that the government had disrupted more than 12,000 cases of corruption the previous year, averting up to 11 billion rubles in prospective losses.[47] In 2021, hundreds of criminal cases for violations of defense procurement laws were initiated in this area.[48] According to former Chief Military Prosecutor Sergei Fridinsky, corruption systematically imposes extra costs on purchased equipment.[49]

Corruption in the Russian defense industry takes many forms. Use of bribes and kickbacks to secure contract awards from corrupt officials is a recurrent problem. Charging inflated prices for the procurement of military products and services is yet another common tactic, as is the improper disposal of assets to favored persons for a fraction of their

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[42] Päiväläinen and Rajala, *Competitiveness of Russia's Defence Industry*, p. 16. Several companies struggled to repay these loans, which reportedly carried a 10 percent interest rate. In 2016, the Russian government stepped in to repay loans totaling about 800 billion rubles.

[43] Päiväläinen and Rajala, *Competitiveness of Russia's Defence Industry*, pp. i, 14.

[44] Päiväläinen and Rajala, *Competitiveness of Russia's Defence Industry*, p. 8.

[45] "Diversification of the Defense Industry: How to Win in Civilian Markets [Диверсификация ОПК: Как побеждать на гражданских рынках]," Instrategy.ru, 2017, http://www.instrategy.ru/pdf/367.pdf.

[46] Beliakova and Perlo-Freeman, *Corruption in the Russian Defense Sector*, p. 10.

[47] Alexander Sukharenko, "Criminal Enemy of the Defense Industry [Криминальный Враг Оборонки]," *Nezavisimiya Gazeta*, May 23, 2018, https://www.ng.ru/kartblansh/2018-05-23/3_7230_kartblansh.html.

[48] Alexander Sukharenko, "The State Defense Order Will Be Supported by Prison Terms and Rework [Гособоронзаказ Поддержат Тюремными Сроками И Переработками]," *Nezavisimiya Gazeta*, Sept. 29, 2022, https://www.ng.ru/kartblansh/2022-09-28/3_8551_kb.html.

[49] Beliakova and Perlo-Freeman, *Corruption in the Russian Defense Sector*, p. 18.

true value. Yet another frequently used ploy is company insiders awarding phony contracts to shell companies as a means to divert state funds, which are later shared by participants in the scheme.[50]

Russian officials often proclaim that combating defense industry corruption remains a top priority. This statement has some truth because the government continues to place high priority on rearming the military and is therefore unwilling to allow wholesale plunder of the annual defense budget. Moreover, the government has taken measures in recent years to reduce the incidence of corruption. In 2017, for example, President Putin signed legislation promising sentences of up to 5 to 10 years for defense company heads who abuse their authority related to work performed under the state defense order.[51] In 2022, the government adopted another law providing similar sentences for procurement violations costing the state 5 percent or more of the total contract value.[52] However, anticorruption measures tend to target two kinds of individuals, either low- and mid-level operators engaging in misconduct outside permitted channels benefiting the ruling elites or former insiders who have fallen out of favor with the regime.[53] As a result, corruption remains endemic to the defense procurement system.

Budget constraints

"We have no funding restrictions." Russian president Putin made this promise to the armed forces high command at the end of 2022.[54] It is a statement that hides the broader economic funding challenges that Russia has faced in prosecuting its war with Ukraine and the initial wrong assumptions that the Kremlin had going into the war. It is not that the budget was insufficient but that it was initially out of sync with the requirements for a country in the process of launching a major war.[55] Until the most recent budget, the Kremlin looked like it was committed to business as usual, relying on traditional economic data as if the demands of war could be managed.

The 2024 budget, however, reveals a change in thinking. For the first time in modern history, the country is set to spend 6 percent of its GDP on the military, up from the 3.7 percent baseline in recent years, with defense spending expected to exceed social spending for the foreseeable future.[56] The war against Ukraine and the West is not only the Kremlin's biggest priority but also the main driver of Russia's economic growth. From Moscow's perspective, the military (including the defense industry) and society must be prepared to fight a war that will not end anytime soon.

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50 See, for example, Beliakova and Perlo-Freeman, *Corruption in the Russian Defense Sector*, p. 10.

51 Sukharenko, "Criminal Enemy of the Defense Industry."

52 Sukharenko, "The State Defense Order Will Be Supported by Prison Terms and Rework."

53 Beliakova and Perlo-Freeman, *Corruption in the Russian Defense Sector*, p. 4.

54 Clare Sebastian and Hanna Ziady, "The Spiraling Cost of War Means Growing Economic Pain for Russia," CNN, Aug. 28, 2023, https://www.cnn.com/2023/08/28/economy/russia-military-spending-economic-impact/.

55 Although the budget did not initially reflect the realities that Russia would face when it invaded Ukraine, the Kremlin had made some financial preparations. Since the annexation of Crimea, Russia had built up a war chest of $600 billion to stave off the effect of sanctions in case of future conflict in the region. This war chest was cut in half when $300 billion of Russian Central Bank assets were frozen immediately after Russia invaded Ukraine, placing Russia in an economic bind at the start of the war. See Nicholas Gordon, "Banks Are Stopping Putin from Tapping a $630 Billion War Chest Russia Stockpiled Before Invading Ukraine," *Fortune*, Mar. 3, 2022.

56 Boris Grozovski, "Russia's Unprecedented War Budget Explained," *The Russia File (Kennan Institute blog)*, Sept. 7, 2023, https://www.wilsoncenter.org/blog-post/russias-unprecedented-war-budget-explained.

Shifting from business as usual to a war economy

The federal budget for 2022 to 2024, which was signed into law at the end of 2021, envisaged an overall budget of 23.694 trillion rubles ($343 billion)[57]—based on a GDP projection of 133.3 trillion rubles with a 4 percent annual inflation rate.[58] The defense budget was about 3.7 percent of the GDP, or 3.502 trillion rubles.[59] The assumptions embedded in these figures were based on a period of tension in the region but not outright conflict.[60] Once the conflict began, the Russian government took measures to reinforce the armed forces and boost military production. Russia's Ministry of Finance made major adjustments on the fly (Table 1), so the effective military spending exceeded the plan by 46 percent (5.1 trillion rubles instead of 3.5 trillion).[61]

Because of this ramp-up in defense spending (and spending related to the COVID-19 pandemic), Russia had a budget deficit of about 2.3 percent (3.3 trillion rubles) in 2022 rather than a planned surplus

Table 1. Projected defense spending increases throughout 2022

Date	Spending
December 2021	3.502 trillion rubles
February 2022	3.646 trillion rubles
March 2022	3.667 trillion rubles (last official figures reported by the Russian government)
August 2022	4.544 trillion rubles
October 2022	4.679 trillion rubles (17 percent of total revised government spending of 27.614 trillion rubles)
End of 2022	5.110 trillion rubles (16 percent of total budget expenditure and 3.4 percent of GDP)[a]

Source: Cooper, *Russia's Military Expenditure*.

[a] According to Ilya Sokolov, budget specialist of the Gaidar Institute for Economic Policy, Moscow, Russia's spending in 2022 on "national defense" was 38 percent higher in real terms (i.e., accounting for inflation) than the actual total for 2021. See Ilya A. Sokolov, "Federal Budget: 2022 Results and 2023 Perspectives [Федеральный бюджет: Итоги 2022 года и перспективы 2023 года]," *Monitoring Ekonomicheskoi Situatsii v Rossii* 167, no. 2 (Mar. 2023).

[57] According to the rate of exchange at the beginning of 2024, 1 US dollar is equal to 87.959997 rubles.

[58] Julian Cooper, *Russia's Military Expenditure During Its War Against Ukraine*, SIPRI Insights on Peace and Security, No. 2023/07, June 2023.

[59] Russian Federal Law no. 390-ФЗ, "On the Federal Budget for 2022 and the Planning Period 2023 and 2024 [О федеральном бюджете на 2022 год и на плановый период 2023 и 2024 годов]," Dec. 6, 2021, cited in Cooper, *Russia's Military Expenditure*. This number was in line with that in previous years. In the years 2019 to 2021, the federal budget allocated 3 to 3.6 trillion rubles to the military annually, representing 14 to 16.5 percent of the federal budget or 3 to 4 percent of the GDP.

[60] According to some sources, the Kremlin was hiding its full projections on its 2022 budget that included a war. However, the fact that the Ministry of Finance had to revise the defense budget several times throughout the year suggests that the Kremlin miscalculated the cost of the conflict rather than hid full projections.

[61] The Russian economy entered a recession in 2022 but held up much better than initially expected despite wide-ranging sanctions. Real GDP contracted by 2.1 percent in 2022, according to data released by Rosstat. Numerous fiscal stimulus measures, combined with record energy export revenues, helped prevent a deeper recession. See Allianz Research, *Russia's War Economy*, Feb. 23, 2023.

of 1 percent.[62] Through a mixture of dipping into previous budget surpluses and the National Welfare Fund, as well as siphoning off oil and gas revenues, the Kremlin was able to manage the deficit.[63]

When it was rolled out, the 2023 budget was set to increase by nearly 6 percent, with a total annual military expenditure of 6.648 trillion rubles, before returning to more normal levels in 2024 and 2025.[64] According to one analyst:

> Total military spending in the 2023 budget represented 23 per cent of the total government budget and 4.4 per cent of forecast GDP. This compares with 21 per cent of total budget spending and 4.4 per cent of GDP in 2022, and 20 per cent of the total and 3.6 per cent of GDP in 2021.[65]

This projection was based on two overarching assumptions. First, the war in Ukraine would begin to settle down, and operations would transition from conflict to stabilization and control over occupied territories. Second, the economic outlook would adhere to positive projections, despite sanctions and economic downturn. An increase in the interest rates and debt-servicing costs would allow the government to find discretionary spending for social programs.[66]

As in 2022, the 2023 official budget quickly succumbed to the spiraling costs of the ongoing conflict. According to one source, during the first six months of 2023, Russia spent 5.6 trillion rubles on the military, exceeding the 5 trillion rubles projected for the entire year[67] and representing a 75 percent increase over the first half of 2022. By mid-2023, war expenditure had reached 37.3 percent of all budget spending, 2.5 times the prewar average.[68]

As summer moved into fall, a shift in Russia's calculation about the war became evident. The proposed budget for 2024 showed that the Kremlin is mobilizing its economy for a long war of attrition (see Table 2). Defense spending in the new budget accounts for 29.4 percent of Russia's total budget expenditure in 2024 and a 7.1 percent share of Russia's GDP.[69] According to Russian Finance Minister Anton Siluanov, "The budget's structure shows that the main emphasis is on ensuring our victory—the Army, defense capability, armed forces, fighters. Everything needed for the front, everything needed for victory, is in the budget."[70]

62 Ivan Nechepurenko, "Russia Posts a $47 Billion Budget Deficit for 2022, Its Second Highest in the Post-Soviet Era," *New York Times*, Jan. 10, 2023.

63 András Rácz, Ole Spillner, and Guntram Wolff, *Russia's War Economy: How Sanctions Reduce Military Capacity*, German Council on Foreign Relations, DGAP Policy Brief No. 3, Feb. 14, 2023, https://dgap.org/en/research/publications/russias-war-economy.

64 Within the 2023 defense budget, defense industry spending is spread across several line items, such as "49: 266 million for the nuclear weapons complex" and "409: 217 million for applied R&D in the field of national defense." Russian Federal Law no. 466-ФЗ, "On the Federal Budget for 2023 and for the Planning Period 2024 and 2025 [О федеральном бюджете на 2023 год и на плановый период 2024 и 2025 годов]," Dec. 5, 2022; Russian Draft Federal Law no. 201614-8, "On the Federal Budget for 2023 and for the Planning Period 2024 and 2025 [О федеральном бюджете на 2023 год и на плановый период 2024 и 2025 годов]," Sept. 28, 2022, appendixes 12 and 15, cited in Cooper, *Russia's Military Expenditure*.

65 Cooper, *Russia's Military Expenditure*.

66 Cooper, *Russia's Military Expenditure*.

67 Spending on the army was especially high at the beginning of the year, when the government needed to provide advance financing to military plants that have received contracts from the army. See Grozovski, "Russia's Unprecedented War Budget Explained."

68 Grozovski, "Russia's Unprecedented War Budget Explained."

69 Julian Cooper, *Another Budget for a Country at War: Military Expenditure in Russia's Federal Budget for 2024 and Beyond*, SIPRI Insights on Peace and Security, Dec. 2023, p. 19, https://www.sipri.org/sites/default/files/2023-12/sipriinsights_2312_11_russian_milex_for_2024_0.pdf.

70 Darya Korsunskaya and Alexander Marrow, "'Everything for the Front': Russia Allots a Third of 2024 Spending to Defence," Reuters, Oct. 2, 2023.

In addition to diverting increasingly more resources toward prosecuting the war, Russia plans to ramp up state borrowing to help fund what it calls "a special military operation" in Ukraine in the coming years and is counting on recovery in oil and gas revenues to preinvasion levels to do so. It will also rely on a gradual devaluation of the ruble to finance soaring defense and social spending in the budget. The resulting budget deficit may help restrain inflation.

Several assumptions undergird the new budget, namely that revenue will grow by more than a third in 2024, reaching 35 trillion rubles. Of that, 11.5 trillion rubles is expected to come from the oil and

Table 2. Military expenditure in the Russian federal budget for 2024–2026, in millions of rubles

Funding Type	2024	2025	2026
National Defense			
Armed forces	3,293,656	3,020,556	3,502,048
Mobilization and training	19,235	19,037	19,513
Economic mobilization	2,713	2,713	2,745
Collective security and peacekeeping	2,968	0	0
Nuclear weapons	62,746	56,932	62,094
International obligations & military-technical cooperation	149,293	32,336	32,745
Applied R&D	396,233	324,966	345,510
Other	6,980,034	5,091,890	3,458,579
Total National Defense	**10,775,442**	**8,534,144**	**7,408,964**
Other Russian Ministry of Defense expenditures	1,415,402	1,263,404	1,307,257
Paramilitary forces	569,195	557,302	585,752
National Guard	358,845	352,123	366,691
Border Guard	210,350	205,179	219,061
Total Other Military Expenditure	**1,994,965**	**1,820,706**	**1,893,009**
Total Military Expenditure	**12,765,284**	**10,349,709**	**9,296,800**
Total Budget Expenditure	**36,660,675**	**34,382,810**	**35,587,392**
National defense as share of total expenditure (%)	29	25	21
Total military expenditure as share of total expenditure (%)	35	30	26
GDP	179,956,000	190,637,000	203,304,000
National defense as share of GDP (%)	6.0	4.5	3.6
Total military expenditure as share of GDP (%)	7.1	5.4	4.6

Source: Cooper, *Another Budget for a Country at War*, pp. 18–19.

gas sector. Planned expenditure is 36.6 trillion (a 26.6 percent rise over 2023), meaning that the budget deficit next year should decrease from a planned 2 percent of GDP in 2023 to .08 percent in 2024.[71] Given that the budget's target oil price is set at $71 per barrel, lower than the actual price of oil over the first six months of 2024, this is a realistic target. Of course, if prices were to collapse in the second half of 2024, then the budget deficit would be higher than expected.

Can the war economy approach deliver?

According to Russian officials, regardless of how the war proceeds, funds will go toward replenishing Russia's depleted military arsenals with enough left over to fund an escalation such as the imposition of martial law or full mobilization.[72] But hidden inside this optimism is risk. It exists on two levels.

At the micro level, the defense industrial complex is part of the command economy, largely divorced from market forces. As such, it exists in a bubble unaffected by the dynamics that promote flexibility and efficiency. When defense companies stray outside this bubble, they pay a price, including competing for parts and technology, which puts a strain on their operating capital. Since the government is ultimately footing the bill, these economic arrangements have down-order effects on government spending, making it more chaotic. Combined with the Western embargo on technologies, components, and industrial equipment, these factors almost inevitably turn arms manufacturing into a financial black hole for the Kremlin.[73] The decline in budgeted spending on R&D suggests at least partial awareness of limitations on resources, even in the relatively short term.

At the macro level, the increasing dependence on the defense industry to drive Russia's overall economy spells a real risk for the country's long-term health. The spending levels talked about in the wartime budget are sustainable only in a time of war.[74] As funds shift from other parts of the economy to defense and basic social needs, Russia will become increasingly reliant on imports, which will cause inflation and, consequentially, a rise in interest rates. Investment in other segments of the economy will dry up. This dynamic will incentivize the Kremlin to engage in ongoing war to keep the economy from collapsing.[75] On the other hand, if military spending is reduced, it will inevitably lead to a significant structural shock that will take considerable time to

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[71] Pavel Luzin and Alexandra Prokopenko, "Russia's 2024 Budget Shows It's Planning for a Long War in Ukraine," Carnegie Politika, Nov. 10, 2023, https://carnegieendowment.org/politika/90753.

[72] The Russian government does not publish detailed breakdowns of defense spending beyond what is presented in Table 2. Much of the direct cost of the war effort is listed under "Other" within the National Defense category. The relatively large sum listed under military-technical cooperation in 2024 is likely related to payments to foreign partners for armaments.

[73] Pavel Luzin, *Russia's Military Industry Forecast: 2023–2025*, Foreign Policy Research Institute Reports, Apr. 30, 2023.

[74] According to one analyst, the Kremlin is willingly taking on severe economic hardship by adopting a wartime economy. He notes that "the economic losses from the fight against inflation are very unevenly distributed across the economy. The winners are army suppliers: they are first in line to receive budgetary payments. The losers are exporters (because of the growing tax burden and the rising price of credit), domestically oriented production (because of the rising cost of credit and reduced consumer demand), and, above all, private consumers. Inflation and high interest rates will push all sectors of the economy except defense into recession. Stagflation in the civilian sectors and continued growth in military production will be a natural outcome of current Russian economic policy." See Boris Grozovski, "The War Tax in Russia," *The Russia File (Kennan Institute blog)*, Nov. 2, 2023.

[75] By shifting the entirety of the increase in budgetary spending to defense and away from other segments of the economy (education, health care, infrastructure, etc.), Putin has decided to mortgage the future to finance the war. See Grozovski, "The War Tax in Russia."

overcome.[76] Within this catch-22, the budgetary constraint is hidden in the current strategy of using the defense industrial complex to prop up the economy.

Sanctions and export controls

Western sanctions operate as a major constraint on the Russian defense production by cutting off Russia's access to a vast array of Western military and dual-use systems, components, and technologies. Ukrainian sanctions have likewise played a role in degrading Russian defense production. In 2014, the new Maidan government in Kyiv imposed a near-complete arms embargo on Russia, halting export of a wide range of military and dual-use components formerly used in Russian defense production. Starting in 2014, the United States in coordination with the European Union (EU) likewise imposed a series of increasingly severe sanctions on Russia's defense industry.[77] Following Russia's 2022 invasion of Ukraine, Western sanctions were expanded dramatically, cutting off the Russian defense industry's access to virtually all remaining Western military and dual-use components.

As Western sanctions on Russia's defense sector have expanded, they have grown to constitute both a comprehensive arms embargo on transfers of Western military equipment and a broadly targeted set of export controls on transfers of dual-use components and technologies formerly used in Russian defense production.[78] Collectively, Western and Ukrainian sanctions have foreclosed Russia's ability to "legitimately" import most Western and Ukrainian military and dual-use systems, components, and technologies. In the process, they are serving as a major constraint on Russian defense production across numerous weapons categories, making it difficult for the Russian military to acquire key components for its war effort.[79]

Export controls imposed as a result of the 2014 Ukraine crisis

Ukrainian sanctions

Moscow's 2014 incursions in the Donbas region and its seizure of Crimea drove Ukraine to abruptly sever nearly all of its defense ties with Russia, cutting off Russia's access to a wide range of military and dual-use components and technologies. These included most notably Ukrainian helicopter engines, air-to-air missile seekers, military transport aircraft, marine turbine engines for Russian warships, and components used in the production of Russian SS-18 intercontinental ballistic missiles. According to official Russian sources, Ukrainian sanctions cut off the Kremlin's access to 186 critical components used in Russian defense production.[80] Yet, according to one informed Russian commentator, Ukrainian sanctions actually affected more than 3,000 components produced by more than 160 Ukrainian companies.[81]

[76] Luzin and Prokopenko, "Russia's 2024 Budget Shows It's Planning for a Long War in Ukraine."

[77] Cory Welt et al., *U.S. Sanctions on Russia*, Congressional Research Service, updated Jan. 18, 2022, https://crsreports.congress.gov/product/pdf/R/R45415.

[78] Welt et al., *U.S. Sanctions on Russia*, p. 2.

[79] Rebecca M. Nelson, *The Economic Impact of Russia Sanctions*, Congressional Research Service, updated Dec. 13, 2022, https://crsreports.congress.gov/product/pdf/IF/IF12092.

[80] Peter Dunai, "Russian Naval Production Has 'Idled,' Admits Rogozin," *Jane's Defence Weekly*, June 3, 2015.

[81] Julian Cooper, "The Military Dimension of a More Militant Russia," *Russian Journal of Economics* 2, no. 2 (June 2016), https://www.sciencedirect.com/science/article/pii/S2405473916300162.

To replace these components, the Kremlin announced a large-scale import substitution program in 2014.[82] According to then Russian Defense Industry Chief Dmitry Rogozin, Moscow prioritized finding substitutes for the most critical Ukrainian components. Over time, the defense industry made progress in producing Russian alternatives for most Ukrainian components, although often at greater cost, lower quality, or both.[83] Nevertheless, Ukrainian sanctions have continued to hinder Russian defense production in certain areas, such as the production of marine turbine engines.[84]

Western sanctions

Western countries also imposed a series of increasingly severe sanctions on Russia in response to the 2014 Ukraine crisis. In this case, the West engaged in two separate lines of effort. First, European countries canceled almost all pending arms sales agreements with Russia for the transfer of advanced Western military equipment. These included pending sales of four French Mistral assault ships and a German ground force training center.[85] Most of these arms sales agreements also provided for technology transfer and in some cases for licensed production rights to enhance Russian defense production. Consequently, their termination set back Russian modernization efforts in several areas, forcing Russia to rely on inferior domestic alternatives.

Second, the United States and its European and Asia-Pacific allies imposed a series of export controls on a range of dual-use systems, components, and technologies used in Russian defense production.[86] These included prohibitions on exports of high-end electronic components, optical systems, composite materials, and advanced machine tools. As Russian Defense Industry Chief Dmitry Rogozin made clear, since the fall of the Soviet Union, Western components had been widely incorporated in Russian weapons systems—as a result of Western sanctions, however, Russia needed to replace 640 separate components.[87] He later admitted that the actual number of Russian defense products affected by the ban on Western component transfers numbered in the tens of thousands.[88] Replacing these components would therefore be a long-term objective for Russia's import substitution program.

Loss of access to Western components played a significant role in degrading Russian defense production. Russian sources admitted, for example, that the lack of Western radiation-resistant microchips had derailed Russian plans to produce

[82] Cooper, "The Military Dimension of a More Militant Russia."

[83] Alexander Zudin, "Russian Ministers Admit Arms Industry Hit by Sanctions," *Jane's Defence Weekly*, July 20, 2015; Max Bergmann et al., *Out of Stock? Assessing the Impact of Sanctions on Russia's Defense Industry*, Center for Strategic and International Studies, Apr. 2023, p. 3, https://www.csis.org/analysis/out-stock-assessing-impact-sanctions-russias-defense-industry.

[84] Sergio Miller, "Russian Shipbuilding Takes a Big Hit—What's Next?," Wavell Room, Mar. 23, 2023, https://wavellroom.com/2023/03/24/russian-shipbuilding/.

[85] Matthew Smith and Peter Dunai, "Analysis: The Impact of Europe's Sanctions on Russia," *Jane's Defence Weekly*, Aug. 1, 2014; Ryan Maass, "France Canceled Mistral Sale to Russia Under NATO Pressure," UPI, Oct. 2, 2015, http://www.upi.com/Business_News/Security-Industry/2015/10/02/France-canceled-Mistral-sale-to-Russia-under-NATO-pressure/4811443808996/.

[86] Welt et al., *U.S. Sanctions on Russia*.

[87] Vladimir Voronov, "No Way for Russian Helicopters Without Ukraine [Российским вертолетам без Украины никак]," *Svoboda*, Apr. 4, 2014, http://www.svoboda.org/content/article/25320203.html; Vladimir Voronov, "'Sevastopol' Is Russian, 'Varyag' Is Chinese [Севастополь – российский, Варяг – китайский]," *Svoboda*, Apr. 30, 2014, http://www.svoboda.org/content/article/25368574.html; Reuben F. Johnson, "Industry Briefing: Ukraine's and Russia's Defence Industrial Base," *Jane's Defence Weekly*, Aug. 1, 2014.

[88] "Rogozin: Import Substitution of Military Industrial Complex Components 90 Percent Completed in 2018 [Рогозин: импортозамещение компонентов ВПК завершится на 90% в 2018 году]," Gazeta.ru, Aug. 11, 2015, http://www.gazeta.ru/business/news/2015/08/11/n_7453253.shtml.

next-generation Glonass-K2 positioning and navigation satellites.[89] Despite sanctions, however, Russia has found ways to maintain access to several advanced Western components, including electronic components used in many Russian weapons systems, sometimes legitimately and sometimes through illicit networks. Nevertheless, loss of access to multiple Western components significantly affected Russian defense production.

Enhanced Western sanctions following Russia's 2022 invasion of Ukraine

Russia's 2022 invasion of Ukraine ushered in a series of additional measures targeting Russia's defense industry. These new Western sanctions abruptly severed the few remaining linkages for transfer of outright military components for Russia. For example, exports of French thermal imagers to Russia, which had continued since 2014 because of a sanctions loophole, were finally halted in the face of Russia's invasion of Ukraine.[90] Even more consequential, Western export controls have been repeatedly expanded since the 2022 invasion, cutting off Russia's access to most of the remaining dual-use items that it formerly imported from the West. These newly prohibited goods include drones and drone components, encryption software, a wide range of advanced electronics, and a range of industrial machinery and machine tools.[91]

In the United States, exports of military and dual-use items are controlled primarily by two parallel US export control regimes. The first is the International Traffic in Arms Regulations (ITAR), administered by the State Department, which controls export of "military" systems and components listed on the US Munitions List. The second is the Export Administration Regulations, administered by the Commerce Department's Bureau of Industrial Security, which regulates exports of dual-use items on the Commerce Control List. Most US allies and partners maintain a comparable set of export controls.

Exports of US military systems and technologies have long been subject to strict export controls under ITAR, with most items excluded from transfer to Russia. For example, the US has long restricted exports of main battle tanks to Russia. By contrast, the US formerly allowed transfer of a wide array of dual-use items to Russia. Export controls imposed after the Ukraine crisis restricted Russia's access to many of the most critical dual-use items formerly sourced from the West. Since 2022, US export controls have been dramatically expanded and have now virtually foreclosed Russia's access to a range of US dual-use technologies, including electronic microchips, advanced computers, telecommunications products, and sensors.[92]

Export controls on dual-use systems target Russia in two ways. First, the most sensitive dual- use items are subject to economy-wide export controls, virtually precluding all transfers to Russia without a license. Moreover, sanctions have been arranged so that

[89] "Sanctions Delay Russia's GLONASS-K2 Program," *GPS World*, Dec. 17, 2014, https://www.gpsworld.com/sanctions-delay-russias-glonass-k2-program/.

[90] Kosma Złotowski, Ryszard Antoni Legutko, and Jadwiga Wiśniewska, "French Shipments of Military Equipment to Russia Despite EU Embargo and the Violation of Rule of Law Principles," European Parliament, Mar. 16, 2022, https://www.europarl.europa.eu/doceo/document/P-9-2022-001087_EN.html.

[91] "Sanctions on Dual-Use Goods," EU Solidarity with Ukraine, European Commission, https://eu-solidarity-ukraine.ec.europa.eu/eu-sanctions-against-russia-following-invasion-ukraine/sanctions-dual-use-goods_en.

[92] Enhanced export controls are largely focused on dual-use technology because transfers of purely military items to Russia have long been strictly controlled. See Emily Kilcrease, "Noteworthy: The New Russia Export Controls," Center for a New American Security, Mar. 7, 2022, https://www.cnas.org/press/press-note/noteworthy-the-new-russia-export-controls. A license is now required to export such items regardless of the recipient involved, and there is a strong presumption of denial for any such license request.

there is a strong presumption against granting such licenses. Second, the Department of Commerce has imposed comprehensive sanctions on designated persons or entities, including most Russian defense enterprises, largely foreclosing exports of virtually all dual-use systems to such recipients.[93] As an example, sanctions targeting Rostec, Russia's largest defense enterprise, have comprehensively restricted the company's legitimate access to most US dual-use products.[94]

Key US allies, including members of NATO, Japan, South Korea, Australia, and New Zealand, have adopted similar sanctions on Russia, extending the ban on exports of dual-use technologies to virtually all corners of the Western world. Combined with Western arms embargoes, sanctions have now virtually foreclosed Moscow's ability to "legitimately" import most military and dual-use items that it formerly obtained from the West.

[93] These provisions operate in tandem such that exports can be permitted under the first provision but still banned under the other.

[94] Welt et al., *U.S. Sanctions on Russia*.

COMPENSATION STRATEGIES

Russia has been using three main strategies to compensate for the effect of sanctions and export controls on its defense industry (see Figure 2). These compensation strategies have largely, but not entirely, mitigated the immediate effect of Western restrictions on the Russian defense industry's ability to produce weapons and equipment for the Russian military.

The first of these, import substitution, is the Russian defense industry's effort to replace sanctioned Western products with domestic counterparts. As

Figure 2. Russian defense industry compensation strategies

Strategies

Import Substitution

- **Definition:** Replace sanctioned Western products with domestic counterparts.
- **Challenges:** Technological weaknesses, limited investment, brain drain.
- **Recent Developments:** Increased focus post-2022, but more rhetoric than progress.

Parallel Import

- **Definition:** Import sanctioned Western products through third countries without sanctions.
- **Legal Framework:** Non-sanctioning countries permit re-export of sanctioned Western goods to Russia.
- **Key Countries Involved:** China, Kazakhstan, Kyrgyzstan, Turkey, United Arab Emirates.
- **Role:** Facilitate evasion of sanctions on dual-use technologies, electronics, and machine tools.

Foreign Cooperation

- **Definition:** Import foreign military and dual-use technology, joint projects with foreign defense industries.
- **Historical Context:** Traditional avoidance of imports, dependence on Western components until 2015.
- **Current Partners:** China (indirect supplies of components like drones, semiconductors), North Korea (ammunition, missiles), and Iran (drones, missiles).

Source: CNA.

discussed in detail in the following subsections, previous efforts to eliminate the Russian defense industry's dependence on Western components have largely failed because of weaknesses in the technological level of Russia's industrial base, limited investment, and inertia. These weaknesses have been exacerbated to some extent by the brain drain of high-tech workers, especially after Russia's invasion of Ukraine. The imposition of stricter sanctions starting in 2022 has led to a greater effort to develop domestic substitutes, although the last two years have seen more rhetoric than actual progress.

The second strategy, usually called parallel import, involves the import of sanctioned Western products through third countries that have not implemented sanctions against Russia.[95] The term *parallel import* refers to the importation of a noncounterfeit product from another country without the permission of the intellectual property owner. Usually, these products are intended for sale in one country but reexported to a third country without the permission of the original producer or holder of intellectual property rights on the product.[96] In response to Western sanctions, the Russian government passed a law allowing the parallel import of a large variety of civilian and dual-use products from companies that have prohibited their products from being legally sold within Russia.[97] In the military and dual-use sphere, the key countries involved in this trade are Kazakhstan, Kyrgyzstan, the United Arab Emirates (UAE), Turkey, and China. All these states are playing an important role in helping Russia evade sanctions on dual-use technologies such as semiconductors and other electronics as well as machine tools.

The third strategy involves foreign cooperation, which consists of imports of foreign military and dual-use technology and, in some cases, joint projects with foreign defense industries. Russia has traditionally avoided imports of weapons and other military technology as much as possible. However, between 2005 and 2015, Russia became dependent on foreign and especially Western electronic components and machine tools and experimented with importing larger components, such as ship engines, and even entire systems, such as amphibious ships and military vehicles, from countries such as France and Italy. In the post-2022 period, the key foreign counterparts for cooperation efforts are Iran and North Korea, with the former providing drones and missiles and the latter providing ammunition and some missiles as well. In addition, although China is not providing direct military assistance, it is turning a blind eye to indirect supplies of components such as gunpowder, drones and drone parts, semiconductors, rifles, and trucks by Chinese companies.

Import substitution: goals, achievements, and limitations

Russia's military industry has a more than century-long history of dependence on imported industrial equipment. Machine tools imported from Germany from the 1920s to the 1940s and from the United States in the 1930s and 1940s were in use in the Soviet Union for decades. Even though the Soviet Union itself was one of the major manufacturers of machine tools in the world, its transition to modern military systems, including the T-72 main battle tank and its derivatives and the fourth generation

[95] Pjotr Sauer and Andrew Roth, "The Grey Zara Market: How 'Parallel Imports' Give Comfort to Russian Consumers," *Guardian*, Aug. 12, 2022, https://www.theguardian.com/world/2022/aug/12/russia-grey-market-parallel-imports-consumers-western-brands-zara.

[96] "Parallel Imports / Gray Market," International Trademark Association, https://www.inta.org/topics/parallel-imports/.

[97] "Russian Minister Says 'Parallel Imports' Scheme Is Working," Reuters, July 4, 2022, https://www.reuters.com/article/us-ukraine-crisis-russia-imports-idUSKBN2OF0ZL/.

of combat aircraft, missiles, and submarines during the 1970s and 1980s would have been impossible without the import of machine tools from West Germany, Switzerland, and Japan.[98]

During the 2000s and the first half of the 2010s, another large round of import of advanced machine tools took place. During this period, up to 90 percent of the machine tools in Russia's military sector were imported, with equipment from Siemens, Fanuc, Mycronic, Akira Seiki, BiSS, Mazatrol, Delta Electronics, and other such companies being purchased continuously until 2022.[99] Purchased industrial equipment allowed Russia to modernize its military industry and start serial manufacture of new arms, resulting in the successful state rearmament programs from 2011 to 2020 and 2018 to 2027.

The entire Russian military industrial complex, as well as Russia's machine tool industry, remains dependent on industrial equipment from Germany, the United States, Japan, Taiwan, France, Italy, Sweden, Switzerland, and South Korea. Moreover, the more sophisticated and advanced any single weapon system is, the more its manufacturer depends on this imported industrial equipment

Import substitution policy

Despite the Kremlin's plan for economic self-sufficiency adopted after the imposition of international sanctions in 2014, Russia has not yet been able to produce everything that it needs in arms manufacturing. Before 2014, Russia's defense industry produced 826 military items using foreign components. This number included 186 items using Ukrainian components and 640 items using components from NATO and EU member states, especially in electronic and optical systems.[100] In 2014, the government announced plans to substitute these components with domestic production by 2020. From 2015 to 2018, the government spent almost $25 billion on pursuing this import substitution policy.[101] However, it was not able to meet its goals and eventually extended the deadline to 2025.

Reverse engineering has been the dominant approach since the very beginning of the import substitution policy. However, this approach has been largely unsuccessful because of insufficient numbers of scientists and engineers. Furthermore, the limited human capital was spread among too many facilities and projects, and the military industrial complex was competing for this human capital with the

98 "Western Technology in the Soviet Union," in *Technology and East-West Trade* (Office of Technology Assessment, 1979), pp. 229–30, https://www.princeton.edu/~ota/disk3/1979/7918/791812.PDF.

99 Elena Nemchinova, "New Equipment for the Foundry [Новое оборудование для литейного цеха]," *Agregat,* Oct. 2019, https://agregat-avia.ru/upload/gazeta/Oct2019.pdf; "Market for Milling Machines [Рынок фрезерных станков]," Komplekt: ITO, July 2022, http://www.ito-news.ru/archive/2022/2207ito-news_10_845910.pdf.

100 "Rogozin Promised to Replace Ukrainian Components in Defense Industry by 2018 [Рогозин пообещал замещение украинских комплектующих в оборонке к 2018 году]," Lenta.ru, July 1, 2015, https://lenta.ru/news/2015/07/01/oboronka/; "Single Day of Acceptance of Military Products [Единый день приёмки военной продукции]," Kremlin.ru, July 15, 2015, http://kremlin.ru/events/president/news/50005.

101 "Russia Spent a 'Huge Amount' on Import Substitution [На импортозамещение в России потратили «огромную сумму»]," Rosbalt, Dec. 10, 2019, https://www.rosbalt.ru/business/2019/12/10/1817635.html.

civilian economy.[102] Because of these limitations, the Russian defense industry has been forced to continue to rely on large-scale imports from willing suppliers to circumvent Western sanctions imposed since 2022.[103] In the next sections, we discuss the extent to which Russia's import substitution policy has made progress in reducing dependence on foreign components in the key sectors of electronic components, communications equipment, and engines.

Electronic components for armaments

At the start of the import substitution program in 2014, Russian authorities' goal was for Russian companies to be able to produce 94.6 percent of electronic components necessary for military production by the end of 2020. The remainder were considered at the time to be "nonreproducible" in Russia.[104] However, the reality diverged significantly from those optimistic expectations. For example, as of December 2015, even the Grad and Smerch Multiple Launch Rocket Systems, which are much simpler than advanced precision weapons, were dependent on electronic components from China, although not from the US, Taiwan, or Europe.[105] In another example, in 2018, the developer of the Tirada-2S satellite communication jamming system failed in its efforts to substitute imported high-voltage power modules, which were then declared nonreproducible.[106]

In 2008, Russia's government sponsored purchasing an old semiconductor production line that belonged to Advanced Micro Devices, Inc. (AMD), the US-based electronics company. This purchase became one of Russia's most significant import substitution efforts in electronics. The production line was transferred to Russia and launched in 2016 by Angstrem-T, a subsidiary of Angstrem, one of Russia's major electronics and communications corporations. However, the factory quickly fell under US sanctions and finally went bankrupt in 2019. The production facility was thereafter nationalized, with the Russian government trying to recruit and relocate several dozen specialists from UMC, a Taiwanese electronics company, with the goal of relaunching the production line in 2021. However, the full-scale

[102] D. A. Vladimirov, "Reverse Engineering as the Main Tool in Increasing the Efficiency of R&D [Обратный инжиниринг как основной инструмент в повышении эффективности проведения НИОКР]," *Nauka i Biznes* 9 (2020), pp. 28–30, https://www.elibrary.ru/item.asp?id=44383661; "Meeting with Heads of Leading Engineering Schools and Their Industrial Partners [Встреча с руководителями передовых инженерных школ и их индустриальными партнёрами]," Kremlin.ru, Sept. 21, 2022, http://special.kremlin.ru/catalog/regions/NGR/events/69396; "Denis Manturov Took Part in the Session 'Updating Russia's Long-Term Industrial Policy for the New Reality,'" Government.ru, June 16, 2023, http://government.ru/news/48779/; Ekaterina Vinogradova, "Reverse Alternative to Parallel Import [Реверсивная альтернатива параллельному импорту]," *RBK*, Dec. 1, 2022, https://www.rbc.ru/newspaper/2022/12/01/6386025c9a79472b2a658961; Yuliia Sanatina, "Demand for Reverse Engineering Has Increased Sharply in the Urals [На Урале резко вырос спрос на обратный инжиниринг]," *Rossiiskaia Gazeta*, July 4, 2022, https://rg.ru/2022/07/04/reg-urfo/revers-vyruchit.html; "Putin Spoke About Reverse Engineering When Specialists Work with Captured Equipment [Путин рассказал про обратный инжиниринг при работе специалистов с трофейной техникой]," *Izvestiia*, July 16, 2023, https://iz.ru/1544886/2023-07-16/putin-rasskazal-pro-obratnyi-inzhiniring-pri-rabote-spetcialistov-s-trofeinoi-tekhnikoi.

[103] Jon Parton, "Two Men Accused of Smuggling US Electronics into Russia," Courthouse News Service, Mar. 20, 2019, https://www.courthousenews.com/two-men-accused-of-smuggling-u-s-electronics-into-russia/; "Germany Jails Russian for Exporting Embargoed Military Tech," *Moscow Times,* Jan. 10, 2020, https://www.themoscowtimes.com/2020/01/10/germany-jails-russian-for-exporting-embargoed-military-tech-a68857; Oleg Rubnikovich, "UEC Top Manager Was Extradited to Russia from the Americans [Топ-менеджера ОДК экстрадировали в Россию от американцев]," *Kommersant,* Aug. 18, 2020, https://www.kommersant.ru/doc/4458318.

[104] E. Pokataeva and E. Petrovskaia, "Import Substitution and Quality Assurance [Импортозамещение и обеспечение качества]," *Elektronika* 3 (2018), pp. 40–48, http://www.electronics.ru/files/article_pdf/6/article_6616_528.pdf.

[105] Nataliia Kaliuzhnaia, "Russian Missile Made in China [Российская ракета made in China]," *Novyi Kompanion*, Dec. 8, 2015, https://www.newsko.ru/articles/nk-2893054.html.

[106] Vladimir Elekotrpribor Factory, *2018 Annual Report*, https://e-disclosure.ru/portal/files.aspx?id=16566&type=2.

invasion of Ukraine led to the cancellation of this plan and the final collapse of this effort to launch a domestic semiconductor production line.[107]

Russia is similarly vulnerable in space-grade electronics. After a decade of import substitution efforts in the space sector, the Russian state-owned space corporation Roscosmos declared in February 2023 that it needed an additional five years for the substitution of all necessary electronic components and onboard equipment for spacecraft.[108] This timeline should be considered as the most optimistic scenario given that recent generations of Russian satellites have contained up to 80 percent imported space-grade electronics, with representatives of Russia's space industry recognizing earlier that the complete import substitution of all imported electronic components onboard Russian satellites would be an impossible task.[109]

As a result of these failures, Russia has been forced to continue to import a wide spectrum of semiconductors for its arms manufacturing, including for cruise missiles and UAVs, despite the strengthening of Western sanctions beginning in 2022. It simply has no alternatives to this policy. Therefore, in the foreseeable future, Russia will be unable to produce domestically the complete range of products and components for manufacturing military equipment that it had previously imported and will have to continue to rely on either purchasing Chinese components to replace those on Western export control lists or allowing the parallel import of the prohibited components.

Communication systems

For years, communications has been one of the weakest aspects of the Russian armed forces. During the 2010s, Russia tried to fill the gap through massive purchases of Russian-made radio communication systems.[110] However, these systems were Russian-made only on paper because significant components were imported from China. Russian industrial facilities such as Angstrem and the Yaroslavl radio manufacturing plant appeared to be unable to fully produce these systems domestically.[111]

Another example is the onboard communication systems of Russian armored vehicles and main battle tanks. In 2023, a massive replacement of the old-fashioned onboard communication systems with the

[107] "'The Angstrem-T Plant Will Be Launched,' the Management Company Is Confident [«Завод „Ангстрем-Т" будет запущен», — уверены в управляющей компании]," Zelenograd.ru, May 19, 2010, https://www.zelenograd.ru/news/4617/; "The Unfinished Angstrem-T Factory Comes Under State Control [Недостроенная фабрика «Ангстрем-Т» переходит под контроль государства]," Zelenograd.ru, Oct. 29, 2009, https://www.zelenograd.ru/news/4047/; Elias Kasmi, "It's Official. Angstrem-T Is Bankrupt [«Ангстрем-Т» банкрот. Признано официально]," CNews, Oct. 28, 2019, https://www.cnews.ru/news/top/2019-10-28_krupnyj_rossijskij_zavod; Elias Kasmi, "Two Factories Were Taken Away from Angstrem-T [У «Ангстрем-Т» отобрали два завода]," CNews, July 30, 2020, https://www.cnews.ru/news/top/2020-07-30_u_angstremt_otobrali_dva; Nikita Korolev, "NM-Tech Attracted Forces from Taiwan [«НМ-Тех» привлек силы с Тайваня]," *Kommersant*, Sept. 20, 2021, https://www.kommersant.ru/doc/4995271.

[108] "Roscosmos Needs Five Years to Completely Replace Imported Instruments for Satellites ["Роскосмосу" нужно пять лет для полного импортозамещения приборов для спутников]," Interfax, Feb. 16, 2023, https://www.interfax.ru/russia/886464.

[109] "Boards Instead of Chips. Russian Satellites Are Switching to Domestic Components at the Expense of Weight and Dimensions [Платы вместо чипов. Российские спутники переходят на отечественные комплектующие в ущерб массе и габаритам]," IXBT, Apr. 27, 2022, https://www.ixbt.com/news/2022/04/27/platy-vmesto-chipov-rossijskie-sputniki-perehodjat-na-otechestvennye-komplektujushie-v-usherb-masse-i-gabaritam.html.

[110] "More Than 2 Thousand Modern Azart Radio Stations Entered the Central Military District Troops in 2021 [Более 2 тыс. современных радиостанций «Азарт» поступили в войска ЦВО в 2021 году]," TASS, Nov. 8, 2021, https://tass.ru/armiya-i-opk/12867881.

[111] Oleg Rubnikovich and Nikolai Sergeev, "The General's Blood Pressure Increased from the Colonels [У генерала повысилось давление от полковников]," *Kommersant*, Oct. 18, 2019, https://www.kommersant.ru/doc/4127747; Oleg Rubnikovich and Nikolai Sergeev, "Military Supplies Are Approached with Civic Passion [К военным поставкам подходят с гражданским азартом]," *Kommersant*, Mar. 4, 2021, https://www.kommersant.ru/doc/4712794; Nikolai Sergeev, "The General Was Accused Without 'Excitement' [Генерала обвинили без «Азарта»]," *Kommersant*, May 5, 2022, https://www.kommersant.ru/doc/5340173.

new Sotnik-BL system began.[112] The key issue is that Sotnik-BL itself is not a communication system but an adapter module used to integrate the Lira civilian car radio system with the electric, control, and communication systems inside Russian tanks and armored vehicles. The Lira radio system is made by a Russian company that uses a Chinese production facility.[113] In other words, Soviet-era Russian communication systems are being replaced by ones made in China, and there is no working alternative to this trend. Although this is not a problem as long as China remains willing to provide dual-use equipment to the Russian military, it does highlight the Russian defense industry's inability to create a fully domestic production capability for communication systems.

Engines for aircraft and ships

Even though Russia produces a wide range of engines for aircraft and ships, after being subjected to sanctions after its initial invasion of Ukraine in 2014, as of 2022, it was still incapable of producing all the engines that it could no longer import. Generally speaking, Russia can domestically produce most components previously sourced from Ukraine through localization of production and the creation of domestic countertypes. However, whether Russian companies can achieve the same volume of output, especially in manufacturing helicopter and naval engines, is still unknown.

Moreover, Russia still does not produce the full range of aircraft engines that it needs for its military. For instance, as late as March–May 2022, Russia was illegally procuring helicopter engines from the Ukrainian company Motor Sich.[114] Although Russia has been capable of producing all necessary helicopter engines by itself for years, the production rates were insufficient to meet the needs of the Russian Helicopters corporation.

In addition, Russia is still unable to provide its own engines and engine parts for key UAVs, such as Orlan-10, Orion, and Altius. Even the substituted UAV engine APD-100/120, a counterpart of the Austria-made Rotax 914 engine designed for the Orion UAV, still depends on key imported components such as its fuel system and is heavier than the original engine.[115]

Russia was able to make domestically produced engines for its PD-14 and PD-8 commercial aircraft by reverse engineering the American PW1000G and French-Russian SaM-146 and Ukrainian D-436 engines. However, the serial production of PD-14 only launched in 2023 and is still far below the planned production rates, whereas serial production of PD-8 has not been launched yet.[116]

Russia also faces challenges with substitution of naval gas turbine engines, which it previously

[112] Dmitry Valiuzhenich, "Russian Tanks Receive the Latest Sotnik-BL Digital Communication Kits [Российские танки получают новейшие комплекты цифровой связи «Сотник-БЛ»]," Anna News Agency, Dec. 10, 2023, https://anna-news.info/rossijskie-tanki-poluchayut-novejshie-komplekty-tsifrovoj-svyazi-sotnik-bl/.

[113] "Car Radio Lira DM-1000 DMR [Радиостанция автомобильная Lira DM-1000 DMR]," Lira, https://lira-radio.ru/catalog/avtomobilnye_i_bazovye/4220/.

[114] Igor Orel and Dmitry Ulianitskiy, "'We Ship Dozens. Everything Goes.' Did Motor Sich Supply Engines for Russian Military Helicopters During a Full-Scale War? Here's What Is Known [«Отправляем десятками. Все идет». «Мотор Сич» во время полномасштабной войны поставляла двигатели для военных вертолётов РФ? Вот что известно]," *Forbes Ukraine*, Oct. 24, 2022, https://forbes.ua/ru/company/motor-sich-pid-chas-garyachoi-viyni-postachala-dviguni-dlya-rosiyskikh-viyskovikh-gvintokriliv-yak-tse-mozhlivo-24102022-9249.

[115] "OKR Code 'Trajectory – B' [ОКР шифр «Траектория – Б»]," Aviatp, https://aviatp.ru/files/newturn/Presentatsiy/11_Agat.pdf.

[116] "The PD-8 Engine Was Launched for the First Time on the SSJ-100 Aircraft [Двигатель ПД-8 впервые запустили на самолете SSJ-100]," TASS, Oct. 12, 2023, https://tass.ru/ekonomika/18986455; "Vladimir Putin Was Informed About the Production of PD-14 and PD-35 Engines for the MS-21 Aircraft [Владимиру Путину доложили о производстве двигателей ПД-14 и ПД-35 для самолета МС-21]," IRK, Oct. 20, 2023, https://www.irk.ru/news/20231020/engine/; "UEC Announced the Start of Serial Production of PD-14 Engines for MS-21 Aircraft [ОДК сообщила о начале серийного производства двигателей ПД-14 для самолетов МС-21]," *Vedomosti*, Apr. 7, 2023, https://www.vedomosti.ru/technology/news/2023/04/07/970077-odk-soobschila-o-nachale-proizvodstva-pd-14.

imported from Ukraine. The Admiral Gorshkov class (Project 22350) frigates are delayed because the Russian manufacturer Saturn was able to supply just two engines for these ships between 2014 and 2021.[117] Although the company has increased the production rate of these naval engines since that time, its production rate is still a constraint on the production of this line of frigates, leading to delays and postponements.[118]

Outcomes of a decade of import substitution

Russia's import substitution policy had limited success from 2014 to 2021, and it became even harder for Russia to achieve the substitution policy in 2022 and 2023. These trends suggest that the more intensive policy is also unlikely to be successful in the coming years: the shortage of human capital and technologies together with limited and more expensive access to the global supply chains will prevent Russia from achieving its import substitution goals. Even if Russia can substitute previously imported components and parts, the cost of manufacturing them has been too high, and the production rates are insufficient. Russia is thus unable to domestically produce advanced electronic components.

Russia's machine tool industry in general, and the military industrial complex specifically, continues to be dependent on imported advanced machine tools and components. The increase in machine tool production rates over the last decade is still not enough to cover all of Russia's domestic needs or even just the needs of the military industry. Furthermore, this increase has been combined with a decrease in the average cost of domestically produced machine tool units, which suggests simplification and the use of lower quality components. In summary, the failure of Russia's import substitution program means that Russia will be forced to continue to rely on importing supplies of critical defense industrial components from abroad in the foreseeable future.

Parallel import

The key pathways for parallel import of Western military and dual-use components include China and Hong Kong, Central Asian states, Turkey, and the UAE. This section presents an overview of the types of channels being used and the types of goods being smuggled through these channels. In Table 3, we present a noncomprehensive list of known types of materials that have been smuggled through these countries into Russia. Detailed discussion of specifics regarding parallel import through each country may be found in Appendix A: Parallel Import Country Studies.

Over the course of 2023, China became the dominant player in providing military and dual-use components to Russia in circumvention of Western export controls. In its July 2023 assessment, the US Office of the Director of National Intelligence noted that it "is difficult to ascertain the extent to which the PRC [People's Republic of China] has helped Russia evade and circumvent export controls."[119] However, by early 2024, a comprehensive Ukrainian analysis of export routes of products used by Russia on the

[117] "Full Speed Ahead: New Marine Engines for the Russian Fleet [Полный вперед: новые морские двигатели для российского флота]," Rostec.ru, Nov. 30, 2021, https://rostec.ru/news/polnyy-vpered-novye-morskie-dvigateli-dlya-rossiyskogo-flota/.

[118] "The Northern Shipyard Spoke About the Delivery Dates for New Frigates [На Северной верфи рассказали о сроках сдачи новых фрегатов]," Sudostroenie.info, Apr. 24, 2019, https://sudostroenie.info/novosti/26617.html.

[119] Office of the Director of National Intelligence, *Support Provided by the People's Republic of China to Russia,* July 2023, p. 5, https://democrats-intelligence.house.gov/uploadedfiles/odni_report_on_chinese_support_to_russia.pdf.

Table 3. Parallel import channels

	Aircraft parts	Semi-conductors	Drones	Rare earths	Machine tools	Commu-nication equipment	Optical equipment	Robotics technology
China	■	■	■					
Kazakhstan	■	■	■	■				
Kyrgyzstan	■		■			■		
Uzbekistan					■			
Tajikistan	■							
Turkey		■			■			
UAE		■	■		■		■	■

Source: CNA.

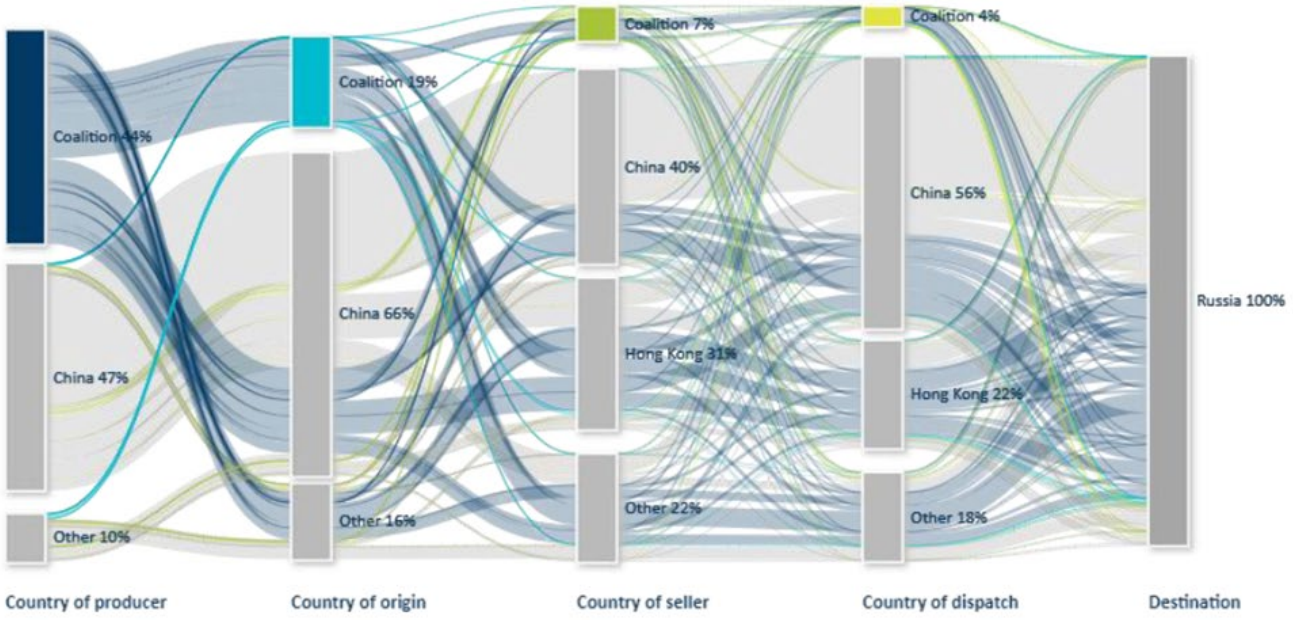
battlefield in Ukraine showed that most products produced by Western companies were exported to Russia through either China or Hong Kong (see Figure 3). This analysis by the Kyiv School of Economics shows that "producers headquartered in [Western] coalition countries were responsible for at least 43.9% of battlefield goods and 32.8% of critical components in January-October 2023."[120] As shown in Figure 4, this study found that two-thirds of the imported products used by Russia on the battlefield that were made by producers headquartered in coalition countries were actually manufactured in China. Furthermore, approximately 30 percent of critical components imported from Western countries were manufactured in China, and more than 75 percent were exported to Russia from China or Hong Kong.[121]

Despite Central Asian states' efforts to avoid being dragged into the conflict and to maintain their autonomy, Russia retains considerable leverage in the region, which limits any interest that they may have in distancing themselves from Moscow. This influence is reflected in the support that many of these states have provided for Russia's war effort, whether by design or default.

[120] Olena Bilousova et al., *Challenges of Export Controls Enforcement: How Russia Continues to Import Components for Its Military Production*, Kyiv School of Economics, Jan. 2024, p. 11, https://kse.ua/wp-content/uploads/2024/01/Challenges-of-Export-Controls-Enforcement.pdf.

[121] Approximately 35 percent of the components were manufactured in coalition countries and then exported through China, Hong Kong, or other countries. The remaining portion were manufactured in other nonaligned countries and then exported either by those countries directly or through Hong Kong. Bilousova et al., *Challenges of Export Controls Enforcement*, p. 17.

Figure 3. Mapping of Russian imports of battlefield goods, January 2023 to October 2023



Source: Bilousova et al., *Challenges of Export Controls Enforcement*, p. 11.

A key aspect of this support is the involvement of the Central Asian states in trade of sanctioned items with Russia, which the European Bank for Reconstruction and Development has termed "the Eurasian roundabout."[122] Although the amount of Russian trade with Central Asia is much smaller than the amount with China, the Eurasian route provides Russia with access to prohibited US and European technologies.[123] The US Department of the Treasury lists Kazakhstan, Kyrgyzstan, Uzbekistan, and Tajikistan among the countries that serve as transshipment points for sanctioned goods destined for Russia.[124] Central Asian states have not imposed sanctions on Russia, but they claim to observe existing ones to avoid countersanctions on their own economies. Efforts to observe Western sanctions involve a certain amount of procedural compliance—prohibiting the use of Russia's Mir payment system—but still allow Russians in their countries to set up local bank accounts or apply for local credit cards.

The lack of customs controls on the countries in the Eurasian Economic Union (currently only Kazakhstan and Kyrgyzstan) expands the opportunity for unregulated trade of both licit and illicit goods to Russia. However, inadequate warehouse and logistics capabilities in the Central Asian states have limited their capacity to serve as intermediaries.[125] Sometimes the sanctioned goods appear to go through only

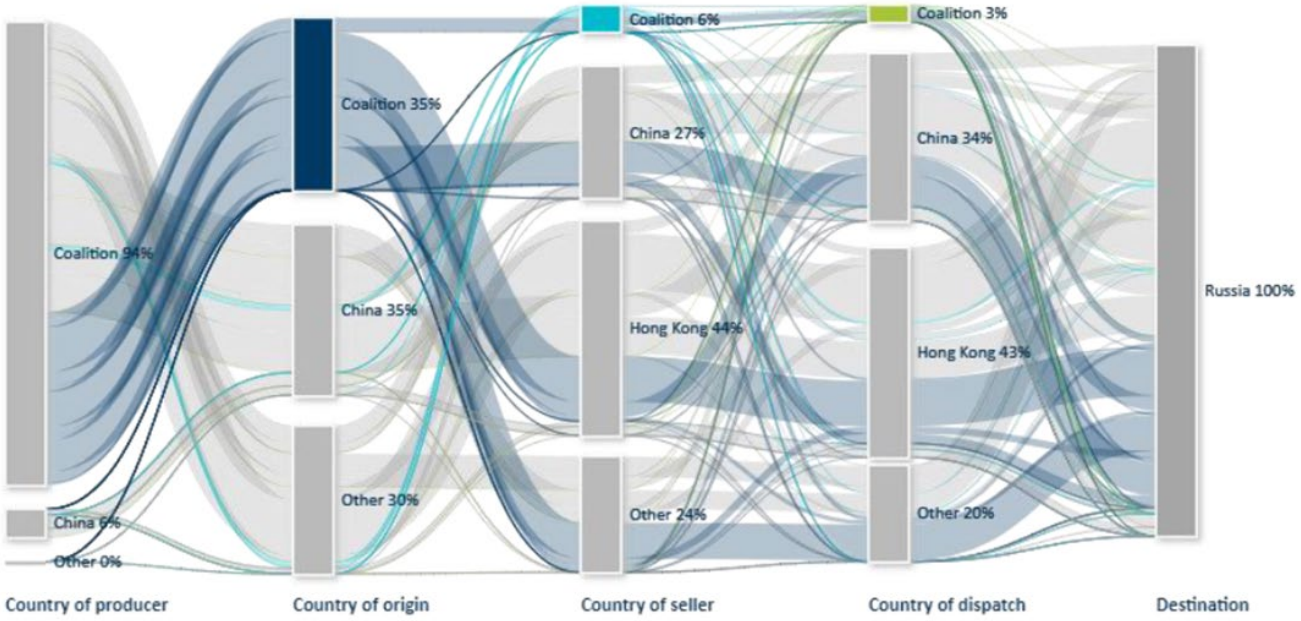
[122] Maxim Chupilkin, Beata Javorcik, and Alexander Plekhanov, *The Eurasian Roundabout: Trade Flows into Russia Through the Caucasus and Central Asia*, The European Bank for Reconstruction and Development, Working Paper 276, Feb. 2023, https://www.ebrd.com/publications/working-papers/the-eurasian-roundabout.

[123] Georgi Kantchev, Paul Hannon, and Laurence Norman, "How Sanctioned Western Goods Are Still Flowing into Russia," *Wall Street Journal*, May 14, 2023, https://www.wsj.com/articles/how-sanctioned-western-goods-are-still-flowing-into-russia-916db262.

[124] Maria A. Blackwood et al., *Central Asia: Implications of Russia's War in Ukraine*, Congressional Research Service, June 9, 2023, p. 15.

[125] "Russia's Parallel Imports Hindered by Central Asia Bottleneck," Eurasianet, Apr. 10, 2023, https://eurasianet.org/russias-parallel-imports-hindered-by-central-asia-bottleneck.

Figure 4. Mapping of Russian imports of critical components from selected coalition countries



Source: Bilousova et al., *Challenges of Export Controls Enforcement*, p. 17.

Central Asia—payment may go through Bishkek or another city in Central Asia, but the goods come directly from the US to Russia through intermediary ports such as Klaipeda in Lithuania. Although they are listed as transit goods destined for Central Asia, their actual destination is Russia.[126]

Since 2022, the UAE, a key US ally in the Middle East, has emerged as a major exporter of dual-use technology to Russia. The UAE tends to act passively in this regard, serving as a transshipment hub for the transfer of sanctioned goods originating in other countries, although there are cases in which UAE entities have participated directly in Russian illicit networks. These activities have continued despite Western pressure for the UAE to curb its ties with the Kremlin.

Total trade turnover between the countries is approaching $10 billion, according to a recent press release by Russian Foreign Minister Sergei Lavrov.[127] By contrast, exports of sanctioned products constitute a relatively small portion of the UAE's total exports to Russia. Between July and November 2022, UAE companies reportedly exported more than $18 million of goods to Russian entities in violation of US export controls. Associated entities were specifically targeted by US and EU sanctions for their role in sustaining the Kremlin's war efforts.[128] In addition, the UAE exported more than $5 million of US export-controlled product that was shipped to Russia in contravention of broader US sanctions on Russia's economy. These included semiconductors used to support Moscow's war efforts in Ukraine.[129]

[126] Carl Schreck et al., "Kyrgyz, Kazakh Companies Send Tech to Firms Linked to Kremlin War Machine," Radio Free Europe/Radio Liberty, June 22, 2023, https://www.rferl.org/a/kyrgyz-kazakh-firms-investigation-western-tech-russia-war-ukraine/32467795.html.

[127] "Foreign Minister Sergey Lavrov's Address at the Opening Ceremony of a UAE Lecture Hall at MGIMO University," Russian Ministry of Foreign Affairs, Sept. 1, 2023, https://mid.ru/en/maps/ae/1902587/.

[128] "Remarks by Assistant Secretary Elizabeth Rosenberg for Terrorist Financing and Financial Crimes at the Association of Women in International Trade," US Department of the Treasury, Mar. 2, 2023, https://home.treasury.gov/news/press-releases/jy1317.

[129] "Remarks by Assistant Secretary Elizabeth Rosenberg."

Turkey has likewise become an important transshipment country in terms of helping Russia to evade sanctions over the war in Ukraine.[130] During the first three quarters of 2022, Turkey reportedly transferred $5.7 billion of goods to Russia, an increase of 42.5 percent over the same period in the previous year, although this amount included both legitimate and illicit transfers. This increase occurred despite a temporary drop in total trade turnover in March 2022, with exports falling by nearly 50 percent following Russia's invasion. Yet two-way trade recovered rapidly starting in April 2022, and by September 2022, it had grown to 2.3 times the total trade level in September 2021.[131]

Parallel import has played an important role in boosting Turkey's trade totals with Russia.[132] Although a NATO member, Turkey declined to join the Western sanctions regime against Russia, citing potentially prohibitive costs to its economy.[133] Turkish officials reiterated that Ankara participates only in sanctions adopted by the United Nations (UN) Security Council, although the country does not expressly condone attempts to evade sanctions on Russia.[134] Turkey has been a major contributor to Russia's war effort in Ukraine despite also providing substantial military support for Kyiv.[135] Disregarding parallel import of sanctioned goods into Russia, especially dual-use electronics, has been Ankara's most important contribution to Russian defense production. Since the invasion, Turkey has become an important transit hub for goods destined for Russia, helping to circumvent the West's economic blockade. Turkish and Russian firms have also been cooperating to ship electronic components, metallurgical equipment, machinery, and vehicles to Russia in contravention of Western sanctions.

Turkish firms have been helping Russia obtain a wide range of dual-use components and technologies. According to data from the Free Russia Foundation, Turkey doubled its exports of heavy machinery and spare parts to Russia and nearly tripled its exports of consumer electronics in 2022.[136] Some of these activities are explicitly helping Russia circumvent sanctions. Turkey has played a particularly significant role in the sales and shipment of computer numerical control (CNC) machines to Russia, a topic that is discussed in more detail in the machine tools case study that follows.[137]

Foreign cooperation

Foreign cooperation has played a critical role in enabling Russian defense industry to continue to supply weapons to the military effort against Ukraine. As already noted, the key countries providing direct military assistance to Russia's war effort include China, North Korea, and Iran. This section presents an overview of the types of assistance being provided to

[130] Alexandra Sharp, "U.S. Imposes Landmark Sanctions on Turkey," *Foreign Policy*, Sept. 14, 2023, https://foreignpolicy.com/2023/09/14/us-turkey-sanctions-russia-ukraine-shipping-nato/; Martin Fornusek, "WSJ: US Concerned over Turkish Companies Helping Russia Evade Sanctions," Yahoo News, Aug. 18, 2023, https://news.yahoo.com/wsj-us-concerned-over-turkish-153627951.html.

[131] Evgeny Gayva, "The EAEU Countries Increased the Import of Goods to Russia by 30 Percent [Страны ЕАЭС увеличили ввоз товаров в Россию на 30 процентов]," *Rossiiskaia Gazeta*, Nov. 23, 2022, https://rg.ru/2022/11/22/tovar-ishchi.html.

[132] Gayva, "The EAEU Countries Increased the Import of Goods to Russia by 30 Percent."

[133] Hamdi Firat and Buyuk Sarajevo, "Turkey Rules Out Sanctioning Russia, Citing Risk to Economy," Balkan Insight, Mar. 14, 2022, https://balkaninsight.com/2022/03/14/turkey-rules-out-sanctioning-russia-citing-risk-to-economy/.

[134] Jared Malsin, "Russia's Ukraine War Effort Fueled by Turkish Exports," *Wall Street Journal*, Feb. 3, 2023, https://www.wsj.com/articles/russias-ukraine-war-effort-fueled-by-turkish-exports-11675447477.

[135] Vicken Cheterian, "Friend and Foe: Russia–Turkey Relations Before and After the War in Ukraine," *Small Wars & Insurgencies* 34, no. 7 (2023), p. 1283.

[136] Free Russia Foundation, *Effectiveness of U.S. Sanctions Targeting Russian Companies and Individuals*, Jan. 30, 2023, https://www.4freerussia.org/effectiveness-of-u-s-sanctions-targeting-russian-companies-and-individuals/.

[137] Bilousova et al., *Challenges of Export Controls Enforcement*, pp. 22–23.

Russia by these countries, as summarized in Table 4. Detailed discussion of specific forms of assistance provided by each country can be found in Appendix B: Foreign Cooperation.

Although there is no evidence that China is providing direct lethal aid to the Russian war effort in Ukraine, Chinese companies have been implicated in providing substantial support to Russia's defense sector. According to the EU, the Russian military sources 70 percent of its high-tech imports from China.[138] PRC state-owned companies have shipped navigation equipment, jamming technology, and parts for fighter jets to Russian state-owned defense companies through smaller brokering companies in the mainland and Hong Kong.[139] According to data from the Silverado Policy Accelerator, since the start of the war, China has become the largest source of semiconductors and related technologies for Russia, accounting for 78 percent of exports of semiconductor devices and 96 percent of smart cards and dominating sales of technology for semiconductor production.[140] DJI and Autel drones have been found on the battlefield in Ukraine, although they are mostly being procured through indirect methods because of restrictions imposed by the Chinese government and by the UAV producers themselves.[141]

Table 4. Foreign weapons and military equipment provided to Russia, 2022–2024

	Ammunition	Missiles	Drones	Trucks	Semiconductors	Electronic equipment	Rifles	Gunpowder
China			■	■	■	■	■	■
North Korea	■	■						
Iran	■		■					
UAE			■	■				

Source: CNA.

[138] Finbarr Bermingham, "EU Says up to 70% of Hi-Tech Imports 'Killing Ukrainians' Are Reaching Russian Military via China," *South China Morning Post*, Sept. 22, 2023, https://www.scmp.com/news/china/diplomacy/article/3235536/eu-says-70-hi-tech-imports-killing-ukrainians-are-reaching-russian-military-china.

[139] Office of the Director of National Intelligence, *Support Provided by the People's Republic of China to Russia,* p. 6. Because China has relatively few SU-35 fighter aircraft and buys parts for them from Russia, one analysis cast doubt on the likelihood that the People's Liberation Army would give up those parts for the war in Ukraine. See A. B. Abrams, "China Has Options to Arm Russia Directly. But Does It Need To?," *Diplomat*, Apr. 17, 2023, https://thediplomat.com/2023/04/china-has-options-to-arm-russia-indirectly-but-does-it-need-to/.

[140] "Russia Semiconductor Imports Dashboard: Pre and Post Invasion Trends," Silverado Policy Accelerator, Aug. 24, 2023, https://silverado.org/news/russia-semiconductor-imports-dashboard-pre-and-post-invasion-trends/.

[141] "DJI Reassesses Sales Compliance Efforts in Light of Current Hostilities," DJI, Apr. 26, 2022, https://www.dji.com/newsroom/news/dji-statement-on-sales-compliance-efforts.

In 2022, Russian leaders began to reach out to North Korea, seeking to purchase millions of shells and rockets to replenish Russia's depleting stockpiles. Despite warnings from US officials of consequences if North Korea helped Russia prolong the war in Ukraine, North Korean leader Kim Jong Un followed through on an agreement reached at a summit with Putin in September 2023 to supply a range of war supplies. Unlike other allies, such as China and Iran, North Korea is limited to supplying low-tech Soviet-era weaponry that is interoperable with Russian systems to support the Russian war effort. Since fall 2023, North Korea has supplied more than a million artillery shells and dozens of KN-23 missiles.[142] There is also some suspicion that North Korea has also supplied less accurate Scud missiles. These supplies are expected to continue for the foreseeable future, with North Korean munitions factories reportedly operating at near full capacity.[143]

Iran has been an important source of weapons and training for Russia's war in Ukraine, despite repeated denials from Iranian officials.[144] At this juncture, Iranian military aid consists of selling and coproducing drones, selling ammunition and artillery shells, and training. Shahid 131 and Shahid 136 drones have been particularly significant in Russia's campaign targeting Ukrainian positions and infrastructure, with thousands of drones delivered already through summer 2023. In November 2022, US media reported that, following a visit by Russian officials to Iran, Russia and Iran reached a deal to coproduce Shahid 136 drones in Russia.[145] Iran has played a key role in replenishing Russian supplies of ammunition and artillery shells. From November 2022 through April 2023, Iran shipped 300,000 artillery shells and 1 million rounds of ammunition across the Caspian Sea to Russia.[146] Ongoing talks about the sale of Iranian ballistic missiles have yet to result in a deal, although one may be imminent, according to US officials.[147]

The UAE has also provided some direct military assistance, although at a much smaller scale than the three countries already discussed. Since 2022, the UAE has transferred civilian drones and equipment for military vehicles to Russia, although given UAE's close economic and security relations with the United States, Western pressure on the UAE to comply with Western sanctions is likely to constrain the country's willingness to engage in technology cooperation with Russia.[148]

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[142] Kim Tong-Hyung, "South Korea's Spy Agency Says North Korea Shipped More Than a Million Artillery Shells to Russia," *Washington Post*, Nov. 1, 2023.

[143] At least one open-source analyst believes that Russia's new North Korean missiles struck a pair of Ukrainian army logistics bases, destroying as many as 10 tanker trucks. See David Axe, "Russia Got 7,500-Pound Rockets from North Korea—and Promptly Blew Up a Pair of Ukrainian Supply Bases," *Forbes*, Jan. 5, 2024.

[144] Giorgio Cafiero, "Iran's Indispensable Role for Russia in the Ukraine War," Gulf International Forum, Feb. 24, 2023, https://gulfif.org/irans-indispensable-role-for-russia-in-the-ukraine-war/.

[145] Joby Warrick, Souad Mekhennet, and Ellen Nakashima, "Iran Will Help Russia Build Drones for Ukraine War, Western Officials Say," *Washington Post*, Nov. 19, 2022, https://www.washingtonpost.com/national-security/2022/11/19/russia-iran-drones-secret-deal/.

[146] Dion Nissenbaum and Benoit Faucon, "Iran Ships Ammunition to Russia by Caspian Sea to Aid Invasion of Ukraine," Apr. 24, 2023, *Wall Street Journal*, https://www.wsj.com/articles/iran-ships-ammunition-to-russia-by-caspian-sea-to-aid-invasion-of-ukraine-e74e8585.

[147] Hans von der Burchard, "G7 Gives Iran Sharp Warning Not to Send Ballistic Missiles to Russia," *Politico*, Apr. 19, 2024, https://www.politico.eu/article/g7-gives-iran-sharp-warning-not-to-send-ballistic-missiles-to-russia/.

[148] Nikita Smagin, "Is the Blossoming Relationship Between Russia and the UAE Doomed?," Carnegie Politika, Apr. 13, 2023, https://carnegieendowment.org/politika/89531; Sergey Safronov, "Andrey Boginsky: We Are Waiting for the First Contract for Ansat with the Aurus VIP Cabin," *Defense & Security*, Nov. 25, 2021.

CRITICAL COMPONENTS CASE STUDIES

Electronic components

Russia's defense industry remains heavily reliant on Western electronic components for production of a wide range of weapon systems. In one recent study, the Royal United Services Institute (RUSI) surveyed collected data on multiple microchips found in 27 Russian weapon systems captured on the battlefields of Ukraine. After physically inspecting many of these components and comparing them with manufacturer data, RUSI analysts found most of these microchips to be an apparent match for chips manufactured by Western companies.[149]

Western microchips were found in a wide range of Russian weapon systems, including cruise missiles, communications systems, and electronic warfare (EW) complexes of various kinds. RUSI researchers discovered numerous examples of Western electronic components being used in these captured Russian weapon systems. These components were mainly manufactured in North America, Europe, and East Asia. Many of these chips have been subject to US export controls since 2014, indicating that Russian defense enterprises have found ways to obtain them illicitly.[150]

Russia's dependence on Western electronic components dates to the collapse of the Soviet Union in 1991. At that time, Moscow opened its economy to foreign imports as part of free market reforms. Soon thereafter, a rapid influx of high-end Western microchips and low-cost electronic components from the Asia-Pacific region precipitated a sharp decline in Russian domestic production as end users switched to foreign electronic components.[151]

Over the next two and a half decades, the defense industry's reliance on foreign electronics continued to increase, driven in part by Russian arms sales. Foreign customers often demanded the incorporation of advanced Western components and subsystems as a condition for purchasing these systems. For example, Malaysia requested that French avionics be installed in Russian Su-30 combat aircraft in lieu of Russian systems as a condition of sale.[152] Subsequently, the defense industry incorporated advanced Western microelectronics in an ever-expanding array of Russian weapon systems.[153] As a result, over time, the defense industry became critically dependent on Western microelectronics.

Export controls on Western electronics

Western sanctions have had a major effect on the defense industry's access to advanced Western electronic components and technologies. On February 25, 2022, just one day after Russia's invasion of Ukraine, the Biden Administration announced sweeping new sanctions on exports of

[149] James Byrne et al., *Silicon Lifeline: Western Electronics at the Heart of Russia's War Machine*, RUSI, Aug. 2022, https://static.rusi.org/RUSI-Silicon-Lifeline-final-updated-web_1.pdf. RUSI could not rule out that some of these chips may have been counterfeits sold on the black market. However, by factoring in other indicators, most of these parts were assumed to be genuine.

[150] Byrne et al., *Silicon Lifeline*, p. 5.

[151] Vasily Borisov, "Russian Electronics: Globalization and National Interests," in *2019 IEEE International Conference on Engineering Technologies and Computer Science*, p. 89.

[152] Carlo Kopp, "Sukhoi Flankers: The Shifting Balance of Regional Air Power," Air Power Australia, last updated 2012, https://www.ausairpower.net/APA-Flanker.html.

[153] Roger McDermott, "French 'Tin Cans' or Technology Transfer? Vysotskiy on the Mistral," Eurasia Daily Monitor 7, no. 144, July 27, 2010, https://jamestown.org/program/french-tin-cans-or-technology-transfer-vysotskiy-on-the-mistral/.

semiconductors, computers, telecommunications equipment, information security equipment, and lasers used in Russian defense production.[154] At the same time, the US adopted a foreign direct product rule, which provides for secondary sanctions on foreign countries exporting advanced electronics to Russia if they were designed or manufactured using US software, technology, or equipment.[155]

Shortly thereafter, the EU, Australia, Britain, Canada, and Switzerland announced similar restrictions on exports of advanced semiconductors, high-end electronics, quantum technologies, and software to Russia.[156] South Korea and Japan, both leading manufacturers of electronic components, also followed suit, joining 30 other nations aligned with the West. Later, Taiwan Semiconductor Manufacturing Company (TSMC), the world's leading contract chip manufacturer, announced that it too would adhere to the sanctions regime. As Russia has attempted to circumvent sanctions, US and EU officials have steadily expanded export controls on Russia while directly targeting dozens of companies and organizations in Russia using even more comprehensive sanctions.[157]

Western bans on the export of advanced electronics have had a major effect on Russia, disrupting supply chains and cutting off access to a wide range of both military and dual-use electronics formerly used in Russian defense production.[158] For example, production of the 9K37 Buk and the 9K22 Tunguska air defense systems was reportedly stopped because of the lack of German-made electronics.[159]

The effect of sanctions on Russian defense production has been relatively uneven, however, affecting some areas more than others. In many areas, Russia was able to sustain defense production by drawing upon existing chip stockpiles that were assembled in advance of the conflict. Over time, however, as its battlefield losses have mounted, Russia has struggled to sustain production at levels needed to replace its equipment losses and has been resorting to other measures to obtain required electronics, including import substitution, parallel import, and foreign cooperation.

Russian countermeasures

Stockpiling of microchips

During the early phases of the war, Russia's defense industry was able to rely, at least in part, on stockpiles of electronic components assembled before the conflict. Since 2014, Russia has been stockpiling components as a hedge against further sanctions, a legacy of Western sanctions imposed during the 2014 Ukraine crisis.[160]

According to Russian internal reporting shared recently by European officials, Russia adopted a new program in 2019 to further reduce its exposure to foreign sanctions. This program included plans to establish a strategic supply of spare parts for 7,244 projects. According to the report, however, as of 2020, Moscow had been able to do so for only

[154] Darryl Coote, "U.S. Imposes Sweeping Export Restrictions on Technology to Russia," UPI, Feb. 25, 2022, https://www.upi.com/Top_News/US/2022/02/25/Russia-technological-export-restrictions/3431645770203/.

[155] Rácz, Spillner, and Wolff, *Russia's War Economy*.

[156] Byrne et al., *Silicon Lifeline*, p. 15.

[157] Ana Swanson and Matina Stevis-Gridneff, "Russia Is Importing Western Weapons Technology, Bypassing Sanctions," *New York Times*, Apr. 18, 2023, https://www.nytimes.com/2023/04/18/business/economy/us-russia-chips-sanctions.html.

[158] Swanson and Stevis-Gridneff, "Russia Is Importing Western Weapons Technology."

[159] Rácz, Spillner, and Wolff, *Russia's War Economy*.

[160] Maria Shagina, *Drifting East: Russia's Import Substitution and Its Pivot to Asia*, Center for Eastern European Studies, Working Paper No. 3, Apr. 2020.

a third of these projects.[161] Evidence also suggests that the Kremlin attempted to increase component stockpiles just before the invasion, as imports of critical components increased significantly during the last quarter of 2021.[162]

Availability of stockpiled components appears to have cushioned the effect of the expansive Western export controls imposed on Russia's defense industry during the initial months of the war.[163] Until March 2023, assessments of Western microchips found in Russian weapon systems captured on the battlefield found that most chips had been manufactured before the outbreak of the conflict. However, in March 2023, investigators found a Russian Lancet drone containing chips that were produced after the invasion, a strong indicator that Russia had previously been able to draw on its existing stockpiles.[164]

There is ample evidence, however, that Russia failed to assemble sufficient stockpiles of microchips to sustain defense production in other areas before the invasion. In March 2022, Uralvagonzavod, Russia's principal tank manufacturer, reportedly halted production of main battle tanks, having temporarily run out of foreign components.[165] Likewise, in May 2022, a senior US official reported that Russia's defense industry was using computer chips taken from dishwashers and refrigerators for production of certain military equipment.[166] In September 2022, the Ukrainian government shared a Russian "shopping list" of Western electronics that the Kremlin was seeking to buy illicitly from foreign sources.[167] These reports all indicate that Russian leaders did not anticipate that they would face such sweeping and long-lasting sanctions and therefore did not stockpile enough foreign components for every contingency ahead of time.[168]

Import substitution

Russia is actively pursuing an import substitution strategy to increase domestic production of electronic components used in defense production. This strategy is hardly new, being instead the most recent iteration of a long-standing policy to reduce Russia's dependence on foreign components and technologies and advance the state of its domestic electronics industry. Shifting to domestic production of electronic microchips has proven challenging for the defense industry, however, because Russia's electronics industry still lags significantly behind the technology frontier in terms of designing and manufacturing advanced semiconductors and electronic components. As a result, import

[161] Alberto Nardelli, "Putin Tried for Years to Stop His Military from Using Western Parts—and Mostly Failed," *Japan Times*, Oct. 15, 2022, https://www.japantimes.co.jp/news/2022/10/15/world/russia-weapons-western-parts/?utm_source=ground.news&utm_medium=referral.

[162] International Working Group on Russian Sanctions, *Strengthening Sanctions to Stop Western Technology from Helping Russia's Military Industrial Complex*, Working Group Paper #12, July 3, 2023, p. 17, https://fsi9-prod.s3.us-west-1.amazonaws.com/s3fs-public/2023-07/sanctions_working_group_-_russian_import_of_critical_components-7-9-2023_final.pdf.

[163] Swanson and Stevis-Gridneff, "Russia Is Importing Western Weapons Technology."

[164] Conflict Armament Research, *Identifying Post-Invasion Components in Russian Weapons*, Apr. 2023, https://storymaps.arcgis.com/stories/00594bef40bc4148b16dc7267172d033.

[165] Christian Hetzner, "Russia's Largest Tank Manufacturer May Have Run Out of Parts," *Fortune*, Mar. 22, 2022, https://fortune.com/2022/03/22/russian-tank-manufacturer-sanctions-ukraine-war/.

[166] Jeanne Whalen, "Sanctions Forcing Russia to Use Appliance Parts in Military Gear, U.S. Says," *Washington Post*, May 11, 2022, https://www.washingtonpost.com/technology/2022/05/11/russia-sanctions-effect-military/.

[167] Zoya Sheftalovich and Laurens Cerulus, "The Chips Are Down: Putin Scrambles for High-Tech Parts as His Arsenal Goes Up in Smoke," *Politico*, Sept. 5, 2022, https://www.politico.eu/article/the-chips-are-down-russia-hunts-western-parts-to-run-its-war-machines/.

[168] Maria Shagina and Emily Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?," *War on the Rocks*, June 2, 2022, https://warontherocks.com/2022/06/can-russia-rebuild-its-tech-sector-with-chinas-help/.

substitution has proven relatively ineffective in offsetting the effect of Western sanctions on advanced electronic components.

During the Soviet era, defense production relied primarily on domestically produced microchips, up to 75 percent of which were slated for the defense and space industries. As noted earlier, after the collapse, Russia's defense industry became increasingly dependent on advanced Western microchips. In 2007, Putin took steps toward reducing Russia's dependence by announcing a new federal program for development of a domestic electronic component base to support the production of radio electronic products. The goal at the time was mainly to reduce the technological gap rather than achieve complete import substitution. By 2014, the state had spent about 110 billion rubles on this program but had little to show for its efforts.[169]

In 2014, when the West imposed the first round of sanctions on sales of advanced microchips, the new ban caused numerous problems for Russia's defense industry, although its effect on the aerospace industry was especially significant.[170] According to one source, for example, Russia had to halt plans to produce its next-generation GLONASS-K2 satellites because of lack of access to Western radiation-resistant electronic components.[171]

In response, the Kremlin launched a major new import substitution program calling for the development of a wide array of domestic components to replace electronic microchips previously sourced from the West.[172] Moreover, in 2015, Dmitry Medvedev created a special commission to oversee import substitution, which included Denis Manturov, then head of the Ministry of Industry and Trade.[173] When the new program was announced, Russian industry specialists said that it would take at least five or six years to achieve self-reliance. This estimate proved to be overoptimistic, however, with Russia's dependence on Western microchips remaining virtually unchanged between 2014 and 2019, according to one expert.[174]

To be sure, Russia's import substitution program has made significant advances in some areas. For example, Russian IT firms made substantial progress in developing new Russian microprocessors to replace central processing unit (CPU) chips made by Intel and AMD in domestically produced tablets, laptops, and servers.[175] Russia's Mikron and later the Moscow Center of SPARC Technologies have designed various versions of the Elbrus microprocessor, a domestically produced CPU chip slated for use in a wide range of personal computers and servers.

At the beginning of its development, Elbrus lagged behind Western analogues by at least one or two generations in terms of applied technologies, although direct performance comparisons are challenging because it has its own architecture. The gap in performance had seemingly grown even

[169] Anastasia Dolgosheva, "Adventures of Electronics [Приключения Электроники]," *Sankt-Peterburgskie Vedomosti*, July 14, 2022, https://spbvedomosti.ru/news/country_and_world/rodine-nuzhny-krylya-rossiya-planiruet-razvivat-mikroelektroniku/.

[170] Julian Cooper, "Sanctions Will Hurt Russia's Rearmament Plans," *Moscow Times*, Aug. 12, 2014, https://www.themoscowtimes.com/2014/08/12/sanctions-will-hurt-russias-rearmament-plans-a38270.

[171] "Sanctions Delay Russia's GLONASS-K2 Program."

[172] "Putin Stated the Need for Industry's Hastened Transition to Import-Substitution [Путин заявил о необходимости ускоренного перехода промышленности к импортзамещению]," Interfax, July 28, 2014, https://www.interfax.ru/business/388216.

[173] Daria Kozlova, "The Nail in the Lid of Import Substitution [Гвоздь в крышку импортозамещения]," *Novaia Gazeta Evropa*, July 25, 2022, https://novayagazeta.eu/articles/2022/07/25/gvozd-v-kryshku-importozameshcheniia.

[174] Andrey Frolov, "Defence Technologies and Industrial Base," in *Defence Industries in Russia and China: Players and Strategies*, ed. Richard A. Bitzinger and Nicu Popescu (Paris: EU Institute for Security Studies, 2017), p. 11.

[175] Shagina and Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?"

larger by 2021. According to a report issued by Sberbank, the backlog in task processing was 23 to 26 times greater than in an Intel processor.[176] Still, the development of Elbrus constituted an important step forward in Russia's quest for self-sufficiency.

Nonetheless, production challenges have proven to be even more daunting for the Elbrus project. When Mikron proved incapable of mastering production of 65 nanometer (nm) processors, production was outsourced to TSMC, the world's leading contract chip manufacturer. Since Russia's 2022 invasion of Ukraine, however, TSMC has halted production of Elbrus microprocessors, having joined the Western sanctions regime, a move that has essentially put a stop to the entire Elbrus project.[177]

The Baikal, an alternative family of microprocessors developed by Russia's Baikal Electronics, met a similar fate when TSMC refused to enter into new production contracts.[178] Although Russian officials are discussing ways to shift production to domestic manufacturers, sanctions on Western equipment needed to produce semiconductor wafers will likely prove insurmountable for Russian production of domestic CPUs for the foreseeable future.[179]

In January 2020, the government approved a new development strategy for the electronics industry through 2030 with the aim of creating a competitive electronics industry. The Kremlin has reportedly allocated 2.74 trillion rubles to fund the new program.[180] Russian leaders set an initial goal to increase market share of Russian-made electronic products to 59 percent of total domestic consumption.[181]

According to Denis Manturov, the government will emphasize mastering the complete production life cycle, including producing required raw materials, intermediate goods, and finished components.[182] To achieve these lofty ambitions, Russia plans to reverse engineer foreign components and technologies to transfer production to Russia and possibly China. Current plans call for local production of key components that Russia currently imports by 2030. The government also plans to increase the number of Russian design centers from 70 to 300 by 2030.[183] Although most of these goals are likely unattainable under current conditions, Russia has made some progress in increasing the production of domestic microchips that the electronics industry had previously mastered. For example, in 2023, Russian leaders announced a 42.6 percent increase in domestic production of Russian computers and microelectronics, albeit of inferior models, over 2022 levels.[184]

Despite such measures, there is little prospect that Russia will achieve the goals set forth in the 2030 import substitution plan given that it lacks

[176] Ekaterina V. Nezhnikova and Daniil A. Kopylov, "Development Focus of Electronics Industry in Russia: Shift from Defense Sector to Market," *RUDN Journal of Economics* 31, no. 3 (2023), pp. 543–56.

[177] Pavel Urusov, "Vital Microchip Sanctions Will Hit Russian Computing Power Hard," *Carnegie Politika*, July 25, 2023, https://carnegieendowment.org/russia-eurasia/politika/2023/07/vital-microchip-sanctions-will-hit-russian-computing-power-hard.

[178] Nikolai Ulyanov, "Do It Yourself [Сделай сам]," *Ekspert*, Jan. 16, 2022; "Taiwan Stopped Production of Russian Server Processors [Тайвань остановил производство российских серверных процессоров]," *Novye Izvestiia*, June 16, 2022, https://newizv.ru/news/2022-06-16/tayvan-ostanovil-proizvodstvo-rossiyskih-servernyh-protsessorov-357585.

[179] Yulia Tishina, "An Investor Will Join Baikal Electronics [В Байкал Электроникс Заплывет Инвестор]," *Kommersant*, Oct. 27, 2020, https://www.kommersant.ru/doc/4548814.

[180] Dolgosheva, "Adventures of Electronics."

[181] Shagina and Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?"

[182] Ulyanov, "Do It Yourself."

[183] Shagina and Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?"

[184] Luzin and Prokopenko, "Russia's 2024 Budget Shows It's Planning for a Long War in Ukraine."

the capability to produce advanced microchips domestically. Although Russia's Mikron has reportedly mastered production of 180 nm semiconductors (while achieving small-scale production of 90 nm chips), Taiwan's TSMC is preparing to produce 2 nm semiconductors.[185] Given that Western sanctions are also targeting the equipment and technology needed to produce advanced microchips, import substitution is unlikely to generate significant results.

Parallel import

Russia has been relying heavily on parallel import to maintain access to advanced Western semiconductors and electronic components. It has taken time for parallel import to ramp up, however. For the first few months following the 2022 Ukraine invasion, Russian microchip imports dropped off sharply as direct sales from the United States and its allies plummeted after the imposition of sanctions. Over time, however, Russian imports of microchips from other countries have been increasing as Russia has developed alternative supply chains with countries still willing to do business with it. From October 2022 to January 2023, for example, parallel import of integrated circuits substantially recovered, reaching 50 percent or more of median prewar levels each month, according to Silverado Policy Accelerator, a bipartisan think tank that tracks Russian semiconductor imports.[186]

According to Silverado, Hong Kong and China currently make up the largest share of Russian imports of integrated circuits, accounting respectively for 48 percent and 35 percent (84 percent in total) of these imports between March 2022 and June 2023. Kazakhstan and Armenia, with 5 percent and 4 percent shares, respectively, are the next most important sources of Russian microchip imports. The remaining 8 percent involve imports from a variety of countries. Hong Kong in particular has emerged as a crucial transshipment hub for dual-use microelectronics destined for Russia.[187]

However, these figures do not fully capture the complexity of Russia's evolving microchip trade because they represent only direct imports from the countries involved and not intermediary countries that these chips may have passed through along the way. For example, Turkey and the UAE have become key transshipment hubs for the reexport of Western electronic components to Russia.[188] Serbia has also emerged recently as a source for Russia of advanced microchips of the kind designated as high priority by US and EU regulators because of their use in Russian armaments employed in Ukraine.[189]

The continued growth in the share of imported electronics from non-Western countries, especially China, has reinforced the long-standing trend toward increasing Russian reliance on Asian sources

[185] Shagina and Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?" Another report indicates that Russia can produce 65 nm chips as well. See Jeffrey A. Sonnenfeld and Michal Wyrebkowski, "The Dangerous Loophole in Western Sanctions on Russia," *Foreign Policy*, Sept. 7, 2023, https://foreignpolicy.com/2023/09/07/western-sanctions-russia-ukraine-war/#cookie_message_anchor.

[186] Swanson and Stevis-Gridneff, "Russia Is Importing Western Weapons Technology."

[187] Because of rounding, the numbers do not match exactly. Byrne et al., *Silicon Lifeline*, p. 5.

[188] Maria Shagina, "Russia Continues to Import Western Weapons Technology Despite Sanctions, Trade Data Shows," *Foreign Policy*, Nov. 9, 2023, https://foreignpolicy.com/2023/11/09/russia-sanctions-weapons-technology-exports-evasion-arms-production-missiles-chips/.

[189] Milos Katic and Mirjana Jevtovic, "Millions of Earnings of Serbian Companies Through a Scheme to Circumvent Russian Sanctions," Radio Slobodna Europa, Nov. 8, 2023, https://www.slobodnaevropa.org/a/srbija-rusija-sankcije-poslovanje/32674619.html.

of components and technology.[190] Since 2014, Russia has been turning to China as a source of advanced microchips that it can no longer source from the West. As early as 2015, Russia reportedly sought to purchase microchips from China valued at approximately $2 billion.[191]

Subsequently, Russia and China engaged in protracted negotiations over a reported deal to swap Russian RD-180 rocket engines for Chinese semiconductor manufacturing equipment, although this arrangement apparently foundered over Russian concerns about China's failure to join the missile technology control regime.[192] Yet the war in Ukraine has greatly accelerated Russia's pivot to Asia when it comes to trade in electronic components.

Despite this shift, Russian electronic component imports continue to be dominated by Western semiconductors and microchips. Imported Western components are simply coming through non-Western channels. According to a recent *Nikkei* report, Russian imports of US electronic components have risen sharply since the invasion. Based on Russian customs data, *Nikkei* found that a total of 3,292 transactions worth $740 million had taken place between February 24 and December 31, 2022. More than 2,350 of them (approximately 70 percent) involved chips that bore labels from well-known US chip manufacturers, including Intel, AMD, and Texas Instruments (TI).

Of these, about 75 percent (with a total value of $570 million) were shipped to Russia directly from Hong Kong or China. Moreover, data showed that exports of US microchips through China and Hong Kong had risen dramatically (from $51 million to $570 million) compared to the same period in 2021. Russian imports included several high-performance Western microchips, including programmable semiconductors used in advanced weapon systems. Most of these transactions were carried out by a shifting network of small trading companies based in Hong Kong or China, many of which operate in the gray zone employing tactics such as frequent name changes to evade sanctions enforcement.[193]

These practices demonstrate the failure of the sanctions regime to completely cut off Russian access to Western microchips. They also demonstrate Russia's inability to find suitable alternatives, given that electronic components produced by China (and other countries falling outside of the sanctions regime) still lag significantly behind the most advanced Western microchips.[194] China could conceivably provide less capable domestically designed and produced microchips, although Russia's defense industry would likely have to redesign weapon systems to use the new chips. Thus far, however, Chinese manufacturers have been loath to risk secondary sanctions by supplying domestically developed microchips because China continues to rely on Western manufacturing

[190] Richard Connolly, *Russia's Response to Sanctions: How Western Sanctions Reshaped Political Economy in Russia*, Valdai Club, Nov. 2018.

[191] Jarosław Ćwiek-Karpowicz and Stanislav Secrieru, eds., *Sanctions and Russia* (Warsaw: Polish Institute of International Affairs, 2015), p. 88.

[192] "Russia Plans to Supply Rocket Engines RD-180 to China," *Defense & Security*, Oct, 14, 2015; Ivan Cheberko, "Roscosmos Cannot Supply Rocket Engines to China [Роскосмос Не Может Поставить Ракетные Двигатели В Китай]," *Izvestiya*, Apr. 8, 2016.

[193] "Special Report: How U.S.-Made Chips Are Flowing into Russia," *Nikkei Asia*, Apr. 12, 2023, https://asia.nikkei.com/Business/Tech/Semiconductors/Special-report-How-U.S.-made-chips-are-flowing-into-Russia.

[194] Shagina and Kilcrease, "Can Russia Rebuild its Tech Sector with China's Help?"

equipment and software to produce its own chips. Consequently, exporting Chinese-designed chips to Russia would likely violate the US foreign direct product rule, which prohibits companies from exporting components made using US equipment, technology, or software.[195]

Foreign cooperation

Although increasing parallel import will likely remain the most important way for Russia to circumvent sanctions over the near- to mid-term, Moscow will need to increase linkages with foreign partners if it hopes to move up the technology value chain and ultimately to produce world-class microelectronics. Currently, no country in the world maintains complete control over its semiconductor supply chains. Instead, electronic components are manufactured using globally integrated supply chains in which different inputs are designed and manufactured in different countries, adding value along the way before ultimately producing the end product. Achieving complete self-sufficiency will be even harder for Russia, a country that lags significantly behind world leaders in the design and manufacture of advanced semiconductors and microchips.

Before the 2022 Ukraine invasion, Russia's electronics industry maintained cooperation with a variety of countries, including the United States, Great Britain, China, South Korea, and Taiwan. In fact, more than 80 percent of the country's IT equipment (including electronics manufacturing equipment) was imported from other countries.[196] For example, Russian firms formerly purchased photolithographic equipment from the United States, including 90–130 nm equipment from US chipmaker AMD.[197] Likewise, up until the invasion of Ukraine, American electronics giant Intel maintained facilities in the Russian Federation.[198]

Russian electronics firms also relied heavily on Taiwanese company TSMC for contract manufacturing of chips and microprocessors developed in Russian design centers.[199] As noted, TSMC was previously engaged to produce Russian-designed microprocessors such as Elbrus and Baikal. However, TSMC cut off production ties after the Ukraine invasion.

Russian firms also lost the opportunity to buy semiconductor manufacturing equipment from European and Japanese companies, including Dutch firm ASML, the world's leader in advanced lithography, and Japan's Canon, a major producer of advanced photolithography, etching equipment, and other key manufacturing inputs, because of the Ukraine invasion.[200] Moreover, in 2021, nearly one-third of Russia's imported chips originated from China. Russia also procured chips from Malaysia, Taiwan, and Vietnam, which accounted for 14 percent, 12.6 percent, and 11 percent of chips, respectively.[201]

Russian cooperation with the most advanced Western and Asian-Pacific companies has now been virtually foreclosed by Western sanctions because of the Ukraine conflict, and cooperation is unlikely to resume anytime soon. Moreover, for the most part,

[195] Shagina and Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?"

[196] Andrey Vaganov, "Chip Situation [Чиповая ситуация]," *Nezavisimaia Gazeta*, Nov. 9, 2022, https://www.ng.ru/nauka/2022-11-08/9_8584_situation.html.

[197] Nikita Korolev, "A Chip Ex Machina," *Defense & Security*, Nov. 19, 2021.

[198] Anatoly Komrakov, "How to Revive Domestic Electronics Production [Как возродить отечественное производство электроники]," *Nezavisimaia Gazeta*, Apr. 7, 2022, https://www.ras.ru/digest/showdnews.aspx?id=9902082d-c747-4be3-a3bf-37d34877bfd0.

[199] Vaganov, "Chip Situation."

[200] Nikita Korolev and Evgeny Khvostik, "Processors in Isolation," *Defense & Security*, Apr. 7, 2022.

[201] Shagina and Kilcrease, "Can Russia Rebuild Its Tech Sector with China's Help?"

countries that have declined to join the sanctions regime against Russia remain leery of engaging in direct cooperation out of fear that they will be subjected to secondary sanctions by the United States and its allies. For example, China has thus far refrained from providing Russia with access to its latest microprocessors produced by Loongson, even though they reportedly use a unique Chinese architecture, because they were likely designed or manufactured with at least some reliance on US technology.[202]

Thus, for the time being, Russian firms will have to content themselves with obtaining parallel import through countries still friendly with Russia. As noted above, China and Hong Kong will likely remain important transshipment points for channeling Western microchips to the Russian Federation. By the same token, Turkey and the UAE will likely remain important transshipment points for obtaining parallel import of advanced Western microchips.[203]

Some countries have been willing to go further. For example, enterprises in Belarus, which overtly supported Russia's invasion of Ukraine, are reportedly working with Russian counterparts in areas such as microelectronics, radio electronics, composite materials, and robotics.[204] Likewise, Chinese firms have continued to cooperate with Russia in some areas. According to one recent report, deliveries of server and network equipment from China are still being carried out without serious restrictions through parallel import mechanisms.[205]

Cooperation with members of the Shanghai Cooperation Organization (SCO) also continues to some extent, with manufacturers from both China and Turkey still operating inside Russia. For example, Chinese electronics firm TPV Technology continues to operate in St. Petersburg, whereas Turkey's Beko maintains a household appliance firm in the Vladimir region. Reportedly, approximately 70 percent of the largest companies from the SCO countries continue to operate at key industrial sites in Russia, providing their Russian partners with access to advanced technological solutions and developments.[206]

Over time, Russia's best prospects for cooperation on high-end electronics remain with the PRC because Chinese firms can do much more to support Russia if circumstances should change. According to a recent report, Chinese companies have been working diligently to develop advanced lithographic equipment to speed up development of their own microchip production capabilities.[207] Similarly, China's Semiconductor Manufacturing International recently announced experimental progress in developing a 7 nm semiconductor.[208] For the time being, however, China's continuing dependence on imported Western chips and semiconductors will likely constrain the PRC's cross-border cooperation with Russia.[209]

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[202] Anatoly Komrakov, "China Does Not Want to Share All Its Technological Secrets with Russia," *Nezavisimaia Gazeta*, Jan. 15, 2023.

[203] Ivan Tkachev, "A Tectonic Shift: How Russia's Foreign Trade Changed in 2022," *Defense & Security*, Jan. 6, 2023; Shagina, "Russia Continues to Import Western Weapons Technology."

[204] Yadviga Yuferova, "Vladimir Gusakov: Unfriendly Countries Provided a Unique Opportunity for Cooperation Between Scientists from Belarus and Russia [Владимир Гусаков: Недружественные страны дали уникальную возможность для сотрудничества ученых Беларуси и России]," *Rossiiskaia Gazeta*, July 13, 2022, https://rg.ru/2022/07/12/druzhit-s-umom.html.

[205] Komrakov, "China Does Not Want to Share All Its Technological Secrets with Russia."

[206] Evgenia Pleshakova, "Why Are These Economic Ties So Important? [Почему так важны эти экономические связи]," *Rossiiskaia Gazeta*, Sept. 16, 2022.

[207] Dmitry Bevza, "Adventures of Electronics [Приключения электроники]," *Rossiiskaia Gazeta*, Feb. 15, 2023.

[208] Che-Jen Wang, "China's Semiconductor Breakthrough," *Diplomat*, Aug. 20, 2022, https://thediplomat.com/2022/08/chinas-semiconductor-breakthrough/.

[209] Komrakov, "China Does Not Want to Share All Its Technological Secrets with Russia."

Conclusion

Despite more than a decade of effort, Russia's import substitution policy has not succeeded in creating a domestically produced alternative to foreign electronic components. The Russian economy in general and its defense industry in particular remain dependent on imports of foreign semiconductors and other advanced electronic components to operate its equipment and weapons systems. Furthermore, although components of older and less sophisticated systems can be purchased from China and other Russian partners, the most advanced systems require components that can only be produced in countries that have implemented export controls against Russia.

As a result, Russia remains highly dependent on parallel import of Western and Taiwanese electronic components, carried out primarily through China and Hong Kong, though also through Turkey and the UAE. Russian military and economic planners are highly aware of this vulnerability. There is strong evidence that Russia stockpiled semiconductors before launching its 2022 invasion of Ukraine, cushioning the initial effect of export controls and giving time for Russian importers to set up channels for parallel imports. Since these stockpiles were exhausted in 2023 and both import substitution and foreign cooperation show no sign of being able to meet Russian defense industry's demand for advanced microchips, actions to significantly restrict parallel import of electronic components can have a major effect on the ability of Russia's defense industry to supply its military with advanced weapons systems.

Supply and production of machine tools

Despite more than a decade of import substitution efforts, Russia's manufacturing industry, including the military industrial complex, still depends on foreign supplies of machine tools. This dependence will inevitably continue for the long term given that Russian domestic production of machine tools covers only 8 percent of Russian domestic needs.[210] Recently announced official plans to increase the share of Russian-made machine tools to meet the needs of more than 50 percent of the domestic market do not look realistic today.[211]

Russian dependence on Western machine tools has decreased in recent years, however, as suppliers from the United States, EU countries, Switzerland, the United Kingdom (UK), Japan, South Korea, and Taiwan have been mostly replaced by suppliers from China and other countries that have not signed on to Western sanctions. Moreover, although the share of Chinese-made machine tools has been growing in Russia for years, it dramatically increased in 2022 and 2023 as Russia pivoted to China to replace supplies from other countries. Furthermore, over the course of 2022 and especially in 2023, Russia was able to develop channels to import sanctioned Western machine tools through China, Hong Kong, and Central Asia. As a result, Russia's ability to maintain its defense industrial production without Western machine tools has been gradually increasing and will likely continue to do so.

[210] Yulia Sanatina, "How to Overcome Russia's Dependence on Imported Machine Tools [Как преодолеть зависимость России от импорта станков]," *Rossiiskaia Gazeta*, Apr. 12, 2023, https://rg.ru/2023/04/12/reg-urfo/zapustit-zavod-zavodov.html.

[211] "Rostec: The Share of Imports of Machine Tools in the Russian Federation Will Be Reduced to Less Than 50% [Ростех: доля импорта станков в РФ сократится менее чем до 50%]," Mashnews, Aug. 23, 2023, https://mashnews.ru/rostex-dolya-importa-stankov-v-rf-sokratitsya-menee-chem-do-50.html.

Import substitution

History of import substitution efforts

Russia first launched an import substitution policy for machine tools in the military industrial complex in 2011, when it launched its state rearmament program for 2011 to 2020 and shifted to a course of confrontation with the United States and its allies. During this period, the strategy was not substitution itself but localization of production facilities belonging to leading foreign manufacturers of machine tools, such as Okuma and DMG Mori, and assembly of Russian-made machine tools from imported components.

The next effort to reduce dependence on foreign machine tools occurred in 2017, when the Ministry of Industry and Trade presented a draft strategy for the development of machine tool manufacturing by 2030. The strategy was approved in November 2020, with an updated target date of 2035.[212] The new strategy acknowledged that the complete substitution of domestic for foreign machine tools was impossible.[213] Instead, the government would focus on revenues derived from sales of machine tools in domestic and global markets rather than on replacement of imported machine tools. As a result, the main goals of the strategy were growth of the Russian manufacturers of machine tools and growth of domestic and global markets without significant substitution.[214] The government launched a federal budgetary project for the development of machine tools manufacturing and invested 3 billion rubles (about $40 million) into the import substitution of machine tools from 2021 to 2023, a much smaller budget than it had allocated in 2011 to 2013.[215] Instead of massive direct investments from the federal budget, the Russian government created tax preferences and subsidized loans and tried to stimulate domestic demand for Russian-made machine tools.[216]

The Russian government's efforts to stimulate the domestic machine tool industry were largely unsuccessful. Besides having to deal with relatively high taxes, land lends, and other costs, machine tool manufacturers had few available investment instruments and needed to rely mainly on their own funds, which increased their operating costs. Table 5 shows the available data on investment in fixed capital of companies that the Russian Federal State Statistics Service combines into the category

[212] The reasons for this delay are unclear. Russia's continuing bet on the imported machine tools and domestic assembly facilities, its limited capabilities in the face of more urgent substitution priorities, and the next round of American sanctions applied in 2017 likely put the substitution of machine tools in a secondary agenda.

[213] The level of localization of machine tools manufacturing would grow from 47 percent in 2019 to 70 percent in 2035 within the innovative and basic scenarios but would decrease to 46 percent within the conservative scenario. At the same time, the share of imports in domestic consumption of machine tools would decrease from 77 percent in 2019 to 57 percent and 62 percent in 2035 within the innovative and basic scenarios, respectively, but this share would increase to 79 percent in the 2020s and stay at this level in 2035 within the conservative scenario.

[214] In this way, by 2035, the Russian manufacturers of machine tools would receive 108.2 billion rubles within the innovative scenario, 79.5 billion rubles within the basic scenario, and 52 billion rubles within the conservative scenario, compared to 32.8 billion rubles in 2019. Government of the Russian Federation, *Russian Government Strategy for the Development of the Machine Tools Industry Through 2035*, Nov. 5, 2020, http://static.government.ru/media/files/NyeLKqLhrJrydnGRBm39nHl0hJNOzHzQ.pdf.

[215] Aleksei Lapshin, "More Than 300 Billion Rubles Will Be Allocated from the Budget for Machine Tool Industry Until 2030 [На станкостроение до 2030 года из бюджета выделят более 300 млрд рублей]," *Parlamentskaia Gazeta*, Nov. 11, 2023, https://www.pnp.ru/economics/na-stankostroenie-do-2030-goda-iz-byudzheta-vydelyat-bolee-300-mlrd-rubley.html.

[216] "Machine Tool Industry in Russia Is the Basis of the Industrial Sector [Станкостроение в России – основа промышленной отрасли]," *Sdelano v Rossii*, Aug. 17, 2023, https://madeinrussia.ru/ru/news/24989. Russian manufacturers of machine tools were highly dissatisfied with these measures and considered them insufficient for the development of a competitive machine tool industry in Russia. Aleksei Korukov, "The Machine Tool Industry in Russia Should Not Be Revived, but Created Anew [Станкостроение в России надо не возрождать, а создавать заново]," VNITEP, Dec. 20, 2021, https://vnitep.ru/news/903/.

"manufacturing of machinery and equipment not included in other groups" (although this category is not limited to machine tool manufacturers).

The data in Table 5 reveal that the machine tools industry, investors, and banks were interested in expanding business in Russia from 2012 to 2015 and that the state rearmament program and governmental promises of extending the import substitution policy stimulated this interest. These efforts have decreased since 2016, when there was a crisis in the Russian economy. In constant prices, the investment in fixed capital of 2016 to 2017 was back at the level of the late 2000s and then decreased even more. By 2022, the machine tool manufacturers invested in fixed capital just 81 percent of the amount that they invested in 2010. With that level of investment, there was no possibility of import substitution, and even sustainable development of Russia's machine tool industry in Russia was at risk.

The situation has changed dramatically since Russia invaded Ukraine in 2022, however. As a result of sanctions, Russian officials declared that government investments in machine tool manufacturing would increase to 300 billion rubles ($3 billion to $3.5 billion) from 2024 to 2030 and that the planned amount of additional investments from regional budgets and nonbudgetary sources would be 200 billion rubles ($2 billion to $2.2 billion).[217] Although

Table 5. Investment in fixed capital within the category "manufacturing of machinery and equipment not included in other groups," 2010–2022

Year	Investment in Fixed Capital, Billion Rubles (Current Prices)				Index of Physical Amount of Investment in Fixed Capital, Constant Prices, % to Previous Year
	Total amount	Investment from own funds	Borrowed funds	Including budgetary investments (as part of borrowed funds)	
2010	62.0	36.6	25.4	0.6	107.6
2011	60.5	47.9	12.6	0.8	91.8
2012	76.2	58.1	18.1	0.8	119.5
2013	92.9	65.8	27.1	0.8	113.7
2014	103.2	69.9	33.3	0.7	110.6
2015	121.8	85.0	36.8	2.7	100.5
2016	63.0	n/a	n/a	n/a	70.4
2017	65.7	54.5	11.2	1.8	101.6
2018	62.5	52.1	10.4	1.1	90.2
2019	72.6	60.0	12.6	1.7	100.4
2020	61.1	50.0	11.1	0.8	77.5
2021	74.9	69.1	5.8	0.9	116.6
2022	81.1	75.9	5.2	1.0	92.4

Source: "Russian Industrial Production," Federal State Statistics Service, https://rosstat.gov.ru/folder/210/document/13225.

[217] Lapshin, "More Than 300 Billion Rubles"; "Meeting of President Putin and Minister for Industry and Trade Denis Manturov," Kremlin.ru, Oct. 24, 2023, http://special.kremlin.ru/catalog/persons/331/events/72579.

the Russian leadership has launched a massive and ambitious machine tools substitution program, it still considers substitution to be a matter of money and underestimates the structural limitations of Russian industry in this area.

Industrial base of Russian machine tool manufacturing

Entities and cooperation ties

The Russian machine tools industry consists of Mekhanika Holding, a subsidiary of Rostec state-owned defense corporation; Kovrov Electro-Mechanical Plant (KEMZ), a subsidiary of NPO Vysokotochnye Kompleksy, which is another subsidiary of Rostec; machine tool facilities belonging to other state-owned corporations; factories established as joint ventures with the leading foreign machine tool companies; and dozens of small factories, most of which have no more than 200 employees and less than 50 million rubles ($600,000) of annual revenue.[218] All these entities are dependent on the import of key components and parts, including CNCs, spindles, tool storage mechanisms, and electric motors.[219]

Moreover, the machine tools needed for manufacturing Russian-made machine tools themselves require separate components from the United States, Europe, Japan, and Taiwan. For example, KEMZ has historically relied on components and parts from foreign companies, including MAZAK, Quaser, Takisawa, and Akira Seiki, serving as these companies' official dealer on the Russian market.[220] Another example is Kalashnikov, a manufacturer of machine tools, among its other activities, that uses components produced by CNC Sinumerik (Siemens) and FlexKraft (KraftPowercon).[221]

Those foreign manufacturers of machine tools that established joint ventures in Russia or purchased old machine tools factories during the 2000s to 2010s, such as Okuma, DMG Mori, SKODA, ZTSU, Chiron Group,[222] and Gühring, made their business on the Russian market while also relying on global supply chains.[223] DMG Mori had the biggest facility, with a production rate of up to 400 CNC lathes a year.[224] Since 2022, these companies have withdrawn from Russia, and the factories, now fully owned either by the Russian partners or by the Russian managers or nationalized, have been trying to maintain

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[218] "List of Members of Machine Tools Association," Stankoinstrument.ru, https://stankoinstrument.ru/members; Lapshin, "More Than 300 Billion Rubles"; Tatiana Karpova, "Machine Tool Industry Yesterday and Today [Станкостроение вчера и сегодня]," *RITM Mashinostroeniia* 5 (2020), https://ritm-magazine.com/ru/public/stankostroenie-vchera-i-segodnya.

[219] "Kovrov Elektromechanical Plant," https://stanki.kemz.org; "Perm Metalworking Center Plant," https://www.pzmc.org; "INELSI," http://inelsy.com/wp-content/uploads/2022/05/IntNC-PRO.pdf; "STAN," https://www.stan-company.ru.

[220] "Kovrov Elektromechanical Plant History," https://stanki.kemz.org/about/Istoriya_zavoda/.

[221] "IZH H600," Kalashnikov Group, https://kalashnikovgroup.ru/catalog/neoruzheynoe-proizvodstvo/produktsiya-promyshlennogo-naznacheniya/additivnye-tekhnologii/izh-h600; "The Ministry of Industry and Trade Confirmed the Status of the Kalashnikov Concern as a Russian Manufacturer of Machine Tools for Three Years [Минпромторг подтвердил на три года статус Концерна «Калашников» как российского производителя станков]," *Ekspert Ural*, Sept. 1, 2023, https://expert-ural.com/news/minpromtorg-podtverdil-na-tri-goda-status-koncerna-kalashnikov-kak-rossiyskogo-proizvoditelya-stanko.html.

[222] Sergei Sergeev, "Missile Weapons Were Sharpened by a German Machine [Ракетное вооружение подточили немецким станком]," *Kommersant*, May 10, 2023, https://www.kommersant.ru/doc/5977759.

[223] Okuma established a joint venture with Pumori Engineering Invest, a dealer of imported machine tools in Yekaterinburg. DMG Mori owned a plant in Ulyanovsk. SKODA purchased Ulyanovsk Plant of Heavy Machine Tools, ZTSU, and then sold it to another Czech company, Alta, in 2019. Chiron Group launched its own plant in Tolyatti, and Gühring launched a plant in Nizhny Novgorod.

[224] "Import Substitution in the Machine Tool Industry: Obvious Benefits and Possible Harm [Импортозамещение в станкоинструментальной промышленности: Очевидная польза и возможный вред]," NSPOIM.ru, Sept. 24, 2021, https://www.youtube.com/watch?v=vjWOoBFFzyU&t=1007s.

production.[225] In this way, for instance, Pumori is relying on a partnership with companies Headman, Priminer, and HSG from China and Ace Micromatic and BFW from India.[226]

A prominent exception to this trend is IPG Photonics Corp. (US), one of the leading manufacturers of laser-cutting machine tools, which has Soviet/Russian roots and a factory in Russia that opened in 1991. The factory, NTO IRE-Polyus in Fryazino (2,000 employees), was a significant part of IPG Photonics' supply chain. Since April 2022, IPG Photonics has frozen its investment in the factory and cut off supplies to it. Even though NTO IRE-Polyus is still operational, it cannot contribute to the Russian machine tools industry without IPG Photonics.[227] Consequently, if Russia wants to substitute imported laser-cutting machine tools made with components from NTO IRE-Polyus, it needs to restore the whole supply and production chain to make the existing factory efficient again.

Workforce

In addition to the aforementioned technological gaps, Russia also lacks the human capital to successfully implement an import substitution strategy for its machine tool industry, as shown in Table 6.

Despite the fragmented nature of these data, the human capital of the Russian machine tool industry was declining throughout the previous decade and is clearly insufficient for the development and manufacture of the whole range of machine tools needed for Russian industries, including the military industrial complex. The number of employees is sufficient only for cooperation between the Russian machine tool manufacturers and advanced foreign partners. In other words, the workforce is sufficient if Russian industry is globalizing but not sufficient if the economy is isolated and cut off from the West.

Examples of import substitution and prospects for reverse engineering machine tools

There is a successful example of machine tool import substitution in Russia. The company Mechatronica develops and manufactures CNCs and machine tool electro drives. CNC systems from Mechatronica are only dependent on imported commercial electronics and electric components widely available on the global market.[228] However, the company is a niche manufacturer that produces only 30 to 50 CNCs a year and has generally preferred to cooperate with leading European and Japanese machine tool

[225] "Information About the Factory," ZTSU, https://www.ztsu.ru/o-zavode/istoriya/; "In Ulyanovsk They Will Restore Production at DMG Mori [В Ульяновске займутся восстановлением производства на DMG Mori]," Media73, July 6, 2022, https://media73.ru/2022/v-ulyanovske-zaymutsya-vosstanovleniem-proizvodstva-na-dmg-mori; "Gühring Opened a Plant in Nizhny Novgorod [Компания Gühring открыла завод в Нижнем Новгороде]," RIA-Novosti, July 21, 2016, https://ria.ru/20160721/1472534555.html.

[226] The probable purpose of this cooperation is replacing advanced components in machine tools that Pumori tries to produce without Okuma. It is hard to say whether this cooperation allows Pumori to replace Okuma, considering the Chinese and Indian machine tools companies are much less advanced. On the other hand, the amount of machine tools, mostly CNC lathes under the brand Genos, that Pumori produced annually in partnership with Okuma hardly exceeded 20 units a year, so Pumori may still have some storage of necessary components for continuing production. This case can be considered relevant to other Russian machine tools manufacturers. However, none of this activity is closer to the actual import substitution of advanced machine tools that could be used for arms manufacturing. "About the Company," Pumori Engineering, https://pumori-invest.ru/o-kompanii/; "Russian-Made GENOS CNC Lathes [Токарные станки с чпу российского производства GENOS]," Pumori Engineering and Invest, https://genos.pumori-invest.ru.

[227] "IPG Optimistic Despite Impact of Strong Dollar and Russia Restructuring," Optics.org, Feb. 15, 2023, https://optics.org/news/14/2/14; Alexander MacDougall, "Russian Problems: How Ukraine War Fallout Could Impact IPG Photonics," *Worcester Business Journal*, May 16, 2022, https://www.wbjournal.com/article/russian-problems-how-ukraine-war-fallout-could-impact-ipg-photonics.

[228] "MNC Hardware and Software Control System [Управляющий программно-аппаратный комплекс MNC]," Mekhatronika, http://mtronics.ru/produktsiya/sistemy-chpu/; "Milling 5-Axis Machine Model MANO-2000 [Фрезерный 5-осевой станок модели МАНО-2000]," Mekhatronika, http://mtronics.ru/produktsiya/fotogallery/; "Mekhatronic Production Catalog," Mekhatronika, http://mtronics.ru/files/new/katalog_2022_curves_print_compressed.pdf.

Table 6. Average annual number of employees in machine tool manufacturing in Russia, 2010–2022, in thousands

Year	Average number of employees in thousands
2010	26.8
2011	23.6
2012	21.7
2013	20.8
2014	17.5
2015	16.4
2016	n/a
2017	5.1
2018	8.1
2019	7.8
2020	7.8
2021	n/a
2022	n/a

Source: "Industrial Production in Russia," Federal State Statistics Service, https://rosstat.gov.ru/folder/210/document/13225.

Note: The data for 2010 to 2015 involve employees engaged in machine tool manufacturing, and the data for 2017 to 2020 involve employees engaged in manufacturing of metalworking machine tools.

manufacturers rather than challenge their positions on the Russian market.[229]

One option for companies such as Mechatronica is to reverse engineer foreign machine tools. For instance, the Ivanovo Machine Tools Plant, a subsidiary of STAN Holding, which in turn is a part of Mekhanika Holding, copied a Czech-made faceplate for machine tools and probably copied an Italian-made vertical milling center originally produced by Camozzi Group that STAN presented as its own product.[230]

There are several crucial challenges related to the reverse engineering strategy, however. First, there is a deficit of engineers who can copy and reproduce the previously imported machine tools. Second, the Russian market is too small to make the reverse engineering of machine tools economically viable. Third, depriving Russia of international industrial cooperation means that the quality of Russian-made machine tools will inevitably decrease over time.

Nevertheless, the government promise of budgetary investments in the hundreds of billions of rubles into the machine tools industry for 2024 to 2035 means that companies will compete for this money. The main actors will be the machine tool manufacturers that are part of Rostec, with the probable participation of other state-owned corporations. The Kremlin's import substitution strategy for machine tools will inevitably entail the redistribution, nationalization, and consolidation of machine tool manufacturers within the small number of beneficiary corporations.

[229] "Domestic Control Systems Can Compete [Отечественные СЧПУ могут конкурировать]," *Rhythm of Machinery*, https://ritm-magazine.com/en/node/1787; Andrei Lovygin, "Russian CNC Is 'Mechatronics' [Российское ЧПУ – это «Мехатроника»]," Planeta CAM, Mar. 16, 2022, https://www.planetacam.ru/articles/exclusive/rossiyskoe_chpu_eto_mekhatronika/. Similar factors have affected the Belarusian machine tools industry. The most advanced factory in Belarus is Ruchservomotor, which produces linear and rotary motors and other components for machine tools as well as some types of industrial equipment. However, Ruchservomotor also relies on imported machine tools and components for its motors and for machine tools that were developed by the company. "Rukhservomotor Production," https://ruchservomotor.com/product_types/servokontrollery/.

[230] "Rostec Professions: Design Engineer in Machine Tool Industry [Профессии Ростеха: инженер-конструктор в станкостроении]," Rostec, Nov. 27, 2023, https://rostec.ru/news/professii-rostekha-inzhener-konstruktor-v-stankostroenii/; Dmitrii Koptev, "A Lie to Save...Whom? [Ложь во спасение… кого?]," *Komsomolskaia Pravda*, May 28, 2019, https://www.kp.ru/daily/26982/4041505/; "SK6P," STAN, https://stan-company.ru/katalogoborudovaniya/portalnyeots/pustayastranitsa_gykk/.

Rostec will probably get the biggest share of the planned state investments into the machine tool industry and is probably preparing for acquisitions of minor machine tool manufacturers.[231]

Key trends in domestic machine tool manufacturing

Despite the significant differences in datasets regularly published by Rosstat, the Russian federal statistics agency, the data show a consistent trend: Russia has more than doubled annual production rates of machine tools since the beginning of the 2010s (see Table 7).

The available data on production of specific types of advanced machine tools give a more nuanced picture (see Table 8). Apparently, laser and ultrasonic machine tools, metalworking centers and multiple-station machines, and CNC lathes were Russia's priority during the past decade, but production of drill and milling machines and boring lathes declined during the same period.

The significant growth of machine tool production rates during the last decade was possible because Russian companies were able to access global supply chains. Two unusual spikes occurred, one from 2015 to 2017 and another starting in 2021. The first spike correlated with Russia's efforts to modernize its military industrial complex and machine tool industry by purchasing foreign machine tools and components for manufacturing Russian-made machine tools and by increasing cooperation with global machine tool companies that were developing facilities in Russia.

Table 7. Machine tool manufacturing in Russia, 2010–2022 and January–November 2023

Year	Data Bulletin[a]	Datasets[b]
2010	2,676	2,961
2011	2,479	3,475
2012	3,417	3,633
2013	3,431	3,082
2014	2,739	4,098
2015	2,919	3,571
2016	3,857	4,523
2017	4,495	4,185
2018	4,188	4,619
2019	4,224	4,638
2020	4,529	5,353
2021	5,458	7,243
2022	7,221	8,152
Jan.–Nov. 2023	7,734	8,325

Sources: [a] "Report on Socio-Economic Status of Russia," Federal State Statistics Service, https://rosstat.gov.ru/compendium/document/50801; [b] "Industrial Production," Federal State Statistics Service, https://rosstat.gov.ru/enterprise_industrial.

The second spike is harder to explain. The available data regarding the cost of produced machine tools may provide some explanation. These data show that the average cost of domestically produced machine tools decreased significantly if expressed in US dollars.[232] Generally speaking, the increasing machine tool production rates, combined with stagnating or declining costs, would suggest the

[231] "Semyon Yakubov Becomes Managing Director of Rostec for Machine Tool Manufacturing [Управляющим директором Ростеха по станкостроению стал Семен Якубов]," Rostec, Dec. 16, 2023, https://rostec.ru/news/upravlyayushchim-direktorom-rostekha-po-stankostroeniyu-stal-semen-yakubov/.

[232] In addition, the ruble prices of Russian-made machine tools are current and do not count monetary inflation and cost-plus inflation during the manufacturing.

Table 8. Machine tool manufacturing in Russia by the most important types, 2010–2022, based on annual data

Year	Laser and Ultrasonic Machine Tools	Metalworking Centers and Multiple-Station Machines	CNC Lathes	Drill Machines	Boring Lathes	Milling Machines	Total
2010	44	31	129		1,270		1,474
2011	80	8	195		1,457		1,740
2012	129	4	166		1,426		1,725
2013	123	10	137		1,287		1,557
2014	161	83	227		897		1,368
2015	177	171	204		522		1,074
2016	356	210	357	141	13	518	1,595
2017	369	255	650	464	41	295	2,074
2018	499	387	497	269	30	252	1,934
2019	260	447	449	237	37	469	1,899
2020	297	387	447	541	39	285	1,996
2021	436	423	563	495	117	452	2,486
2022	609	345	606	580	82	946	3,168

Source: "Industrial Production," Federal State Statistics Service, https://rosstat.gov.ru/enterprise_industrial.

relative simplification of these machine tools, with manufacturers decreasing quality, relaxing specifications, or both. In addition, the advanced imported components would be gradually replaced by Chinese components that have a lower price.

Even so, the increased machine tool manufacturing rate is still well below what is needed to meet basic industrial requirements. For instance, although the United Aircraft Corporation (UAC) acquired 50 machine tool units from Mekhanika Holding from 2019 to 2021, as of May 2022, UAC needed at least 300 additional units by 2026 just to replace existing aging machine tools in its inventory.[233] As a result, the need for growing quantities of machine tools cannot be met domestically as long as Western countries maintain their embargo without resorting to parallel import and smuggling.

[233] "Holding 'Mechanika' Will Become an Industrial Partner of UAC in the Field of Machine Tool Manufacturing [Холдинг «Механика» станет индустриальным партнером ОАК в области станкостроения]," Rostec, May 27, 2022, https://rostec.ru/news/kholding-mekhanika-stanet-industrialnym-partnerom-oak-v-oblasti-stankostroeniya/.

Foreign cooperation and parallel import

Structural transformation of machine tool import in Russia

Russia's invasion of Ukraine led to a tectonic change in the Russian market of metalworking machine tools in just one year. Table 9 shows the import of metalworking machine tools by country in 2021 compared to 2022, according to the National Union of Suppliers of Metalworking Machine Tools, the Russian nongovernmental organization (NGO) established by the machine tool manufacturers.

According to the quoted data, the average cost of each imported unit decreased from $71,000 in 2021 to $63,000 in 2022, which points to growing dominance of the cheaper Chinese-made machine tools.[234]

Another set of data from Russian industrial experts demonstrates the significant increase of total metalworking machine tool imports in Russia (see Table 10). More detailed UN Comtrade database data, as shown in Appendix C: Trends in Russian Purchases of Imported Machine Tools, suggest that imported tools represent a quarter of the metalworking machine market. The decrease in average cost shown in the data means that even after considering inflation and additional costs related to logistics and financial transactions of parallel import, Russian companies are purchasing less advanced metalworking machine tools, primarily from China.

The trend of Russian industrial companies importing more machine tools while giving priority to quantity instead of quality may have the following explanations. First, Russia's access to advanced machine tools in general has become more limited

Table 9. Import of metalworking machine tools in Russia by country, 2021 vs. 2022, in millions of dollars

2021			2022		
Country	**Share, $M**	**Share, %**	**Country**	**Share, $M**	**Share, %**
Germany	202.90	24.84	China	248.29	43.25
Italy	148.40	18.18	Taiwan	88.68	15.44
China	89.30	10.93	Italy	62.51	10.89
Taiwan	79.60	9.75	Germany	51.45	8.96
South Korea	77.50	9.49	Turkey	36.30	6.32
Finland	58.00	7.10	South Korea	35.85	6.24
Japan	48.30	5.91	Other	50.99	8.90
Other	112.80	13.80	—	—	—
Total	**816.80**	**100.00**	**Total**	**574.10**	**100.00**
Total quantity	**11,433**		**Total quantity**	**9,074**	

Source: Olga Miagchenko, "Russia Is Replacing Western Machines with Chinese Ones [Россия замещает западные станки китайскими]," Mashnews, May 24, 2023.

[234] How the data have been collected in the absence of the detailed official statistics of import is unclear, however. Also, no data are provided for earlier time periods. Liubov Romanova, "How Russia's Foreign Trade Has Changed over the Past Year [Как за год изменилась внешняя торговля России]," *Vedomosti*, Mar. 14, 2023, https://www.vedomosti.ru/economics/articles/2023/03/14/966321-kak-izmenilas-vneshnyaya-torgovlya-rossii.

since 2022. Second, the Russian industrial sector needs to replace a significant amount of machine tools purchased in previous decades that cannot be maintained properly because parts are absent or have reached the end of their operational lifetime. Third, Russia has attempted to stock up on metalworking machine tools, considering the prospect of toughening sanctions and efforts to increase domestic manufacturing.

Dependence on China

According to the UN Comtrade database and other sources, China has been able to drastically increase its share in Russia's machine tool market. Table 11 shows the export of machine tools from China to Russia according to China's General Administration of Customs.

The UN Comtrade database gives almost identical numbers and also provides information on numbers of units (see Table 12).

These numbers mean that China's share of the Russian machine tool market jumped from 12.6 percent in 2017 to 28 percent in 2021 to 59 percent in 2022 and finally to 90 percent or more (extrapolated) in 2023. In addition, these numbers contradict Russian assessments of China's share, which were quoted in Table 8. However, the probable explanation of this contradiction is that most Russian assessments do

Table 10. Import of metalworking machine tool units in Russia, 2018–2022

2018	2019	2020	2021	2022
13,992	13,014	13,325	16,442	20,876

Source: "In 2022, Imports of Metalworking Machines to Russia Increased by 27% and Reached 20.9 Thousand Units [В 2022 г импорт металлообрабатывающих станков в Россию увеличился на 27% и достиг 20,9 тыс шт]," Businesstat, https://businesstat.ru/news/metalworking_machines/.

Table 11. Export of machine tools from China to Russia, 2017–2023, in millions of US dollars

Tool type	2017	2018	2019	2020	2021	2022	2023
Machine tools	31.0	43.0	47.0	66.0	90.0	161.0	198.0
Machining centers	16.0	17.0	20.0	16.0	43.0	94.0	390.0
Horizontal lathes	21.0	18.0	22.0	25.0	30.0	101.0	324.0
Non-horizontal lathes	2.5	1.9	3.9	2.7	2.2	5.4	31.0
Total	**69.0**	**79.0**	**92.0**	**109.0**	**165.0**	**362.0**	**943.0**

Source: Customs Statistics, General Administration of Customs of the People's Republic of China, http://stats.customs.gov.cn/indexEn.

not count imported machine tools that come to Russia and then are converted into "Russian-made" machine tools.

The same level of dependence extends to machine tool parts (see Table 13).

These data sources demonstrate that China's share in the Russian import of machine tool parts grew gradually from 13 percent in 2017 to 32 percent in 2022 and then jumped to approximately 80 to 90 percent in 2023. The data show that Russia's industrial sector became heavily dependent on machine tools imported from China in 2023. This commercial imbalance could have political consequences, particularly if China were to use its leverage in this area against the Russian government.

Role of other suppliers of machine tools

Russia's attempts to diversify its sources of supply and use Turkey, India, and other countries for the parallel import of metalworking machine tools deserves particular focus. Even though they neither balance the role played by China nor fully replace Russia's traditional partners in Europe, Asia, and the United States, such supplies help Russia to maintain some diversity of supply in metalworking machine tools and prevent Russia's total dependence on China. See Table 14 and Table 15 for a summary of the extent of supply from traditional and alternative partners.

Table 12. Export of machine tools from China to Russia, 2017–2022 and January–September 2023, in units

	2017	2018	2019	2020	2021	2022	Jan.–Sept. 2023
Machine tools	n/a	15,010	21,789	18,529	23,512	42,375	50,056
Machining centers	205	362	396	378	666	2,390	4,756
Horizontal lathes	390	511	639	846	1,023	2,980	5,231
Non-horizontal lathes	22	128	135	132	52	52	218

Source: UN Comtrade database, https://comtradeplus.un.org.

Table 13. Export of specific categories of machine tool parts from China to Russia, 2017–2023, in millions of US dollars

	2017	2018	2019	2020	2021	2022	2023
Machine tool parts	12	14	16	15	20	18	77

Source: UN Comtrade database; Customs Statistics, General Administration of Customs of the People's Republic of China.

Table 14. Supplies of metalworking machine tools from Western coalition states to Russia, 2017–2022 and January–November 2023, in millions of US dollars

	2017	2018	2019	2020	2021	2022	Jan.–Nov. 2023
Austria	10.0	11.0	8.6	56.0	20.0	3.0	n/a
Czech Republic	25.0	25.0	15.0	18.0	15.0	1.1	n/a
France	1.0	0.5	2.5	2.8	18.0	0.1	n/a
Germany	137.0	134.0	114.0	119.0	97.0	26.0	4.4
Italy	28.0	41.0	40.0	26.0	38.0	21.0	2.3
Poland	16.0	25.0	11.0	13.0	10.0	3.7	~0.0
Spain	5.7	8.1	6.3	11.0	21.0	6.4	12.0
Switzerland	29.0	50.0	32.0	16.0	26.0	2.7	n/a
US	18.0	14.0	11.0	10.0	1.7	1.1	0.3
Japan	43.0	46.0	45.0	32.0	18.0	3.9	n/a
Republic of Korea	31.0	28.0	29.0	20.0	33.0	42.0	n/a
Taiwan	65.0	65.0	74.0	52.0	75.0	92.0	n/a
Total	**410.0**	**450.0**	**386.0**	**376.0**	**374.0**	**203.0**	**19.0**

Source: UN Comtrade database.

Table 15. Supplies of metalworking machine tools from alternative partners to Russia, 2017–2022 and January–November 2023, in millions of US dollars

	2017	2018	2019	2020	2021	2022	Jan.–Nov. 2023
Armenia	n/a	0.3	0.3	0.4	0.6	1.0	1.4
Belarus	9.4	5.2	4.6	6.1	22.0	n/a	n/a
India	1.8	1.1	1.4	1.7	2.2	5.9	21.0
Malaysia	0.1	n/a	~0.0	0.3	~0.0	n/a	0.6
Turkey	5.6	7.7	5.2	5.8	6.2	33.0	78.0
Uzbekistan	0.1	n/a	n/a	n/a	n/a	0.4	0.9
Total	**17.0**	**14.0**	**12.0**	**14.0**	**31.0**	**40.0**	**101.0**

Source: UN Comtrade database.

Since 2021, when supplies from Germany were curtailed, China has clearly become the dominant source for Russia's machine tool imports. Since 2022, Turkey and India have become the second and third major suppliers of metalworking machine tools to Russia, respectively. Even though these two countries are not major producers of machine tools, they probably play a role as hubs for reselling advanced metalworking machine tools from other countries to Russia.

CNC machines: an example

CNC machines play a critical role in the production of a variety of military systems, including helicopter rotor blades, tank engines, radar circuit boards, warship propulsion systems, missile hulls, machine gun barrels, and numerous other weapons.[235] These machines include a variety of precision lathes, mills, and grinders. One type of CNC machine is shown in Figure 5. Russia's defense industry is estimated to comprise approximately 70 to 80 percent of the Russian CNC machine tool market.[236] Most CNC machines on the global market are produced in China, Germany, and Japan, with Italy, the United States, South Korea, Taiwan, and Switzerland also playing a role in the market. Of these, the primary exporting countries are Germany, Japan, China, Italy, and Taiwan.[237]

Despite extensive government efforts beginning in 2014 to reduce Russia's dependence on imported

Figure 5. CNC lathe

Source: "6 Common CNC Machines & What They Do," Universal Technical Institute, June 21, 2020, https://www.uti.edu/blog/cnc/6-cnc-machines. Photograph by cnc.com.

CNC machine tools, little progress had been made by the end of 2021. Russia remained highly dependent on imports of CNC machine tools, with at least 70 percent of new machine tools purchased in Russia in 2021 being imported, a figure only slightly lower than the level of import dependence in 2014.[238] Furthermore, some evidence shows that a significant fraction of the machines that were described as being domestically produced were actually imported machines being falsely presented as Russian.[239] Reasons for Russia's dependence on foreign CNC machines include disruption of continuity caused by the industrial collapse of the 1990s; the small size of the Russian market, which makes domestic

[235] "From Guns to Warships: Applications of CNC Machining in the Defense Industry," AT Machining, Mar. 7, 2023, https://at-machining.com/cnc-machining-in-defense-industry/; Ronan Ye, "CNC Machining Use Cases in the Military and Defense Industries," 3ERP, July 6, 2020, https://www.3erp.com/blog/cnc-machining-use-cases-in-the-military-and-defense-industries/.

[236] Olena Yurchenko et al., *CNC Machinery 2.0: Updated Research on the Strategic Role of CNC Machines in Curtailing Russia's Military Capacity*, Economic Security Council of Ukraine, Nov. 2023, p. 27, https://reb.org.ua/storage/220/cnc-machines-2-0-website.pdf.

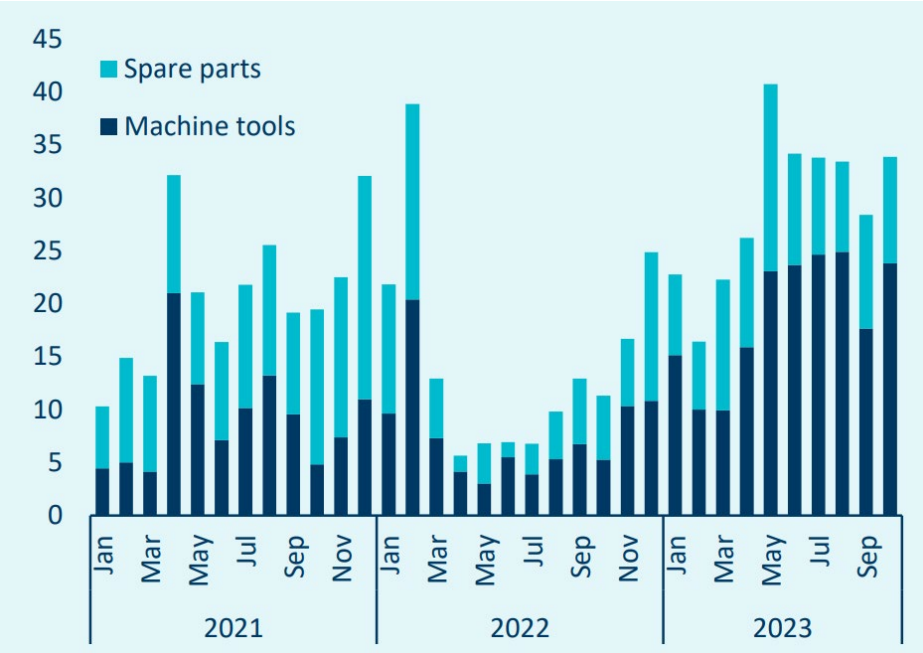
[237] Jan Schafer, "World Machine Tool Production and Consumption Modestly Down in 2022," Modern Machine Shop Online, Oct. 7, 2023, https://www.mmsonline.com/articles/world-machine-tool-production-and-consumption-modestly-down-in-2022.

[238] Yurchenko et al., *CNC Machinery 2.0*, pp. 19, 27.

[239] "The Head of the Baltic Industrial Company Was Detained in Moscow Because of a Chinese Machine Tool [Главу Балтийской промышленной компании задержали в Москве из-за китайского станка]," *BBC News Russian Service*, Dec. 24, 2021, https://www.bbc.com/russian/news-59784138; Koptev, "Chinese Machine Tool Manufacturers Receive Billions from the Russian Budget [Ложь во спасение… кого?"; "Китайские производители станков получают миллиарды из бюджета РФ]," News.ru, Nov. 21, 2019, https://news.ru/business/kak-minpromtorg-spasaet-stankostroenie/.

production economically inefficient; and insufficient investment in the production base and R&D. Moreover, until the advent of strict sanctions in 2022, Russian defense manufacturers preferred to use imported CNC machine tools and found ways to circumvent both domestic and foreign restrictions on their purchase.[240]

Figure 6. Russian imports of CNC machinery from 38 key companies, in millions of US dollars



Source: Bilousova et al., *Challenges of Export Controls Enforcement*, p. 22.

After strict sanctions were introduced in 2022, Russian imports of CNC machine tools initially experienced a significant drop, as shown in Figure 6. However, imports began to rise almost immediately and by 2023 had reached levels comparable to 2021 levels. According to data compiled by the Kyiv School of Economics, monthly average imports of CNC machinery were 88 percent higher in 2023 than before the full-scale invasion, whereas monthly average imports of spare parts were 14 percent lower.[241] The sources of imports have changed to some extent but not as much as the path of import. In 2021, 35 percent of imported CNC machine tools came from Germany and Italy, with another 20 percent coming from Taiwan and South Korea and only 11 percent coming from China.[242] In 2023, the share of Chinese-produced CNC machine tools in Russia's import market doubled to 22 percent, and Germany, Taiwan, and South Korea retained prominent roles in production. However, instead of being imported directly, CNC machine tools are now being sold through intermediaries in China, Turkey, Hong Kong, and a few other countries.[243] The graphs in Figure 7 show supply being cut off quickly in March 2022 and then increasing gradually through new international supply chains beginning in late 2022. The pattern shows that parallel import is the primary method being used to counter the Western export control regime, with cooperation with new foreign partners playing a much smaller role and import substitution remaining relatively insignificant.

Several factors combine to make it possible for Russia to continue to import CNC machine tools

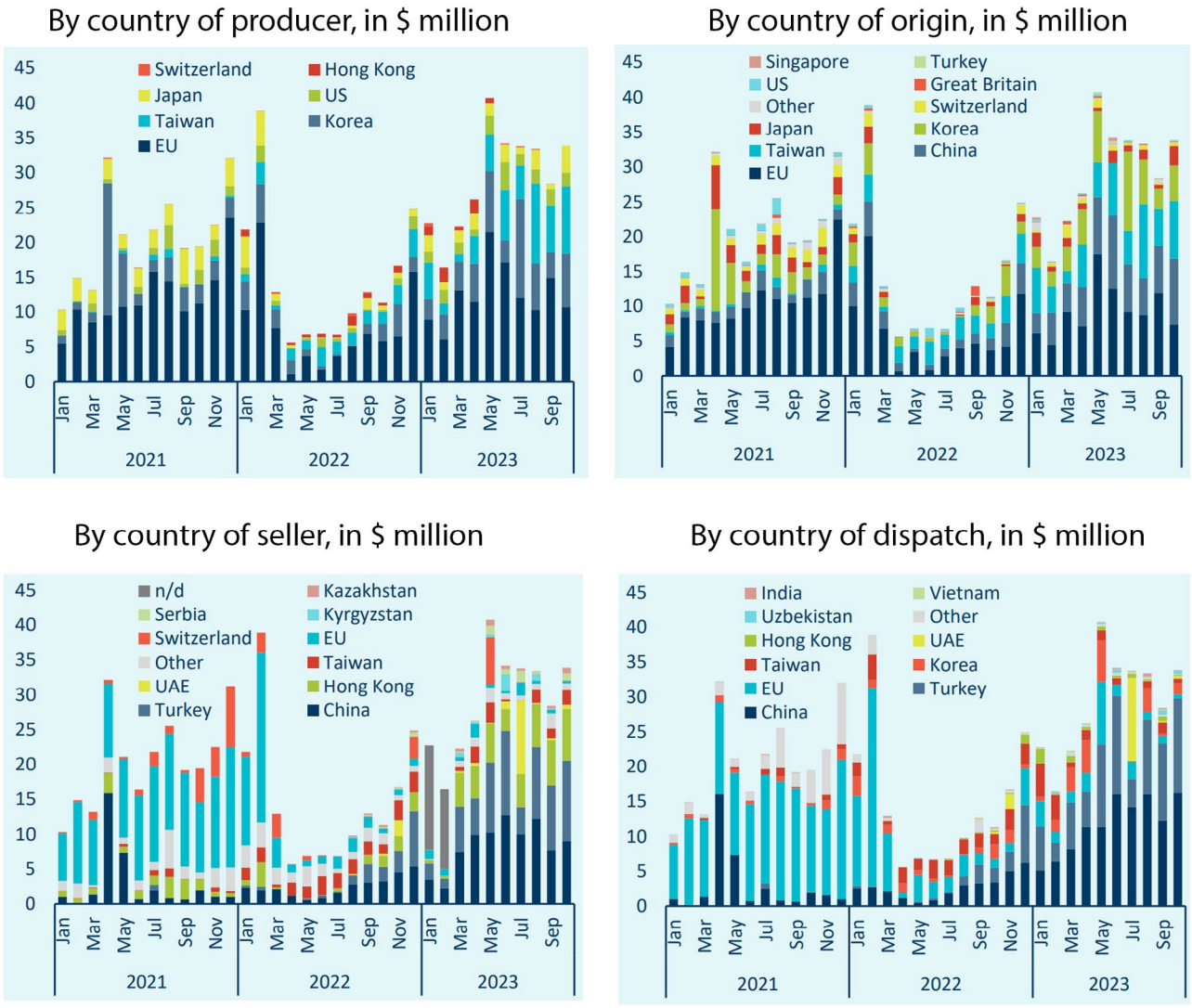
[240] Yurchenko et al., *CNC Machinery 2.0*, pp. 20–22.

[241] Bilousova et al., *Challenges of Export Control Enforcement*, p. 21.

[242] Olga Miagchenko, "Russia Is Replacing Western Machines with Chinese Ones [Россия замещает западные станки китайскими]," Mashnews, May 24, 2023, https://mashnews.ru/rossiya-zameshhaet-zapadnyie-stanki-kitajskimi.html.

[243] Bilousova et al., *Challenges of Export Controls Enforcement*, pp. 22–23.

Figure 7. Sources of Russian imports of CNC machine tools



Source: Bilousova et al., *Challenges of Export Controls Enforcement*, p. 23.

despite export controls. These factors include the absence of controls on certain kinds of less precise CNC machines, poor export control enforcement that "create[s] broad room for forgery of end-user certificates [and] lenient pre-transactional and post-transactional due diligence," and insufficient capacity of enforcement bodies.[244]

Conclusion

Russia's import substitution policy in machine tools cannot be considered a sustainable compensation strategy in the face of the Western sanctions against Russia. Russia's machine tool industry, as well as Russia's military industrial complex, still relies on the American, European, Japanese, and Taiwanese machine tools and components that were

[244] Yurchenko et al., *CNC Machinery 2.0*, p. 39.

purchased during the 2010s. The planned huge budgetary investments cannot solve the problems of a relatively small amount of available human capital and disrupted cooperation ties with Western machine tools companies.

Despite the failures of import substitution both in the long term over the last decade and in the short term since the introduction of strict export controls by Western states in 2022, Russia has found ways to supply its military industry with the machine tools that it needs to maintain production. It has done so primarily by setting up new supply chains that allow continued import of Western machine tools in circumvention of export controls, mostly through China and Turkey. The import of machine tools designed and produced in countries that have not signed up for the export control regime, again primarily China, has played a supplementary role in fulfilling Russian needs. These compensation strategies come with costs, including higher prices for equipment acquired through parallel import and the partial substitution of lower quality Chinese machine tools in place of higher quality tools made in Germany and Italy. That said, Russia can currently acquire and produce the machine tools necessary to maintain the military industrial production that it needs to continue its war in Ukraine.

EFFECT ON RUSSIAN DEFENSE PRODUCTION

This section examines the extent to which Russia's compensation strategies have succeeded in allowing the Russian defense industry to produce sufficient quantities of key weapons systems for its war against Ukraine. We examine two key types of weapons: precision-guided missiles and UAVs. We find that in the early phases of the war, Russia had inadequate rates of production of both types of weapons, which resulted in efforts to find alternative sources of supply abroad in the short term and to expand domestic production in the medium to long term.

Russia has been quite effective at increasing the available supply of UAVs through both importing drones from Iran and expanding domestic production. In the meantime, foreign states have been somewhat more reluctant overall to provide Russia with missiles, although some missiles have been imported from North Korea. At the same time, rates of domestic production of missiles remain far below the targets set by the Russian military. As a result, the Russian military continues to have to ration its missile strikes against Ukraine and to use missiles in unorthodox ways, such as using S-300 air defense missiles in a ground attack capacity. The rest of this section examines the production of these two types of weapons in greater detail.

Russian missiles

This section seeks to address several key questions regarding Russia's missile production. Is Russia continuing to produce precision-guided missiles at the necessary rate and quality level for war in Ukraine? What constraints does Russia face in missile production? Is quality being sacrificed to maintain the quantity of production? How do we explain the declining numbers of missile strikes in the second half of 2023?

The evidence is contradictory. Evidence of missiles produced since February 2022 has been found on the battlefield, but experts disagree about Russia's ability to maintain production at necessary levels. Some see signs of increasing production, whereas others point to several problems that will likely affect quantity and quality. The latter further note that in the past year, Russia has been importing lower quality North Korean missiles and substituting other types of domestically produced missiles for precision-guided missiles.

After reviewing this evidence, we find that sanctions have not prevented Russia from producing missiles in the short term, although their quantity and quality are decreasing over time because of sanctions on machining equipment. International attention has focused on Russia's ability to obtain microchips, but its access to high-quality machining equipment may be more central to constraining missile production. Evidence of repurposing missiles for other uses and imports from North Korea (and possibly Iran as well) are further indicators of difficulties in the production process in Russia.

We consider three types of domestically produced precision-guided missiles:

1. Kalibr sea-launched missiles
2. Kh-101 air-launched cruise missiles (ALCMs)
3. 9M273 Iskanders

3M-14K Kalibr (NATO code name SS-N-30A) medium-range cruise missiles (Figure 8) are capable of hitting targets in Ukraine. Kalibr is a sea-launched land attack cruise missile with a range of 1,500 to 2,500 kilometers.[245]

The Kh-101/Kh-102 Raduga (AK-23a KODIAK) is a conventional and nuclear-capable ALCM with a range of 5,000 kilometers (Figure 9).[246] The missile aims to avoid air defenses by flying low, but Ukrainian experts who examined downed missiles did not find evidence that the missile had radar-absorbing

Figure 8. Kalibr sea-launched cruise missile

Source: "3M-14 Kalibr (SS-N-30A) Russian Anti-Ship Cruise Missile," OE Data Integration Network.

Figure 9. Kh-101 air-launched cruise missile

Source: Vermylen, "Kh-101/102."

[245] "3M14 Kalibr (SS-N-30A) Russian Anti-Ship Cruise Missile," OE Data Integration Network, https://odin.tradoc.army.mil/WEG/Asset/78f02506cc5fb64138eef94b42541e9a; "3M-14 Kalibr (SS-N-30A)," CSIS Missile Defense Project, Apr. 23, 2024, https://missilethreat.csis.org/missile/ss-n-30a/; Valeriy Akimenko, *Russia and Strategic Non-Nuclear Deterrence: Capabilities, Limitations, and Challenges*, Chatham House Russia and Eurasia Programme, July 2021, https://www.chathamhouse.org/sites/default/files/2021-08/2021-07-29-russia-strategic-non-nuclear-akimenko.pdf.

[246] "Kh101-Kh102 Russian Air Launched Cruise Missile," OE Data Integration Network, https://odin.tradoc.army.mil/WEG/Asset/Kh-101_::_Kh-102_Russian_Air_Launched_Cruise_Missile.

material as Russia had claimed.[247] The missile has no booster and is dependent on bombers (Tu-95S, Tu-160, Su-34) to achieve altitude.[248]

The 9M273 Iskander (SS-26 Stone) is a short-range ballistic missile with a range of up to 500 kilometers that requires a transporter erector launcher (TEL) (Figure 10). The missile has the capability to maneuver to evade missile defenses and reportedly has a separating warhead that can maneuver in the terminal stage. As of 2019, Russia had 11 combat brigades of TELs, with each brigade including 12 TELs and support vehicles. The 9K720 is the export model of this missile.[249]

These three types of precision-guided missiles have been central to the Russian war effort in Ukraine by providing support for Russia's ground operations, threatening civilian and military infrastructure in Ukraine, and terrorizing the population in an effort to erode the will to fight.[250]

The debate on Russian missile stocks

According to the Ukrainian Defense Ministry, Russia has launched more than 8,000 missile strikes against Ukraine since the start of the war (through mid-March 2024).[251] This figure may be an underestimate

Figure 10. Iskander ballistic missile

Source: "9K720 Iskander Short-Range Ballistic Missile," OE Data Integration Network.

because it does not include misfires or missiles that failed to reach their target in Ukraine.

As Figure 11 shows, 6,500 of these strikes occurred during the first year and a half of the war. Figure 12 shows a very different picture (i.e., dwindling missile attacks in the second half of 2023 followed by an uptick in late December 2023 and early January 2024, then followed by another decline). Polish researchers identify the December 2023 and January 2024 missile strikes as among the top five Russian missile strikes in terms of quantity of missiles fired.[252] Others view this pattern as a part of a Russian strategy to increase strikes during winter.[253]

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[247] "The Russian Stealth Was Fake Research Shows: No Radar Absorbent Coating on KH-101," Defense Express, Mar. 6, 2024, https://en.defence-ua.com/weapon_and_tech/the_russian_stealth_was_fake_research_shows_no_radar_absorbent_coating_on_kh_101_missile-5966.html.

[248] Mark Vermylen, "Kh-101/102," Missile Defense Advocacy Alliance, May 2017, https://missiledefenseadvocacy.org/missile-threat-and-proliferation/todays-missile-threat/russia/kh-101102/.

[249] "9K720 Iskander Short-Range Ballistic Missile," OE Defense Integration Network, https://odin.tradoc.army.mil/WEG/Asset/9K720_Iskander_(SS-26_Stone)_ Russian_Surface_to_Surface_Short_Range_Ballistic_Missile; "9K720 Iskander (SS-26)," CSIS Missile Defense Project, Apr. 23, 2024, https://missilethreat.csis.org/missile/ss-26-2/.

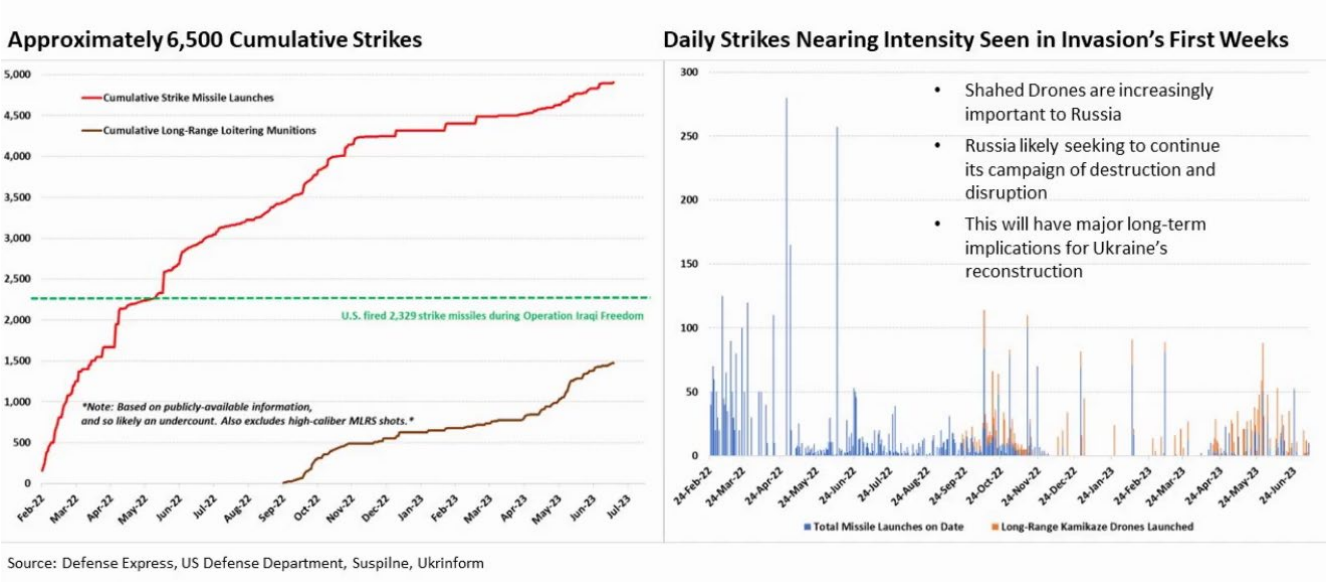
[250] Paul Schwartz, *A War of Attrition: Assessing the Impact of Equipment Shortages on Russian Military Operations in Ukraine*, CSIS, July 31, 2023, https://www.csis.org/analysis/war-attrition.

[251] Olena Harmash and Ivan Lyubysh-Kirdey, "Russia Launches Largest Missile Attack Against Kyiv in Weeks," Reuters, Mar. 21, 2023, https://www.reuters.com/world/europe/ukraines-capital-kyiv-is-under-russian-missile-attack-mayor-says-2024-03-21/.

[252] Andrzej Wilk and Piotr Zochowski, "Russian Missile Terror: Day 678 of the War," OSW, Jan. 4, 2024, https://www.osw.waw.pl/en/publikacje/analyses/2024-01-04/russian-missile-terror-day-678-war.

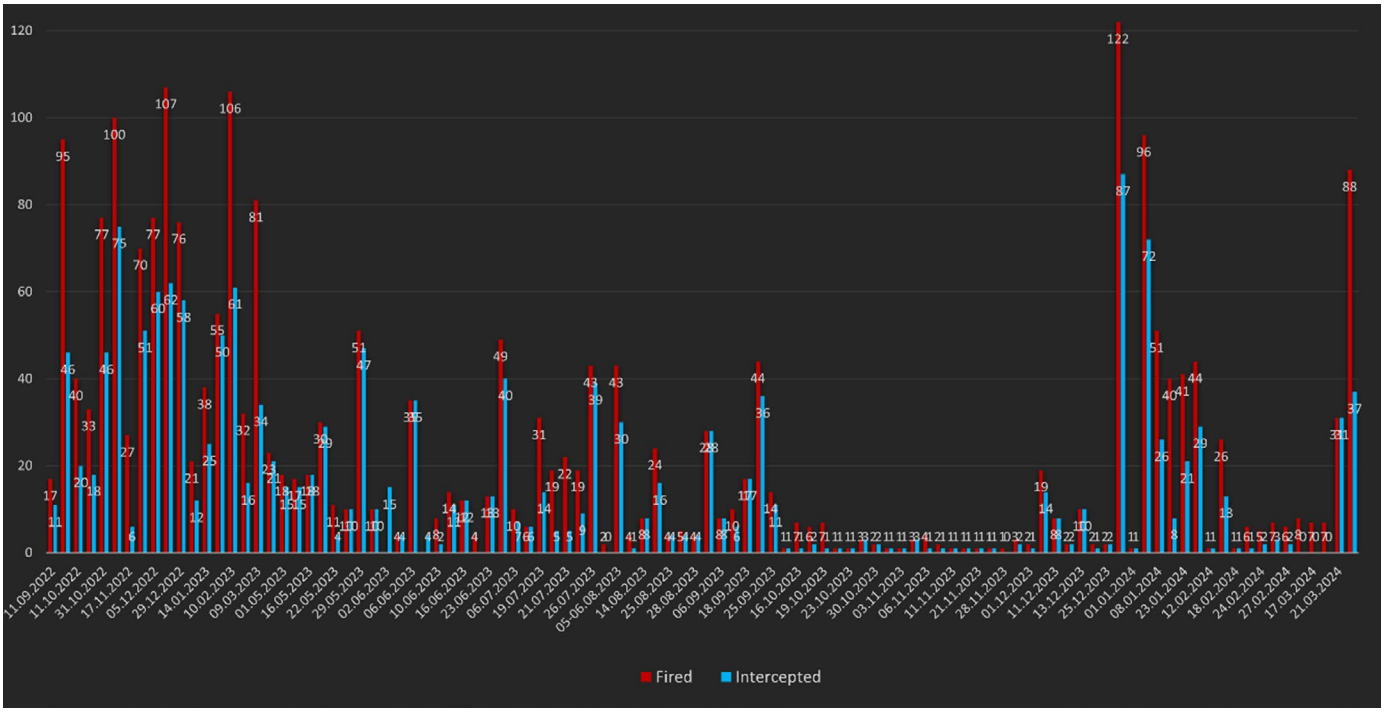
[253] Bilousova et al., *Challenges of Export Control Enforcement*, p. 5.

Figure 11. Quantifying Russia's missile and drone strikes on Ukraine



Source: "Quantifying Russia's Missile and Drone Strikes on Ukraine," Collins Research Portal, July 10, 2023, https://collinsresearchportal.com/2023/07/10/russias-missile-drone-strikes-on-ukraine-10-july-2023-update/.
Note: The source that included these figures noted that the number of strikes is "likely an undercount, as it relies substantially on intercept data that do not always show how many munitions Russian forces launched."

Figure 12. Russian air and missile strikes on Ukraine (Shahed drones excluded)



Source: "Russian Air and Missile Strikes on Ukraine," Rochan Consulting, Mar. 22, 2024, https://twitter.com/konrad_muzyka/status/1771086829019607091.

Experts disagree in their assessments of these patterns of missile use. Some contend that Russia is managing to replenish its supply of precision-guided missiles despite sanctions. Others point to evidence that Russian defense production is struggling to produce the quantity and quality of missiles needed. Changing patterns of missile use may also reflect a reassessment of the ability of these missiles to achieve Russian war aims,[254] especially given their high cost.

View 1: supplies are increasing

Some analysts of Russian military production assess that Russia is capable of sustaining combat operations in Ukraine,[255] including producing or acquiring enough missiles to fire on Ukrainian targets and causing significant damage and loss of life, despite Ukraine's notable air defense successes.[256] Norwegian Foreign Minister Espen Barthe Eide suggested that Russia has been increasing missile production since its full-scale invasion of Ukraine.[257] RUSI has found evidence that Russian stockpiles of cruise missiles had dwindled by 2023 but increased significantly by early 2024.[258] In the first three months of 2024, Russia fired 180 missiles at Ukrainian targets.[259]

Ukrainian forces have found evidence of Russian Kh-101 cruise missiles produced in 2023.[260] Satellite imagery shows that in late 2023, a new building was constructed in Dubna (north of Moscow) at the Raduga plant, a part of the state-owned weapons producer Tactical Missile Corporation. Raduga produces missiles, including the Kh-101.[261] However, other evidence from the battlefield highlights the unusually quick turnaround between production and use, indicating thinning stores of missiles.[262] Conflict Armament Research (CAR), a UK NGO that researches supply chains in military conflict, examined the remnants of several Kh-101s recovered in Ukraine and found that the missiles were used within two to three months of production.[263]

[254] Ian Williams, *Putin's Missile War*: *Russia's Strike Campaign in Ukraine*, CSIS, May 2023, https://csis-website-prod.s3.amazonaws.com/s3fs-public/2023-05/230505_Williams_Putin_Missile.pdf.

[255] For example, see Andrew S. Bowen, *Russian Military Performance and Outlook*, Congressional Research Service, Mar. 8, 2024, p. 2, https://crsreports.congress.gov/product/pdf/IF/IF12606.

[256] Ian Williams, "Russia Isn't Going to Run Out of Missiles," CSIS, June 28, 2023, https://www.csis.org/analysis/russia-isnt-going-run-out-missiles.

[257] John Grady, "Russia Expanding Munitions Production Says Norwegian Foreign Minister," USNI News, Feb. 8, 2024, https://news.usni.org/2024/02/08/russia-expanding-munitions-production-says-norwegian-foreign-minister.

[258] Jack Watling and Nick Reynolds, "Russian Military Objectives and Capacity in Ukraine Through 2024," RUSI, Feb. 13, 2024, https://www.rusi.org/explore-our-research/publications/commentary/russian-military-objectives-and-capacity-ukraine-through-2024. Also see Julian E. Barnes, Eric Schmitt, and Thomas Gibbons-Neff, "Russia Overcomes Sanctions to Expand Missile Production, Officials Say," *New York Times*, Sept. 13, 2023, https://www.nytimes.com/2023/09/13/us/politics/russia-sanctions-missile-production.html.

[259] "Ukraine Says Russia Has Fired Five Zircon Missiles at Kyiv This Year," Reuters, Apr. 1, 2024, https://www.reuters.com/world/europe/ukraine-says-russia-has-fired-five-zircon-missiles-kyiv-this-year-2024-04-01/.

[260] "Unexploded Kh-101 Warhead Shows Russia Uses Missiles Fresh from Conveyor for Shelling," Defense Express, Jan. 23, 2024, https://en.defence-ua.com/industries/unexploded_kh_101_warhead_shows_russia_uses_missiles_fresh_from_conveyor_for_shelling_ukraine-9272.html. CAR has similar data. See Conflict Armament Research, *Dating Newly Produced Russian Missiles Used in Kyiv Attacks*, Ukraine Field Dispatch, Dec. 2022 (updated Dec. 2023), https://storymaps.arcgis.com/stories/81bc6b71fdc64361a05a21020c3d6d5e.

[261] Kyrylo Ovsyaniy, "Satellite Images Suggest Russia Is Ramping Up Production Capacity for Its War Against Ukraine," Radio Free Europe/Radio Liberty, Nov. 1, 2023, https://www.rferl.org/a/russia-ramping-up-war-production/32658857.html; Conflict Armament Research, *Dating Newly Produced Russian Missiles*.

[262] Tim Martin, "Weapons Tracing Shows Russia Firing New Cruise Missiles at Ukraine Just Weeks After Production," Breaking Defense, May 10, 2023, https://breakingdefense.sites.breakingmedia.com/2023/05/weapons-tracing-shows-russia-firing-new-cruise-missiles-at-ukraine-just-weeks-after-production/.

[263] John Ismay, "Russian Guided Missiles Miss the Mark," *New York Times*, May 9, 2022, https://www.nytimes.com/2022/05/09/us/politics/russia-air-force-ukraine.html.

View 2: production quantity and quality are insufficient to meet desired usage needs

The Foundation for the Defense of Democracies reported that despite increasing Russian missile production in 2023, supplies are insufficient to meet the desired usage rate, and Russia is unable to replace the thousands of missiles used since 2022.[264] According to Major General Vadym Skibitsky, deputy head of Ukraine's Main Directorate for Military Intelligence, Russia has been producing about 115 to 130 missiles with a range greater than 350 kilometers monthly since fall 2023. He noted that availability of necessary foreign components was a necessary factor for maintaining this level of production and that production had stopped during some months (e.g., December 2023) because of component shortages. Skibitsky attributed the sharp decline in missile strikes in fall 2023 to Russia's effort to maintain a strategic reserve of missiles. However, he pointed out that the reserve is not very large because very recently produced missiles are regularly found on Ukrainian battlefields.[265] In a March 2024 interview, Ukrainian Director of Military Intelligence Kyrylo Budanov claimed that Russia was stockpiling Kalibr missiles for imminent use because the supply of Kh-101s (which Budanov contended Russia considers more effective) had been temporarily exhausted.[266]

RUSI further emphasizes that the rising cost of foreign components for missile production is an additional constraint that only enables defense manufacturers to stabilize production, despite increasing shifts and production lines.[267] According to the Bank of Finland Institute for Emerging Economies, some countries charge as much as 60 percent more for exports of sanctioned goods.[268]

Ukraine's National Agency for Corruption Prevention concluded that 2,800 parts for Russian weapons (including missiles, drones, and armored systems) came from foreign countries, 95 percent of which came from coalition partners and 72 percent from the US.[269] Ukrainian sources find that Russia has sought to obfuscate the sourcing of components by deliberately grinding off serial numbers on missiles.[270]

Ukrainian cyber operatives take credit for delaying missile production by four to six months in 2023 by revealing foreign suppliers of sanctioned components, causing Russian producers to seek new sources.[271] The Institute for the Study of War contends that Russian missile production rates do

[264] John Hardie, "Russian Munitions Production Higher but Still Insufficient," *Long War Journal*, Jan. 2024, https://www.fdd.org/analysis/op_eds/2024/01/18/russian-munitions-production-higher-but-still-insufficient/.

[265] Uliana Bezpalko and Daria Dmytriieva, "Russians Motivated to Fight for Money, 1,000-1,100 People Join Army Every Day—Defense Intelligence Representative," RBC-Ukraine, Jan. 25, 2024, https://newsukraine.rbc.ua/interview/russians-motivated-to-fight-for-money-1000-1705323575.html.

[266] "Russia's Stocked Up Kalibr Missiles for New Attacks: Budanov," *Kyiv Post*, Mar. 31, 2024, https://www.kyivpost.com/post/30378.

[267] Watling and Reynolds, "Russian Military Objectives and Capacity."

[268] "British Intelligence Analyzes Russia's Arms Production Under Sanctions," Ukrinform, Apr. 1, 2024, https://www.ukrinform.net/rubric-economy/3847159-british-intelligence-analyzes-russias-arms-production-under-sanctions.html.

[269] Bilousova et al., *Challenges of Export Control Enforcement*, p. 5.

[270] Sofiia Syngavskaya, "Russia Deploys the Kh-101 Missile Manufactured in Q4, Ukraine Cracks New Missile Code (Photos)," Defense Express, Jan. 2, 2024, https://en.defence-ua.com/analysis/_russia_deploys_the_kh_101_missile_manufactured_in_q4_2023_ukraine_cracks_new_missile_code_photos-9061.html.

[271] Ivashkiv Olena, "Russia's Missile Production Is 6 Months Behind Due to Cyber Resistance Activists," *Ukrainska Pravda*, Mar. 9, 2024, https://www.pravda.com.ua/eng/news/2024/03/9/7445670/.

not allow for regular major attacks.[272] Production challenges manifest on the battlefield, as Ukrainian sources have reported finding some debris from malfunctioning Kh-101 missiles.[273]

A potential consensus: supplies are adequate for now, but evidence of ongoing difficulties abounds

In addition to sanctions and the cost of imported sanctioned goods discussed in the previous section, several other factors limit Russia's ability to produce and deliver precision-guided missiles.

Cost

The periodic lulls in Russia's use of precision-guided missiles have been attributed to their high cost. A widely shared article by *Forbes Ukraine* provides very high estimates of Russia's missile production cost, which another Ukrainian publication, Defense Express, disputes (Table 16).[274]

Although cost is an important consideration, it may not be the most significant reason for Russia's decision to repurpose other domestically produced missiles for use in Ukraine and to buy foreign missiles and drones.

Lack of necessary machining equipment

Studies of Russian defense production reveal that Russian Defense Minister Sergei Shoigu's boast in December 2023 that Russia is quadrupling defense production has no basis in fact. Analyst Pavel Luzin argues that the volume of production of key metals is not at the levels needed to increase production rates of missiles and that there is no major increase in electrical power usage, which would accompany a major expansion of arms production.[275] Precision machining is a key chokepoint for Russia's defense production. Although attention focuses on Russia's ability to obtain sanctioned microchips, a study by Rhodus Intelligence argues that Russia's missile

Table 16. Cost of missile production, in millions of US dollars

	Forbes Ukraine	**Defense Express**
Kalibr	6.5 million	Up to 1 million
Iskander	3 million	1–2 million
Kh-101	13 million	1.2 million

Sources: "What Is the Real Price"; Tarasovskiy and Gnenny, "Russia Spent About $620 Million."

[272] Christina Harward et al., "Russian Offensive Campaign Assessment, December 29, 2023," Institute for the Study of War, Dec. 29, 2023, https://www.understandingwar.org/backgrounder/russian-offensive-campaign-assessment-december-29-2023.

[273] Kateryna Hodunova, "UK Military Intelligence: Russia Likely Faces Issues in Kh-101 Missile Production Due to Sanctions," Kyiv Independent, Apr. 9, 2024, https://kyivindependent.com/uk-military-intelligence-russia-likely-faces-issues-in-kh-101-missile-production-due-to-sanctions/.

[274] "What Is the Real Price of Russian Missiles: About the Cost of 'Kalibr,' 'Kh-101,' and 'Iskander' Missiles," Defense Express, Nov. 1, 2022; Yury Tarasovskiy and Konstantin Gnenny, "Russia Spent About $620 Million on Shelling Ukraine on January 2, Forbes Estimates," *Forbes Ukraine*, Jan. 2, 2024, https://forbes.ua/news/rosiya-vitratila-na-obstril-ukraini-2-sichnya-blizko-620-mln-otsinka-forbes-02012024-18257.

[275] Pavel Luzin, "Kremlin Exaggerates Production of Russian Arms Manufacturing in 2023," *Eurasia Daily Monitor* 21, no. 17 (Feb. 5, 2024), https://jamestown.org/program/kremlin-exagerates-production-of-russian-arms-manufacturing-in-2023/.

capability depends on precision machining, especially metalworking, because most missile parts (engine, rocket body, fuel tanks) require machining.[276] In the past, Russia generally purchased this technology from US allies, especially Germany and Japan, and Russian defense production is 95 percent dependent on foreign imports of machine tools.[277] Chinese technology reportedly lags far behind, and Russia does not use it. In fact, China is considered a last choice supplier.[278]

Security

Russian missile production facilities appear to be vulnerable to Ukrainian hacking efforts. The Russian Volunteer Group (an anti-Putin paramilitary group of Russians in Ukraine) recruited a volunteer informant at a Russian defense entity who provided secret information about the production of Kalibr and Iskander missiles and key personnel.[279] Ukraine's Resistance Center claims that cyber activists unearthed evidence of manufacturing problems in Russian missile production and used the information to reveal foreign suppliers of sanctioned products.[280]

Delivery

Ukraine's ability to attack Russian naval assets in Sevastopol has constrained Russia's use of Kalibr missiles, which are launched from surface ships and Kilo-class submarines. According to Natalia Kremeniuk, a spokesperson for Ukraine's southern forces, the logistics infrastructure needed to load Kalibr missiles onto ships and submarines is based in Crimea.[281] However, Ukraine's successful attacks on Russia's Black Sea headquarters in Sevastopol as well as on several warships forced Russia to relocate its fleet to the eastern part of the Black Sea.[282]

Shortfalls in missile production boost demand for imports and lead to repurposing

Difficulties have led Russia to buy missiles from North Korea, seek to purchase them from Iran, and repurpose other Russian missiles not originally designed for offensive strikes against targets on land.

North Korean missiles

The US National Security Council reported that Russia used North Korean ballistic missiles in Ukraine for the first time on December 30, 2023, and January 1, 2024, in violation of UN Security Council resolutions.[283] CAR identified the missiles as Hwasong-11A (KN-23) and Hwasong-11B (KN-24).[284] Ukrainian sources also claim that Russia used the Hwasong-11A in the February 2024 attack on Kharkiv.[285] Yuriy Belousov, the head of the War Crimes Department in Ukraine's

[276] Kamil Galeev et al., *How Does Russia Make Missiles?*, Rhodus Intelligence, Jan. 2024, p. 7, https://assets-global.website-files.com/65ca33870401867f9de42990/65d85b88de8fba03ae83ea46_Rhodus.%20How%20Russia%20makes%20missiles.pdf.

[277] Galeev et al., pp. 10, 24.

[278] Galeev et al., pp. 11, 31.

[279] "Russian Volunteers' Cyber Op Reveals Kalibr and Iskander Missile Secrets," Militarnyi, Apr. 3, 2024, https://mil.in.ua/en/news/russian-volunteers-cyber-op-reveals-kalibr-and-iskander-missile-secrets/.

[280] Brendan Cole, "Russia Suffering Missile Production Headache, According to Kyiv," *Newsweek*, Mar. 4, 2024, https://www.newsweek.com/ukraine-russia-missiles-problems-1877548.

[281] Ellie Cook, "Russia 'Limiting' Kalibr Cruise Missiles Hints at Deeper Logistics Trouble," *Newsweek*, Apr. 2, 2024, https://www.newsweek.com/russia-kalibr-cruise-missiles-ukraine-black-sea-fleet-crimea-1885891.

[282] Dmitry Gorenburg, "The Other Frontline in Ukraine: The Will to Fight," *InDepth (CNA blog)*, Feb. 22, 2024, https://www.cna.org/our-media/indepth/2024/02/the-will-to-fight-in-ukraine.

[283] Kelsey Davenport, "Russia Uses North Korean Missiles Against Ukraine," Arms Control Today, Mar. 2024, https://www.armscontrol.org/act/2024-03/news/russia-uses-north-korean-missiles-against-ukraine.

[284] Conflict Armament Research, *Documenting a North Korean Missile in Ukraine*, Ukraine Field Dispatch, Jan. 2024, https://storymaps.arcgis.com/stories/3a4e9d713f59426d9d1ea3881abecbf3.

[285] Davenport, "Russia Uses North Korean Missiles."

Office of the Prosecutor General, claims that 50 North Korean missiles have been used in Ukraine in 2024 (through mid-March). Although the missiles resulted in 100 injuries and 24 deaths, Belousov emphasizes that the North Korean weapons are of extremely low quality, with a 20 percent success rate. He believes that North Korea is using the war in Ukraine to test its missiles.[286]

Iranian missiles

On February 21, 2024, Reuters reported that Iran had begun shipping missiles to Russia in January 2024—400 mostly short-range ballistic missiles in the Fateh-110 family such as the Zolfaghar.[287] No Iranian missiles have yet been identified on the battlefield in Ukraine, however, and the US claims that there is no evidence of the delivery of these missiles.[288] If delivered, these missiles would pose a greater challenge than the North Korean missiles because the Iranian weapons are known for powerful warheads and accurate targeting.[289]

Repurposing of Russian missiles

Russia's use of a wider range of missiles (such as Oniks, Tornado-S, Kh-44, and Kh-32), many of which were repurposed for offensive use in Ukraine, indicates shortfalls in production of precision-guided missiles and an effort to use the existing arsenal sparingly.[290] Although they enable Russia to sustain its attack on Ukraine, these missiles are of lower quality and are less accurate.[291] Nevertheless, a Center for Strategic and International Studies study highlights that Russia increasingly prioritized using Iranian Shahed drones in the second half of 2023 (compared to the first six months of the year) rather than these repurposed missiles.[292]

Reusing Ukrainian missiles

The Schemes Unit of Radio Free Europe/Radio Liberty found evidence that Russia has been using Ukrainian missiles that were transferred to Moscow in 1999 (as part of Ukraine's compliance with the first Strategic Arms Reduction Treaty). Although these missiles are imprecise and some are even fired without warheads, their size and fuel cause damage upon impact.[293]

Assessment

Patterns of Russian missile use against Ukraine and continuing efforts to import missiles from North Korea and Iran suggest that Russian missile manufacturers are having difficulty keeping up with the Russian military's demand for new missiles. Throughout 2023 and early 2024, significant time passed between missile salvos, suggesting that Russia was saving up newly procured missiles to fire larger salvos that had a higher likelihood of overwhelming Ukrainian air defenses. Analysis of missile fragments found in Ukraine lends further evidence to this theory because components in the

[286] "North Korean Missiles Fired by Russia 'Low Quality': Ukraine Official," Kyodo News, Mar. 15, 2024, https://english.kyodonews.net/news/2024/03/10e0778eecdc-n-korean-missiles-fired-by-russia-low-quality-ukraine-official.html.

[287] Parisa Hafezi et al., "Exclusive: Iran Sends Russia Hundreds of Ballistic Missiles," Reuters, Feb. 21, 2024, https://www.reuters.com/world/iran-sends-russia-hundreds-ballistic-missiles-sources-say-2024-02-21/.

[288] "Iran Has Already Sent Missiles to Russia, Report Says," Foundation for Defense of Democracies, Feb. 22, 2024, https://www.fdd.org/analysis/2024/02/22/iran-has-already-sent-missiles-to-russia-report-says/.

[289] Federico Borsari, "Russia's Swelling Missile Arsenal Threatens to Tip the Scales of War," CEPA, Mar. 4, 2024, https://cepa.org/article/russias-swelling-missile-arsenal-threatens-to-tip-the-scales-of-war/.

[290] Bergmann et al., *Out of Stock?*, p. 8.

[291] Schwartz, *A War of Attrition*, pp. 16–18.

[292] Williams, "Russia Isn't Going to Run Out of Missiles."

[293] Serhiy Andrushko and Ray Furlong, "Revealed: Documents Show That Russia Is Hitting Ukraine with Ukrainian Missiles," Radio Free Europe/Radio Liberty, Aug. 11, 2023, https://www.rferl.org/a/ukraine-russia-cruise-missiles-kh55/32544148.html.

more modern missile types have been found to have been manufactured quite recently, which suggests that stockpiles of missiles are very low, limited to a small number being held back for contingencies.

UAVs

Despite heavy use of UAVs in Ukraine and continued sanctions pressure by the West and its allies, the Russian defense industry and the country's military do not seem to lack UAVs to prosecute the war in Ukraine. After a slow start in 2022 immediately following the invasion of Ukraine, the Russian defense industry and the growing number of volunteer communities that support the military are now responsible for a drone delivery pipeline that enables the Russian forces to conduct intelligence, surveillance, and reconnaissance (ISR); target tracking; and different combat missions practically around the clock.

UAV production and usage during the war in Ukraine

The Russian government occasionally releases the number of drones and UAVs that it uses in Ukraine through state media outlets to highlight the size and scale of production and use. Although such figures should be closely scrutinized because they constitute a part of Russia's propaganda narrative about the war, they nonetheless help to determine the emphasis that the Russian Ministry of Defense (MOD) places on specific weapons development and fielding.

The actual number of drones in use by the Russian military is still difficult to estimate. In late 2023, the Russian MOD announced that Russian forces had received some 22,000 drones and UAVs over the course of the year.[294] The major Russian drone manufacturers announced an increase in production to meet the growing demand—for example, in May 2023, Kalashnikov announced that it intends to increase its overall production of ISR UAVs and loitering munitions by several times in 2024.[295] In February 2024, the Special Technological Center (STC) announced that it had increased the production of Orlan-10 and Orlan-30 ISR drones by several times compared to 2021 (before the invasion of Ukraine), with Orlan-10 output growing 3 to 4 times and Orlan-30 output by 25 times.[296] In March 2024, the Russian manufacturer of the Albatros-M5 ISR UAV announced that it is making 30 of these drones per month to meet the frontline demand.[297] Also in March 2024, NATO officials estimated that Russia is producing between 300 and 350 Shahed/Geran-2 long-range loitering munitions each month.[298]

The 22,000 number mentioned above likely includes a proportion of first-person view (FPV) and light quadcopter types, although the Russian MOD did not break down how many such drones were delivered by the domestic defense industrial enterprises and how many were sent by a growing number of volunteer efforts that engage in large-scale assembly and purchasing of such UAVs. In January 2024, the Russian MOD promised an increase in drone

[294] "The Russian Armed Forces Received More Than 1.5 Thousand Tanks and 22 Thousand Drones in 2023 [ВС РФ получили в 2023 году более 1,5 тыс. танков и 22 тыс. Беспилотников]," TASS, Dec. 29, 2023, https://tass.ru/armiya-i-opk/19650835.

[295] Guy Faulconbridge, "Russian Arms Maker Kalashnikov Boosts Output of Kamikaze Drones," Reuters, May 26, 2023, https://www.reuters.com/business/aerospace-defense/russian-arms-maker-kalashnikov-boosts-output-kamikaze-drones-2023-05-26/.

[296] "Russia Increases Output of Orlan Drones Several Times," TASS, Feb. 15, 2024, https://tass.com/defense/1746679.

[297] "In Russia, up to 30 Long-Range Reconnaissance 'Albatross M5' UAVs Are Produced Monthly [В России ежемесячно выпускают до 30 БПЛА-разведчиков дальнего действия 'Альбатрос М5']," TASS, Mar. 29, 2024, https://tass.ru/armiya-i-opk/20388907.

[298] Katie Bo Lillis et al., "Exclusive: Russia Producing Three Times More Artillery Shells Than US and Europe for Ukraine," CNN, Mar. 11, 2024, https://www.cnn.com/2024/03/10/politics/russia-artillery-shell-production-us-europe-ukraine/index.html.

production for the military that includes short-range FPV, ISR, and mid- and long-range reconnaissance and combat models.[299] In 2024, the Russian MOD is also pushing ahead with introducing new aerial drone and UAV designs.[300]

As of April 2024, the Russian defense sector is producing ISR and one-way loitering munitions in significant numbers to attack both Ukrainian military and civilian targets. Overall, Russian forces are relying on numerous drone types, from short-range tactical FPV and commercial quadcopters to short- and mid-range ISR variants such as Eleron-3, Eleron-7, Orlan-10, Orlan-30, Zala, Albatross, and Supercam to Lancet and Kub loitering munitions that can range up to 50 to 70 kilometers to long-range Shahed/Geran-2 variants with a reported range of up to 1,000 kilometers. The demand to manufacture large numbers of these drones is dictated by the battlefield, which is teeming with different countermeasures, and a high UAV loss ratio caused by EW, air defense activity, radio electronic reconnaissance, and even pilot error.

Drone manufacture and sanctions evasion

Shahed/Geran-2 loitering munition

The Russian military has come to rely increasingly on the long-range Geran-2 loitering munition, a variant of the Shahed 136 drone provided to Moscow by Iran in 2022. This simple UAV is used continually to strike Ukrainian stationary civilian and military targets, such as energy infrastructure and key industrial and manufacturing facilities, as well as civilian neighborhoods and buildings.[301] The military demand for such drones resulted in the construction of a large-scale drone assembly facility in Alabuga, a town east of Kazan and deep in Russia's hinterland. According to data made public by Western investigative journalists, the Alabuga enterprise intends to build from 6,000 to 10,000 Geran-2 drones in the next several years.[302] By December 2023, an estimated 3,700 Geran-2 drones had already been fired in Ukraine—these UAVs are used as a surrogate for long-range missiles, which are in short supply across the Russian military.[303]

According to Western reports, Geran drone production in Alabuga will include improvements on Iranian fabrication processes and advances in the drone's capabilities through inclusion of domestic technology and high-tech components. Russia is opting to build so many Gerans mainly because this UAV is manufactured with many readily available commercial components that Russia can easily procure with the help of allies and partners around the world. Iran likely transferred Shahed drone kits and parts to Russia that could be assembled quickly for use against Ukrainian targets in 2022 and 2023. The Russian defense enterprise responsible for assembling these drones has since gained knowledge and instructions for a full roster of parts and components needed to manufacture this UAV. Western investigations point to Russia's plan to

[299] "The Ministry of Defense Will Form a Serial Line of Drones of All Types, Shoigu Said [Минобороны сформирует серийную линейку дронов всех типов, заявил Шойгу]," RIA-Novosti, Jan. 9, 2024, https://ria.ru/20240109/shoygu-1920282063.html.

[300] ZALA (ZalaAero), "Product 55 [*Изделие* 55]," Telegram post, Dec. 29, 2023, https://t.me/ZalaAero/145.

[301] Pavel Polityuk, "Ukraine Says Russian Drone, Missile Attacks Damage Power Facilities," Reuters, Mar. 30, 2024, https://www.reuters.com/world/europe/blasts-reported-several-ukrainian-regions-amid-russian-missile-attack-2024-03-29/.

[302] Sam Skove, "Russia May Be Trying to Build 10,000 Attack Drones a Year for Use in Ukraine," Defense One, Feb. 7, 2024, https://www.defenseone.com/threats/2024/02/russia-may-be-trying-build-10000-attack-drones-year-use-ukraine/394015/.

[303] Max Hunder and Yuliia Dysa, "Russia Has Fired 7,400 Missiles, 3,700 Shahed Drones in War So Far, Kyiv Says," Reuters, Dec. 21, 2023, https://www.reuters.com/world/europe/russia-has-fired-7400-missiles-3700-shahed-drones-war-so-far-kyiv-says-2023-12-21/.

ultimately phase out imported parts for a wholly domestic manufacturing process, but for now, readily available commercial components enable the manufacture of hundreds of such drones at a relatively low cost. Recent investigations of downed Shahed drones in Ukraine revealed Western-origin parts, including American-made components such as microchips, microprocessors, circuit boards, voltage regulators, and other parts built by companies in Texas, Massachusetts, and Arizona.[304]

The US-based companies are likely not aware of how their parts ended up in Iranian UAVs because such components are in widespread commercial use and are regularly sold to overseas and international distributors. Because many components used in Shahed drones were not designed as military-only products, they can be purely civilian or dual-use products and are therefore difficult to regulate in commercial transactions. According to a public document by the United States Institute of Peace (USIP), large distributors normally sell to smaller distributors or resellers through legal processes and procedures that are part of global trade flows. According to USIP, the initial transactions may be legal sales to reputable entities, "but the fourth or fifth sale down the line could go to a smuggler with links to the Iranian military," presumably without the knowledge of the company that originated the sales.[305] Another issue identified by USIP is that many companies regularly make large numbers of microchips—up to several million—so a relatively small subset might be easy to hide and smuggle across borders. Although the United States has restricted certain export goods to Iran, Iranian importers, including defense and intelligence agencies, have become very adept over the past several decades at circumventing such limitations, including acquiring parts and components in countries where export controls may not apply.[306]

A November 2023 investigation by the US-based Institute for Science and International Security (the Institute) revealed detailed information about the types and origins of electronic components in the Shahed 136 kamikaze drone that is assembled in Russia as Geran-2. The investigation acknowledges that almost all the electronic components that enable this UAV's continued operation against Ukrainian targets are made in the West,[307] such as the Nasir electronic module that can hinder Ukrainian jamming efforts. The Institute explained that to build Nasir, Russia and Iran must import large quantities of electronic components. This investigation further revealed that each drone depends on approximately 140 electronic components, which "reveal[s] Alabuga's (and Iran's) dependence on successfully obtaining these parts from abroad, with up to 80 percent originating in the United States."[308] The Institute further confirmed that a significant number of such components are not made in Russia, Iran, or China, so Russia will require continued access to Western electronic goods for the duration of the plan to manufacture up to 10,000 drones.[309] Despite several rounds of sanctions, the Russian defense industry is clearly undeterred in its quest to procure needed components for this drone.

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[304] "Explainer: American Parts in Iranian Drones," *The Iran Primer (USIP blog)*, Mar. 1, 2023, https://iranprimer.usip.org/blog/2023/mar/01/explainer-american-parts-iranian-drones.

[305] "Explainer: American Parts in Iranian Drones."

[306] "Explainer: American Parts in Iranian Drones."

[307] David Albright and Sarah Burkhard, *Electronics in the Shahed-136 Kamikaze Drone*, Institute for Science and International Security, Nov. 14, 2023, https://isis-online.org/isis-reports/detail/electronics-in-the-shahed-136-kamikaze-drone.

[308] Albright and Burkhard, *Electronics in the Shahed-136 Kamikaze Drone*.

[309] Albright and Burkhard, *Electronics in the Shahed-136 Kamikaze Drone*.

Lancet loitering munition

Another critical Russian military drone is the Lancet loitering munition, with more than 1,000 recorded uses of this drone against Ukrainian high-value targets such as Western-provided long-range and precision artillery as of February 2024.[310] Similar to its efforts with the Shahed/Geran-2 drones, the Russian defense industrial sector employs various methods to procure microelectronics and other components to assemble this UAV. Another investigation by the Institute revealed that parts from companies based primarily in the United States, Switzerland, and the Czech Republic were identified as key to this UAV's assembly and operation.[311]

According to the Institute, the Western components allow the Lancet-3 variant to have advanced targeting capabilities and to defeat Ukraine's defense systems more effectively. ZALA-Aero—the Lancet and Kub manufacturer—claims to be the producer of the airframe and the camera, but the Institute points out that the Western products that make up the drone include analytical modules, the engine, communication components, telemetry, and guidance. Moreover, throughout the war, the Russian defense sector and state media have made repeated claims about an artificial intelligence (AI) capability that enables the Lancet to better navigate and fly toward targets. According to the Institute's findings, Lancet-3's analytical and image processing capabilities are powered by a Jetson module, which is produced by US-based NVIDIA and uses NVIDIA software. This module supposedly enables the drone to autonomously seek and track specific objects alone or in groups, a claim that is disputed because of lack of evidence. In addition, the drone system is equipped with a Swiss-manufactured U-Blox guidance and navigation module that contains advanced antijamming and antispoofing capabilities that enable the drone to counter Ukrainian EW countermeasures.[312]

The Kalashnikov Concern—ZALA's parent company—has converted a shopping center in the Russian city of Izhevsk into a drone manufacturing plant to assemble the Lancet and Italmas drone variants.[313] The Russian defense industry may look to use available facilities such as empty shopping malls in the wake of the April 3, 2024, Ukrainian UAV attack on the Alabuga drone manufacturing facility—it may want to disperse its production rather than concentrate it in a single location that is vulnerable to a massive Ukrainian long-range drone strike.[314]

Orlan-10 ISR drone

One of the most important Russian UAVs being used in Ukraine is the Orlan-10 drone, which conducts ISR missions and helps guide Russian forces, systems, and even other drones to Ukrainian targets. In December 2022, UK-based RUSI published an in-depth investigation on the extent to which the Orlan-10 depended on imported components for manufacture and assembly. The investigation revealed that Western imports were procured by SMT-iLogic, a St. Petersburg–based company, on behalf of STC, the Orlan-10 manufacturer. These

[310] "The Use of Loitering Ammunition 'Lancet' in the Zone of the Special Military Operation [Применение барражирующих боеприпасов "Ланцет" в зоне СВО]," Lostarmour, https://lostarmour.info/tags/lancet.

[311] Spencer Faragasso, *Russian Lancet-3 Kamikaze Drone Filled with Foreign Parts: Western Parts Enable Russian Lancet-3 Drone to Have Advanced Targeting and Anti-Jamming Capabilities*, Institute for Science and International Security, Dec. 18, 2023, https://isis-online.org/isis-reports/detail/russian-lancet-3-kamikaze-drone-filled-with-foreign-parts.

[312] Faragasso, *Russian Lancet-3 Kamikaze Drone Filled with Foreign Parts*.

[313] Ovsyaniy, "Satellite Images Suggest Russia Is Ramping Up Production Capacity."

[314] Laura Gozzi, "Ukraine War: Deepest Ukraine Drone Attack into Russian Territory Injures 12," *BBC*, Apr. 3, 2024, https://www.bbc.com/news/world-europe-68712158.

components were shipped to Russia by many distributors in the United States, Europe, China, South Korea, and Hong Kong.[315]

RUSI determined that many such efforts to export components to Russia are operated by Russian nationals or expatriates based abroad. Some of these initiatives are spearheaded by dual nationals willing to ship export-controlled components in violation of US or European export controls. According to RUSI, some of SMT-iLogic's largest suppliers were companies based in Hong Kong with a history of evading sanctions and providing military equipment to the Chinese government. RUSI concluded that "the production quantities required to increase Orlan-10 numbers while also replacing combat losses imply a continued requirement for large volumes of components to be brought in through the networks identified in the report."[316] Considering that the output of Orlan-10 drones has grown severalfold since the start of the Russian invasion, many schemes and formulas identified by RUSI in 2022 likely continue to function to feed STC a constant supply of components and materials.

Commercial quadcopters and FPV drones

Besides the drones mentioned above, the Russian military continues to rely on commercial UAVs such as the Chinese-made DJI and Autel quadcopters that are popular among all belligerents for conducting ISR and precision-drop missions. Many Russian volunteer organizations have sprung up across the country to purchase such drones in bulk to deliver to the front. Despite DJI's official stance that it is not supplying drones for the war in Ukraine, numerous Russian volunteers advertise their DJI acquisitions on social media platforms such as Telegram. Such acquisition will likely continue well into 2024 and possibly beyond given that no Russian defense company has so far produced a suitable DJI drone replacement.[317]

However, the most common type of drone that has become increasingly valuable across the Russian military is an FPV drone assembled almost entirely from Chinese-made commercial components. Such drones typically cost about $400 to $500 to assemble, have flight ranges up to 12 kilometers (up to 20 kilometers with a signal repeater), and can carry weapons and munitions weighing up to 5 kilograms while traveling at nearly 100 miles per hour to reach their target. Such drones have become increasingly dangerous to all vehicles, systems, and soldiers in the field, including even well-protected tanks, given the drone operator's ability to maneuver this UAV to a specific spot or location.

Unlike most military drones mentioned previously, practically all FPV drones are assembled by the country's sprawling volunteer effort that includes individuals, organizations, startups, and enterprises that fundraise for support among regular Russian citizens as well as wealthy individuals and regional governments.[318] The sheer quantity of Russian FPV drones is difficult to estimate—in late 2023, Ukrainian volunteers and the military estimated that the number of Russian volunteer-built FPV drones and light

[315] James Byrne et al., *The Orlan Complex: Tracking the Supply Chains of Russia's Most Successful UAV*, RUSI, Dec. 2022, https://static.rusi.org/SR-Orlan-complex-web-final.pdf.

[316] Byrne et al., *The Orlan Complex*.

[317] For examples of Russian volunteers such as KatyaValya, DroneZ and Sudoplatov purchasing DJI Mavic and Matrice products, see the following Telegram posts: https://t.me/katya_valya_dnr/4537, https://t.me/katya_valya_dnr/4495, https://t.me/sudoplatov_official/1501, https://t.me/sudoplatov_official/1456, https://t.me/c/1718212276/1490, and https://t.me/c/1718212276/1484.

[318] Jeffrey Edmonds and Samuel Bendett, *Russia's Use of Uncrewed Systems in Ukraine*, CNA, Mar. 31, 2023, DRM-2022-U-034223-Final, https://www.cna.org/reports/2023/05/russias-use-of-drones-in-ukraine.

quadcopters may total about 300,000 per month.[319] Although this number may seem high (especially in light of the official Russian MOD data stating that the Russian military received roughly 22,000 drones of all types via official Russian MOD channels for the entirety of 2023), some Russian volunteers announced that their combined nationwide assembly efforts can build up to 100,000 FPVs per month. If other Russian volunteer assembly efforts are included, it is entirely possible that up to 300,000 FPVs could be available for the front.[320] Such numbers, even if exaggerated, imply a continuous flow of Chinese components to numerous Russian assembly efforts.[321] Some of the go-to Chinese drone solutions come from Tarot, T-Motor, and Flash Hobby companies, with others likely as sources for practically everything needed to assemble an FPV drone.[322] Many components and solutions are readily available on online platforms such as AliExpress.[323] Moreover, by the Russian government's own admission, the domestic drone industry is 95 to 98 percent dependent on imported parts such as electronics, engines, steering gears, and batteries.[324]

Other imported parts in Russian drones

According to investigations by Western institutions, including the aforementioned Institute, other Western products have been found in drone systems operated by the Russian military. For example, Swiss-made U-Blox global positioning systems have been found in Orlan-10 and Shahed 136 drones. American-made NVIDIA AI modules have been sought by the manufacturer of the Albatros-M5 reconnaissance drone. The Institute concludes that the "recurring appearance of these Western products in Russian drone systems shows a keen dependence on them for key capabilities in the drone systems."[325] Repeated use of these parts also confirms Russia's continued efforts to use different schema to procure and acquire such components, Western sanctions notwithstanding.

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[319] Lyuba Balashova and Taisya Melnyk, "Hands for Wings. Ukrainian Companies Produce About 50,000 FPV Drones Every Month, Hundreds of Thousands Are Needed. How the Shortage of Personnel Slows Down the Industry [Руки для крил. Українські компанії виготовляють близько 50 000 FPV-дронів щомісяця, потрібно – сотні тисяч. Як кадровий голод гальмує галузь]," *Forbes Ukraine*, Nov. 29, 2023, https://forbes.ua/innovations/ukrainski-inzheneri-pratsyuyut-u-boeing-ta-airbus-virobniki-droniv-strazhdayut-cherez-defitsit-kadriv-yak-rozvyazati-tsyu-problemu-20112023-17379.

[320] UAV Developer (UAVDEV), Telegram post, Feb. 1, 2024, https://t.me/UAVDEV/5406.

[321] For example, this Russian-language page on China's AliExpress website features all components needed to assemble an FPV drone: https://shorturl.at/gnxUm. Russia's iDrone.ru website likewise features many Chinese components to assemble light quadcopters and commercial drones: https://idrone.ru/shop/fpv/komponenty-dlya-sborki-koptera/.

[322] Dada Lindell and Andrei Zaiakin, "Homemade Products from Skolkovo: Who and How in Russia Produces FPV Drones to Kill Ukrainians [Самоделкины из Сколково: кто и как в России производит FPV-дроны, чтобы убивать украинцев]," TheInsider.ru, Apr. 3, 2024, https://theins.ru/obshestvo/270242.

[323] A Russian-language page on China's AliExpress website features all components needed to assemble an FPV drone: https://tinyurl.com/e732vefu.

[324] Olga Ageeva, "The Government Will Allocate Part of the Budget of the Project 'Ecology' to Drones [Правительство направит часть бюджета нацпроекта «Экология» на беспилотники]," *Forbes*, Sept. 27, 2023, https://www.forbes.ru/finansy/497389-pravitelstvo-napravit-cast-budzeta-nacroekta-ekologia-na-bespilotniki; "Kremlin Establishing Supply Channels for Chinese Drones Bypassing Beijing Authorities," Robert Lansing Institute, Dec. 5, 2023, https://lansinginstitute.org/2023/12/05/kremlin-establishing-supply-channels-for-chinese-drones-bypassing-beijing-authorities/.

[325] Faragasso, *Russian Lancet-3 Kamikaze Drone Filled with Foreign Parts*.

IMPLICATIONS

We conclude this report with some overall implications that summarize the extent to which the Russian defense industry has been able to cope with the advent of strict export controls and highlight some of the weak points of Russian defense production that lead to recommended actions that may help reduce the Russian defense industry's ability to sustain Russia's war effort in Ukraine.

In the aftermath of Russia's invasion of Ukraine in early 2022, the Russian defense industrial complex initially faced serious disruptions because of the imposition of strict Western sanctions and export controls in addition to underlying structural problems such as a labor shortages, outdated equipment, and inadequate financing. However, the government's decision to transition to a full war footing in the second half of 2022 mitigated some of the problems caused by structural issues and led Russia to focus on ways to circumvent or blunt the effects of sanctions and export controls. On the structural side, the Russian government vastly increased funding for the defense industry and other military expenses, doubling the share of GDP devoted to military expenses in the overall budget. It increased salaries to try to reduce the defense industry's labor shortage, even as it shifted the industry to round-the-clock production. It also made plans to build new factories for military production, resulting in a rapid expansion of production capacity in both high-tech fields such as UAVs and air defense missiles and low-tech areas such as artillery shells.

As shown in this report, over time, the Russian government has found ways to circumvent export controls, primarily through a combination of direct import of weapons and critical components from friendly countries and parallel import of Western-produced components through a range of countries that are either supporting Russia or looking to maintain neutrality in its conflict with the West. Cooperation with foreign partners was critical in shifting the balance on the ground to Russia's advantage in 2023. North Korean ammunition supplies were key to alleviating Russia's shell hunger, allowing Russia to regain advantage in artillery fires during the fall of 2023. Licensed production of Iranian Shahed drones, combined with rapid adoption and adaptation of commercial drones, has largely negated the earlier Ukrainian advantage in the UAV sphere as well. Meanwhile, Russia has rapidly ramped up domestic production of various weapons systems and ammunition. As a result of these compensating actions, Russia's defense industrial complex is well positioned to provide its military with sufficient armaments to sustain the war effort over the next one to two years.

That said, much of the equipment that is being brought into service is refurbished existing stocks, especially tanks and armored vehicles. Except for drones, there is little evidence to date of expansion of new production other than in low-tech areas such as ammunition. Moreover, production of advance missile systems has struggled to keep pace with the missile expenditures, leading to recurring shortages. Meanwhile, in the longer term, the technological gap between Russia and the West will likely widen. Although Russia has found ways to import the components that it needs to produce its existing military platforms and weapons, it has had more difficulty importing the most advanced microelectronics and other components necessary for future generations of military hardware. When combined with Russia's failure to develop a domestic capability to produce advanced microchips and machine tools, this import gap may lead to a gradual stagnation in Russia's ability to build advanced weaponry.

Because of the direct and indirect long-term effects of sanctions and export controls, Russia will find it more difficult to build advanced weapons that depend on advanced microchips and high-end machine tools. It will be able to maintain production of its existing designs, but as Western machine tools wear out and adequate amounts of replacement tools fail to arrive, production of advanced weapons will likely slow as well.

The key vulnerabilities remain in microelectronics and high-end machine tools. Although Russia has for the moment been able to maintain its supply of both these types of components, its defense industry would be highly vulnerable if supply were cut off. Current Western export control policies apply only to the most precise machine tools and to higher end electronic components. Although these policies may ensure that the technological gap between Russia and the West grows in the long run, they allow Russia to import the types of components that its military industry uses currently, which in turn allows Russia to build weapons for its ongoing military campaign in Ukraine. Given the Russian defense industry's vulnerability in these sectors and the difficulty in a priori distinguishing between potentially legitimate and illegitimate uses of imported machine tools and microprocessors, a blanket ban on the export of machine tools and microprocessors would potentially play a major role in damaging Russian military production. One benefit of instituting a blanket ban on the export of all types of machine tools and microprocessors to Russia is that it would have a greater effect on the Russian defense industry's ability to supply its military with weapons in the immediate term.

A second benefit of a blanket ban would be to simplify the enforcement of export controls. Currently, ambiguity regarding the specific types of components being exported to Russia allows importers to evade export controls. Expanding the extent of the ban on exports would close this loophole. In addition, better coordination among all countries involved in the export control regime to synchronize their restrictions would further eliminate potential loopholes. Finally, increasing the capacity of relevant national enforcement bodies by increasing funding and personnel dedicated to sanctions enforcement would heighten the risk to companies looking to violate the export control regime and would thereby lead to increased compliance.[326]

Although a blanket ban would address some of the problems associated with ongoing permitted transfers of advanced Western technologies to Russia, Western countries should consider additional measures to combat Russia's parallel import programs. For one, the West should explore using secondary sanctions against countries that permit transshipment hubs to operate unabated within their territories. Current Western efforts to target individual persons or entities participating in illicit transshipments to Russia have been largely ineffective because of the ability of these companies to rapidly change names, adopt new forms, and otherwise evade enforcement actions. By targeting the host countries themselves, Western states can raise the costs associated with allowing this kind of activity while encouraging local enforcement action.

Likewise, another measure Western states can pursue is to target their enforcement actions at the most critical supply chains to magnify the effects of their limited enforcement resources. Russia's warfighting ability in Ukraine is more dependent on certain kinds of weapon systems than others. For example, Russia is highly dependent on EW systems to counter Ukrainian UAVs, jam communications, and disrupt kill chains for precision strike weapons—yet production

[326] Some of the recommendations in this section are inspired by the extensive set of recommendations provided by a group of experts from the Economic Security Council of Ukraine. See Yurchenko et al., *CNC Machinery 2.0*, pp. 45–52.

of the most advanced Russian EW systems requires high-end microchips and specialized materials largely supplied by the West. The same is likely to be true for the production of certain advanced Russian air defense systems, fourth-generation combat aircraft, and advanced missile systems. Moreover, the most advanced Western technologies are less readily available on global markets and thus harder for Russia to obtain through parallel import channels. In some cases, denying Russia access to just a few critical components could potentially disrupt production of a key weapon system.

Finally, Western policy-makers should consider ways to better coordinate sanctions activities with military assistance programs. For example, increasing the attrition rates for key Russian weapons systems would exacerbate the Russian defense production challenges. An obvious example would be to further strengthen Ukraine's air defenses to allow it to intercept a higher percentage of Russian cruise missiles and drones. This effort in turn would put even more pressure on Russian missile manufacturers who are already struggling to keep up production because of the effects of Western sanctions.

APPENDIX A: PARALLEL IMPORT COUNTRY STUDIES

People's Republic of China and Hong Kong

Investigations by Western media and nongovernmental organizations (NGOs) have identified some specific examples of the global supply chains that enable Russia to attain Western components for key military technologies. A study by the Royal United Services Institute (RUSI), Reuters, and iStories documents the important role that Hong Kong companies have played in sourcing key components for Russia's Orlan-10 uncrewed aerial vehicle (UAV), which the Russian military uses to target Ukrainian forces and vehicles and to destroy Ukrainian air defenses. Because of the Orlan-10's relatively low cost, flexibility, and effectiveness, the Ukrainian military considers countering it a top priority.[327] The study found that Asia-Pacific Links—which is owned by Anton Trofimov, a Russian national, and headquartered in Hong Kong—is the largest supplier of microelectronics to Russian defense companies, supplying 25 percent of its microelectronics in 2022.[328] Both Trofimov and his company are under US sanctions. The study also identified two Hong Kong–based companies, Xinghua Co. Ltd. and Sinno Co. Ltd., as key participants in the Russian military's supply chain. Xinghua is directed by Yuan Jilun, a People's Republic of China (PRC) national who also owns Luchengtech Co. Ltd., which supplies information technology (IT) equipment to China's defense sector.[329]

Another example involves semiconductors produced by Texas Instruments (TI). Although export controls have largely eliminated the direct supply of electronics produced by TI, they did not eliminate Russian imports entirely. In fact, as shown in Figure 13, although volumes of imports initially dropped to very low levels after the introduction of export controls, they had recovered to approximately two-thirds of prewar levels by the summer of 2022. The recovery was possible in part because most TI components are produced in China and Southeast Asia and shipped to Russia through China, Hong Kong, Turkey, or the UAE. A significant amount of the inventory was shipped by Hong Kong–based Tardan Industries, a shell company that has already been sanctioned by both the United States and the European Union (EU) but was nevertheless responsible for $16.5 million in sales to Russia in the first 10 months of 2023. At the same time, the prices of TI components imported into Russia had increased by 2.6 times, resulting in higher aggregate costs despite the decline in volume. In 2023, at least 16 percent of TI products shipped to Russia were purchased by companies with established ties to Russia's military industry.[330]

[327] Byrne et al., *The Orlan Complex*, pp. 7–8.

[328] Byrne et al., *The Orlan Complex*, p. 20.

[329] Byrne, et al., *The Orlan Complex*, p. 19. Sinno is implicated in the sale of semiconductors and microelectronics to a wide range of companies in the Russian defense sector. James Byrne et al., *Silicon Lifeline: Western Electronics at the Heart of Russia's War Machine*, RUSI, Aug. 2022, pp. 53–54, https://static.rusi.org/RUSI-Silicon-Lifeline-final-updated-web_1.pdf.

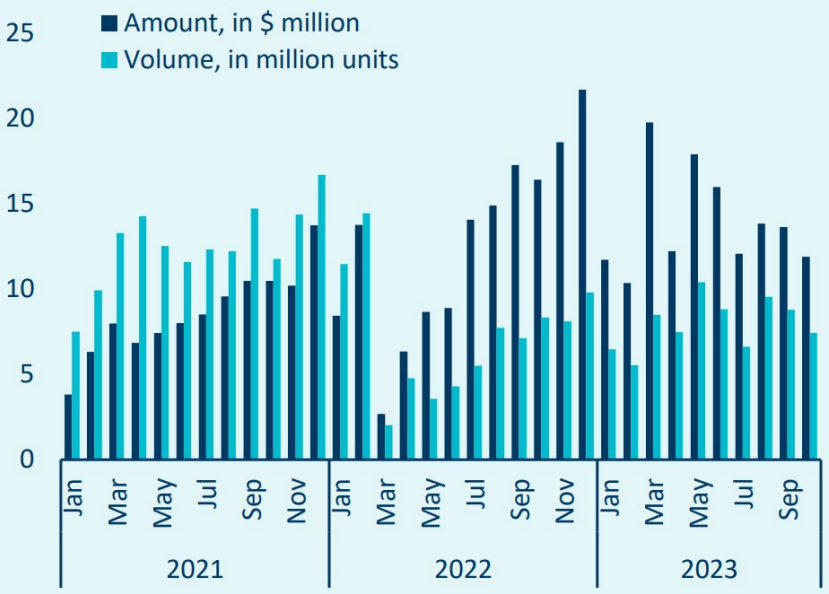
[330] Bilousova et al., *Challenges of Export Controls Enforcement*, pp. 19–20.

Central Asian states

Kazakhstan

Kazakhstani president Tokayev has pushed back publicly against Russian positions on Ukraine, provided aid to Ukraine, and welcomed draft dodgers from Russia.[331] There is much discussion in academic circles about a trend toward decolonization in Kazakhstan,[332] but the country nonetheless serves as the main transshipment point in Central Asia for parallel import in support of the Russian war effort for two reasons: (1) the lengthy border between Kazakhstan and Russia lacks customs checks because Kazakhstan is a part of the Eurasian Economic Union, and (2) Kazakhstan's location between China and Russia facilitates transshipment of goods from China to Russia.

Figure 13. Russian imports of TI products



Source: Bilousova et al., *Challenges of Export Controls Enforcement*, p. 19.

According to a study by experts at the Kazakhstan School of Applied Politics, Kazakhstan's exports boomed in 2022, rising to $80 billion, a major increase over the previous seven years, when exports typically did not exceed $60 billion per year. Kazakhstan's imports also surged in 2022 to $50 billion, a $10 billion increase over 2021 despite no change in domestic consumption patterns. These experts also note that a major discrepancy exists between Kazakhstani figures for imports of goods from China and Chinese data, which show much greater exports to Kazakhstan in 2022, indicating that a significant portion of imports from China went unreported.[333] Similarly, a large "ghost trade" exists between the EU and Kazakhstan—according to an analysis by the *Financial Times*, $2.9 billion in goods exported from the EU to Kazakhstan went missing. This analysis shows that the surge in Kazakhstan's imports in 2022, when reexported to Russia, compensates for 40 percent of the decline in Russia's imports because of EU sanctions.[334] An analysis by Radio Free Europe/Radio Liberty (RFE/RL) shows huge increases in Kazakhstani imports of computer technology in 2022 compared to 2021 and a corresponding surge in exports of these products to Russia in 2022.[335]

[331] Kamila Auyezova, "Russia's Ukraine Invasion Is Eroding Kremlin Influence in Kazakhstan," *UkraineAlert (Atlantic Council blog)*, Mar. 28, 2023, https://www.atlanticcouncil.org/blogs/ukrainealert/russias-ukraine-invasion-is-eroding-kremlin-influence-in-kazakhstan/.

[332] Marie Dumoulin, *Steppe Change: How Russia's War on Ukraine Is Reshaping Kazakhstan*, European Council on Foreign Relations, Apr. 13, 2023, p. 9, https://ecfr.eu/publication/steppe-change-how-russias-war-on-ukraine-is-reshaping-kazakhstan/.

[333] Rahimbek Abdrahmanov and Kamshat Zhumagulova, "How Kazakhstan Helps Russia Bypass Western Sanctions," *Diplomat*, Oct. 25, 2023, https://thediplomat.com/2023/10/how-kazakhstan-helps-russia-bypass-western-sanctions/.

[334] Chris Cook, Federica Cocco, and Max Seddon, "EU Goods at Least Worth $1bn Vanish in Russia's 'Ghost Trade,'" *Financial Times*, May 10, 2023, https://www.ft.com/content/76c91b2-3494-4022-83d0-9d6647b38e3d.

[335] Schreck et al., "Kyrgyz, Kazakh Companies Send Tech."

Some trade may not involve dual-use goods but may involve items such as washing machines and automobiles that are then cannibalized for their semiconductors and reused in Russian military technology.[336] Statistics show that Kazakhstan is playing a key role in the reexport of consumer electronics to Russia. In the first eight months of 2022, Kazakhstan exported $150 million in cell phones to Russia, 8 times the amount sold in 2021, when Kazakhstani cell phone exports primarily went to Kyrgyzstan. Similarly, Kazakhstan sold $30 million in washing machines to Russia, although in 2021 it had purchased $13 million in washing machines from Russia. Sales of monitors to Russia increased by 300 times in 2022 compared to 2021.[337]

For those Kazakhstani traders living near the border with Russia who support its war, the sanctions have been a boon to their cross-border business.[338] Kazakhstani Deputy Foreign Minister Roman Vasilenko contends that some of the increased trade between Kazakhstan and Russia can be attributed to disruption of supply chains and the necessary rerouting of trade because of the war in Ukraine.[339] However, during his visit to Kazakhstan in April 2023, Assistant Secretary of the Treasury for Export Enforcement Matthew Axelrod emphasized that the US was concerned about clear violations of export controls, not iPhones and washing machines, adding that "we are talking about specific items of computer technology used to power and navigate missiles and drones used by the Russian military machine to kill civilians and soldiers on Ukrainian soil."[340] Since the full-scale invasion, Kazakhstan also has increased the sale of certain resources that could be used for Russian military production such as bauxite for aluminum (exports increased 2.5 times), untreated zinc (exports increased 2.1 times), and uranium (exports increased 2 times).

The Kazakhstani government has become concerned about the prospect of Western countersanctions and has sought to demonstrate that it does not facilitate Russian efforts to evade sanctions. Beginning on April 1, 2023, Kazakhstan instituted an online system to track goods crossing into Russia in real time.[341] After Elizabeth Rosenberg, deputy assistant secretary for terrorist financing and crimes at the US Department of the Treasury, warned Kazakhstan that its companies and banks could face sanctions if found to be assisting the Russian war effort, on April 25, 2023, the Kazakhstani Stock Exchange immediately instructed Halyk Finance, Kazakhstan's top investment bank, to refrain from assisting Russians and Belarusians in trading non-tenge–denominated securities.[342]

According to Reuters, Russian companies have been flooding Kazakhstan with requests to provide a wide range of sanctioned goods, including ball bearings,

[336] David A. Merkel, "Kazakhstan's Backdoor Trade with Russia Must Be Stopped," *Nikkei Asia*, June 15, 2023, https://asia.nikkei.com/Opinion/Kazakhstan-s-backdoor-trade-with-Russia-must-be-stopped#.

[337] Darya Timofeeva, "Re-Export Through Central Asia: How Russia Bypasses Western Sanctions [Реэкспорт через Центральную Азию: как Россия обходит западные санкции]," Nastoiashchee Vremia, Apr. 1, 2023, https://www.currenttime.tv/a/sanctions-russia-central-asia/32343807.html.

[338] Anatolij Weisskopf, "Kazakhstan Small Businesses Profit from Russia Sanctions," DW, May 18, 2023, https://www.dw.com/en/kazakhstan-small-businesses-profit-from-russia-sanctions/a-65663621.

[339] Aygerim Sarymbetova, "Kazakhstan Denies Shipping Chips to Russia for Military Purposes," Caspian News, Mar. 12, 2023, https://caspiannews.com/news-detail/kazakhstan-denies-shipping-chips-to-russia-for-military-purposes-2023-3-12-0/.

[340] Weisskopf, "Kazakhstan Small Businesses Profit."

[341] "Kazakhstan to Launch Customs Monitoring to Avoid Circumventing Russia Sanctions," Commonspace.eu, Mar. 24, 2023, https://www.commonspace.eu/news/kazakhstan-launch-customs-monitoring-avoid-circumventing-russia-sanctions.

[342] "Kazakhstan Spooked by U.S. Warning of Secondary Sanctions," Eurasianet, Apr. 26, 2023, https://eurasianet.org/kazakhstan-spooked-by-us-warning-of-secondary-sanctions.

aircraft parts, and rare earths.[343] In October 2023, the Kazakhstani vice minister for trade and integration announced that the country would prohibit the export of 106 types of goods to Russia "connected with the international situation."[344] As of this writing, no Kazakhstani company has been sanctioned.

Major Kazakhstani companies, especially those that do business overseas, are more likely to observe Western sanctions than small companies. An analysis by the Organized Crime and Corruption Reporting Project (OCCRP) shows how Russian companies have circumvented sanctions on dual-use equipment by setting up subsidiaries in Kazakhstan. In one example, Nebesnaya Mekhanika (also known as SKYMEC), a Russian company, managed to purchase Chinese DJI drones by registering an affiliate in Kazakhstan, Aspan Arba. Facing criticism on the use of its products on the battlefield in Ukraine, DJI claimed that it was not selling drones to Russia (or Ukraine). SKYMEC sold $7.5 million in DJI drones in 2022 and 2023, and one of its clients was DJI Ars Moscow (run by a former SKYMEC employee).[345] DJI Ars sells its wares on Ozon, a major Russian e-commerce platform that registered in Kazakhstan after the US NASDAQ stock exchange delisted it.[346] Russian soldiers use the Ozon platform to purchase equipment for the war in Ukraine.

SKYMEC imported some 500 drones from Aspan Arba, which has no restrictions on importing DJI drones from China. Conveniently, SKYMEC and Aspan Arba are both owned by the same Russian man, Ilya Goldberg. The director of Aspan Arba, Mikhail Sopozhnikov, is a former SKYMEC employee. Aspan Arba is the official dealer of DJI drones in Kazakhstan and has licenses to import 18,000 of the devices from DJI Europe for $45 million. According to the OCCRP, before 2022 so few drones were imported to Kazakhstan that they were not even listed on its customs data. By 2022, Kazakhstan was importing $5 million in drones and listing $1.23 million as exports to Russia.[347]

Kyrgyzstan

Like Kazakhstan, Kyrgyzstan is a member of the Eurasian Economic Union, whose lack of customs controls makes it easier for sanctioned goods to flow into Russia. In 2022, Kyrgyzstan's exports to Russia surged by 250 percent over 2021 and included many goods that had never been exported previously.[348] Radio Azzatyk, RFE/RL's Kyrgyz service, found that Kyrgyzstan suddenly became an importer of $3.5 million in aircraft parts, helicopters, and drones in 2022, mostly from the US, although it had imported none of this equipment previously. UN trade data

[343] Olzhas Auyezov and Mariya Gordeyeva, "Russians Flood Kazakhstan with Sanction Busting Requests - Sources," Reuters, Mar. 17, 2023, https://www.reuters.com/business/russians-flood-kazakhstan-with-sanction-busting-requests-sources-2023-03-17/.

[344] "Kazakhstan Stopped Supplying Hundreds of Goods to Russia [Казахстан перестал поставлять в Россию сотню товаров]," Zakon.kz, Oct. 19, 2023, https://www.zakon.kz/sobytiia/6410894-kazakhstan-perestal-postavlyat-v-rossiyu-sotnyu-tovarov.html.

[345] Maria Zholobova et al., "Kazakhstan Has Become a Pathway for the Supply of Russia's War Machine. Here's How It Works," OCCRP, May 19, 2023, https://www.occrp.org/en/investigations/kazakhstan-has-become-a-pathway-for-the-supply-of-russias-war-machine-heres-how-it-works.

[346] "Russian E-Commerce Firm Ozon's ADS Delisted from Nasdaq," Reuters, Nov. 9, 2023, https://www.reuters.com/technology/russian-e-commerce-firm-ozons-ads-delisted-nasdaq-2023-11-09/.

[347] Zholobova et al., "Kazakhstan Has Become a Pathway." This investigation also found that Kazakhstan's imports of microchips doubled to $75 million in 2022 over the previous year after only moderate growth in earlier years.

[348] Joby Warrick, "In Central Asia, a Hidden Pipeline Supplies Russia with Banned Tech," *Washington Post*, July 18, 2023, https://www.washingtonpost.com/national-security/2023/07/18/russia-sanctions-weapons-china-drones/.

identified that Kyrgyzstan reported exporting $1.5 million of these products to Russia, raising the question of the destination of the other $2 million.[349]

Although many of these deliveries took advantage of the porous border between Kyrgyzstan and Kazakhstan, unusually, Kazakhstani customs officials stopped a truckload of Chinese DJI Agras T-30 quadcopter all-weather drones destined for Russia in mid-2023. Reexports from China to other destinations in the Eurasian Economic Union have long been important for Kyrgyzstan's trade, but this seizure highlighted the challenge of stemming the tide of dual-use items into Russia.[350] Subsequently, the US imposed sanctions on four Kyrgyzstani companies and several individuals.[351] Kyrgyzstani president Japarov has denied that his country enables Russia to circumvent sanctions.[352]

Small companies in Bishkek with connections in Russia often are involved in such transactions, and Kyrgyzstani officials claim that they may be unwittingly involved in parallel trade with Russia.[353] Radio Azzatyk established that RM Design and Development, a Bishkek-based company, was supplying amplifiers for secure battlefield communications to Mikropribor, a company in Izhevsk and a center for weapons production in Russia. The director of Mikropribor worked for another company, Izhevsk Radio Plant, that supplies the Russian army and is under US sanctions. RM Design has been connected to at least two other Russian suppliers for the Russian army.[354]

The ability of Kyrgyzstani companies to circumvent sanctions on Russia depends largely on Kazakhstan's position—compliance by Kazakhstan forces a rerouting of sanctioned goods along a circuitous path via Uzbekistan, Turkmenistan, and the Caspian Sea to Russia. Although Kyrgyzstan is much poorer than Kazakhstan, according to a Canadian expert, Kyrgyzstan's upstream position gives it leverage over Kazakhstani water supplies that could be used in the interest of maximizing smuggling profits from Russia trade.[355]

Uzbekistan

In the first eight months of 2022, Uzbekistan's trade with Russia increased by 45 percent. Uzbekistan's imports from certain countries saw dramatic increases (Brazil 59 percent, Germany 54 percent, India 42 percent), likely an indication of reexports to Russia.[356] Uzbekistan's exports of certain products to Russia skyrocketed in 2022 compared to 2021: nuclear reactors, boilers, and machinery (264 percent increase); copper (171 percent increase); electrical

[349] Kubatbek Aibashov et al., *Investigation: How Companies in Kyrgyzstan and Kazakhstan Are Supplying Western Equipment to Russian Firms Linked to the War in Ukraine*, Radio Azzatyk, June 22, 2023, https://efile.fara.gov/docs/7246-Informational-Materials-20231017-20.pdf; Schreck et al., "Kyrgyz, Kazakh Companies Send Tech."

[350] Warrick, "In Central Asia, a Hidden Pipeline Supplies Russia"; "US Primes Sanctions in Fight Against Hidden Kyrgyzstan Pipeline of Banned Goods for Russia," BNE IntelliNews, July 19, 2023, https://www.intellinews.com/us-primes-sanctions-in-fight-against-hidden-kyrgyzstan-pipeline-of-banned-goods-for-russia-285077/.

[351] "U.S. Treasury Imposes Sanctions on Kyrgyzstan- and Tajikistan-Based Entities," AKIpress, Dec. 13, 2023, https://akipress.com/news:748712:U_S__Treasury_imposes_sanctions_on_Kyrgyzstan-_and_Tajikistan-based_entities/.

[352] Justin Burke, "Kyrgyzstan President Pushes Back on US Accusations of Sanctions-Busting Behavior," Eurasianet, Aug. 16, 2023, https://eurasianet.org/kyrgyzstan-president-pushes-back-on-us-accusations-of-sanctions-busting-behavior.

[353] "Kyrgyzstan Denies Helping Russia Bypass Sanctions," *The Defense Post*, July 21, 2023, https://www.thedefensepost.com/2023/07/21/kyrgyzstan-russia-bypass-sanctions/.

[354] Aibashov et al., *Investigation: How Companies in Kyrgyzstan and Kazakhstan Are Supplying Western Equipment*.

[355] Robert M. Cutler, "Kazakhstan Resisting Kyrgyz Pressure to Break Russian Sanctions," *Asia Times*, July 31, 2023, https://asiatimes.com/2023/07/kazakhstan-resisting-kyrgyz-pressure-to-break-russian-sanctions/.

[356] Timofeeva, "Re-Export Through Central Asia: How Russia Bypasses Western Sanctions."

machinery (151 percent increase); and ceramic products (for possible use in body armor, a 2,121 percent increase).[357]

Sanctions have been placed on several companies and individuals in Uzbekistan, including Uzbekistani holdings such as Akhangarancement Joint Stock Company associated with Alisher Usmanov, an Uzbek-born Russian billionaire, as well as several other Uzbekistani citizens involved in his networks based in Cyprus and the United Arab Emirates (UAE).[358] The US Department of Commerce also accused Alfa Beta Creative and GFK Logistic Asia, both based in Tashkent, of evading sanctions and acquiring US products for use in the Russian war effort.[359] Alfa Beta Creative was established in June 2022, just four months after the start of Russia's full-scale invasion.[360] In November 2023, the US added Mvizion, a Tashkent-based company, to the US Department of Commerce Entity List for providing telecommunications equipment to the Russian army.[361]

Tajikistan

With Russia's war on Ukraine, Tajikistan is in a highly vulnerable position because of its high dependence on remittances from the 1 million migrant workers in Russia (30 percent of its GDP) and on Russian forces in Tajikistan to maintain stability.[362] For these reasons, it has been particularly difficult for President Emomali Rahmon to resist Russian pressure to support Putin's war in Ukraine.[363] Ukrainian sources report that Russia hopes to purchase Soviet-era military equipment from Tajikistan (such as 220 mm Uragan rockets and 203 mm shells for the Pion self-propelled artillery system) and entice retired Tajikistani military personnel to fight for Russia in Ukraine.[364]

The US Department of the Treasury imposed sanctions on the Tajikistan-based Chamaiyati Doroi Masauliyati Makhdudi Kafolati Komil (Kafolati Komil) for sending foreign-made aviation parts to Russia via the UAE,[365] which helps to explain why Tajikistan's export of aircraft parts to Russia increased by 4,185

[357] Viktoriia Akhapova, "Parallel Import 'Technologies': How the EU Sells Prohibited Goods to Russia," Vox Ukraine, Sept. 15, 2023, https://voxukraine.org/en/parallel-import-technologies-how-the-eu-sells-prohibited-goods-to-russia.

[358] "Further Curbing Russia's Efforts to Evade Sanctions and Perpetuate Its War Against Ukraine," US Department of State, Apr. 12, 2023, https://www.state.gov/further-curbing-russias-efforts-to-evade-sanctions-and-perpetuate-its-war-against-ukraine-2/; "Treasury Targets Russian Financial Facilitators and Sanctions Evaders Around the World," US Department of the Treasury, Apr. 12, 2023, https://home.treasury.gov/news/press-releases/jy1402.

[359] Department of Commerce, Bureau of Industry and Security, "Additions to the Entity List," Apr. 12, 2023, https://public-inspection.federalregister.gov/2023-07840.pdf.

[360] "US Imposes New Sanctions on Usmanov Affiliated Entities and Citizens of Uzbekistan," Gazeta.uz, Apr. 13, 2023, https://www.gazeta.uz/en/2023/04/13/sanctions-uzb/.

[361] "US Department of Commerce Imposes Sanctions Against Mvizion Company from Uzbekistan," Kun.uz, Nov. 3, 2023, https://kun.uz/en/news/2023/11/03/us-department-of-commerce-imposes-sanctions-against-mvizion-company-from-uzbekistan.

[362] Toghrul Ali, "The Caspian Region's Reactions to the Current Russo-Ukrainian War, a Series: Tajikistan," Caspian Policy Center, Oct. 31, 2022, https://www.caspianpolicy.org/research/security-and-politics-program-spp/the-caspian-regions-reactions-to-the-current-russo-ukrainian-war-a-series-tajikistan.

[363] Barmak Pazhwak, "Russia's Ukraine War Weighs Heavily on Tajikistan," US Institute of Peace, May 5, 2022, https://www.usip.org/publications/2022/05/russias-ukraine-war-weighs-heavily-tajikistan.

[364] "Ukrainian Intelligence: Russia Looks to Buy Soviet-Era Munitions from Tajikistan," *Kyiv Independent*, Sept. 13, 2022, https://kyivindependent.com/ukrainian-intelligence-russia-looks-to-buy-soviet-era-munitions-from-tajikistan/.

[365] "Treasury Imposes Sanctions on More Than 150 Individuals and Entities Supplying Russia's Military-Industrial Base," US Department of the Treasury, Dec. 12, 2023, https://home.treasury.gov/news/press-releases/jy1978.

percent in 2022.[366] Tajikistani emigrants to the US and Canada also have been implicated in schemes to supply Russia with $7 million in US-made electronic components.[367] Although Tajikistan cooperates with Iran to produce the Ababil-2 drone for domestic use, these are not the Iranian drones in use in Ukraine (those are the much larger Shahed 136).[368]

Middle East

In the Middle East, the UAE and Turkey have been the most instrumental in facilitating parallel import of Western goods and technologies to the Russian Federation,[369] so this section focuses exclusively on these two countries' contributions to Russia's parallel import strategy.

United Arab Emirates

UAE transshipments of sanctioned goods encompassed a wide range of dual-use technologies, although exports of advanced Western electronic components have predominated.[370] In July 2023, for example, Washington designated Amegino FZE, a UAE engineering and services company, as a sanctions violator for having allegedly sent dozens of shipments of Western electronics, including integrated circuits, to Russia since the Ukraine invasion.[371]

Likewise, Hulm Al Sahra, a UAE-based electrical appliances wholesaler, was sanctioned by the US Department of the Treasury for allegedly sending multiple shipments of electronics, machinery, and optical equipment to Russia, including almost $190,000 of US export-controlled semiconductors shipped between July 2022 and November 2022. Among these were shipments to Russia's Machine Building Design Bureau, a major player in the development of Russian precision strike weapons. UAE companies have also engaged in unauthorized transfers of quadcopter UAVs and robotics technology in contravention of US sanctions. [372]

During the earlier phases of the conflict, Washington appeared somewhat hesitant to designate the UAE for sanctions evasion efforts. However, Washington did publicly acknowledge the UAE as a country of focus to pressure the UAE into adopting more stringent export controls.[373] But only in November 2023 did Washington finally designate multiple UAE entities for sanctions evasion, primarily for supporting Russia's acquisition of high-priority electronic components, even though many of these

[366] Akhapova, "Parallel Import 'Technologies'"; Catherine Putz, "Brooklyn Busts: Several Indicted in New York for Smuggling Sanctioned Goods to Russia," *Diplomat*, Nov. 9, 2023, https://thediplomat.com/2023/11/brooklyn-busts-several-indicted-in-new-york-for-smuggling-sanctioned-goods-to-russia/.

[367] Farangis Najibullah, "Tajik-U.S. Businessman, Russian Accomplices Accused of Smuggling Technology to Support Russia's War in Ukraine," Radio Free Europe/Radio Liberty, Nov. 7, 2023, https://www.rferl.org/a/russia-military-us-technology-smuggling/32675092.html.

[368] Catherine Putz, "Tajik-Made Iranian Drones Are Not in Ukraine Either," *Diplomat*, Nov. 1, 2022, https://thediplomat.com/2022/11/tajik-made-iranian-drones-are-not-in-ukraine-either/.

[369] Evgeny Gayva, "The EAEU Countries Increased the Import of Goods to Russia by 30 Percent [Страны ЕАЭС увеличили ввоз товаров в Россию на 30 процентов]," *Rossiiskaia Gazeta*, Nov. 23, 2022, https://rg.ru/2022/11/22/tovar-ishchi.html.

[370] "U.S. Sanctions Turkey, China, UAE Entities to Disrupt Russia War," *Moscow Times*, Nov. 2, 2023, https://www.themoscowtimes.com/2023/11/02/us-sanctions-turkey-china-uae-entities-to-disrupt-russia-war-a82982.

[371] "Treasury Sanctions Impede Russian Access to Battlefield Supplies and Target Revenue Generators," US Department of the Treasury, July 20, 2023, https://home.treasury.gov/news/press-releases/jy1636.

[372] "Treasury Targets Russian Financial Facilitators and Sanctions Evaders Around the World," US Department of the Treasury, Apr. 12, 2023, https://home.treasury.gov/news/press-releases/jy1402.

[373] "Remarks by Assistant Secretary Elizabeth Rosenberg."

activities had reportedly been taking place since the beginning of Russia's war in Ukraine.[374] Despite such measures, UAE transshipments to Russia have continued.

Yet continued cooperation between the UAE and Russia has not been free of trouble for the Emiratis. In September 2023, in response to continuing Western pressure, Bloomberg reported that the UAE was considering requiring export licenses for transfers of chips and other components sanctioned by the US. As a result, UAE companies would be required to provide evidence that shipped components were destined for civilian use.[375] In November 2023, the EU made it known that the UAE had also agreed to restrict the reexport of certain goods to Russia. However, assurances can be difficult to verify, and the Kremlin and its willing partners in the UAE can alter their supply routes to continue to evade sanctions.[376]

Turkey

Many Russian companies have opened branch offices in Turkey in recent years, and some are reportedly cooperating with Turkish counterparts to establish front companies to conceal their illicit export activities. The number of companies with Russian capital located in Turkey quadrupled in the first eight months of 2022.[377] Overall, Turkey has become one of the top five places for Russians to open a new franchise.[378] In addition to direct shipments by sea, the Turkish port of Mersin has become a key transfer point for shipments of goods to Russia via land, with more than 250 vessels being unloaded each month onto 3,000 trucks.[379]

On occasion, Turkish companies have served as facilitators for the supply of US-made products to support Moscow's war. Sanctions imposed by the US Department of the Treasury in November 2023 highlighted the shipment of Western-produced electronic integrated circuits and multilayer ceramic capacitors by Azint Elektronik, Smart Techno Group, and Bosphorus Gate; batteries and instruments for metal processing by Basilevs Lojistik; metalworking machine tools by Jacbac Technology; and trucks by Kuzey Logistics.[380] For example, Turkish firm Dexias has served as a financial intermediary for the supply of Western electronics technology for Russia's Radioavtomatika, which specializes in procuring foreign items for use in Russian defense production, leading the US Department of the Treasury to impose secondary sanctions on the company in April 2023.[381] The department also designated Azu International, a Turkey-based electronics firm, for multiple shipments of foreign-source electronics, including advanced computer chips, to the Russian

[374] "Taking Additional Sweeping Measures Against Russia," US Department of State, Nov. 2, 2023, https://www.state.gov/taking-additional-sweeping-measures-against-russia/.

[375] Henry Meyer, Alberto Nardelli, and Ben Bartenstein, "UAE Considers Export Controls That May Hurt Russia's War Machine," Bloomberg, Sept. 21, 2023, https://www.bloomberg.com/news/articles/2023-09-21/russia-s-war-in-ukraine-uae-considers-trade-licenses-for-sanctioned-tech.

[376] Jorge Valero and Alberto Nardelli, "EU Says UAE to Restrict Key Exports to Russia Used for War," Bloomberg, Nov. 9, 2023, https://www.bloomberg.com/news/articles/2023-11-09/eu-says-uae-to-curb-key-exports-to-russia-used-in-war-in-ukraine.

[377] "Russians Leading in New Foreign Corporate Openings in Türkiye," RT News, Jan. 22, 2023, https://www.rt.com/business/570285-russians-leading-foreign-corporate-openings-turkiye/; "Turkey's Refusal to Go Along with Sanctions on Russia and Its Transformation into a Russian Transit Hub," European Parliament, Oct. 25, 2022, https://www.europarl.europa.eu/doceo/document/E-9-2022-003495_EN.html.

[378] "Rossiski Franshaizing: Statistika 2023," Franshiza.ru, 2023, https://franshiza.ru/article/read/statistika_franchisinga_2023/.

[379] "Turkey's Refusal to Go Along."

[380] "Treasury Hardens Sanctions with 130 New Russian Evasion and Military-Industrial Targets," US Department of the Treasury, Nov. 2, 2023, https://home.treasury.gov/news/press-releases/jy1871.

[381] "Treasury Targets Russian Financial Facilitators and Sanctions Evaders."

Federation.[382] In November 2023, the department sanctioned Berk Turken, a Turkish national, for his role in an illicit procurement network linked to Russian intelligence services.[383]

Similarly, in May 2023, the US Department of the Treasury targeted Margiana, a Turkish entity, for sending hundreds of shipments to SMT-iLogic and Saturn EK, two Russian entities. SMT-iLogic is involved in the production of Russian military UAVs, and Saturn EK is an electronic components supplier and producer of electronic equipment. Margiana's shipments to these Russian entities reportedly included components similar to those recovered in multiple Russian weapons systems, such as the Kalibr cruise missile, the Kh-101 cruise missile, and the Orlan-10 UAV. [384]

Moreover, according to open-source reports, NATO member states may have used Turkey to conduct indirect transfers of sanctioned products to the Russian Federation.[385] Notably, as of November 2023, Dutch exports to Turkey had grown by 91 percent compared to the same period two years prior. In addition, reports surfaced that certain Dutch companies were bypassing EU sanctions on Russia by routing goods through Turkey, including office equipment and heavy vehicles.[386] Turkish shipping companies were also sanctioned recently for providing materials and ship repair services to blocked vessels for companies affiliated with the Russian MOD.[387]

Western pressure and more stringent controls have had some effect in curbing Turkey's appetite for doing business with Russia, however. In 2022, for example, Turkish banks began using Russia's Mir payment system to allow Russian tourists to continue to make purchases in Turkey after Mastercard and Visa ceased operations in Russia.[388] When Washington listed the entity that runs Mir on an expanded sanctions list, three Turkish state banks suspended use of the Mir payment system altogether.[389] Recently, Ankara has been considering adopting more stringent export controls after the EU took measures to cut off indirect exports to Russia through third-party intermediaries.[390]

382 "Treasury Targets Russian Financial Facilitators and Sanctions Evaders."

383 "U.S. Sanctions Turkey, China, UAE Entities to Disrupt Russia War."

384 "With Wide-Ranging New Sanctions, Treasury Targets Russian Military-Linked Elites and Industrial Base," US Department of the Treasury, Sept. 14, 2023, https://home.treasury.gov/news/press-releases/jy1731.

385 "Dutch Products Ending Up in Russia via Turkey," NL Times, Nov. 6, 2023, https://nltimes.nl/2023/11/06/dutch-products-ending-russia-via-turkey.

386 "Dutch Companies Allegedly Circumvent Russia Sanctions via Turkey: Report," Turkish Minute, Nov. 7, 2023, https://www.turkishminute.com/2023/11/07/dutch-companies-allegedly-circumvent-russia-sanctions-via-turkey-report/.

387 "Imposing Further Sanctions in Response to Russia's Illegal War Against Ukraine," US Department of State, Sept. 14, 2023, https://www.state.gov/imposing-further-sanctions-in-response-to-russias-illegal-war-against-ukraine/.

388 Huileng Tang, "5 of Turkey's Banks Have Adopted Russia's Payment System, and Western Officials Are Concerned It Could Be Used to Skirt Sanctions," Business Insider, Aug. 8, 2022, https://www.businessinsider.com/turkey-banks-russia-mir-payments-systems-sanctions-putin-erdogan-sochi-2022-8.

389 Can Sezer, "Turkey's State Banks Suspend Use of Russian Mir Payment System—Finance Minister," Reuters, Sept. 20, 2023, https://www.euronews.com/next/2022/09/30/ziraatbank-mir.

390 Valero and Nardelli, "EU Says UAE to Restrict Key Exports to Russia Used for War."

APPENDIX B: FOREIGN COOPERATION

People's Republic of China

US policy-makers see potential PRC direct military support for Russia in Ukraine as a red line, in that lethal aid would help replenish dwindling Russian military stocks of key material and enable Russian companies to circumvent sanctions and export controls. As yet, US officials have not found conclusively that the PRC is providing direct lethal aid to the Russian war effort in Ukraine, but PRC companies do provide substantial support to Russia's defense sector. According to the EU, the Russian military sources 70 percent of its high-tech imports from China.[391] Because both Russia and Ukraine make prevalent use of commercial drones on the battlefield, the PRC is playing a hidden but substantial role in the Russian war on Ukraine.[392]

Although most attention has focused on deterring the PRC from making direct deliveries of lethal aid to Russia for its war on Ukraine, the PRC government can avoid the reputational and economic costs of this pathway by ignoring the substantial direct and indirect exports of dual-use equipment by PRC companies to Russian intermediaries and individuals. We did not find evidence at the unclassified level of PRC government support or requests for these types of indirect forms of assistance. The Department of Defense's 2023 report to Congress on PRC military power assesses that

> Beijing probably has taken a discreet, flexible, and cautious approach to providing material support to Russia to enable the PRC to maintain plausible deniability, control material transfers, create off-ramps to renege on agreements, and maximize the PRC's options to aid Russia.[393]

Direct lethal aid

Direct aid is the pathway that has most concerned Western officials, who have warned Beijing of dire consequences if such a step were taken. The repeated warnings indicate ongoing concern that the PRC is close to a decision to provide lethal aid to Russia. At least some of the intelligence regarding the prospect of PRC lethal aid came from Russian officials, although other sources reportedly confirmed the information.[394] The US Office of the Director of National Intelligence (ODNI) found that although the PRC represents a key economic partner for Russia as it prosecutes its war on Ukraine, there is less certainty about PRC direct military support. A July 2023 statement to Congress assessed that

[391] Finbarr Bermingham, "EU Says up to 70% of Hi-Tech Imports 'Killing Ukrainians' Are Reaching Russian Military via China," *South China Morning Post*, Sept. 22, 2023, https://www.scmp.com/news/china/diplomacy/article/3235536/eu-says-70-hi-tech-imports-killing-ukrainians-are-reaching-russian-military-china.

[392] Paul Mozur and Valerie Hopkins, "China Wields Hidden Power in Drone War," *New York Times*, Oct. 2, 2023, https://www.nytimes.com/2023/09/30/technology/ukraine-russia-war-drones-china.html.

[393] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China 2023: Annual Report to Congress*, p. 14, https://media.defense.gov/2023/Oct/19/2003323409/-1/-1/1/2023-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA.PDF.

[394] Courtney Kube and Carol E. Lee, "US Intel on China Considering Lethal Aid for Putin's War Was Gleaned from Russian Officials," NBC News, Mar. 3, 2023, https://www.nbcnews.com/politics/us-intel-china-considering-lethal-aid-putins-war-was-gleaned-russian-o-rcna72994. For a chronology of PRC actions and statements on Ukraine, see "China's Position on Russia's Invasion of Ukraine: Key Events and Statements from February 21, 2022 through April 30, 2024," U.S.-China Security and Economic Review Commission, Mar. 31, 2024, https://www.uscc.gov/research/chinas-position-russias-invasion-ukraine.

the PRC "has become an increasingly important buttress for Russia, *probably* supplying Russia with key equipment and dual-use technology used in Ukraine" (emphasis added).[395] Although ODNI's finding reflects a consensus in the US intelligence community, the statement suggests ongoing uncertainty about the parameters of PRC military support to Russia.

Direct sales of dual-use technology

There is considerable evidence of dual-use technology made in China supporting the Russian war effort in Ukraine. Under Xi Jinping, the PRC government has promoted a strategy of civil-military integration domestically, increasing the challenge of differentiating between production for military and nonmilitary purposes.[396] Moreover, the PRC is not a party to the Wassenaar Arrangement, which promotes transparency in dual-use technology transfers.[397]

This section addresses sales by PRC firms to Russia for the war and resulting US sanctions. ODNI finds that the PRC provides some dual-use technology to Russia despite international sanctions and export controls. ODNI assesses that PRC state-owned companies have shipped navigation equipment, jamming technology, and parts for fighter jets to Russian state-owned defense companies via smaller brokering companies in the mainland and Hong Kong.[398] The following subsections focus on the following dual-use technologies: semiconductors, rifles, ammunition, trucks, and drones.

Semiconductors

The PRC was always an important supplier of semiconductors for the Russian market, but PRC semiconductor exports to Russia more than doubled after the war began, from $200 million in 2021 to $500 million in 2022.[399] According to data from the Silverado Policy Accelerator, since the start of the war, the PRC has become the largest source of semiconductors and related technologies for Russia, accounting for 78 percent of exports of semiconductor devices and 96 percent of smart cards and dominating sales of technology for semiconductor production.[400] PRC semiconductor technology has improved in quality, but the PRC still lacks the technology to produce the most advanced chips.[401] However, the Russian newspaper *Kommersant* highlighted the increased failure rate in the PRC imports—from 2 percent before the war to 40 percent today—which was attributed to the involvement of less experienced, often unauthorized companies in lengthy supply chains.[402]

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[395] Office of the Director of National Intelligence, *Support Provided by the People's Republic of China to Russia*, p. 3.

[396] Rose Tenyotkin et al., *Economic Statecraft: How China Legally Accesses Foreign Technologies to Build Military Capabilities*, CNA, June 2020, DRM-2020-U-027240-1Rev, p. 2.

[397] Charlie Campbell, "Is China Providing Russia with Military Support? It's Hard to Tell and That's the Point," *Time*, Mar. 2, 2023, https://time.com/6259688/china-russia-dual-use-military-civil-fusion-strategy/.

[398] Office of the Director of National Intelligence, *Support Provided by the People's Republic of China to Russia*, p. 6. Because China has relatively few SU-35 fighter aircraft and buys parts for them from Russia, one analysis cast doubt on the likelihood that the People's Liberation Army would give up those parts for the war in Ukraine. See A. B. Abrams, "China Has Options to Arm Russia Directly. But Does It Need To?," *Diplomat*, Apr. 17, 2023, https://thediplomat.com/2023/04/china-has-options-to-arm-russia-indirectly-but-does-it-need-to/.

[399] Free Russia Foundation, *Effectiveness of U.S. Companies Targeting Russian Companies and Individuals*, p. 48.

[400] "Russia Semiconductor Imports Dashboard: Pre and Post Invasion Trends," Silverado Policy Accelerator, Aug. 24, 2023, https://silverado.org/news/russia-semiconductor-imports-dashboard-pre-and-post-invasion-trends/.

[401] Office of the Director of National Intelligence, *Support Provided by the People's Republic of China to Russia*, p. 6.

[402] Timofey Kornev, "Defective Goods Are Becoming More Widespread in Russia. Electronics Manufacturers Are Receiving More and More Unusable Components [В России растет популярность брака Производители электроники получают все больше негодных компонентов]," *Kommersant*, Oct. 17, 2022, https://www.kommersant.ru/doc/5619160.

Many Hong Kong companies are under sanction for providing dual-use equipment to Russia for the war in Ukraine. These companies act as intermediaries for PRC firms and are instrumental in providing Russia with the advanced semiconductors that it needs for military equipment and in circumventing global sanctions. US Department of the Treasury officials visited the territory in June 2023 to encourage greater attention to preventing technology on export control lists from reaching Russia.[403]

Rifles

According to Russian customs data, China North Industries Group Corporation Limited, one of the PRC's largest defense manufacturers, sent 1,000 CQ-A rifles to Russia between June and December 2022. The guns, listed as hunting rifles, were sent to Tekhrim, a supplier for the Russian military.[404]

Ammunition

Poly Technology, a subsidiary of Poly Group Corporation, the PRC state-owned company already under US sanctions for supplying missile technology to Iran, shipped enough gunpowder to Russia in 2022 to produce 80 million rounds of ammunition (Russia reportedly goes through 20,000 rounds daily in Ukraine). Poly Technology shipped the gunpowder across the border in Zabaikalsk, from where it would be directed to the Barnaul Cartridge Plant, reportedly a training base for the Wagner Group.[405] Poly Technology also allegedly shipped antiaircraft radar to Russia's Almaz Antey, a state-owned defense company, in January 2022, just before the start of the war.[406]

Trucks

Just before the invasion, US Lt. Col. Alex Vershinin observed that Russia lacks sufficient trucks to conduct a major operation in Ukraine.[407] Analysis from the Atlantic Council shows that a huge increase in PRC truck exports to Russia is designed to help address this weakness in Russian logistics. According to the Atlantic Council data, PRC truck exports to Russia in December 2022 increased by 1,143 percent compared to the same period in 2021. Although heavy trucks are not considered lethal aid, exports of such equipment provide critical support to the Russian war effort.[408] Silverado reported a 37 percent increase in PRC exports of all vehicles from January to August 2023 compared to January to August 2021, with vehicles amounting to 20 percent of all exports.[409]

Drones and drone parts

In the first year of the war, 70 PRC companies sold Russia 26 different brands of drones worth $12 million. Major producers such as DJI Technology and Autel were involved, as well as smaller companies,

[403] Echo Wang and Pak Liu, "U.S. Treasury Warned Hong Kong on Tech Exports to Russia," *Nikkei Asia*, July 6, 2023, https://asia.nikkei.com/Business/Tech/Semiconductors/U.S.-Treasury-warned-Hong-Kong-banks-on-tech-exports-to-Russia.

[404] Erin Bianco and Sarah Anne Aarup, "'Hunting Rifles'—Really? China Ships Assault Weapons and Body Armor to Russia," *Politico*, Mar. 16, 2023, https://www.politico.eu/article/chinese-companies-are-shipping-rifles-body-armor-to-russia/.

[405] Ana Swanson and John Ismay, "Chinese Firm Sent Large Shipments of Gunpowder to Russian Munitions Factory," *New York Times*, June 23, 2023, https://www.nytimes.com/2023/06/23/business/economy/china-russia-ammunition.html.

[406] C4ADS, *Trade Secrets: Exposing China-Russia Defense Trade in Global Supply Chains*, July 2022, p. 3, https://c4ads.org/wp-content/uploads/2022/07/TradeSecrets-Report.pdf.

[407] Alex Vershinin, "Feeding the Bear: A Closer Look at Russian Army Logistics," *War on the Rocks*, Nov. 23, 2021, https://warontherocks.com/2021/11/feeding-the-bear-a-closer-look-at-russian-army-logistics/.

[408] Markus Garlauskas, Joseph Webster, and Emma C. Verges, "China's Support May Not Be Lethal Aid but It's Vital to Russia's Aggression in Ukraine," *New Atlanticist (Atlantic Council blog)*, May 8, 2023, https://www.atlanticcouncil.org/blogs/new-atlanticist/chinas-support-may-not-be-lethal-aid-but-its-vital-to-russias-aggression-in-ukraine/.

[409] "China's Exports to Russia: Overall Trends and Key Products," Silverado Policy Accelerator, Sept. 22, 2023, https://silverado.org/news/silverado-china-s-exports-to-russia/.

some of which serve as intermediaries for more established firms.[410] DJI claims to oppose the use of its commercial drones on the battlefield and suspended its operations in Russia and Ukraine in April 2022, but the company noted that it "cannot prevent users or organizations from purchasing in countries or regions other than Russia and Ukraine, and then transship[ping] or gift[ing] them to Russia and Ukraine."[411]

Russian customs data document the purchases from the PRC. According to information that *Nikkei Asia* obtained for the period from December 2022 through April 2023, Russia purchased at least 37 UAVs from China worth $103,000, documenting them "for use in the special military operation." Russia also spent another $1.2 million on 22 devices for detecting and jamming drones, equipment also identified in the customs paperwork as intended for use in the war.[412]

Der Spiegel reported in April 2023 that Russia was negotiating with China's Xian Bingo Intelligent Aviation Technology over the production of kamikaze drones, similar to Iran's Shaheed 136, for Russia. After delivering prototypes, the company would provide Russia with the equipment to produce 100 of the drones monthly.[413] Xian Bingo subsequently denied having a commercial relationship with Russia.[414] However, the Chinese Sunflower-200 drone, an upgraded version of the Shaheed 135, was featured in Army-2023, the Russian MOD arms industry annual trade show, and video of a test launch was shared on X (formerly Twitter) in September 2023.[415] Which PRC company is producing this drone is unclear.

Because of the challenges that Russia faces in developing supply chains to circumvent export controls on dual-use equipment, Russian volunteers have been traveling to the PRC to buy needed equipment.[416] The volunteers then post about their purchases on Telegram. Russia analyst Samuel Bendett posted a video on X by two such volunteers, Katya and Valya, who seem to have visited an Autel drone store in the PRC and claim to have bought "military grade drones."[417] Autel Robotics claims that it complies with PRC laws and that "'military use' was not the original intent of its product design," although Autel drones are one of the most popular drones on the battlefield in Ukraine.[418]

[410] Paul Mozur, Aaron Krolik, and Keith Bradscher, "As War in Ukraine Grinds on, China Helps Refill Russian Drone Supplies," *New York Times*, Mar. 21, 2023, https://www.nytimes.com/2023/03/21/business/russia-china-drones-ukraine-war.html.

[411] Cited in Benoit Faucon and Ian Talley, "Chinese Drones Still Support Russia's War in Ukraine, Trade Data Show," *Wall Street Journal*, Feb. 18, 2023, https://www.wsj.com/articles/chinese-drones-still-support-russias-war-in-ukraine-trade-data-show-cd39d40b.

[412] Nikkei Staff Writers and Jacob Fromer, "Special Report: Russia Buying Civilian Drones from China for War Effort," *Nikkei Asia*, July 1, 2023, https://asia.nikkei.com/Politics/Ukraine-war/Special-report-Russia-buying-civilian-drones-from-China-for-war-effort.

[413] "China Reportedly Negotiating with Russia to Supply Kamikaze Drones," *Der Spiegel*, Feb. 2, 2023, https://www.spiegel.de/international/world/the-war-in-ukraine-china-is-reportedly-negotiating-with-russia-to-supply-kamikaze-drones-a-13909157-4740-4f84-830e-fb3c69bc1dff. Topcor.ru, a Russian news website, also cast doubt on the *Der Spiegel* report, claiming that Russia needed reconnaissance drones most of all. "What Drones of Chinese Origin Are Needed by the Russian Armed Forces: Versions and Reflections [Какие дроны китайского происхождения нужны ВС РФ: версии и размышления]," Reporter, Feb. 25, 2023, https://topcor.ru/32494-kakie-drony-kitajskogo-proishozhdenija-nuzhny-vs-rf-versii-i-razmyshlenija.html.

[414] Alan Wong, "'No Commercial Contact': Chinese Drone Maker Denies Selling Arms to Russia," Vice, Feb. 24, 2023, https://www.vice.com/en/article/xgye5z/chinese-drone-sales-russia-report-xian-bingo-intelligent-aviation.

[415] David Hambling, "Is China's Kamikaze Drone Clone Headed to Russia?," *Forbes*, Sept. 11, 2023, https://www.forbes.com/sites/davidhambling/2023/09/11/is-chinas-kamikaze-drone-clone-headed-to-russia/.

[416] CNA Russian Studies Program, "Russian and Ukrainian Deployment of sUAS and sUAS Countermeasures," Jan.–July 2023, p. 4.

[417] Samuel Bendett (@sambendett), "Valya posted this video today discussing the results of their trip to China, talking about acquiring 'military'-grade Autel drones, other, updated FPV models," Post, X, Sept. 2, 2023, https://twitter.com/sambendett/status/1697949448607776817.

[418] Ishveena Singh, "Autel Decries Military Use of Drones; Doesn't Deny Russian Rebranding," Drone DJ, June 27, 2023, https://dronedj.com/2023/06/27/autel-drone-russia-rebranding-patriot/.

Volunteers also purchase equipment for assembling do-it-yourself drones in Russia, enabling them to circumvent the prodigious Russian procurement bureaucracy.[419] There are also efforts to attract PRC companies to set up drone production in Russia. Russian media reported that several smaller PRC companies were interested in localizing production in Russia, including Fimi (part of the Xiaomi Group), Zero Robotics, and AEE.[420] These are mainly smaller producers that are not concerned about reputational costs or sanctions in Western markets. Both joint ventures and independent production are being explored, although questions remain about the attractiveness of the relatively small but growing Russian market for these PRC companies.[421] Russian observers point to likely difficulties in obtaining needed certifications to produce the drones jointly and note that localization of production is unlikely to reduce the cost of drones in Russia because of the difficulties in obtaining needed electronic components.[422]

PRC government restrictions

The PRC also has imposed some restrictions of its own on the export of some dual-use technologies to avoid their use in military conflicts, especially in Ukraine, where the PRC government claims to be impartial. DJI, a PRC UAV firm that has a 70 percent global market share, suspended sales to Russia and Ukraine early in the Russia-Ukraine war.[423] Ukraine had complained that the company was providing Russia with data about Ukrainian military positions. However, a study by Molfar, a Ukrainian business consulting group, showed that a year after the suspension, Russia continues to use DJI drones widely in Ukraine and some Russian drone training centers even advertise their use on their websites.[424]

In July 2023, the PRC Ministry of Commerce imposed restrictions on long-range heavier drones that could be used by militaries and some related technologies, such as lasers, communications equipment, drone engines, and antidrone systems. These are UAVs that can stay aloft for at least 30 minutes and weigh more than 7 kilograms (15.5 pounds).[425]

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[419] Sebastien Roblin, "Russia's Pro-War Volunteers Complain Government Worse Than Useless Getting Drones to Troops," *Forbes*, June 30, 2023, https://www.forbes.com/sites/sebastienroblin/2023/06/30/russias-pro-war-volunteers-complain-government-worse-than-useless-getting-drones-to-troops/.

[420] Ruslan Avdeev, "Chinese Drones Are Landing in Russia [Китайские дроны идут на посадку в РФ]," *Kommersant*, June 19, 2023, https://www.kommersant.ru/doc/6053996; Artyom Feoktistov, "Chinese UAV Manufacturers Are Thinking About Assembling Drones in Russia [Китайские производители БПЛА задумались о сборке дронов в России]," *Gazeta*, June 19, 2023, https://www.gazeta.ru/business/news/2023/06/19/20697818.shtml.

[421] Avdeev, "Chinese Drones Are Landing in Russia."

[422] Natalia Trushina, "The Chinese Wanted to Assemble Drones on Russian Territory [Китайцы захотели собирать беспилотники на территории России]," MK, June 19, 2023, https://www.mk.ru/economics/2023/06/19/kitaycy-zakhoteli-sobirat-bespilotniki-na-territorii-rossii.html.

[423] "DJI Reassesses Sales Compliance Efforts in Light of Current Hostilities," DJI, Apr. 26, 2022, https://www.dji.com/newsroom/news/dji-statement-on-sales-compliance-efforts. On DJI, see "China's Thriving Drone Industry," Arc Group, June 9, 2021, https://arc-group.com/china-thriving-drone-industry/.

[424] Ukraine also uses DJI drones, but sales of Chinese drones to Russia are much more substantial—$14.5 million in the first six months of 2023, compared to $200,000 to Ukraine. Reid Standish, "Chinese Drones Flow to Training Centers Linked to Russian War in Ukraine," Radio Free Europe/Radio Liberty, Oct. 5, 2023, https://www.rferl.org/a/russia-ukraine-chinese-drones-training-centers/32621432.html.

[425] Joe McDonald, "China Restricts Civilian Drone Exports, Citing Ukraine and Concern About Military Use," AP, July 31, 2023, https://apnews.com/article/china-ukraine-russia-drone-export-dji-e6694b3209b4d8a93fd76cf29bd8a056; "China Curbs Export of Drone Equipment amid U.S. Tech Tension," Reuters, July 31, 2023, https://www.reuters.com/world/china-curbs-exports-drone-related-equipment-amid-us-tech-tensions-2023-07-31/.

According to Russian commentators, the new PRC restrictions may have an effect if they include a broad array of components (engines, polymer batteries, steering gears, etc.) that Russia still must import from the PRC, despite efforts to develop domestic UAV production. Russia mainly purchases smaller drones from DJI and other companies, such as the much lighter Mavic quadcopter, and the heavier drones would be more likely to be used for agriculture than combat.[426]

North Korea

In 2022, Russian leaders began to reach out to North Korea, seeking to purchase millions of shells and rockets to replenish Russia's depleting stockpiles. Despite warnings from US officials of consequences if North Korea helped Russia prolong the war in Ukraine, Kim Jong Un followed through on an agreement reached at a summit with Vladimir Putin in September 2023 to supply a range of war supplies. Unlike other allies, such as China and Iran, North Korea is limited to supplying low-tech Soviet-era weaponry that is interoperable with Russian systems to support the Russian war effort. Although open-source intelligence is thin on exactly what North Korea is supplying, unclassified imagery has shown spikes in train traffic passing through the Russian–North Korean border and suspicious maritime activity since late 2022, in violation of UN resolutions aimed at curbing weapons proliferation from Pyongyang. At the beginning of 2024, North Korean munitions were confirmed on the battlefield in Ukraine.

Weapons sales

Despite repeated denial of allegations of arms sales to Russia, Pyongyang asserted its right as a sovereign nation to sell weapons to other countries in September 2022: "Not only the development, production, possession of military equipment, but also their export and import are the lawful right peculiar to a sovereign state, and nobody is entitled to criticize it."[427]

Two months later, in December 2022, the US accused North Korea of selling "infantry rockets and missiles" to the Russian paramilitary organization the Wagner Group for use in Ukraine in violation of UN sanctions.[428] According to the US Department of the Treasury, a Slovakian national worked with North Korean officials to facilitate transfer of more than two dozen kinds of weapons and munitions for Russia in exchange for commercial aircraft, raw materials, and commodities to the Democratic People's Republic of Korea (DPRK).[429] Whether these weapons transfers went through is unclear. The US Department of the Treasury said that the transfer was "attempted." Other reports identified a North Korean citizen, Rim Yong Hyok, as providing

[426] "From September 1, China Will Introduce Restrictions on the Export of Certain Types of Drones and a Number of Their Components. How Will This Affect Russia? [Китай с 1 сентября введет ограничения на экспорт определенного вида дронов и ряда их компонентов. Как это коснется России]," Bfm.ru, July 31, 2023, https://dzen.ru/a/ZMffMffpOHtoOxrt.

[427] Quote attributed to the North Korean vice director of the General Bureau of Equipment, cited in "North Korea Denies U.S. Claims It Supplies Arms to Russia," *Washington Post*, Sept. 22, 2022.

[428] "North Korea Sold Rockets to Russian Paramilitary Group for Ukraine War, US Says," NK News, Dec. 23, 2022.

[429] "Treasury Sanctions Facilitator for Attempted Arms Deals Between North Korea and Russia," US Department of the Treasury, Mar. 30, 2023. The Department of the Treasury's Office of Foreign Assets Control sanctioned Mkrtychev for attempting to facilitate arms deals between Russia and the DPRK. Mkrtychev is the president of Versor, the founder and owner of Verus, and the sole director of Defense Engineering. All three organizations were sanctioned by the US Treasury for their ties to a sanctions evasion network attempting to support arms deals between Russia and the DPRK. See "Treasury Sanctions Entities Tied to Arms Deals Between North Korea and Russia," US Department of the Treasury, Aug. 16, 2023.

"material, financial, and technological support" for the head of the Wagner Group, Yevgeny Prigozhin, and "facilitating shipments of munitions to the Russian Federation."[430] Rim Yong Hyok is the deputy head of the Korea Mining Development and Trading Corporation, North Korea's main munitions exporter. He is located in Syria, "one of the two most lucrative markets for North Korean arms-related goods and services."[431] Although both Pyongyang and Moscow denied US and South Korean claims that North Korea had been transferring arms supplies to Russia, South Korea's National Intelligence Service (NIS) stated that North Korea sent more than a million artillery shells to Russia between August and October 2023 to help fuel Russia's war on Ukraine.[432] That number of shells would amount to roughly two months of supplies for the Russians.[433]

The growing defense relationship between Russia and North Korea captured the attention of the international community in July 2023 when the Russian Minister of Defense Sergei Shoigu visited Pyongyang.[434] In addition to having discussions on how to broaden the relationship beyond the North Korean sales to the Wagner Group, Shoigu met with Kim Jong Un, who showed him around a large-scale weapons exhibition, showing off drones and missiles capable of striking the United States. Accompanying Shoigu was Deputy Minister of Defense Aleksei Krivoruchko, who is responsible for procurement of new weaponry for the Russian armed forces. According to experts, Russian interest beyond artillery (such as 152 millimeter and 122 millimeter artillery shells) included short-range ballistic missiles such as North Korea's KN-23, KN-24, and KN-25. North Korea is the only country other than China that can develop and provide Russia with weapons similar to its own systems, such as the Iskander.[435] This meeting also had a strategic messaging component in that it allowed Moscow to send a warning to Seoul not to provide weapons to Ukraine.

In August 2023, media reports began to speculate about Russia–North Korea munitions transfers. Stories about ships moving between the vicinities of North Korean defense production areas and sensitive Russian defense rail hubs fit within a narrative of upcoming arms talks between the two countries. In the following months, information about a network of sea and rail transport operating under a veil of concealment began to emerge, which seemed to suggest major shipments of weapons from North Korea to Russia.[436]

A September 2023 summit between Kim Jong Un and Vladimir Putin at the Vostochny cosmodrome outside the city of Tsiolkovsky in the Russian Far East included several North Korean defense officials, such as Jo Chun Ryong, director of the Munitions Industry Department, Park Thae Song, chair of the National Space Science and Technology Committee, and Kim Myong Sik, commander of the navy.[437] Putin's delegation included Foreign Minister Sergei Lavrov and Defense Minister Shoigu. Although very little is

[430] Anton Sokolin, "US Sanctions North Korean for Facilitating Arms Sales to Russia's Wagner Group," NK News, July 21, 2023.

[431] Sokolin, "US Sanctions North Korean."

[432] Kim Tong-Hyung, "South Korea's Spy Agency Says North Korea Shipped More Than a Million Artillery Shells to Russia," *Washington Post*, Nov. 1, 2023.

[433] Lee Jeong Ho, "N. Korea Has Shipped 1 Million Shells to Russia: S Korea Intel," Radio Free Asia, Nov. 1, 2023. South Korea's NIS assesses that North Korea has engaged in the transportation of artillery shells and other weaponry on approximately 10 occasions since early August 2023, using Russian ships and transport planes.

[434] This was the first visit by a Russian defense minister to North Korea since 1991.

[435] Ifang Bremer, "'Top Salesman' Kim Jong Un Used Arms Expo to Hawk Weapons to Russia: Experts," NK News, July 27, 2023.

[436] Shipments from Russia to North Korea, be they economic resources or defense goods, have been less visible.

[437] "Makeup of N. Korea's Delegation to Russia Suggests Arms Deal Is on Horizon," *Hankyoreh*, Sept. 13, 2023.

known about what was discussed, many observers assumed that one of the topics was a deal whereby North Korea would help Russia replenish its stocks of artillery shells and send a considerable number of workers to staff Russian factories, and Russia in return would provide humanitarian aid—specifically food—as well as support for Pyongyang's space program.[438]

According to reporting from South Korea's NIS, North Korean munitions factories have been operating at near full capacity since Kim Jong Un's meetings with Russian Defense Minister Shoigu and later with President Putin. North Korean media referenced subsequent tours led by Kim that took place near presumed weapons factories followed by reports that North Korea dispatched weapons experts to Russia in October 2023 to counsel Russian officials on how to use the exported North Korean weapons.[439] In addition, various open-source and intelligence reports indicated patterns of ship and rail movement that suggested that large numbers of containers of munitions were being transferred from North Korea to Russia.[440] This activity overlapped with the construction of a weapons depot near the Ukrainian border, presumably the final destination for munitions shipped from North Korea.[441]

North Korean weapons appear on the battlefield

In December 2023, information began to emerge from the battlefield that Russian forces were using North Korean munitions. These reports focused on artillery, which Russian forces often disparaged for inconsistencies in trajectory, range, and accuracy. According to one military expert, the shells had different powders, and the powder bundles had different weights. Some charges lacked a de-copper, a lead wire meant to reduce copper buildup inside the barrel. In addition, some of the shells had traces indicating that hermetic lids had been opened. In practice, these issues led to an avalanche of consequences, including requiring more time to accomplish time-on-target tasks (because of the need to expend more rounds to achieve results) and placing artillery troops in danger because Ukrainian forces have more time to determine their firing location.[442]

One month later, North Korean sales to Russia escalated further. Reports indicated that Russia had received dozens of ballistic missiles from its ally and begun firing them into Ukraine from positions just north of the border.[443] Based on assessments from many analysts, it appears that Russia has begun to employ the KN-23, a solid-fuel missile

[438] "Department Press Briefing—September 13, 2023," US Department of State, Sept. 13, 2023.

[439] "Department Press Briefing—September 13, 2023."

[440] James Byrne, Joseph Byrne, and Gary Somerville, "The Orient Express: North Korea's Clandestine Supply Route to Russia," RUSI, Oct. 16, 2023; Anton Sokolin, "How Russia Used Lookalike Ships to Conceal Suspected North Korea Arms Trade," NK Pro, Oct. 20, 2023; Joseph S. Bermudez Jr., Victor Cha, and Jennifer Jun, "Dramatic Increase in DPRK-Russia Border Rail Traffic After Kim-Putin Summit," Beyond Parallel, Oct. 6, 2023; Ramy Inocencio, Justine Redman, and Tucker Reals, "North Korea Provides Russia Artillery for the Ukraine War as U.S. Hands Kyiv Ammunition Seized from Iran," CBS News, Oct. 5, 2023; Colin Zwirko, "North Korean Trains in Alleged Russia Arms Deal Pass Through Key Weapons Hub," NK Pro, Oct. 25, 2023.

[441] Anton Sokolin, "Major Russian Container Port Tied to Alleged North Korean Weapons Trade," NK News, Oct. 23, 2023.

[442] These insights were provided in a post by Georgian blogger TheDeadDistrict. See "Dissatisfied with Quality and Quantity of North Korean Artillery Shells, Russians Complain," Defense Express, Dec. 9, 2023.

[443] At least one open-source analyst believes that Russia's new North Korean missiles struck a pair of Ukrainian army logistics bases, destroying as many as 10 tanker trucks. See David Axe, "Russia Got 7,500-Pound Rockets from North Korea—and Promptly Blew Up a Pair of Ukrainian Supply Bases," *Forbes*, Jan. 5, 2024.

similar to the Russian Iskander.[444] Although not as accurate as the Iskander,[445] the KN-23 can be used to target buildings or compounds,[446] making it the perfect weapon to destroy infrastructure or other civilian nodes.[447] In addition to the KN-23, North Korea may have supplied Russia with Scud missiles. Although less accurate than the KN-23, Scuds would effectively target cities and large towns as the ongoing campaign to wear down Ukraine continues. The effect on the battlefield appears to be important but not a paradigm shift. In other words, the missiles that North Korea is selling to Russia are there to augment Russia's dwindling missile stocks because of high-tempo combat operations. These missiles will allow Russia to continue a high rate of fire and attack on Ukrainian targets and therefore help to magnify the effects of Russia's long-range strike campaign against Ukraine.[448]

Iran

Iran has been an important source of weapons and training for Russia's war in Ukraine, despite repeated denials from Iranian officials.[449] At this juncture, Iranian military aid consists of selling and coproducing drones, selling ammunition and artillery shells, and training. Ongoing talks about the sale of Iranian ballistic missiles have yet to result in a deal, although one may be imminent, according to US officials.

UAVs

Iranian UAV technology is important for the Russian war effort in Ukraine, and Russia sources these drones in three ways: purchases, copies, and coproduction in Russia.

According to the US Defense Intelligence Agency (DIA), beginning in September 2022, Iran has been providing Russia with three types of drones: Shahed 131 UAVs, which the Russians renamed Geran-1; Shahed 136 UAVs, renamed Geran-2; and Mohajer 6 multirole UAVs. DIA was able to identify the Iranian provenance of the drones by comparing drones downed in Ukraine with UAVs found on other battlefields in the Middle East. Iran initially denied selling drones to Russia for use in the war and then claimed falsely that they were sent to Russia before the full-scale invasion of Ukraine. According to DIA, Russia purchased the Iranian drones after depleting its own supplies of precision-guided munitions in mid-2022.[450] By some estimates, Iran may have sent Russia as many as 1,700 drones to attack Ukrainian

[444] Bruce E. Bechtol, "Russia Is Using North Korean Missiles in Ukraine: What Happens Next?," *The National Interest*, Jan. 12, 2024.

[445] According to a Ukrainian source that examined the wreckage of one of the spent KN-23s, "The production method is not very modern…There are deviations from standard [Russian-produced] Iskander missiles, which we previously saw during strikes on Kharkiv. That is why we are leaning toward the version that this may be a missile which was supplied by North Korea." That said, Ukrainian sources do not discount that the missile could be a KN-24, which is an apparent copy of the US-made Army Tactical Missile System. See "Did Russia Fire North Korean Missiles at Ukraine?," Radio Free Europe/Radio Liberty, Jan. 8, 2024.

[446] The inertially guided KN-23 usually launches from a wheeled transporter erector launcher. It ranges approximately 400 miles and should strike within 35 yards of its aimpoint. Russia aimed its initial KN-23 attacks at Zaporizhzhia in southern Ukraine—a city without Patriot cover. See Axe, "Russia Got 7,500-Pound Rockets from North Korea."

[447] Axe, "Russia Got 7,500-Pound Rockets from North Korea."

[448] Axe, "Russia Got 7,500-Pound Rockets from North Korea."

[449] Giorgio Cafiero, "Iran's Indispensable Role for Russia in the Ukraine War," Gulf International Forum, Feb. 24, 2023, https://gulfif.org/irans-indispensable-role-for-russia-in-the-ukraine-war/.

[450] Defense Intelligence Agency, *Iranian UAVs in Ukraine: A Visual Comparison, August 2023 Update*, Aug. 2023, p. 3, https://www.dia.mil/Portals/110/Documents/News/Military_Power_Publications/UAV_Book.pdf.

military targets and civilian infrastructure.[451] Ukrainian President Volodymyr Zelensky contends that Russia ordered 2,400 Shahed drones in 2022.[452] In October 2022, the US and UK reported that Iran sent a small contingent from the Iranian Revolutionary Guard Corps to Crimea to assist Russian troops in using Iranian-made UAVs.[453] That same month, Iranian officials traveled to Moscow to discuss selling additional Shahed 136 drones as well as Fateh-110 and Zolfaghar short-range ballistic missiles.[454] Amir Chahaki, an Iranian political scientist based in Germany, contends that in exchange for the drones, Russia agreed to boost assistance to Iran's space program, launching the Khayyam remote sensing spacecraft from the Baikonur spaceport (which Russia leases from Kazakhstan) on August 9, 2022.[455]

According to a report by the Ukrainian government, the Shahed 131 and Shahed 136 drones contain many European components, in violation of existing export controls, and some may be produced in plants in Syria.[456] CAR found evidence of a Chinese voltage converter produced in January 2023 in an Iranian drone shot down in Ukraine in April 2023. This was the first evidence of a Chinese part in the Iranian drone production effort for Russian use in Ukraine and attests to the role of a PRC company in the effort to rapidly resupply the Russian military effort.[457] In addition, the engine for the Shahed 136 drone is made by Beijing MicroPilot Flight Control Systems but is based on a reverse-engineered German design. These examples highlight increasing Chinese-Iranian military cooperation and this cooperation's contribution to Russia's military effort against Ukraine.[458]

Reportedly, Iranian production of UAVs has had difficulties in meeting Russian demand, which explains why the two countries have entered into a coproduction arrangement to allow them to be produced in Russia, as discussed in further detail later.[459] Nevertheless, British Sky News reports that Iran continues to gear its UAV production for Russia's use and is developing a new drone, the Shahed 107, for Russia. The drone is believed to have a range of 1,500 kilometers and to be equipped with video transmitters to facilitate targeting.[460] The *Guardian* revealed in February 2023 that Iran smuggled several

[451] Steven Feldstein, "Larger Geopolitical Shift Behind Iran's Drone Sales to Russia," Carnegie Endowment for International Peace, Oct. 26, 2022, https://carnegieendowment.org/2022/10/26/larger-geopolitical-shift-behind-iran-s-drone-sales-to-russia-pub-88268.

[452] Shamsudddoza Sajen, "Iran's Drone Industry: Past, Present, Future," Foreign Affairs Insights and Review, Feb. 12, 2024, https://fairbd.net/iran-drone-industry-history/.

[453] Aamer Madhani and Zeke Miller, "US: Iranian Troops in Crimea Backing Russian Drone Strikes," AP, Oct. 20, 2022, https://apnews.com/article/government-and-politics-8b085070758120c31d421f68a65e4b14.

[454] "Iran Agrees to Ship Missiles, More Drones to Russia," Reuters, Oct. 18, 2022, https://www.reuters.com/world/exclusive-iran-agrees-ship-missiles-more-drones-russia-defying-west-sources-2022-10-18/.

[455] Ruslan Suleymanov, "From Tyranny to the Stars [Из тирании — к звездам]," *Novaya Gazeta*, Jan. 10, 2023, https://novayagazeta.eu/articles/2023/01/10/iz-tiranii-k-zvezdam; Sajen, "Iran's Drone Industry."

[456] Daniel Boffey, "Revealed: Europe's Role in the Making of Russia Killer Drones," *Guardian*, Sept. 27, 2023, https://www.theguardian.com/world/2023/sep/27/revealed-europes-role-in-the-making-of-russia-killer-drones.

[457] Dion Nissenbaum, "Chinese Parts Help Iran Supply Drones to Russia Quickly, Investigators Say," *Wall Street Journal*, June 12, 2023, https://www.wsj.com/articles/china-helps-iran-supply-drones-to-russia-quickly-investigators-say-dd492264.

[458] Sine Ozkarasahin, "Beyond Arms and Ammunition: China, Russia, and the Iran Back Channel," *China Brief* 23, no. 6 (Mar. 31, 2023), https://jamestown.org/program/beyond-arms-and-ammunition-china-russia-and-the-iran-back-channel/; "Ukraine War: Chinese Knock-Off Parts Used in Russia's Iran-Made Suicide Drones, Report Says," *South China Morning Post*, Nov. 2, 2022, https://www.scmp.com/news/world/russia-central-asia/article/3198060/ukraine-war-chinese-knock-parts-used-russias-iran-made-suicide-drones-report-says.

[459] "Russia Receives New Batch of Iranian Drones," Iran International, Dec. 19, 2022, https://www.iranintl.com/en/202212199035.

[460] Deborah Haynes, "Explosive New Attack Drone Developed by Iran for Russia's War in Ukraine," Sky News, Jan. 10, 2024, https://news.sky.com/story/explosive-new-attack-drone-developed-by-iran-for-russias-war-in-ukraine-13045093.

long-range armed drones to Russia. Those drones include 6 Mohajer 6 drones and 12 Shahed 191 and Shahed 129 drones. Mohajer 6 drones have a range of about 200 kilometers and can carry two missiles under each wing.[461]

In addition to purchasing drones from Iran, Russia has been making copies of the Shahed 136, renamed Geran-2, according to a July 2023 report by CAR. CAR had previously documented Russia's use of Shahid 131 and Shahid 136 drones in Ukraine, and the July 2023 report emphasized that "evidence that the Russian Federation has begun producing its own domestic versions marks a significant evolution in the country's UAV capabilities that will allow it to sustain its reliance on single-use UAVs."[462] Iranian media republished a *New York Times* account of the CAR findings, highlighting that the drones that Russia has been using in Ukraine were produced in Russia, not in Iran, as US and European officials have alleged.[463]

In November 2022, US media reported that, following a visit by Russian officials to Iran, Russia and Iran had reached a deal for coproducing Shahid 136 drones in Russia.[464] After this meeting, Iran began transferring designs and components to Russia.[465] The deal enables Russia to replenish its stockpile of drones, and Iran may believe that it will be easier to avoid further Western sanctions if the drones are assembled in Russia.[466] The US and European countries see the drone deal as a further indication of Iran and Russia's deepening military partnership. Before the deal, several Iranian UAV companies and individuals connected to them were sanctioned.[467] The US and European countries contend that by providing drone technology to Russia, Iran is violating UN Security Council sanctions on Iranian arms transfers.[468] US intelligence officials fear that the drone coproduction deal could have a major effect on the battlefield in Ukraine and significantly boost Russian capabilities.[469]

The *Washington Post* reported, based on leaked documents, that there are plans to produce as many as 6,000 drones by 2025 at a facility in the Russian Republic of Tatarstan's Alabuga special economic zone. The purpose of the Russia-based production line is to produce Shahid 136 drones

[461] Sajen, "Iran's Drone Industry"; Martin Chulov and Dan Sabbagh, "Iran Smuggled Drones into Russia Using Boats and State Airline, Sources Reveal," *Guardian*, Feb. 12, 2023, https://amp.theguardian.com/world/2023/feb/12/iran-uses-boats-state-airline-smuggle-drones-into-russia.

[462] Conflict Armament Research, *New Evidence Confirms Identity of Iranian Drone Engine Maker*, Apr. 2023, https://storymaps.arcgis.com/stories/31ca7fc85b4e47f791377ded5621c360.

[463] "Russia Uses Drones That Are Produced from the Iranian Example," Mashregh News, Aug. 21, 2023, https://shorturl.at/cQG5q. The Iranian article drew from *New York Times* reporting. See John Ismay, "Russia Is Replicating Iranian Drones and Using Them to Attack Ukraine," *New York Times*, Aug. 10, 2023, https://www.nytimes.com/2023/08/10/us/russia-iran-drones-ukraine.html.

[464] Joby Warrick, Souad Mekhennet, and Ellen Nakashima, "Iran Will Help Russia Build Drones for Ukraine War, Western Officials Say," *Washington Post*, Nov. 19, 2022, https://www.washingtonpost.com/national-security/2022/11/19/russia-iran-drones-secret-deal/.

[465] Sajen, "Iran's Drone Industry."

[466] "IntelBrief: Iran-Russia Drone Production Deal Draws Tehran Deeper into Ukraine War," The Soufan Center, Dec. 12, 2022, https://thesoufancenter.org/intelbrief-2022-december-12/.

[467] Michael Crowley, "U.S. Issues New Sanctions Targeting Iran's Missile and Drone Programs," *New York Times*, Oct. 18, 2023, https://www.nytimes.com/2023/10/18/us/politics/us-sanctions-iran-nuclear-deal.html.

[468] Kylie Atwood, "Russia to Build Attack Drones for Ukraine War with the Help of Iran, Intelligence Assessment Says," CNN, Nov. 21, 2022, https://edition.cnn.com/2022/11/21/politics/russia-iran-drones-intel-assessment/index.html.

[469] Natasha Bertrand, "Iran Helping Russia Build Drone Stockpile That Is Expected to Be 'Orders of Magnitude Larger' Than Previous Arsenal, US Says," CNN, July 25, 2023, https://www.cnn.com/2023/07/25/politics/us-russia-iran-drones/index.html.

on a larger scale than that in Iran and to introduce some improvements, such as enhancing quality control and developing an autonomous swarming capacity.[470]

According to the Institute for Science and International Security, a US NGO that reviewed the leaked documents for the *Washington Post*, the coproduction contract began in January 2023 and consists of three stages. First, the Russian plant would assemble fully made disassembled drones from Iran. Next, the Russian plant would assemble the drones on site with Iran providing the necessary components and training. Finally, the Russian plant would develop the capability to localize 80 percent of the production while continuing to import many electronic components.[471] According to recent reports, construction at the plant is ahead of schedule, and the plant had already provided 4,500 drones to the Russian military by the end of April 2024.[472]

Many US observers attribute Russia's decision to source drone technology from Iran to the need to fill gaps in production, substitute cheaper drones for more expensive missiles, and improve drone capabilities. Although Russian forces had drones for reconnaissance and surveillance, they lacked attack drones such as the Turkish Bayraktar TB2 drone that the Ukrainian forces used in the early months of the conflict.[473] Russian forces began to use Iranian drones to supplement their guided missiles, even if Ukrainian forces were able to shoot down 91 percent of these UAVs (compared to 89 percent of missiles).[474] Cost is a key factor—a Kalibr missile costs $6.5 million, a Kh101 cruise missile costs $10 million, and a Kinzhal missile costs $10 to $15 million, compared to $20,000 for a drone. For example, the attack by Russia on January 2, 2024, involved 99 missiles, most of which were intercepted, and cost $620 million, according to the Ukrainian military.[475] The Iranian drones are a cost-effective option, even if they are not of the highest quality. According to the UK Ministry of Defense, the Shahids do not necessarily destroy their intended targets but nevertheless are useful as decoys to divert Ukraine's air defense away from more capable Russian missiles.[476]

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[470] Dalton Bennett and Mary Ilyushina, "Inside the Russian Effort to Build 6,000 Attack Drones with Iran's Help," *Washington Post*, Aug. 17, 2023, https://www.washingtonpost.com/investigations/2023/08/17/russia-iran-drone-shahed-alabuga/.

[471] David Albright, Sarah Burkhard, and Spencer Faragasso, *Highlights of Institute Assessment of the Alabuga Drone Documents Supplied by Dalton Bennett and the Washington Post*, Institute for Science and International Security, Aug. 17, 2023, https://isis-online.org/isis-reports/detail/highlights-of-institute-assessment-of-alabuga-drone-documents.

[472] Benoit Faucon, Nicholas Bariyo, and Matthew Luxmoore, "The Russian Drone Plant That Could Shape the War in Ukraine," *Wall Street Journal*, May 28, 2024, https://www.wsj.com/world/the-russian-drone-plant-that-could-shape-the-war-in-ukraine-7abd5616.

[473] Douglas Barrie, "Explainer: Russia Deploys Iranian Drones," *The Iran Primer (USIP blog)*, Oct.17, 2022, https://iranprimer.usip.org/blog/2022/oct/12/explainer-russia-deploys-iranian-drones; Ellen Nakashima and Joby Warrick, "Iran Sends First Shipment of Drones to Russia for Use in Ukraine," *Washington Post*, Aug. 29, 2022, https://www.washingtonpost.com/national-security/2022/08/29/iran-drones-russia-ukraine-war/.

[474] Williams, "Russia Isn't Going to Run Out of Missiles." The extensive use of drones has resulted in a decline in interception rates of missiles because drones have helped to overwhelm Ukrainian air defenses. Alistair MacDonald et al., "Russia's Bombardment of Ukraine Is More Lethal Than Ever," *Wall Street Journal*, May 13, 2024, https://www.wsj.com/world/russias-bombardment-of-ukraine-is-more-lethal-than-ever-afd733c4.

[475] "Russia Spent US$620 Million on Missile Attack on 2 January, Forbes," *Ekonomichna Pravda*, Jan. 2, 2024, https://www.pravda.com.ua/eng/news/2024/01/2/7435545/.

[476] Brendan Cole, "Russia May Have Run Out of Iranian Shahed-136 Drones: U.K.," *Newsweek*, Feb. 25, 2023, https://www.newsweek.com/russia-run-out-iranian-shahed-136-drones-uk-1783805.

Other military aid

Ballistic missiles

The US fears that Iran is contemplating selling ballistic missiles to Russia in exchange for far-reaching defense cooperation.[477] Iran has so far refrained from doing so because of external political pressure and domestic opposition to a deepening commitment to Russia.[478] The expiration of UN controls on Iranian missile exports in October 2023 may give new impetus to ongoing talks between Russia and Iran. Russia is reportedly interested in the highly accurate Fateh-110 with a range of 300 kilometers and the Zolfaghar with a range of 700 kilometers, which can reach targets in eastern and central Ukraine.[479] An additional stockpile of missiles would help Russia to maintain pressure on Ukraine's air defenses.[480] Although there were reports in February 2024 that a deal had been concluded and some missiles had already been transferred,[481] as of April 2024, no Iranian ballistic missiles had been detected in use against Ukraine.[482]

Ammunition and artillery shells

Iran has played a key role in replenishing Russian supplies of ammunition and artillery shells. From November 2022 through April 2023, Iran shipped 300,000 artillery shells and 1 million rounds of ammunition across the Caspian Sea to Russia.[483] Documents obtained by British Sky News show that Iran is taking advantage of Russia's need for the ammunition by charging above market rates.[484] Howitzer shells with Chinese markings found on the battlefield in Ukraine in June 2023 were apparently part of a lot provided by China to Iran in the 1980s and recently reexported to Russia.[485]

United Arab Emirates

Despite Western pressure, the UAE has continued to maintain good relations with Russia and has elected not to join the Western sanctions regime. Notably, Emirati president Shaikh Mohammed bin Zayed recently participated in the St. Petersburg Economic Forum.[486] In December 2022, the Russian-

[477] Jeff Mason and Steve Holland, "White House: Iran May Be Considering Providing Ballistic Missiles to Russia," Reuters, Nov. 21, 2023, https://www.reuters.com/world/white-house-iran-may-be-considering-providing-ballistic-missiles-russia-2023-11-21/.

[478] Julian Borger, Peter Beaumont, and Dan Sabbagh, "Iran Has Not Sent Ballistic Missiles to Russia So Far, Says Ukrainian Official," *Guardian*, Dec. 6, 2022, https://www.theguardian.com/world/2022/dec/06/mikhailo-podolyak-iran-has-not-sent-ballistic-missiles-to-russia-so-far-says-ukrainian-official.

[479] Bohdan Tuzov, "Analysis: The Iranian Missiles Could Soon Be Heading to Russia," *Kyiv Post*, Oct. 12, 2023, https://www.kyivpost.com/analysis/22648.

[480] Michael R. Gordon, Gordon Lubold, and Benoit Faucon, "Russia Moves Forward with Plans to Buy Iranian Ballistic Missiles," *Wall Street Journal*, Jan. 4, 2024, https://www.wsj.com/world/russia-moves-forward-with-plans-to-buy-iranian-ballistic-missiles-cf3560e4.

[481] Hafezi et al., "Exclusive: Iran Sends Russia Hundreds of Ballistic Missiles."

[482] Hans von der Burchard, "G7 Gives Iran Sharp Warning Not to Send Ballistic Missiles to Russia," *Politico*, Apr. 19, 2024, https://www.politico.eu/article/g7-gives-iran-sharp-warning-not-to-send-ballistic-missiles-to-russia/.

[483] Dion Nissenbaum and Benoit Faucon, "Iran Ships Ammunition to Russia by Caspian Sea to Aid Invasion of Ukraine," Apr. 24, 2023, *Wall Street Journal*, https://www.wsj.com/articles/iran-ships-ammunition-to-russia-by-caspian-sea-to-aid-invasion-of-ukraine-e74e8585.

[484] "Iran Cashes In on Russia Running Low on Munition," Iran International, June 5, 2023, https://www.iranintl.com/en/202306052171; Deborah Haynes, "Arms Contract Shows Iran Has Sold Russia Ammunition for Ukraine War, Says Security Source," Sky News, June 5, 2023, https://news.sky.com/story/arms-contract-shows-iran-has-sold-russia-ammunition-for-ukraine-war-says-security-source-12896127.

[485] "Breaking News: China Provides Ammunition to Russia? Evidence: 152mm Ammunition Clearly Has Chinese Characters Written on It [突发快讯，中国为俄提供弹药？证据：152毫米弹药赫然写着中国]," NetEase, June 28, 2023, https://www.163.com/dy/article/I8BLR6DL05562BTO.html.

[486] Andrew Osborn, "Putin Thanks UAE Leader for Ukraine Help, Hails Growing Economic Ties," Reuters, June 13, 2023, https://www.reuters.com/world/putin-thanks-uae-leader-ukraine-help-hails-growing-economic-ties-2023-06-16/.

led Eurasian Economic Union decided to pursue a free trade agreement with the UAE. In connection with this transaction, Russia and the UAE are reportedly pursuing a bilateral trade and investment agreement.[487] Trade with the UAE has been especially strong in recent years and is now approaching $10 billion per annum, surpassing Moscow's trade with all other Arab countries.[488]

Cooperation on both military and dual-use technology has continued apace. In addition to microchip exports, the UAE transferred 158 civilian drones valued at $600,000 to Russia in 2022.[489] Beyond parallel import, technology cooperation has been less well developed, characterized primarily by several low-level engagements.

In the military domain, the UAE sent an army delegation to Russia in 2017, and the two sides reached an agreement to enhance cooperation between their respective ground forces. As part of this effort, the UAE delegation also visited enterprises of the military industrial complex to explore avenues of cooperation.[490] At the 2021 IDEX arms exhibition held in Abu Dhabi, Russia reportedly held talks with the UAE's Tawazun Economic Council, Mubadala Investment Company, and EDGE Group about joint production of composite materials and telecommunications for Russia's fifth-generation Su-57 Checkmate fighter, although no agreements were announced.[491]

Moreover, in 2021, the UAE's Tawazun Foundation invested €90 million to acquire a 49.9 percent stake in Russian design bureau VR-Technologies, which focuses on rotary-wing aircraft design.[492] In 2023, the US Department of the Treasury disclosed that UAE firm Hulm Al Sahra had been involved with a Russian company in joint development and manufacture of thermoelectric air conditioners for military vehicles.[493] Russia also participated in IDEX 2023, featuring more than 200 full-scale samples of its latest weaponry for regional arms purchasers.[494]

The two sides are also cooperating with respect to dual-use technologies. In 2021, for example, the two sides signed an intergovernmental agreement on peaceful space exploration and a separate document on future cooperation in the aviation and hydrogen industries.[495] Recently, Russia and the UAE agreed

[487] Aysel Gereykhanova, "Five and Common Markets [Пятерка И Общие Рынки]," *Rossiiskaia Gazeta*, Dec. 12, 2022; "Russia-UAE: 2023-24 Trade and Investment Dynamics," Russia Briefing, Aug. 20, 2023, https://www.russia-briefing.com/news/russia-uae-2023-24-trade-and-investment-dynamics.html/.

[488] Veniamin Popov, "The Middle East Finds Its Identity [Ближний Восток обретает свою идентичность]," *Nezavisimaia Gazeta*, Sept. 18, 2023, https://www.ng.ru/dipkurer/2023-09-17/12_8828_east.html.

[489] Nikita Smagin, "Is the Blossoming Relationship Between Russia and the UAE Doomed?," Carnegie Politika, Apr. 13, 2023, https://carnegieendowment.org/politika/89531.

[490] "A Bilateral Meeting of Military Delegations of the Ground Forces of the United Arab Emirates and Russia Took Place in Moscow [В Москве прошла двухсторонняя встреча военных делегаций сухопутных войск Объединенных Арабских Эмиратов и России]," Russian Ministry of Defense, June 13, 2023, https://function.mil.ru/news_page/country/more.htm?id=12470299@egNews.

[491] "Russian Firm Eyes Options in Middle East for 'Joint Production' of Tech, Including 5th-Gen Fighters," Breaking Defense, Feb. 20, 2023, https://breakingdefense.com/2023/02/russian-firm-eyes-options-in-middle-east-for-joint-production-of-tech-including-5th-gen-fighters/.

[492] Sergey Safronov, "Andrey Boginsky: We Are Waiting for the First Contract for Ansat with the Aurus VIP Cabin," *Defense & Security*, Nov. 25, 2021.

[493] "Treasury Targets Russian Financial Facilitators and Sanctions Evaders Around the World."

[494] "Rosoboronexport to Propose New Joint Industrial Cooperation Projects at IDEX 2023," Rosoboronexport.ru, Feb. 16, 2023, http://roe.ru/eng/press-service/press-releases/rosoboronexport-to-propose-new-joint-industrial-cooperation-projects-at-idex-2023/.

[495] "Foreign Minister Sergey Lavrov's Statement Following Talks with UAE Minister of Foreign Affairs and International Cooperation Abdullah bin Zayed bin Sultan Al Nahyan, Moscow, March 17, 2022," Russian Ministry of Foreign Affairs, Mar. 17, 2022, https://mid.ru/en/maps/ae/1804836/.

to participate in the newly created International Association of BRICS+ Universities, a consortium of leading universities from the BRICS countries whose mission includes joint R&D.[496] In 2019, Russia's Ministry of Industry and Trade noted that the two countries were cooperating on civil aviation, including development of new prototypes.[497] The extent to which technology cooperation with the UAE will deliver tangible results for Russia's defense industry remains unclear, however. Although tensions exist in US-UAE relations, the UAE remains highly dependent on the US for both its national and economic security. Thus, Western pressure on the UAE to comply with Western sanctions will likely constrain the country's willingness to engage in technology cooperation with Russia, at least to some extent.

[496] Maria Nabirkina, "Mission Possible [Миссия Выполнима]," *Rossiiskaia Gazeta*, Oct. 10, 2023.

[497] Mikhail Yushkov, "Ministry of Industry and Trade Reported Possible Delivery of Aircraft and Helicopters to the UAE," *Defense & Security*, Oct. 14, 2019.

APPENDIX C: TRENDS IN RUSSIAN PURCHASES OF IMPORTED MACHINE TOOLS

The UN Comtrade database provides a more detailed and complicated view of Russian dependence on imported machine tools.[498] This database lists four types of advanced metalworking machine tools:

1. Machine tools; for working any material by removal of material, by laser or other light or photon beam, ultrasonic, electro-discharge, electro-chemical, electron beam, ionic-beam, or plasma arc processes; water-jet cutting machines (code 8456)
2. Machining centers, unit construction machines (single station) and multi-station transfer machines for working metal (code 8457)
3. Lathes; for removing metal, horizontal, numerically controlled (code 845811)
4. Lathes; for removing metal, numerically controlled, other than horizontal lathes (code 845891)

Even if the data from the database are approximate and do not reflect the complete picture, the numbers in Table 17 demonstrate clear trends. Because the total domestic machine tool market in Russia in 2022 was worth approximately $4 billion (275 billion rubles), the four listed categories of imported metalworking machine tools represent a quarter of this market.[499] Therefore, imported metalworking machine tools still play a crucial role for the Russian machine-building industries, including arms manufacturing.

At the same time, the average cost of each machine tool unit in each category demonstrates that

Table 17. Import of specific categories of metalworking machine tools in Russia, 2017–2022 and January–November 2023, in millions of US dollars

Code	2017	2018	2019	2020	2021	2022	Jan–Nov 2023
8456	114	127	118	140	165	191	205
8457	224	241	196	174	213	195	364
845811	176	152	153	182	160	189	282
845891	34	58	51	40	50	37	26
Total	**548**	**577**	**517**	**536**	**593**	**613**	**878**

Source: UN Comtrade database.

[498] UN Comtrade Database, https://comtradeplus.un.org.

[499] Government of the Russian Federation, *Russian Government Strategy for the Development of Manufacturing Industry Through 2030 and the Period Through 2035*, Sept. 9, 2023, p. 6, http://government.ru/docs/all/149530/?page=6.

Russian manufacturing industries have shifted to purchasing cheaper machining centers (code 8457) and numerically controlled lathes (codes 845811 and 845891) since losing direct access to Western machine tools in 2022. The decrease in average cost shown in Table 18 means that even after accounting for inflation and additional costs related to logistics and financial transactions of parallel import, Russian companies are purchasing fewer advanced metalworking machine tools.

Table 18. Average cost of imported metalworking machine tools in Russia, 2017–2022 and January–November 2023, in US dollars

Code	2017	2018	2019	2020	2021	2022	Jan–Nov 2023
8456	3,855	2,909	2,811	2,880	3,096	3,063	3,161
8457	138,859	155,003	212,824	168,112	148,497	55,367	70,764
845811	58,223	94,475	104,079	86,052	67,862	47,582	49,839
845891	97,451	150,808	178,157	86,903	113,802	110,871	52,034

Source: UN Comtrade database.

FIGURES

TABLES

ABBREVIATIONS

AI	artificial intelligence
ALCM	air-launched cruise missile
AMD	Advanced Micro Devices, Inc.
CAR	Conflict Armament Research
CNC	computer numerical control
CPU	central processing unit
DIA	Defense Intelligence Agency
DPRK	Democratic People's Republic of Korea
EU	European Union
EW	electronic warfare
FPV	first-person view
GDP	gross domestic product
ISR	intelligence, surveillance, reconnaissance
IT	information technology
ITAR	International Traffic in Arms Regulations
KEMZ	Kovrov Electro-Mechanical Plant
MOD	Ministry of Defense (Russia)
NATO	North Atlantic Treaty Organization
NGO	nongovernmental organization
NIS	National Intelligence Service (South Korea)
nm	nanometer
OCCRP	Organized Crime and Corruption Reporting Project
ODNI	Office of the Director of National Intelligence
PRC	People's Republic of China
R&D	research and development
RFE/RL	Radio Free Europe/Radio Liberty
RUSI	Royal United Services Institute
SCO	Shanghai Cooperation Organization
STC	Special Technological Center
TEL	transporter erector launcher
TI	Texas Instruments
TSMC	Taiwan Semiconductor Manufacturing Company
UAC	United Aircraft Corporation

UAE	United Arab Emirates
UAV	uncrewed aerial vehicle
UK	United Kingdom
UN	United Nations
USIP	United States Institute of Peace

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DRM-2024-U-038857-1Rev