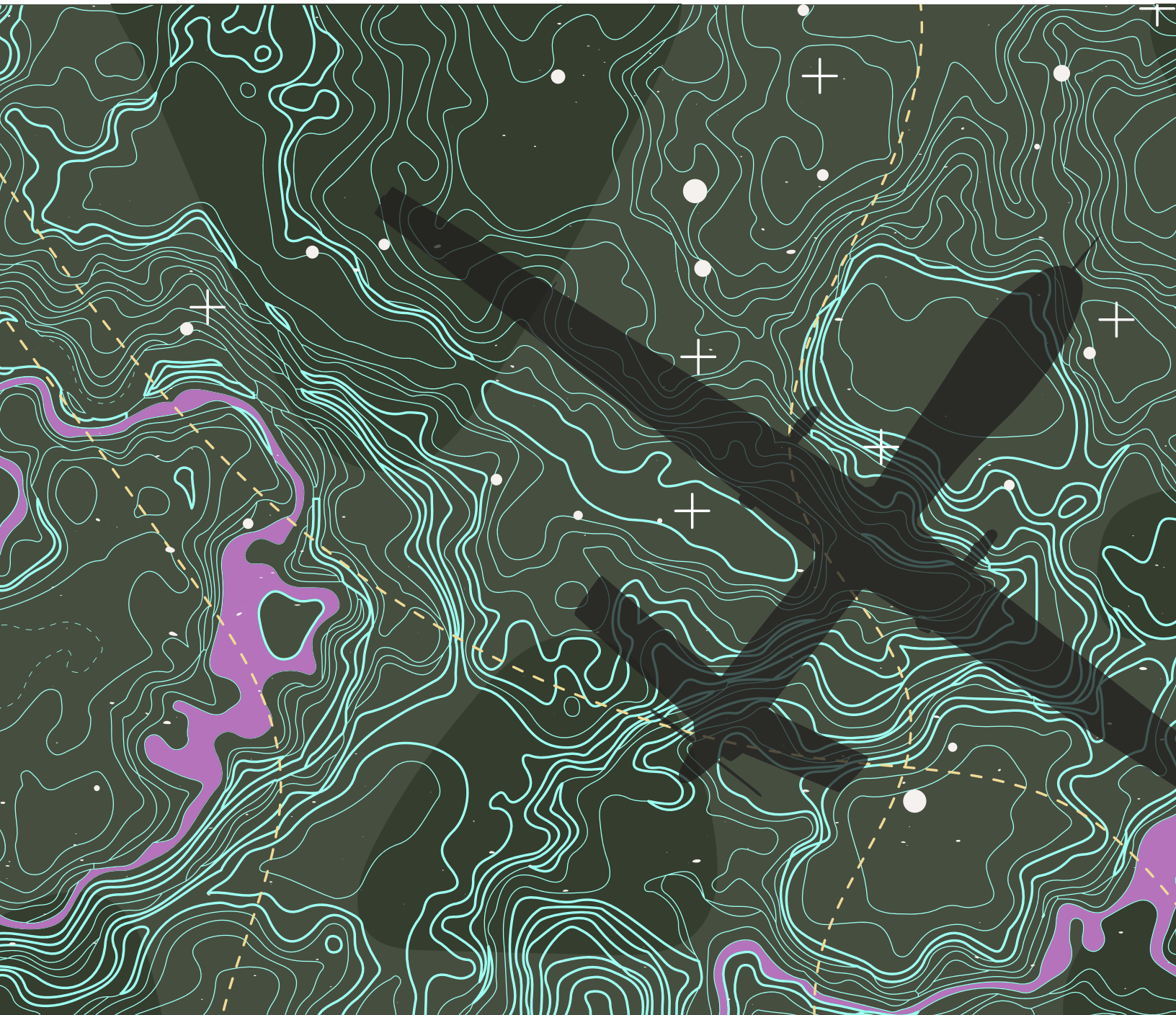
FOREIGN POLICY RESEARCH INSTITUTE | EURASIA PROGRAM

RUSSIAN MILITARY DRONES

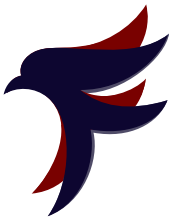
PAST, PRESENT, AND FUTURE OF THE UAV INDUSTRY

PAVEL LUZIN



The views expressed in this report are those of the author alone and do not necessarily reflect the position of the Foreign Policy Research Institute, a non-partisan organization that seeks to publish well-argued, policy-oriented articles on American foreign policy and national security priorities.

November 2023

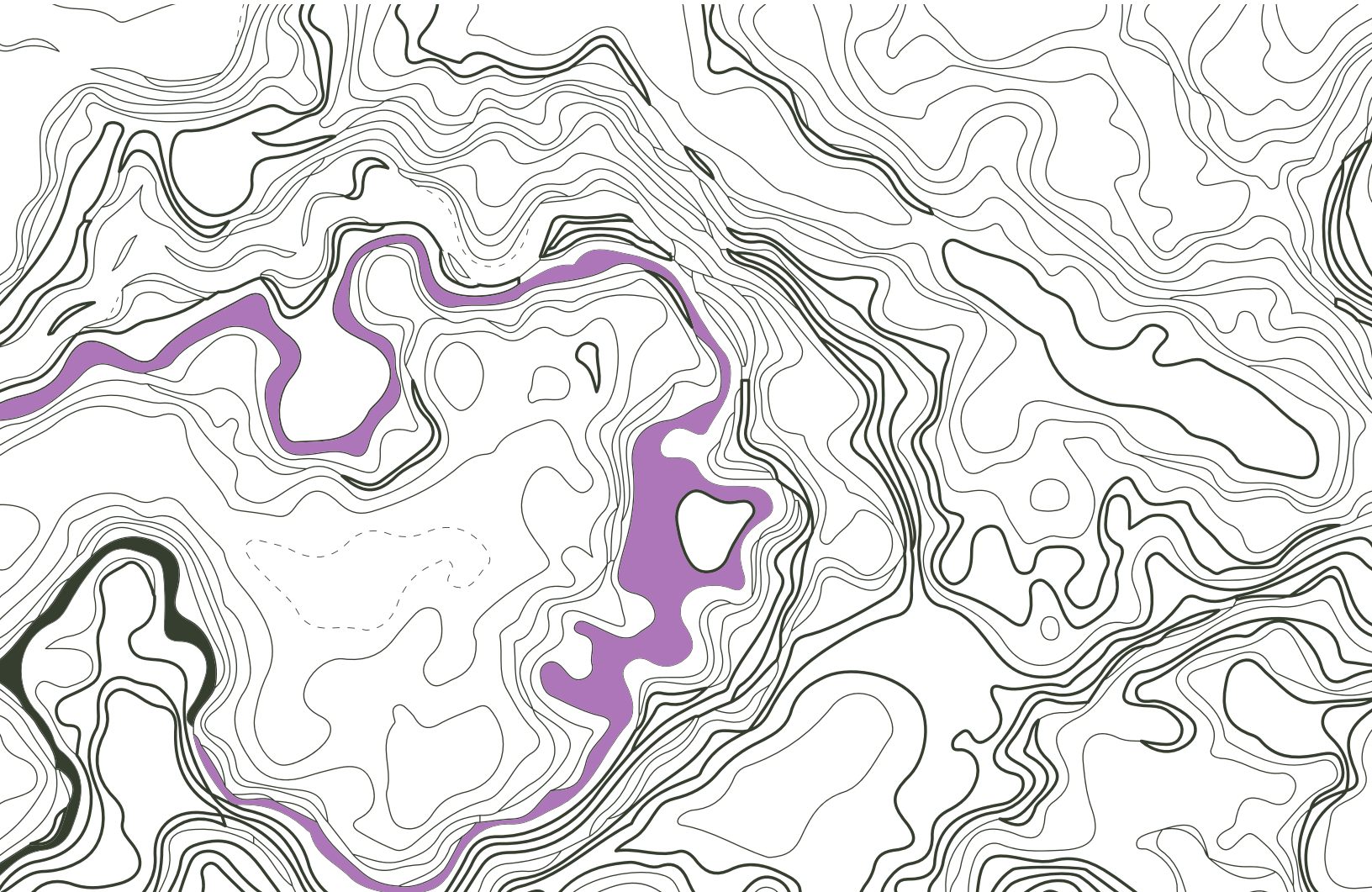


FOREIGN POLICY RESEARCH INSTITUTE | EURASIA PROGRAM

RUSSIAN MILITARY DRONES

Past, Present, and Future of the UAV Industry

Pavel Luzin



About the Author

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

About the Eurasia Program

The Eurasia Program at the Foreign Policy Research Institute was founded in 2015 with the aim of examining the political, security, economic, and social trends shaping Europe and Eurasia. Our research agenda covers the increasingly tense competition roiling the region from several angles. It has a multi-year focus on the Baltic Sea, the Black Sea, and Central Asia, emphasizing how geography, economics, ideology, and history continue to shape politics and security in these regions. The program also publishes analyses of Russian foreign policy, including Russia's role in Europe, Asia, Africa, and the Middle East. The Russia Political Economy Project, along with the Bear Market Brief, analyzes the linkages between Russia's economy, society, and its political system. The Eurasia Program's thematic initiatives also include the Democracy at Risk rubric, which examines the trends of democratization and authoritarian pushback in the region.

INTRODUCTION

Since 2009, Russia has invested significant effort into developing unmanned aerial vehicles (UAVs), or drones, for military purposes. They have used drones for reconnaissance, targeting, electronic warfare, and direct strikes. Some of these UAVs have been used in Ukraine and Syria since 2014, while combat UAVs (i.e., the Orion and Altius drones) still were on the research and development phase at the beginning of 2022.

However, after a year of war in Ukraine, the Russian military has lost the biggest part of its tactical reconnaissance and targeting UAVs. At the same time, it was still unable to deploy advanced combat UAVs. As soon as fall 2022, or roughly six months into Russia's full invasion of Ukraine, Russia started the large-scale use of Iranian loitering munitions, and continues to be highly dependent on them as of fall 2023.

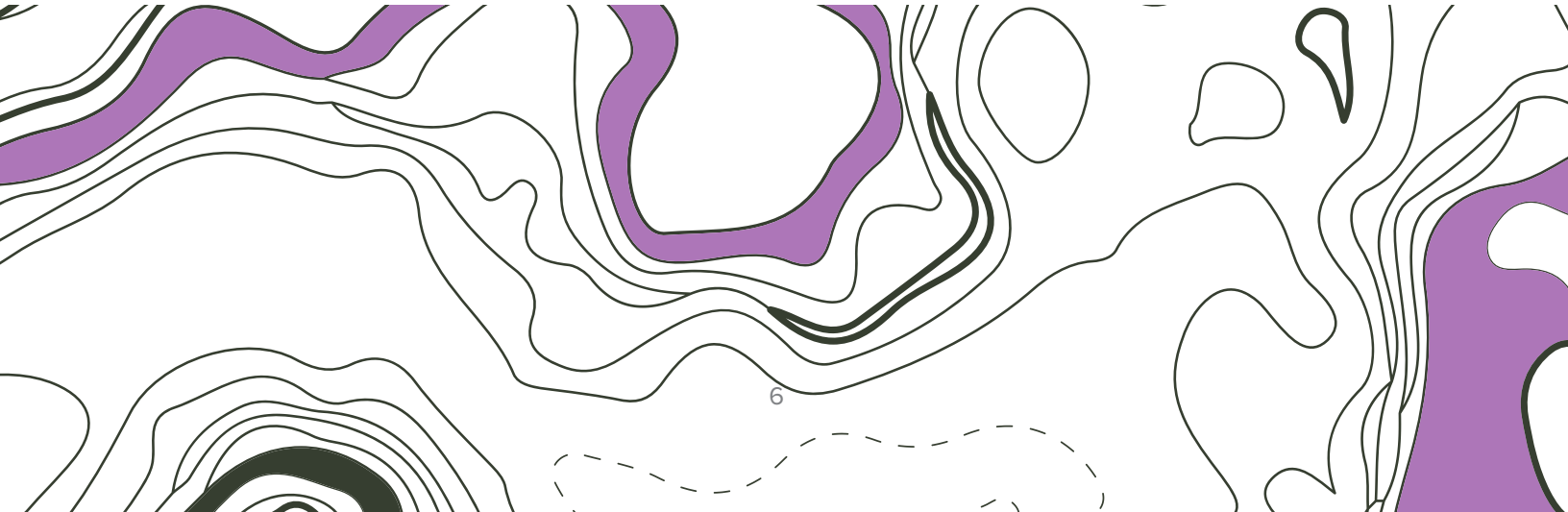
Despite efforts towards increasing their production, Russia's use of its own loitering munitions remains insignificant.

KEY FINDINGS

- Relying on global supply chains, Russia was able to develop its own UAV industrial base in the late 2000s and early 2010s. For UAV production, Russia imported electronics, engines, and industrial equipment (which is more important than electronic components) from Europe, the United States, Israel, and Japan, among other places.

- The fundamental problem of integrating UAVs into the different branches of the Russian armed forces and Russian military doctrine was not solved by 2022. The full-scale aggression against Ukraine challenged Russia's approaches towards UAVs and the UAV industrial base. Significant parts of the drone supply chains that Russia purchased before 2022 havebeen lost. Western sanctions and Russia's decreasing financial, technological, and human capabilities undermine sophisticated UAV projects started in the 2010s, as well as the Strategy of Development of Unmanned Aviation for 2030–2035 issued in 2023.[1]

- The Russian military recognized that Ukraine processed and exchanged information between drones and artillery much faster, and this processing—together with general compatibility of different systems in the Russian armed forces—needed crucial improvements.



- The lack of command, control, and communication systems—together with an over-centralized decision-making process and the huge Ukrainian theater—made smaller tactical units in the Russian military dependent on imported small commercial and agricultural drones like those produced by the Chinese company DJI.

- Unlike Ukraine, Russia cannot rely on the wide civic movement that systemically provides the armed forces with commercial drones and other equipment.

- Based on the experience of using Iran-made “Shahed-136” and “Shahed-131” loitering munitions, the Russian military started efforts towards better tactics of using drone swarms as well as developing an efficient command and control system.

- At the same time, the Russian military focused on further developing and improving counter-UAV capabilities in the face of swarms of small, cheap Ukrainian drones.

- Uncertainty in the Russian UAV industry—and in the whole aerospace industry—will persist, if not increase, in coming years.

- Given Russia’s long-term dependence on imported components and industrial equipment, together with a limited workforce and massive losses of UAVs during the ongoing war, Russia’s capabilities in reconnaissance and targeting, as well as in high-precision weapons, will stagnate, if not decrease, in the foreseeable future. Considering that Ukraine is making significant advances in using drones with assistance of its Western allies, Russia will not be able to restore its superiority in this aspect of military power.

Evolution of Russia's UAV programs and policy (1960s–2010s)

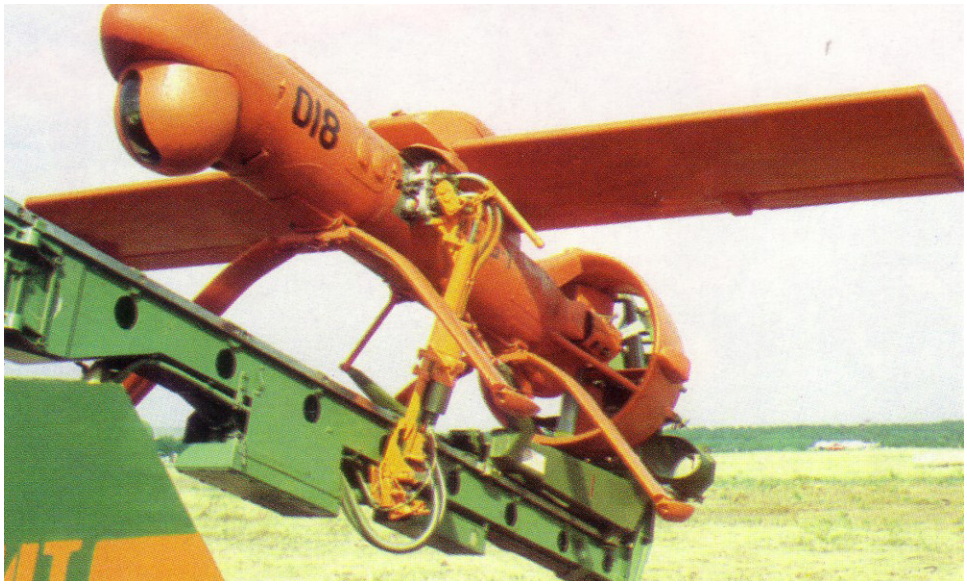
The Soviet Union developed early UAVs from the 1960s to 1980s. Its approach was rather limited; by the beginning of 1980s there were only two types of reconnaissance UAVs. The Tu-141 Strizh UAV, produced by the Tupolev Design Bureau, first flew in 1974 and was incorporated into service in 1979. At roughly the same time, Tupolev also produced the Tu-143 Reis UAV. These UAVs were countertypes of the American drones like Ryan Model 147, and were aimed for theater and tactical reconnaissance respectively. Both the Strizh and Reis replaced the Tu-123 Yasterb, a theater reconnaissance expendable UAV that entered service in 1964 (1964–1980). The Tu-141 and Tu-143 could not provide information in real-time because of their technical specifications and operational difficulties, but they did deliver photo and videotapes after the missions.

The growing Western advantage in electronics, command and control systems, engines, and other technologies related to the UAVs were challenged for first time during the war in Lebanon in 1982. Syria, a Soviet client state, used the Tu-143, while Israel used two UAVs for tactical reconnaissance, the Tadiran Mastiff and IAI Scout.

The Soviet Union moved in two directions with respect to drones. Firstly, it invested in further developing and modernizing jet reconnaissance UAVs originally derived from surface-to-surface and air-to-surface cruise missiles. Two new drones, the Krylo-1 (from the Sokol Design Bureau) and the Tu-243 (or Reis-D,from the Tupolev Design Bureau) appeared. Krylo-1 was planned for tactical reconnaissance with a range of 45 km. The Tu-243 was a version of Tu-143 with improved onboard and reconnaissance equipment and the range extended to 300–400 km. And these two UAVs had an imagery data transmission in real time that allowed the Soviet military to get reconnaissance information much faster. Other Soviet design bureaus, like Myasischev Design Bureau, Sukhoi Design Bureau, and Kamov Design Bureau, conducted research and development on heavy reconnaissance and even combat UAVs.[2]

The Soviet Union tried to develop light UAVs for tactical reconnaissance and artillery spotting in the range of 45–60 km. These efforts resulted in the piston-engine Shmel-1 UAV, which entered service in 1983. A decade later, the Pchela-1T UAV, which also used a piston engine, was designed by the Yakovlev Design Bureau.

In 1983, the 924th Center for Unmanned Aviation was established within the Soviet armed forces. The UAV combat units were subordinated to the center, and it was also responsible for testing and pre-commissioning new UAVs.[3]



Pchela-1T UAV on a starting ramp 1986. (Wikimedia Commons/Piotr Butowski)

M-141 Tu-141 "Strizh" Cruise Missile at Monino Central Air Force Museum in Moscow. (Wikimedia Commons/ Bernhard Gröhl)

Despite this early progress, all the efforts stalled by the end of 1980s as the Soviet system deteriorated and eventually collapsed. The dissolution of the Soviet Union in 1991 brought about the fragmentation of the military industry, which negatively impacted UAV development during the 1990s. Despite the fact that post-Soviet Russia continued the Tu-243 and Pchela-1T projects and even commissioned them in service, these drones were in service mostly on paper and were hardly operational. There were several combat missions of Pchela-1T during the Chechen wars of 1994–1996 and 1999–2009, but it was mostly experimental and the drone was almost useless because of technical troubles and short service life. Russia did not use the Krylo-1 and Tu-243 during the post-Soviet decades, including in Chechnya, Georgia, and later in Ukraine and Syria.[4]

As a result, by the end of 2000s, Russia was two decades behind the United States and other competitors in developing UAVs. Paradoxically, while the companies of the former Soviet military industry were unsuccessful with their UAVs and the Russian armed forces experimented with old-fashioned and unreliable Soviet-era drones, the new private Russian companies developed drones for other Russian agencies. The first one was Eniks, established in 1988 by a group of people in Tatarstan who are still unknown to this day. It has conducted research and development of the UAV technologies since the very beginning. Its main focus was flying target and reconnaissance drones for military intelligence, the FSB, and interim forces (Rosgvardia).[5] The Eleron UAV, its most-produced tactical reconnaissance UAV, and its variants appeared by the end of 2000s and its serial manufacturing launched starting in the early 2010s when the Russian military ordered them for the ground forces.

The second private Russian firm in the UAV market was the Zala Aero Group, established by Alexander Zakharov in Izhevsk in 2004. Its first small, multi-purpose UAV was presented in 2006. While the Russian military possessed a number of hardly useful UAVs like the Pchela-1T, Krylo-1, and Tu-243, the Russian police became a first user of Zala UAVs and soon the company started to supply its UAVs to Gazprom and to other leading Russian oil and gas companies for the purpose of pipeline and power transmission line inspections.[6] The ministry of defense did not pay much attention to this at the time because it probably considered Zala UAVs unreliable in combat—its commercial onboard electronics imported from abroad made it hard to integrate into the typical organization structure and command, control, and communication systems of the Russian armed forces.

Immediately following the August 2008 war in Georgia, the Russian military leadership prioritized developing and purchasing UAVs.

Immediately following the August 2008 war in Georgia, the Russian military leadership prioritized developing and purchasing UAVs. The urgent purpose was filling a gap in tactical reconnaissance and artillery spotting which was considered crucial by the political and military leadership. The long-term purpose was to develop long-endurance and long-range reconnaissance and combat UAVs. These types of drones were planned to fill a gap in satellite reconnaissance and targeting of medium-range and long-range precision weapons. They were also intended to improve Russia's ground-attack aviation capacity and military power-projection capabilities.

At the same time, most of the Soviet-era design bureaus were incapable of developing new UAVs based on the modernization of existing UAVs.[7]

Russian President Vladimir Putin (R) and Defence Minister Igor Sergeyev (2R) look at a model of "Pchela-M", a small pilotless airplane used for reconaissance against rebels in Chechnya, as they visit a weapons exhibition in the Ural's city of Nizhny Tagil July 14, 2000. (Reuters)

Consequently, Russia's UAV program started almost from scratch at the end of the 2000s. This structure involved several major state-owned corporations in Russia's defense industry that became dominant actors, and a number of private companies that were merged either by the state-owned sector or by the formally private businesses affiliated with the Russian political elite by the mid-2010s.

Russian authorities planned to develop the entire range of UAVs at the same time, from small tactical electric reconnaissance UAVs to the heavy long-range, long-endurance reconnaissance and combat drones with turboprop and jet engines. Russia had spread limited financial and human sources among too many projects. UAV development became one of Russia's top priorities, even for its president. The promise to increase the share of UAVs in Russia's combat aviation by 40 percent meant that significant financial resources would be redistributed in favor of those companies and single factories that would be engaged in the research and development programs and further procurement. In this way, the UAV program became a matter of bureaucratic (and consequently non-market) competition between agencies, state-owned corporations, and smaller stakeholders like regional elites, universities, etc.[8]

In 2009–2010, Russia purchased two Israeli reconnaissance UAVs—IAI Searcher and Bird-Eye-400—and the license for their manufacturing in Russia under the names

Forpost and Zastava respectively. The Ural Works of Civil Aviation (also known as UZGA), which became a subsidiary of the Rostec state-owned corporation in 2009,[9] launched production of the licensed Israeli UAVs in 2012.[10] In 2021, the combat version of the Forpost drone, Forpost-RU, was presented during Army-2021, the main Russian military forum.

In 2010, the IT-company Special Technology Center—established in the early 2000s by former military officers who graduated from the Military Academy of Communications—started serial manufacturing of the most mass-produced modern Russian tactical reconnaissance UAV, Orlan-10[11], which became an essential part of Russian artillery units.[12] Some Oraln-10 UAVs are also equipped as tactical electronic warfare drones within the Leer-3 systems.

Another Russian IT company, Transas, was originally only focused on naval navigation, mapping, and naval and aviation simulators. Its subsidiary startup Kronshtadt began developing reconnaissance UAVs for the FSB in the late 2000s. In 2011[13], it got the contract from the Russian Ministry of Defense for developing the long-endurance reconnaissance UAV Orion.[14] At the same time, the Russian company Industrial Investors became the main owner of Kronshtadt[15], and in 2015[16], sold it to AFK Sistema.[17] In 2021[18], AFK Sistema sold Kronshtadt to an unknown entity.[19] UAV Orion has been commissioned in trial operations since 2019 and soon got combat experience. The quantity production of this UAV started in 2022.[20]

Sokol Design Bureau (OKB Sokol), which was re-named Simonov Design Bureau in 2014 in Tatarstan, survived in the decades after the Cold War due to the production of flying targets (or target drones). It was privatized in the early 2000s[21] by representatives of the Tatarstan political elite and finally got a contract from the Ministry of Defense to develop the heavy long-endurance piston UAV Altair,[22] also known as Altius.[23] Simonov Design Bureau developed Altair in cooperation with Transas (Kronshtadt) in order to unify Altius and Orion as much as possible.[24] Problems appeared later when Simonov Design Bureau failed the final stages of research and development: the head of Simonov Design Bureau was arrested[25] and Altius has been transferred to the Ural Works of Civil Aviation in 2018.[26] The development of Altius was completed in 2020 and the first contract for its supply was signed in 2021.[27]

Another major project of the early 2010s was the S-70 Okhotnik. It is a heavy jet drone that has been developed since 2012 by Sukhoi, a subsidiary company of the United Aircraft Corporation (UAC).[28] UAC itself was merged with Rostec in 2019–2020 because of massive losses.[29] This drone can be considered as a counterpart of the American RQ-170 Sentinel drone with a combat option.[30] Serial manufacturing of Okhotnik was scheduled for 2023 but was recently delayed until 2025.[31]

A police officer looks at a monitor displaying a view from a camera installed on a Russian-made drone, an unmanned aerial vehicle (UAV), "Zala-42180", near the Siberian city of Krasnoyarsk, October 28, 2010. According to the police, the new drones will be used to help them monitor the district, search for people, detect forest fires, and other tasks. REUTERS/Ilya Naymushin

The Zala Aero Group received contracts with the Ministry of Defense in 2016. Soon after it was purchased by Kalashnikov Group, which was controlled by Rostec and headed and co-owned by Alexei Krivoruchko,[32] the current deputy minister of defense.[33] In 2019, Zala demonstrated its loitering munitions KUB-BLA and Lancet, which completed trials in 2021 and became operational in 2022.[34] Kalashnikov Group also has a second subsidiary in UAV development and production, Izhevsk Unmanned System, the manufacturer of the Granat and Takhion tactical reconnaissance drones.

Other Russian state-owned companies, factories, and state-owned research institutions—including those belonging to the Ministry of Defense—also presented their projects of UAVs at that time and got contracts for supply, like Eleron drones made by Eniks. Moreover, there were even tests of drones available on the common market.[35] Nevertheless, the military leadership finally put its main bet on Orlan-10, Orion, Altius, Okhotnik, and small reconnaissance UAVs and loitering munitions made by Zala Aero Group, Izhevsk Unmanned Systems, and Eniks.

There was still a fundamental problem of integrating UAVs into the armed forces and their doctrine, different branches, and command, control, and communication structures. The first inter-agency concept of operations of government UAVs for 2030 appeared in 2013 with the participation of the emergencies ministry, FSB, Ministry of

People at an exhibition displaying destroyed Russian military equipment and parts of downed Russian missiles and drones, located on the main Khreschatyk street during the celebration of Independence Day of Ukraine in downtown Kyiv, Ukraine, on August 24, 2023 (Photo by Maxym Marusenko/ NurPhoto/Reuters)

Internal Affairs, and Ministry of Defense.[36] This document meant efforts towards inter-agency unification and technical standardization of UAVs themselves, and their command, control, and communication systems. It aimed to give authorities and the industry a common vision towards the further development and procurement of the UAVs.

In 2014–2015, the Ministry of Defense issued two documents: the program of development of advanced military robotics until 2025[37] and the concept of development of UAV operations.[38]The Russian military focused on the following: increasing the effectiveness of reconnaissance using UAVs, developing and improving UAV software and hardware, further developing UAVs and their command ground-based systems, and increasing the efficiency of integrating UAVs with the branches of the armed forces, military units, and single combat systems.[39] These points reflected the long-term challenges which the Russian armed forces tried to solve during the 2010s and early 2020s.

The Russian armed forces created UAV squadrons within each division and brigade of the motor-rifle and airborne troops by the mid-2010s. The 924th Center for Unmanned

Aviation was transformed into the state center of the Ministry of Defense in 2014 and consequently took the main role in training UAV operators for the armed forces and for different law enforcement agencies. Therefore, the Ministry of Defense restored its leading role during UAV development and operations.

Key Vulnerabilities of the Industrial Base: Engines and Equipment

In the 2010s, the Russian military was able to develop and produce a wide range of UAVs, relying on imported components and industrial equipment. For example, as of 2016–2017, the share of imported components in each Russia-made military UAV was up to 80 percent.[40] Russia was able to develop its own UAV industrial base by relying on global supply chains. For UAV production, Russia imported electronics, engines, and industrial equipment from Europe, the United States, Israel, Japan, and elsewhere.

This industry supplied the Russian armed forces more than 2,000 reconnaissance drones of different types by 2022.[41] Possibly, this number was even closer to 3,000. However, the share of combat drones and loitering munitions among this number was likely very small.

There are also several dozen contractors and subcontractors of UAV manufacturing in Russia. However, the imported optics and different types of electronic components are only a part of the challenge that Russia faced, an aspect which was covered by the expert community in 2022–2023.[42]

Another part of the problem for Russia is engines. The issue of UAV engines explains why Russia could not modernize the Soviet-era UAVs like Tu-141, Tu-143, or Krylo-1. The existing small gas-turbine engines at the time were not robust for multiple use, and there is still no sustainable domestic serial production of engines for any of the mentioned types of the Russian UAVs.

The Russian state-owned Central Institute of Aviation Motors (with approximately 400 employees) in Moscow, together with the GMZ Agat plant (with approximately 2,000 employees) in Gavrilov-Yam in Yaroslavl region, developed the APD-100/120 piston engine, a counterpart of Austrian-made Rotax 914 piston engine, which is used in the Orion reconnaissance-combat UAV. The dry mass of APD-100/120 engine is 96 kg, compared to 74.7 kg of the Rotax 914 engine, with all its support systems. Moreover, fifty parts (3.6 percent) of the APD-100/120 engine still come from abroad[43] and relates to the fuel system.[44] Therefore, this engine is still in the research and development stage.

The Kronshtadt company built a UAV factory in Dubna in 2022. The company invested 12.5 billion rubles ($170 million) instead of the originally planned 4 billion rubles. The factory hopes to produce forty-five Orion

Figure 1: Factories that produce military UAVs in Russia

Company	Location	Type of UAVs	Other Products	Number of Employees	UAV annual production rate (2023)
STC	St. Petersburg	Orlan-10 (-20, -30)	No	2200	200-300
Kronshtadt UAV factory	Dubna	Orion	No	1500	<10
Luch Design Bureau (Vega Holding)	Rybinsk	Tipchak, Lastochka-M	Avionics	800	<20 of each type
ZALA Aero Group (Kalashinkov)	Izhevsk	ZALA drones, KUB-BLA, Lancet	Counter-UAV EW systems	100	200-300
Izhevsk Unmanned Systems (Kalashnikov)	Izhevsk	Granat-1 (-2,-3,-4), Takhion	No	180	<100
Supercam Unmanned Systems	Izhevsk	Supercam	No	250	150
Eniks	Kazan	Eleron	Flying Targets	300	<50
UZGA	Yekaterinburg	Forpost, Zastava, Altius	Light commerial aircrafts, repair of engines	4300-4500	<10 Forpost, <10 Zastava, single UAVs Altiius (protoypes)
Novosibirsk aircraft plant	Novosibirsk	S-70 Okhotnik	Su-34, parts for combat and commercial aircrafts	6800-7000	Single UAVs for trials (prototypes)

Figure 2: UZGA's production plan towards the localized UAVs "Forpost"

2021	2022	2023	2024	2025	2026
4	6	8	12	18	30

UAVs per year by 2024, yet it is not clear how the factory will be able to achieve anything close to this production rate in the absence of the Russian-made engine and without access to Rotax engines. Likewise, it is also not clear how many Rotax 914 engines have been purchased by Kronshtadt before 2022 and if the company has procured these engines through the third countries.[45]

The company ODK-Klimov, a subsidiary of the United Engine Corp. (another subsidiary of Rostec), develops the VK-800SM turboprop engine, which is planned for use in the Altius heavy UAV. Until 2021, the firm planned to use the German-made RED A03 diesel engine in the Altius.[46]

Each Altius has two engines: The VK-800SM is much lighter than RED A03 (170 kg versus 360 kg), but certification of the new turboprop engine is scheduled for the end of 2024. Another problem is their planned production rate; it should be thirty engines annually after the certification and after the beginning of serial production.[47] They plan to use this engine in the Altius UAV and the new light single-engine commercial aircraft LMS-901 Baikal. The planned production rate is between twenty to twenty-five units annually, but Russia will hardly be able to produce more than two Altius UAVs every year after 2024, which may be an optimistic scenario for the Russian military.

At the same time, the APD-500 piston engine could be applied for Altius. The engine is developed by the Central Institute of Aviation Motors together with the Central Scientific Research Automobile and Automotive Engine Institute (NAMI), and its specifications are comparable to RED A03 engine—but APD-500 uses gasoline instead of diesel. APD-500 derives from the car engine which was developed by NAMI in cooperation with Porsche during the 2010s. That means the engine is inevitably dependent on imported components, especially in its fuel system (including injectors) and control system. It is not clear if Russia will be able to start a serial production of APD-500 by its own.[48] This engine uncertainty means that the heavy reconnaissance and combat Altius models will not be operational in significant numbers any time soon.

The UZGA has also worked on finding alternative engines for the Forpost UAVs, which used either German-made Limbach L550 engines or Australia-made Jabiru 2200 engines. The first Russian counterpart of Limbach and Jabiru engines was APD-80, which used a whole cylinder block and some other systems from Jabiru 2200. The following version, APD-85, officially appeared in 2019.[49] However, there were still some issues with this engine by 2022. Figure 2 on page 16 shows UZGA's production plan towards the localized UAVs "Forpost."[50]

It is not clear whether this plan has been reviewed since February 24, 2022, but these numbers indicate that the annual production rate of APD-85 is insignificant and serial production is scheduled for the period after 2025.

The problem facing jet engines for long-range/long-endurance reconnaissance and combat UAVs also does not have a proper solution. The first trial units of S-70 Okhotnik drone used AL-31FP jet engines developed in early 1980s. This engine was replaced by the AL-41F-1S engine developed during the 2000s, produced by the ODK-UMPO, the biggest Russian aircraft engine plant in Ufa belonging to the United Engine Corp., and used in Su-35 and Su-57 fighter jets. The AL-31FP and AL-41F-1S engines are mass-produced and have a service life of up to 1,500 and 4,000 hours, respectively.[51]

The rectangular nozzle developed for the Okhotnik drone needs an engine without an after burner in order to fit the dimensions.[52] However, without an afterburner, the maximum thrust of AL-31FP is 74.5 kilonewton (kN) or 7,600 kilogram-force (kgf), and the maximum thrust of AL-41F-1S is 76 kN, or 7,770 kgf. This makes them comparable to the PD-8 turbofan engine being developed for the SSJ-100 Russian commercial regional aircraft. These aircraft engines have 78 kN (8,000 kgf) of maximum thrust, about 8,000 hours of service life, and better fuel efficiency. The development of PD-8 started in 2019, seven years later than the S-70 Okhotnik drone.[53] Consequently, the drone will hardly be switched to the commercial engine despite how serial manufacturing of Okhotnik is scheduled for 2025 and the serial manufacturing of PD-8 is scheduled for 2024. This means Russia will not get long-endurance jet drones any time soon, even if it commissions Okhotnik into service in 2025–2026.

Access to advanced industrial equipment is another problem. The whole Russian military industry depends on the industrial equipment from Germany, United States, Japan, Taiwan, France, Italy, Sweden, and South Korea, and UAV manufacturers are not an exception here. Equipment from Siemens, Fanuc, Mycronic, Akira Seiki, Mazatrol, Delta Electronics, etc. has been purchased during the 2000–2010s and until 2022.[54] Neither China, Iran, nor North Korea can provide Russia with the industrial equipment of the same quality. In this way, the main efforts of the United States and its allies must focus on further preventing Russia's access to advanced industrial equipment, parts, software, and even special coolants.

The whole Russian military industry depends on the industrial equipment from Germany, United States, Japan, Taiwan, France, Italy, Sweden, and South Korea, and UAV manufacturers are not an exception here.

Even those Russian companies that produce the advanced industrial equipment like Mekhanika Holding, STAN, Kovrov Electro-Mechanical Plant, and Perm Plant of Metal-Working Tools are dependent on command-

Russia's first specialized facility for the manufacturing of large-sized military UAVs, which Kronstadt has established in Dubna, near Moscow. The Sirius UAV, according to Kronstadt, is the next step in the development of the current Orion UAV. The improvements included increased size and mass, some design changes, and the installation of new electronic equipment. In comparison to its predecessor, the drone will be able to carry a bigger payload and operate at a higher altitude. (EyePress News/Reuters)

and-control systems, electric engines, and other key components of equipment previously supplied by American, European, and Asian companies (e.g., Akira Seiki, BiSS, Delta Electronics, and others).[55] Therefore, the current spectrum of Russian UAV research and development programs and drone manufacturing will become impossible in the long term.

Even if Russia could keep limited access to advanced industrial equipment and try to replace it with lower-quality equipment from China and North Korea, there will be a competition amongstate-owned corporations and even single factories with participation of different bodies of the Russian government for the equipment as well as for qualified personnel. This means Russia objectively needs to decrease the scale of its UAV program.

As a result, the Russian industrial base aimed for UAV manufacturing was relatively effective only when it relied on global supply chains. Since Russia is cut off from most of supply chains, it has faced many troubles in its research and development and manufacturing programs related to drones. The ongoing adaptation of Russia's UAV industrial base to this new reality will inevitably result in the simplifying of manufacturing processes, further delays in serial production of the most sophisticated UAVs, and/or decreasing production rates.

Russian Drones in the War in Ukraine

The full-scale aggression against Ukraine challenged approaches of the Russian military towards UAVs and its UAV industrial base. Western embargos imposed after the invasion—and decreasing Russian financial, technological, and human sources available to the Kremlin—made Moscow's UAV projects started in the 2010s impossible to complete on time. According to the open-source intelligence media Oryx, there were 300 losses of the Russian reconnaissance and combat UAVs in Ukraine confirmed by photo or video between February 24, 2022, and September 13, 2023. Losses included 183 Orlan-10 drones and their modifications, thirty-eight Eleron drones, thirty-eight Zala drones, six Orion drones, six Forpost drones, and others.[56]

According to the general staff of Ukrainian armed forces, Russia lost 4,650 drones of different types including many hundreds of Iran-made Shahed drones (loitering munitions) and probably some commercial drones which the Russian armed forces intensively use together with military-grade drones. It is not clear how many drones Russia lost on the occupied territories of Ukraine due to technical issues and human errors. It is also unclear how many small commercial drones like DJI Mavic and others supplied by the Russian regional administrations and volunteers have been lost. Nevertheless, considering the known production rates, Russia may have lost at least a significant part of its reconnaissance/combat UAV fleet.

Considering the known production rates, Russia may have lost at least a significant part of its reconnaissance/combat UAV fleet.

The Russian military also realized that there is often miscommunication and lack of interoperability even between the UAV units and artillery units, which were the priority of modernization efforts during the 2010s.[57]

The Russian military also recognized that information processing and exchange between drones and artillery is much faster on the Ukrainian side, and this processing—together with general compatibility of different systems in the Russian armed forces—needs crucial improvements.[58]

The differences between Russian and Ukrainian UAV units derives from a couple of fundamental facts. Firstly, the Ukrainian armed forces have relied on software and hardware solutions and on the organizational practices coming from the private sector since 2014. Moreover, the Ukrainian volunteer network, which supplies a significant number of drones

A motor of UAV (unmanned aerial vehicle) Geran-2 (Shahed-136), used by the Russia against Ukraine, is seen during a media briefing of the Security and Defense Forces of Ukraine in Kyiv, Ukraine on 13 April 2023, amid Russian invasion of Ukraine. Security and Defense Forces of Ukraine representatives held a media briefing about situation on the Russian-Ukrainian war and the security situation in the country. (STR/NurPhoto/Reuters)

to the armed forces, also played a crucial role here. In Russia, the armed forces and military industry are in an overregulated and non-flexible institutional environment, which prevents the Russian military from fast improvements. Secondly, Ukraine received assistance from the Western allies in the form of drones themselves, but also in command, control, and communication systems, and in military training, and all these efforts improved Ukraine's capabilities in many aspects, including using UAVs on the battlefield.

The Russian military leadership likely expected that the combat experience of the campaigns in Ukraine in 2014–2015 and in Syria in 2015–2017 would translate to the invasion of Ukraine in 2022. For example, during the Syrian campaign of 2015–2017, there was no more than 70 permanently deployed Russian drones, mostly Orlan-10 and Forpost.[59] That means scaling of using drones on the battlefield faces both technical and organizational challenges in the Russian armed forces. Moreover, that means Russia was incapable to solve all the issues related to the efficient integration of

drone units into the structure of the armed forces.

One more fundamental problem which has become crucial in the Russian armed forces since February 2022 is a deficit of small drones on the tactical level. For years, Russia has focused on developing reconnaissance UAV squadrons within the airborne and motor-rifle brigades as well as reconnaissance and combat UAV squadrons within the aerospace forces. These squadrons aim to provide information on the bottom levels of troops.

In Russia, the armed forces and military industry are in an overregulated and non-flexible institutional environment, which prevents the Russian military from fast improvements.

However, the lack of command, control, and communication systems, together with over-centralized decision-making processes and the huge Ukrainian theater made smaller tactical units and groups of the Russian forces dependent on imported small commercial and agricultural drones like those produced by the Chinese company DJI and others. Most of these drones are provided by pro-Kremlin businessmen and volunteers from different regions. Regional administrations and some companies also established facilities for assembling small drones from consumer-grade imported parts and components.[60]

This measure partly compensated for the shortfall of tactical reconnaissance drones, but it did not challenge the Ukrainian superiority in drones at all. Unlike Ukraine, Russia cannot rely on the wide civic movement that systemically provides the armed forces with drones and other equipment.

New priorities appeared at the same time. Based on the experience of using Iran-made loitering munitions (expendable drones) Shahed-136 and Shahed-131, the Russian military started improving tactics of using drone swarms as well as developing an efficient command and control system for the drone swarms.[61] Although there are no signs that Russia has already made any significant advance here, it still needs foreign hardware and sophisticated software that can be efficiently developed only within the private sector. And the private sector has been under the administrative and law enforcement pressure in Russia for many years and faces further shrinking.

The Russian military also realized that it needs to further develop and improve counter-UAV capabilities in the face of swarms of the Ukrainian small and cheap drones. Despite the wide range of air defense and electronic warfare systems, the combat and cost efficiency of these systems against swarms is moderate or even low.

In this way, the Russian military considers modernizing old ZU-23 anti-aircraft guns by adding modern electronic control systems to be one of the most effective defenses, like Ukraine did in fall 2022.[62] However, it is not clear that the Russian military has a better solution to the drone attack early awareness problem. Nevertheless, the problem of counter-UAV capabilities takes additional sources from the UAV program.

The Russian UAV program became reactive, not proactive, in 2022–2023. The military prioritized solving immediate problems and did not focus on developing a long-term UAV strategy.

Russia is also trying to increase its production of loitering munitions. Besides the KUB-BLA and Lancet, which are mostly used by the Russian special operation forces, Russia launched a factory for domestic large-scale production of the Iranian Shahed drones. For Moscow, these loitering munitions compensate the deficit of cruise missiles with a range of more than 300 km, which is why it launched an assembly factory for producing Shahed-136 UAVs in Tatarstan in 2023.[63] However, the problem remains the same: obtaining components and engines which Russia does not produce itself. There is also a problem with recruiting qualified personnel for this factory, and consequently the management makes efforts to recruit young Russian men from sixteen to twenty-one years old.[64]

The Russian UAV program became reactive, not proactive, in 2022–2023. The military prioritized solving immediate problems and did not focus on developing a long-term UAV strategy.

More recently, the Russian government issued a strategy for developing UAVs until 2030. According to the document, the basic scenario of the UAV industry in Russia presumes 330,000 employees in research and development, while producing and exploiting drones by 2026—1 million by 2030 and 1.5 million by 2035. The number of drones produced in Russia is planned to be 52,100 during 2023–2026 (the average annual production rate exceeds 13,000), 105,500 in 2027–2030 (the average annual production rate exceeds 26,000) and 177,700 in 2031–2035 (the average annual production rate exceeds 35,500).The indicators of a progressive scenario are even higher: 450,000 employees by 2026 and 55,400 drones produced in 2023–2026; 1.1 million employees by 2030 and 116,800 drones produced in 2027–2030; and 1.6 million employees by 2035 and 199,100 drones produced in 2031–2035. Both basic and progressive scenarios are absurd because they do not take into consideration the realities of the Russian labor market and demography.[65]

Russian Defense Minister Sergei Shoigu inspects Russia's first specialized facility for the manufacturing of large-sized military UAVs, which Kronstadt has established in Dubna, near Moscow, according to a press release of Russian Ministry of Defense on Thursday, 27 January, 2022. The Sirius UAV, according to Kronstadt, is the next step in the development of the current Orion UA. (Eyepress/Reuters)

Regardless of the unrealistic projected numbers of the drone industry employees, the projected production rates mean that the Russian government is not going to create the Russian counterpart of the Chinese company DJI, which sells millions of small consumer drones every year. The Russian government does, however, believe that the Russian industry would produce much more sophisticated UAVs, both military and civil.

The last point inevitably means that Russia is going to follow the extensive model of development of the UAV industry that appeared in the beginning of the 2010s: the government will invest more money into drones, more state-owned or semi-state-owned companies will engage in the research, development, and production of drones, and these companies will rely on imported components and industrial equipment. This should lead to more UAV projects and investments from the government. For example, in 2018–2022, Russia's public institutions and state-owned companies and entities spent more than 13 billion rubles for purchasing UAVs, and the share of the Ministry of Defense and law enforcement agencies in these procurements was 30 percent, or 3.9

billion rubles. These numbers do not take into acccount the additional spending on research and development of UAVs, and there is still no clear data of all costs. For example, the known cost of the first prototype of the heavy jet combat drone S-70 Okhotnik exceeded 1.5 billion rubles (almost $21 million) in 2020.[66]

However, the existing deficit of financing sources, technologies, equipment, components, and human capital—together with Russia's cut-off from the industrial cooperation with the developed countries—made this model non-viable in terms of material outcomes.

> **The turbulence in the Russian UAV industry and in the whole aerospace industry will persist—if not increase—in the coming years.**

As a result, the turbulence in the Russian UAV industry and in the whole aerospace industry will persist—if not increase[67]—in the coming years. It will be harder for the Russian authorities to manage all the issues related to the drone manufacturing, especially in the military sector. At the same time, the abandonment of this model is politically unacceptable for the Russian political elite because it plays the role of additional redistribution mechanism in favor of the military sector, together with other arms procurement programs.

Consequently, despite all the governmental efforts, the Russian armed forces will become increasingly dependent on consumer-grade small drones in reconnaissance and relatively simple loitering munitions (expendable drones) for short, medium, and long-range strikes. This means Russia's capabilities in reconnaissance and targeting as well as in high-precision weapons will stagnate, if not decrease, in the foreseeable future. Considering that Ukraine is making significant advances in using drones with assistance of its allies, Russia will not be able to restore its superiority in this aspect of military power anytime soon.

1. Government of Russia "Government approved the Strategy for development of unmanned aviation until 2030," , June 28, 2023,http://government.ru/news/48875/.

2. A. Kh Karimov, "Unmanned aircrafts: maximum capacity,"*Nauka iZhizn,* No. 6, 2002,https://www.nkj.ru/archive/articles/4323/.

3. Ministry of Defense of the Russian Federation, 924th State Center of the Unmanned Aviation of the Ministry of Defense of the Russian Federation," Accessed September 30, 2023, https://function.mil.ru/news_page/country/more.htm?id=12438222percent40cmsArticle.

4. Richard D. Wallwork, Maj., British Army, "Artillery in Urban Operations: Reflections of Experiences in Chechnya," *Fort Leavenworth, Kansas, 2004*, https://apps.dtic.mil/sti/pdfs/ADA429031.pdf.

5. "About Company,"*Enics*, Accessed September 30, 2023, https://web.archive.org/web/20160728040422/http://www.enics.ru/company/.

6"Zala Aero Group is a leading Russian developer and manufacturer of unmanned aircrafts since 2004," *Zala Aero* Group, Accessed September 30, 2023, https://web.archive.org/web/20230921145620/http://zala.aero/about/bolee-250-kompleksov-zala-kruglosutochno-rabotayut-ot-kaliningrada-do-vladivostoka/.

7. Arms-Tass, "Tupolev company plans modernization of unmanned aircraft fleet,"*Arms-TASS*, May 19, 2008, https://web.archive.org/web/20110927132131/http://www.arms-tass.su/?page=article&cid=percent2025&aid=54884&part=10.

8. "UAVs will make up almost half of Russian combat aviation," *RIA Novosti*, August 5, 2009, https://ria.ru/20090805/179779333.html.

9. "Ural aircraft factory becomes a part of helicopter holding,"*RIA Novosti*, June 16, 2009, https://ria.ru/20090616/174487413.html.

10. Marina Kropotova, "Assembly of UAVs began in Sverdlovsk region,"*Oblastnaya Gazeta*, October 6, 2012, https://old.oblgazeta.ru/economics/2418/.

11. "Patents and Quality Management,"*STC*, Accessed September 20, 2023, https://www.stc-spb.ru/company/patents/.

12. Military Academy of Communications, "Honored inventors of the Russian Federation," , Accessed September 20, 2023,http://web.archive.org/web/20211222064859/https://vas.mil.ru/Nauka/Zasluzhennye-izobretateli-RF/1/.

13. "CJSC R.E.T. Kronshtadt plans to get contract for R&D of UAV "Dozor" from FSB Aviation this year,"*AviaPort,* January 28, 2009, https://www.aviaport.ru/digest/2009/01/28/165720.html.

14. Irina Alshaeva, "There is a ton of UAV developments in Russia – Interview with Sergei Bogatikov, head of Kronshtadt company,"*Gazeta.ru*, November 14, 2021, https://www.gazeta.ru/army/2021/11/14/14201881.shtml?updated.

15. "'Industrial Investors' Group reached agreement with Transas Group on purchasing 25 percent+1 share for $50 million,"*PortNews.ru*, June 17, 2011, https://portnews.ru/news/66309/.

16. "'Industrial Investors' will focus on Transas growth after sale of FESCO," *PrimaMedia.ru*, June 20, 2012, https://primamedia.ru/news/211876/.

17. "AFK 'Sistema' bought 'Kronshtadt' Group for 4.8 billion rubles,"*Kommersant*, October 2, 2015, https://www.kommersant.ru/doc/2824430.

18. "'Sistema' consolidated RTI and 'Kronshtadt' in new holding and reduced its stake to non-controlling interest,"*Interfax*, July 15, 2021, https://www.interfax.ru/business/778154.

19. "AFK 'Sistema' withdrew from RTI and Kronshtadt defense companies,"*TASS*,May 4, 2022, https://tass.ru/ekonomika/14548705.

20. "Head of Dubna Sergei Kulikov met with employees of the Center of unmanned aviation established by Kronshtadt,"*Vesti Dubny*, July 4, 2022, https://indubnacity.ru/news/obschestvo/glava-dubny-sergey-kulikov-otvetil-na-voprosy-sotrudnikov-centra-bespilotnoy-aviacii-sozdannogo-kompaniey-kronshtadt6.

21. "History of company,"*OKB Simonova*, Accessed September 30, 2023, http://okbsimonova.ru/about/history/.

22. "Sokol-Invest" bought out state-owned stake of Sokol Design Bureau from the government of Tatarstan,"*Kommersant*, September 28, 2013, https://www.kommersant.ru/doc/2307920.

23. Alexey Nikolsky, "Design of secret drone is disclosed during Shoigu's photosession,"*Vedomosti*, February

8, 2013,https://www.vedomosti.ru/technology/articles/2013/02/08/oblik_sekretnogo_bespilotnika_raskryt_izza_fotosessii_shojgu.

24. “Transas and Sokol will standardize their drones after winning tender for UAV for the Russian army,”*VPK.name*, December 2, 2011, https://vpk.name/news/61511_tranzas_i_sokol_pobedivshie_v_tendere_na_sozdanie_bla_dlya_rossiiskoi_armii_maksimalno_unificiruyut_svoi_apparaty.html.

25. Artem Kuznetsov, Timur Latypov, Victor Osmanov, “Kazan drones: corporate raiding, breakthrough, or collapse of hopes?” *Biznes Online*, May 24, 2018, https://www.business-gazeta.ru/article/383267.

26. Timur Latypov, “‘Milking’ dry: ‘Altair’ transferred from Kazan to Yekaterinburg,”*Biznes Online*, October 9, 2018, https://www.business-gazeta.ru/article/398202.

27. “State contract for preproduction batch of Kazan combat drones “Altius” signed,”*Biznes Online*, February 20, 2021, https://www.business-gazeta.ru/news/500019.

28. Sergey Smirnov, “Combat drone by “Sokhoi,”*Gazeta.ru*, July 6, 2012, https://www.gazeta.ru/politics/2012/07/06_a_4672589.shtml?updated.

29. “UAC incorporated by Rostec,”*Kommersant*, October 24, 2018, https://www.kommersant.ru/doc/3779517.

30. Elena Gorshkova, “Producing of stealth drone will start in Russia,”*ura.ru*, May 18, 2022, https://ura.news/news/1052554303.

31. “Series production of UAV ‘Okhotnik’ is planned for launching in Novosibirsk,”*TASS*, April 23, 2023, https://tass.ru/armiya-i-opk/17601195.

32. “‘Kalashnikov’ focuses on drones and speedboats,”*Kommersant*, February 22, 2015, https://www.kommersant.ru/doc/2673552.

33. “Ministry of Defense will purchase reconnaissance drones made by ‘Kalashnikov,’” *TASS*, September 1, 2016, https://tass.ru/armiya-i-opk/3582349.

34. “‘Kalashnikov’ plans to complete state trials of loitering munitions ‘KUB’ this year,” *VPK.name*, February 24, 2021, https://vpk.name/news/487406_kalashnikov_rasschityvaet_na_zavershenie_v_etom_godu_gosispytanii_drona-kamikadze_kub.html.

35. “Light quadcopters for the Russian army,” *VoyennoyeObozreniye*, September 22, 2021, https://topwar.ru/187335-legkie-kvadrokoptery-dlja-rossijskoj-armii.html.

36. Novikov A.V., Zevin V.V., Raschepkin I.A., “Issues of exploitation of the military air robotic systems in armed forces of the Russian Federation,”*VoennayaMysl’*, 2018, https://cyberleninka.ru/article/n/problemy-ekspluatatsii-robototehnicheskih-kompleksov-voennogo-naznacheniya-vozdushnogo-primeneniya-v-vooruzhennyh-silah-rossiyskoy.

37. “Special program for development of military robots has been adopted,”*RIA Novosti*, December 4, 2014, https://ria.ru/20141204/1036508024.html.

38. Novikov A.V., Zevin V.V., Raschepkin I.A.,*VoennayaMysl*, 2018.

39. Ministry of Defense of the Russian Federation, “Prospects of development and application of complexes with unmanned aerial vehicles: I conference proceedings,” 2016, https://function.mil.ru/files/morf/Sbornik_dokladov_konferencii_bla.pdf; Ministry of Defense of the Russian Federation, “Prospects of development and application of complexes with unmanned aerial vehicles: II conference proceedings,” 2017, https://mil.ru/files/morf/Sbornik-konferencii-2017.pdf;Ananiev A.V., Filatov S.V., Petrenko S.P., Rybalko A.G., “System development of joint force surveillance and strike information environment,” *VoennayaMysl’*, No. 8, 2020, https://cyberleninka.ru/article/n/formirovanie-sistemy-mezhvidovyh-razvedyvatelno-udarnyh-konturov/viewer; Zyuzin S.V., Umerenkov S.A., Shadrin S.V., “Prospects of application of robotic military complexes in rocket forces and artillery,” *VoennayaMysl’*, No. 12, 2019, https://cyberleninka.ru/article/n/perspektivy-primeneniya-robototehnicheskih-kompleksov-voennogo-naznacheniya-v-raketnyh-voyskah-i-artillerii/viewer.

40. Novikov A.V., Zevin V.V., Raschepkin I.A., *VoennayaMysl*, 2018.

41. President of Russia, “Meeting with heads of Ministry of Defense and entities of defense industry,” November 2, 2021, http://kremlin.ru/events/president/news/67056;“Borisov: Russia has full drone arsenal,” *Interfax-AVN*,November 7, 2021,https://www.militarynews.ru/story.asp?rid=1&nid=559928&lang=RU.

42. James Byrne, Dr Jack Watling , Professor Justin Bronk, Gary Somerville, Joe Byrne, Jack Crawford, Jane Baker, “The Orlan Complex: Tracking the Supply Chains of Russia’s Most Successful UAV,” RUSI, December 15, 2022,

https://rusi.org/explore-our-research/publications/special-resources/orlan-complex-tracking-supply-chains-russias-most-successful-uav; Bohdan Miroshnychenko, "How Western Technology Is Keeping Russia Stocked With Drones,"*Worldcrunch*, August 29, 2023, https://worldcrunch.com/world-affairs/russia-ukraine-war-weapons;"Dissecting Iranian drones employed by Russia in Ukraine," *Conflict Armament Research*, November 2022, https://storymaps.arcgis.com/stories/7a394153c87947d8a602c3927609f572; Brian (Chun Hey) Kot, "Hong Kong's Technology Lifeline to Russia," Carnegie Endowment for International Peace, May 17, 2023, https://carnegieendowment.org/2023/05/17/hong-kong-s-technology-lifeline-to-russia-pub-89775.

43. "Air mobility and aviation technologies,"*GMZ Agat OAO Technology Platform*, Accessed September 30, 2023, https://aviatp.ru/files/newturn/Presentatsiy/11_Agat.pdf.

44. "914 UL F," *Rotax*, Accessed September 30, 2023, https://www.flyrotax.com/products/914-ul-f.

45. "'Kronshtadt' company began construction of factory for series production of drones," April 16, 2021, *Kronshtadt*, https://kronshtadt.ru/press-center/article/kompaniya-kronshtadt-nachala-stroitelstvo-zavoda-po-serijnomu-proizvodstvu-bespilotnikov; "Factory for production of large drones in Dubna to achieve full production rate in 2024," *Expert.ru*, February 1, 2022, https://expert.ru/2022/02/1/zavod-po-proizvodstvu-bpla-v-dubne-viydet-na-polnuyu-moschnost-v-2024-m/; "Interview with Sergei Bogatikov," *RIA Novosti*, August 20, 2021, https://ria.ru/20210820/bespilotniki-1746359692.html.

46. "Preproduction prototype of VK-800 engine for LMS-901 'Baikal' aircraft to appear by March 2023," *VPK.name*,May 19, 2022.https://vpk.name/news/603470_nazvany_sroki_poyavleniya_predseriinogo_obrazca_rossiiskogo_dvigatelya_vk-800_dlya_samoleta_lms-901_baikal.html;Lars Reinhold, "Engines exported to Russia: five years in prison," *Flug Revue*, August 30, 2023,https://www.flugrevue.de/flugzeugbau/red-aircraft-motoren-nach-russland-exportiert-fuenf-jahre-haft/.

47. Andrey Fomin, "VK-800SM engine for LMS-901 "Baikal" to be certified by the end of 2024," *Vzlet*, April 6, 2023, http://www.take-off.ru/item/4534-dvigatel-vk-800sm-dlya-samoleta-lms-901-bajkal-planiruetsya-sertifitsirovat-k-kontsu-2024-goda;"UZGA will replace foreign engines for L-410 aircraft with Russian engines," *ATO.ru*, April 5, 2018, http://www.ato.ru/content/uzga-zamenit-zarubezhnye-dvigateli-dlya-l-410-na-rossiyskie.

48. "APD-500: the first flight within Yak-18T is coming soon," *Avaition21.ru*, September 6, 2021, https://aviation21.ru/apd-500-pervyj-polyot-v-sostave-yak-18t-uzhe-skoro/;"Prototype of APD-500 engine is installed in aircraft and will be demonstrated at MAKS-2021," *AEX.ru*, July 13, 2021, https://www.aex.ru/news/2021/7/13/231704/;"Advanced Russian piston aircraft engine APD-500 was tested by roll outs and hops," *CIAM*, October 14, 2021, https://www.ciam.ru/press-center/news/perspektivnyy-rossiyskiy-porshnevoy-aviadvigatel-apd-500-ispytali-probezhkami-i-podletami-/;Yuri Zubko, "All engines for autos of 'Kortezh' project have been revealed," *RG.ru*, July 13, 2017, https://rg.ru/2017/07/13/stali-izvestny-vse-dvigateli-dlia-avtomobilej-proekta-kortezh.html.

49. "'Forpost' made first flight after import substitution," *Vesti.ru*, August 22, 2019, https://www.vesti.ru/article/1356563.

50. "UZGA: Project implementation status "Production localization of small aircrafts with using of composite materials," *Investment portal of the Sverdlovsk region*, Accessed September 30, 2023, https://invest-in-ural.ru/upload/iblock/c44/Презентацияpercent20УЗГАpercent20(Планpercent20развитияpercent20Дивизионpercent20самолеты).pdf.

51. "AL-41F-1S," *ODK-UMPO*,Accessed September 30, 2023, https://umpo.ru/products/turboreaktivnye-dvigateli/al-41f-1s/?sphrase_id=4584;"AL-31F engine: history of development, current status and prospects," *ODK-Saturn,* April 11, 2006, https://www.uec-saturn.ru/?rssid=1172735764&sat=7&slang=0;"UMPO shows product 117S," *ATO.ru*, August 18, 2011, http://www.ato.ru/content/umpo-demonstriruet-izdelie-117s.

52. "Source: "Okhotnik" with rectangular nozzle will make first flight in summer," *RIA Novosti*, January 24, 2022, https://ria.ru/20220124/okhotnik-1769184546.html;"Source reported how many 'Okhotnik' UAVs are in production," *Naked-science.ru*, February 12, 2021, https://naked-science.ru/article/tech/istochnik-soobshhil-skolko-ohotnikov-sejchas-stroyat-v-rossii.

53. "PD-8: engine core has been tested," *Vzlet*, October 5, 2021, http://www.take-off.ru/item/4384-pd-8-ispytan-gazogenerator.

54. "Vacancies at UZGA facility in Kazan," *HH.ru*, Accessed September 30, 2023, https://kazan.hh.ru/employer/9389541?hhtmFrom=vacancy; HH.ru, "Vacancies at STC," Accessed September 30, 2023, https://spb.hh.ru/employer/2519536?hhtmFrom=vacancy; Agregat, "Ambulance" for machine tools,"October 2019, https://agregat-avia.ru/upload/gazeta/Oct2019.pdf.

55. Kovrov Electromechanical Plant, Accessed September 30, 2023, https://stanki.kemz.org; STP Perm Metal Centers Factory, Accessed September 30, 2023, https://www.pzmc.org; STAN, Product Catalog of 2023, Accessed September 30, 2023, https://www.stan-company.ru/upload/catalog_STAN_2023_web.pdf;INELSI, Product Catalog of 2022,

Accessed September 30, 2023, http://inelsy.com/wp-content/uploads/2022/05/IntNC-PRO.pdf.

56. “Attack On Europe: Documenting Russian Equipment Losses During The Russian Invasion Of Ukraine,” *Oryx*, February 24, 2022, https://www.oryxspioenkop.com/2022/02/attack-on-europe-documenting-equipment.html.

57. Matviychuk I.V., Borisevich M.A., Merkulov E.V., “Fire control and fire adjustment in artillery units with using short-range reconnaissance air systems,” *VoennayaMysl’*, No. 7, 2023, https://cyberleninka.ru/article/n/upravlenie-i-korrektirovanie-ognya-artilleriyskih-podrazdeleniy-kompleksami-vozdushnoy-razvedki-blizhnego-deystviya.

58. Ivanov V.G., Gudkov M.A., Lukyanchik V.N., “Unified information environment of the armed forces of the Russian Federation as a basis for troop information support in international armed conflicts,” *VoennayaMysl’*, No. 5, 2023, https://cyberleninka.ru/article/n/edinoe-informatsionnoe-prostranstvo-vooruzhennyh-sil-rossiyskoy-federatsii-osnova-informatsionnogo-obespecheniya-voysk-v.

59. Averchenko S.V., Belousov V.V., “Unmanned aerial vehicles in armed conflicts in second half of XX – beginning of XXI centuries: key historical milestones,” *SovremennayaNauchnayaMysl’*, 2023, https://cyberleninka.ru/article/n/bespilotnye-letatelnye-apparaty-v-voennyh-konfliktah-vtoroy-poloviny-xx-nachala-xxi-vekov-osnovnye-vehi-istorii.

60. “Drone assembly for special military operation in Ukraine,” *Orenburg Regional TV Youtube-channel*, September 6, 2023, https://www.youtube.com/watch?v=B_I5bI7LC6U; “Special operation identified UAVs most needed for the army,” *Vzglyad*, May 15, 2022, https://vz.ru/society/2022/5/15/1156004.html; “All Russia helps: how drones for special military operation in Ukraine are being assembled,” *MK.ru*, February 13, 2023, https://www.mk.ru/politics/2023/02/13/vsya-rossiya-pomogaet-kak-sobirayut-drony-dlya-svo.html; “Drones for army will be produced in Moscow,” *Vesti MoskovskogoRegiona*, October 25, 2022, https://www.mosregion.info/2022/10/25/v-moskve-nachnut-proizvodit-drony-dlya-armii/.

61. Selin A.I., Turkin I.K., “Overview of target objects for using groups of unmanned aerial vehicles,” *NauchnyiVestnik MGTU GA, No. 2*, 2023, https://cyberleninka.ru/article/n/obzor-tselevyh-obektov-primeneniya-bespilotnyh-letatelnyh-apparatov-rabotayuschih-v-sostave-gruppy/viewer;Gubanov S.V., “Application of miniaturized unmanned aerial vehicles within the unified information environment of tactical level,” *VoennayaMysl’*, No. 7, 2023, https://cyberleninka.ru/article/n/primenenie-bespilotnyh-letatelnyh-apparatov-klassa-mini-v-edinoy-sisteme-upravleniya-takticheskogo-zvena/viewer.

62. Tulkin M.V., Mischuk B.V., Evstifeev Y.A., “Design rationale and main combat tasks of advanced counter-mini-UAV system,” *VoennayaMysl’*, No. 2, 2023, https://cyberleninka.ru/article/n/obosnovanie-oblika-i-osnovnyh-zadach-boevogo-primeneniya-perspektivnogo-kompleksa-protivodeystviya-mini-bpla-protivnika/viewer;Selin A.I., Turkin I.K., “Overview of target objects for using groups of unmanned aerial vehicles,” *NauchnyiVestnik MGTU GA, No. 2*, 2023, https://cyberleninka.ru/article/n/obzor-tselevyh-obektov-primeneniya-bespilotnyh-letatelnyh-apparatov-rabotayuschih-v-sostave-gruppy/viewer.

63. “KUB” and “Lancet” for operations of special forces,” *Natsional’nayaOborona*, March 10, 2022, https://oborona.ru/product/kedrov-ilya/kub-i-lancet-dlya-operacij-specnaza-43366.shtml;“Putin requested to increase production of ‘KUB’ and ‘Lancet’ UAVs,” *Interfax*, August 7, 2023, https://www.interfax.ru/russia/915129; “Alabuga. Franchise production of Iranian drones,”*Protokol*, July 3, 2023, https://protokol.band/2023/07/03/alabuga-iranskie-drony/.

64. “Alabuga. Production of death by hands of students,”*Protokol*, July 24, 2023, https://protokol.band/2023/07/24/alabuga-rukami-studentov/; “Vacancy at UAV factory in Elabuga,” *Mrqz.me*, Accessed September 30, 2023, https://mrqz.me/patriots?utm_source=yandex_master&utm_medium=do25&yclid=4424511874473202204.

65. Government of Russia, “Government approved the Strategy for development of unmanned aviation until 2030,” June 28, 2023, http://government.ru/news/48875/.

66. Government of Russia, “Government approved the Strategy for development of unmanned aviation until 2030,” June 28, 2023, http://government.ru/news/48875/;“‘Okhotnik’ for one billion: cost of the most powerful Russian drone has been revealed,” *Izvestia*, June 4, 2020, https://iz.ru/1019351/anton-lavrov-bogdan-stepovoi/okhotnik-na-milliard-stala-izvestna-tcena-samogo-moshchnogo-drona-rossii.

67. Pavel Luzin,“Western Sanctions and Personnel Shortages Plague Russia’s Aircraft Industry,”Jamestown Foundation, September 8, 2023, https://jamestown.org/program/western-sanctions-and-personnel-shortages-plague-russias-aircraft-industry/.

FOREIGN POLICY RESEARCH INSTITUTE

The Foreign Policy Research Institute (FPRI) is a nonpartisan Philadelphia-based think tank dedicated to strengthening US national security and improving American foreign policy.

Established in 1955 by the noted 20th century geopolitical strategist, Ambassador Robert Strausz-Hupé, FPRI was founded on the premise that an informed and educated citizenry is essential for the United States to understand complex international issues and formulate foreign policy. FPRI remains committed to this principle and strives to inform both policymakers and the general public through FPRI research and educational programs.

FPRI is a nonpartisan 501(c)(3) non-profit organization and takes no institutional positions on issues andt conducts no advocacy. The organization has six main research programs, covering US National Security, the Middle East, Eurasia, Europe, Asia, and Africa. Each program produces reports, articles, public events, and private briefings for policymakers, FPRI members, and the general public.

Foreign Policy Research Institute

123 S. Broad Street, Suite 1920

Philadelphia, PA 19109

215.732.3774

www.fpri.org

@FPRI

FOREIGN POLICY RESEARCH INSTITUTE