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# The Role of Space in Russia's Operations in Ukraine

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**Abstract**

This paper examines how Russia has employed its space and counterspace capabilities during the conflict in Ukraine. It begins with an assessment of the role of space in Russian military theory and doctrine, followed by a discussion of the role and functions of Russia's Space Forces, how they are organized, and their inventory of "orbital groupings." The paper then provides a detailed analysis of the military's space-related capabilities and activities in Ukraine by functional area (reconnaissance, communications, navigation, and counterspace). It concludes with an assessment of Russia's potential future courses of action in the space domain.



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Cover image: Russian spacecraft, December 31, 2021. Russian Ministry of Defense Press Service.

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# THE ROLE OF SPACE IN RUSSIA'S OPERATIONS IN UKRAINE

The Russian military has spent much of the last decade attempting to rebuild the capabilities of its Space Forces (*Kosmicheskie voyska Rossii*, or KV) after decades of neglect by upgrading and expanding its constellations of satellites and ground-based space infrastructure. The force acquitted itself well during Russian operations in Syria, providing the Russian Air Force and other services with intelligence and targeting data, channels for secure satellite communications (SATCOM), and global position, navigation, and timing (PNT) capabilities. However, the refurbishment of Russia's military space capabilities was still a work in progress when Russia's "special military operation" (SVO) in Ukraine started on February 24, 2022. The scale of the operation, which substantially exceeds that of the operation in Syria, has stressed the Russian military's space and counterspace capabilities beyond their limits.

This paper explores how Russia has employed its space and counterspace capabilities in Ukraine. It begins with an overview of Russian theory and doctrine about the role of space in conflict followed by an assessment of the roles, missions, and functions of Russia's Space Forces. The paper then provides a detailed analysis of the military's space-related capabilities and activities in Ukraine by functional area (reconnaissance, communications, navigation, and counterspace). The paper concludes with an assessment of Russia's potential future courses of action in the space domain.

## The role of space in war, according to Russian theory and doctrine

Many Russian military thinkers describe space as a nascent theater of military action. Nevertheless, Russian military doctrine recognizes that space is a warfighting domain and that maintaining access to space-based military information, while denying such access to the adversary, is a decisive factor in winning modern wars.[1] Controlling access to space-based information is seen as conferring enormous advantage in terms of increased situational awareness and enhanced warfighting capability, enabling the side possessing this advantage to conduct effective long-range military operations and cross-domain attacks while leaving the adversary disoriented, disorganized, and vulnerable to defeat.[2] According to the head of the General Staff Academy, Colonel General V. B. Zarudnitsky, the space domain will continue to shift from mostly supporting activities in other domains

THE SPACE DOMAIN WILL CONTINUE TO SHIFT FROM MOSTLY SUPPORTING ACTIVITIES IN OTHER DOMAINS TO HOSTING ACTIVE OFFENSIVE AND DEFENSIVE OPERATIONS IN ITS OWN RIGHT.

to hosting active offensive and defensive operations in its own right:

> "All of this [the shift in activities] predetermines the need for proactive elaboration of the theoretical foundations of new forms of warfare in outer space, in particular, antisatellite combat, systemic military operations to destroy state infrastructure facilities, orbital satellite battle, anti-space operations, and others. During these operations, the main efforts will be focused on the disorganization of the enemy control system by destroying the ground infrastructure supporting space forces' actions and means. According to [Russian] military experts, this is one of the most vulnerable places for the U.S. and NATO. [Stalling their] aggressive intentions is directly related to the decommissioning of systems intelligence, control, and destruction."[3]

Russian observers claim that the factors driving Russia to develop its space capabilities include actions by the US and others to militarize space, allegedly in contravention of international law; the growing threat of cyberattacks against Russian satellites, especially Russia's early warning constellation; the evolution and rapid development of counterspace weapons systems; and the growing potential to place weapons in space for use against terrestrial targets.[4]

The time-phasing of space operations is critical in Russian thinking. Space operations—both offensive (counterspace) and defensive—figure prominently during the initial period of war, when both sides are likely to preempt with, in Russian parlance, an "information strike" to disable adversary command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR). Russian theory posits that this phase, which marks the transition from threat to armed conflict, will likely be defined by massed aerospace and missile attacks, aerospace defense, and countering operations, along with the beginning of strategic operations in continental (land) and maritime theaters.[5] Russia's perceptions in this regard are driven by its observations of the US approach to warfare and its actions in conflicts ranging from the Balkans to the Middle East.

To counter such an attack, the Russian General Staff has developed a strategic operational concept, Strategic Aerospace Operations (SVKO). The SVKO consists of "a set of strategic measures and defensive offensive actions to identify and repel an enemy aerospace attack from all directions, to protect the armed forces and economic facilities from strikes by ground, air, and space-based strategic strike forces."[6] The SVKO is focused primarily on activities in the air domain, although space operations are considered a subset of these efforts.

According to an article in the Russian Aerospace Forces Academy journal, offensive space operations will precede offensive operations in other domains as well as actions taken to secure Russia's information space:

> "Space operations will precede air, naval, and land offensive operations and will be directed at gaining supremacy in near-Earth space to ensure the functioning of Russia's orbital constellations. The main missions of space operations will be to destroy an enemy's space infrastructure and to disrupt their command and control. Once the supremacy of space information systems and independent military operations is assured in strategic space (meaning offensive missions will predominate to gain the initiative in war), it is then possible to consider defensive operations to defend information resources."[7]

Figure 1 provides a notional model of the time-phasing of space operations.

**Figure 1. Space operations by phase**

| Purpose of space resources ↓ | MAIN PERIODS OF HPE | | |
|---|---|---|---|
| | **Peacetime** | **Threatened period** | **Initial and subesequent periods of war** |
| | Purposes of application of space capabilities | | |
| | Information support for the ground forces and navy | Detection, preparing for enemy attack, and securing information for combat planning and operations | Provision of information to troops and fleet forces for plannng, fighting, and conducting strikes |
| **Warning about missile attack** | Ballistic missile launch detection and missile attack warning | | |
| **Intelligence services** | • Operational reconnaissance of the space situation and the issuance of data for target designation<br>• Identification (clarification) of the deployment, combat composition of [adversary] armed forces, determination of their characteristics and coordinates<br>• Uncovering signs of a change in the composition and location [of adversary armed forces]<br>• Monitoring the locations of local wars and major exercises | | |
| | [Monitoring] compliance with arms control agreements | | |
| | | • Observation of RES and PU areas, clarification of their coordinates, issuance of data to the intelligence, weapons and electronic warfare control authorities<br>• Observation of strike, defensive and support groups of the Navy and the issuance of data for taret designation to the systems of the Navy weapons<br>• Opening measures for operational equipment of combat areas, regrouping of strike forces and reserves | |
| | | | Monitoring the results of strikes |

| Purpose of space resources | MAIN PERIODS OF HPE | | |
|---|---|---|---|
| | Peacetime | Threatened period | Initial and subesequent periods of war |
| | Purposes of application of space capabilities | | |
| | Information support for the ground forces and navy | Detection, preparing for enemy attack, and securing information for combat planning and operations | Provision of information to troops and fleet forces for plannng, fighting, and conducting strikes |
| **Communications, combat management and information relay** | • Providing combat control of strategic nuclear forces. Ensuring communication and data transmission in the control systems of the RF Armed Forces<br>• Retransmission of intelligence information from space reconnaissance means. | | |
| **Navigation** | Providing data for navigation of mobile objects of the ground forces and navy | | |
| **Meteorology** | • Collection of meteorological information for the command and control bodies of troops and weapon systems<br>• Issuance of weather forecasts and climate information | | |
| **Cartography** | Providing data for cretation and updating topographic, digital maps, city plans and photographic documents | | Clarification of the topogeodesic characteristics of districts [involved in] combat |
| **Geodesy** | Providing data to refine geodesic constants, parameters of the earth's navigation field | | |
| **Special security** | Ensuring the alignment and calibration of air defense weapon systems | | |
| **Containment** | | | Mitigating failures in critical systems |

Source: Ministry of Defense of the Russian Federation, https://encyclopedia.mil.ru/encyclopedia/dictionary/details.htm?id=13357@morfDictionary.

Space and counterspace capabilities and operations using kinetic and non-kinetic means to target an adversary's spacecraft and terrestrial infrastructure can be used for deterrence as well, providing Russia's leaders with options to control escalation over the course of a conflict. Some Russian military analysts consider space activities to be part of a larger cross-domain strategic deterrence framework. A. B. Palitsyn and D. B. Zhilenko note the following:

> "To effectively deter a potential adversary using spacecraft for military purposes, it is necessary to organize effective, active, and comprehensive opposition. Under these conditions, one should understand the whole range of possible countermeasures—from performing camouflage activities for objects and troops (passive measures) up to destruction of elements of the enemy space grouping (both kinetic and informational) in orbit, as well as degradation of appropriate infrastructure for its provision on earth and in space (active measures against earth and space-based infrastructure for supporting space activities). Effective countering of spacecraft will deter or compel [the enemy] to renounce military action, since without space-based means they will be ineffective."[8]

Space could also constitute a separate theater of military operations in which "orbital groups of space systems for various purposes are based and function on a permanent basis, and are also rapidly deployed and used, depending on the prevailing conditions of the situation, to solve support and combat tasks." In this "space theater," groupings for forces can conduct technological and tactical "maneuvers" to gain information superiority over their adversaries, as in other theaters.[9]

A. P. Kovalev, S. A. Sotnik, and D. S. Sotnik, writing in *Military Thought*, note that the defining characteristics of conflict in space are its colossal scale as well as its high tempo of operations:

> "Considering the nature of hostilities that can unfold in outer space, one should note their features that are also characteristic of modern combined arms combat: decisiveness, tension, high tempo of conduct and transience, rapid and abrupt changes in the situation. However, in space, all these characteristics will have an exaggerated new quality, which is determined by the colossal scope of the space theater, the space of which contains many millions of cubic kilometers; cosmic speeds, measured in tens of thousands of kilometers per hour; time intervals of combat situations, which will be counted, as a rule, in seconds, as well as many other factors and parameters that are unusual for the traditional human environment."[10]

Thus, space, more than some other domains, necessitates "highly automated or even automatic" adjustments to decision-making, employing artificial decision-making and "combat algorithms that have the ability to adapt to changes in situation."[11] The authors recommend, however, that a human remain in control of space operations and the implementation of such algorithms, thereby sidestepping the issue of unintended escalation in space.[12]

Although Russian officials often highlight space as a distinct vulnerability for the US and its North Atlantic Treaty Organization (NATO) allies, who are heavily dependent on space-based systems for communications, intelligence, and navigation, they also tacitly acknowledge that the development of military space systems by the United States is

evidence of a growing gap between the military capabilities of the two countries.[13] This gap undermines Russia's ability to maintain strategic parity with the United States and introduces a degree of instability into the relationship, especially when paired with perceptions of US/NATO vulnerabilities, as Bruce McClintock notes in the context of counterspace operations:

> "This makes Russia less concerned about the potential adverse impacts of orbital debris on the space domain. Russia's recognition that space is more important to the U.S. creates potential opportunities and greater motivation for Russia to pursue space weapons designed to attack U.S. systems. Russia's history and extensive experience with electronic warfare, directed energy weapons and rendezvous and proximity operations (RPO) make the possibility of highly effective Russian counterspace weapons tangible rather than aspirational."[14]

Based on Russian doctrine, strategy, and theoretical writings, we can deduce the general contours of conflict in space from a Russian perspective:

- Space control (KPP) is viewed as vital to maintaining increased situational awareness and enhanced warfighting capability in conflict.
- The initial period of war is a critical phase to establish KPP.
- Space and counterspace capabilities provide Russian military leaders with options to manage escalation across the different phases of conflict.
- Russia anticipates a massed aerospace attack in a major conflict with the US and its NATO allies. Russia's concept of a strategic aerospace operation—which includes offensive and defensive activities in space—is designed to counter a massed aerospace attack and preserve Russia's room for maneuver.

In the following sections, we assess Russia's space capabilities and analyze how they have been employed in the Ukraine conflict. As we shall see, there are some areas of overlap with Russian doctrine and theoretical writings, particularly in terms of time-phasing. But there are also critical divergences, most of which stem from the nature and scope of the Ukraine conflict, the involvement of third parties and the commercial space sector, and Russian capability gaps in critical areas.

## Organization and inventory

Since the collapse of the Soviet Union, the military, civilian, and commercial organizations with space-related functions and responsibilities have undergone numerous reorganizations. During the Cold War, Soviet air and space forces were separate entities under different chains of command. However, in 2015, the Russian Ministry of Defense (MOD) merged Russia's air, space, and air defense forces under a single chain of command within the new Aerospace Forces (VKS). According to Sergei Shoigu, minister of defense, the move was prompted by a shift in the "combat 'center of gravity' toward the aerospace theater," a desire to maximize efficiencies, and the need to counter the US military's Prompt Global Strike program.[15] The move also probably stemmed from the evolving perception by Russia's military leadership that the air and space domains are increasingly linked and therefore necessitate a synchronized response with a unified chain of command.[16] The Space Forces (KV) are therefore a sub-branch of the VKS, along with the Russian Air Force.


The KV's current missions include space situational awareness; early warning of ballistic missile attack; satellite launches and operations, including dual-use satellites operating under the military's control; maintenance of the military's space infrastructure, including ground stations and launch sites; and the detection of threats to Russia in space and from space (including ballistic missiles) and, if necessary, fending off these threats.[17]

The operational component of the KV—which is responsible for conducting the missions described above—is the 15th Special Purpose Aerospace Army, which operates the 820th Main Missile Attack Warning Center, the 821st Main Space Reconnaissance Center, and the 153rd Titov Main Test and Space Systems Control Center.[18] The KV also manages the Plesetsk Cosmodrome, a recently refurbished spaceport located in the Arkhangelsk Oblast. Separately, the KV also operates the A. F. Mozhaisky Military Space Academy, which trains KV personnel and offers advanced degrees in aerospace-related sciences.[19] Civilian space activities are managed by the Roscosmos state corporation, a successor to the Russian Federal Space Agency, which merged with the United Rocket and Space Corporation in 2015.[20]

The KV's operational forces include its "orbital groupings," constellations of satellites. According to the Union of Concerned Scientists, which maintains a database of more than 5,000 satellites orbiting earth, as of May 1, 2022, 172 Russian satellites were in orbit. Russia ranks third, behind the US and China, in total number of satellites, but it is well behind the other two countries. For comparison, the US had 3,433 satellites in orbit and China had 451. Moreover, many of Russia's satellites are operating beyond their shelf life and are due for replacement.

Of the 172 Russian satellites in the database, 73 are military, 17 are government, 8 are civil, 39 are commercial, and 35 are potentially dual-use, either military-commercial (mostly navigation/PNT) or civil/government–commercial. A further breakdown of the military satellites yields 43 communications (including relay) satellites, 20 earth observation satellites (electro-optical (EO) (3), signals intelligence (SIGINT)/electronics intelligence (ELINT) (10), synthetic aperture radar (SAR) (2), and early warning (5)), 2 earth science satellites, 2 space observation satellites, and 6 technology development satellites.[21]

Despite the effect of Western sanctions, the Russian government has prioritized investment in its military space capabilities and appears to be maintaining spending at stable levels, at least for the near term. Current Duma space-related budgets for 2023, 2024, and 2025 are $3.97 billion, $3.93 billion, and $3.92 billion, respectively.[22] Russia also continues to launch additional systems into orbit. In 2022, Russia expanded its arsenal of

military satellites, launching 14 additional systems into space:[23] 3 GLONASS navigation satellites, 2 Lotos-S1 ELINT satellites, a Meridian-M comsat, a Tundra early warning satellite, 3 inspector satellites (for space observation but could potentially be used for co-orbital anti-satellite (ASAT)), a cartography satellite (Bars-M), 2 small (reportedly experimental) imagery satellites (EO-MKA or EMKA), and a Neitron satellite (Russian designation Kosmos 2553) whose function appears to be radar imaging.[24] One of the EO-MKA satellites subsequently failed after its orbit decayed in May, one month after launch.[25] Although this represents a relatively ambitious launch schedule for 2022, it may not be indicative of future performance because many of the launches were scheduled—and paid for—in previous years.

Russia's civil and commercial space sectors appear to be faring worse than its military space program. Roscosmos' budget depends heavily on infusions of cash from foreign companies paying for its launch services. However, its share of the international commercial space launch market had been declining for several years before the invasion of Ukraine because of a variety of factors, including the rise of low-cost competitors such as SpaceX, sanctions stemming from Russia's last invasion of Ukraine in 2014, aging infrastructure, and a failure to innovate. Since Russia's 2022 intervention in Ukraine, foreign demand for Roscosmos' launch services has more or less dried up. Russia's space industry, which consists of numerous companies and design bureaus and is managed by Roscosmos, has also been negatively affected by sanctions, which have resulted in loss of revenue and access to critical high-tech components produced by foreign companies, especially semiconductor chips, which play a crucial role in satellite technology.[26] The long-term effect of sanctions on Russia's space efforts is difficult to gauge. It will depend on several factors, including how long the conflict in Ukraine lasts, whether sanctions persist, and to what degree Russia's space industry can expand on its relationships with its remaining international partners, especially China.[27]

## Reconnaissance

Russia's KV operates the military's reconnaissance satellites (and associated ground stations), most of which are controlled from the Titov Space Control Center in Krasnoznamensk near Moscow.[28] However, the collection, processing, and dissemination of most of the data collected from these satellites is the responsibility of the Main Directorate (GU—formerly GRU) of the General Staff, the intelligence branch of the armed forces.[29] The intelligence that the satellites collect is funneled to the GU's Directorate of Space Intelligence (K-500), formerly the GRU's Sixth Directorate, for processing.[30] The data are then shared with organizations such as the Main Computational Center (GVC) of the General Staff, which develops targeting solutions for cruise and ballistic missiles.[31]

Unfortunately, open-source information on how space reconnaissance data are then channeled to lower echelon commands is lacking. However, we can deduce a fair bit about the quality of the intelligence provided based on the inventory of Russia's earth observation and SIGINT satellites. Compared to the US and China, Russia has limited capabilities in this regard, especially in optical reconnaissance. Space reconnaissance systems were neglected for many years and have only recently become a priority for the KV. The KV's capabilities had atrophied so much in this area that as late as 2015 it was still using film canister satellites.[32] Today, the KV has only three optical imaging satellites in its arsenal: two Persona satellites and one small experimental high-resolution EMKA satellite. The Persona satellites are capable systems, reportedly able to cover a swath of territory 1,300 kilometers wide with a spatial resolution of up

to 0.5 to 0.3 meters.[33] However, they are operating beyond their intended shelf life and reportedly rely on outdated Soviet-era hardware and system architecture.[34] Their intended replacement will be a constellation of three Razdan satellites, reportedly with a resolution capability of around 6 centimeters.[35] However, the Razdan program has been plagued by delays; despite a planned launched date of 2019 for the first satellite, no Razdan systems have yet been placed in orbit.

In the interim, the Russian military has developed the EMKA series of small high-resolution optical reconnaissance satellites. Reportedly, these have a resolution in the range of 0.9 meters in panchromatic mode.[36] Three EMKA satellites have been launched, but two failed and only one remains functional.

Faced with a dearth of organic optical reconnaissance capabilities, the Russian military has tended to rely heavily on civilian systems operated by Roscosmos, primarily from the Resurs and Kanopus families of satellites. Potentially, these two systems could contribute an additional nine satellites to the KV's arsenal of systems, but their capabilities are somewhat limited. They possess low-resolution imaging capabilities, and their revisit rates hover between 3 and 15 days.[37] Colonel Igor Smirnov, a former commander of the GU's Space Intelligence Directorate, noted in an interview that "Resurs and Kanopus are not capable of conducting either multispectral reconnaissance or detailed photo reconnaissance. These satellites can only give one an idea of the big picture. But on the basis of their data, it is impossible, for example, to build a target designation system for Kalibr missiles."[38] The military also operates at least three cartography satellites (Bars-M) designed to provide high-resolution stereo images of the earth's surface.[39] Although these systems fall outside of the space reconnaissance rubric, they could be used to identify large fixed targets in a conflict.

In addition to its limited number of optical reconnaissance satellites, Russia possesses a few radar imaging and SIGINT satellites. Before 2021, Russia had no SAR satellites. However, the Kondor FKA and Neitron, launched in 2023 and 2022, respectively, have filled a distinct gap in that area, along with the first of two PION-NKS SAR/SIGINT satellites (launched in 2021), although the latter's radar is optimized for detecting targets in the maritime realm.[40] All three systems are theoretically capable of imaging through cloud and foliage cover. In terms of radar imaging capacity, however, Russia is also far behind its competitors. By comparison, the US government, US military, and US commercial space companies have fielded at least 30 radar imaging satellites.[41] As Pavel Podvig, a scholar of Russia's space program, notes, "The absence of SAR capability in Russia is notable, especially if considered in contrast with the rapid development of commercial SAR satellites in the West."[42]

THE ABSENCE OF SAR CAPABILITY IN RUSSIA IS NOTABLE, ESPECIALLY IF CONSIDERED IN CONTRAST WITH THE RAPID DEVELOPMENT OF COMMERCIAL SAR SATELLITES IN THE WEST.

Although assessing Russia's space reconnaissance capabilities is a relatively straightforward process, analyzing how the Russian military employs its overhead collections to support its military

operations is somewhat harder, given the lack of available sources on the topic. In Syria, the Russian military reportedly relied on a mix of military and government reconnaissance satellites to support its air and ground operations. General Valery Gerasimov, chief of the General Staff, stated that "ten imagery and electronic warfare reconnaissance satellites, including civilian-use spacecraft," were used in the operation.[43] These included the two Persona imagery satellites in the KV's inventory as well as several Resurs and Kanopus EO satellites operated by Roscosmos.[44] Apparently, the orbits of some of the satellites were altered to maximize their coverage over the theater of operations.[45] Russian overhead collectors were also used to identify targets for VKS aircraft, including Su-34s, Su-24Ms, and Su-25SMs.[46] In addition to enabling the military's "space reconnaissance and target designation system (KSRTs)," the Russian MOD used satellite reconnaissance data for political purposes, most notably when it publicly released satellite and aerial imagery showing Turkish government involvement in illicit oil trading with Islamic militant groups in Syria and Iraq.[47]

Although the 10 satellites referenced above were probably sufficient to support operations in Syria, the scope and scale of the SVO in Ukraine has challenged the KV in unprecedented ways. The military's requirements for remote sensing data have undoubtedly increased severalfold, far outpacing the ability of the KV to provide given the size of the operating area, the numbers of units involved, and the constraints on other potential sources of intelligence, surveillance, and reconnaissance data (e.g., the VKS has had a difficult time operating manned collection platforms in Ukrainian-controlled airspace).

Although Ukraine has a large space industry mainly dedicated to the export market, it lacks its own fleet of satellites. The Space Agency of Ukraine operates a single small remote sensing satellite—Sich 2-1—with an estimated ground resolution of 7.8 meters.[48] However, the Ukrainians have been able to acquire commercial imagery from various foreign providers and lease a SAR satellite from the Finnish company ICEYE.[49] The Ukrainians are also reportedly benefiting from space intelligence–sharing arrangements with partner governments in the West.[50]

Russian observers speculate that the support Ukraine that has received from foreign commercial imagery providers has given the Ukrainians a select advantage over the Russians in the space domain, allowing the Ukrainians to probe Russian defenses along the line of control for weak spots.[51] Nathan Eismont, a research at Russia's Space Research Institute, notes the disparity in Russia-Western capabilities:

> "Western countries have more observation satellites than ours by an order of magnitude. The more of them, the more often they can fly over the desired area and collect intelligence information about the location and movement of our troops. If our devices fly over some regions of Ukraine 2–3 times a day, then Western devices, replacing each other, can "hang" there almost continuously, transmitting intelligence information online."[52]

Russian officials have hinted that the intelligence support provided by commercial satellite companies such as Maxar, Planet Labs, and BlackSky to Ukraine could render the satellites of those companies viable military targets. For instance, Konstantin Vorontsov, deputy director of the Department for Nonproliferation and Arms Control of the Russian Foreign Ministry, offered a warning in a meeting of the United Nations (UN) General Assembly:

"Separately, we would like to emphasize an extremely dangerous trend that has clearly manifested itself in the course of events in Ukraine. We are talking about the use by the United States and its allies of civil infrastructure components in space, including commercial ones, in armed conflicts. Quasi-civilian infrastructure could be a legitimate target for retaliation."[53]

Given the relative imbalance in terms of remote sensing capabilities, it is unsurprising that the KV has turned to government and commercial providers to address optical and radar imagery shortfalls. Referring to the conflict in Ukraine, former Roscosmos chief executive officer Dmitry Rogozin noted that Roscosmos was providing intelligence support to the military "around the clock and in sufficient resolution."[54] Russian commercial providers have no remote sensing satellites in their inventories, so the Russians have had to turn to foreign providers. Sanctions have effectively closed off avenues to acquire imagery from Western companies, so Russia has turned to China instead. In January 2023, the US Department of the Treasury's Office of Foreign Assets Control sanctioned a Chinese company—Spacety China—for providing SAR imagery of Ukraine to Terra Tech, a Russian technology firm affiliated with the private military contractor Wagner.[55] Presumably, Wagner is sharing the Chinese SAR data with the Russian military, although this could not be verified from open-source reporting.

Sources that address how the Russians are employing remote sensing data in Ukraine are lacking; however, we can surmise that the information is being used to enhance the situational awareness of the different groupings of forces; ascertain the disposition of Ukrainian forces; identify potential targets, especially those outside the effective range of reconnaissance of unmanned aircraft systems; and conduct post-strike assessments. The utility of such data for striking mobile—as opposed to fixed—targets that employ "shoot-and-scoot" tactics, such as High Mobility Artillery Rocket System (HIMARS) batteries, is questionable. Russia's much vaunted reconnaissance strike/reconnaissance fire complex has turned out to be somewhat inflexible and unresponsive. Delays of 40 minutes to 4 hours for indirect fires routinely occur, according to Russian observers.[56] In practical terms, such delays have meant that strike missions often hit their intended locations with precision accuracy but long after their intended targets have moved on or dispersed. In addition, remote sensing data, especially imagery, require time for processing before they can be used to develop targeting solutions, thus contributing to latency issues.[57]

## Communications

Russia operates a diverse array of military[58] and commercial communications satellites (comsats) that can provide mobile and fixed SATCOM services at a variety of latitudes. The military satellites make up the Integrated Satellite Communication System (ESSS), an important component of Russia's integrated command and control system. The ESSS consists of at least 46 comsats[59] but, as Pavel Luzin points out, more than 30 of these, including many Strela-3 and Rodnik systems, have exceeded the warranted lifetime and are probably degraded by now.[60] Two constellations are the mainstays of the ESSS: six Meridian comsats in highly elliptical orbit (HEO), designed to enable communications between units operating in the Arctic, Siberian, and Far East regions, and three Raduga-1M comsats, operating in geo-stationary earth orbit (GEO). The Russian military is beginning to field its third generation of comsats (ESSS-3), the mainstay of

which will be the Sfera-S and Sfera-V, which are intended to operate in HEO and GEO, respectively. Roscosmos launched the first Sfera comsat into orbit in October 2022—a demonstrator that will test communication protocols for broadband internet connectivity.[61]

The Sfera multi-spectrum constellation is intended as a counterpoint to Starlink, providing broadband access to its users all over the world. Russian military commentator Dmitry Kornev highlights the importance of satellites for Russian communications:

> "For the military, at least two main aspects of satellites are important in terms of organizing communications. Firstly, it is the transfer of commands of the strategic level, the nuclear missile triad....The second is a big direction, which is the provision of operational communications between units and units of the conventional armed forces. Both civilian satellites and dual-use satellites are used here. Probably, over the past two decades, our lag behind the United States and the European Community in terms of the number of satellites in orbit has grown. 'Sfera' is one of these projects that should compensate for this lag and bring us to the top three [of countries] in matters of space communications."[62]

The Russian government's goal of fielding more than 600 Sfera satellites in only a few years is probably overly ambitious[63] and will likely be constrained by sanctions and lack of access to critical high-tech components from foreign providers. In the meantime, the Russian military can utilize Russian civilian SATCOM systems, including 14 Express geostationary satellites belonging to the state-owned Russian Satellite Communication Company and 18 Gonets-M comsats operated by Roscosmos.[64]

In addition to the systems noted above, the KV operates two large constellations of "store-and-dump" low-orbital communications systems, Rodnik (Strela-3M) and Strela. These systems are designed to facilitate communications in remote areas where alternative transmission means may be lacking. As noted above, some of the satellites in these constellations may no longer be operating because of their age.[65]

Another important component of the KV's communications network is its constellations of geostationary data relay satellites, which provide contact between mission control and low-orbiting satellites when they fly out of direct view of ground stations.[66] The newest generation of relay satellites is Garpun 11L and Garpun 12L, developed by ISS Reshetnev and launched in 2011 and 2015, respectively. The Garpuns provide data relay for military reconnaissance satellites operating in low earth orbit (LEO), such as Persona and Bars-M, as well as the Liana constellation. Garpuns also support the military's Command and Relay System, also known as Rassvet.[67] Another constellation of four data relay satellites, Blagovest, apparently handles non-sensitive military traffic.[68]

Russian units in Ukraine appear to be using the MK VTR-016, a ground-based mobile video transmission system, to connect with military and commercial comsats. The MK VTR-016, which was first produced in 2014 and previously used by Russian troops in Syria, employs very small aperture terminal technology and is designed to work in difficult field conditions. It is reportedly compatible with non-Russian commercial networks, including Intelsat and Eutelsat, although Russian forces are unlikely to have access to such networks.[69] The transmitter/receiver for the MK VTR-016 is the Auriga 1.2V (see Figure 2), a portable system that handles high-speed duplex channels of communications with satellites operating in the C band (5.925–6.425 GHz uplink/3.7–4.2 GHz downlink) and Ku-band

**Figure 2. Russian paratrooper with Auriga 1.2V portable satellite communications system**

Source: Officer Enclave, Twitter, https://twitter.com/OfficerEnclave/status/1508874253575282696?lang=en.

(14 GHz uplink/10.9–12.75 GHz downlink).[70] In April 2022, the Ukrainian military captured an Auriga 1.2V. Its capture confirms that the Russians are using SATCOM and high-frequency (3 MHz to 30 MHz) radio for trunk communications in Ukraine.[71]

Whether Russia's SATCOM networks (military and commercial) are sufficient for the military's purposes in Ukraine is unclear. Russia has terrestrial communications alternatives, such as encrypted military-grade mobile phones, but there are times when satellite communications are preferred, especially in a degraded environment. The scale of the operations, with more than 190,000 troops operating on multiple fronts, would seem to necessitate the widespread distribution of MK VTR-016 systems (or a similar alternative), which is unlikely given the Russian military's resource constraints and logistical challenges. Also, Russia's comsat constellations are only marginally better than its remote sensing ones, and the Russian military is still far behind the US and China in this area. Until the Sfera constellation is operational, the Russian military is still relying on dated systems, such as Gonets and Meridian, which suffer from low-bandwidth/high-latency issues.[72] Poor communications security practices, stemming from the tendency of Russian troops to rely on unencrypted commercial radios and personal cell phones for field communications, could indicate a lack of viable communication alternatives, although such practices could also stem from other factors, such as poor training. Finally, the Ukrainians have conducted cyber and jamming attacks against Russian SATCOM networks, degrading their capabilities periodically.[73]

Over the course of the conflict in Ukraine, SATCOM networks have been a focus for counterspace operations by both sides. On the first day of

the conflict, February 24, 2022, Russian forces attempted to disrupt Ukrainian command and control by launching a "disorganizing" cyberattack on Viasat's KA-SAT satellite network. Using a new strain of wiper malware called AcidRain, GU actors were able to disrupt Ukrainian military and civilian access to Viasat's broadband network for several weeks.[74] Russian electronic warfare (EW) troops have also jammed commercial comsat (including Starlink) downlinks and uplinks using systems such as the mobile Tirada-2S.[75] The Ukrainians have also attempted to disrupt Russian command and control with attacks on Russian commercial satellites.[76] So far, the effects of these operations appear to be temporary.

## Navigation

Russia's satellite navigation system—GLONASS—first reached limited operational capability in 1993. GLONASS became fully functional two years later, but because of declining budgets, the system was allowed to deteriorate to such an extent that it was unreliable for much of the 2000s. In 2011, the system was restored to full capacity, and in 2016, the Russian military formally accepted it into service.[77] As of May 2022, there were 28 GLONASS satellites in orbit, 25 of which were operational, designed and built primarily by ISS Reshetnev but operated by the KV.[78] In addition, there is a GLONASS ground segment, mostly located within Russia, consisting of upload stations, laser ranging stations, monitoring and measuring stations, and multiple telemetry, tracking, and command centers. Russia is currently fielding its latest generation of GLONASS satellites—the GLONASS-K—but is apparently experiencing problems acquiring space-grade radiation-resistant electronics from foreign suppliers because of sanctions.[79] GLONASS is reportedly accurate up to 3 meters, which is comparable to GPS.[80]

GLONASS is a dual-use system, like GPS—that is, it has both commercial and military applications. The Russian military actively employs GLONASS both for PNT functions and for targeting. The PNT component of GLONASS is likely handled by the Military Topographic Directorate of the General Staff and the 945th Main Center for Space Geodesy, Navigation and Cartography of the Russian MOD.[81] The Russian military's Strelets reconnaissance, control, and communications system has a GLONASS satellite receiver for navigation and can likely use US GPS signals as well.[82] Russian military topographers operating in Ukraine have used GLONASS high-precision navigation receivers to carry out geodetic binding for the launch positions of Iskandar-M and other missile systems.[83]

Military cartographers also use GLONASS—and GPS—to create 3D maps, using automated tools such as TRONA-1 and 1T134M topographic surveyors to increase the accuracy of missile, rocket, and artillery strikes.[84] In addition, many Russian precision strike systems are equipped with GLONASS and GPS satellite navigation guidance systems in addition to inertial guidance and, in some cases, terrain contour–matching guidance systems.[85]

Russian forces engaged in some jamming of GPS in Ukraine,[86] although not as much as might have been expected given past instances of GPS jamming (e.g., in Syria). Dana Goward, writing in C4ISRNET, offers several reasons for this, including the fact that high-power terrestrial jammers, such as R-330Zh Zhitel, are easily targeted and, more compelling, that Russian forces are, in fact, heavily dependent on GPS themselves. As evidence of the latter, he notes that captured Russian systems have featured commercial off-the-shelf GPS receivers, which are plentiful and cheap to acquire. GLONASS receivers and the Russian military's terrestrial

navigation system Chakya (equivalent to Loran)[87] may not be available in sufficient quantities to deployed Russian forces.[88]

## Counterspace

In the context of the Ukraine conflict, Russia's counterspace activities appear to have been limited to jamming satellite transmissions and conducting at least one high-profile cyberattack on a commercial SATCOM network. True to Russian doctrine and theoretical writings, these activities escalated rapidly in the early phase of the conflict (the initial period of war). Russia has not managed to achieve space control, nor is it likely to, given the strategic imbalance in capabilities between its space forces and those of Ukraine's allies. However, Russia retains several counterspace options that it could use depending on how the conflict plays out. These options are explored in more detail in the next section. In this section, we analyze Russia's counterspace capabilities and activities to date by category.

### *Electronic warfare/jamming*

The Russian military views EW as an important tool for disrupting adversary C4ISR-T and achieving information superiority.[89] Russian forces have developed a range of fixed and mobile EW systems that could jam or spoof the signals of comsats (Tirada-2S and Bylina-MM), counter radar reconnaissance satellites and airborne radar reconnaissance systems (Krasukha-4, Krasukha-2, and Divnomorye), and jam satellite navigation systems (Zhitel and Borisoglebsk-2).[90] Some of these systems, including Zhitel, have been deployed—and used—widely in Ukraine, whereas others, notably the Bylina-MM, do not yet appear to have been fielded. To date, Russia has employed jamming extensively in Ukraine to disrupt signals from the GPS constellations, with a noticeable effect on Ukrainian munitions and drones that rely on satellite navigation.[91] Russian forces have also intermittently jammed GPS signals over Russian territory, especially over regions bordering Ukraine and major cities, such as Moscow and St. Petersburg.[92] Russian sources also claim to have used the Tirada mobile jamming system to disrupt SpaceX's Starlink constellation.[93] As noted above, some observers have suggested that Russian jamming efforts have not been as extensive as expected in Ukraine, possibly because the Zhitel and other high-power jammers are easily targeted and Russian forces are heavily dependent on GPS themselves.[94] Nevertheless, Russian EW troops have successfully disrupted Ukrainian precision-guided weapon systems and drone operations fairly regularly. For the Russians, at this stage in the conflict, jamming is probably the most viable counterspace option, given Russia's extensive EW capabilities and the fact that jamming attacks are non-kinetic and deniable and thus unlikely to be perceived as escalatory or cause space debris.

### *Cyberattacks*

Russia has also employed offensive capabilities in support of its counterspace operations in Ukraine. On February 24, 2022—the first day of Russia's invasion—hackers believed to be affiliated with the GU conducted a malware attack against modems and routers that communicate with the broadband network of US satellite company Viasat.[95] The GU employed a form of destructive wiper malware known as AcidRain, which effectively erased all the data on the systems, permanently disabling them when they rebooted.[96] The Ukrainian military, which used the Viasat network, was the obvious target, but the attack had spillover effects, disrupting civilian systems throughout Western Europe.[97] Cyberattacks, like jamming and other EW efforts, are a core component of Russia's tools

for engaging in "information confrontation." Like jamming, cyberattacks are advantageous, assuming that Russia seeks to avoid escalation, in that they offer plausible deniability and their effects are generated by non-kinetic means (although in this instance the effects were not as transitory in nature and were not limited to their intended targets).

## Direct ascent ASAT

Russia is also developing kinetic direct ascent (DA)-ASAT systems, a couple of which are in the advanced stages of development or are being fielded. The PL-19 Nudol, which is part of the A-235 missile defense complex, is a mobile ground-launched ballistic missile that can destroy not only missiles but also satellites in LEO. The Nudol program has been maturing rapidly, and its ASAT capabilities were aptly demonstrated on November 15, 2021, when the missile was used to destroy an inactive Russian ELINT satellite, Kosmos-1408, in the process creating an orbital debris field.[98] Whether the Nudol has been fielded is unclear, although the program, run by VKO Almaz-Antey, is evidently at a mature stage. Reportedly, the S-500 mobile air defense system, which was recently fielded,[99] can also target satellites in LEO.[100] At least one other kinetic ASAT system, the Burevestnik air-launched rocket (designed to be launched from a MIG-31 interceptor aircraft) is still in development.[101] As of June 2023, Russia had not used its DA-ASAT capabilities in the context of the Ukraine conflict, although some Russian writers have suggested that it remains an option. As mentioned above, Konstantin Vorontsov, deputy director of the Department for Nonproliferation and Arms Control of the Russian Foreign Ministry, stated at a UN General Assembly meeting that commercial satellites that are used to support Ukraine could become a legitimate target for Russian ASAT systems.[102]

## Directed energy weapons

Russia has developed several ground-based systems that can dazzle or blind satellite sensors. The most notable of these is the Peresvet laser weapon, one of the six "new types of strategic weapons" unveiled by Russian President Vladimir Putin in 2018. According to Russian sources, Peresvet systems can target satellites up to 1,500 kilometers, covering most of the region of LEO.[103] An upgraded version of the Peresvet, the Zadir, has reportedly been deployed in Ukraine, although there is no evidence that it has been used in a counterspace role.[104] Russia is also experimenting with airborne ASAT lasers, although there is no evidence that such systems have been fielded.[105] A. V. Skrypnik, writing in the Russian journal *Armaments and Economics*, notes some of the advantages of directed energy weapons compared to kinetic counterspace systems. According to him, directed energy weapons can be quicker, more selective, and precise and likely minimize the potential for orbital debris. He also argues that their utility for deterrence in the earlier phases of conflict is greater because they are more "humanitarian."[106]

## Co-orbital ASAT

Russia is also developing on-orbit capabilities that could be used to kinetically target satellites. Since 2013, the KV has launched several dual-purpose micro-inspector satellites that are ostensibly designed to survey and possibly fix damaged spacecraft. To date, four "Nivelir" satellites, designed by the Central Research Institute of Chemistry and Mechanics, have been placed in orbit. These satellites have conducted proximity operations around US satellites that have convinced US officials that their function is offensive in nature.[107] In the context of the Ukrainian conflict, the Russian MOD stated that KV's Directorate of Space Intelligence has been using inspector satellites to "monitor the composition and

condition of orbital constellations of foreign space systems, as well as conducting experiments in orbit with the spacecraft of foreign states."[108]

## *Space situational awareness*

Space situational awareness—specifically the ability to track spacecraft in orbit—is an important component of counterspace operations. Russia's space surveillance network is managed by the KV's 821st Main Space Reconnaissance Center. It consists of numerous telescopes, radars, and other sensors designed to detect and monitor satellites in earth orbit. A Defense Intelligence Agency report clarifies its abilities:

> "This network allows Russia to support its various missions including intelligence collection, counter-space targeting, spaceflight safety, satellite anomaly resolution, and space debris monitoring. Some of these sensors also perform a BMEW [ballistic missile and early warning] function as their primary mission."[109]

Russia also benefits from a diverse array of bilateral and multilateral scientific partnerships dedicated to tracking objects in space.

# RUSSIA'S SPACE AND COUNTERSPACE OPTIONS

Russian observers generally concede that in the space domain, Russia has been operating at a disadvantage since the start of the conflict in Ukraine, primarily because of the support (commercial and military) provided to Ukraine by the United States and its allies. An article in *Nezavisimaia Gazeta* notes one example of this disadvantage:

> "The development of the special military operation (SVO) in Ukraine has demonstrated [the role played by] space intelligence data and its close link to targeting by high-precision weapons, reliable secure communications and electronic warfare (EW) systems, [controlling] satellite-controlled drones, and the use of the internet for organizing coordination during battle, and [sustaining] motivation and continuous training of personnel. All this, with the support of the information war organized in the media and social networks, is included in the list of factors that determined the course of hostilities in Ukraine. The Russian Army and the Armed Forces of Ukraine, by and large in February 2022, were not ready to take into account these important factors. The United States and NATO improved the situation for the Armed Forces of Ukraine not only by mass deliveries of modern weapons, but also by deploying Starlink satellite internet terminals there in March 2022. Their delivery…allowed the Armed Forces of Ukraine to be relatively independent from the effects of electronic warfare and have reliable closed communications in their units up to the battalion level."[110]

By contrast, the author notes that the Russian military has had to limit its maneuvers to a depth of 60 to 70 kilometers, despite having a numerical advantage in armor and artillery.[111]

The stark disparity in Russian versus US satellite systems is noted in an article in *Moskovskii Komsomolets:*

> "It is no coincidence that on Cosmonaut Day, the president spoke about the need for a sharp increase in the number of our satellites. We have about 150 of them, maybe a little more. That's all together—civil, military, scientific, communications, navigation, and surveillance. By comparison, China has 300–400 systems, including about a hundred military ones. The United States until recently had 1,400 systems. But since Elon Musk implemented his Starlink low-orbit satellite communications project, the number of American devices in orbit has exceeded 4,000. Western countries have an order of magnitude more [satellites] than ours, including observation satellites."[112]

From the Russian perspective, the involvement of Western commercial space companies, including SpaceX, Maxar Technologies, Planet Labs, and BlackSky, in the Ukraine conflict has been a decisive enabler for Ukraine's C4ISR-T efforts.[113] As noted above, Russia has assiduously been attempting to address gaps in its capabilities by doubling down on the development, production, and launch of new satellites, especially earth observation, ELINT, and communications satellites. Last year alone, the KV added 14 satellites to its inventory.[114] However, this number is dwarfed by the production and fielding

capacity of Western companies such as SpaceX. On March 24, 2023, SpaceX conducted its 20th launch of the year, adding 56 satellites to its Starlink constellation in a single launch.[115] Russia simply cannot compete at this rate. Moreover, as the conflict in Ukraine drags on, Western sanctions will likely exacerbate the endemic inefficiencies of Russia's space industry, further constraining the ability of the KV to address its gaps. Russia's inability to import advanced radiation-resistant microchips because of sanctions has been particularly problematic for Russian satellite development and production since the 2014 Ukraine crisis.[116]

Russia can use its counterspace capabilities to address the space imbalance and has been doing so using EW methods and offensive cyber tools. Russia has a demonstrated DA-ASAT capability, which it could use to further diminish Ukraine's advantages and deter Western space-related collaboration with Ukraine. Indeed, some Russians have argued that such a step would be justified and should remain on the table for consideration. The justification by Konstantin Vorontsov at the Russian Foreign Ministry was noted above, but there are other examples as well. For instance, State Duma Deputy Mikhail Sheremet suggested that Russia use its counterspace capabilities to "extinguish" NATO constellations because of the support that they provide to Ukrainian troops conducting HIMARS multiple launch rocket system strikes on Russian troops.[117]

If Russia wishes to escalate short of employing nuclear weapons, DA-ASAT could be an option. But it is also fraught with risks. As Victor Litovkin, the head of the military news editorial office at the TASS news agency, notes, "We have the means to deal with enemy satellites, but all attempts to seriously influence them directly will lead to an open military conflict between Russia and the United States—in fact, to a third world war."[118] There is also a problem of scale. Russia cannot selectively target all the relevant satellites operating in LEO that are supporting Ukraine—it does not have the capacity.[119] Furthermore, if Russia were even to attempt to do so, it would create a debris field that would interfere with the constellations of neutral countries, such as China.

In an article in the online newspaper *Vzglyad* titled "How Russia Can Deprive Ukraine of Support from Space," Mikhail Kotov, a journalist who specializes in space issues, makes an interesting analogy while referring to Vorontsov's call to arms. According to Kotov, the situation is reminiscent of attacks on commercial shipping during the First and Second World Wars:

> "The logic is about the same: a civilian ship can carry out military tasks—to transport weapons or military personnel. True, at that time there was a full-fledged world war, whereas an attempt to shoot down an enemy spacecraft could easily become just a *casus belli* to start such a war. But the main problem lies elsewhere. Hunting for enemy transports, in addition to destroying them, forced the enemy to complicate logistics, develop new [and] less convenient and longer routes, and divert warships to provide security. In the case of a satellite, the destruction of one of them will not stop and practically will not affect the operation of the others. [So] the only purely military and most radical option to eliminate this threat is the massive destruction of satellites in orbit."[120]

Kotov goes on to note that extensive kinetic strikes on satellites would lead to destruction on a massive scale, not just for Russia's enemies but also for Russia and its allies. Kotov concludes that this is not a viable option. For want of a better solution, his recommendation is for Russia "to become space leaders ourselves in conditions when orbital groupings have become the basis of modern space."[121]

# CONCLUSION

The conflict in Ukraine is a useful case study for providing insights into how the Russian military utilizes its space capabilities in support of operations in other domains. Space has played a critical role as an enabler for Russian forces in the SVO, for instance, by facilitating theater precision strikes, enabling encrypted communications at the tactical-operational level, and providing a means of navigation for ground, air, and naval units. Russian forces have also selectively employed counterspace capabilities—jamming and cyberattacks—to degrade Ukrainian C4ISR-T. But the performance of the KV in Ukraine indicates that significant gaps remain in its capabilities, especially in the areas of earth imaging and reconnaissance.

As the conflict continues to evolve, Russia retains several options for escalating in the space domain, should it choose to do so. Russian doctrine and theoretical writings suggest that counterspace operations could be a useful tool for deterrence and signaling intent. Russian officials have suggested that Russia could escalate in space—for instance, by conducting a DA-ASAT strike against a commercial constellation—and that such a move would be justified, from their perspective, given the support provided by Western governments and companies to the Ukrainian military. Whether Moscow chooses to escalate in space will probably be influenced by several factors, including its threat perceptions, the successes or failures of its operations on the ground in Ukraine, and actions taken by Ukraine and its partners in space.

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