

APRIL 2023

Out of Stock? Assessing the Impact of Sanctions on Russia's Defense Industry

AUTHORS

Max Bergmann
Maria Snegovaya
Tina Dolbaia
Nick Fention

CONTRIBUTOR

Samuel Bendett

A Report of the CSIS Europe, Russia, and Eurasia Program

CSIS | CENTER FOR STRATEGIC &
INTERNATIONAL STUDIES

APRIL 2023

Out of Stock? Assessing the Impact of Sanctions on Russia's Defense Industry

AUTHORS

Max Bergmann
Maria Snegovaya
Tina Dolbaia
Nick Fenton

CONTRIBUTOR

Samuel Bendett

A Report of the CSIS Europe, Russia, and Eurasia Program

About CSIS

The Center for Strategic and International Studies (CSIS) is a bipartisan, nonprofit policy research organization dedicated to advancing practical ideas to address the world's greatest challenges.

Thomas J. Pritzker was named chairman of the CSIS Board of Trustees in 2015, succeeding former U.S. senator Sam Nunn (D-GA). Founded in 1962, CSIS is led by John J. Hamre, who has served as president and chief executive officer since 2000.

CSIS's purpose is to define the future of national security. We are guided by a distinct set of values—nonpartisanship, independent thought, innovative thinking, cross-disciplinary scholarship, integrity and professionalism, and talent development. CSIS's values work in concert toward the goal of making real-world impact.

CSIS scholars bring their policy expertise, judgment, and robust networks to their research, analysis, and recommendations. We organize conferences, publish, lecture, and make media appearances that aim to increase the knowledge, awareness, and salience of policy issues with relevant stakeholders and the interested public.

CSIS has impact when our research helps to inform the decisionmaking of key policymakers and the thinking of key influencers. We work toward a vision of a safer and more prosperous world.

CSIS does not take specific policy positions; accordingly, all views expressed herein should be understood to be solely those of the author(s).

© 2023 by the Center for Strategic and International Studies. All rights reserved.

Center for Strategic & International Studies
1616 Rhode Island Avenue, NW
Washington, DC 20036
202-887-0200 | www.csis.org

Acknowledgments

Special thanks and recognition to Samuel Bendett, whose expertise, direction, and insight were vital to the production of this report.

The research team thanks the Center for Army, Conversion, and Disarmament Studies' (CACDS) experts—Mykhailo Samus and Volodymyr Solovian—for their assistance with data gathering, fact checking, and written analysis. The research team is grateful to Manya Mirzoyan, research intern with the CSIS Europe, Russia, and Eurasia Program, for tracking valuable Russian-language defense data and assisting with the written analysis. The authors also thank Michael Naki and the members of the Conflict Intelligence Team (CIT) for providing information regarding Russian weapons systems and the Kremlin's import-substitution efforts. Finally, the authors would like to express their gratitude toward Dara Massicot, Paul Schwartz, Jack Watling, Clint Reach, Pavel Luzin, Sijbren de Jong, and Ian Williams for providing feedback on the paper and helping the research team improve this piece.



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.

Contents

Executive Summary	1
Introduction	2
Russia's Capacity to Deliver Key Military Equipment and Technology	4
The Kremlin's Existing Vulnerabilities	13
Russia's Sanctions Adaptation Strategy	17
Conclusion	22
About the Authors and Contributors	26
Endnotes	28

Executive Summary

This report examines the overall impact of Western sanctions and allied export regulations on Russia's defense sector to date, as well as the Kremlin's ability to overcome them. First, it analyzes Russia's supply and production of the core weapons and systems that make up its war machine, including tanks, missiles, uncrewed aerial vehicles, aircraft, and electronic warfare systems. It also looks at the key foreign components, restricted by the allied export control measures, needed to produce high-end Russian defense technology, such as optical systems, bearings, machine tools, engines, and microchips. Second, the report examines the Kremlin's efforts to mitigate the ramifications of the international sanctions regime through methods such as import substitution and sanctions-evasion techniques.

The report finds that sanctions create shortages of higher-end foreign components and force Moscow to substitute them with lower-quality alternatives. For now, Moscow's efforts at state-backed import substitution remain largely unsuccessful. This ultimately impacts Russia's ability to manufacture, sustain, and deliver advanced weapons and technology to the battlefield in Ukraine. Therefore, while the quality of the military equipment used by the Ukrainian army continues to improve thanks to the Western aid, the quality of Russia's weapons continues to degrade. At the same time, the Kremlin still possesses a significant degree of adaptability to Western sanctions, taking advantage of its prewar stockpiles of older equipment, as well as countries willing to supply Moscow with restricted dual-use items and technology via a web of illicit supply chains. Overall, the Kremlin still has the capacity to fight this war in the longer term.

The report concludes that considering these limitations, Russia will opt for a slower-paced attritional campaign in Ukraine, putting pressure on Kyiv and its Western partners, but thereby further stressing its military and industrial base already stretched thin by sanctions and the last 12 months of the invasion.

Introduction

Following Russia’s invasion of Ukraine on February 24, 2022, the United States—along with its allies and partners—introduced an unprecedented set of sanctions and export-control restrictions targeting Russia’s military industrial complex, placing Russian and Belarusian firms operating “in the defense and related materiel, aerospace, electronics, marine, or technology sectors” on the sanctioned entity list.² This restricted the flow of sensitive dual-use U.S.-origin technology and software, as well as foreign technology and software made using U.S.-origin products, to the sanctioned companies.³ Many allied nations in Europe and East Asia, from which Russia would typically purchase such items, have issued similar directives.

As a result of these measures, Moscow has reportedly faced challenges accessing the foreign-made components necessary to produce and sustain a range of weapons systems, from missiles to tanks and aircraft.⁴ Western officials have struck an optimistic tone, with U.S. secretary of commerce Gina Raimondo remarking in April 2022, “The Russian military is struggling to find spare parts for their tanks, for their satellites, for their rocket-mounting systems,” adding that the international sanctions regime had blocked Russian access to “almost all semiconductors, night-vision goggles, avionics.”⁵ Similarly, in February 2023, U.S. deputy secretary of the treasury Wally Adeyemo declared, “Today, Russia can’t produce enough arms to meet their basic needs,” and described the Russian economy as “nothing like the Russian economy you saw before the invasion.”⁶ Yet despite these statements, multiple indicators suggest that the Kremlin has created new ways to circumvent export-control restrictions and secure much-needed foreign components to sustain and produce its weapons systems and wage war on Ukraine.

This report examines the practical ramifications of Western sanctions on Russia’s military industrial base to date and the Kremlin’s ability to overcome them. It does so by analyzing Russia’s defense production capabilities and limitations, including the specific military equipment and technology that Moscow may be able to replace domestically or will struggle to produce going forward, as well as defense capabilities the Kremlin is prioritizing one year into the war.

The unprecedented sanctions and export controls are no doubt having a negative effect on Russia's industrial complex. Moscow is under pressure to adapt, often turning to less-reliable and costlier suppliers and supply routes, lower-quality imports, or trying to reproduce Western components internally. This is likely hampering the rate and quality of Russian defense production. Nevertheless, available evidence indicates that the Kremlin will still be able to maintain its war efforts in Ukraine. Sanctions and export controls are not a silver bullet that will force Russia to bring the war to an end. Russia's large prewar equipment stockpiles, its massive military industrial complex, and the prioritization of defense production (especially for parts and components also used in civilian industrial sectors) as part of Moscow's wartime mobilization are likely to enable the Kremlin to continue to wage war in Ukraine, albeit with limitations.

This does not mean that sanctions and export controls are not having a battlefield impact. The quality of the Russian military in terms of advanced equipment will likely decline, at least over the near term. Russia's ability to conduct offensive operations that require precision and coordination may be further limited, leading Moscow to rely on potential manpower advantages. Meanwhile, if Western aid continues, the equipment used by the Ukrainian army may continue to improve. Thus, the quality of military equipment used by the Ukrainian and Russian militaries are currently going in opposite directions—and as quality suffers, so will Moscow's ability to match the North Atlantic Treaty Organization (NATO) conventionally or maintain a vibrant high-end export market for its defense systems. Sanctions and export controls are therefore having an important impact on Russia's military, which will be felt on the battlefield and into the future.

Expounding upon these points, this report first examines the ability of the Russian defense sector to field the core weapons and systems that make up its war machine. More specifically, it analyzes Moscow's supply and production of tanks, missiles, uncrewed aerial vehicles (UAVs), aircraft, and electronic warfare (EW) systems. Next, the report looks at the impact of sanctions on the Russian procurement capacity of key foreign components needed to produce high-end defense technology, from advanced tanks to EW devices. These components include optical systems, bearings, machine tools, engines, and microchips. The paper then turns to the Kremlin's efforts to adapt to the international sanctions regime through methods such as import substitution and sanctions-evasion techniques like illicit trade via land corridors. Finally, the report presents concluding assessments of the impact of international sanctions on the Russian war effort in Ukraine, before outlining a list of recommendations to Western policymakers working to tighten the sanctions net.

Russia's Capacity to Deliver Key Military Equipment and Technology

Since the start of the 2022 invasion, Russia's Ministry of Defense has classified all information on military equipment and technologies lost in Ukraine. Yet reliable estimates exist from Oryx, a Dutch open-source intelligence website, which lists destroyed, damaged, abandoned, and captured Russian weapons systems.⁷ Oryx only documents losses for which there is visual proof, meaning that its accounting likely represents the lower bound for equipment losses, as there are inevitably battlefield losses without any publicly available corroborating visual evidence. Based on this list, one year into the war, Moscow is no longer in possession of more than 9,700 pieces of military equipment and technology. In addition to Oryx, the Armed Forces of Ukraine (ZSU) also releases data on Russian equipment losses through daily reports, claiming that Russian losses are at least twice as high as Oryx estimates (see **Table 1**).⁸ While the ZSU has access to significantly more information than open-source analysis does, there may also be incentives for Kyiv to over-report battlefield successes. The CSIS research team therefore views these numbers as lower and upper bounds documenting the lost Russian weapons systems.

Table 1: Oryx vs. ZSU Data Showcasing Russian Equipment Losses as of March 18, 2023

Lost Russian weapons systems*	Oryx data Lower bound	ZSU data Upper bound
Armor, including tanks, trucks, and jeeps	7,733	15,745
Artillery systems	641	2,560
Uncrewed aerial vehicles (UAVs)**	201	2,159
Multiple launch rocket system (MLRS)	181	506

Aircraft and helicopters	157	595
Missile systems	139	907
Naval ships	12	18

Source: ZSU data was acquired from the Kyiv Independent (@KyivIndependent) official Twitter account and Oryx data was acquired from the Oryx website. Please reference endnotes 7–8 for more information.

* These estimates will most likely be higher by the time this report is published, as Russia continues to experience daily vehicle, weapons, and manpower losses in Ukraine.

** The CSIS research team believes that the stark difference in the UAV data has to do with the chosen methodologies. The Oryx investigators count the losses of military UAVs, including the Orlan-10 and Eleron-3, while the Ukrainian side counts losses of all types of UAVs, including commercial drones and quadcopters purchased by Russia from third countries.

Despite the conflicting data, the levels of equipment losses experienced in Ukraine are clearly unprecedented for post-Soviet Russia, and much higher than the Kremlin’s total equipment losses recorded during the first (1994-1996) and second (1999-2000) Chechen wars and in the 2008 Russo-Georgian war.⁹ But Russia’s military capabilities still greatly outnumber those of Ukraine on most indicators, including man-, air-, land, and naval power. While an accurate count of Moscow’s current military stocks is not available publicly, it has been roughly estimated that, as of February 2023, the total number of aircraft at the Kremlin’s disposal has been 13-15 times more than Kyiv’s. Russia has nearly 7-8 times more tanks and 4 times more armored fighting vehicles, while its naval fleet is 12-16 times larger than Ukraine’s.¹⁰ Yet many Russian stockpiled munitions are also older and of lesser quality, with many also requiring refurbishment before they are battle ready.¹¹

Therefore, although Russia retains a formidable arsenal numerically, it is nonetheless important to evaluate its current capacity to deliver key military equipment and technologies to the battlefield in Ukraine. This, in turn, will aid a broader analysis of Moscow’s sanctions-affected defense production capabilities. While Russia relies on a wide range of conventional munitions in Ukraine, the authors of this report have examined the following five weapons systems and technologies widely regarded as crucial to Moscow’s war effort: tanks, missiles, UAVs, aircraft, and EW technologies.

TANKS

Armor, especially main battle tanks (MBTs), remains one of the chief strengths of Russia’s defense industry.¹² Moscow is estimated to have lost anywhere from 1,845 to 3,511 tanks one year into the war—but is thought to hold around 5,000 old tanks in reserve.¹³ Recent reports claim that Moscow has experienced particularly heavy losses of its modern T-72B3 MBT—which was delivered in 2013 as an upgraded version of the T-72B MBT.¹⁴ This has ultimately forced Russia to bring older tanks, manufactured several years and sometimes decades prior to the start of Russia’s military modernization program in 2011, into service as replacements.¹⁵

Furthermore, the rather rare appearance of more advanced equipment such as the T-90A and T-90M third-generation MBTs or the modernized T-80BVM MBT may suggest that they have been intentionally kept off the front lines. In 2020, reliable Russian-language military sources indicated that around 700 T-90 and T-80 MBTs and up to 2,000 mainline T-72 MBT variants were held in Russian military service. By that time, Russia was also estimated to have had 200 T-90, 3,000 T-80, and 7,000 T-72 MBTs in storage—along with thousands of older T-54/T-55/T-62 tanks.¹⁶ As mentioned above, many of these older tanks, including the T-54s and T-55s, have been taken out of storage and sent to the front in Ukraine to supplement earlier losses.¹⁷



An abandoned Russian T-72 tank in eastern Ukraine in September 2022.

Source: Juan Barreto/AFP/Getty Images

The evidence also suggests that the demand on modern MBTs outstrips the current production rate. For instance, Russian liberal media has reported that UralVagonZavod, a Russian plant producing tanks, can only make 20 tanks per month. By contrast, Russia has lost at least 148 tanks each month, based on Oryx estimates.¹⁸ Recently, deputy head of the Russian security council Dmitry Medvedev has claimed that the Russian military industrial complex will produce 1,500 modern MBTs in 2023—a statement that independent Russian military experts have assessed as “absolutely impossible.”¹⁹ Some have also suggested that, while it is unlikely that the Kremlin will manufacture 1,500 completely new MBTs, instead Moscow may largely modernize its Soviet-era tanks, equipping them with new communications systems, electronics, and other components. According to a source close to the Russian Ministry of Defense, even though the ministry plans to produce several hundred new T-90M and T-14 MBTs, it will allegedly mostly upgrade its T-80, T-72, and older T-62 tanks.²⁰ Therefore, while the Russian military industrial complex may struggle to roll out new MBTs, its domestic defense enterprises might be adapting to the challenges brought about by sanctions by repurposing older equipment for tanks and other armored vehicles.²¹ This may enable them to resurrect around 90 older MBTs per month, by some accounts.²²

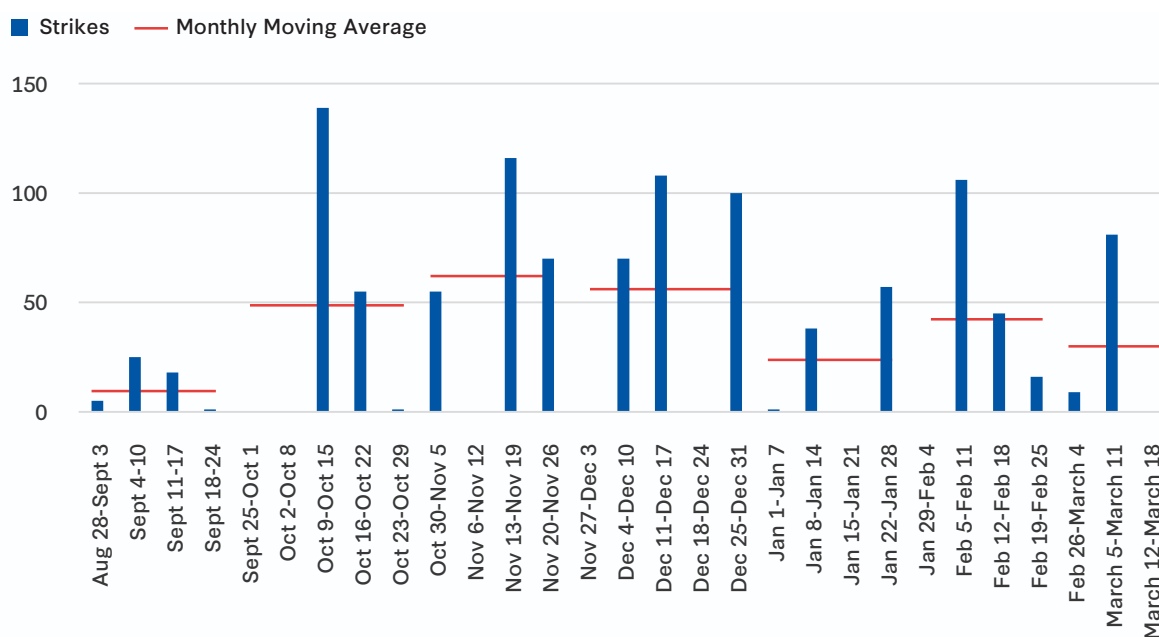
Overall, even though Russia has lost a sizable share of its prewar tank fleet—up to 40 percent, according to some estimates—it likely retains some of its post-2011 MBT stockpiles, as well as large amounts of the Cold War-era tanks and defense industrial capacity to repair and modernize this equipment.²³ Therefore, the Kremlin will likely be able to maintain the supply of tanks to its forces in Ukraine for some time.²⁴ However, in the longer term, the allied export restrictions on certain key Western spare parts used in modern tank production—discussed in detail in the following section—may significantly degrade Moscow’s defense industrial capacity to manufacture advanced MBTs.

MISSILES

Missiles have played an important role in Moscow’s offensive military operations against Kyiv. While Russia has reportedly fired around 5,000 missiles and lost at least 139 missile systems within the past year (see Table 1), exact information about the Kremlin’s initial and remaining stockpiles is extremely difficult to ascertain.²⁵

Figure 1 depicts the total weekly numbers of missiles that Russia used to strike military and civilian targets in Ukraine between late August 2022 and mid-March 2023. While patterns of greater strike frequency tend to follow periods of relative inactivity, it cannot be decisively concluded solely from this data that the Kremlin currently experiences serious issues with its missile stockpiles.

Figure 1: Average Number of Missiles Russia Launched against Ukraine, August 2022 to March 2023



Source: Based on data compiled by the CSIS Europe, Russia, and Eurasia team with assistance from the Conflict Intelligence Team using open-source data.

The major issue for Ukraine is that while its air defense capabilities have expanded and improved, giving it an ability to defend against many types of Russian missiles, it does not have an ability to intercept some of Moscow’s newer and more advanced systems, including the hypersonic Kinzhal missiles, as well as older but repurposed munitions such as the S-300 missiles.²⁶ For instance, during a March 9 missile barrage, Ukraine was only able to intercept 38 of the 81 missiles that Russia had fired.²⁷ Kyiv is expected to receive the Patriot missile defense systems and the SAMP/T-MAMBA air defense system from its Western partners sometime in spring 2023, which should give it a greater ability to defend against Russian missiles.²⁸ However, a critical question is how long Moscow can sustain its barrage of Ukrainian targets with more advanced missile systems.

This also raises questions both about Russia’s ability to produce new missiles and its depth of stockpiles. According to James O’Brien, head of the office of sanctions coordination at the U.S. Department of State, Russia can currently make around 60 to 90 “missiles and strategic weapons” per month.²⁹ Moscow does not provide such data, but it asserts that it has sufficient reserves of long-range precision munitions and that Russian factories are also currently producing more of these weapons, claims that are backed by some Western and Ukrainian sources.³⁰ For instance, evidence documented by Conflict Armament Research (CAR) suggests that the two Kh-101 latest-generation air-to-surface long-range cruise missiles deployed by the Russian Armed Forces in a November 2022 attack in Ukraine had been almost certainly produced no more than two months before their use.³¹ More recently, Ukraine’s military intelligence has reported that Russia makes around 30 Kh-101s and 20 Kalibrs a month.³² Moscow’s ability to make

advanced cruise missiles such as the Kh-101 and Kalibr could indicate that it has found ways to acquire foreign-produced microelements by circumventing existing export regulations—or that it accrued significant stockpiles of those components in the years preceding the 2022 invasion.³³ If the latter stands true and foreign electronics used in Russian missiles today were purchased and stockpiled before February 2022, once this supply decreases due to the war and export controls, missile production will also be affected.

In fact, some experts believe that there are already very visible signs of Moscow’s long-range precision-missile stocks decreasing, while their production rate may not be sufficient to enable Moscow to continue frequent missile strikes.³⁴ In late November 2022, Ukrainian minister of defense Oleksii Reznikov stated that the Kremlin had lost around 24 percent of its ground-, sea-, and air-launched high-precision missiles. These numbers included reduced stocks of the Kalibr and Kh-101 inventories (around 37 percent and 50 percent of the initial stocks, respectively).³⁵ More recent reports from the front also suggest that the Kremlin might be running out of its modern Iskander ballistic munitions.³⁶

These stockpile losses might have diminished Russia’s ability to sustain the current rate of fire using modern precision-guided munitions, ultimately forcing Moscow to rely on its older and less accurate, yet more generous, missile arsenal and, in certain cases, draw on its stockpiles of nuclear delivery systems to sustain conventional missile strikes.³⁷ For instance, Russia has repurposed its S-300 surface-to-air defense missiles to hit ground targets in Ukraine.³⁸ While, as mentioned above, the S-300s are difficult to intercept, they are also less accurate, often exploding hundreds of yards from their initial targets.³⁹ Moscow has also repurposed its anti-ship missiles like the Onyx to strike surface targets, as well as the older Kh-55 missiles—initially designed to carry nuclear warheads—allegedly to exhaust Kyiv’s air defenses.⁴⁰



A Russian S-300 missile system presented during the Victory Day parade on May 9, 2015.

Source: Handout/Getty Images Europe

Even though in a March 9 air strike Russian forces fired six new hypersonic Kinzhal missiles, resulting in a much higher than usual success rate, such powerful munitions have been very rarely used in Ukraine (usually, to hit targets of high importance such as the Ukrainian energy infrastructure). Kyiv claims Moscow to have no more

than 50 Kinzhals in storage, which can explain why they are deployed at much lower rates in Ukraine.⁴¹ There is also a limit to how many prestige weapons systems Russia can expend in Ukraine without undermining its defense posture against NATO and other militarily advanced countries. To put Russia's missile stockpiles in perspective, a recent RAND Corporation report found that building up large stockpiles of long-range precision-strike missiles was viewed by the Russian military as vital to deterring NATO. Using publicly available targeting information from Western campaigns and Russian theoretical writings, RAND estimated that large military areas, such as airfields, would need around 30-60 cruise missiles, and critical military facilities and complex air defense structures might require 75-100.⁴² Going forward, without an assured supply chain to manufacture more, the Kremlin might have to retain a large proportion of its already decreasing long-range precision munition stockpiles, ultimately restricting the ability of the Russian Armed Forces to frequently strike Ukraine with missiles in the coming months—leaving them to rely more on long-range drone strikes, as discussed below.

Overall, Russia is likely depleting its stockpile of advanced long-range precision munitions in Ukraine. However, it has demonstrated an ability to continue to manufacture new missiles, albeit at a slower pace, and has stockpiles of older and less precise systems. As Kyiv acquires additional advanced Western air defense, this may impact Russia's willingness to expend its precious, hard-to-produce advanced missile systems in Ukraine.

UNCREWED AERIAL VEHICLES

UAVs, including combat drones, remain one of Moscow's pivotal combat elements against Ukraine. According to the Kremlin, at the start of the war in February 2022, Russian troops had approximately 2,000 military drones of all types at their disposal across the services and military commands.⁴³ By the end of 2022, several hundred of these drones had been destroyed by Ukrainian air defense, EW countermeasures, or Russian pilot errors. Still, Russian-made UAVs—including the Orlan-10 intelligence, surveillance, and reconnaissance (ISR) and Lancet-3 loitering kamikaze drones—continue to fly in Ukraine, indicating that this pivotal aerial capability matches at least part of Moscow's demand for ISR and combat missions against Kyiv.⁴⁴



A downed Russian drone in Kyiv in March 2022.

Source: Aris Messinis/AFP/Getty Images

Since the start of the war, Russian officials have stressed the importance of launching a large-scale production of UAVs of various kinds.⁴⁵ Russian defense conglomerate Rostec also confirmed in January 2023 that it is manufacturing new reconnaissance and combat drones, albeit without providing any production rate numbers.⁴⁶ However, recent statements by Russian UAV industry representatives suggest that due to high demand, domestic defense enterprises might be struggling to provide UAV-related IT solutions, as well as necessary information security products and equipment.⁴⁷

To compensate for the existing domestic constraints with UAV manufacturing, the Kremlin has increased its reliance on Chinese commercial drones despite their limited range and capabilities as civilian-designed UAVs.⁴⁸ Most of these civilian drones are produced by Chinese tech companies, including Da-Jiang Innovations Science & Technology Co. (DJI), and up until recently could have been purchased through the Chinese online retail service AliExpress. In an effort to restrict these drones' use on the battlefield in Ukraine, AliExpress has temporarily restricted Russians from buying DJI drones as of March 2, 2023, and those already purchased will allegedly have their functionality limited.⁴⁹ This may reflect a concern among China-based companies of being subject to potential secondary sanctions from the West. However, these drones can be purchased from other countries and ultimately shipped to Russia. There is also a continuous flow of DJI quadcopters to the front due to Russian volunteers' organized procurement efforts.

Russia has also received—and will likely continue to receive—loitering (kamikaze) UAVs from Iran and commercial DJI-type quadcopters and multirotor UAVs via supply chains from the United Arab Emirates, Hong Kong, and Singapore as late as November and December 2022.⁵⁰ Moscow is particularly interested in acquiring up to 6,000 Iranian drones due to their low cost and apparent ease of operation.⁵¹ The Shahed-136 (flying under a Russian Geran-2 name), for example, an Iranian drone frequently used by the Russian military against Ukrainian energy infrastructure and military targets, is relatively cheap with a price range of around \$20,000 to \$50,000 per unit.⁵² Moscow's potential acquisition of more Iranian loitering drones—whether via a transfer or by constructing a UAV-manufacturing factory in Russia proper—may enable continuous rounds of Russian drone attacks, extracting significant costs on Ukrainian air defense and impacting both dual-use targets and the civilian population.⁵³

AIRCRAFT

Russia is estimated to have lost anywhere between 78 and 305 aircraft in the war and to have kept roughly 4,000 in reserve.⁵⁴ Moscow has largely deployed older aircraft in Ukraine, including the Su-25s, with limited success.⁵⁵ More advanced aircraft such as the Su-34s and Su-35s, the latter considered Russia's flagship heavy fighter, have also been spotted over the skies in Ukraine (especially the Su-34s).⁵⁶ While Russia's next-generation fighter aircraft, the Su-57s, due to their high cost and limited production rate, were most likely restricted from flying over Ukraine to avoid being shot down by Ukrainian air defenses.⁵⁷ Interestingly, as the war demonstrated the relative effectiveness of less-expensive weapons systems like missiles and drones over Russian aircraft, the Kremlin reportedly traded more than 60 Su-35s to Iran in exchange for several thousand drones used to target Ukrainian civilian and dual-use infrastructure.⁵⁸

Furthermore, Russia's aviation sector is among the industries hardest hit by the allied export restrictions. Following the invasion, major U.S. and French plane manufacturers Boeing and Airbus ceased deliveries of new foreign jets and spare parts to Russia.⁵⁹ Sanctions have impacted Moscow's ability to sustain its older aircraft, as well as to further develop and mass produce its next-generation combat vehicles, including the Su-57s, which depend on imported advanced machine tools and engines (as discussed in the next section).⁶⁰ As there is some overlap between parts used for military and civilian aircraft, Russia reportedly started stripping spare parts from its passenger aircraft in summer 2022, which has created additional complications, most

mechanical in nature, for the already struggling domestic civilian aircraft industry.⁶¹ More recently, Rosaviatsia, Russia’s Federal Air Transport Agency, has approved “aircraft cannibalization,” allowing spare parts from grounded airframes to be reinstalled on in-service aircraft.⁶²

Going forward, sanctions will likely make it even more difficult for Russia to manufacture next-generation combat vehicles, ultimately impacting the military reputation of the Russian Air Force and Moscow’s ability to find customers for its domestically manufactured combat aircraft.



In October 2022, a Su-34 crashed into a residential building in the Russian town of Yeysk, located near Ukraine. Russian authorities said a “technical malfunction” was a likely cause for the accident.

Source: Stringer/AFP/Getty Images

ELECTRONIC WARFARE SYSTEMS

Electronic warfare (EW) uses radio signals, infrared sensing, jamming, and radar to track adversaries and interfere with their communications systems. During the 2010s, Moscow made considerable advances in EW, acquiring several hundred various new and modernized EW systems designed to defend ground forces, aircraft, and surface ships from the enemy’s radar and precision-guided munitions and to conduct ISR operations.⁶³ Throughout 2022, Russia has used these EW systems with relative success, reportedly eliminating up to 90 percent of the drones Kyiv possessed in February by summer 2022 and actively jamming the air-to-ground and air-to-air communications of Ukrainian pilots.⁶⁴

Among the specific EW technologies used by the Russian Armed Forces, the Palantin EW system has been the most effective at jamming small Ukrainian drones.⁶⁵ Other notable EW technologies are the Svet and Tirada EW systems—which Russia has used to determine the position of enemy forces⁶⁶—and the Rtut EW device that has impacted radio fuses on Ukrainian artillery shells.⁶⁷

Russian EW systems also come with downsides that have restricted their ability to prevent Ukrainian military advances during the Kyiv, Kharkiv, and Kherson offensives. First, they cannot cover the entirety of the front, only parts of it, which has enabled Ukrainian military activity even at close range, as evidenced by numerous videos of Ukrainian drones dropping munitions right on top of Russian ground positions. Russia's EW systems also work best when their operators have plenty of time to set up and coordinate different functions and hence are less effective when Russian battalions attack and retreat quickly.⁶⁸ Due to poor planning and lack of coordination, Russian EW troops even jammed their own communications in the first days of the war.⁶⁹

An additional limitation is that these systems cannot work continuously. With a restricted lifetime of around 900 to 1,000 hours, each EW system can only be turned on for three to four hours per day, meaning that at least six to eight systems are needed to cover a particular zone for 24 hours.⁷⁰

Finally, to produce its EW systems, Russia keeps relying on Western electronics, including components restricted by the allied export regulations such as microcontrollers, microprocessors, controller area network (CAN) transceivers, digital signal processors, and Global Positioning System (GPS) receivers, among others.⁷¹

While not directly related to EW, another important factor worth noting is the Russian military's flawed use of communications systems. For instance, at the beginning of the invasion, Russian forces used civilian mobile phones and Chinese portable radios for communication purposes that lacked military-grade encryption, naturally impacting their performance on the battlefield. Recent reports show that, while this issue has been acknowledged, the Russian military still, in some cases, relies on unencrypted communications, endangering operational security in Ukraine. Reportedly, Russians are also purchasing China-made counterfeit radio stations.⁷²

Going forward, the Armed Forces of Ukraine can exploit the downsides exhibited by Russian EW and communications systems to negate the alleged strengths of these technologies on the battlefield.

The Kremlin's Existing Vulnerabilities

The previous section demonstrated that high reliance on imports of sensitive technology is one of the main vulnerabilities of Russia's defense sector. This section identifies the key dual-use components, restricted under the allied export regulations, likely to present particular challenges for Russia's efforts to continue producing advanced MBTs, missiles, UAVs, aircraft, and EW devices.

OPTICAL SYSTEMS

Optical systems are pivotal to Russia's modern MBT industry. Before the war, the Russian military imported a critical mass of its leading tank optical systems from France, which has now cut off Russian producers from this important component.⁷³ Russia appears to be retrofitting its T-80BVM MBT with an optics configuration, the 1G42 gunner sight, which originates from an older model vehicle.⁷⁴ Similarly, there are reports that the Russian military is retrofitting its T-72B3M tanks with the less-sophisticated 1PN96MT-02 sight, rather than the higher-end Sosna-U, which can spot enemy tanks up to two kilometers farther away.⁷⁵ Additionally, unlike the 1PN96MT-02, the higher-grade Sosna-U system has a daytime channel, instead of just a thermal-imaging channel, and the more advanced ability to use computer sensors to help track targets.⁷⁶ It is likely that sanctions and export controls are directly contributing to Moscow's decision to replace higher-end optical systems with their less advanced alternatives.

Russia's tank fleet will likely become even less sophisticated as the war continues. With recent announcements of Western tank deliveries to Ukraine, a mismatch in tank technology could prove costly for Russian efforts to shift the line of battle westward.

BEARINGS

Bearings are critical to producing any type of moving vehicle. Historically, Russia has imported most of its high-quality bearings from Western manufacturers. In 2020, for instance, Russia imported over \$419 million

worth of ball bearings, around 55 percent of which originated in Europe and North America; Germany was Russia's largest trading partner, taking up 17 percent of its total imports that year.⁷⁷ Following the start of the invasion, major Western producers of bearings exited Russia and ended their sales there.⁷⁸ The U.S. government believes that Russia already faces a shortage of this key component, which impacts the production of all vehicles, from tanks to aircraft and even submarines.⁷⁹ This shortage is also felt in the civilian industry, as Russia's rail-dependent economy finds the production and repair of trains directly impaired.⁸⁰ Russian domestic producers claim they can reverse the deficit in bearings via import substitution initiatives.⁸¹ Russia could also expand its imports of bearings from China or countries in Southeast Asia such as Malaysia.⁸²

In sum, while Moscow might be able to substitute the import of Western bearings and thus maintain the level of defense-sector production needed to continue its war effort, these bearings will most likely be of a lower quality, which could impact reliability.

MACHINE TOOLS

Similarly, Russia's dependence on Western-produced precision machine tools is a structural supply chain weakness aggravated by increased economic isolation. Machine tools are critical in the production of numerous weapons and military vehicles, including aircraft. Even before Russia's 2022 invasion, the country's machine tool industry had long been in crisis.⁸³ Despite efforts to diversify away from Western sources since 2014, Western-aligned firms together still provided the overwhelming majority of Russia's imported machine tools in 2017.⁸⁴ Estimates claim that Russia depends on imported products for up to 70–80 percent of its machine tools and construction equipment.⁸⁵ With 85 percent of Russian machine tool demand allegedly coming from the defense industry, it is surprising that the government has allowed Western countries to continue to play such a pivotal role in the Russian supply chains of the most technically advanced tools.⁸⁶ China, the largest total producer of these items worldwide, also remains dependent on Western imports to build the kind of medium- to high-end machine tools that Russia's domestic defense market lacks.⁸⁷

Ultimately, Russia faces a critical deficiency of complex multi-coordinate precision machine tools of the most advanced categories, and it lacks the time and capability needed to find substitutes for Western suppliers.⁸⁸ While Russian producers claim to have designed and built a high-end computer numerical control (CNC) machine tool entirely out of domestically produced components, assertions like this are difficult to trust or verify.⁸⁹

ENGINES

Russia has struggled to access certain important aircraft engines since 2014 due to its dependence on the Ukrainian producer Motor Sich for key components in their production.⁹⁰ By 2005, the Kremlin had already identified the need to move toward fully domestic helicopter engine production, but this goal has remained seemingly unrealized.⁹¹ In 2014, Russia state-aligned media announced the expansion of operations at the St. Petersburg Klimov plant—a subsidiary of the state-owned Rostec corporation—with the explicit goal of replacing the Russian military's dependence on Motor Sich's aircraft engines.⁹² Yet the October 2022 arrest of Motor Sich's owner, Viacheslav Bohuslaiev, in Ukraine on charges that his firm relied on transnational networks to supply Russia with helicopter engines and components suggests that Moscow's own efforts to increase its supply of engines through import substitution remain incomplete.⁹³ Indeed, Russia's trouble with production of high-end engines was already notable before the 2022 invasion. For example, the new Su-57 fighter jets allegedly still rely on older fourth-generation engines—specifically the Saturn AL41-F1 engines used in the previous Su-35S aircraft—while efforts to produce a more advanced engine have been repeatedly delayed, providing further evidence of Russia's difficulties to produce the most cutting-edge fighter jet engines.⁹⁴

Russia's civil industries similarly suffer from the shortage of aircraft engines. For example, its Sukhoi Superjet 100 airplanes might now be relying on engines produced from the used components of 17 types of older engines.⁹⁵ Similarly, Chinese engine producer Weichai has stopped providing engines for use in tractors produced by the Russian firm KamAZ, as the latter was placed under Western sanctions for being an alleged supplier of materiel to the Russian military. Just as with the Sukhoi Superjet 100, KamAZ is now apparently producing tractors with an outdated 820 (V8) gas engine.⁹⁶ These examples suggest that export controls are in some cases forcing Russian producers to turn to older models to fulfill engine production targets.

MICROCHIPS

Russia's domestic chip production is many years behind the industry standard in the West, making its weapons, communications, and EW systems highly reliant on Western-manufactured microchips, which are currently restricted under the allied export regulations.⁹⁷ For instance, according to the UK-based Royal United Services Institute (RUSI), the Orlan-10 UAV contains U.S.-origin chips manufactured by Texas Instruments and Honeywell.⁹⁸ Open-source data also confirms the presence of Western-manufactured chips inside Russia's Lancet drone.⁹⁹ Furthermore, an investigation by Conflict Armament Research has shown that satellite navigation units in several Russian missiles—such as the 3M14, 9M544, Kh-59, and Kh-101—contain multiple foreign-made microcomponents manufactured between 2012 and 2020.¹⁰⁰

Russia's newly developed radio communications systems—including the Azart portable radio station, designed to provide jamming and secure communications at the tactical level—also appear to rely on many Western-produced components.¹⁰¹ According to data provided by the Center for Army, Conversion, and Disarmament Studies (CACDS), the Azart holds six components of foreign origin, including the Spartan-6 chip, which encrypts communications and is produced by the U.S. company Xilinx in Taiwan. As a dual-use item, the Spartan-6 is commercially available and can be purchased via AliExpress. Similarly, Russia's reconnaissance, command, and communications complex Strelets-M relies on seven components of foreign origin, including a chip produced by the U.S.-based Microchip Technology.

The dependence of Russia's military industrial complex on foreign-manufactured microchips can be explained by at least two factors. First, chips and chip microprocessors produced domestically by a small number of companies—such as Baikal Electronics, STC Module, SPC Elvis, and MCST¹⁰²—tend to be of inferior quality to Western designs. In early 2022, the Russian Ministry of Internal Affairs even complained about the difficulties of launching and operating equipment based on the domestic Elbrus-8C processors.¹⁰³ Following the imposition of Western sanctions, these companies have been unable to officially purchase technologies from the United States and its allies participating in the sanctions regime, including the Taiwan Semiconductor Manufacturing Company (TSMC) on which Russian chip producers greatly relied.¹⁰⁴ Replacing these components with Chinese options in some cases requires a complete redesign of electronic equipment and restructuring of cooperation chains, which may take years to complete.¹⁰⁵ Moreover, Chinese chips often lag behind the leading Western microchip designs. While certain chips (such as the Spartan-6, the TSOP66, and the LQFP64) found in the Russian-made Azart and 9M544 precision missile can be purchased via AliExpress, as mentioned above, dependence on such commercially available elements can make Russian weapons systems less reliable and prone to failure.¹⁰⁶ For example, Deputy Secretary of the Treasury Wally Adeyemo suggested that “nearly 40 percent of the less advanced microchips Russia is receiving from China are defective.”¹⁰⁷

Second, the Russian chip industry cannot meet high demand for these elements. Today, the country requires up to 30,000 plates of basic-level microchips per month, but only 8,000 plates can be made domestically.¹⁰⁸ Recently, the government announced the launch of a new technology park in the country's Ulyanovsk region

as part of an effort to accelerate its chip production.¹⁰⁹ Yet, under the export controls, it would be difficult to estimate the park's production rate and quality of its products.

Due to these restrictions, and to ensure continued access to high-quality microchips for its weapons systems, Moscow has developed a number of illegal supply chains, discussed below.

Russia's Sanctions Adaptation Strategy

Russia was first sanctioned by the West in 2014, following its intervention in Ukraine. In response, Moscow made it a national security priority to reduce its dependency on Western imports, including in the high-tech sector, albeit with limited success.¹⁰ Since the start of the 2022 invasion, the Kremlin has expanded upon the 2014 import substitution efforts, aiming at replacing imports in all aspects of its economy, including the military sector, with domestically produced materials.¹¹ Yet import substitution has proved to be a daunting task for Russia's defense industry given its reliance on foreign-produced microelements and spare parts. While Iran—already a sanctioned economy—continues to supply Russia with certain military equipment and technologies, many countries outside of the transatlantic community cannot openly aid Moscow's war effort without risking sanctions by the West.¹² This forces Moscow to rely on illicit supply chains to obtain restricted foreign elements. While Russia's efforts to circumvent sanctions will have successes and will mitigate their impact, the Kremlin's sanctions-evasion efforts also face their own limitations. Sanctions are thus likely to reduce the volume of components Russia can import, increase the costs of those imports, and lead to supply disruptions that affect industrial output. This section examines Russia's ongoing attempts to adapt to the Western sanctions regime and mitigate its impacts on the domestic defense sector.

THE KREMLIN'S IMPORT SUBSTITUTION EFFORTS

The Russian government has repeatedly promised to accelerate import substitution for domestically produced equipment heavily reliant on foreign components, including armored vehicles, UAVs, and EW technologies.¹³ Yet several months before the war, Russia's own internal assessment of the defense program introduced in 2019 found it largely unable to provide domestic replacements for Western equipment and electronics.¹⁴ Western intelligence corroborates this assessment.¹⁵

More recent initiatives the Kremlin introduced after the invasion also tend to be viewed as too ambitious and far-fetched by local defense and military experts. For instance, to reduce Russia's dependence on imported

microchips, in mid-October 2022 the government introduced the National Project for Electronics, aimed at significantly boosting production of microprocessors and supplying around 30 percent of Russian households with Russian-made electronics by 2030.¹¹⁶ But Russian tech specialists criticized this project, with its estimated cost of up to \$42 billion, for being “virtually impossible to implement” within the given timeframe.¹¹⁷ Russia is far behind the technology frontier to produce the full range of advanced microchips its defense industry requires within this timespan. Similarly, in mid-February 2023, the Kremlin announced a new national project featuring a grant program to produce necessary UAV components inside the country.¹¹⁸ However, the implementation of this project will take years, if not decades, to realize. Even Russian minister of finance Anton Siluanov recently acknowledged that “it just takes more time” to replace foreign equipment and electronics with domestically produced alternatives.¹¹⁹

One of the government’s more tangible approaches includes funding existing defense enterprises to boost their production. Russian state-owned defense conglomerate Rostec is one of the chief enablers (and beneficiaries) of the Kremlin’s decision to pivot to domestic production. Rostec routinely advertises its capacity to help manufacture a range of modern weapons systems, including UAVs, tanks, aircraft, and missiles.¹²⁰ Since the start of the war, it has promoted its ability to create high-quality technologies that can be exported abroad, among them Russian-made anti-drone (the Repellent-1, RLK-MCE, RB-504P-E, and RB-504A-E) and anti-aircraft (the Pantsir-S1, Tor-M2KM, Tor-M2E, and S-350E Vityaz) missile systems.¹²¹ Rostec is expected to attract a significant share of state funding, including 4.7 billion rubles (around \$62.6 million) in the 2023 fiscal year.¹²² Although the United States and its allies sanctioned Rostec and its subsidiaries in June 2022, specific transactions involving certain Rostec-affiliated blocked entities, such as those that ensure the safety of civil aviation, can still be authorized.¹²³ This might allow the defense conglomerate to circumvent sanctions by acquiring certain dual-use technologies through its affiliated firms involved in civil aviation.¹²⁴



The Rostec headquarters in Moscow, Russia.

Source: Natalia Kolesnikova/AFP/Getty Images

The government has also supported private defense enterprises, including the Kronshtadt Group, a Russian defense contractor manufacturing UAVs such as the Orion drones, which have also been deployed in Ukraine.¹²⁵ While the United States sanctioned Kronshtadt in March 2022, the company has long claimed that it can domestically produce all components for its growing list of ISR and combat UAVs.¹²⁶ Yet anecdotal evidence suggests that the firm might have an office in Antalya, Turkey—in theory enabling Kronshtadt to import necessary components for its UAV production.¹²⁷

Overall, Russia's current efforts at import substitution are fraught with challenges stemming from largely inadequate state aid programs and limited official supply chains, which are ultimately restricting the production capabilities of Russian defense enterprises.

SANCTIONS-EVADING LAND CORRIDORS

Facing obvious import substitution challenges, the Russian government swiftly established alternative routes to access restricted foreign components and technologies. This effort, which increased throughout the second half of last year, has so far proved to be somewhat successful, as imports of dual-use commodities to Russia in 2022 exceeded their prewar levels, according to multiple sources. For instance, the value of semiconductor imports rose from \$1.82 billion in 2021 to \$2.45 billion in 2022, based on estimates by the Free Russia Foundation.¹²⁸ But to reach Russia shipments now have to go through numerous obscure suppliers and multiple land corridors, as detailed below, making this experience rather volatile, costly, and time-consuming for the Kremlin.¹²⁹

Despite facing additional Western sanctions for aiding Moscow's war efforts, Iran has remained one of Russia's regular suppliers of both key weapons systems, including the Shahed-136 UAVs, and restricted dual-use components.¹³⁰ Interestingly, according to CACDS, even Iranian-origin Shahed-136 drones contain microelements produced across various Western nations, including microcontrollers and microprocessors made by the U.S.-based Texas Instruments and NXP USA Inc., respectively. Given that Iran has decades of experience circumventing Western sanctions, Tehran can likely illegally access such components for its growing UAV industry and share that experience with Moscow.¹³¹

One of the Islamic Republic's ways to receive Western-manufactured weapons and components is across its poorly monitored borders with Iraq.¹³² According to Middle East expert Vera Mironova, Iraq purchases multiple high-tech Western-produced components, including engines, under the pretext of an alleged war on terrorism.¹³³ Those items are then sent to Iran, ultimately ending up in Russian ports, including Astrakhan, via the Caspian Sea. This geographical corridor features numerous existing and newly constructed infrastructure projects from Iran across the Caspian Sea and into Russia.¹³⁴ Tehran and Moscow are also considering a sanctions-evading rail link, running along the coast of the Caspian Sea, that would connect India to Russia through Iran and Azerbaijan. This project, which supposedly will be completed in three years, is considered a much shorter and less time-consuming alternative to the current sea route that requires India to ship goods to Russia through Europe.¹³⁵

Besides Iran, China is reportedly another Russian source for dual-use goods. Based on Russian customs data, Chinese state-owned defense enterprises export microchips and microchip components, engine pieces, navigation equipment, jamming technology, and jet fighter parts to the sanctioned Russian defense companies, including Rostec and its affiliates.¹³⁶ Russian entities might have also received up to 1,000 "civilian hunting rifles," as well as 12 shipments of drone parts and around 12 tons of body armor from Chinese firms, which were routed via Turkey and the UAE between June and December 2022.¹³⁷ While Chinese officials say that Beijing is committed to promoting peace talks, there are growing signs that it might actually be considering supplying the Russian military with the ZT-180 prototype kamikaze drones, which bear a close resemblance to the Shahed-136 UAVs.¹³⁸

The Balkan peninsula is another popular location for intermediary companies involved in sanctions evasion. For instance, Bosnian firm Inzenjering BN, based in the Republic of Srpska, has reportedly supplied helicopter engine parts to the Russian army with the help of Ukrainian company Motor Sich since 2017.¹³⁹ In 2018, Motor Sich delivered more than 600 shipments containing the TV3-117 helicopter engines to Inzenjering BN, which then allegedly shipped them to Russia.¹⁴⁰ In October 2022, Ukrainian authorities arrested the head of Motor Sich, Viacheslav Bohuslaiev, for supplying Moscow with helicopter engines and other spare parts. Yet the company could have delivered significant shipments prior to Bohuslaiev’s detainment.¹⁴¹ More recently, an investigation by the Balkans-Ukraine Cooperation Network discovered that Moscow-based Russian military-affiliated manufacturer Aerotehnikservis (ATS), which supplies helicopters and aviation components, closely cooperates with the firm Aero Engineering Solutions (AES).¹⁴² AES is owned by Canada-based company Aerosupport Solutions Ltd., with offices in Sarajevo and the Republic of Srpska. In 2022, AES sent several cargoes of Western-manufactured components needed for Russian-made helicopters (including the MI-8 and MI-171) to ATS through these routes.¹⁴³

Turkey has also emerged as an important intermediary involved in smuggling sanctioned goods. According to Reuters, Turkish company Azu International alone has exported more than \$20 million worth of components to Russia, including U.S.-origin microchips.¹⁴⁴ Another firm, CTL Diş Ticaret Limited Şirketi, established by Russian national Pavel Pertsov in March 2022, shipped navigation equipment, potentially including GPS systems with anti-jamming technology and high-precision positioning products for UAVs, from a Canadian firm to Russian enterprises supplying the domestic defense sector.¹⁴⁵ Even though Turkish customs authorities have reportedly been rejecting transit declarations for sanctioned goods that had Russian and Belarusian entities listed as end users due to “pressure from the European Union” since March 2023, this will not eliminate an important transit hub, but will make it costlier for Moscow to access the restricted components via Turkey.¹⁴⁶



Photo Source: Andrey Borodulin/AFP/Getty Images

Many post-Soviet countries across Central Asia and the South Caucasus also take considerable risks to supply Russia.¹⁴⁷ For example, imports of different Western-made spare parts from Armenia, Georgia, and Kyrgyzstan have increased significantly since the start of the war.¹⁴⁸ Some Western manufacturers now even ask their customers to confirm that their physical location is outside of Russia by scheduling video calls with

procurement officers.¹⁴⁹ Illegal supply chains also run through the member states of the Russia-led Eurasian Economic Union (EEU), which includes Armenia, Belarus, Kazakhstan, and Kyrgyzstan. The EEU offers a particularly convenient land corridor for avoiding sanctions, as products imported into the EEU countries are also provided with guarantees valid for Russia.¹⁵⁰ While, recently, Kazakhstan has promised to “closely monitor our mutual trade with all partners” (including Russia), in an effort to avoid secondary sanctions, time will show the effectiveness of such an effort.¹⁵¹ In addition to the EEU member states, Georgia may also be providing another route via modernized Black Sea port facilities.¹⁵² Reportedly, cargoes with shipping labels for Central Asia are offloaded in Georgia and then transported to Russia by various trucking companies. Lastly, Belarus is emerging as an important corridor for clandestine transfer of Chinese goods and/or equipment to Russia, such as combat drones, personal weapons, and artillery shells.¹⁵³

Although extensive, these land corridors do not provide a complete picture of the sanctions-evading supply chains developed by Moscow. In 2022, Russia imported numerous restricted high-tech components from third countries across Asia, Africa, and Europe through a multitude of shell and front companies using false end-user certificates and transshipments.¹⁵⁴ While these exporters are, in many cases, operated by foreign-based Russian nationals or expatriates with limited public profiles, the local authorities of countries allegedly used as land corridors should monitor the situation more carefully to avoid the risk of secondary sanctions.¹⁵⁵

Conclusion

Since the start of the 2022 Russian invasion of Ukraine, the U.S. government and its allies have initiated a commendable effort to prevent the Russian military from accessing the key components, elements, and materials outlined in this paper. U.S. intelligence has estimated that since February 2022, export controls have degraded Russia's ability to replace more than 6,000 pieces of military equipment, forced key defense industrial facilities to halt production, and caused shortages of critical components for tanks and aircraft, among other effects.¹⁵⁶ Efforts by the Department of the Treasury's Office of Foreign Assets Control (OFAC) span the globe and represent some of the widest sanctions attempted against a country to date. The Kremlin is aware of this work and seeks to circumvent OFAC and its affiliated initiatives in a race that may well determine the outcome of the war in Ukraine. The Department of the Treasury and broader U.S. government recognize the magnitude of the task before them and are adjusting their actions based on real and intended outcomes. These efforts will become even more important as the war enters its second year and the Russian military shows no signs of abandoning its major goal of occupying Ukraine.

Due to the classified nature of the data in question, many of the assessments in this paper have had to rely on incomplete or circumstantial evidence. Nonetheless, this paper draws several conclusions about the impact of sanctions to date.

1. Sanctions work by creating shortages of certain higher-end components and forcing the Russian Ministry of Defense to substitute them with lower-quality alternatives.

In particular, the sanctions have forced Russia to rely on older and less accurate missiles. However, the Russian military's continued strikes against Ukraine are an important indicator that the Ministry of Defense can still adapt by repurposing different types of missiles. As long as the Russian forces can conduct such attacks—even if they are less frequent and less accurate—there is still a danger to the Ukrainian military and to civilian targets, not to mention the collateral damage that is an egregious and

unfortunate consequence of such strikes. Russia's ability to continue such attacks may be augmented by efforts of partner nations such as Iran or China, whose deliveries of parts and technology may not be impacted by the U.S.-led sanctions efforts. Given the Russian military's prioritization of missile strikes on the battlefield, such tactics will likely continue, albeit with limited frequency, well into 2023.¹⁵⁷

Second, the impact on engine production can have long-term effects on the Russian military, especially on recovery, repair, and rebuilding efforts and attempts to develop and deliver newer military systems to the front, including aircraft. The Russian government is aware of this impact, evidenced by its continuing attempts to portray domestic heavy industry and the war effort as being unaffected by sanctions.¹⁵⁸

Third, the Russian government's efforts to acquire microchips produced by the world's leading companies has received significant attention since the start of the war. Numerous investigations, some outlined in this report, point to the difficulty of fully and completely controlling the flow of this technology to Russia. Given their importance to Russian military systems, weapons, and technologies, the Kremlin's efforts to acquire microchips may become even more pronounced in 2023. Reliance on imported microelectronics products that may be inferior to some of the market leaders could potentially affect the quality of Russian-manufactured weapons but will not entirely slow down or prevent the Ministry of Defense from conducting military operations. At the same time, Russia's own domestic push to launch microchip production is a long-term effort that is unlikely to deliver immediate results for either civilian industries or the military.¹⁵⁹ As the war enters its second year, the Russian government is likely to intensify its attempts to acquire microchips via existing efforts outlined in this paper, as well as through new schemes to circumvent sanctions.

Fourth, Russia is likely experiencing shortages of advanced optical systems, forcing it to retrofit its tanks with less-sophisticated systems, a mismatch that could prove costly for Russian efforts to shift the line of battle westward.

Fifth, Russia likely faces a shortage of bearings, which impacts the production of all vehicles. However, Russia might be able to substitute existing shortages with Asian components of a lower quality. The full impact of such shortages is unknown given Russia's ability to wage war well into 2023.

2. *Russia still possesses a remarkable degree of adaptability to Western sanctions.*

The Russian military is crafty in its use of dual-use components. Russia is by no means the first country to turn to civilian technology to augment its military capabilities, but the size and scope of this war is forcing Moscow to work on an unprecedented scale.

Last year's U.S. sanctions efforts have also revealed the difficulty of controlling the flow and acquisition of civilian and dual-use components and products that may end up in military systems, giving the Russian military some breathing space as its global acquisition efforts evolve to match the endeavors of OFAC. As this report shows, there are still plenty of ways for the Russian Ministry of Defense to get what it needs, as the Kremlin takes advantage of the global economy, complex supply chains, and partner countries willing to work with Moscow.

Major supply shortages are forcing Russia to turn to less technologically advanced items, as well as Soviet-era defense stocks. As the Russian military starts fielding older systems modernized in recent months—and as it continues to use imported military technology—the quality of such military operations is coming into question, especially compared to Ukraine's ongoing acquisition and fielding of Western-supplied weapons and systems. The pace and quality of Russian military operations will

in fact depend on the Ukrainian military's ability to field systems capable of countering Russian tactics. In other words, the Russian military can still field a modernized T-62 tank (first unveiled in the early 1960s) on the battlefield even if this vehicle lacks sophisticated countermeasures or optics. But the effectiveness of these systems will be significantly offset by Ukraine's continued access to more advanced Western technology such as Javelin, Stugna, or NLAW anti-tank weapons or precision-guided artillery. Additionally, the Russian military can continue to launch Iranian-provided Shahed-136 combat drones at Ukrainian energy infrastructure without worrying that most are shot down, placing the onus on the Ukrainian defenders to expend valuable air-defense ammunition. This is the crux of this war in its second year: the Russian military can rely on its mass and continue feeding older or less than state-of-the-art technology as long as it thinks it can simply outlast the Western deliveries of weapons and systems to Ukraine.

3. *Sanctions have made Moscow opt for a slower-paced attritional campaign.*

Russia has lost a significant number of military vehicles, which could limit its capacity for large-scale ground offensives. This could be one reason why the Russian government, and President Putin in particular, are presenting this war as a long-term endeavor necessary to ensure Russia's security. Ensuring a long-term struggle that slowly exhausts Ukrainian weapons stocks while outlasting Western aid efforts appears central to Russia's strategy in Ukraine.

At the same time, turning this war into a slow-paced attritional campaign creates a little breathing space for the sanctioned Russian domestic defense industry to come up with the necessary solutions and workarounds outlined in this report. There is some evidence that the Russian government and military are exhausted and would prefer this conflict to enter the concluding stage, managed by the international community. In a statement on February 28, 2023, a Kremlin spokesperson indicated that peace negotiations with Kyiv are possible if Russia gets to keep the Ukrainian regions it currently controls: Donetsk, Luhansk, Kherson, and Zaporizhzhya, along with Crimea.¹⁶⁰ But even if Kyiv were to agree to such negotiations, it remains unclear whether the Russian government would limit its ambitions to the regions it already occupies if Ukraine maintains its pro-Western political and military orientation.

Thus, as long as the Kremlin maintains its current outlook on Ukraine, the war is expected to continue, with Moscow preferring a slower-paced attritional campaign without significant breakthroughs or advances that could put further pressure on its military and industrial base already stretched thin by sanctions and the last 12 months of the invasion.

RECOMMENDATIONS

While it is not possible to completely control the flow of commercial parts that end up in the Russian military system, the authors of this report propose several ways for Western policymakers to close the loopholes actively used by the Russian government:

- Continue supplying Ukraine with higher-end military equipment at a pace that exceeds Russia's production rate, which will make it harder for Russia to maintain an attritional war.
- Identify and target illicit networks, and particularly individuals involved in current sanctions-evasion efforts. In doing so, the United States should use its leverage in the post-Soviet region more proactively, including in Armenia, Georgia, and Kazakhstan.
- Restrict any existing transactions with Russian and Russia-linked defense companies and their affiliates. For example, Rostec subsidiaries and affiliated companies involved in civil aviation should be prevented

from importing and sending sanctioned dual-use technologies to other Rostec affiliates involved in the production of different weapons systems.

- Eliminate the loopholes that allow some Western companies to import equipment into Russia by extending past contracts that preceded the imposition of sanctions.¹⁶¹
- Work toward creating an OFAC equivalent at EU level. Currently, the monitoring of sanctions implementation and compliance lies within the member states, which may lead to disparities, as EU states have varied capacity in this regard. Such a structure will require strong local expertise to perform the necessary investigation.

About the Authors and Contributors

Max Bergmann is the director of the Europe Program and the Stuart Center in Euro-Atlantic and Northern European Studies at the Center for Strategic and International Studies (CSIS). Prior to joining CSIS, he was a senior fellow at the Center for American Progress, where he focused on Europe, Russia, and U.S. security cooperation. From 2011 to 2017, he served in the U.S. Department of State in a number of different positions, including as a member of the secretary of state's policy planning staff, where he focused on political-military affairs and nonproliferation; special assistant to the undersecretary for arms control and international security; speechwriter to then secretary of state John Kerry; and senior adviser to the assistant secretary of state for political-military affairs. Before serving in the State Department, Bergmann worked at the Center for American Progress as a military and nonproliferation policy analyst and at the National Security Network as the deputy policy director. Bergmann holds a master's degree in comparative politics from the London School of Economics and Political Science and a bachelor's degree in political science from Bates College. His recent commentary has been published in outlets such as *Politico*, the *Washington Post*, *Foreign Affairs*, and *Sasakawa USA*.

Maria Snegovaya is a senior fellow for Russia and Eurasia with the Europe, Russia, and Eurasia Program at CSIS and a postdoctoral fellow in Georgetown University's Walsh School of Foreign Service. She studies Russia's domestic and foreign policy, as well as democratic backsliding in post-communist Europe and the tactics used by Russian actors and proxies who exploit these dynamics in the region. Her analysis has been published in multiple policy and peer-reviewed journals. Her research and commentary have appeared in a number of publications such as the *New York Times*, the *Wall Street Journal*, Bloomberg, *The Economist*, and *Foreign Policy*. Throughout her career she has collaborated with multiple U.S. research centers and think tanks such as the Center for a New American Security and Center for European Policy Analysis. Snegovaya holds a PhD in political science from Columbia University.

Tina Dolbaia is a research associate with the Europe, Russia, and Eurasia Program at CSIS, where she examines and analyzes political, economic, and security developments in Russia and Eurasia. Previously, Tina worked in the international development sector, including at organizations such as Chemonics International and the Center for International Private Enterprise. She holds an MA in Eurasian, Russian, and East European studies from Georgetown University's School of Foreign Service, where she also worked as a graduate fellow, examining the intersection of the Russian defense and technology sectors, as well as great power competition in Eurasia. Tina is originally from Tbilisi, Georgia, where she obtained her bachelor of science in sociology.

Nick Fenton is a program coordinator and research assistant with the Europe, Russia, and Eurasia Program at CSIS, where he supports the program's event management, outreach, and research agenda. Before joining CSIS, Nick completed a Fulbright grant working as an English teacher in Omsk, Russia, at Omsk State Pedagogical University. Additionally, he worked as a security and defense intern at the German Marshall Fund of the United States. Nick holds a master's degree in European and Russian studies from Yale University, where his research focused on the intellectual history of Soviet foreign policy during the interwar period. Nick earned his bachelor's degree at the University of Virginia, where he double majored in political and social thought and Russian and Eastern European studies.

Samuel Bendett is an adviser with the Russia Studies Program at the Center for Naval Analysis and an adjunct senior fellow with the Technology and National Security Program at the Center for a New American Security. His work involves research on Russian defense and technology developments; uncrewed, robotic, and autonomous military systems; artificial intelligence; and Russian military capabilities. Prior to joining the Center for Naval Analysis, Bendett worked at the National Defense University on emerging and disruptive technologies to aid the Department of Defense (DOD) in responding to domestic and international crisis situations. His previous experience includes working for the U.S. Congress, the private sector, and nonprofit organizations on foreign policy, international conflict resolution, and defense and security issues. Bendett received a master of arts in law and diplomacy from the Fletcher School at Tufts University as well as a bachelor of arts in politics and English from Brandeis University. He has native fluency in Russian.

Endnotes

- 1 The coalition of allied countries includes the United States, Canada, EU member states, the United Kingdom, Switzerland, Australia, New Zealand, Japan, South Korea, and Taiwan.
- 2 “Treasury-Commerce-State Alert: Impact of Sanctions and Export Controls on Russia’s Military-Industrial Complex,” U.S. Department of the Treasury, U.S. Department of Commerce, and U.S. Department of State, October 14, 2022, https://home.treasury.gov/system/files/126/20221014_russia_alert.pdf.
- 3 Bureau of Industry and Security, U.S. Department of Commerce, “Implementation of Sanctions Against Russia Under the Export Administration Regulations (EAR),” *Federal Register* 87, no. 42 (March 3, 2022): 12226, <https://www.federalregister.gov/documents/2022/03/03/2022-04300/implementation-of-sanctions-against-russia-under-the-export-administration-regulations-ear>; Emily Kilcrease, “Noteworthy: The New Russia Export Controls,” Center for a New American Security, March 7, 2022, <https://www.cnas.org/press/press-note/noteworthy-the-new-russia-export-controls>.
- 4 “Treasury-Commerce-State Alert,” U.S. Department of the Treasury.
- 5 Eric Martin, “U.S., Allies Cut Bulk of Russia High-Tech Imports, Raimondo Says,” Bloomberg, April 21, 2022, <https://www.bloomberg.com/news/articles/2022-04-21/u-s-allies-cut-bulk-of-russia-high-tech-imports-raimondo-says#xj4y7vzkg>.
- 6 Fatima Hussein, “Treasury Deputy: Russia Sanctions Are Degrading Its Military,” Associated Press, February 21, 2023, <https://apnews.com/article/russia-ukraine-us-department-of-the-treasury-wally-adeyemo-business-b781d7fb4737bf2b993ca55c19d7fbca>.
- 7 The Oryx team obtains data from different social media platforms, including Russian- and Ukrainian-language Telegram channels, which are being actively used as powerful mediums for information warfare. Stijn Mitzer and Jakub Janovsky, “Attack on Europe: Documenting Russian Equipment Losses During the 2022 Russian Invasion of Ukraine,” Oryx, February 24, 2022, <https://www.oryxspioenkop.com/2022/02/>

- attack-on-europe-documenting-equipment.html?m=1; Stijn Mitzer, “List of Aircraft Losses During the 2022 Russian Invasion of Ukraine,” Oryx, March 20, 2022, updated March 4, 2023, <https://www.oryxspioenkop.com/2022/03/list-of-aircraft-losses-during-2022.html>.
- 8 The Kyiv Independent (@KyivIndependent), “Russia’s losses as of March 18,” Twitter photo, March 18, 2023, <https://twitter.com/KyivIndependent/status/1637051654158548994>.
 - 9 Stijn Mitzer and Joost Oliemans, “Russia’s Wars: Listing Equipment Losses During the First Chechen War (1994-1996),” Oryx, November 21, 2022, <https://www.oryxspioenkop.com/2022/11/russias-wars-listing-equipment-losses.html>; Stijn Mitzer and Joost Oliemans, “Russia’s Wars: Listing Equipment Losses During the Second Chechen War (1999-2000),” Oryx, November 22, 2022, https://www.oryxspioenkop.com/2022/11/russias-wars-listing-equipment-losses_22.html; Stijn Mitzer and Joost Oliemans, “Russia’s Wars: Listing Equipment Losses During the 2008 Russo-Georgian War,” Oryx, October 4, 2022, <https://www.oryxspioenkop.com/2022/10/russias-wars-listing-equipment-losses.html>.
 - 10 Defense data was compiled from the following sources: “Comparison of Ukraine and Russia Military Strengths (2023),” Global Firepower, accessed March 7, 2023, <https://www.globalfirepower.com/countries-comparison-detail.php?country1=ukraine&country2=russia>; “Comparison of the Military Capabilities of Russia and Ukraine as of 2023,” Statista, February 2023, <https://www.statista.com/statistics/1296573/russia-ukraine-military-comparison/>; and “Ukraine vs Russia,” ArmedForces.eu, accessed March 7, 2023, https://armedforces.eu/compare/country_Ukraine_vs_Russia.
 - 11 “Comparison of the Military Capabilities of Russia and Ukraine as of 2023,” Statista. This information has also been confirmed during private conversations with relevant field experts in March 2023.
 - 12 “Russia and Ukraine Military Comparison,” GlobalData, accessed March 7, 2023, <https://www.globaldata.com/data-insights/macroeconomic/russia-and-ukraine-military-comparison-overview/>.
 - 13 Mitzer and Janovsky, “Attack on Europe”; The Kyiv Independent (@KyivIndependent), “Russia’s losses”; Dan Sabbagh, “Russian Army Has Lost Up to Half of Key Battle Tanks, Analysts Estimate,” The Guardian, February 15, 2023, <https://www.theguardian.com/world/2023/feb/15/russian-army-has-lost-up-to-half-of-key-battle-tanks-analysts-estimate-ukraine>.
 - 14 Sabbagh, “Russian Army Has Lost Up to Half of Key Battle Tanks.”
 - 15 After 2011, numerous Russian armored vehicles underwent modernization, including engine, chassis, combat-module, sensor, and armor upgrades. See “Модернизация БТР и БМП” [Modernization of armored personnel carriers and infantry fighting vehicles], [militaryarticle.ru](http://militaryarticle.ru/zemlya/bronetehnika/19908-modernizacija-btr-i-bmp), <http://militaryarticle.ru/zemlya/bronetehnika/19908-modernizacija-btr-i-bmp>; IISS, “The IISS Launches The Military Balance 2023, Analysing Russia and Ukraine’s Military Forces and China’s Military Modernisation,” press release, February 15, 2023, <https://www.iiss.org/press/2023/02/military-balance-2023>.
 - 16 Diana Mihailova (diana_maihailova), “Численность танкового парка Российской армии” [Tank fleet numbers of the Russian army], LiveJournal post, June 21, 2020, <https://diana-mihailova.livejournal.com/5058244.html>; Ihor Mykhaylenko, “Аналіз запасів танків РФ на базах зберігання за Уралом” [Analysis of Russian tank stocks at storage bases in the Urals], Mil.In.UA (blog), August 22, 2022, <https://mil.in.ua/uk/blogs/analiz-zapasiv-tankiv-rf-na-bazah-zberigannya-za-uralom/>.
 - 17 Data compiled from: Isabel van Brugen, “Video Shows Old Russian Tanks Taken Out of Storage to Be Used in Ukraine,” *Newsweek*, September 23, 2022, <https://www.newsweek.com/video-russian-old-soviet-tanks-storage-ukraine-war-1745776>; Oryx (@oryxspioenkop), “#Russia appears to be bringing T-54s and T-55s out of storage for deployment in #Ukraine,” Twitter photo, March 22, 2023, <https://twitter.com/oryxspioenkop/status/1638472120534458368>.

- 18 “How Quickly Can Russia Rebuild Its Tank Fleet?” *The Economist*, February 27, 2023, <https://www.economist.com/the-economist-explains/2023/02/27/how-quickly-can-russia-rebuild-its-tank-fleet>.
- 19 “Слова Медведева о выпуске 1500 новых танков в год принадлежат глубоко больному человеку — военный эксперт Лузин,” [Medvedev’s words about the release of 1,500 new tanks a year belong to a deeply sick person - military expert Luzin], *The Insider*, March 23, 2023, <https://theins.ru/news/260391>.
- 20 “Вопрос о производстве танков в России в 2023 году” [Regarding the Tank Production in Russia in 2023], LiveJournal, March 25, 2023, <https://bmpd.livejournal.com/4676984.html>.
- 21 Kontakt6 (@Kontakt642), “New footage suggests the Russian tank industry is struggling to roll out modernized tanks!,” Twitter thread, January 23, 2023, <https://twitter.com/Kontakt642/status/1617584716646948864>.
- 22 “How Quickly Can Russia Rebuild Its Tank Fleet?,” *The Economist*.
- 23 Sabbagh, “Russian Army Has Lost Up to Half of Key Battle Tanks.”
- 24 Ibid.
- 25 Jamey Keaten, “The Calculus of War: Tallying Ukraine Toll an Elusive Task,” Associated Press, February 24, 2023, <https://apnews.com/article/russia-ukraine-war-numbers-8768880034d9d7cd6ac6f3e34abd66f5>.
- 26 Dara Massicot (@MassDara), “I’ve been comparing Russian missile strikes against Ukraine over the last few months,” Twitter photo, March 10, 2023, <https://twitter.com/massdara/status/1634300311744438272?s=12&t=HRkTEA3HvNMdVPwJYXZc3g>.
- 27 Ben Hall and Roman Olearchyk, “Military Briefing: Russian Hypersonic Missiles Bring New Menace to Ukraine,” *Financial Times*, March 10, 2023, <https://www.ft.com/content/e85762ec-ccc5-43e4-896c-074a451dad30>.
- 28 Data compiled from: Dominique Vidalon, “France, Italy Ready to Deliver SAMP/T Anti-missile System to Ukraine,” *Reuters*, February 3, 2023, <https://www.reuters.com/world/europe/france-italy-ready-deliver-sampt-anti-missile-system-ukraine-2023-02-03/>; and Natasha Bertrand and Haley Britzky, “US to Send Patriot Missile Systems and Tanks to Ukraine Faster Than Originally Planned,” CNN, March 21, 2023, <https://www.cnn.com/2023/03/21/politics/us-patriots-ukraine/index.html>.
- 29 James O’Brien and Mark Leonard, “James O’Brien on Sanctions,” *Mark Leonard’s World in 30 Minutes*, Apple Podcast episode, March 6, 2023, <https://podcasts.apple.com/us/podcast/mark-leonards-world-in-30-minutes/id340460705?i=1000603549474>.
- 30 Matt Lee and Nomaan Merchant, “Explainer: What’s the State of Russia’s Missile Arsenal?” Associated Press, October 13, 2022, <https://apnews.com/article/russia-ukraine-kyiv-moscow-fb4f603cd7e8694e788eb764da9e23ac>.
- 31 “Dating Newly Produced Russian Missiles Used in Kyiv Attacks,” Conflict Armament Research, December 2022, <https://storymaps.arcgis.com/stories/81bc6b71fdc64361a05a21020c3d6d5e>.
- 32 Igor Kossov, “How Many Missiles Does Russia Have Left?” *Kyiv Independent*, January 13, 2023, <https://kyivindependent.com/national/how-many-missiles-does-russia-have-left>.
- 33 John Ismay, “Russian Cruise Missiles Were Made Just Months Ago Despite Sanctions,” *New York Times*, December 5, 2022, <https://www.nytimes.com/2022/12/05/us/politics/cruise-missiles-russia-ukraine-sanctions.html>. It may also be possible that for much of 2022, Russian missile manufacturers were prioritized over other industrial sectors, with advanced components being directed toward the missile-producing industry.

- 34 Lee and Merchant, “Explainer.”
- 35 Oleg Danylov, “How Many Missiles are Left in Russia? Unfortunately, a Lot,” *Mezha*, November 22, 2022, <https://mezha.media/en/2022/11/22/how-many-missiles-are-left-in-russia-unfortunately-a-lot/>.
- 36 Max Hunder, “Ukraine Says Russian Strike Pattern Suggests It Is Low on Ballistic Missiles,” Reuters, January 16, 2023, <https://www.reuters.com/world/europe/ukraine-says-russian-strike-pattern-suggests-it-is-low-ballistic-missiles-2023-01-16/>.
- 37 “Senior Military Official Holds a Background Briefing,” U.S. Department of Defense, transcript, December 12, 2022, <https://www.defense.gov/News/Transcripts/Transcript/Article/3243794/senior-military-official-holds-a-background-briefing/>.
- 38 Kossov, “How Many Missiles Does Russia Have Left?”
- 39 Andrew E. Kramer, “Russia’s Latest Missile Barrage Highlights the Growing Complexity of the Air War,” *New York Times*, March 9, 2023, <https://www.nytimes.com/live/2023/03/09/world/russia-ukraine-news?smid=nytcore-ios-share&referringSource=articleShare#russias-latest-missile-barrage-highlights-the-growing-complexity-of-the-air-war>.
- 40 Kossov, “How Many Missiles Does Russia Have Left?”; Marc Santora, “Russia Is Using Old Ukrainian Missiles Against Ukraine, General Says,” *New York Times*, December 12, 2022, <https://www.nytimes.com/2022/12/12/world/europe/russia-ukraine-missiles.html?searchResultPosition=3>.
- 41 Kossov, “How Many Missiles Does Russia Have Left?”
- 42 Clint Reach et al., *Russia’s Evolution Toward a Unified Strategic Operation: The Influence of Geography and Conventional Capacity* (Santa Monica, CA: RAND Corporation, 2023), https://www.rand.org/pubs/research_reports/RRA1233-8.html.
- 43 Vedomosti, “Путин назвал количество беспилотников в российской армии” [Putin named the number of UAVs in the Russian army], *Vedomosti*, November 2, 2021, <https://www.vedomosti.ru/politics/news/2021/11/02/894119-putin-nazval-kolichestvo-bespilotnikov-v-rossiiskoi-armii>.
- 44 “Известия показали работу «Акаций» и «Орланов» по позициям боевиков,” [Izvestia shows the work of ‘Akatsy’ and ‘Orlans’ on the positions of militants], *Izvestia*, February 10, 2023, <https://iz.ru/1468001/2023-02-10/izvestiia-pokazali-rabotu-akatcii-i-orlanov-po-pozitciiam-boevikov>; Alex Vershinin, “What’s Ahead in the War in Ukraine,” *Russia Matters*, December 22, 2022, <https://www.russiamatters.org/analysis/whats-ahead-war-ukraine>.
- 45 “Russia to Launch Mass Production of Effective Drones – Medvedev,” TASS, October 14, 2022, <https://tass.com/defense/1523079>.
- 46 Marina Sovina, “В «Ростехе» рассказали о создании способных атаковать противника «роем» дронов” [Rostec spoke about the creation of drones capable of attacking the enemy], *Lenta.Ru*, January 27, 2023, <https://lenta.ru/news/2023/01/27/drony/>.
- 47 “Россия сталкивается с дефицитом технологий для дронов, заявил эксперт” [Russia faces shortage of drone technology, expert says], *RIA Novosti*, February 6, 2023, <https://ria.ru/20230206/drony-1849921206.html>.
- 48 Pavel Luzin, “Russian Drones: What Has Gone Wrong? – Analysis,” *Eurasia Review*, November 14, 2022, <https://www.eurasiareview.com/14112022-russian-drones-what-has-gone-wrong-analysis/>.
- 49 Karina Levitskaya, “Aliexpress заблокировал продажу дронов для клиентов из России, - росСМИ” [Aliexpress blocked the sale of drones for customers from Russia, - RosSMI], *RBC-Ukraine*, March 2, 2023,

<https://www.rbc.ua/ukr/news/aliexpress-zablokuvav-prodazh-droniv-klientiv-1677769354.html>.

- 50 Sebastian Bienkowski et al., *Effectiveness of U.S. Sanctions Targeting Russian Companies and Individuals* (Washington, DC: Free Russia Foundation, January 2023), <https://www.4freerussia.org/wp-content/uploads/sites/3/2023/01/frf-sanctions-web.pdf>.
- 51 Dion Nissenbaum and Warren P. Strobel, “Moscow, Tehran Advance Plans for Iranian-Designed Drone Facility in Russia,” *Wall Street Journal*, February 5, 2023, <https://www.wsj.com/articles/moscow-tehran-advance-plans-for-iranian-designed-drone-facility-in-russia-11675609087>.
- 52 Data compiled from the following sources: Mia Jankowicz, “Iranian-Made Drones Cost as Little as \$20,000 to Make but up to \$500,000 to Shoot Down, a Growing Concern in Ukraine, Report Says,” *Business Insider*, January 4, 2023, <https://www.businessinsider.com/suicide-drones-much-cheaper-launch-than-shoot-down-ukraine-nyt-2023-1>; Daniel Boffey, “Financial Toll on Ukraine of Downing Drones ‘Vastly Exceeds Russian costs’,” *The Guardian*, October 19, 2023, <https://www.theguardian.com/world/2022/oct/19/financial-toll-ukraine-downing-drones-vastly-exceeds-russia-costs>. The availability of commercial components for the Shahed-136 is the defining feature of its low production costs, given that the Iranian defense sector does not need to constantly develop proprietary technology and can instead procure required parts in any quantity at commercial marketplaces.
- 53 Nissenbaum and Strobel, “Moscow, Tehran Advance Plans”; Steven Feldstein, “The Larger Geopolitical Shift Behind Iran’s Drone Sales to Russia,” *Carnegie Endowment for International Peace*, October 26, 2022, <https://carnegieendowment.org/2022/10/26/larger-geopolitical-shift-behind-iran-s-drone-sales-to-russia-pub-88268>.
- 54 The Kyiv Independent (@KyivIndependent), “Russia’s losses as of March 3”; Mitzer, “List of Aircraft Losses During the 2022 Russian Invasion of Ukraine.” The number of reserve aircraft also likely includes retired munitions awaiting dismantlement. “Comparison of the Military Capabilities,” Statista.
- 55 Michael Bohnert, “Russian Aircraft Keep Crashing. Could Sanctions Be the Cause?” *RAND Corporation*, November 22, 2022, <https://www.rand.org/blog/2022/11/russian-aircraft-keep-crashing-could-sanctions-be-the.html>.
- 56 Peter A. Wilson and John V. Parachini, “Russia’s Su-35: Are Its Military Aircraft Exports Headed for a Fall?” *RAND Corporation*, October 20, 2022, <https://www.rand.org/blog/2022/10/russias-su-35-are-its-military-aircraft-exports-headed.html>.
- 57 Tanmay Kadam, “How Much Russia Spends on Su-57 Fighters, Ka-52 Choppers & Other Systems Deployed To Ukraine? A Breakdown,” *The Eurasian Times*, February 13, 2023, <https://eurasianimes.com/how-much-russia-spends-on-su-57-fighters-ka-52-choppers/>.
- 58 Wilson and Parachini, “Russia’s Su-35.”
- 59 “Sanctioned Russian Aviation Sector Hit By Slew of Incidents in New Year,” *Moscow Times*, January 10, 2023, <https://www.themoscowtimes.com/2023/01/10/sanctioned-russian-aviation-sector-hit-by-slew-of-incidents-in-new-year-a79903>.
- 60 Wilson and Parachini, “Russia’s Su-35.”
- 61 “Sanctions-Hit Russia Starts Stripping Aircraft for Parts - Reuters,” *Moscow Times*, August 9, 2022, <https://www.themoscowtimes.com/2022/08/09/sanctions-hit-russia-starts-stripping-aircraft-for-parts-reuters-a78535>; Bohnert, “Russian Aircraft Keep Crashing”; Marina Aronova, “Punished by Western Sanctions, Russia’s Airlines Are Showing More Cracks and More Problems,” *Radio Free Europe/Radio Liberty*, January 29, 2023, <https://www.rferl.org/a/russia-aviation-industry-problems-western->

sanctions/32244641.html.

- 62 “Russian Regulator Approves Aircraft Cannibalization amid Sanctions,” *Aviation Week*, January 20, 2023, <https://aviationweek.com/air-transport/maintenance-training/russian-regulator-approves-aircraft-cannibalization-amid>.
- 63 Pavel Luzin, “Electronic Warfare: Russia’s Approach,” Foreign Policy Research Institute, February 23, 2022, <https://www.fpri.org/article/2022/02/electronic-warfare-russias-approach/>.
- 64 David Axe, “Russia’s Electronic-Warfare Troops Knocked Out 90 Percent Of Ukraine’s Drones,” *Forbes*, December 24, 2022, <https://www.forbes.com/sites/davidaxe/2022/12/24/russia-electronic-warfare-troops-knocked-out-90-percent-of-ukraines-drones/>.
- 65 Samuel Cranny-Evans, “Russia’s Palantin Electronic Warfare System Makes Training Debut,” *Janes*, September 19, 2019, <https://www.janes.com/defence-news/news-detail/russias-palantin-electronic-warfare-system-makes-training-debut>.
- 66 Game of Drones (droneswar), “Российский ассортимент спецсредств РЭБ глушит радиосвязь, ловит беспилотники противника и блокирует спутниковый интернет” [Russian range of special electronic warfare jamming radio communications, catching enemy drones and blocking satellite internet], Telegram post, October 28, 2022, <https://t.me/droneswar/4550>.
- 67 Pavel Shishkin, “В зоне спецоперации ВС РФ на Украине замечена российская система СПР-2 «Ртуть-БМ»” [Russian system SPR-2 ‘Mercury-BM’ spotted in the special operation zone of the RF Armed Forces in Ukraine], *Voennoe Delo*, May 16, 2022, <https://voennoedelo.com/posts/id23556-prbktddbattfzzymw6vr>.
- 68 Axe, “Russia’s Electronic-Warfare Troops.”
- 69 Michael Peck, “Russian Forces Were Suffering from ‘Electronic Fratricide’ within Days of Attacking Ukraine, a New Report Says,” *Business Insider*, November 21, 2022, <https://www.businessinsider.com/russian-ew-campaign-in-ukraine-undermined-by-electronic-fratricide-2022-11>.
- 70 Luzin, “Electronic Warfare.”
- 71 Sean Carberry, “Just In: How Russia Is Using U.S. Electronics to Attack Ukraine,” *National Defense*, January 26, 2023, <https://www.nationaldefensemagazine.org/articles/2023/1/26/how-russia-is-using-us-electronics-to-attack-ukraine>; James Byrne et al., *Silicon Lifeline: Western Electronics at the Heart of Russia’s War Machine* (London: Royal United Services Institute, August 2022), https://static.rusi.org/RUSI-Silicon-Lifeline-final-updated-web_1.pdf.
- 72 Data compiled from the following sources: Dylan Malyasov, “Russian Soldiers Use Chinese Portable Radios during Kremlin’s Invasion of Ukraine,” *Defence Blog*, March 13, 2022, <https://defence-blog.com/russian-soldiers-uses-chinese-portable-radios-during-kremlins-invasion-of-ukraine/>; GlobalData, “Unencrypted Communications by Russia Undermines Operational Security in Ukraine,” *Army Technology*, January 26, 2023, <https://www.army-technology.com/comment/unencrypted-communications-russia/>; Сергей Флэш, “Мене часто питають: звідки «Вагнера» беруть Моторолу?” [I Am Often Asked: Where does Wagner get Motorola from?], Facebook post, March 26, 2023, <https://www.facebook.com/Serhii.Flash/posts/pfbid0B1FS4kois5WiEgqw5rokHcLcCn1SpMoTVYW8meKZq1zSqMmGphGFGYndXM7FDe8U1>.
- 73 David Axe, “Now Russia Is Adding Inferior Optics to Its T-80 Tanks, Too,” *Forbes*, February 9, 2023, <https://www.forbes.com/sites/davidaxe/2023/02/09/now-russia-is-adding-inferior-optics-to-its-t-80-tanks-too/>.
- 74 Kontakt6 (@Kontakt642), “New footage suggests.”
- 75 Vadim Botnaryuk, “Модернизированные танки ВС РФ начали оборудовать простыми прицелами 1ПН96МТ-02” [Modernized tanks of the RF Armed Forces began to be equipped with simple sights

- IPN96MT-02], Discover24, January 27, 2023, <https://discover24.ru/2023/01/modernizirovannye-tanki-vs-rfnachali-oborudovat-prostymi-pritselami-1pn96mt-02/>.
- 76 Edward Perov, “Новые танки Т-80БВМ для спецоперации: на прицелах, похоже, пришлось экономить” [New T-80BVM tanks for a special operation: it looks like they had to save on sights], Top War, February 24, 2023, <https://topwar.ru/211474-novye-tanki-t-80bvm-dlja-specoperacii-na-pricelah-pohozhe-prishlos-jekonomit.html>.
- 77 “Ball Bearings in Russia,” Observatory of Economic Complexity, accessed March 8, 2023, <https://oec.world/en/profile/bilateral-product/ball-bearings/reporter/rus?redirect=true>.
- 78 “Bearing Industry Updates Related to Ukraine - Russia Conflict (April 2022),” Bearing News, April 27, 2022, <https://www.bearing-news.com/bearing-industry-updates-related-to-ukraine-russia-conflict-april-2022/>.
- 79 Julian E. Barnes, “Western Sanctions Have Hampered Russia’s Ability to Resupply Its Army, a U.S. Report Says,” *New York Times*, October 14, 2022, <https://www.nytimes.com/2022/10/14/us/sanctions-russia-army-weapons.html>.
- 80 Sean Spoons, “SITREP: Russian Rail Sidelined by Sanctions,” SOFREP, September 4, 2022, <https://sofrep.com/news/sitrep-russian-rail-sidelined-by-sanctions/>.
- 81 Ksenia Potaeva, “В России нарастает дефицит подшипников для инновационных грузовых вагонов” [In Russia, there is a growing shortage of bearings for innovative freight cars], *Vedomosti*, August 31, 2022, <https://www.vedomosti.ru/business/articles/2022/08/31/938372-narastaet-defitsit-podshipnikov>.
- 82 “Российский ВПК не успевает восполнять потребности своей армии в условиях боевых действий, — Мусиенко” [The Russian military industrial complex does not have time to meet the needs of its army in the conditions of hostilities - Musienko], FREEDOM TV, October 20, 2022, <https://uatv.ua/rossijskij-vpk-ne-uspevaet-vozpolnyat-potrebnosti-svoej-armii-v-usloviyah-boevyh-dejstvij-musienko/>.
- 83 Ben Aris, “Long Read: Russia’s Sanctions Soft Underbelly: Precision Machine Tools,” *bne IntelliNews*, June 13, 2021, <https://www.intellinews.com/long-read-russia-s-sanctions-soft-underbelly-precision-machine-tools-213024/>.
- 84 Tomas Malmlöf, *The Russian Machine Tool Industry: Prospects for a Turnaround?* (Stockholm: Swedish Defence Research Agency, February 2019), <https://www.foi.se/rest-api/report/FOI-R-4635--SE>.
- 85 “Kubota and Other Japanese Machinery Makers to Halt Russia Operations,” *Nikkei Asia*, March 11, 2022, <https://asia.nikkei.com/Politics/Ukraine-war/Kubota-and-other-japanese-machinery-makers-to-halt-russia-operations>.
- 86 Nobuo Sugahara, “Рассвет российского машиностроения на фоне экономических санкций” [The dawn of Russian engineering against the backdrop of economic sanctions], *InoSMI.ru*, June 6, 2017, <https://inosmi.ru/20170606/239519820.html>; German Machine Tool Builders’ Association, *Market Report 2021: The German Machine Tool Industry and Its Position in the World Market* (Frankfurt: The German Machine Tool Builders’ Association, June 2022), https://vdw.de/wp-content/uploads/2022/06/pub_vdw-marktbericht_2021_2022-06-10_web.pdf.
- 87 “China Is Largest Machine Tool Maker in the World,” *MRO Magazine*, April 1, 2005, <https://www.mromagazine.com/features/china-is-largest-machine-tool-maker-in-the-world/>; “China’s Machine Tools Industry: Can Local Companies Catch Up with Foreign Manufacturers?” *Daxue Consulting*, November 9, 2022, <https://daxueconsulting.com/chinas-machine-tools-industry/>.
- 88 “Санкции и развитие станкостроения в России” [Sanctions and the development of the machine tool industry in Russia], *PanorHub.ru*, November 23, 2022, <https://panorhub.ru/2022/11/23/sankczii-i-razvitie-stankostroeniya-v-rossii/>.

- 89 Vyacheslav Golovanov, “Российские инженеры разработали полностью российский токарный станок с ЧПУ” [Russian engineers have developed a completely Russian CNC lathe], Habr, November 23, 2022, <https://habr.com/ru/news/t/701214/>.
- 90 Chandler Sachs and John V. Parachini, “Russia Engine Troubles: Is Putin’s Behavior Catching Up with Him?” RAND Corporation, June 15, 2021, <https://www.rand.org/blog/2021/06/russia-engine-troubles-is-putins-behavior-catching.html>.
- 91 Alisa Gritskova, Dmitry Dzhepa, and Oleg Panteleev, “Моторостроителей Быстро Запрягли, Но Они Медленно Едут” [Motor builders were quickly harnessed, but they are moving slowly], AviaPORT, April 15, 2010, <https://www.aviaport.ru/news/2010/04/15/193600.html>.
- 92 “St. Petersburg Engine Plant to Substitute Ukraine Imports with Own Output by 2015,” TASS, June 20, 2014, <https://tass.com/russia/736959>.
- 93 “SBU Detains Motor Sich Head Suspected of Supplying Military Equipment to Russia,” Kyiv Independent, October 23, 2022, <https://kyivindependent.com/news-feed/sbu-detains-motor-sich-president-suspected-of-supplying-military-equipment-to-russia>.
- 94 Alex Hollings, “Russia’s Su-57 Can’t Compete with the US’s and China’s 5th-Gen Fighter Jets, but It Doesn’t Need To,” Business Insider, June 9, 2022, <https://www.businessinsider.com/russia-su57-cant-compete-us-chinese-5th-gen-fighter-jets-2021-6>; Pavel Luzin, “Fifth-Generation Fighter Jets,” Riddle, January 13, 2022, <https://ridl.io/fifth-generation-fighter-jets/>.
- 95 Charlotte Seet, “100 Sukhoi Superjets to Be Equipped with Used Engines,” Simple Flying, November 24, 2022, <https://simpleflying.com/100-sdu-equipped-used-engines/>.
- 96 “Китайская Weichai перестала поставлять «КамАЗу» газовые двигатели из-за санкций” [Chinese Weichai stopped supplying gas engines to KamAZ due to sanctions], *Vedomosti*, September 1, 2022, <https://www.vedomosti.ru/business/news/2022/09/01/938683-weichai-perestala-postavlyat-kamazu-dvigateli>.
- 97 David Manners, “Russia’s Backward Chip Industry,” *Electronics Weekly*, April 19, 2022, <https://www.electronicsworld.com/blogs/mannerisms/dilemmas/russias-backward-chip-industry-2022-04/>.
- 98 James Byrne et al., *The Orlan Complex: Tracking the Supply Chains of Russia’s Most Successful UAV* (London: Royal United Services Institute, December 2022), <https://rusi.org/explore-our-research/publications/special-resources/orlan-complex-tracking-supply-chains-russias-most-successful-uav>. While not directly connected with chips, CACDS’s own examination of the Orlan-10 drone also found a thermal-imaging matrix manufactured by French company Lynred (formerly Sofradir), suggesting that Russia’s dependence on Western-produced technologies goes far beyond the dual-use items discussed in this report.
- 99 Constantine (@Teoyaomiquu), “Lancet Drone internals was shared by a friend of mine,” Twitter post, January 30, 2023, <https://twitter.com/Teoyaomiquu/status/1620195517262094336>.
- 100 “Component Commonalities in Advanced Russian Weapon Systems,” Conflict Armament Research, September 2022, <https://storymaps.arcgis.com/stories/239f756e2e6b49a5bec78f5c5248bf3d>.
- 101 “Azart: Unified Radio Communications System of the Tactical Control Level,” Rosboronoexport (Russian Defense Export), accessed February 28, 2022, <https://roe.ru/eng/catalog/land-forces/military-communications-equipment-and-automated-control-systems/radiocomms/azart/>; Leonid Bershidsky, “The Ukraine War Is Still Relatively Low-Tech – for Now,” Bloomberg, January 12, 2023, <https://www.bloomberg.com/opinion/articles/2023-01-12/ukraine-war-is-still-low-tech-for-now>.
- 102 Recently, MCST was purchased by a Rosatom subsidiary, which might boost its investment in chip production. See “Структура «Росатома» купила производителя процессоров «Эльбрус» – «Ъ»” [The ‘Rosatom’ corporation bought the manufacturer of processors ‘Elbrus’ - ‘Ъ’], *vc.ru*, February 10, 2023,

- <https://vc.ru/tech/604733-struktura-rosatoma-kupila-proizvoditelya-processorov-elbrus>; Nikita Korolev, “Процессоры вышли из запаса” [Processors out of stock], ComNews, March 3, 2023, <https://www.comnews.ru/content/224262/2023-02-03/2023-w05/processorov-vyshli-zapasa>.
- 103 Andrey Zlobin, “МВД раскритиковало работу серверов на российских процессорах «Эльбрус»” [The Ministry of Internal Affairs criticized the work of servers on Russian Elbrus processors], *Forbes Russia*, January 31, 2022, <https://www.forbes.ru/tekhnologii/454097-mvd-raskritikovalo-rabotu-serverov-na-rossijskih-processorah-el-brus>.
- 104 Jeanne Whelan, “Computer Chip Industry Begins Halting Deliveries to Russia in Response to U.S. Sanctions,” *Washington Post*, February 25, 2022, <https://www.washingtonpost.com/technology/2022/02/25/ukraine-russia-chips-sanctions-tsmc/>.
- 105 Ivan Kuzmin, “Чипы под санкциями. Способна ли Россия обеспечить себя микроэлектроникой” [Chips under sanctions. Is Russia able to provide itself with microelectronics], *The Firm's Secret*, April 12, 2022, <https://secretmag.ru/technologies/chipy-pod-sankciyami-sposobna-li-rossiya-obespechit-sebya-mikroelektronikoi.htm>.
- 106 “На микросхемах з AliExpress: «аналоговнѣтна» система наведення «Торнадо-С» з РФ (фото)” [On microcircuits from AliExpress: ‘analog’ guidance system ‘Tornado-S’ from the Russian Federation (photo)], *Defense Express*, August 3, 2022, https://defence-ua.com/weapon_and_tech/na_mikroshemah_z_aliexpress_analogovnjeta_sistema_avedennja_tornado_s_z_rf_foto-8418.html.
- 107 U.S. Department of the Treasury, “Remarks by Deputy Secretary of the Treasury Wally Adeyemo on International Sanctions Against Russia,” press release, February 21, 2023, <https://home.treasury.gov/news/press-releases/jy1286>.
- 108 Venera Petrova and Diana Galieva, “Чипнезависимость со скидкой” [Chip independence at a discount], *Kommersant*, November 15, 2022, <https://www.kommersant.ru/doc/5667792>.
- 109 Sergey Titov, “Чипичный путь” [Microchip way], *Kommersant*, January 9, 2023, <https://www.kommersant.ru/doc/5759442>.
- 110 Evgeny Gontmakher, “Russia’s Import Substitution: Effects and Consequences,” GIS, December 2, 2021, <https://www.gisreportonline.com/r/import-substitution/>.
- 111 Sergey Muzykantov, “Импортозамещение в России в 2022 году” [Import substitution in Russia in 2022], *LiteBox*, April 12, 2022, <https://litebox.ru/blog/for-business/importozameshchenie-v-rossii-v-2022-godu/>.
- 112 Gabriela Rosa Hernández, “Iran Supplies Arms to Russia,” *Arms Control Association*, November 2022, <https://www.armscontrol.org/act/2022-11/news/iran-supplies-arms-russia>.
- 113 Alina Ramos Martin, “Putin Highlighted the Potential of the Russian Military Industry,” *Prensa Latina*, September 20, 2022, <https://www.plenglish.com/news/2022/09/20/putin-highlighted-the-potential-of-the-russian-military-industry/>; RIA Volga, “Спецоперация на Украине дала толчок развитию российского военно-промышленного комплекса” [Special operation in Ukraine gave impetus to the development of the Russian military-industrial complex], *РИА Волга*, August 26, 2022, <https://astravolga.ru/news/spetsoperatsiya-na-ukraine-dala-tolchok-razvitiyu-rossiyskogo-voennopromyshlennogo-kompleksa/>.
- 114 Alberto Nardelli, “Putin Tried for Years to Stop His Military From Using Western Parts – And Mostly Failed,” *Bloomberg*, October 14, 2022, <https://www.bloomberg.com/news/articles/2022-10-14/putin-tried-for-years-to-stop-his-military-using-western-parts-and-mostly-failed>.
- 115 UK Ministry of Defence (@DefenceHQ), “Latest Defence Intelligence update on the situation in Ukraine - 15 February 2023,” Twitter post, February 15, 2023, <https://twitter.com/defencehq/status/1625746370291290112?s=46&t=uYBwDxHPZ9nUREO6Bku32Q>.

- 116 Nikita Korolev, “Правительство снацпроектировало электронику” [Government designed electronics], *Kommersant*, April 15, 2022, <https://www.kommersant.ru/doc/5306920>.
- 117 Ibid.
- 118 “Key Official Weighs In on Building Up Russia’s Drone Industry,” TASS, February 13, 2023, <https://tass.com/defense/1575645>; “РФ запустит грантовую поддержку разработки комплектующих для авиабеспилотников” [Russia will launch grant support for the development of components for aircraft drones], Interfax, February 13, 2023, <https://www.interfax.ru/russia/885879>.
- 119 Readovka, “Быть самодостаточным по критическим технологиям— министр финансов России о распределении бюджета во время санкций,” Telegram post, March 3, 2023, <https://t.me/readovkanews/53997>.
- 120 “Innovations: Advanced Designs,” Rostec, accessed February 28, 2023, <https://rostec.ru/en/innovations/#projects>.
- 121 “Россия представит на Aero India 2023 передовые средства борьбы с беспилотниками” [Russia to present advanced anti-drone weapons at Aero India 2023], TASS, February 9, 2023, <https://tass.ru/armiya-i-opk/17005037>.
- 122 “Депутаты приняли закон о федеральном бюджете РФ на 2023-2025 гг” [The deputies adopted the law on the federal budget of the Russian Federation for 2023-2025], Interfax, November 24, 2022, <https://www.interfax.ru/business/874004>.
- 123 U.S. Department of the Treasury, “U.S. Treasury Sanctions Nearly 100 Targets in Putin’s War Machine, Prohibits Russian Gold Imports,” press release, June 28, 2022, <https://home.treasury.gov/news/press-releases/jy0838>.
- 124 The same has been argued about Russia’s space agency, Roscosmos. While U.S. sanctions and export-control measures allow U.S.-Russian civil space cooperation, Washington did sanction several Roscosmos-affiliated companies—involved in the production of automated vehicles, navigation and communications systems, and microelectronic devices—for allegedly providing Russia’s defense industry with imported dual-use items. “US Sanctions against Roscosmos Companies Not Hindering Cooperation on ISS – NASA,” TASS, September 16, 2022, <https://tass.com/science/1509063>.
- 125 “Drone Production Facility outside Moscow to Get into Top Gear in 2024,” TASS, February 1, 2022, <https://tass.com/defense/1395835>.
- 126 U.S. Department of the Treasury, “U.S. Treasury Sanctions Russia’s Defense-Industrial Base, the Russian Duma and Its Members, and Sberbank CEO,” press release, March 24, 2022, <https://home.treasury.gov/news/press-releases/jy0677>.
- 127 The research team obtained this information at a private workshop held in accordance with the Chatham House rule but was subsequently unable to find additional data through open-source intelligence that would back this statement. Yet considering the preponderance of foreign components in Russian weapons systems and various ways the Kremlin is attempting to obtain the restricted electronics, the team decided to include this information, deeming it a distant possibility.
- 128 Bienkowski et al., *Effectiveness of U.S. Sanctions*.
- 129 Polina Ivanova and Max Seddon, “Russia’s Wartime Economy: Learning to Live without Imports,” *Financial Times*, December 14, 2022, <https://www.ft.com/content/6c01e84b-5333-4024-aaf1-521c1f207eb4?shareType=nongift>.
- 130 Amanda Macias, “U.S. Slaps Iran with Another Round of Sanctions over Drones Used in Russia’s War

- on Ukraine,” CNBC, January 6, 2023, <https://www.cnn.com/2023/01/06/us-sanctions-iran-over-drones-used-in-russias-war-on-ukraine.html>; Rob Lee (@RALee85), “Interesting details from @Gerjon_ and @olga_pp98 possibly indicating a quick turn around between Shahed/ Geran-2 UAVs arriving in Russia from Iran and being used against Ukraine,” Twitter post, January 26, 2023, <https://twitter.com/RALee85/status/1618488225840140288>.
- 131 “Фурсенко: ‘Российско-иранский диалог’ направлен на получение странами новых возможностей” [Fursenko: ‘Russian-Iranian dialogue’ is aimed at obtaining new opportunities for countries], TASS, December 2, 2022, <https://tass.ru/politika/16485579>.
- 132 Tom Westcott and Afshin Ismaeli, *Sanctions and Smuggling: Iraqi Kurdistan and Iran’s Border Economies* (Geneva: The Global Initiative Against Transnational Organized Crime, April 2019), <https://globalinitiative.net/analysis/iran-iraq/>.
- 133 Phone interview with the author, February 15, 2023.
- 134 Debby Wu, “US Concerned Iran and Others Aiding Russia to Secure Chips,” Bloomberg, February 15, 2023, <https://www.bloomberg.com/news/articles/2023-02-16/us-concerned-iran-and-others-aiding-russia-to-secure-chips>.
- 135 David Rogers, “Iran, Russia, and Azerbaijan Agree Rail Link,” Global Construction Review, January 19, 2023, <https://www.globalconstructionreview.com/iran-russia-and-azerbaijan-agree-rail-link/>.
- 136 Ian Talley and Anthony DeBarros, “China Aids Russia’s War in Ukraine, Trade Data Shows,” *Wall Street Journal*, February 4, 2023, <https://www.wsj.com/articles/china-aids-russias-war-in-ukraine-trade-data-shows-11675466360>.
- 137 Erin Banco and Sarah Anne Aarup, “‘Hunting Rifles’ - Really? China Ships Assault Weapons and Body Armor to Russia.” *Politico*, March 16, 2023, <https://www.politico.com/news/2023/03/16/chinese-rifles-body-armor-russia-ukraine-00087398>.
- 138 Ibid.; “China Reportedly Negotiating with Russia to Supply Kamikaze Drones,” *Spiegel International*, February 23, 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-fb3c69bcd1df>; Adam Edelman, “U.S. Warns China That Helping Russia in War in Ukraine Would ‘Alienate’ it from World,” NBC News, February 26, 2023, <https://www.nbcnews.com/politics/national-security/us-warns-china-helping-russia-war-ukraine-alienate-nation-rcna72368>.
- 139 Anatoly Ostapenko, “‘Мотор Січ’ нардепа Богуслаєва постачає деталі для двигунів військовим РФ, працює у Криму і т.зв. ДНР” [People’s Deputy Bohuslaev’s ‘Motor Sich’ supplies parts for engines to the Russian military, works in Crimea and the so-called Donetsk People’s Republic], *bihus*, July 9, 2019, <https://bihus.info/motor-sich-nardepa-boguslaeva-postachae-detali-dlya-dviguniv-viyskovim-rf-pracyue-ukrimu-i-tzv-dnr/>.
- 140 “Motor Sich Factory and Its Covert Ties to Russia,” *The Ukrainian Tribune*, September 21, 2019, <https://uatribune.com/en/the-motor-sich-factory-and-its-covert-ties-to-russia/>.
- 141 “SBU Detains Motor Sich Head,” *Kyiv Independent*.
- 142 Balkans-Ukraine Cooperation Network, “Avoiding Sanctions,” Google sheets, accessed February 2022, <https://docs.google.com/spreadsheets/d/13TBajpfFwEs097GWCqeWN1QdYnco79JsyMgAdQAgWf0/edit#gid=0>. This spreadsheet was provided to CSIS by the team at CACDS.
- 143 “‘AES’ d.o.o.,” *Company Wall*, updated August 8, 2017, <https://companywall.ba/firma/aes-doo/MMpxYg0>.
- 144 Steve Stecklow, David Gauthier-Villars, and Maurice Tamman, “The Supply Chain That Keeps Tech

- Flowing to Russia,” Reuters, December 13, 2022, <https://www.reuters.com/investigates/special-report/ukraine-crisis-russia-tech-middlemen>.
- 145 Maxim Kondratenko, Nick Grothaus, and Robert Kim, “Russian Defense Companies Import Advanced Electronics Through Turkey,” Kharon, February 23, 2023, <https://brief.kharon.com/updates/russian-defense-companies-import-advanced-electronics-through-turkey/>.
- 146 Наталья Скорлыгина, Тимофей Корнев, Ольга Никитина, Полина Смертина, Айгуль Абдуллина, “Страна неограниченных таможенностей,” *Kommersant*, March 9, 2023, <https://www.kommersant.ru/doc/5864376>.
- 147 Jack Watling and Nick Reynolds, “Operation Z: The Death Throes of an Imperial Delusion,” Royal United Services Institute, April 22, 2022, <https://static.rusi.org/special-report-202204-operation-z-web.pdf>.
- 148 Sergey Mingazov, “ЕБРР заподозрил соседние с Россией страны в помощи ей в обходе санкций Запада” [EBRD suspected Russia’s neighbors of helping it bypass Western sanctions], *Forbes Russia*, February 19, 2023, <https://www.forbes.ru/biznes/485131-ebrr-zapodozril-sosednie-s-rossiej-strany-v-pomosi-ej-v-obhode-sankcij-zapada>.
- 149 Ivanova and Seddon, “Russia’s Wartime Economy.”
- 150 Vladislav Inozemtsev, “Import Substitution or ‘Going Parallel?’”, Riddle, July 7, 2022, <https://ridl.io/import-substitution-or-going-parallel/>.
- 151 Anastasia Stognei and Polina Ivanova, “Kazakhstan to Step Up Monitoring of Goods Re-Exported To Russia,” *Financial Times*, March 23, 2023, <https://www.ft.com/content/b4e8c02a-adb5-4148-9b15-c0cf2845fa0f>.
- 152 Ivan Nechepurenko, “How Western Goods Reach Russia: A Long Line of Trucks Through Georgia,” *New York Times*, January 13, 2023, <https://www.nytimes.com/2023/01/13/world/europe/georgia-russia-cargo-border.html>.
- 153 Riley Bailey, Grace Mappes, Kateryna Stepanenko, Nicole Wolkov, and Frederick W. Kagan, “Russian Offensive Campaign Assessment,” The Institute for the Study of War, February 25, 2023, <https://www.understandingwar.org/sites/default/files/Russian%20Offensive%20Campaign%20Assessment%20February%2025%2C%202023.pdf>
- 154 Andrew Duehren, “Janet Yellen Warns South Africa About Breaching Russia Sanctions,” *Wall Street Journal*, January 27, 2023, <https://www.wsj.com/articles/janet-yellen-warns-south-africa-about-breaching-russia-sanctions-11674828642>; Byrne et al., “Silicon Lifeline.”
- 155 Byrne et al., “The Orlan Complex.”
- 156 Don Graves, “America’s Hidden Tool Is Hobbling Russia’s War Machine with Multilateral Impact,” *War on the Rocks*, February 1, 2023, <https://warontherocks.com/2023/02/americas-hidden-tool-is-hobbling-russias-war-machine-with-multilateral-impact/>.
- 157 Bruce McClintock, “Russia’s National Security Space Strategy: How to Avoid Repeating History,” Institute for International Political Studies, November 19, 2020, <https://www.ispionline.it/en/publication/russias-national-security-space-strategy-how-avoid-repeating-history-28335>.

- 158 Daniil Irinin, “«Армата», Циркон и «Посейдон» Военная техника России: где производят лучшие танки, ракеты и подлодки страны?» [‘Armata,’ Zircon, and ‘Poseidon’ military equipment of Russia: Where are the best tanks, missiles and submarines of the country produced?], Lenta.Ru, December 11, 2022, https://lenta.ru/articles/2022/12/11/mil_industry/; Alexander Vorontsov, “Россия получит 800 модернизированных Т-62 - акт отчаяния или серьезная боевая единица” [Russia to receive 800 modernized T-62s - an act of desperation or a serious combat unit], Top War, October 18, 2022, <https://topwar.ru/203438-t-62.html>.
- 159 “Ректор Сколтеха: Россия не может ликвидировать огромное отставание в микроэлектронике” [Skoltech President: Russia cannot close huge gap in microelectronics], Russian Electronics, June 21, 2022, <https://russianelectronics.ru/2022-06-21-skolteh/>.
- 160 “Kremlin: Russia Open to Ukraine Talks, but Won’t Give Up Annexed Regions,” Reuters, February 28, 2023, <https://www.reuters.com/world/europe/kremlin-russia-open-ukraine-talks-wont-give-up-annexed-regions-2023-02-28/>.
- 161 Chris Matthews, “France, Germany and Italy Sold Hundreds of Millions of Pounds Worth of Arms and Military Kit to Russia for Years Despite Embargo,” *Daily Mail*, March 18, 2022, <https://www.dailymail.co.uk/news/article-10627511/France-Germany-Italy-sold-hundreds-millions-pounds-worth-arms-Russia-despite-ban.html>.

COVER PHOTO -/SPUTNIK/AFP/GETTY IMAGES

CSIS | CENTER FOR STRATEGIC &
INTERNATIONAL STUDIES

1616 Rhode Island Avenue NW
Washington, DC 20036
202 887 0200 | www.csis.org