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Advanced military technology in Russia

Capabilities and implications

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Contents

Summary

- Russia has been incrementally integrating novel force-multiplier technologies into established weapons systems, including nuclear and non-nuclear strategic weapons and general-purpose forces, as well as asymmetric non-military methods and means. These new systems have the potential to provide an advantage in time and space. Uncertainties remain, nonetheless, about Russia's ability to keep up with the competition.

- The purpose of Russia's recently announced five major nuclear-capable weapons programmes is to ensure Russia's ability to penetrate US current and future missile defence systems and to guarantee a second-strike capability for the foreseeable future. The development of sub-strategic *superoruzhie* ('super weapons') – such as the Kinzhal [Dagger] and Tsirkon [Zircon] – is driven by a sense of inferiority in conventional weaponry. In all these programmes, Russian designers have shown an ability to identify shortcuts to innovation that are based on the creative adaptation of existing capabilities.

- Russia is in the process of upgrading or replacing legacy Soviet military space systems. It is developing a new range of systems that can disrupt satellite operations and potentially attack satellites in orbit. With the possible exception of electronic warfare, there is no evidence that these capabilities have been integrated into military operations.

- Russia has successfully integrated unmanned vehicles into its military operations, but it is a long way from incorporating aerial and ground vehicle teaming for more effective battlefield management. In the near term, the unmanned ground vehicle testing space will help define how Russian ground forces could fight future wars, and whether such systems can function effectively with manned formations. At the same time, Russia's ability to manufacture and test deep-diving unmanned underwater vehicles presents one of the greatest challenges to Western and NATO forces.

- In artificial intelligence (AI)-based technologies, Moscow's focus is on disrupting and destroying the adversary's command and control systems and communication capabilities, as well as on establishing information superiority during the initial period of war. If Russia manages to test these new technologies in near-operational and combat conditions, it could gain an edge in data collection for training more resilient AI algorithms as well as in human–machine teaming. NATO must therefore augment its cyber defence, although technical solutions alone are unlikely to be sufficient in countering the psychological elements and societal effects of Russia's AI-enabled information warfare.

- For NATO, in addition to pursuing technologies central to 4IR (the Fourth Industrial Revolution, or Industry 4.0), adapting and upgrading existing systems able to threaten the supporting infrastructure that enables Russia's new capabilities might be one more cost-effective and efficient way of responding to new threats. In areas where the US and NATO already possess technological superiority, for instance in autonomous systems or C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance), the focus should be on integrating and scaling these C4ISR capabilities throughout the alliance as well as hardening them to adversarial attacks.

01 Military technology developments and advanced capabilities

Russia is pursuing military innovation in specific force-multiplier technologies and asymmetric capabilities in order to give itself an advantage against the perceived military superiority of peer or near-peer competitors.

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Introduction

Procuring advanced and modern military capabilities for its armed forces is critical to Russia. The current leadership wants to enhance its ability to conduct modern warfare operations, compete for military advantage (especially asymmetrically) against more powerful competitors, and ultimately ensure the security of the homeland.

The Kremlin leadership's aim in putting time and effort into modernizing its armed forces and providing them with advanced military technology capabilities is to turn foreign policy aspirations into reality. Fundamentally, Moscow considers itself to be a great power in a state of conflict with more powerful competitors,[1] specifically the US and NATO, and now, increasingly, China. Leveraging force-multiplier technologies and asymmetric capabilities against more technologically advanced adversaries has now become a priority for the General Staff and the Ministry of Defence.

Russia is determined to pursue the development of advanced military technology capabilities in targeted defence industry fields within the military-industrial complex (referred to as the 'OPK' in Russian). This is taking place alongside evolving military thinking around the integration of such capabilities within the force structure,[2] new concepts of operation, and the use of modern systems in future warfare.[3]

Innovation must also be viewed within the framework of the current procurement cycle for the Russian armed forces: the state armament programme for the period 2020–27 (GPV 2027). This cycle of procurement is expected to provide the Russian armed forces with next-generation systems and more modern fighting capabilities.[4]

Russian approaches to military modernization and innovation

The modernization of military equipment has been a major priority within the armed forces and the OPK since the start of the 'New Look' reform initiated by former defence minister Anatoliy Serdyukov in 2008.[5] Modernization in the Russian sense represents a complicated combination of procuring 'new' systems and upgrading existing legacy platforms to 'modern' standards. In that sense, new does not always mean modern.[6] Modernized systems work as 'gap-fillers'[7] when genuinely new ones are not available and allow the armed forces to extend the active service life of battle-proven hardware.

1 Boulègue, M. (2021), 'Myth 04: 'Russia is not in a conflict with the West', in Allan, D., Bohr, A., Boulègue, M., Giles, K., Gould-Davies, N., Hanson, P., Lough, J., Lutsevych, O., Mallinson, K., Marin, A., Nixey, J., Noble, B., Petrov, N., Schulmann, E., Sherr, J., Wolczuk, K. and Wood, A. (2021), *Myths and misconceptions in the debate on Russia: How they affect Western policy, and what can be done*, Research Paper, London: Royal Institute of International Affairs, https://www.chathamhouse.org/2021/05/myths-and-misconceptions-debate-russia/myth-04-russia-not-conflict-west (accessed 30 Jun. 2021).
2 Zysk, K. (2020), 'Defence innovation and the 4th industrial revolution in Russia', *Journal of Strategic Studies*, 44(4): doi:10.1080/01402390.2020.1856090 (accessed 30 Jun. 2021).
3 Bērziņš, J. (2020), 'The Theory and Practice of New Generation Warfare: The Case of Ukraine and Syria', *The Journal of Slavic Military Studies*, 33(3): pp. 355–80, doi:10.1080/13518046.2020.1824109 (accessed 30 Jun. 2021).
4 Connolly, R. and Boulègue, M. (2018), *Russia's New State Armament Programme: Implications for the Russian Armed Forces and Military Capabilities to 2027*, Research Paper, London: Royal Institute of International Affairs, https://www.chathamhouse.org/sites/default/files/publications/research/2018-05-10-russia-state-armament-programme-connolly-boulegue-final.pdf (accessed 30 Jun. 2021).
5 Giles, K. (2017), *Assessing Russia's Reorganized and Rearmed Military*, White Paper, Washington, DC: Carnegie Endowment for International Peace, https://carnegieendowment.org/2017/05/03/assessing-russia-s-reorganized-and-rearmed-military-pub-69853 (accessed 30 Jun. 2021).
6 For the distinction, see Gorenburg, D. (2017), 'What does Modern Mean?', Russian Defense Policy, 18 November 2017, https://russiandefpolicy.com/2017/11/18/what-does-modern-mean (accessed 30 Jun. 2021).
7 Westerlund, F., Oxenstierna, S., Persson, G., Kjellén, J., Dahlqvist, N., Norberg, J., Goliath, M., Hedenskog, J., Malmlöf, T. and Engvall, J. (2019), *Russian Military Capability in a Ten-Year Perspective*, Stockholm: Swedish Defence Research Agency (FOI), https://www.foi.se/en/foi/reports/report-summary.html?reportNo=FOI-R--4758--SE (accessed 30 Jun. 2021).

Russian military technology only needs to be good enough to contest and deny the perceived conventional military advantage of more advanced competitors. In other words, the Russian armed forces retain both a repair-and-upgrade and a 'retain-and-adapt'[8] approach to military innovation. Russian military research and development (R&D) innovation as a whole is structured around the OPK's limited ability to produce genuinely new systems.[9] Indeed, even many 'new' systems can be traced back to legacy Soviet designs dating back to the 1980s and 1990s.

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This does not mean, however, that military innovation does not happen at all in Russia. When needed, the OPK is able to meet the express needs of the armed forces and military planners. This is particularly relevant when considering how Russia has been recapitalizing its space industry since Soviet times, or how it created a fully-fledged military-industrial base for the drone industry and electronic warfare (EW) after the 'wake-up call' of the war with Georgia in 2008.

Military innovation is enabling Russia's way of war

New military technology applications and advanced systems are enablers for Russia's way of war, especially in the context of leveraging its military-scientific base against technologically superior peer or near-peer competitors. Russia perceives itself to be in conventional military inferiority against such competitors. As Chapter Two of this paper contends, instead of trying to catch up with the West (and increasingly China) in the traditional way, Russia seeks to counter and contest by developing technologically-enabled force multipliers in the specific sectors that are examined in detail in this report.

Asymmetric leverage also means that Russia is using a well-established toolkit of 'shock-and-awe' tactics aimed at establishing credibility around its weapons systems. This was particularly visible when President Vladimir Putin first introduced these systems in March 2018,[10] since when they have

8 Radin, A., Davis, L E., Geist, E., Han, E., Massicot, D., Povlock, M., Reach, C., Boston, S., Charap, S., Mackenzie, W., Migacheva, K., Johnston, T. and Long, A. (2019), *The future of the Russian military, Russia's Ground Combat Capabilities and Implications for U.S.-Russia Competition*, Santa Monica: RAND Corporation, https://www.rand.org/content/dam/rand/pubs/research_reports/RR3000/RR3099/RAND_RR3099.pdf (accessed 30 Jun. 2021).
9 Mills, C. (2017), *Russia's rearmament programme*, House of Commons, Briefing Paper Number 7877, 24 January 2017, https://researchbriefings.files.parliament.uk/documents/CBP-7877/CBP-7877.pdf (accessed 30 Jun. 2021).
10 Trevithick, J. (2018), 'Here's The Six Super Weapons Putin Unveiled During Fiery Address', The Drive, 1 March 2018, https://www.thedrive.com/the-war-zone/18906/heres-the-six-super-weapons-putin-unveiled-during-fiery-address (accessed 30 Jun. 2021).

often been referred to by nicknames such as 'Doomsday' or 'Death Star' weapons, or 'Wunderwaffen'. Such announcements are an efficient way to own the narrative of a technological race in which Russia has declared itself a participant: in many ways, the message itself becomes the weapon. A close, research-based scrutiny of the claimed Russian technological advances, actual and planned, is therefore of critical importance to a correct understanding of Russia's capabilities.

Military innovation is further shaped by unyielding Russian foreign policy perceptions, notably the 'besieged fortress' narrative or the idea that Russian 'security interests' are not sufficiently respected.[11] More than three decades of threat construction against NATO and its allies have vindicated the Kremlin leadership in being able to fall back on military power and coercion as a privileged tool of foreign policy,[12] honed by the perceived necessity to employ limited action and pre-emptive neutralization of threats, surprise and deception, asymmetric means, and decisiveness.[13]

Lessons learned from recent deployments

Russian military innovation relies on lessons learned in theoretical studies and, more importantly, in the field. Recent developments in military science would not be as substantial without the operational experience acquired in Syria since 2015, and, less officially, in Ukraine since 2014. Both military campaigns allowed Russia to test new and experimental systems, and to showcase combat-proven weapons. Throughout different stages of the Syrian campaign, OPK engineers and experts have been deployed alongside Russian forces to test new systems in combat situations.[14]

This operational experience is particularly relevant for command and control systems, unmanned platforms (notably drones and anti-unmanned aerial vehicle – UAV – capabilities, as well as for demining operations), EW, and precision-guided munitions.[15] Such technological advances and tactical adaptations will continue to inform future innovation and procurement priorities, as well as Russian military doctrine, well into the 2020s.

11 Allan, D. et al. (2021), *Myths and misconceptions in the debate on Russia*.
12 Renz, B. (2019), 'Russian responses to the changing character of war', *International Affairs*, 95(4): pp. 817–34, doi:10.1093/ia/iiz100 (accessed 30 Jun. 2021).
13 ВПК.name [vpk.name] (2019), 'Герасимов рассказал об ответе на американскую стратегию "Троянского коня" [Gerasimov spoke about the response to the American Trojan Horse strategy], 4 March 2019, https://vpk.name/news/255804_gerasimov_rasskazal_ob_otvete_na_amerikanskuyu_strategiyu_troyanskogo_konya.html (accessed 30 Jun. 2021); *Красная звезда* [*Red Star*] (2019), 'Векторы развития военной стратегии' [Development vectors of military strategy], 4 March 2019, http://redstar.ru/vektory-razvitiya-voennoj-strategii (accessed 30 Jun. 2021).
14 Kommersant (2018), '«Лучше один дорогостоящий прицельный удар, чем сто ударов без разбора» Дмитрий Рогозин о планах по перевооружению армии, развитию Арктики и освоению космоса' [Better one expensive aimed hit than a hundred indiscriminate hits, Dmitry Rogozin on plans to re-equip the army, develop the Arctic and space exploration], 26 February 2018, https://www.kommersant.ru/doc/3558424 (accessed 30 Jun. 2021).
15 Clark, M. (2021), *The Russian Military's Lessons Learned in Syria*, Washington, DC: Institute for the Study of War, http://www.understandingwar.org/sites/default/files/The%20Russian%20Military%E2%80%99s%20Lessons%20Learned%20in%20Syria_0.pdf (accessed 30 Jun. 2021).

Lessons learned from recent deployments also inform and reinforce Russian military innovation and procurement policies related to defence, deterrence, and the peacetime organization of force to increase combat readiness, as is evident from investments in modern command and control, network-centric warfare,[16] force mobility and deployability, and military logistics (specifically the storage and pre-positioning of forces). The peacetime organization of force aims to increase combat readiness while reflecting procurement choices around defensive systems – including long-range precision-strike weapons.

About this paper

The main body of this research paper starts by offering an overview of the major pathways in Russian defence innovation and its organizational structure, as well as military R&D advantages and limitations (Chapter Two). The paper then assesses Russia's modern military capabilities and advanced technologies in key sectors. These cover specific weapons systems, including new strategic and sub-strategic systems (Chapter Three), space technology (Chapter Four), autonomous systems and military robotics (Chapter Five), and artificial intelligence applications (Chapter Six).

These front-line technologies and areas of innovation have been selected specifically because they are considered to be development priorities for the Russian armed forces and because they relate to one another as force multipliers in leveraging asymmetric advantages. They are all considered to be advanced technologies that have concrete implications on the battlefield, as well as implications for NATO and its members at a more strategic level.

The authors also discuss the effects of military innovation on Russian military thinking, as well as its impact on potential adversaries – namely the US, and NATO and its members.

The authors recognize that the themes mentioned above continue to evolve in Russia as the country's defence and policy community deliberate how existing and conceptual weapons and systems will affect its combat operations and military readiness. Therefore, the information contained in this report should be viewed as part of an ongoing debate on Russia's overall military research, development and experimental space. While each of the authors is responsible for his or her own chapter, they have collectively written and agreed the executive summary and the report's policy recommendations, which are found in Chapter Seven.

16 Ramm, A. (2019), *The Russian Army: Organization and Modernization*, Arlington, VA: CNA, https://www.cna.org/CNA_files/PDF/IOP-2019-U-021801-Final.pdf (accessed 30 Jun. 2021); Adamsky, D. (2018), *Moscow's Syria Campaign: Russian Lessons for the Art of Strategy*, Notes de l'Ifri, Russie.Nei.Visions No. 109, IFRI, https://www.ifri.org/sites/default/files/atoms/files/rnv_109_adamsky_moscow_syria_campaign_2018.pdf (accessed 30 Jun. 2021).

02 Military R&D, innovation and breakthrough technologies

Russia is continuing its pursuit of breakthrough technologies, while integrating the results thus far to improve existing weapons systems, infrastructure, and operations, leading to incremental change and a gradual evolution in the Russian way of war.

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Russia has joined the contest for military-technological superiority between major powers, driven by an understanding that the ongoing competition has major implications both for Russia's security and for the international system at large. This new wave of the artificial intelligence (AI)-driven Revolution in Military Affairs (RMA), as noted by Michael Raska,[17] has the potential to spur significant military change because it differs from past 'IT-RMA' waves in several ways in terms of its political, strategic, technological and operational diffusion paths and patterns.

First, the US faces a strategic peer competitor for the first time in decades, as China is capable of potentially negating the strategic and operational advantages of the US military. The danger of other countries creating new threats to Russia's

17 Raska, M. (2020), 'The sixth RMA wave: Disruption in Military Affairs?', *Journal of Strategic Studies*, 44(4): pp. 456–79, https://doi.org/10.1080/01402390.2020.1848818 (accessed 30 Jun. 2021).

security with technological advances, as well as the promise of Russia gaining a potential edge over its adversaries, have been among the central drivers in the Russian leadership's push for new and breakthrough technologies.

Second, advanced military-industrial sectors are no longer the main sources of technological innovation: this is now primarily driven by the commercial sector, with dual-use potential. Russia is an outlier among major powers with its traditional state-driven, top-down innovation model. Yet that model has been modified to take advantage of the advances being made in the civilian sector, thus partly emulating the US and Chinese approaches to innovation.[18] Moreover, by creating synergies between the military and the civilian sector, Russian authorities hope to generate a much-needed nationwide economic revival and boost the country's competitiveness.[19]

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Third, trends such as the diffusion of autonomous and AI-enabled weapons systems, the convergence between human–machine learning (ML) and cognitive manipulation, and cyber and AI developments, coupled with novel operational concepts and force structures, seem to the Russian authorities certain to influence the trajectory and character of future warfare and of human involvement therein.[20] A representative example of this reasoning was expressed by Vitaly Davydov, the deputy director-general of the Advanced Research Foundation (ARF, see also below) and head of its scientific-technological council. As Davydov put it, it is only a question of time before robots, with various degrees of autonomy, will take over the role of soldiers on the battlefield, given superior qualities such as the ability to act faster, with greater precision and more selectively than humans.[21] Such assets may, in the future, complement manned units and free up soldiers for more complex tasks: for example, robots may guard facilities or be employed to penetrate dangerous environments with less risk.

18 Zysk, K. (2020), 'Defence innovation and the 4th industrial revolution in Russia', *Journal of Strategic Studies*, 44(4): https://www.doi.org/10.1080/01402390.2020.1856090 (accessed 30 Jun. 2021).
19 For example, see this article by Major-General Andrey Goncharov, head of the Russian defence ministry's GUNID (Main Directorate of Research and Technological Support of Advanced Technologies – Innovative Research): Goncharov, A. (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia], Национальная оборона [National Defence], 23 March 2020, https://2009-2020.oborona.ru/includes/periodics/armedforces/2020/0323/103628949/detail.shtml (accessed 30 Jun. 2020); see also the connection between modernization in the defence sector and national economic development made by Vladimir Putin: Putin, V. (2013), 'Послание Президента Федеральному Собранию' [Address of the President to the Federal Assembly], President of Russia/kremlin.ru, 12 December 2013, http://kremlin.ru/events/president/news/19825 (accessed 30 Jun. 2021); Putin, V. (2012), 'Послание Президента Федеральному Собранию' [Address of the President to the Federal Assembly], President of Russia/kremlin.ru, 12 December 2012, http://kremlin.ru/events/president/news/17118 (accessed 30 Jun. 2021).
20 Raska (2020), 'The sixth RMA wave: Disruption in Military Affairs?'.
21 Interview with Vitaly Davydov, the deputy director-general of the Advanced Research Foundation and head of its scientific-technological council: РИА Новости [RIA Novosti] (2020), 'В ФПИ оценили перспективы замены живых солдат боевыми роботами' [The FPI assessed the prospects of replacing soldiers with combat robots], 21 April 2020, https://ria.ru/20200421/1570333326.html (accessed 30 Jun. 2021).

Traditionally, technological prowess has been regarded in Russia as a critical element of military effectiveness and strategic advantage.[22] Gaining or losing ground in the contest for cutting-edge military technology and more effective weapons systems may have far-reaching consequences: for national security and Russia's place in the international hierarchy of power, and for fundamental aspects of international security such as deterrence, arms control, and strategic stability.

This chapter provides an overview of the major trajectories of defence innovation and the development of militarily relevant technologies in Russia. It is based on the assumption that while a disruptive shift in Russian warfare cannot be excluded, given the possible non-linear nature of the search for breakthrough technologies, to date the Russian approach to warfare has been characterized by incremental change.[23] The analysis is organized into two main parts: the first examines the main research and development (R&D) pathways and Russia's progress in accessing and leveraging selected new and emerging technologies; the second discusses obstacles and future prospects, together with some of the implications that military technology development has for NATO and the US.

Innovation trajectories and infrastructure

Russia has been increasing its focus on expanding military R&D since the early 2000s, with a surge in pace in the 2010s in particular. Development has been moving along three major pathways:

1. Modernization and upgrading of existing and well-established nuclear and non-nuclear technologies;
2. Experimentation in and pursuit of 'risky' innovation projects within a broad spectrum of novel technologies that can potentially yield significant advantages; and
3. Integration of some of the new technologies into the established weapons systems.

After nearly two decades of decline in the defence sector following the fall of the Soviet Union, in 2008 Russia embarked on a large-scale modernization effort, with the objective of rapidly bolstering defence and deterrence options by refurbishing old assets and developing selected new symmetric ones. The nuclear triad topped the priority list, followed by the modernization of strategic conventional and general-purpose forces.[24] Nuclear weapons have remained at the core of Russian defence, deterrence

22 Adamsky, D. (2008), 'Through the Looking Glass: The Soviet Military-Technical Revolution and the American Revolution in Military Affairs', *Journal of Strategic Studies*, 31(2): pp. 257–94, doi:10.1080/01402390801940443 (accessed 30 Jun. 2021); Adamsky, D. (2010), *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the US, and Israel*, Palo Alto, CA: Stanford University Press.
23 Zysk (2020), 'Defence innovation and the 4th industrial revolution in Russia'.
24 Renz, B. (2018), *Russia's Military Revival*, Cambridge: Polity; Zysk, K. (2015) 'Managing Military Change in Russia' in Bekkevold, J. I., Bowers, I. and Raska, M. (eds) (2015), *Security, Strategy and Military Change in the 21st Century: Cross-Regional Perspectives*, London: Routledge, pp. 155–77; Woolf, A. F. (2020), *Russia's Nuclear Weapons: Doctrine, Forces, and Modernization*, R45861, Washington, DC: Congressional Research Service, https://fas.org/sgp/crs/nuke/R45861.pdf (accessed 30 Jun. 2021); Westerlund, F., Oxenstierna, S., Persson, G., Kjellén, J., Dahlqvist, N., Norberg, J., Goliath, M., Hedenskog, J., Malmlöf, T. and Engvall, J. (2019), *Russian Military Capability in a Ten-Year Perspective*, Stockholm: Swedish Defence Research Agency (FOI), https://www.foi.se/en/foi/reports/report-summary.html?reportNo=FOI-R--4758--SE (accessed 30 Jun. 2021).

and coercive options. Consequently, Russia has continued to build and field increasingly diverse and expanding nuclear capabilities, delivery systems and supporting infrastructure. Gradually, and especially since 2010, modernized and new conventional weapons have increasingly strengthened the credibility of Russia's non-nuclear defence and deterrence – developed, nonetheless, in close integration with nuclear weapons.[25]

Simultaneously, and since the early 2010s in particular, Russia has increasingly devoted attention to new and potentially disruptive military-relevant technologies. Russian programmes include all the major elements of the so-called fourth industrial revolution (also known as 4IR, or Industry 4.0), such as AI, big data, and quantum computing, promising to provide far more secure communications, autonomous and AI-enabled unmanned systems, robotics, advanced ML algorithms to significantly multiply the speed of information and data processing, and automation for weapons platforms and surveillance systems. Russia is also working on automated decision-making, hypersonics, space capabilities, and 'weapons based on new physical principles', i.e. directed energy, radiological, genetic and electromagnetic weapons.[26] Russia has also shown an interest in additive manufacturing (known as 3D printing) and the use of new state-of-the-art materials, including composites, nanotechnology and nanomaterials with new properties that have the potential to improve military equipment in multiple ways, such as making them more resistant, lighter and harder to detect.[27]

The Russian political and military leadership has played a central role in fostering innovation, overriding institutional conservatism, and increasing the responsiveness of the extensive defence-sector bureaucracy since sweeping military reforms were set in motion in 2008.[28] The basic approach to stimulating and organizing innovation in the Russian defence sector has been embedded in the traditional, centralized state-driven top-down model, albeit with some modifications. Notably, Russia has partly emulated the US innovation model of military–civilian sector cooperation by establishing joint collaborative platforms. The objective is to create and leverage synergies between defence–civilian and commercial developments to increase the state's access to talent and amplify the exchange of ideas, inventions, expertise and experience.[29] It is possible that the inspiration also comes in part from the Chinese military–civilian fusion model, with science and technology parks being connected to the campuses of large military universities.[30]

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25 Johnson, D. (2018), *Russia's Conventional Precision Strike Capabilities, Regional Crises, and Nuclear Thresholds*, Livermore Papers on Global Security No. 3, Livermore, CA: Lawrence Livermore National Laboratory Center for Global Security Research, https://www.osti.gov/servlets/purl/1424635 (accessed 30 Jun. 2021); McDermott, R. N. and Bukkvoll, T. (2017), *Russia in the Precision-Strike regime – military theory, procurement and operational impact*, FFI-Rapport 17/00979, Kjeller: Norwegian Defence Research Establishment (FFI), https://publications.ffi.no/nb/item/asset/dspace:2671/17-00979.pdf (accessed 30 Jun. 2021).
26 Zysk (2020), 'Defence innovation and the 4th industrial revolution in Russia'; Ministry of Defence of the Russian Federation (undated): Encyclopedia, 'Оружие на новых физических принципах' [Weapons based on new physical principles], Military Encyclopaedic Dictionary, http://encyclopedia.mil.ru/encyclopedia/dictionary/details_rvsn.htm?id=13770@morfDictionary (accessed 30 Jun. 2021).
27 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
28 Zysk, K. (2015) 'Managing Military Change in Russia'.
29 See, for instance, the current list of partners of the Era technology campus: https://era-tehnopolis.ru/partners.
30 Dear, K. (2019), 'Will Russia Rule the World Through AI? Assessing Putin's Rhetoric Against Russia's Reality', *The RUSI Journal*, 164(5–6): pp. 36–60, doi:10.1080/03071847.2019.1694227 (accessed 30 Jun. 2021); Sidorkova, I. (2018), 'Военное «Сколково»: зачем Шойгу строит технополис в Анапе' [Military Skolkovo: why Shoigu is building a technopolis in Anapa], RBC News, 13 March 2018, https://www.rbc.ru/politics/13/03/2018/5a9e82869a7947860d0516ca (accessed 30 Jun. 2021); Kania, E. (2019), 'Innovation in the New Era of Chinese Military Power', The Diplomat, 25 July 2019, https://thediplomat.com/2019/07/innovation-in-the-new-era-of-chinese-military-power (accessed 30 Jun. 2021).

Among the main collaborative 'radical innovation centres' is the Advanced Research Foundation (*Fond perspektivnykh issledovanii*, ARF), created in 2012[31] and tasked with the development of civil and dual-use technologies, and the Era technopolis (technology campus), established in 2018 in Anapa, on the Black Sea coast. In contrast to the ARF, Era focuses explicitly on technology for the Russian armed forces, although the Russian authorities hope that it will also produce dual-use technologies applicable in the civilian sector. The guiding idea for the technoparks is to bring theory and practice closer together by combining scientists and experts from environments that are normally separated from each other, thus accelerating the process from invention to full implementation.[32]

The ARF's programmes, initially featuring projects dating from the Soviet era and developed by other companies, have gradually expanded to include technologies central to 4IR, with high priority being given to AI,[33] and a focus on unmanned vehicles (e.g. the Marker unmanned ground vehicle – UGV); autonomous systems and automated decision-making; superconductors (Liman); additive technology of polymetallic products (Matritsa); a full-ocean depth autonomous deep-submergence vehicle (Vityaz'-D); and ultra-thin materials for improving individual camouflage and protection (Tavolga).[34] According to the Russian defence ministry, ARF was implementing 40 innovation projects in 2020, 15 of which were launched in 2019.[35] Russia is also working on developing

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31 Фонд перспективных исследований [Advanced Research Foundation] (undated), https://fpi.gov.ru (accessed 30 Jun. 2021).
32 Ministry of Defence of the Russian Federation (2021), 'В состав технополиса «ЭРА» интегрированы три научные роты' [Three scientific companies are integrated into the ERA technopolis], 19 January 2021, https://function.mil.ru/news_page/organizations/more.htm?id=12339557@egNews (accessed 30 Jun. 2021); *Красная звезда* [*Red Star*] (2020), 'Эффективность научного поиска призвана поднять правовая основа деятельности Военного инновационного технополиса ЭРА' [The legal framework for the activities of the ERA Military Innovative Technopolis is designed to enhance the effectiveness of scientific research], 27 July 2020, http://redstar.ru/effektivnost-nauchnogo-poiska (accessed 30 Jun. 2021); Ministry of Defence of the Russian Federation (2018), 'Военный Инновационный Технополис «ЭРА» создан в соответствии с Указом Президента Российской Федерации от 25 июня 2018 г. No. 364' [Military Innovative Technopolis 'ERA' was created in accordance with the Decree of the President of the Russian Federation of June 25, 2018, No. 364], 3 May 2020, http://mil.ru/era/about.htm (accessed 30 Jun. 2021); Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
33 Putin, V. (2018), 'Послание Президента Федеральному Собранию' [Address by the President to the Federal Assembly], President of Russia/kremlin.ru, 1 March 2018, http://kremlin.ru/events/president/news/56957 (accessed 7 Jul. 2021); President of Russia/kremlin.ru (2019), 'Указ Президента Российской Федерации от 10.10.2019 No. 490' [Decree of the President of the Russian Federation of 10.10.2019 No. 490], 10 October 2019, http://www.kremlin.ru/acts/bank/44731 (accessed 7 Jul. 2021); *Военное Обозрение* [*Military Review*] (2018), 'Шойгу призвал военных и гражданских ученых объединиться для работы над искусственным интеллектом' [Shoigu urged military and civilian scientists to unite to work on artificial intelligence], 14 March 2018, https://topwar.ru/137827-shoygu-prizval-voennyh-i-grazhdanskih-uchenyh-obedinitsya-dlya-raboty-nad-iskusstvennym-intellektom.html (accessed 7 Jul. 2021). See also Nocetti, J. (2020), *The Outsider: Russia in the Race for Artificial Intelligence*, Etudes de l'Ifri, Russie.Nei.Reports, No. 34, IFRI, https://www.ifri.org/en/publications/etudes-de-lifri/russieneireports/outsider-russia-race-artificial-intelligence (accessed 7 Jul. 2021); Dear (2019), 'Will Russia Rule the World Through AI?'; and CNA's newsletter *Artificial Intelligence and Autonomy in Russia*, https://www.cna.org/centers/cna/sppp/rsp/russia-ai.
34 Фонд перспективных исследований Проекты [ARF Projects] (undated), https://fpi.gov.ru/projects; see also RIA Novosti (2020), 'ФПИ не состязается с американским DARPA, заявил замгендиректора' [FPI does not compete with the American DARPA, said the deputy director general], 5 February 2020, https://ria.ru/20200205/1564265957.html (accessed 7 Jul. 2021); RIA Novosti (2020), 'В России начались работы по созданию первой многоразовой ракеты' [In Russia, work began on the creation of the first reusable rocket], 28 February 2020, https://ria.ru/20200228/1565311556.html (accessed 7 Jul. 2021); RIA Novosti (2019), 'ФПИ: Россия может войти в пятерку лидеров по квантовым вычислениям [FPI: Russia may become one of the five leading countries in quantum computing], 29 November 2019, https://ria.ru/20191129/1561716907.html (accessed 27 Jul. 2021).
35 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].

UGVs (e.g. the Udar unmanned tank) that aim to acquire the capability to move autonomously and interact with drones.[36]

Meanwhile, the R&D at Era is organized in clusters of 14 prioritized fields: AI; small spacecraft; robotics; information security; automated control systems and IT systems; power-supply technologies and life-support machines; technical vision and pattern recognition; informatics and computer engineering; biotechnical systems and technologies; nanotechnology and nanomaterials; hydrometeorological (meteorological) and geophysical support; hydroacoustic object detection systems; military geoinformation platforms; and weapons based on new physical principles.[37] In 2019, the Russian defence ministry assessed research results, of which some of the more prominent involved telemedicine, AI for diagnostic systems, artificial neural networks, technical vision and autonomous control of unmanned aerial vehicles (UAVs).[38]

The Era's so called 'bank of ideas'[39] is to be filled by more than 100 enterprises of the military-industrial complex in joint projects[40] as well as by representatives from the main weapons manufacturers, including the Kalashnikov concern (Russia's largest manufacturer of small arms, guided artillery shells and high-precision weapons); the Sukhoi Company (a major aircraft manufacturer); and the Sozvezdie concern (Russia's leading developer and manufacturer of electronic warfare – EW – and electronic countermeasure systems). The list, which continues to expand, also includes the Hevel Group (the largest cells-to-module photovoltaic manufacturer in Europe); Niagara (a producer of supercomputers); Mikran (Russia's leading manufacturer of electronic devices); the cybersecurity company Rostelecom-Solar; SearchInform (risk-management product developers), and others.[41]

Furthermore, the Russian defence ministry has transferred to Era some of the scientific units (*nauchnye roty*) created since 2013 on the foundations of the Russian military research institutions and higher educational institutions for specific scientific and applied tasks.[42] As of March 2021, eight scientific units were operating at Era working within its R&D priority fields,[43] as well as supporting specific needs of several specialist units: the Aerospace Forces,

36 Rostec (2021), '«Удар» на автопилоте' ['Strike' on autopilot], 11 February 2021, https://rostec.ru/news/udar-na-avtopilote (accessed 7 Jul. 2021); TASS (2021), 'Робот "Удар" научится воевать на автопилоте и взаимодействовать с дронами' [The 'Strike' robot will learn to fight on autopilot and interact with drones], 11 February 2021, https://tass.ru/armiya-i-opk/10672669 (accessed 7 Jul. 2021).
37 Era Technopolis (undated), https://www.era-tehnopolis.ru.
38 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
39 Ministry of Defence of the Russian Federation (2021), 'В состав технополиса «ЭРА» интегрированы три научные роты' [Three scientific companies are integrated into the ERA technopolis].
40 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
41 Ministry of Defence of the Russian Federation (2021), 'В военном инновационном технополисе «ЭРА» прошло первое межвидовое совещание' [The first joint meeting was held in the military innovation technopolis 'ERA'], 30 January 2021, https://function.mil.ru/news_page/organizations/more.htm?id=12341486@egNews (accessed 7 Jul. 2021); For Era's partners, see https://era-tehnopolis.ru/partners.
42 Ministry of Defence of the Russian Federation (2016), 'Около 400 новобранцев весеннего призыва отобраны для службы в научных ротах' [About 400 spring draft recruits selected to serve in scientific companies], 7 July 2016, https://function.mil.ru/news_page/country/more.htm?id=12089407@egNews (accessed 7 Jul. 2021).
43 Ministry of Defence of the Russian Federation (undated), 'Научные роты' [Scientific companies], https://recrut.mil.ru/for_recruits/research_company/companies.htm; Era Technopolis (undated), 'Научные Роты: Элита российской армии' [Scientific companies: the Elite of the Russian Army], https://www.era-tehnopolis.ru/education.

the 12th Main Directorate of the Russian defence ministry,[44] the Military Topographic Directorate of the General Staff, the Hydrometeorological Service of the Russian Armed Forces, and the defence ministry's Main Directorate of Research and Technological Support of Advanced Technologies (Innovative Research) (GUNID).[45]

Russia has been also connecting the Era technopolis in joint projects with universities and research institutes,[46] including Russia's largest interdisciplinary laboratory, the Kurchatov Institute. The institute hosts nuclear physics facilities and focuses on next-generation nuclear power, on information technology (IT), nanotechnology, biotechnology, cognitive technology and other cutting-edge technologies. Kurchatov's president, Mikhail Kovalchuk, is responsible for the general management of research at Era, while specialized bodies of the military administration are responsible for the scientific leadership of research.[47] Era is managed by a council headed by Deputy Prime Minister and former deputy minister of defence Yury Borisov. The council consists of representatives of the defence ministry, national and local government, heads of state corporations, leading educational and scientific organizations including the Kurchatov Institute, and the ARF.[48]

R&D activity at Era is coordinated by GUNID, the Russian defence ministry's Main Directorate of Research and Technological Support of Advanced Technologies (Innovative Research),[49] although innovation is a relatively new field of work for the ministry.[50] GUNID was created to organize and support the development and implementation of advanced R&D programmes and scientific projects, and to foster the conditions favourable to creating advanced weapons, and military and special equipment.[51] The early stages of the innovation were marked by some accidental decisions that lacked a strategic direction and efficient management. For instance, the former head of GUNID, Colonel Vyacheslav Presnukhin, argued in 2014 that domestic industry had initially created a large

44 The 12th Main Directorate is responsible for the safety, diagnostics, storage, maintenance, and transfer of nuclear warheads from national-level to base-level storage facilities and combat units. See Podvig, P. and Serrat, J. (2017), *Lock them Up: Zero-deployed Non-strategic Nuclear Weapons in Europe*, United Nations Institute for Disarmament Research, pp. 18–9, https://unidir.org/publication/lock-them-zero-deployed-non-strategic-nuclear-weapons-europe (accessed 7 Jul. 2021).
45 Ministry of Defence of the Russian Federation (2021), 'В состав технополиса «ЭРА» интегрированы три научные роты' [Three scientific companies are integrated into the ERA technopolis].
46 A total of 12 academic institutions were thus connected to Era as of March 2021.
47 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
48 Ibid.
49 Ministry of Defence of the Russian Federation (undated), 'Главное управление научно-исследовательской деятельности и технологического сопровождения передовых технологий (инновационных исследований) Министерства обороны Российской Федерации' [Main Directorate of Research Activities and Technological Support of Advanced Technologies (Innovative Research) of the Ministry of Defence of the Russian Federation], https://structure.mil.ru/structure/ministry_of_defence/details.htm?id=11376@egOrganization.
50 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
51 Interview with Colonel Vyacheslav Presnukhin, Head of the Main Directorate of Research and Technological Support of Advanced Technologies (Innovative Research) of the Russian Ministry of Defence; Koshukov, I. (2014), 'Инновации на службе Министерства обороны' [Innovation at the service of the Ministry of Defence], Национальная оборона [National Defence], 19 September 2014, https://oborona.ru/includes/periodics/armedforces/2014/0919/193114105/detail.shtml (accessed 7 Jul. 2021).

number of robotic systems that were developed without taking into account the actual needs and requirements of the various services within the Russian armed forces,[52] hence the products were largely useless and needs remained unmet.

To solve the problem, the current head of GUNID, Major-General Andrey Goncharov, reports that GUNID established cooperation and communication channels with the military commands to collect information on their requirements and thus to ensure that innovation projects corresponded with the needs of the armed forces. To this end, representatives of GUNID take part in exercises and in the experimentation and testing phase of the various projects, involving different types of weapons and of military and special equipment.[53] Such experiments can focus on specific branches of the Russian armed forces. For instance, one experiment conducted in 2020 focused on the possibility of rapidly building a deployable underwater lighting system aimed at combating small-sized targets, such as unmanned underwater vehicles (UUVs) and underwater saboteurs, with the use of UUVs, hydroacoustic stations and UAVs as transmitters of control signals and information.[54]

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According to Major-General Goncharov, GUNID has developed an extensive cooperation framework involving, in addition to Era, more than 1,200 entities, including industrial parks, engineering centres, various technological development platforms, financial development institutions and leading Russian universities and research institutes, including the Russian Academy of Sciences.[55] The Commission for Innovative Projects and Technologies at the defence ministry manages the implementation of advanced military and dual-purpose technologies. According to official sources, it assessed 120 projects in 2019, of which 42 were approved for implementation.[56]

52 Koshukov (2014), 'Инновации на службе Министерства обороны' [Innovation at the service of the Ministry of Defence].
53 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
54 VPK (2020), 'Андрей Гончаров доложил о результатах работы Комиссии по инновационным проектам в 2020 году' [Andrey Goncharov reported on the results of the work of the Commission on Innovative Projects in 2020], 27 November 2020, https://vpk.name/news/466091_andrei_goncharov_dolozhil_o_rezultatah_raboty_komissii_po_innovacionnym_proektam_v_2020_godu.html (accessed 7 Jul. 2021).
55 Ibid.
56 Ibid.

Another of GUNID's key tasks is to conduct the constant monitoring and documenting of innovative technologies, both in Russia and abroad,[57] not least those that could undermine national security. An additional tool for monitoring developments in new and breakthrough technologies is the annual ARMY International Military-Technical Forum, providing an arena for presenting the most advanced innovative technologies.[58]

Impediments and future prospects

Over the past decade, Russia has developed an extensive – and still growing – defence R&D network of collaborating platforms, involving the armed forces and civilian state and private actors. To what extent this widespread, dense, and centrally coordinated top-down network will provide a successful breeding ground for innovation is yet to be seen. Another aspect that merits further observation is to what extent the Russian defence ministry will manage to maintain an overview of and successfully coordinate this vast range of military and civilian entities. Correspondingly, the question arises as to whether the Russian government has drawn conclusions from the less than impressive results of the Skolkovo innovation centre created in 2009, promoted as the Russian Silicon Valley and based on a model of a public–private consortium.

The pace of development of various Russian defence innovation projects, examined in more detail in subsequent chapters of this research paper, varies from experimentation to testing and implementation in the structure of the Russian armed forces in a number of cases. Compared to the scope of the development in the US and China, however, Russia lags behind their advances for several reasons.

One of them is decline in innovation in Russia generally. Its basic indicators – such as the level of innovation activity – have been stagnating. Over the period 2013–16, Russia managed to significantly improve its standing in the Global Innovation Index, rising from 62nd to 43rd place.[59] However, the upward trend proved short-lived, and in 2017 Russia dropped down the rankings to 45th place, falling further to 46th place in 2018–19 and to 47th in 2020.[60] According to Leonid Gokhberg, director of the Institute for Statistical Studies and Economics of Knowledge at the Higher School of Economics in Moscow (and member of the International Advisory Board of the Global Innovation Index), in a healthy and efficient economy, innovative activity is the main strategy by which enterprises

57 Ministry of Defence of the Russian Federation (undated), 'Выдержка из Положения о Главном управлении научно-исследовательской деятельности и технологического сопровождения передовых технологий (инновационных исследований) Министерства обороны Российской Федерации' [Excerpt from the Provisions on the Main Directorate of Research Activities and Technological Support of Advanced Technologies (Innovative Research) of the Ministry of Defence of the Russian Federation], https://doc.mil.ru/documents/quick_search/more.htm?id=11919505@egNPA (accessed 27 Feb. 2021).
58 Goncharov (2020), 'Особенности организации инновационной деятельности в Минобороны России' [Characteristics of the organization of innovation activities in the Ministry of Defence of Russia].
59 Bateneva, T. (2020), 'Топчемся на месте: Результаты инновационной деятельности в России ниже ожидаемых' [Marking in place: The results of innovation performance in Russia are lower than expected], *Российская газета* [*Russian Newspaper*], 30 November 2020, https://rg.ru/2020/11/30/rezultaty-innovacionnoj-deiatelnosti-v-rossii-okazalis-nizhe-ozhidaniia.html (accessed 7 Jul. 2021).
60 Global Innovation Index (2020), 'Analysis', https://www.globalinnovationindex.org/analysis-indicator (accessed 7 Jul. 2021).

can achieve success. However, specific changes in market conditions, the level of competition, and the quality of regulation may lead to a negative trend where only a small number of enterprises rely on innovation as a driver of development.[61] In Gokhberg's view, the stagnation of innovation in Russia has resulted less from insufficient funding and resources than from inefficiency in using the resources that are already available. Among impediments are an unfavourable business climate and the poor quality of regulations hampering development.

Yet another constraint is the low productivity of labour in Russia, which is among the lowest in the world's major economies,[62] and the high share of the state sector in the Russian economy, which has increased systematically during the 2000s. Other systemic problems involve corruption, political pressure, the weak rule of law, the poor enforcement of intellectual property rights, and heavy bureaucratic control, in addition to development trends in education that do not provide a solid basis for high-tech development.[63] There are also indications that 'brain drain' risks becoming an increasing problem in the future.[64]

Furthermore, Western sanctions in the wake of Russia's 2014 annexation of Crimea have imposed limitations on Russian modernization projects and slowed down progress in selected areas.[65] The Russian military-industrial complex also struggles with shortages of professional expertise.[66]

Russia is attempting to solve the latter problem in several ways. The scientific companies at the Era campus are to provide a base for training and developing the new generation of highly qualified professionals needed in the defence sector. After the end of their military service, many of the servicepeople of the scientific units choose to continue their research work at institutes connected to the defence ministry, including at Era.[67] While this development is favourable and may help alleviate the problem, it is unlikely to provide a solution to the aforementioned systemic deficiencies.

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61 Bateneva (2020), 'Топчемся на месте: Результаты инновационной деятельности в России ниже ожидаемых' [Marking in place: The results of innovation performance in Russia are lower than expected].
62 See OECD (undated), 'Level of GDP per capita and productivity', https://stats.oecd.org/Index.aspx?DataSetCode=PDB_LV# (accessed 7 Jul. 2021); Vaisburd, V. A. et al. (2016), 'Productivity of Labour and Salaries in Russia: Problems and Solutions', *International Journal of Economics and Financial Issues*, 6(S5), pp. 157–65, https://www.econjournals.com/index.php/ijefi/article/view/2882 (accessed 7 Jul. 2021).
63 Zysk (2020), 'Defence innovation and the 4th industrial revolution in Russia'. Under one per cent of graduating Russians earned their degree in IT, communication or other forms of technology: Dear (2019), 'Will Russia Rule the World Through AI?', pp. 43–4.
64 A poll on emigration sentiments conducted in 2019 by the Yury Levada Analytical Center found that 53 per cent of Russians between the ages of 18 and 24 years expressed a desire to move abroad on a permanent basis. Levada Center (2019), 'Эмиграционные Настроения' [Emigration Sentiments], 26 November 2019, https://www.levada.ru/2019/11/26/emigratsionnye-nastroeniya-4 (accessed 7 Jul. 2021).
65 See, for instance, Luzin, P. (2020), 'Sanctions and the Russian defence industry', *Riddle*, 30 October 2020, https://www.ridl.io/en/sanctions-and-the-russian-defence-industry (accessed 7 Jul. 2021); Gressel, G. (2020), 'The sanctions straitjacket on Russia's defence sector', European Council on Foreign Relations, 13 February 2020, https://ecfr.eu/article/commentary_the_sanctions_straitjacket_on_russias_defence_sector (accessed 7 Jul. 2021); Connolly, R. and Boulègue, M. (2018), *Russia's New State Armament Programme: Implications for the Russian Armed Forces and Military Capabilities to 2027*, Chatham House Report, London: Royal Institute of International Affairs, https://www.chathamhouse.org/sites/default/files/publications/research/2018-05-10-russia-state-armament-programme-connolly-boulegue-final.pdf (accessed 7 Jul. 2021); Zysk (2020), 'Defence innovation and the 4th industrial revolution in Russia'.
66 Tsvetkov, Prof. V. A. (2016), *Оборонно-промышленный комплекс России: проблемы и перспективы развития* [*The Russian military-industrial complex: problems and development prospects*], abridged report of lecture given to the Second Conference 'The Economic Potential of Industry in the Service of the Military-Industrial Complex', Moscow, 9–10 November 2016, Financial University Under the Government of the Russian Federation, http://www.ipr-ras.ru/old_site/appearances/tsvetkov-opcconf-2016.pdf (accessed 7 Mar. 2021).
67 Koshukov (2014), 'Инновации на службе Министерства обороны' [Innovation at the service of the Ministry of Defence]; Ministry of Defence of the Russian Federation (2021), 'В состав технополиса «ЭРА» интегрированы три научные роты' [Three scientific companies are integrated into the ERA technopolis].

Conclusions

Russia has managed to stem the decline in its innovatory activities and partially rebuild its innovation capability by setting up advanced technological development programmes. To date, the innovation pathways followed by Russia's R&D have been characterized by incremental change, leading to a gradual evolution rather than a revolutionary change in the character of Russian warfare.[68] Russia has been integrating some of the novel technologies into its established weapons systems, including nuclear and non-nuclear strategic weapons, general-purpose forces, and asymmetric non-military methods and means. For instance, AI is being introduced in robotic systems, in command and control, and in situational awareness infrastructure to increase the precision and speed of information collection and decision-making; and UUVs, UAVs and UGVs are adopted to enhance nuclear and non-nuclear missions.[69] The systems enhanced with 4IR technologies do not immediately change the strategic and operational landscape in a radical way. Nonetheless, they constitute an improvement to the existing Russian weapons systems and infrastructure, and have the potential to provide Russia with an advantage on the battlefield.

Many of the key Russian defence innovation programmes resemble 4IR projects being pursued by the US, and are a response to the perceived vulnerabilities created by asymmetry of power, especially in the conventional field. However, it would be misleading to assume that Russian defence innovation will continue to simply mirror and react to the development trajectory pursued by its perceived competitors. Indeed, Russia may take a diverging path in the course of the experimental phase, and develop novel technologies and weapons systems, as well as the means and methods to apply them.

Furthermore, technological innovation is an ongoing process, and especially in the field of breakthrough technologies it may as per definition become non-linear and disruptive, with implications that are hard to predict, especially in the initial phases of the development of the various projects. Importantly, Russia has demonstrated a willingness and an ability to take risks and to experiment with the potential of new technologies, which are important qualities in innovation.[70] Although Russian defence development has so far been predominantly a continuation of the previous modernization effort, it also carries the hallmarks of a potentially disruptive shift in warfare. This concerns in particular the field of human–machine interactions and autonomy, within which AI and algorithms are likely to increasingly shape human decision-making.

Some aspects of this development are already affecting regional stability, forcing the NATO alliance and the US to take additional measures to maintain a credible deterrence. One example is hypersonic technology, which could have

68 Zysk (2020), 'Defence innovation and the 4th industrial revolution in Russia'.
69 See, for instance, Shpikerman, V. (2020), 'Робот тебе поможет: Искусственный интеллект встанет на страже наших морей' [The robot will help you: Artificial intelligence will guard our seas], *Военно- промышленный курьер* [*The Military-Industrial Courier*], 24 June 2020, https://www.vpk-news.ru/articles/57500 (accessed 7 Jul. 2021); Khvostik, E. (2020), 'У военных развился искусственный интеллект: Боевое применение полноценных систем ИИ стало реальностью' [The military has developed artificial intelligence: Combat use of full-fledged AI systems has become a reality], Kommersant, 23 December 2020, https://www.kommersant.ru/doc/4627092 (accessed 7 Jul. 2021).
70 Zysk (2020), 'Defence innovation and the 4th industrial revolution in Russia'.

a destabilizing impact on nuclear security. This is due in part to a significant challenge with identification of their targets and warheads, given these missiles are developed as dual-capable. Their high manoeuvrability and the likelihood that they may approach targets from unpredictable trajectories may lead them to pose a challenge to crisis stability, taking into account the likely prohibitively high cost of defending against them, potentially increasing the likelihood of offence dominance in a conventional strike.[71] This may also create problems of arms-race instability, with a negative impact on strategic stability.[72] Yet certain qualities of hypersonic weapons may be overestimated, since they do not travel faster than existing ballistic missiles and are detectable for most of their flight paths by conventional means.[73] Still, even if Russian hypersonic cruise missiles do not fundamentally change the strategic and operational landscape today, they constitute an improvement to existing weapons systems and create new challenges.

Similarly, the AI-driven RMA has a range of implications for international security, with the potential to galvanize new phases of arms competition across the world,[74] a development that is of concern also to the Russian leadership.[75] The question is to what extent Russia will be able to keep up with developments in terms of overcoming systematic limitations, budgetary and other resource allocation, and achieve the necessary organizational flexibility in order to adapt doctrines and operational concepts – and thus take advantage of technological gains. Another important factor will be Russia's perceptions – and potential misperceptions – of advantages the AI-driven RMA may yield to its adversaries. Moscow's choice of symmetric and asymmetric responses to this development will have implications for its force structure, education, recruitment patterns and operations, and more broadly for the domains in which the Russian armed forces will be set to operate.

71 Ibid.
72 Ibid.
73 Tracy, C. L. and Wright, D. (2020), 'Modelling the Performance of Hypersonic Boost-Glide Missiles', *Science & Global Security,* 28(3): pp. 135–70, https://doi.org/10.1080/08929882.2020.1864945 (accessed 7 Jul. 2021).
74 Raska (2020), 'The sixth RMA wave: Disruption in Military Affairs?'.
75 President of Russia/kremlin.ru (2019), 'Указ Президента Российской Федерации от 10.10.2019 No. 490' [Decree of the President of the Russian Federation of 10.10.2019 No. 490]; *Военное Обозрение* [*Military Review*] (2018), 'Шойгу призвал военных и гражданских ученых объединиться для работы над искусственным интеллектом' [Shoigu urged military and civilian scientists to unite to work on artificial intelligence]; Putin (2018), 'Послание Президента Федеральному Собранию' [Address by the President to the Federal Assembly].

03 Putin’s ‘super weapons’

Newly-unveiled ‘super weapons’ signal Russia's willingness to produce innovative solutions to emerging military threats. These offer insights into both Russia’s defence-industrial capabilities and the challenges they pose for NATO and its allies.

Richard Connolly
Director, Eastern Advisory Group and Associate Fellow, Royal United Services Institute (RUSI)

In his address to the Federal Assembly in March 2018,[76] Russian President Vladimir Putin revealed the existence of five major nuclear-capable weapons programmes. Dubbed Putin’s *superoruzhie* (‘super weapons’), these new systems signalled Russia’s determination to produce innovative solutions to emerging military threats, principally those emanating from the US. Four of the systems unveiled by Putin can be described as strategic in so far as they are all long-range weapons (i.e. possessing a range greater than 5,000 km). Only one of the ‘super weapons’ – the Kinzhal – is a sub-strategic system (i.e. with a range of less than 5,000 km). However, at around the same time as Putin’s announcement, more details emerged of another novel sub-strategic system, the Tsirkon hypersonic ship-launched missile.

This chapter examines the development of the six new Russian weapons systems. The first section provides a brief description of each of the systems, and the second examines how each of these systems might be expected to be used by the Russian military. The third section examines what the ‘super weapon’ programmes tell observers about Russian defence-industrial capabilities. The final section considers what these developments might mean for the US and its allies.

76 Putin, V. (2018), ‘Послание Президента Федеральному Собранию’ [Address of the President to the Federal Assembly], President of Russia/kremlin.ru, 1 March 2018, http://kremlin.ru/events/president/news/56957.

The 'super weapons'

Sarmat

The inclusion of the RS-28 Sarmat intercontinental ballistic missile (ICBM) (NATO reporting name SS-X-29 or SS-X-30) in Putin's speech in 2018 was no surprise to analysts. The super-heavy, liquid-fuelled ICBM has been under development by the Makeyev Rocket Design Bureau since 2009. The Sarmat is expected to replace the Soviet-era RS-36M Voevoda (SS-18 'Satan') in the Uzhurskaya and Dombarovskaya divisions of the Strategic Missile Forces of the Russian Federation (RVSN).[77] Successful launch tests were carried out in 2020 and by February 2021 preparations were under way for flight tests[78] at the Severo-Yenisei test site. According to the commander of the Strategic Missile Forces, Colonel-General Sergey Karakaev, the new missile should enter service in 2022 with the 62nd Missile Division based at Uzhur (Krasnoyarsk region), where the construction of new facilities to house the missile is under way.[79]

The Sarmat should perform much the same functions as the RS-36M it is envisaged to replace. It will be much larger than other Russian ICBMs, such as the RS-24 Yars (SS-29), as well as their US counterparts. It should be capable of carrying a range of different payloads, including a mixture of re-entry vehicles and decoys to overcome ballistic missile defences. The most notable differences between the Sarmat and its predecessors are its claimed long range (reportedly up to 18,000 km) and its ability to attack via a fractional orbit to approach targets, raising the possibility of it being able to approach the US via the South Pole, thereby bypassing existing missile detection and defence systems. The Sarmat may also carry the Avangard hypersonic glide vehicle (HGV) in the future.[80]

Avangard

The Avangard missile system combines the old and the new: the old in the form of a Soviet-era RS18A (SS-19 'Stiletto') ICBM, and the new in the form of the Yu-71 HGV. The Avangard system emerged after the Soviet-era Albatross research project to develop an HGV was resurrected following the US withdrawal from the Anti-Ballistic Missile (ABM) Treaty in 2002. After a number of unsuccessful tests during the 2010s, several successful tests took place over the course of 2015–16. The most recent test took place in December 2018 after President Putin's 'super

77 Interfax (2020), 'Рогозин ожидает скорого принятия на вооружение межконтинентальной ракеты 'Сармат' [Rogozin anticipates that the 'Sarmat' ICBM will soon be accepted into service], 10 August 2020, https://www.militarynews.ru/story.asp?rid=0&nid=536077&lang=RU (accessed 7 Jul. 2021).
78 Kornev, D. (2021), '«Посейдон» в помощь: начинаются испытания стратегического оружия РФ' ['Poseidon' to help: testing of strategic weapons of the Russian Federation begins], *Izvestiya*, 7 February 2021, https://iz.ru/1121208/dmitrii-kornev/poseidon-v-pomoshch-nachinaiutsia-ispytaniia-strategicheskogo-oruzhiia-rf (accessed 7 Jul. 2021).
79 Tikhonov, A. (2019), 'Ядерный щит высочайшей надёжности' [A nuclear shield of the highest reliability], *Красная звезда* [*Red Star*], 16 December 2019, http://redstar.ru/yadernyj-shhit-vysochajshej-nadyozhnosti (accessed 10 September 2021).
80 Safronov, I. and Nikolsky, A. (2019), 'Испытания новейшей российской ядерной ракеты стартуют в начале года' [Tests of the newest Russian nuclear missile start at the beginning of the year], *Vedomosti*, 30 October 2019, https://www.vedomosti.ru/politics/articles/2019/10/29/815013-letnie-ispitaniya-sarmat (accessed 7 Jul. 2021).

weapons' announcement in March of that year.[81] The first two Avangard systems were placed on active duty at the end of 2019.[82] Russian officials have also expressed the hope that enough Avangard systems will be produced to fully equip two missile regiments (approximately 18–20 missiles in total) by the end of the GPV 2027 state armament programme.[83]

The novelty of the Avangard lies in the fact that it does not, like conventional ICBM re-entry vehicles, follow a ballistic trajectory outside the earth's atmosphere for the majority of its flight. Instead, the HGV spends most of its journey travelling at high speed in the upper atmosphere. While the hypersonic aspect of the Avangard is often emphasized by commentators, it does not in fact travel as fast as a conventional ballistic missile. The operational utility of the system is instead derived from its ability to manoeuvre while in the atmosphere, enabling it to evade interception by existing missile defence systems.

Poseidon

The existence of the Poseidon nuclear-armed, unmanned underwater vehicle (UUV) was first revealed publicly in November 2015, when broad details became available after photographs were taken of programme schematics in a Ministry of Defence meeting. Initially known as the 'Oceanic Multipurpose System Status-6' – or simply as 'Status-6' – it was characterized as a large, autonomous (i.e. crewless) and fast (i.e. with a reported speed of around 70 knots) nuclear-tipped torpedo. After the system was renamed as the Poseidon in 2018 by a public poll, Putin and other defence officials steadily revealed more information about both the system and its intended role. According to Putin, the Poseidon is a multipurpose UUV that 'can carry either conventional or nuclear warheads, which enables them to engage various targets, including aircraft [carrier] groups, coastal fortifications and infrastructure'.[84] It is also powered by a miniature nuclear reactor, giving it an unlimited range (in practical terms).[85] The Poseidon is also reported to be capable of diving to depths of up to 1 km, rendering it safe from existing manned submarines.

The first Poseidon weapons will be carried and launched by the K-329 Belgorod nuclear-powered submarine, currently under construction at Russia's vast Sevmash shipyard in Severodvinsk that specializes in the construction of nuclear-powered

81 TASS (2020), '"Авангард" доказали его способность разгоняться до 27 Махов' [Borisov: tests of the Avangard complex have proven its ability to accelerate to Mach 27]', 27 December 2018, https://tass.ru/armiya-i-opk/5958896 (accessed 7 Jul. 2021).
82 *Izvestiya* (2019), 'Первый полк «Авангарда» заступил на боевое дежурство' [The first Avangard regiment took up combat duty], 27 December 2019, https://iz.ru/959126/2019-12-27/shoigu-dolozhil-putinu-o-postanovke-na-boevoi-dezhurstvo-avangarda (accessed 7 Jul. 2021).
83 TASS (2020), 'Источник: первый полк 'Авангардов' доведут до полного состава в 2021 году' [Source: the first Avangard regiment will be brought to full strength in 2021], 23 December 2020, https://tass.ru/armiya-i-opk/10329229 (accessed 7 Jul. 2021).
84 Putin (2018), 'Послание Президента Федеральному Собранию' [Address of the President to the Federal Assembly].
85 Lavrov, A. and Ramm, A. (2021), '«Посейдон» в лодке: субмарину готовят к испытаниям ядерных роботов' ['Poseidon' in a boat: the submarine is being prepared for testing nuclear robots], *Izvestiya*, 11 February 2021, https://iz.ru/1123160/anton-lavrov-aleksei-ramm/poseidon-v-lodke-submarinu-gotoviat-k-ispytaniiam-iadernykh-robotov (accessed 7 Jul. 2021).

submarines. The Belgorod was scheduled to begin sea trials in 2021.[86] Further vessels are expected to be built over the course of the decade, with the Northern and Pacific Fleets each envisaged to eventually receive two vessels capable of launching the Poseidon.[87]

The Poseidon may be capable of performing several functions beyond assuring a nuclear second-strike capability. According to Dara Massicot and Edward Geist, alternative roles might include serving as a test bed for nuclear-powered UUV technologies, enabling the Russian navy to develop systems that could 'easily outrun the fastest manned submarines and stay at sea for months or even years'.[88] If sufficient advances are made in the development of artificial intelligence (AI) or underwater communications, the Poseidon has the potential to 'inaugurate an ominous new era of autonomous undersea warfare'.[89]

Burevestnik

Of the four strategic systems unveiled by Putin in 2018, the least is known about the 9M730 Burevestnik [Petrel] (SSC-X-9 'Skyfall') ground-launched, nuclear-powered cruise missile. When Putin publicly revealed the programme in 2018, he stated that the novelty and operational utility of the Burevestnik is in its unlimited (in practical terms) range, which would enable the missile to evade any adversary's air defence systems. The missile might also be much more difficult to detect, principally because its unlimited range would permit it to fly at low altitudes throughout its journey.[90] By contrast, the range of other, conventionally-powered, cruise missiles – such as those included in both the US-made Tomahawk and Russian-made Kalibr families of missiles, which are powered by turbojets or turbofans – is curtailed, the longer that they fly at low altitudes.

If Russia has successfully developed a nuclear-powered cruise missile, it will be the first of its kind in the world.

The technical barriers to attaining such a capability are, however, considerable. If Russia has successfully developed a nuclear-powered cruise missile, it will be the first of its kind in the world. Because of the considerable engineering

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86 Kornev (2021), '«Посейдон» в помощь: начинаются испытания стратегического оружия РФ' ['Poseidon' to help: testing of strategic weapons of the Russian Federation begins].
87 TASS (2019), 'Russian Navy to put over 30 Poseidon strategic underwater drones on combat duty – source', 12 January 2019, https://tass.com/defense/1039603 (accessed 7 Jul. 2021).
88 Massicot, D. and Geist, E. (2019), 'Understanding Putin's Nuclear 'Superweapons'', *SAIS Review of International Affairs*, 39(2): pp. 103–17, doi:10.1353/sais.2019.0019 (accessed 7 Jul. 2021).
89 Ibid.
90 Ketenov, S. (2020). '«Буревестник» на заклание: Нет смысла продлевать СНВ-3 ценой отказа от самого перспективного оружия' ['Petrel' to the slaughter: There is no point in extending START-3 at the cost of giving up the most promising weapon], *Военно-промышленный курьер* [*Military-Industrial Courier*], 7 December 2021, https://www.vpk-news.ru/articles/59856 (accessed 8 Jul. 2021).

challenges associated with building a miniaturized nuclear propulsion unit, it is possible that serious obstacles have been encountered since the suspected accident at the Nyonoksa naval missile test range in August 2019.[91]

Kinzhal

The 9-S-7760 Kinzhal [Dagger] air-launched ballistic missile (ALBM) was the only sub-strategic system unveiled by Putin in 2018. It is a modified variant of the 9M723 Iskander ground-launched ballistic missile, but is launched by the MiG-31K missile carrier – a modified version of the MiG-31 Foxhound interceptor. The MiG-31K is used to launch the missile at high (i.e. supersonic) speed, thereby boosting the speed of the Kinzhal. The Kinzhal, therefore, like the Iskander, follows an aero-ballistic flight profile. According to Putin, the Kinzhal eventually reaches a speed of Mach 10 and is capable of manoeuvring throughout all phases of its flight trajectory.[92] It is reported to possess a range of around 2,000 km from the point of release from the MiG-31K. It has also been reported that the Kinzhal will be launched from the supersonic Tu-22M3M Backfire bomber that is under development and, further in the future, the Su-57 Felon fifth-generation fighter aircraft.

The Kinzhal differs from the strategic systems described above both in range and in likely mission. As a theatre weapon, it is capable of being fitted with both nuclear and conventional warheads, and therefore of being used in a broader range of missions. Russian media reports have suggested that the Kinzhal would be used for anti-ship missions, as well as strikes on US ballistic missile defence facilities. It is also plausible that it was designed to attack time-sensitive or other high-value targets at intermediate range without violating the now-defunct Intermediate-Range Nuclear Forces (INF) Treaty (which prohibited the deployment of ground-launched intermediate-range ballistic missiles). Several recently-published journal articles by Russian military scholars have mentioned other possible roles for the Kinzhal. These include non-nuclear strategic deterrence (as well as 'signalling' missions before the nuclear threshold is crossed),[93] or serving as a tool to disrupt multi-domain operations by the enemy through pre-emptive strikes at the infrastructure critical for such operations (e.g. airfields).[94]

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91 Belyanitsov, K (2019) 'Взрыв в Нёноксе укрепил веру США в «Буревестник»' [The explosion at Nyonoska has strengthened US faith in the 'Petrel'], Kommersant, 13 August 2019, https://www.kommersant.ru/doc/4060305 (accessed 10 September 2021).
92 Putin (2018), 'Послание Президента Федеральному Собранию' [Address of the President to the Federal Assembly].
93 Yevsyukov, A. V. and Khryapin, A. L. (2020), 'Роль Новых Систем Стратегических Вооружений В Обеспечении Стратегического Сдерживания' [The role of new strategic weapons systems in providing strategic deterrence], *Военная мысль* [*Military Thought*], No. 12, pp. 26–30, December 2020, https://vm.ric.mil.ru/upload/site178/AMIei6v9c7.pdf (accessed 8 Jul. 2021).
94 Stuchinskij, V. I. and Korolkov, M. V. (2020), 'Обоснование применения авиационного боя для срыва комплексного массированного авиаудара в многопрофильной операции противника' [The aviation battle application justification to disrupt an integrated massive air strike in the enemy multi-sphere operation], *Воздушно-космические силы: Теория и практика* [*Aerospace Forces, Theory and Practice*], 6: pp. 29–36, http://xn----7sbajajhyox3duj.xn--p1ai/images/docs/vks/16-2020/29-36.pdf (accessed 10 September 2021).

Tsirkon

The 3M22 Tsirkon [Zircon] (SS-N-33) ship-launched hypersonic anti-ship missile was not mentioned by Putin in his 2018 address to the Federal Assembly, although details of the programme were revealed soon afterwards. As with the Kinzhal, it is likely that the Tsirkon is a dual-capable system that is designed to strike high-value targets on land and at sea, such as carrier air groups. Available information suggests that it is a hypersonic missile, but at the 'low hypersonic' end of the speed range, with the highest announced speed being Mach 9.[95] The Tsirkon is reported to be capable of hitting targets at a range of 500–1,000 km, although tests have so far been confined to distances of 450 km against land and sea surface targets, with reported top speeds of around Mach 7.

Developed by the Mashinostroyeniya NPO (design and engineering bureau), part of the Tactical Missiles Corporation JSC (joint stock company), the Tsirkon is likely to comprise two elements. A solid fuel booster (possibly two-stage) is used for the first part of its flight, taking the missile from the point of launch to a high altitude (potentially exoatmospheric) from where it follows a semi-ballistic 'skip-glide' trajectory towards its target. Once the target is within range, a detachable warhead – perhaps with its own engine to maintain terminal speed – is used to destroy the target, either with a warhead or with kinetic energy. A similar two-stage concept is employed with the 3M54/3M54E anti-ship cruise missiles of the Kalibr family.[96] In this respect, it is unlikely that the Tsirkon is a 'pure' hypersonic cruise missile (i.e. one that uses a scramjet for the entirety of its flight profile). Instead, it is more likely to be an aero-ballistic missile, like the Kinzhal. So far, the Tsirkon has only been tested in launches from the *Admiral Gorshkov* frigate.[97] It has been suggested that the missile will be tested from Yasen M-class nuclear-powered guided missile submarines in the future.[98]

What does the Russian military want to achieve with these weapons?

It is likely that each of the different 'super weapons' will have been designed to perform distinct functions. Precisely what those functions are, though, remains unclear.

The purpose of the four main strategic systems is perhaps easiest to divine. Maintaining strategic nuclear forces that can deliver assured retaliation – that would cause unacceptable damage to any adversary – is of paramount importance to policymakers in Moscow. As a result, considerable effort has been made in

95 Putin, V. (2019), 'Presidential Address to Federal Assembly', President of Russia/kremlin.ru, 20 February 2019, http://en.kremlin.ru/events/president/news/59863 (accessed 8 Jul. 2021).
96 Ракетная техника [Rocket Technology] (2021), 'Противокорабельная ракета 3М-54Э/3М-54Э1 [Anti-ship missile 3M-54E/3M-54E1]', https://missilery.info/missile/3m54e1 (accessed 8 Jul. 2021).
97 TASS (2020), 'Источник: гиперзвуковую ракету 'Циркон' впервые испытали с корабля' [Source: 'Zircon' hypersonic missile first tested from ship], 27 February 2020, https://tass.ru/armiya-i-opk/7847853 (accessed 8 Jul. 2021).
98 TASS (2020), 'Подлодки Северного флота проведут стрельбы гиперзвуковыми ракетами' [Northern Fleet submarines to fire hypersonic missiles], 19 March 2020, https://tass.ru/armiya-i-opk/8031533 (accessed 8 Jul. 2021).

modernizing Russia's strategic nuclear delivery systems over the past decade. The need to upgrade Russia's strategic arsenal – both now and in the future – is motivated by two fears. First, that Russia's Soviet-era weapons might not be able to guarantee penetration of emerging US missile defence systems that were, according to Putin, designed 'primarily for countering strategic arms that follow ballistic trajectories'.[99] Second, US efforts to develop long-range precision conventional weapons, such as the Prompt Global Strike programme, generated growing concern in Moscow over the survivability of Russia's strategic arsenal.

The development of novel strategic systems is therefore seen as vital to ensuring Russia's ability to penetrate current and future US missile defence systems (as well as those of other potential adversaries) and to guarantee a second-strike capability for the foreseeable future. The 'super weapons' revealed by Putin in 2018 are not first-strike weapons – with the sole exception of the Sarmat, which will replace the existing SS-18. The relatively wide range of systems under development suggests that Russian officials view a diverse range of capabilities as a crucial component of successful nuclear deterrence.

A second potential reason for developing new strategic systems might be that they could be traded away in future strategic arms negotiations. The extension of the New START Treaty in February 2021 (to February 2026) means that there is now a five-year window in which both sides can seek a better negotiating position for any prospective successor treaty. Some of the 'super weapons' – especially those that remain at the development stage and that have uncertain prospects for success, such as the Burevestnik or Poseidon – could therefore be sacrificed before they even enter service, if doing so would deliver concessions from the US in other areas.

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While much of the political and military planning in Russia is focused on seeking a balance of power in strategic nuclear systems, the development of the two sub-strategic 'super weapons' is driven by a sense of inferiority in other areas. Fears that Russia might be vulnerable to a sudden and decisive US naval or aerospace blitzkrieg are surely important factors in explaining the emphasis on the development of theatre-level hypersonic missiles such as the Kinzhal and Tsirkon. Rather than developing these capabilities for passive purposes

99 Putin (2018), 'Послание Президента Федеральному Собранию' [Address of the President to the Federal Assembly].

(e.g. to defend against carrier-based forces that might be threatening Russian territory), it is likely that they represent a step towards Moscow being able to threaten the territory of potential adversaries (i.e. the US and its NATO allies) with similar capabilities to those that Russian defence planners have long feared.

Speaking at the Academy of Military Science a year after Putin's speech announcing the 'super weapons' programmes, the chief of the General Staff, Valery Gerasimov, made it clear that Russia was developing capabilities that would enable Russian forces to 'seize and maintain the initiative […] destroy key decisive points of the enemy, such as C2 [command and control] nodes and launchers designed to strike Russia [and to] use surprise, decisiveness and continuity of action [using] hypersonic missile systems'. Gerasimov concluded his remarks by stating that 'to answer a threat we need to create a threat'.[100] These remarks demonstrate quite firmly that the new weapons are unlikely to be envisaged for use in a passive fashion. Instead, military planners are intent on developing capabilities that will enable Russia to strike early, fast, and with precision in any future military conflict. The possession of such a capability could, as Gerasimov stated earlier in 2017, 'allow [Russia] to leave nuclear deterrence in favour of conventional deterrence'.[101]

In this respect, the emergence of hypersonic, dual-capable, sub-strategic weapons is perhaps of much greater importance than the strategic systems revealed by Putin. After all, the new weapons will, once they are deployed, give Russia's military a much broader range of options to choose from in the event of any future conflict. By reducing the pressure on Moscow to resort to either the large-scale use of conventional forces or even nuclear weapons, planners may be able to develop capabilities that form part of a broader doctrine of 'active defence'. As Gerasimov stated, 'acting quickly we must pre-empt our adversary with preventive measures, identify his vulnerabilities in a timely manner, and create the threat that unacceptable damage will be inflicted'.[102]

100 *Красная звезда* [*Red Star*] (2019), 'Векторы развития военной стратегии' [Development vectors of military strategy], 4 March 2019, http://redstar.ru/vektory-razvitiya-voennoj-strategii (accessed 8 Jul. 2021).
101 Nikolskiy, A. (2017), 'Россия готова к неядерному миру' [Russia is ready for a non-nuclear world], *Vedomosti*, 13 January 2017. These sentiments echo writings from within the Russian military that emerged over the previous decade. See, for example, Chekinov, S. G. and Bogdanov, A. S. (2007), 'Эволюция Сущности И Содержания Понятия «Война» В Xxi Столетии' [Evolution of the Essence and Content of the Concept of 'War' in the 21st Century], *Военная мысль* [*Military Thought*], No. 1, pp. 32–45; and Litvinenko, V. I. and Rusanov, I. P. (2014), 'Основные тенденции огневого поражения в современных операциях (боевых действиях)' [The main trends in effective engagement in modern operations (combat actions)], *Военная мысль* [*Military Thought*], No. 10, p. 21. These works emphasized, *inter alia*, the utility of long-range precision-guided munitions in rapidly striking a wide range of civilian and military targets in Western countries with the objective of sapping an opponent's political will to engage in conflict with Russia.
102 *Красная звезда* [*Red Star*] (2019), 'Векторы развития военной стратегии' [Development vectors of military strategy].

What do the new weapons tell us about Russian defence-industrial capabilities?

The development of the 'super weapons' that are analysed in this chapter provides at least three important insights into the Russian defence industry and its capacity for innovation.

First, it shows the utility of reanimating and adapting older Soviet-era designs. Several of the systems described here were either conceived in the late Soviet period (e.g. Avangard) or are incremental adaptations of older systems (e.g. Kinzhal).

Second, the new weapons reveal the ability of Russian designers to integrate old and new technologies to produce new capabilities. The Kinzhal, for instance, integrates two established technologies – the MiG-31 and the Iskander – to produce a genuinely new capability. Elsewhere, the fact that the Tsirkon appears to be an aero-ballistic missile rather than a 'pure' hypersonic cruise missile is unlikely to make it any easier to deal with at the tactical or operational level. In both cases, Russian designers have shown an ability to identify shortcuts to innovation that are based on the creative application of existing capabilities rather than on the more costly – and riskier – development of technologies from scratch. In this respect, Russian designers are clearly pragmatic enough to avoid the trap of letting the best be the enemy of the good.

Third, the Russian defence industry continues to prove adept at creating a wide range of new designs. Beyond the 'super weapons' discussed here, a multitude of new systems emerge from design bureaux and manufacturers with great regularity. These include new autonomous platforms and systems utilizing AI, as well as more traditional platforms and weapons used across all domains of warfare. The ability of the defence industry to innovate at a rate that is appreciably higher than in the civilian economy is largely because Russia's national innovation system is geared overwhelmingly towards funding military–scientific innovation.

Nor is there any reason to think that this is unsustainable in a financial sense. Comments in February 2021 by former defence minister Sergey Ivanov (now serving as special presidential representative for environmental protection, ecology and transport), suggested that around one-fifth of the annual state defence order (GOZ) budget for research and development (R&D) was absorbed by work on the 'super weapons' during his time in office at the defence ministry (2001–07).[103] Given that the GOZ R&D budget expanded significantly after Ivanov left his position, it is unlikely that the development costs of these systems will have been so onerous as to prevent the development of other systems.

103 RIA Novosti (2021), 'Названа стоимость разработки новейших систем российского оружия' [The cost of developing the latest systems of Russian weapons has been revealed], 11 February 2021, https://ria.ru/20210211/vooruzheniya-1596956813.html (accessed 8 Jul. 2021).

Conclusions

Western reactions to the emergence of new Russian capabilities tend to veer between the two extremes of over-reaction and contempt. This has been no different in the case of the 'super weapons' programmes unveiled by Putin in 2018. Some observers have pointed to the hypersonic missile 'gap' that has apparently opened up between Russia (and China), on the one hand, and the US and its allies on the other. Other observers have disparaged some of the more unconventional designs. The Burevestnik and the Poseidon, for example, have been described as either technically unfeasible or militarily 'ridiculous'.[104] The truth probably lies somewhere in between these two extremes. The new weapons are unlikely to change the nature of warfare or to entirely upset existing Western military plans. But they will pose new challenges that will require proportionate and carefully calibrated responses. Two observations stand out as important when considering how to respond to the new systems.

First, the strategic 'super weapons' do not radically change the nature of Russia's strategic nuclear capability. After all, the fact that ballistic missile defence is not designed to deal with the Russian arsenal means that nothing has fundamentally changed in the nature of the strategic nuclear balance between the US and Russia. Both sides are just as capable of destroying the other as they were before Putin's announcement in March 2018.

Where perhaps the greatest changes will be observed is in Russia's sub-strategic conventional and nuclear strike capabilities. In this respect, Tsirkon and Kinzhal add a genuinely new string to the Russian bow. Nevertheless, while Russian advances in this sphere should not be underestimated, it remains the case that there are important capability gaps that mean the new weapons might not have the utility that some analysts fear.

While Russian advances in this sphere should not be underestimated, it remains the case that there are important capability gaps that mean the new weapons might not have the utility that some analysts fear.

Most important is the fact that Russia's 'battle network' – or 'kill chain' – linking 'sensors', which deal with target acquisition and tracking, on the one hand, and the hypersonic 'shooters', on the other, are underdeveloped. In practical terms, this means that faster missiles might not result in a substantially greater probability of destroying an enemy aircraft carrier, for example, than older and slower missiles. For as long as this weak link persists, Russia's hypersonic weapons will not represent a revolutionary threat, at least not to moving targets (fixed targets are another matter).

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104 Billingslea, M. S. (@M_S_Billingslea) (2021), 'One of Russia's ridiculous doomsday science projects. Russia should shelve this project. The Biden Admin. could have demanded a stop to this and Skyfall in exchange for New START extension. But they didn't.', tweet, 27 February 2021, https://twitter.com/M_S_Billingslea/status/1365663287707398144 (accessed 8 Jul. 2021).

Second, Western planners should avoid the temptation to match Russian capabilities. In many respects, the new weapons have emerged as 'asymmetric' and relatively low-cost responses to Western – and primarily American – conventional superiority. Specifically, the strategic systems are designed to circumvent ballistic missile defence, while sub-strategic systems appear designed to counteract US dominance in aerospace and naval power. Consequently, attempting to develop and deploy like-for-like systems may be wasteful. Instead, it may be more prudent to focus on capabilities that disrupt and degrade the enabling military infrastructure – e.g. C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) and other kill chain systems – that give the new weapons such potential.

04
Russian space systems and the risk of weaponizing space

Russia maintains an active space programme that includes systems supporting military operations. It pursues capabilities to counter and disrupt the space activities of its competitors, while remaining open to arrangements regulating military space.

Pavel Podvig
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Russian Nuclear
Forces Project

Military operations have been an important part of space activity since the beginning of the space age. During the Cold War, the Soviet Union invested in a wide range of space programmes – military as well as civilian – and created a formidable space industry, building an expansive infrastructure to support satellite operations. After the end of the Cold War and the break-up of the Soviet Union, Russia experienced serious difficulties with maintaining key elements of the Soviet space programme but, starting in the early 2010s, it began regaining at least some of the capabilities lost during previous decades. Even though this process is far from completed, Russia has demonstrated that it has the capability to maintain and probably expand its presence in space.

Military space continues to be an important part of the space programme that benefits from both the consistent support of the political and military leadership and increasingly steady access to resources. This inevitably raises the question of the future direction of the military space programme and the risk of a confrontation in space that may result from the growing role of space systems in military operations. It becomes particularly important in view of a number of recent developments which suggest that Russia is working on systems that can provide it with the capability to carry out offensive operations in space.

This chapter provides a brief overview of the status of Russia's space-related military programmes in an attempt to assess the risk of weaponizing space that can be linked to its recent activities.

Russia's space forces

During the last three decades, both the space industry and the divisions of the armed forces that are responsible for space operations have undergone numerous reorganizations. In the current structure of the Russian armed forces, established in 2015, the space forces exist as a separate branch within the Air and Space Forces (VKS). The VKS is a service that also includes the military air force and the air- and space-defence forces.

The space forces' areas of responsibility include space situational awareness, early warning of ballistic missile attack, satellite launches and operations, and maintaining all elements of the space infrastructure at a high degree of readiness. One of the tasks assigned to the space forces is the detection of 'threats to Russia in space and from space, and, if necessary, fending off these threats'.[105] This mission, however, does not include missile defence, which is assigned to the air- and space-defence forces.

The Russian military is clearly aware of the nature of modern warfare, which relies on situational awareness and reliable communication, including that provided by satellite-based systems. It is logical to assume that the disruption of these systems would be an important element of Russia's military strategy in space, especially as its potential adversaries become increasingly dependent on space assets.[106] At the same time, the space forces' mission is defined in a way that calls for action only in response to a threat 'in space and from space'. This suggests that it is defence rather than offence that is considered the primary mission of the space forces, although offensive operations in space are not ruled out.

The notion of a threat from space can be traced back to the concept of 'strike weapons in space' – that is, space-based weapons that can attack targets on Earth. This concept has occupied an important place in Soviet and then Russian military and political discourse since at least the early 1980s.[107] This category of weapons appears to include a broad range of systems. For example, in the draft Treaty on the Prevention of Placement of Weapons in Outer Space, submitted by Russia and China to the Conference on Disarmament (CD) in 2014, a 'weapon in outer

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105 Ministry of Defence of the Russian Federation (2015), 'Космические войска' [Space Forces], https://structure.mil.ru/structure/forces/vks/cosmic.htm (accessed 8 Jul. 2021).
106 Weeden, B. and Samson, V. (2020), *Global Counterspace Capabilities: An Open Source Assessment*, Secure World Foundation, April 2020, https://swfound.org/media/206957/swf_global_counterspace_april2020_es.pdf (accessed 8 Jul. 2021).
107 See, for example, UN General Assembly (1983), *Conclusion of a Treaty on the Prohibition of the Use of Force in Outer Space and from Space Against the Earth, A/38/194*, 23 August 1983, https://undocs.org/pdf?symbol=en/A/38/194 (accessed 8 Jul. 2021).

space' is defined as a space-based object that can destroy or damage 'objects in outer space, on the Earth's surface or in the air'.[108] It is normally understood that space-based elements of a missile defence system, such as interceptors or directed-energy weapons, would fall into this category. Moreover, Russian officials often emphasize that a space-based missile defence could be used to pre-emptively attack its strategic forces.[109]

Since none of the weapons systems of these kinds have been developed or are in development at the present time, Russia's concerns about weapons in space are probably unwarranted. However, Russia does seem to use this view of potential threats in space to justify its own work on systems to counter these threats. In the absence of an agreement that prohibits the deployment of weapons in space, the development of tools that could repel an attack initiated from space can be considered a legitimate step.

This approach was particularly prominent in the 1980s, at which time Soviet work on anti-satellite systems received a considerable boost when the mission of these systems was reframed in terms of the need to counter elements of the US Strategic Defense Initiative.[110] A similar dynamic is likely to exist today, especially as the Russian political leadership appears to give its full support to programmes that offer a capability to counter US missile defence systems.

In the absence of an agreement that prohibits the deployment of weapons in space, the development of tools that could repel an attack initiated from space can be considered a legitimate step.

This does not necessarily mean that Russia has a coordinated strategy of relying on the capability to target space assets, or a dedicated programme of integrating that capability into its military operations. While several projects in this area are clearly under way, as detailed in the following sections, at this point they appear to be driven primarily by the interests of the developers rather than by demand for a specific military mission.

This state of affairs is characteristic for the organization of military research and development in Russia, largely inherited from the Soviet Union. Normally, the enterprises of the defence industry have significant flexibility in pursuing projects within their area of expertise. Russia has created a number of organizational structures and governmental bodies to direct this process, provide general oversight, and ensure efficiency. In 2015, it created the Roscosmos State Space Corporation, which includes design bureaux, missile and satellite production

108 See: *Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects*, 10 June 2014, https://reachingcriticalwill.org/images/documents/Disarmament-fora/cd/2014/documents/PPWT2014.pdf (accessed 8 Jul. 2021).
109 Россия сегодня [Russia Today], 'Брифинг заместителя Министра иностранных дел Российской Федерации Сергея Рябкова' [Briefing by Deputy Minister of Foreign Affairs of the Russian Federation Sergei Ryabkov], 11 February 2021, http://pressmia.ru/pressclub/20210211/953090432.html (accessed 8 Jul. 2021).
110 Podvig, P. (2017), 'Did Star Wars Help End the Cold War? Soviet Response to the SDI Program', *Science & Global Security*, 25(1): pp. 3–27, doi:10.1080/08929882.2017.1273665 (accessed 8 Jul. 2021).

facilities and the infrastructure that supports testing and operations of missile and space systems. In government, the defence industry is overseen by a deputy prime minister, who also chairs the Military-Industrial Commission, a body that coordinates the economic activity of the defence industry.

Finally, the ministry of defence has a certain degree of control over all defence-related projects through its role as the customer. This control, however, does not necessarily give the military a capability to determine which specific systems the industry must work on. The research, development, and acquisition process is driven largely by what the industry can offer rather than by what the military requests.[111]

This pattern applies to virtually all military space programmes that are currently implemented in Russia. Most of them are aimed at reconstituting the capabilities that were built in the Soviet Union, using the expertise and experience accumulated at the time.

Military space programmes and projects

Navigation

Russia's satellite navigation system, known as GLONASS, is built on the same principle as its US counterpart, the Global Positioning System (GPS). A full GLONASS constellation consists of 24 satellites that can provide accuracy of up to about 3 metres, comparable to that of the GPS system.

The system first reached limited operational capability in 1993, and the full constellation was deployed for the first time in 1995. However, in the following years the system deteriorated to a serious extent and was unable to provide a reliable service. With considerable effort, the system was restored to an operational condition by the early 2010s, and in 2016 the defence ministry formally accepted the system for service.

This process included the development of second-generation satellites, GLONASS-M, and the opening of the system to civilian users. The modernization of the system continues – Russia has already deployed several GLONASS-K spacecraft, and is working on the next modification. This programme, however, appears to be experiencing some difficulties as the economic sanctions imposed on Russia in 2014 in the wake of its annexation of Crimea have limited access to the space-grade electronic components used in these satellites.[112]

Russian appears to be actively using the GLONASS system to support military operations, especially as its armed forces begin to deploy an increasing number of high-precision weapons. GLONASS is believed to be an important factor in

111 Podvig, P. (2018), 'Russia's Current Nuclear Modernization and Arms Control', *Journal for Peace and Nuclear Disarmament*, 1(2): pp. 256–67, doi:10.1080/25751654.2018.1526629 (accessed 8 Jul. 2021).
112 Cheberko, I. (2020), 'Космический масштаб импортозамещения' [The cosmic scale of import substitution], *Vedomosti*, 27 September 2020, https://www.vedomosti.ru/technology/articles/2020/09/27/841310-kosmicheskii-masshtab (accessed 8 Jul. 2021).

the success of the Russian military operation in Syria.[113] This trend is expected to continue, so in the future the Russian armed forces are likely to increase their reliance on the navigation services provided by the GLONASS system. The difficulties caused by sanctions would probably make this more challenging, but Russia could maintain the current capability of the system by relying on previous-generation satellites, even though this may require increasing the number of launches.

Early warning

Russia's nuclear command and control relies on a ballistic missile early-warning system for detecting launches of ballistic missiles and assessing attacks. This system includes a network of ground-based radars deployed on the periphery of the country and a constellation of satellites that provide early launch detection. The space tier has always been considered an essential element of the early-warning system, even though its practical role is somewhat limited.[114]

Deployment of the first space-based early-warning system, Oko, began in the late 1970s. The constellation was designed to include two types of satellites, deployed on highly elliptical orbits (HEO) or placed in geosynchronous orbits (GEO). The system began limited operations in 1982 and for a long time was only capable of detecting launches from US territory. Starting in 1991, Russia has launched a number of geostationary satellites that provided coverage of the oceans as well, but that constellation, Oko-1, was never completed.[115] In 2014, the last satellite of the Oko generation stopped its operations, leaving Russia without a space-based component of the early-warning system.[116]

In the 1990s, Russia began developing a new space-based early-warning system, known as EKS or Kupol. The first launch of a new early-warning satellite, Tundra, took place in 2015. With the launch of a fourth satellite in May 2020, the constellation of satellites that are deployed in HEO reached initial operational capability. The full constellation, with ten satellites on highly elliptical and geosynchronous orbits, will provide coverage of all potential missile launch regions. The deployment of the system is expected to be completed in 2024.[117]

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113 Nikolsky, A. (2017), '«Глонасс» и силы спецопераций – причины военных успехов России в Сирии' ['Glonass' and the Special Operations Forces are the reasons for Russia's military successes in Syria], *Vedomosti*, 1 March 2017, https://www.vedomosti.ru/politics/articles/2017/03/01/679434-glonass-spetsoperatsii (accessed 8 Jul. 2021).
114 Podvig, P. (2006), 'Reducing the Risk of an Accidental Launch', *Science & Global Security*, 14(2–3): pp. 75–115, doi:10.1080/08929880600992990 (accessed 8 Jul. 2021).
115 Podvig, P. (2002), 'History and the Current Status of the Russian Early-Warning System', *Science & Global Security*, 10(1): pp. 21–60, doi:10.1080/08929880212328.
116 Podvig, P. (2015), 'Russia Lost All Its Early-Warning Satellites', Russian Strategic Nuclear Forces, 11 February 2015, http://russianforces.org/blog/2015/02/russia_lost_all_its_early-warn.shtml (accessed 8 Jul. 2021).
117 Podvig, P. (2020), 'Fourth Tundra Early-Warning Satellite Is in Orbit', Russian Strategic Nuclear Forces, 22 May 2020, http://russianforces.org/blog/2020/05/fourth_tundra_early-warning_sa.shtml (accessed 8 Jul. 2021); Svirilova, A. (2021), 'Предупреждён – значит защищён' [Forewarned means protected], *Красная звезда* [*Red Star*], 15 February 2021, http://redstar.ru/preduprezhdyon-znachit-zashhishhyon (accessed 8 Jul. 2021).

Signal intelligence

Two other legacy Soviet systems that Russia is working to reconstitute are the signal intelligence (SIGINT) Tselina and the ocean electronic reconnaissance system, known as EORSAT or US-P. The last launches of the previous-generation satellites took place in 2007 and 2006 respectively. The system that is being built to replace them, known as Liana, will include satellites of two types – signal intelligence Lotos and ocean reconnaissance Pion-NKS. Although nominally part of an integrated system, these satellites have different missions and capabilities. While Lotos is a passive SIGINT collection spacecraft, it appears that Pion-NKS will have an active radar on board and will be able to provide targeting information to the Russian navy.

The first launch of a prototype Lotos-S spacecraft took place in 2009, but regular launches of the satellites, now known as Lotos-S1, did not begin until 2014. In February 2021, Russia launched its fourth Lotos-S1. At least four more spacecraft were ordered in 2017, indicating that the programme is largely successful.

The other component of the Liana network, a Pion-NKS constellation, is farther from deployment. The programme has suffered several setbacks, some of which were related to the cessation of cooperation with developers in Ukraine. Nevertheless, work on the programme continues, and the defence ministry has repeatedly emphasized the importance of the project. The first satellite of the Pion-NKS constellation was launched in June 2021. It is, however, unclear when the system will reach initial operating capability.

Communication

The main element of Russia's military communication system is the Integrated Satellite Communication System (ESSS). The system includes a constellation of Meridian satellites deployed in HEO, optimized to provide services to the northern regions of the hemisphere. It also includes satellites of the Raduga-1M type deployed in GEO.

Russia maintains two constellations of geostationary data relay satellites – Garpun, which supports the operations of reconnaissance satellites, and Blagovest, which appears to be handling non-sensitive military traffic.[118] Another military system deployed by Russia is the constellation of Rodnik satellites (also known as Strela-3M). These low-earth orbit (LEO) satellites provide store-dump communication capability and are believed to be used primarily by military intelligence and other similar services. The system has a civilian counterpart, known as Gonets. That system uses a network of ground stations that link satellites with other communication networks and support the collection of messages or their

118 Krasilnikov, A. (2017), 'Военный связной «Благовест» на сотом «Протоне-М»' [Military messenger 'Blagovest' on the hundredth 'Proton-M'], *Новости космонавтики* [*Cosmonautics News*], 10: pp. 36–38.

dissemination over an area within the direct line of sight to a satellite (approximately 5,000 km in diameter). Neither system, however, supports continuous communication between users.

Remote sensing

Russia is still in the process of building a set of modern remote sensing tools, including the capability to obtain optical or radar images of the surface of the earth. In photoreconnaissance, until relatively recently Russia relied on satellites carrying returnable film capsules to obtain high-resolution optical images. The programme, known as Kobalt-M, ended in 2015. The effort to develop a digital optical reconnaissance system encountered a series of problems. One possible candidate, Persona, proved only partially successful: the first satellite, launched in 2008, failed shortly after reaching orbit, and two subsequent satellites, launched in 2013 and 2015, apparently did not demonstrate adequate performance. No new satellites of this type were launched after that, as the defence ministry decided to support a different project, Razdan, which is a photoreconnaissance system believed to provide a capability similar to that of the US KH-11 series of satellites. The original plan called for the deployment of three satellites between 2019 and 2024, but as of 2021, the programme was yet to launch its first satellite.[119]

In 2018, Russia launched a first small imaging satellite, EMKA, which is reported to provide imagery with a resolution of less than one metre. This satellite became a prototype for a series of Razbeg spacecraft, the first of which was launched in September 2021.[120]

Another potential source of satellite imagery is the Bars-M series of satellites. The primary purpose of these satellites is cartography, but they can provide optical reconnaissance capability as well. Two satellites of this type have been launched so far, in 2015 and 2016. They have been deployed in low-earth sun-synchronous orbits.

In addition to a dedicated military photoreconnaissance capability, Russia is probably relying on the information provided by the civilian satellites of the Resurs-P class. Another civilian remote-sensing system that could potentially be used by the military is the Obzor-R series of synthetic aperture radar (SAR) satellites. The first Obzor-R launch is expected in the second half of 2021. 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.

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119 Safronov, I. (2016), 'На противника посмотрят с двухметровой объективностью' [They will look at the enemy with a two-meter objectivity], Kommersant, 28 July 2016, https://www.kommersant.ru/doc/3049019 (accessed 8 Jul. 2021); Hendrickx, B. (2019), 'Razdan: Russia's KH-11 Class Reconnaissance Satellite', NASASpaceFlight, 11 December 2019, https://forum.nasaspaceflight.com/index.php?topic=49654.0 (accessed 8 Jul. 2021).
120 Hendrickx, B. (2020), 'Upgrading Russia's fleet of optical reconnaissance satellites', The Space Review, 10 August 2020, https://www.thespacereview.com/article/4006/1 (accessed 10 Sep. 2021).

Inspector satellites

Starting in 2013, Russia began deploying satellites that demonstrated the capability to approach and inspect satellites in orbit. While there is no direct evidence that would suggest that these programmes have an anti-satellite mission, this is one of the potential applications of this technology.

One series of satellites designed for rendezvous missions appears to be under development as part of a programme known as Nivelir. Satellites that were involved in these missions are normally launched as auxiliary payloads, which suggests that they are relatively small. The first satellite of this programme was probably Cosmos-2491, which was launched in December 2013 but which appeared to have failed shortly after launch. It was followed by Cosmos-2499 and Cosmos-2504, launched in March 2014 and March 2015 respectively. These satellites performed a series of rendezvous with the upper stages that delivered them into orbit.[121]

While there is no direct evidence that would suggest that these programmes have an anti-satellite mission, this is one of the potential applications of this technology.

In June 2017, Russia launched Cosmos-2519, which was described in the official launch announcement as a 'platform that carries Earth observation equipment and equipment that will be used to photograph various space objects'.[122] This satellite later released two additional objects. One of them, Cosmos-2521, performed a series of rendezvous manoeuvres. The other, Cosmos-2523, may have been a test of a projectile, as it separated from its host with a relatively high velocity.[123]

A similar pattern of behaviour was observed after a launch conducted in July 2019. Two of the four satellites placed in orbit – Cosmos-2535 and Cosmos-2536 – were involved in a series of proximity manoeuvres approaching each other. The proximity operations were officially confirmed by the Russian ministry of defence.[124]

Another proximity operation satellite, Cosmos-2542, was launched in November 2019. The official announcement issued by the Russian ministry of defence stated that the spacecraft was placed into an orbit from which it could monitor the status of other Russian satellites.[125] Less than a month into the flight, Cosmos-2542 released another satellite, Cosmos-2543. Unlike its predecessors, which would

121 Weeden and Samson (2020), 'Global Counterspace Capabilities: An Open Source Assessment'.
122 Interfax-Military News Agency (2017), 'Спутник 'Космос-2519' Минобороны РФ будет фотографировать космические объекты' [Cosmos-2519 satellite of the Russian Ministry of Defence will photograph space objects], 24 June 2017, https://www.interfax.ru/russia/567888 (accessed 10 Sep. 2021).
123 Weeden and Samson (2020), 'Global Counterspace Capabilities: An Open Source Assessment'.
124 Ibid.
125 Ministry of Defence of the Russian Federation (2019), 'Воздушно-космические силы провели пуск ракеты-носителя «Союз-2» с космодрома' Плесецк [Aerospace Forces launched Soyuz-2 carrier rocket from Plesetsk cosmodrome], 26 November 2019, https://function.mil.ru/news_page/country/more.htm?id=12263690@egNews (accessed 8 Jul. 2021).

normally approach other Russian satellites, Cosmos-2543 positioned itself in an orbit that allowed it to observe a US optical reconnaissance satellite, USA 245.[126] Furthermore, in July 2020, Cosmos-2543 released a new object – an event that US Space Command described as an 'in-orbit weapons test'.[127]

Russia also conducted a series of proximity operations in GEO. A satellite launched in September 2014, known as Luch/Olymp, performed a series of manoeuvres that brought it to the vicinity of a number of Russian and foreign geostationary satellites.[128] Luch/Olymp appears to be an electronic intelligence satellite that can intercept communication between GEO satellites and their ground stations.

These operations suggest that Russia has an active programme or several programmes to develop a capability to approach and inspect orbital objects. While there is no direct evidence of an anti-satellite dimension to these programmes, it is possible that this capability could be used to damage or destroy other satellites.

Other military projects

Russian military-related space activities include several other missions. Among those are the geodetic Geo-IK-2 satellites, as well as several small satellites used to calibrate radars or study atmospheric drag. The mission of one small satellite, ERA-1, which was launched in December 2020, was described as the development of 'future micro devices and micro components of guidance and attitude control systems'.[129]

Anti-satellite programmes

In addition to space systems that may have anti-satellite missions, Russia appears to be exploring land-based anti-satellite capability. These include systems that are designed to destroy satellites, as well as several systems that can interfere with satellite operations.

One project in this area, known as Nudol, is believed to be a direct-ascent anti-satellite system.[130] The Nudol interceptor appears to be mounted on a mobile launcher, which could expand the range of orbits that it could target. For targeting, Nudol probably relies on the existing network of early-warning radars that provide data for the Russian space situational awareness system. It may also include a dedicated radar to guide the interceptor to the target.

126 Weeden and Samson (2020), 'Global Counterspace Capabilities: An Open Source Assessment'.
127 U.S. Space Command Public Affairs Office (2020), 'Russia conducts space-based anti-satellite weapons test', 23 July 2020, https://www.spacecom.mil/MEDIA/NEWS-ARTICLES/Article/2285098/russia-conducts-space-based-anti-satellite-weapons-test (accessed 8 Jul. 2021).
128 Weeden and Samson (2020), 'Global Counterspace Capabilities: An Open Source Assessment'.
129 Podvig, P. (2020), 'Cosmos-2548 – a small developmental satellite', Russian Strategic Nuclear Forces, 3 December 2020, http://russianforces.org/blog/2020/12/cosmos-2548_-_a_small_developm.shtml (accessed 8 Jul. 2021).
130 Weeden and Samson (2020), 'Global Counterspace Capabilities: An Open Source Assessment'.

Work on Nudol reportedly started in 2009, and initial tests of its various components were conducted in 2012–13. The interceptor failed on the first flight test, conducted in August 2014, as well as on the second one in April 2015. The first successful test took place in November 2015. By the end of 2020, Russia had conducted about 10 tests of the interceptor, almost all of them from the Plesetsk test site.[131] None of the tests involved destroying a target satellite.

Although the US assesses Nudol to be an ASAT system, it is possible that it is being developed as an exoatmospheric tier of the future upgraded Moscow missile defence, known as A-235.[132] A missile defence interceptor will, of course, have the capability to intercept LEO satellites.

Another system with potential ASAT capability is the S-500, which is the latest addition to the family of long-range air-defence systems. Although the S-500 has never demonstrated the capability to intercept targets outside the atmosphere, it might indeed be capable of targeting LEO satellites.

A further example of a programme with potential anti-satellite applications is an air-based space launcher that can deliver into orbit a small satellite inspector or an interceptor. The programme, known as Burevestnik (unrelated to the ground-launched nuclear-powered cruise missile project described in Chapter Three of this paper), is developing a system that includes a modified MiG-31 aircraft carrying a solid-propellant rocket. It appears that, rather than attack the target directly, the rocket is supposed to place its payload in an orbit from where it will approach the target. It is possible that the payload of the Burevestnik system has been tested in one of the 'proximity operations' missions conducted by Russia in previous years.[133]

A different category of land-based system is designed to disrupt satellite observations or communications rather than destroy them. One system of this kind is the Peresvet laser system that was publicly unveiled in 2018. Shelters housing elements of the system are being deployed in the vicinity of road-mobile intercontinental ballistic missile bases, which suggests that Peresvet could play a role in protecting these bases. The laser is unlikely to be powerful enough to physically destroy attacking vehicles, such as cruise missiles or drones, but may have enough power to dazzle or blind their optical sensors. It is also possible that the Peresvet laser could dazzle or damage the sensors of reconnaissance satellites.[134]

Russia has also developed a range of electronic warfare systems that could jam or spoof the signal of communication satellites (Tirada-2 and Bylina-MM), counter radar reconnaissance satellites (Krasukha-4 and Divnomorye) or protect

131 Podvig, P. (2020), 'Nudol ASAT system tested from Plesetsk', Russian Strategic Nuclear Forces, 16 December 2020, http://russianforces.org/blog/2020/12/nudol_asat_system_tested_from.shtml (accessed 8 Jul. 2021).
132 Weeden and Samson (2020), 'Global Counterspace Capabilities: An Open Source Assessment'; Stukalin, A. (2011), "Samolet-M' and the Future of Moscow Missile Defense', *Moscow Defense Brief*, 4(26).
133 Hendrickx, B. (2020), 'Burevestnik: A Russian air-launched anti-satellite system', The Space Review, 27 April 2020, https://www.thespacereview.com/article/3931/1 (accessed 8 Jul. 2021).
134 Hendrickx, B. (2020), 'Peresvet: A Russian mobile laser system to dazzle enemy satellites', The Space Review, 15 June 2020, https://www.thespacereview.com/article/3967/1 (accessed 8 Jul. 2021).

Russian satellites from electronic attacks (Tobol).[135] It appears that these systems are in active development, so it is likely that the Russian military will continue its investment in these capabilities.

Table 1. Key Russian military-related space programmes (as of September 2021)

Programme	Satellites	Mission	Orbit
GLONASS	Uragan	Navigation	MEO[136]
Kupol/EKS	Tundra	Early warning	HEO
Liana	Lotos	Signal intelligence	LEO
	Pion-NKS	Ocean reconnaissance	LEO
Persona		Optical reconnaissance	LEO
Razbeg	EMKA, Razbeg	Optical reconnaissance	LEO
Bars-M		Cartography	LEO
ESSS	Meridian	Communication	HEO
	Raduga-1M	Communication	GEO
Garpun		Data relay	GEO
Blagovest		Data relay	GEO
Rodnik		Store-dump communication	LEO
Nivelir		Inspector satellites	LEO
Luch/Olymp		Proximity operations	GEO

Source: Author's compilation.

135 Hendrickx, B. (2020). 'Russia gears up for electronic warfare in space (Part 1)', The Space Review, 26 October 2020, https://www.thespacereview.com/article/4056/1 (accessed 8 Jul. 2021); Hendrickx, B. (2020), 'Russia gears up for electronic warfare in space (Part 2)', The Space Review, 2 November 2020, https://www.thespacereview.com/article/4060/1 (accessed 8 Jul. 2021).
136 Medium-earth orbit.

Conclusions

An overview of Russia's programmes strongly suggests that it will continue to develop its military space capabilities. Russia has successfully reconstituted a number of old Soviet programmes, for example in the areas of satellite navigation or ballistic missile early warning, upgrading them as necessary in the process. Although in other areas progress has been slower, the industry certainly has the potential to develop modern space-based systems that could provide support to Russia's armed forces.

However, it will take the Russian military significant time and effort to integrate these capabilities into military operations to the extent that they become indispensable. This means that the potential vulnerability of Russia's space assets will not present a serious problem for the military in the short to medium term. From that point of view, Russia would be interested in protecting its current and future military satellites and therefore should be expected to support efforts aimed at limiting the use of force against space assets or interference with space operations.

Given the current status of US–Russian relations, it should be expected that Russia will continue its investment in systems that can target assets in space.

In the short term, Russia may see certain advantages in developing the capability to interfere with the space operations of its adversaries, for example with reconnaissance or communications. The anti-satellite systems being developed in Russia today may offer a limited capability of this kind, although the scale of this work does not suggest that it can pose a serious threat to the space assets of other countries. In the long term the effectiveness of investment in these kinds of counter-space systems is rather questionable, as they can be defeated by a variety of means, from countermeasures and satellite hardening to the creation of distributed systems with a high degree of redundancy. Resilience provides the most reliable way to counter the threat that counter-space systems can pose. These considerations notwithstanding, the ability to hold US space assets at risk appears to be a significant driver of Russia's anti-satellite programmes, especially given the degree to which the US relies on space-based systems in its military operations.

Historically, a more significant factor behind Russia's contribution to the weaponization of space was its concern about the potential deployment of space-based missile defence systems. Developments in this area would be very difficult to contain. The future of missile defence is highly uncertain and will remain so for a long time. While the US has no current plans to deploy missile defence in space, this does not seem to constrain Russia's efforts to develop systems that could be used to counter it.

An arrangement along the lines of the Treaty on the Prevention of Placement of Weapons in Outer Space that Russia and China introduced to the CD in 2014 could provide only a partial solution, as it is unlikely to limit the development of land-based missile defences which could provide considerable anti-satellite capability. A limit on missile defence could offer another way to address the threat of weaponization of space. This limit could be established by a negotiated agreement; alternatively, it could be the result of a mutual restraint. Either would help undermine the case for counter-space capabilities.

Given the current status of US–Russian relations, it should be expected that Russia will continue its investment in systems that can target assets in space. It is far from certain, however, that this investment will produce a useful military capability, especially if it will have to deal with highly resilient systems. Russia's own dependence on space for military operations is rather modest and will remain so for a considerable time.

Nevertheless, Russia has already expressed interest in constraining the use of force in space, and that interest will grow as it introduces new systems and capabilities. It has consistently supported the Prevention of an Arms Race in Outer Space (PAROS) process and indicated that it is open to a discussion of the draft Treaty on the Prevention of Placement of Weapons in Outer Space which it introduced to the 2014 CD in conjunction with China. One of the first formal consultations between Russia and the US held after the change of US administration in early 2021 was devoted to a broad range of issues related to space security.[137]

Although Russia's position on space security is very different from that of the US and its allies, Russia appears to be ready to enter into discussions on the subject, for example within the framework of the strategic stability dialogue launched jointly with the US in July 2021. Russia's readiness to engage in dialogue on space security provides an opportunity to limit the threat to space assets that should not be missed. Finally, reaching an understanding regarding the limits on missile defence and on offensive space-based weapons could provide a way to address the concerns related to the counter-space programmes and activities.

137 Ministry of Foreign Affairs of the Russian Federation (2021), 'О российско-американских консультациях по вопросам космической безопасности' [On Russian-American consultations on space security issues], 23 March 2021, https://www.mid.ru/foreign_policy/news/-/asset_publisher/cKNonkJE02Bw/content/id/4648434 (accessed 8 Jul. 2021).

05 Military robotics development

Russia is pursuing the development and fielding of aerial, ground and maritime autonomous and robotic systems as force multipliers, while determining their utility in the fast-changing pace of today's and future combat.

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Over the past two decades, the Russian military has undergone a significant modernization in its warfighting capabilities and doctrine. A major effort undertaken by the defence ministry has involved the adoption and continued development of autonomous and robotic military systems. Today, such technology is becoming a key part of the Russian concept of operations (CONOPS) and tactics, techniques and procedures (TTPs). This technology is viewed as a mission multiplier, while removing and safeguarding military personnel from harm.[138] Starting from 2021, the ministry and its military-industrial community will be building on their armed forces' experience in using such systems, while formulating the theory of how such technology will influence the way the Russian armed forces fight. This chapter will explore Russian thinking and discussion on military autonomy, followed by specific examples of Russian developments of such systems for the air, land and maritime domains. The chapter will conclude with a summary of what these developments mean for the future of warfare in Europe and on a global scale.

138 Voennoe (2014), 'Минобороны утвердило программу по созданию военных роботов' [The Ministry of Defense approved a program for the development of military robots], 4 December 2014, https://военное.рф/2014/Оборонка38 (accessed 9 Jul. 2021).

Framing the need for autonomous systems and military robotics

Despite the Russian military establishment often using the words 'robotic', 'unmanned' and 'autonomous' to denote the different platforms discussed in this paper, the overarching technical reality today is that practically all the systems are controlled remotely by a human operator. At the same time, Russian military planners and the defence establishment are actively discussing fully autonomous operation as the eventual concept for air, land and maritime systems.[139]

These debates indicate that the Russian military's future threat analysis points to it potentially facing a technologically advanced adversary that is capable of fielding a vast array of defensive and offensive systems, including robotic and precision-guided weapons. The Russian military has identified the need to invest in high-tech systems that include different types of autonomous vehicles in order to counter this potential threat.[140] At the same time, the defence ministry is discussing the widespread use of such technology in all manner of conflicts that also involve low-tech adversaries and, especially, urban combat operations.[141]

This debate on future war is being driven by key Russian military institutions such as the Advanced Research Foundation (ARF), Russia's equivalent of the US's Defense Advanced Research Projects Agency (DARPA). Both ARF and DARPA are tasked by their respective country's militaries with developing breakthrough concepts and technologies. In 2016, ARF General Director Andrey Grigoryev noted that future combat will be a war of robotic vehicles, while soldiers will gradually become their operators and move away from direct combat.[142] In 2020, ARF Deputy General Director Vitaly Davydov echoed Grigoryev by saying that the eventual mass use of military robotics is inevitable if armies do not want human soldiers dying in combat, as human fighters will be gradually supplanted by robotic and autonomous systems that can act faster, more accurately and more selectively than people.[143] While recognizing that the ability of these systems to conduct military operations is growing increasingly sophisticated, the Russian defence ministry nonetheless repeatedly emphasizes the need for human control

139 Компания Кронштадт [Kronstadt Group] via Facebook (2021), 'Создать совершенный искусственный интеллект – одна из основных задач «Кронштадта». ИИ – это ключ к автономности наших беспилотников' [To create perfect artificial intelligence is one of the main tasks of Kronstadt. AI is the key to the autonomy of our drones], photograph, 29 March 2021, https://www.facebook.com/kronstadtcompany/photos/a.1659352407665333/2844983289102233/?type=3 (accessed 9 Jul. 2021).
140 Zakvasin, A. (2018), '«Контуры войны будущего»: как российская армия готовится к конфликтам нового поколения' ['The contours of future war': how the Russian army is preparing for new generation conflicts]', RT, 27 March 2018, https://russian.rt.com/russia/article/496787-gerasimov-voina-novoe-pokolenie (accessed 9 Jul. 2021); Kiselev, V. A. (2017), 'К каким войнам необходимо готовить Вооруженные Силы России' [For what kind of war is it necessary for the Russian Armed Forces to prepare], *Военная мысль* [*Military Thought*], No. 3, March 2017, pp. 37–46.
141 Bendett, S. (2019), 'Russia's Military Is Writing an Armed-Robot Playbook', DefenseOne, 26 November 2019, https://www.defenseone.com/ideas/2019/11/russias-military-writing-armed-robot-playbook/161549 (accessed 9 Jul. 2021).
142 RIA Novosti (2016), 'Фонд перспективных исследований считает, что войны будущего поведут роботы'[Advanced Research Foundation believes robots will lead the future wars], 6 July 2016, https://ria.ru/20160706/1459555281.html (accessed 9 Jul. 2021).
143 RIA Novosti (2020), 'Виталий Давыдов: живых бойцов заменят терминаторы' [Vitaly Davydov: terminators will replace human soldiers], 21 April 2020, https://ria.ru/20200421/1570298909.html (accessed 9 Jul. 2021).

over these weapons for now.[144] At the same time, the defence ministry recognizes that fully autonomous systems may be inevitable, both in terms of concepts being developed currently and of future real weapons.[145]

The defence ministry began to formulate specific requirements for this technology after extensive testing of its aerial, ground and maritime remote-controlled systems, especially in Syrian combat, and following extensive reviews of other countries' use of such technology.[146] The list that guides current research, development, testing and evaluation (RDT&E) includes greater autonomy for faster decision-making, especially in the rapidly changing urban combat environment.[147] Additional requirements include modularity, multifunctionality, assured command and control, the ability to withstand significant electronic warfare (EW) countermeasures, the ability to cooperate with different manned and unmanned platforms in multiple domains, and the ability to integrate into existing and future military formations in teams and swarms.[148] For urban-type warfare, Russian future plans envisage teams of light and heavy combat unmanned ground vehicles (UGVs) working with aerial drones in identifying and attacking targets, while cooperating with manned units and formations for extended periods of time.[149]

These operations are envisaged outside an urban combat setting, in potentially countering a peer adversary's forces and attriting their capabilities, especially in disrupting enemy reconnaissance, information exchange and EW systems.[150] In these scenarios, the Russian military envisages units equipped with robotics for a continuous long-term impact to force the adversary to expend and expose human, military and material resources.[151] For the maritime domain, the Russian defence-industrial establishment envisages a global network of underwater, aerial and surface autonomous and unmanned vehicles integrated with submarines, surface vessels and logistics ships for a single common operating picture.[152]

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144 RIA Novosti (2020), 'Виталий Давыдов: живых бойцов заменят терминаторы' [Vitaly Davydov: terminators will replace human soldiers]; For more detailed description of the defence ministry's human-in-the-loop approach, please see CNA (2020), *AI in Russia*, Newsletter No. 10, September 2020, https://www.cna.org/centers/cna/sppp/rsp.
145 For more details, please see Edmonds, J., Bendett, S. et al. (eds) (2021), 'Military AI and Autonomy in Russia' in *AI and Autonomy in Russia*, Arlington, VA: CNA, https://www.cna.org/centers/cna/sppp/rsp/russia-ai (accessed 9 Jul. 2021).
146 This paper distinguishes between Russia's public discussions of its military forces in Syria and the Russian political establishment's official denials regarding participation in Eastern Ukraine conflict.
147 TASS (2019), 'Российские боевые роботы в будущем смогут сами распознавать и поражать цели' [In the future, Russian combat robots will be able to recognize and hit targets on their own], 5 February 2019, https://tass.ru/armiya-i-opk/6081210 (accessed 9 Jul. 2021); RIA Novosti (2020), 'Источник: в РФ разработают тактику применения роботов в уличных боях' [Source: Russia will develop tactics for using robots in street battles], 3 March 2020, https://ria.ru/20191124/1561522690.html (accessed 9 Jul. 2021).
148 Dulnev, P. A. (2017), 'Применение Робототехнических Комплексов При Штурме Города (Укрепленного Района' [Employment Of Robotic Complexes During Assault Of A City], *Вестник Академии военных наук* [*Bulletin of the Academy of Military Sciences*], 3(60): pp. 26–32.
149 Ibid.
150 Dulnev, P. A. and Sychev, S. A. (2019), 'Актуальные Вопросы Построения Боевого Порядка Робототехнических Подразделений' [Key Issues In Developing The Robotic System's Combat Formation], *Вестник Академии военных наук* [*Bulletin of the Academy of Military Sciences*], 3(68): pp. 48–53.
151 Ibid.
152 D-Russia.ru (2020), 'Глава «Рубина» сообщил об идее создания глобальной сети из подводных, надводных и воздушных беспилотников' [Rubin design bureau chief announced the development of a global network of underwater, surface and aerial unmanned systems], 10 June 2020, http://d-russia.ru/glava-rubina-soobshhil-ob-idee-sozdanija-globalnoj-seti-iz-podvodnyh-nadvodnyh-i-vozdushnyh-bespilotnikov.html (accessed 9 Jul. 2021).

To many ministry officials and scientists, the autonomy and cooperative engagement they want to see in military robotics is not possible without integrating artificial intelligence (AI) elements such as machine vision, image recognition and natural language processing into the systems' command and control. Therefore, the use and application of AI can also be traced throughout the Russian debate on robotics CONOPS and TTPs. Recently, President Vladimir Putin identified the development of weapons with elements of AI as one of the defence ministry's five major priorities for the near future, in order to counter perceived US and NATO threats.[153] Specifically, Colonel-General Vladimir Zarudnitsky, head of the Military Academy of the Armed Forces General Staff, noted that the development and use of unmanned and autonomous military systems, the 'robotization' of all spheres of armed conflict, and the development of AI for robotics will have the greatest medium-term effect on the Russian armed forces' ability to meet their future challenges.[154] What remains unresolved in the defence ministry's public statements and deliberations is the discrepancy between current assurances of human control over such systems, and the aspiration for them to operate with full autonomy in the future, presumably after a human operator has approved targeting designations.[155]

Current and future robotic aerial vehicle development

Currently, practically all the unmanned aerial vehicles (UAVs) Russia has in service are remote-controlled, with several vehicles aspiring to greater operational autonomy. Russian defence officials note that small UAVs are key to current and future operational success.[156] They point out the growing evolution of UAVs from reconnaissance roles to EW, relaying communications, delivering supplies and providing target designations to ultimately conducting autonomous strikes.[157] Looking ahead, the priorities for military UAV development include introducing elements of AI into the drone control system, and integrating UAVs into a common airspace with manned aircraft, along with the development of UAV swarms.[158]

Drones like Eleron-3, Orlan-10 and Forpost are now integrated into the defence ministry's reconnaissance-strike and reconnaissance-fire contours, which ensures that data on the ground, surface and aerial environment is acquired in real time,

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153 Kretsup, R. and Ramm, A. (2020), 'Идут «Авангарды»: президент определил пять задач для Минобороны' ['Avangards' are on the march: the Russian president has identified five tasks for the Ministry of Defence], Iz.ru, 21 December 2020, https://iz.ru/1102784/roman-kretcul-aleksei-ramm/idut-avangardy-prezidentopredelil-piat-zadach-dlia-minoborony (accessed 9 Jul. 2021).
154 Zarudnitsky, V. B. (2021), 'Характер и содержание военных конфликтов в современных условиях и обозримой перспективе' [The nature and content of military conflicts today and in the foreseeable future], *Военная мысль* [*Military Thought*], No. 1, January 2021, pp. 34–44.
155 For more details, please see Edmonds, Bendett et al. (eds) (2021), 'Military AI and Autonomy in Russia'.
156 Biryulin, R. (2020), 'Оружие России опережает время' [Russia's weapons are ahead of their time], Interview with Alexey Krivoruchko, Deputy Minister of Defence of the Russian Federation, *Красная звезда* [*Red Star*], 30 December 2020, http://redstar.ru/oruzhie-rossii-operezhaet-vremya (accessed 9 Jul. 2021).
157 Ibid.
158 Biryulin (2020), 'Оружие России опережает время' [Russia's weapons are ahead of their time]; TASS (2020), 'Long-range UAVs of enhanced endurance to be provided for Russian army by end of 2021', 23 December 2020, https://tass.com/defense/1241331 (accessed 9 Jul. 2021).

most notably in Russian operations in Syria.[159] In particular, EW has become one of the key areas for UAV use. Most notable in this field is the Leer-3 complex, which incorporates an Orlan-10 UAV with a range of up to 120 km for cell tower hijacking and mobile communications jamming. This drone-borne system was sighted in Ukraine,[160] was used in Syria[161] and today is widely involved in EW training in the Russian armed forces.[162]

Table 2. Principal UAV systems deployed by the Russian armed forces

Name	Function	Range	Manufacturer
Eleron-3	UAV – ISR	30 km	Eniks
Orlan-10	UAV – ISR	120 km	Special Technology Center (STC)
Forpost	UAV – ISR	250 km	Uzga
Molniya	UAV swarm concept	To be determined	Kronstadt
Orion	UAV – ISR and combat	250 km	Kronstadt
S-70 Okhotnik	UCAV	6,000 km	Sukhoi (Rostec)
Altius	UCAV	10,000 km	Uzga
Grom	UCAV – 'loyal wingman' concept	To be determined	Kronstadt
Kub	Loitering munition	30 mins at 100 km/h	Rostec
Lancet	Loitering munition	40 mins at 100 km/h	Rostec

Note: The table displays all UAV systems mentioned in this chapter. ISR stands for Intelligence, Surveillance and Reconnaissance; UCAV for unmanned combat aerial vehicle.
Source: Edmonds, J., Bendett, S. et al. (eds) (2021), *AI and Autonomy in Russia*, Arlington, VA: CNA, https://www.cna.org/centers/cna/sppp/rsp/russia-ai.

159 Biryulin (2020), 'Оружие России опережает время' [Russia's weapons are ahead of their time]; Milenin, O. V. and Sinnikov, A. A. (2019), 'О роли авиации воздушно-космических сил в современной войне. Беспилотные летательные аппараты как тенденция развития военной авиации' [On the role of air-space forces aviation in modern war. Unmanned aircraft as a trend in the development of military aviation], *Военная мысль* [*Military Thought*], No. 11, November 2019: pp. 50–7 (accessed 9 Jul. 2021).
160 Bellingcat.com (2018), 'Новые российские системы радиоэлектронной борьбы на востоке Украины' [New Russian electronic warfare systems in eastern Ukraine], 10 September 2018, https://ru.bellingcat.com/novosti/russia/2018/09/10/new-russian-ew-donbas (accessed 9 Jul. 2021).
161 Military-informant.com (2016), 'В Сирии обнаружили российские комплексы подавления мобильной связи «Леер-3»' [Leer-3 mobile communications suppressor identified in Syria], 14 March 2016, https://military-informant.com/army/v-sirii-obnaruzhili-rossiyskie-kompleksyi-podavleniya-mobilnoy-svyazi-leer-3.html (accessed 9 Jul. 2021); Aex.ru (2020), 'Россия отправила в Карабах проверенные в Сирии беспилотники' [Russia sent Syria-tested UAVs to Karabakh], 26 November 2020, https://www.aex.ru/news/2020/11/26/219839 (accessed 9 Jul. 2021).
162 Ministry of Defence of the Russian Federation (2020), 'Специалисты РЭБ подавили связь условного противника в ходе учения под Самарой' [EW specialists suppressed adversary communications during Samara exercise], 20 July 2020, https://function.mil.ru/news_page/country/more.htm?id=12303064@egNews (accessed 9 Jul. 2021).

In Syria, Moscow used UAVs around the clock for the first time in 2015, convincing the defence ministry that drones constitute an essential element of modern combat.[163] Today, military UAVs are present across the entire Russian military force structure, with drone companies embedded in motorized rifle and tank brigades and divisions and separate reconnaissance brigades.[164] There are unmanned units in the artillery, engineer-sapper, missile, reconnaissance and railway brigades, with UAV squadrons also having been formed in the Aerospace Forces.[165] Each combined-arms army, brigade and division has two drone platoons for every UAV company, equipped with several drones with ranges between 10 km and 120 km.[166] This structure is replicated across the Airborne Forces and Naval Infantry, with UAV companies present in the Northern and Pacific Fleets.[167] The defence ministry plans to organize long-range heavy drone units into individual reconnaissance aviation squadrons.[168]

While Syria became a massive testing ground for Russia's short-range drone fleet, the lack of unmanned aerial vehicles capable of striking targets at long range was acutely felt, as the military had to scramble crewed aviation for attack missions, potentially putting pilot lives in danger.

To meet the growing military demand, Russian UAV developers are actively pursuing multiple projects that involve quadcopter, multi-rotor, helicopter-type, fixed-wing and other designs. In line with the overarching theme that military autonomy is supposed to save human lives, concept intelligence, surveillance and reconnaissance (ISR) drones are being developed to replace the crewed ISR aircraft in service today.[169] Swarming and AI RDT&E are being actively pursued[170] – for example, within the Molniya concept, which involves launching multiple jet-powered stealth drones from crewed and uncrewed platforms to conduct aerial and ground strikes and to provide EW and reconnaissance capabilities.[171]

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163 Baranets, V. (2017), 'Начальник Генштаба Вооруженных сил России генерал армии Валерий Герасимов: «Мы переломили хребет ударным силам терроризма»' [Chief of the General Staff of the Armed Forces of Russia, Army General Valery Gerasimov: 'We have broken the spine of the shock forces of terrorism'], 26 December 2017, KP.ru, https://www.kp.ru/daily/26775/3808693 (accessed 9 Jul. 2021).
164 Ramm, A. (2021), 'Куда летит беспилотная авиация' [Where unmanned aircraft are flying], Iz.ru, 21 January 2021, https://nvo.ng.ru/armament/2021-01-21/1_1125_aviation.html (accessed 9 Jul. 2021).
165 Ibid.
166 Ibid.
167 Ibid.
168 Ibid.
169 Ibid.
170 Bendett, S. (2021), 'Strength in Numbers: Russia and the Future of Drone Swarms', Modern War Institute, 20 April 2021, https://mwi.usma.edu/strength-in-numbers-russia-and-the-future-of-drone-swarms (accessed 9 Jul. 2021).
171 RIA Novosti (2021), 'Источник: для ВКС создают работающие в стае реактивные беспилотники' [Source: Swarming jet-propelled drones in development for videoconferencing], 1 March 2021, https://ria.ru/20210301/bespilotniki-1599368302.html (accessed 9 Jul. 2021).

While Syria became a massive testing ground for Russia's short-range drone fleet, the lack of UAVs capable of striking targets at long range was acutely felt, as the military had to scramble crewed aviation for attack missions, potentially putting pilot lives in danger. This recognition is now driving the defence ministry's RDT&E of longer-range combat drones. One such significant development is the medium-altitude, long-endurance Orion UAV, with a 250-km range, which was finally acquired by the Russian military in late 2020, becoming the first official combat UAV in service.[172] Another combat UAV project is the Altius, which has a range of up to 10,000 km and took to the air in 2019,[173] with a manufacturing and supply contract finally signed by the state in 2021.[174]

No other drone has received as much global attention as the heavy S-70 Okhotnik. First flown in 2019, it is designed as an interceptor and a ground-attack platform to overcome adversary air defence systems, radar stations and possibly military aircraft. Its key feature is integration with Su-57 fifth-generation manned fighters in 'loyal wingman' formations.[175] The Russian defence ministry envisages the Su-57 pilot controlling multiple S-70 drones, with the Okhtonik potentially being armed with hypersonic missiles for greater striking range.[176] According to current deliberations across the defence ministry and its expert community, such teaming could potentially replace entire squadrons of piloted aircraft for reconnaissance and combat missions in the near future.[177] The ministry also plans for the Altius and Okhtonik to have on-board AI for autonomous operations.[178] Additionally, the Kronstadt Bureau – the maker of Orion drones – has unveiled several unmanned combat aerial vehicle (UCAV) projects, including the Grom [Thunder] 'loyal wingman' concept, which is capable of launching its own drone swarms, and the Sirius, a long-range UCAV that is already slated for acquisition starting in 2023.[179] The defence ministry's thinking and aspirations for future

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172 Ramm (2021), 'Куда летит беспилотная авиация' [Where unmanned aircraft are flying].
173 Ibid.
174 Galeeva, D. (2021), 'Подписан госконтракт на поставку беспилотников «Альтиус-РУ», созданных в Казани' [A state contract was signed for the supply of 'Altius-RU' drones created in Kazan], Tatar-inform.ru, 20 February 2021, https://www.tatar-inform.ru/news/business/20-02-2021/podpisan-goskontrakt-na-postavku-bespilotnikov-altius-ru-sozdannyh-v-kazani-5808072 (accessed 9 Jul. 2021).
175 Ramm (2021), 'Куда летит беспилотная авиация' [Where unmanned aircraft are flying].
176 Lavrov, A. (2021), 'Закрытое небо: в России создается инновационная система воздушных боев' [Closed sky: Russia is developing an innovative aerial combat], Iz.ru, 24 February 2021, https://iz.ru/1127710/anton-lavrov/zakrytoe-nebo-v-rossii-sozdaetsia-innovatcionnaia-sistema-vozdushnykh-boev (accessed 9 Jul. 2021).
177 Iz.ru (2020), 'Стратегический ракетоносец Ту-95МС отработал управление беспилотником' [Strategic missile carrier Tu-95MS completed drone control tests], 23 December 2020, https://iz.ru/1103388/2020-12-23/strategicheskii-raketonosetc-tu-95ms-otrabotal-upravlenie-bespilotnikom (accessed 9 Jul. 2021).
178 TASS (2020), 'Минобороны решило сделать тяжелый беспилотник 'Охотник' дальним перехватчиком' [The Ministry of Defence decided to make the heavy drone Okhotnik an interceptor], 26 August 2020, https://tass.ru/armiya-i-opk/9299951 (accessed 9 Jul. 2021); Tadviser (2020), '2020: Ударный дрон «Охотник» будет оснащен ИИ' [2020: 'Okhotnik' UCAV will employ AI], 27 August 2020, https://www.tadviser.ru/index.php/Продукт:Охотник_(ударный_дрон) (accessed 9 Jul. 2021); Yuferev, S. (2020), '«Альтиус». Тяжёлый российский беспилотник с искусственным интеллектом' ['Altius'. Heavy Russian drone with artificial intelligence], TopWar.ru, 27 March 2020, https://topwar.ru/169438-altius-tjazhelyjrossijskij-bespilotnik-s-iskusstvennym-intellektom.html (accessed 9 Jul. 2021).
179 BMPD Military Blog (2020), 'Беспилотный летательный аппарат «Гром» в экспозиции форума «Армия-2020»' ['Grom' UAV displayed at 'ARMY-2020' forum], 25 August 2020, https://bmpd.livejournal.com/4122894.html (accessed 9 Jul. 2021); TASS (2021), 'Ударный беспилотник 'Гром' сможет управлять роем из десяти дронов 'Молния'' ['Grom' attack drone will direct a swam of ten Molniya drones], 11 March 2021, https://tass.ru/armiya-i-opk/10876259 (accessed 9 Jul. 2021); *Российская газета* [*Russian Newspaper*] (2021), 'Новые ударные беспилотники "Иноходец-РУ" поступят в войска в 2023 году' [New 'Inokhodets-RU' attack drones will enter service troops in 2023], 26 August 2021, https://rg.ru/2021/08/26/reg-cfo/novye-udarnye-bespilotniki-inohodec-ru-postupiat-v-vojska-v-2023-godu.html (accessed 11 Sep. 2021).

crewed and uncrewed combat can be summarized by the recently-unveiled Su-75 'Checkmate' light fighter jet concept.[180] Its developer, the state corporation Rostec, envisions this aircraft in both crewed and uncrewed versions, with on-board AI for situational awareness and command and control, and capable of flying with UAVs in a coordinated group.[181]

Finally, the Nagorny Karabakh war of 2020 was a striking demonstration of the potential of a conventional military that acts in concert with UCAVs and loitering munition (or 'kamikaze') drones. Like the Syrian conflict, it also laid bare Russia's lack of either UAV class in active service. Following the conclusion of the war, the Russian defence ministry asked the defence-industrial sector to accelerate the development and testing of these drones. Rostec responded by officially announcing in February 2021 that two of its 'kamikaze' drones – the Kub and the Lancet – had been tested in Syria, with the Russian military having priority on their eventual acquisition.[182] Rostec is also planning to incorporate these drones into the new 'aerial mining' concept for both ground and aerial targeting. To do this, loitering munitions like the Lancet fly in an aerial 'net', forming a 'minefield'. When detecting an intruder, these drones then fly at the target, supposedly increasing the chances of success by their sheer numbers.[183]

Current and future robotic ground vehicle development

Russian development of UGVs is driven by the defence ministry's evaluation of the changing nature of ground combat, by the desire to save soldiers' lives, and to make operations more effective. The Russian defence leadership thinks that introducing combat robotic vehicles with troops while developing their combat employment CONOPS will change how military formations accomplish their tactical tasks in battle.[184] By 2021, Russian defence enterprises had manufactured, tested and fielded multiple models such as Platforma-M, Nerehta, Soratnik, Kungas, Scarab, Sphera, Shturm, Udar, Uran-6, Uran-9 and Uran-14, to name but a few.[185] Numerous smaller tracked and wheeled models for ISR and logistics are also being developed for both the military and the security services.[186]

180 Cenciotti, D. (2021), 'Let's Have a Look At All The Latest Claims About 'Checkmate', Russia's New Light Tactical Fighter', TheAviationist.com, 23 July 2021, https://theaviationist.com/2021/07/23/checkmate-latest-claims (accessed 28 Jul. 2021).
181 Ibid.
182 Ramm, A. (2021), '« У России есть своя линейка беспилотников-камикадзе»' ['Russia has its own lineup of kamikaze drones'], Iz.ru, 19 February 2021, https://iz.ru/1126653/aleksei-ramm/u-rossii-est-svoia-lineika-bespilotnikov-kamikadze (accessed 9 Jul. 2021).
183 Tuchkov. V. (2021), 'Барражирующий «Ланцет»' [Loitering 'Lancet'], VPK-news.ru, 22 June 2021, https://vpk-news.ru/articles/62626 (accessed 11 Sep. 2021).
184 TASS (2019), 'Russia launches work on combat robotic vehicle', 24 December 2019, https://tass.com/defense/1103393 (accessed 9 Jul. 2021) (accessed 9 Jul. 2021).
185 Zubov, V. (2018), 'Отечественные Вооруженные Робототехнические Комплексы' [Domestic military robotic complexes], *Обозрение Армии И Флота* [*Army & Navy Review*], no. 3.
186 Ibid.

Table 3. Principal UGV systems deployed by the Russian armed forces

Name	Function	Manufacturer
Platforma-M	Combat UGV	NITI Progress
Nerehta	Combat UGV	Degtyaryov plant and ARF
Soratnik	Combat UGV	Rostec
Kungas	UGV swarm concept	Special Engineering Design Bureau
Scarab	Demining UGV (short-range)	CET-1
Sphera	Demining UGV (short-range)	CET-1
Marker	UGV RDT&E concept	ARF
Uran-6	Demining UGV (short-range)	JSC 766 UPTK (Kalashnikov-Rostec)
Uran-9	Combat UGV (operator is located at up to 4 km from the vehicle)	JSC 766 UPTK (Kalashnikov-Rostec)
Uran-14	Firefighting UGV	JSC 766 UPTK (Kalashnikov-Rostec)
Udar	Combat UGV	Rostec
Prohod -1	Heavy demining UGV	High Precision Weapons JSC
Shturm	Heavy UGV for urban combat	Uralvagonozavod
T-14 Armata	Next-generation main battle tank	Rostec

Note: All systems are mentioned in this chapter.
Source: Edmonds, J., Bendett, S. et al. (eds) (2021), *AI and Autonomy in Russia*, Arlington, VA: CNA, https://www.cna.org/centers/cna/sppp/rsp/russia-ai.

Broadly speaking, there are two main UGV development pathways in Russia today. One features new vehicles developed from scratch, like the demining Uran-6 and combat Uran-9, along with the Soratnik, Nerehta and Marker concepts. The remote-controlled demining Uran-6 UGV took part in operations in Syria to identify and clear unexploded ordnance, improvised explosive devices and other obstacles harmful to military and civilians,[187] and this vehicle is starting to enter Russian service with engineer battalions and demining units.[188] The Marker has a special role as a testing and evaluation platform for further UGV development. ARF, the Marker project lead, is discussing the vehicle as a test bed for computer vision, fully autonomous movement, and swarm control, while testing deep neural networks on the vehicle to assist in decision-making and to perform tasks

187 Novosti VPK (2018), 'Роботы 'Уран-6', 'Скарабей' и 'Сфера' будут приняты на вооружение в 2018 году' ['Uran-6', 'Scarab' and 'Sphera' robots will be put into service in 2018], 23 May 2018, https://vpk.name/news/216049_roboty_uran-6_skarabei_i_sfera_budut_prinyaty_na_vooruzhenie_v_2018_godu.html (accessed 9 Jul. 2021).
188 Ramm, A. (2021), 'Война людей-роботов' [Robo-human combat], NVO.NG.ru, 28 January 2021, https://nvo.ng.ru/realty/2021-01-28/1_1126_war.html (accessed 9 Jul. 2021).

independently.[189] The Marker is built to interact with existing and future UAVs, and the ARF team is testing voice control technology for a MUM-T (manned-unmanned teaming) application.[190] Another key design is the Uran-9 that was tested in Syria in a 'near-combat setting'. There, the vehicle experienced multiple failures in transportation, communication, firing and the operator's situational awareness capabilities.[191] These failures guided defence ministry thinking about future combat UGV development, and influenced the current debate among military experts and developers on the utility of ground robotics in combat – such as using Uran-9-type vehicles in single engagements as part of mixed formations to identify adversary positions, hard points and to draw enemy fire. Today, the Uran-9 is acquired by the Russian military in combat and engineering battalions.[192]

The second UGV development initiative has multiple UGV projects, like the Udar, Prohod-1 and Shturm, which are built on the chassis of tanks and other combat vehicles already in service with the Russian military.[193] For example, the Udar's developer chose the BMP-3 armoured vehicle as the basis for this UGV, based on the BMP-3's already long service and soldiers' familiarity with it. Specifically, the developer, Rostec, noted that creating a UGV like this from scratch would take many years, while vehicle models are already available for redevelopment and experimentation.[194] As planned, Udar is envisaged as part of the ground forces' combat and support units, used both independently and as part of UAV and UGV formations.[195] Another concept, the Shturm heavy unmanned combat vehicle, is based on a T-72 tank chassis, one of the most widespread across the Russian military. The defence ministry took over the Shturm's development in 2019 in order to turn it into an urban combat vehicle, and in August 2021 signed the first acquisition contract.[196]

A further example of a UGV based on an existing platform is the Prohod-1 heavy demining vehicle, based on a T-90 tank chassis.[197] This type of UGV RDT&E also includes ongoing tests of the T-14 Armata main battle tank, along with self-propelled combat systems, for potential autonomous and semi-autonomous operations. Recently, the Uralvagonozavod enterprise, which builds the majority of Russian tanks, announced work on unmanned armoured vehicle concepts based on tank platforms, highlighting the utility of working with available and proven technology to create next-generation fighting systems.[198]

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189 TASS (2020), 'Олег Мартьянов: в будущем будет не армия терминаторов, а армия умных 'Маркеров" [Oleg Martyanov: there won't be an army of terminators. There will be an army of 'Markers'], 29 June 2020, https://tass.ru/interviews/8831445 (accessed 9 Jul. 2021).
190 Ibid.
191 BMPD Military Blog (2018), 'Проблемные вопросы развития робототехнических комплексов военного назначения' [Problematic issues of the development of military robotic systems], 16 June 2018, https://bmpd.livejournal.com/3239351.html (accessed 9 Jul. 2021).
192 Ramm, A. (2021), 'Война людей-роботов' [Robo-human combat].
193 CNA (2021), *Artificial Intelligence in Russia*, newsletter: issue 21, 26 February 2021, https://www.cna.org/CNA_files/PDF/DOP-2021-U-029296-Final.pdf (accessed 9 Jul. 2021).
194 Latyshev, A. and Komarova, E. (2021), '«Гарантирует сохранность жизни людей»: что представляет собой созданный на базе БМП-3 российский боевой робот «Удар»' ['Guarantees the safety of people's lives': Russian 'Udar' combat robot created on the basis of the BMP-3], RT, 12 February 2021, https://russian.rt.com/russia/article/831267-rossiya-armiya-udar-robot (accessed 9 Jul. 2021).
195 Ibid.
196 TASS (2019), 'Russia launches work on combat robotic vehicle'; TASS (2021), 'Минобороны РФ заключило первый контракт на робототехнический комплекс "Штурм"' [The Russian Ministry of Defence signed the first contract for the Shturm robotic complex], 24 August 2021, https://tass.ru/armiya-i-opk/12205511 (accessed 11 Sep. 2021).
197 CNA (2021), *Artificial Intelligence in Russia* newsletters.
198 TASS (2021), "Уралвагонзавод' работает над созданием беспилотной бронетехники' ['Uralvagonozavod' is working on unmanned armored vehicles], 21 February 2021, https://tass.ru/armiya-i-opk/10755979 (accessed 9 Jul. 2021).

In arguing for using existing vehicle platforms over newly created ones, Russian military commentators note that such platforms are both larger and better protected.[199] UGV logistics play another role in this debate, with experts arguing that smaller vehicles need to be delivered and unloaded for combat, while the likes of the Udar are fully-fledged armoured vehicles that can already operate in conventional motorized rifle units.[200] Other Russian military analysts debate whether the current UGV crop should be used in combat in the first place. Some analysts argue that UGVs like the Uran-9 should be used only in a limited capacity, such as in low-intensity conflict or reconnaissance missions,[201] since Uran-9-like systems would be 'annihilated by heavy artillery fire' in battles where a significant amount of armoured vehicles are used by both sides, given that this UGV's dexterity and manoeuvrability would be inferior to those of specialized crewed units.[202]

With the imagined clash of Russian military robots against enemy counterparts potentially still many years away, the Russian defence ministry has time to further formulate concepts for its growing unmanned ground vehicle combat force requirements.

Despite the development of multiple UGV types, the defence ministry and the Russian military expert community conceptualize their eventual autonomous use in combat, with the vehicles navigating in an unstructured environment and performing tasks in accordance with targets they have been assigned, without direct human participation.[203] This would presumably be accomplished with the help of AI, as the ongoing Marker RDT&E demonstrates. The next logical step for the defence ministry is to test the combination of these and other unmanned vehicles in combined formations to evaluate their capabilities. To that end, the ministry recently announced it would be standing up a unit of 20 Uran-9 UGVs to study their application in combat over the next few years. The lessons from this testing and evaluation will inform the ministry's drafting of concepts for the applications of military robotics, adding to the data acquired via other UGV and UAV projects discussed in this section.[204] With the imagined clash of Russian military robots against enemy counterparts potentially still many years away, the Russian defence ministry has time to further formulate concepts for its growing UGV combat force requirements.

199 Latyshev and Komarova (2021), '«Гарантирует сохранность жизни людей»: что представляет собой созданный на базе БМП-3 российский боевой робот «Удар»' ['Guarantees the safety of people's lives': Russian 'Udar' combat robot created on the basis of the BMP-3].
200 Ibid.
201 Tuchkov, V. (2021), 'Искусственный интеллект за рычагами танка' [AI behind the controls of a tank], VPK-news.ru, 11 January 2021, https://vpk-news.ru/articles/60333 (accessed 9 Jul. 2021).
202 Ibid.
203 Murakhovsky, V. (2021), Telegram post, 28 May 2021, https://t.me/Viktor_Murakhovskiy/93 (accessed 28 Jul. 2021).
204 TASS (2021), 'Russian Army to set up first military unit armed with strike robots', 9 April 2021, https://tass.com/defense/1276039 (accessed 9 Jul. 2021).

Current and future maritime robotic vehicle development

For the Russian military, maritime unmanned and autonomous technology today has an overarching ISR scope – to obtain data on the undersea environment and to inform related surface, aerial, undersea or land-based components. Future envisioned roles involve situational awareness as part of anti-submarine (ASW) and counter-mine (CMW) warfare operations, along with the protection of key naval assets such as port facilities.[205] A growing share of Russian unmanned underwater vehicles (UUVs) may acquire combat roles to identify, track and engage adversary assets below and above the surface. Ultimately, the Russian navy has plans to equip its vessels with surface and subsurface (along with aerial) robotic complements, making each ship a potential carrier and user of unmanned and autonomous technology.[206] Another key principle that guides Russia's unmanned naval RDT&E is the increasing general automation in the maritime domain.[207] The latest Russian development proposals highlight equipping vessels and carriers with a high degree of automation and the use of robotic systems.[208]

Russia's proposals for combat maritime autonomy include the much-discussed Poseidon nuclear-capable UUV (see Chapter Three for more details).[209] Another potential combat design is the supposedly anti-submarine Cephalopod UUV,[210] which is possibly intended for escort and guard duties.[211] Finally, the Surrogat UUV can reproduce an acoustic and electromagnetic signature that either mimics an adversary or a Russian submarine, to draw enemy assets out or hide Russian vessels from detection.[212]

Russia's multiple ISR UUV projects point to the desire to acquire data and information across the undersea domain. This includes the Vityaz deep-water autonomous vehicle, which reached the bottom of the Mariana Trench in 2020.[213]

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205 Gizitdinova, M. R. and Cherkasov, S. M. (2008), 'Роль Мобильных Подводных Роботов В Решении Задач Военно-Морского Флота' [Role Of Mobile Submarine Robots In Solving The Tasks Of The Navy], *Военная мысль* [*Military Thought*], no. 1, January 2008: pp. 16–21; RIA Novosti (2018), 'В ФПИ оценили перспективы использования роботов для охраны морских границ' [ARF reviewed the possibility of using robots to defend nation's borders], 17 January 2018, https://ria.ru/science/20180117/1512760432.html?inj=1 (accessed 9 Jul. 2021).
206 TASS (2019), 'Седьмой тральщик проекта 12700 заложат в Петербурге в июле' [7th Project 12700 trawler will be laid in St Petersburg in July], 10 April 2019, https://tass.ru/ekonomika/6318333 (accessed 9 Jul. 2021); Valchenko, S. and Surkov, N. (2018), '«Горшковы» получат роботов-помощников' ['Gorshkovs' will receive robotic assistants], Iz.ru, 7 February 2018, https://iz.ru/697285/sergei-valchenko-nikolai-surkov/gorshkovy-poluchat-robotov-pomoshchnikov (accessed 9 Jul. 2021).
207 Flot.com (2021), 'Главком ВМФ рассказал о подготовке экипажей новых кораблей' [The Commander-in-Chief of the Russian Navy spoke about the crew training], 14 January 2021, https://flot.com/2021/Вмф1 (accessed 9 Jul. 2021).
208 TASS (2021), 'Невское ПКБ представило проект универсального морского корабля 'Варан" [Nevsky Design Bureau unveils unique 'Varan' ship concept], 18 January 2021, https://tass.ru/armiya-i-opk/10488643 (accessed 9 Jul. 2021).
209 Vesti.ru (2018), 'Подводные беспилотники 'Посейдон' поступят в ВМФ России до 2027 года' ['Poseidon' underwater drones will enter service before 2027], 12 May 2018, https://www.vesti.ru/doc.html?id=3016466 (accessed 9 Jul. 2021).
210 Sutton, H. I. (2019), 'Cephalopod', H.I. Sutton website, 27 July 2018, http://www.hisutton.com/Cephalopod.html (accessed 9 Jul. 2021).
211 Ivanin, A. (2020). 'Цефалоподы атакуют косаток' [Cephalopods are attacking killer whales], NVO.NG.ru, 17 September 2020, https://nvo.ng.ru/nvo/2020-09-17/1_1109_robots.html (accessed 9 Jul. 2021).
212 Yudina, A. (2018), 'Гид по самым секретным подводным роботам России' [Guide to the most secret Russian underwater robots], TASS, 26 July 2018, https://tass.ru/armiya-i-opk/5402375 (accessed 9 Jul. 2021).
213 RIA Novosti (2020), 'Аппарат 'Витязь' стал первым 'роботом', достигшим дна Марианской впадины' [Vityaz is the first robot to descend to the bottom of the Mariana Trench], 9 May 2020, https://ria.ru/20200509/1571206567.html?in=t (accessed 9 Jul. 2021).

ARF, one of its developers, highlighted that Vityaz's complete autonomy via AI allowed the vehicle to carry out undersea tasks.[214] Another AI-enabled project is the Galtel underwater vehicle, which was tested by the military in Syria in late 2017 and early 2018[215] in order to map out the Tartus port area.[216] Another deep-water ISR project is the Klavesin-2R-PM, designed to reach a depth of 6,000 metres.[217] There are multiple smaller UUV models undergoing different stages of RDT&E for mid- to long-term operation.[218]

Table 4. Principal UUV systems deployed by the Russian armed forces

Name	Function	Manufacturer
Poseidon	Long-range combat underwater vehicle	Rubin and Malahit design bureaux
Cephalopod	Combat UUV	Rubin Design Bureau
Surrogat	Combat UUV	Rubin Design Bureau
Vityaz	ISR UUV	ARF and Rubin Design Bureau
Galtel	ISR UUV	Institute of Marine Technology Problems (RAS)
Klavesin-2R-PM	ISR UUV	Rubin Design Bureau
Sarma	Long-range ISR UUV	ARF and Lazurit
Inspektor MK-2	Mine countermeasures USV	ECA Group (France)
Iskatel	Mine countermeasures and ISR USV	Research and Production Enterprise 'Aviation and Marine Electronics'
Skanda	Mine countermeasures and ISR USV	Mnev and Co. Shipbuilding
Buk-600	Mine countermeasures and ISR USV	Peter the Great St. Petersburg Polytechnic University

Note: All systems are mentioned in this chapter.
Source: Edmonds, J., Bendett, S. et al. (eds) (2021), *AI and Autonomy in Russia*, Arlington, VA: CNA, https://www.cna.org/centers/cna/sppp/rsp/russia-ai.

214 Ibid.
215 Interfax AVN (2018), 'Подводный робот 'Галтель' успешно выполнил боевую задачу в Сирии – член коллегии ВПК' [Galtel UUV successfully completed its mission in Syria – member of the Military-Industrial Commission], 22 February 2018, http://www.militarynews.ru/story.asp?rid=1&nid=474342 (accessed 9 Jul. 2021).
216 *Российская газета* [*Russian Newspaper*] (2018), 'Российский подводный робот выполнил боевую задачу в Сирии' [Russian underwater robot completed its military mission in Syria], 22 February 2018, https://rg.ru/2018/02/22/rossijskij-podvodnyj-robot-vypolnil-boevuiu-zadachu-v-sirii.html (accessed 9 Jul. 2021).
217 Yudina (2018), 'Гид по самым секретным подводным роботам России' [Guide to the most secret Russian underwater robots].
218 Yudina (2018), 'Гид по самым секретным подводным роботам России' [Guide to the most secret Russian underwater robots]; Moiseev, A. and Surkov, N. (2016), 'Минобороны получит сверхавтономный подводный планер' [MOD will get a super-autonomous underwater glider], Iz.ru, 19 December 2016, http://izvestia.ru/news/651540 (accessed 9 Jul. 2021).

The exploration and securing of multiple natural assets in the Arctic region likewise guides defence ministry development of autonomous maritime systems. In 2019, the ARF unveiled the long-range Sarma UUV project for the Northern Sea Route, designed to cover long distances without surfacing and without external communication with satellites in order to conduct situational awareness and ISR duties.[219] Recently, the Rubin Design Bureau and the ARF unveiled the 'Iceberg' concept, which includes crewed and uncrewed vehicles for seismic prospecting, drilling, energy and hydrocarbon production in the Arctic in the near future.[220] Envisaged as a civilian project to give Russia the advantage in the Arctic hydrocarbons race, it could provide the military with additional ISR capabilities on this region. Finally, the defence ministry is designing an underwater microbot swarm that can work in Arctic conditions for hours at a time.[221]

The exploration and securing of multiple natural assets in the Arctic region guides defence ministry development of autonomous maritime systems.

At the same time, Russia's debate about unmanned surface vehicle development is dominated by divisions over the utility of foreign imports and domestic technical capabilities.[222] Russian naval end-users were supposedly unhappy with the French Inspektor Mk 2 unmanned surface vehicle (USV) acquired for the Project 12700 minesweeper, citing manufacturer's defects.[223] The Russian defence industry has since unveiled domestic USV prototypes.[224] Since 2017, the Russian navy has tested several USVs designed for minesweeper vessels, such as the Iskatel,[225] Skanda,[226] and Buk-600 models,[227] which have various degrees of autonomy, for C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance).[228] It should be noted that among Russia's many ongoing UUV and USV projects, only the Galtel maritime robotic system has been used in a combat environment, in stark contrast to the multiple Russian UAVs and UGVs that were tested in Syria for further evaluation and development.

219 RIA Novosti (2018), 'В России началось строительство сверхдальнего морского беспилотника 'Сарма'' [Russia started the construction of Sarma long-range UUV], 24 October 2018, https://ria.ru/defense_safety/20181024/1531327404.html (accessed July 2021).
220 Yudina, A. (2017), 'Главный конструктор ЦКБ 'Рубин': мы создаем подводный город для освоения богатств Арктики' [Rubin's Chief Designer: we are creating an underwater city in order to get to Arctic riches], TASS, 20 September 2017, https://tass.ru/interviews/4572997 (accessed 9 Jul. 2021).
221 Yudina, A. (2017), 'Центр робототехники Минобороны РФ: в Арктике появятся микророботы 'карманного' формата' [MOD's Robotics Center: 'pocket'-sized drones will appear in the Arctic], TASS, 24 August 2017, https://tass.ru/interviews/4502372 (accessed 9 Jul. 2021).
222 ECA Group (undated), 'Inspector 90/USV/Unmanned Surface Vehicle', http://www.ecagroup.com/en/solutions/unmanned-surface-vehicle-inspector-mk2 (accessed 9 Jul. 2021).
223 Valagin, A. (2019), 'Беспилотный катер для ВМФ испытают в Черном море' [A USV will be tested in the Black Sea for the Russian Navy], *Российская газета* [*Russian Newspaper*], 27 February 2019, https://rg.ru/2019/02/27/reg-ufo/bespilotnyj-kater-dlia-vmf-ispytaiut-v-chernom-moreispytaniia.html (accessed 9 Jul. 2021).
224 Ibid.
225 BMPD Military Blog (2017), 'Безэкипажный катер 'Искатель' на испытаниях в Кронштадте' ['Iskatel' USV tested in Kronstadt], 12 July 2017, https://bmpd.livejournal.com/2725709.html (accessed 9 Jul. 2021).
226 BMPD Military Blog (2018), 'Безэкипажный катер 'Сканда' российской разработки' [Russian 'Skanda' USV], 5 August 2018, https://bmpd.livejournal.com/3294327.html (accessed 9 Jul. 2021).
227 Flotprom.ru (2018), 'Безэкипажный катер 'Бук-600' представят на МВМС-2019' ['Buk-600' USV will be presented at the MVMS-2019], 28 September 2018, https://flotprom.ru/2018/Мвмс3 (accessed 9 Jul. 2021).
228 Ibid.

Conclusions

In the immediate future, the Russian military will continue to build out its UAV fleet capabilities, incorporating and increasing swarm and 'loyal wingman' abilities that tie together piloted and uncrewed systems for greater striking range and better situational awareness. Russia's reconnaissance-fire and reconnaissance-strike contours pose the greatest challenge to adversary forces, given Russia's continuing efforts to refine UAV use in practically all major units and formations. As the Russian long-range UCAV capabilities will grow, so will Russia's ability to deliver strikes against ground and aerial targets at greater distances, increasing the defence ministry's combat reach. Just as important is the impending proliferation of Russian combat and ISR drones, giving the Russian industry access to new markets and new data on their potential use against US assets and allies.[229] The Russian defence ministry will also continue to experiment with UAV–UGV teaming for more effective battlefield management. In the near term, the UGV testing space will help define how Russian ground forces could fight future wars, and whether such systems can function effectively with manned formations. This trend is exemplified by the use of UGVs and UAVs in September 2021 during the Zapad-2021 military exercises, with the Russian military using Uran-9 UGVs for combat reconnaissance and fire support, Uran-6s for demining operations, Nerehta UGVs for reconnaissance and fire support, and Platforma-M for urban combat missions and passing through minefields.[230] Specifically, Uran-9 and Nerehta UGVs were used in the combat formations of combined arms units. Additionally, the Russian military used Orlan-10 and Forpost UAVs for ISR and target acquisition missions, while Forpost and Orlan-10 combat versions, together with an Orion UCAV, were used for the first time in support of ground attacks.[231]

Russia's ability to manufacture and test deep-diving UUVs presents one of the growing challenges to Western and NATO forces, as the defence ministry will seek to gain better situational awareness below the waves, while crafting an unmanned systems doctrine that could challenge Western surface and sub-surface assets. At the same time, the Russian navy is far from the mass use of such systems, in contrast to the nearly-ubiquitous aerial drone use. If the Russian military succeeds in designing a multi-domain robotic swarm, it could potentially challenge current Western military superiority by forcing NATO to expend its assets on low-cost Russian robotic systems.

At the same time, unmanned and autonomous technologies were not used in a true peer conflict until the Nagorny Karabakh war of 2020. Today, the US, NATO and Russian forces are testing and using their autonomous technologies against mostly

229 RIA Novosti (2021), 'Компания "Кронштадт" рассказала об экспортных контрактах по ударным дронам' [The Kronstadt company discussed export contracts for attack drones], 1 September 2021, https://ria.ru/20210901/kontrakty-1748141698.html (accessed 11 Sep. 2021).
230 Finance.Rambler.ru (2021), '" Запад-2021": Россия впервые применила два новых ударных робота' ['Zapad-2021': Russia used new combat robots for the first time], 14 September 2021, https://finance.rambler.ru/other/47196990/-zapad-2021-rossiya-vpervye-primenila-dva-novyh-udarnyh-robota (accessed 14 Sep. 2021).
231 RIA Novosti (2021), 'Ударные беспилотники "Иноходец" и "Форпост" впервые применили на практике' ['Inokhodets' and 'Forpost' strike drones were first used in practice], 13 September 2021, https://ria.ru/20210913/bespilotniki-1749891464.html (accessed 14 Sept. 2021); Voennoe (2021), 'Беспилотник "Ласточка" вооружили управляемой миной "Грань"' [UAV 'Swallow' armed with a guided mine 'Gran'], 13 September 2021, https://xn--b1aga5aadd.xn--p1ai/2021/%D0%A3%D1%87%D0%B5%D0%BD%D0%B8%D1%8F5 (accessed 14 Sep. 2021).

militarily inferior and low-tech adversaries. In the future, the Russian military will continue to refine its robotics technologies and will upgrade its proposed plans for integrating these systems with manned formations to train for a conflict against a peer adversary. On 21 May 2021 Russian defence minister Sergey Shoigu announced that his country had commenced mass production of military robots with AI that can fight autonomously.[232] He did not specify which vehicles he was referring to, and the military expert community debated which of the systems described in this chapter may have been implied in Shoigu's statement.[233] Regardless of which vehicles may eventually fit Shoigu's definition, this chapter has discussed multiple projects undertaken by the defence ministry in order to develop technologies that could give Russian forces a battlefield advantage. Should such efforts prove successful, the defence ministry's investments may result in a force structure that would be better positioned to engage its adversary via a range of unmanned and autonomous systems that are first to the fight, do not carry a human cost in case of a failed mission, and can provide a better situational awareness of the adversary's forces and intentions.

These developments are not a foregone conclusion, given the Russian military industry's ongoing struggles with key manufacturing components for autonomous systems, such as microelectronics and engines.[234] Nonetheless, Russia's mass manufacturing of, and experimentation with, different types of military autonomous systems signals a readiness to change how it conducts military operations, with speed, effectiveness, precision and massed use as the ultimate goals. To address these impending changes to military CONOPS, the US and its European allies should continue to experiment with, and conduct an ongoing analysis of, robotic technologies for gaining a key edge in this emerging technological race. Just as important in the future will be the ability to develop training against adversarial capabilities that is part of an objective evaluation of Russian military robotics CONOPS and TTPs.

232 RIA Novosti (2021), 'Шойгу заявил о производстве в России серийных боевых роботов' [Shoigu announced mass military robot production in Russia], 21 May 2021, https://ria.ru/20210521/robot-1733352974.html (accessed 9 Jul. 2021).
233 Ibid.
234 Hodarenok, M. (2020), 'Впереди даже Турция: Россия проспала беспилотную революцию' [Even Turkey is ahead: Russia slept through the drone revolution], Iz.ru, 1 November 2020, https://www.gazeta.ru/army/2020/10/31/13340929.shtml (accessed 9 Jul. 2021).

06 Military applications of artificial intelligence: the Russian approach

Russia's approach to military AI prioritizes technologies and capabilities that can be used to debilitate the adversary's command, control and communications systems, as well as gain information superiority.

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Since his appointment as defence minister in 2012, Sergey Shoigu, in close coordination with President Vladimir Putin, has successfully shepherded the Russian military modernization effort, with notable accomplishments in 'the procurement of modern radars, communications equipment, electronic warfare [EW] systems, robotics, unmanned aerial vehicles [UAVs], and high-precision strike assets'.[235] Now, as Shoigu recently proclaimed, 'it is necessary to ensure the introduction of artificial intelligence [AI] technologies in weapons that determine the future appearance of the Armed Forces'.[236]

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235 McDermott, R. (2020), 'Shoigu's Image of Russia's Armed Forces: Mobile, Modern and Efficient', The Jamestown Foundation, 27 March 2020, https://jamestown.org/program/shoigus-image-of-russias-armed-forces-mobile-modern-and-efficient (accessed 9 Jul. 2021).
236 Ministry of Defence of the Russian Federation (2021), 'The Russian Defence Minister opened an operational mobilization session with the leadership of the Armed Forces', 9 February 2021, http://eng.mil.ru/en/news_page/country/more.htm?id=12343091@egNews (accessed 9 Jul. 2021).

The Russian defence establishment is quite enthusiastic about the potential of AI. Over the past few years, the defence ministry has set up a network of research and development (R&D) organizations spanning the military-industrial complex, academia and the private sector to continue work on military robotics and the integration of AI into military systems. [237] Moreover, over 600 new weapons and other items of military equipment have been tested in combat conditions in Syria, with 200 of these items being described as 'next-generation'.[238]

Western national security decision-makers would be unwise to discount Russia's potential to use AI-enabled technologies in ways that undermine US and NATO interests.

Western observers, however, are generally sceptical of Russia's potential in emerging technologies. Russia spends much less on R&D than either the US or China, in terms of both overall value and share of GDP.[239] The private-sector AI ecosystem is relatively small, and there are real problems with talent development and retention.[240] Russia's AI-related research also lags behind the US and China. For example, between 2010 and 2018, compared to Russian researchers, US researchers published 58 times the number of papers indexed under machine learning (ML) and 42 times the number exploring computer vision.[241] Russia's micro-electronics industry – the hardware on which all AI runs – is nascent, and despite recent efforts to implement an import substitution strategy, the country's civilian technology sector is still heavily reliant on semiconductor equipment from the US, Taiwan and South Korea.[242]

These challenges notwithstanding, Western national security decision-makers would be unwise to discount Russia's potential to use AI-enabled technologies in ways that undermine US and NATO interests. Russian strategists see remotely operated, automatic, autonomous, and AI-enabled technologies as augmenting both traditional and more recently developed advantages in intelligence, surveillance, and reconnaissance (ISR) capabilities, EW, cyber warfare, information operations, and ground-based fires. But how these new

237 Galkin, D. V., Kolyandra, P. A. and Stepanov, A. V. (2021), 'The Condition and Use Prospects of Artificial Intelligence in Military Affairs', *Военная мысль* [*Military Thought*], January 2021, pp. 113–24, https://vm.ric.mil.ru/upload/site178/8sGnTJ8GHJ.pdf (accessed 9 Jul. 2021); For updates on Russia's AI developments, see the *Artificial Intelligence in Russia* newsletters, published by CNA, https://www.cna.org/centers/cna/sppp/rsp.
238 Bybelezer, C. (2018), 'How Russia is using Syria as a military 'guinea pig'', *The Jerusalem Post*, 28 February 2018, https://www.jpost.com/Middle-East/How-Russia-is-using-Syria-as-a-military-guinea-pig-543839 (accessed 9 Jul. 2021).
239 Kudrin, A., Radygin, A. and Sinelnikov-Murylev, S. (eds) (2019), *Russian Economy in 2018: Trends and Outlooks*, Gaidar Institute Publishers, Issue 40: pp. 461–3, https://www.iep.ru/files/text/trends/2018-eng/Book.pdf (accessed 9 Jul. 2021); UNESCO Institute for Statistics (2021), 'How much does your country invest in R&D?', http://uis.unesco.org/apps/visualisations/research-and-development-spending (accessed 20 February 2021).
240 Dear, K. (2019), 'Will Russia Rule the World Through AI? Assessing Putin's Rhetoric Against Russia's Reality', *The RUSI Journal,* 164(5–6): pp. 36–60, https://doi.org/10.1080/03071847.2019.1694227.
241 Konaev, M. and Dunham, J. (2020), *Russian AI Research 2010–2018*, Center for Security and Emerging Technology, October 2020, https://doi.org/10.51593/20200040 (accessed 9 Jul. 2020).
242 Petrella, S., Miller, C. and Cooper, B. (2020), 'Russia's Artificial Intelligence Strategy: The Role of State-Owned Firms', *Orbis*, Winter 2021, 65(1): pp. 75–100, https://sites.tufts.edu/hitachi/files/2021/02/1-s2.0-S0030438720300648-main.pdf (accessed 9 Jul. 2021).

technologies may be employed is equally important, with a high priority being placed on disrupting and destroying the adversary's command-and-control systems and communication capabilities, and a focus on non-military means to establish information superiority during the initial period of war, expanding far into peacetime.

The US and its NATO allies have taken some steps to counter Russia's more advanced systems and capabilities, including enhancing their EW capabilities; modernizing and hardening command, control, and communications infrastructure; and developing technologies to counter unmanned aerial systems. But the strategic thinking behind these solutions and the operational concepts guiding their potential use could be improved by contextualizing Russian AI-enabled technologies and capabilities within the broader framework of Russia's way of war.

The chapter proceeds in three parts. The first section reviews the key guiding concepts and principles in Russia's way of war and the role played therein by emerging technologies and capabilities. The second section covers the key areas for AI and ML investments, focusing specifically on EW, unmanned systems and information warfare. The last section assesses the implications Russian advances in military AI could have for the US and NATO.

Guiding concepts and principles

Russia considers itself both a great power and a nation that is embroiled in an asymmetric competition with more powerful great powers, specifically the US and NATO. The Russian General Staff has therefore repeatedly expressed interest in developing technologies and capabilities that can serve as force multipliers and be employed as asymmetric responses against high-tech adversaries.

While Russia's military posture is primarily defensive, in the event of a major conflict Russian forces aim to disorient and disrupt the adversary, preventing it from operating in its preferred fashion and slowing its ability to respond to developments on the battlefield. Russia's emphasis on deception, EW and strikes against command and control, as well as layered air defences and ground-based fires, all play into the broader operational and tactical conception of a disjointed battle.[243] The current focus on the development of UAVs, ISR capabilities, and EW that combine to make the battlefield more visible and controllable and allow Russian forces to mass fires quickly and effectively fits these objectives.

Beyond making the armed forces more mobile, modern, and efficient, Russia's investments in new technologies also aim to enable a successful confrontation via non-military means during crisis, establishing information superiority over

243 Boston, S. and Massicot, D. (2017), 'The Russian Way of Warfare: A Primer', RAND Corporation, https://www.rand.org/content/dam/rand/pubs/perspectives/PE200/PE231/RAND_PE231.pdf (accessed 9 Jul. 2021).

the adversary during the initial period of war.[244] Technological developments have now made it possible to deploy cyber and information tools into foreign systems and societies in peacetime – to conduct reconnaissance, plant viruses and execute wide-scale, targeted information operations.[245]

In this context, the integration of ML techniques into cyber operations could potentially augment existing Russian strengths, enhancing the country's ability to influence and manipulate potential opponents, undercut democratic institutions, disrupt and disable critical infrastructure, and stir chaos and discord along an array of political and societal vectors.[246] Such efforts can significantly undermine Russia's potential adversaries' abilities to organize, mobilize, command and conduct military operations, and, from the Russian perspective, are inherently intertwined with the more conventional aspects of war.

Key areas for AI and machine-learning investments

Russian leaders and military strategists identify a broad range of areas for the employment of AI, including command and control, robotic systems, EW, cyberspace and information warfare, military logistics, training, health and medicine, and forecasting.[247] While the Western – and especially American – culture of innovation is marked by high levels of tech optimism and a tendency to view and use cutting-edge technologies as a solution to tactical and strategic problems, Russia's approach to military applications of AI is more utilitarian and pragmatic.[248] AI technologies are largely discussed as enablers and amplifiers of established, albeit continuously evolving, means and methods of warfare – reflecting an evolutionary rather than revolutionary approach to emerging technologies.[249]

The discussion below elaborates on three key areas where investments in AI fit into the broader framework of Russia's way of war and could have implications for the US and NATO.

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244 Kofman, M. (2018), 'The Role of Pre-Conflict Conflict and the Importance of the Syrian Crucible', *Current Russia Military Affairs*, United States Army War College, July 2018, pp. 21–25, https://publications.armywarcollege.edu/pubs/3545.pdf (accessed 9 Jul. 2021); Chekinov, S. G. and Bogdanov, S. A. (2012), 'Initial Periods of War and their Influence on a Country's Preparation for Future War', *Военная мысль* [*Military Thought*], no. 11, pp. 14–27; Thomas, T. L. (2019), *Russian Military Thought: Concepts and Elements*, MITRE, August 2019, https://www.mitre.org/sites/default/files/publications/pr-19-1004-russian-military-thought-concepts-elements.pdf (accessed 9 Jul. 2021).
245 Thomas (2019), *Russian Military Thought: Concepts and Elements*; Chekinov and Bogdanov (2012), 'Initial Periods of War and their Influence on a Country's Preparation for Future War'.
246 Thomas, T. L. (2020), 'Information Weapons: Russia's Nonnuclear Strategic Weapons of Choice', *The Cyber Defense Review*, 5(2): pp. 125–144.
247 Galkin, Kolyandra and Stepanov (2021), 'The Condition and Use Prospects of Artificial Intelligence in Military Affairs'.
248 Lake, D. (2012), 'Technology, Qualitative Superiority, and the Overstretched American Military', *Strategic Studies Quarterly*, December 2012, 6(4): pp. 71–99.
249 Grau, L. and Bartles, C. (2016), 'The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces', *Foreign Military Studies Office*, pp. 378–9, https://www.armyupress.army.mil/Portals/7/Hot%20Spots/Documents/Russia/2017-07-The-Russian-Way-of-War-Grau-Bartles.pdf (accessed 9 Jul. 2021).

Electronic warfare

Since 2009, Russia has made significant strides in developing its EW capabilities, with investments in this area representing a critical aspect of a broader effort to implement the Ministry of Defence's network-centric warfare vision through C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) integration.[250] Currently, Russia has a range of highly mobile EW systems in its arsenal, and at least one has been publicly discussed as having AI capabilities.[251]

According to news reports, the RB-109A Bylina EW system is an automated decision-support system, capable of independently identifying and selecting targets such as radio stations, communication systems, radars, satellites, and other facilities, and deciding how to suppress them and what jamming stations to use. The system then issues the relevant sequence of orders by automatically interfacing with battalion and company command posts and individual radio-electronic warfare (REB) stations, conducting its operations without interfering with friendly REB stations.[252]

In the summer of 2018, the Bylina, as well as three other distinct EW systems, were spotted in the Donbas region of Ukraine, where they were presumed to be providing 'valuable information and experience to the Russian Armed Forces for future conflicts'.[253] In April 2020, *Izvestiya* reported that the defence ministry had approved plans to deliver Bylina systems to military units by 2025. According to experts cited in the newspaper, the systems could 'increase the efficiency of EW by 40%–50%'.[254]

Russia's investments in EW capabilities seek to take advantage of the fact that most US and NATO military systems and weapons are hooked to satellite communications, Global Positioning System (GPS) navigation, and high-bandwidth internet. The integration of AI into EW systems could enhance Russia's already notable capabilities in this area, providing the ability to make faster decisions while simultaneously suppressing the opponent's decision-making abilities.

For example, integrating AI into EW systems could improve EW effectiveness by more accurately classifying signals, helping translate massive amounts of data into actionable intelligence, concentrating attention on the most important

250 McDermott, R. (2017), 'Russia's Electronic Warfare Capabilities to 2025: Challenging NATO in the Electromagnetic Spectrum', *International Centre for Defence and Security*, https://icds.ee/wp-content/uploads/2018/ICDS_Report_Russias_Electronic_Warfare_to_2025.pdf (accessed 9 Jul. 2021).
251 Sukhankin, S. (2017), 'Russia Introduces EW Spetsnaz to Western Military District', The Jamestown Foundation, 7 November 2017, https://jamestown.org/program/russia-introduces-ew-spetsnaz-western-military-district (accessed 9 Jul. 2021).
252 Thomas, T. (2020), 'Russia's Electronic Warfare Force: Blending Concepts With Capabilities', MITRE, 10 September 2020, https://www.mitre.org/sites/default/files/publications/pr-19-2714-russias-electronic-warfare-force-blending-concepts-with-capabilities.pdf (accessed 9 Jul. 2021).
253 DFRLab (2018), '#MinskMonitor: New Russian Electronic Warfare Systems in Eastern Ukraine', 22 August 2018, https://medium.com/dfrlab/minskmonitor-new-russian-electronic-warfare-systems-in-eastern-ukraine-5b913afbb455 (accessed 9 Jul. 2021).
254 Interfax (2020), 'Defense Industry; Russian Armed Forces to be Supplied with AI-Based Electronic Warfare Systems – Media', *Russia & CIS Military Information Weekly,* 17 April 2020; Ramm, A. (2020), 'Видит цель: «Былина» сможет атаковать противника без участия оператора' [Target visible: 'Bylina' will be able to attack the enemy without the participation of an operator]; *Izvestiya*, 16 April 2020, https://iz.ru/1000101/aleksei-ramm-bogdan-stepovoi/vidit-tcel-bylina-smozhet-atakovat-protivnika-bez-uchastiia-operatora (accessed 28 Jul. 2021).

signals, and developing a clear sense of the electromagnetic environment and how it looks from a friendly, neutral, or adversarial perspective.[255] Some experts, however, are highly sceptical of Russia's ability to develop modern AI algorithms and do not foresee 'sudden, significant improvement in AI-enabled EW from Russia' that would provide its forces with an overwhelming advantage.[256]

Unmanned systems

As the smart software behind autonomous physical systems, AI has the potential to increase the speed, persistence, reach and endurance of unmanned systems in the air, on the ground, under water and in space, as well as to enhance coordination in both human–machine teams and between multiple unmanned systems.[257] Technological breakthroughs that enable a shift from remotely operated unmanned systems to AI-enabled autonomous systems could also allow for a broader range of missions in denied and hostile environments, all while minimizing the risk to military personnel.[258] While the topic of unmanned systems is discussed at length in Chapter Five of this paper, the section below summarizes some of the Russian military thinking and advances in AI in unmanned systems.

Outside of experimental prototypes, all of Russia's current UAVs and unmanned ground vehicles (UGVs) are remotely operated. Russian strategists, however, anticipate that AI will play an increasingly larger role in air combat platforms, which may lead to the development of fully autonomous combat systems.[259] Some even foresee the greater robotization of war, and future warfare involving more machines and 'not soldiers shooting at each other on the battlefield'.[260] But in the near future, there is a greater emphasis on human–machine teaming and 'the rational combination of the capacities of soldiers and military hardware'.[261] Russia's approach to robotization predominantly entails 'grafting robotic capabilities to existing platforms', rather than 'trying to develop completely new systems'.[262]

255 Stefanick, T. (2019), 'AI in the Aether: Military Information Conflict' in Rugge, F. (2019), *The Global Race for Technological Superiority: Discover the Security Implications*, Brookings, https://www.brookings.edu/wp-content/uploads/2019/12/FP_20191211_military_information_conflict_stefanick.pdf (accessed 9 Jul. 2021).
256 Ibid, p. 128.
257 Konaev, M., Chahal, H., Fedasiuk, R., Huang, T. and Rahkovsky, I. (2020), *U.S. Military Investments in Autonomy and AI: A Strategic Assessment*, Center for Security and Emerging Technology, October 2020, pp. 13–16, https://cset.georgetown.edu/wp-content/uploads/U.S.-Military-Investments-in-Autonomy-and-AI_Strategic-Assessment-1.pdf (accessed 9 Jul. 2021).
258 Ibid.
259 Kashin, V. (2019), *Artificial intelligence and military advances in Russia*, Stockholm International Peace Research Institute, https://www.jstor.org/stable/pdf/resrep24532.13.pdf?refreqid=excelsior%3A67 1e447f938067c153e799accdf1ac1c (accessed 9 Jul. 2021).
260 RIA Novosti (2016), 'FPI head: there will be a war of operators and robots, not soldiers on the battlefield', 6 July 2016, https://ria.ru/20160706/1459606647.html (accessed 9 Jul. 2021).
261 Sputnik News (2016), 'Robotroops: Russia to Roll Out Robot Fighting Force by 2025', 11 February 2016, https://sputniknews.com/russia/201602111034577452-russia-army-robots (accessed 9 Jul. 2021).
262 Grau and Bartles (2016), 'The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces'.

Thus far, Russia's UAV development, especially heavy combat UAVs, has been much slower than Moscow wanted, lagging behind that of both China and the US.[263]

The Altius long-range drone, for example, has been in development since 2011, with the most recent variation promising to be equipped with AI elements for command and control as well as increased autonomy for navigation, target identification, and potentially also target engagement.[264] The S-70 Okhotnik-B heavy combat UAV, meanwhile, could be delivered to Russian forces in 2024.[265] According to defence ministry reports, the Okhotnik recently flew in automated mode for the first time and practiced interoperability with an Su-57 lead aircraft. Ultimately, the goal is to deploy Su-57 pilots alongside these combat drones in swarms enabled by AI.[266]

As the US and NATO invest in ways to counter unmanned aircraft systems and capabilities, attention should be paid to technologies and skill sets for detecting tactical drones that have small infrared and electromagnetic signatures and can evade current air tracking systems.

Assets such as the heavy strike drone Okhotnik are particularly relevant for large-scale operations against peer adversaries, where they can be tasked with suppressing long-range air-defence systems, hitting targets deep inside enemy territory, and providing cover to manned aircraft from ground-based fires.[267] It is therefore notable that some Western and Russian analysts doubt Russia's ability to deliver on these large-scale combat drones, predicting that Russia's 'developers of UAVs will continue to focus on reducing the radar signature of UAVs, their further miniaturization, lower prices, increased autonomy, reliability and accuracy of output to the target'.[268] With this in mind, as the US and NATO invest in ways

263 According to Defence Minister Shoigu, Russia has a 'large fleet of unmanned aerial vehicles, approximately 2,000 different systems'. Around 70 UAVs have been deployed or tested in Syria, predominantly for ISR roles. See Interfax (2020), 'Defense Industry; Russian Defense Ministry Plans to sign Major Contracts on Robots, Drones before Year-End – Shoigu', *Russia & CIS Military Information Weekly,* 28 August 2020. This number fits with previous estimates: see Markotin, N. and Chernenko, N. (2020), 'Developing Artificial Intelligence in Russia: Objectives and Reality', Carnegie Moscow Center, 5 August 2020, https://carnegie.ru/commentary/82422 (accessed 9 Jul. 2021); Barrie, D. and Hackett, J. (2020), *Russia's Military Modernisation: An Assessment*, London: International Institute for Strategic Studies.
264 Edmonds, J., Bendett, S. et al. (eds) (2021), 'Military AI and Autonomy in Russia' in *AI and Autonomy in Russia*, p. 118, Arlington, VA: CNA, https://www.cna.org/centers/cna/sppp/rsp/russia-ai.
265 Interfax (2021), 'Russian troops to start receiving Okhotnik strike drone in 2024 – official', 13 April 2021, https://tass.com/defense/1277657 (accessed 28 Jul. 2021); Interfax (2020), 'Defense Industry; Mass Deliveries of Okhotnik Combat Drones to Russian Armed Forces to Start in 2024 – Military-Industrial Commission Board Member', *Russia & CIS Military Information Weekly*, 18 December 2020.
266 Edmonds, Bendett et al. (2021), *AI and Autonomy in Russia*, p. 118.
267 Kuzovkov, V. (2020), 'Копия против оригинала: чем наш дрон «Орион» уступает американскому оригиналу' [Copy versus original: how our Orion drone is inferior to the American original], Новые Известия [New News], 30 October 2020, https://newizv.ru/news/tech/30-10-2020/kopiya-protiv-originala-chem-nash-dron-orion-ustupaet-amerikanskomu-originalu (accessed 9 Jul. 2021).
268 McDermott, R. (2020), 'Russia's Interest in UAV Strike Capability Gathers Pace', The Jamestown Foundation, 13 November 2020, https://jamestown.org/program/russias-interest-in-uav-strike-capability-gathers-pace (accessed 9 Jul. 2021); Khodarenok, M. (2020), 'Впереди даже Турция: Россия проспала беспилотную революцию' [Even Turkey is ahead: Russia slept through the drone revolution], Gazeta.ru, 11 January 2020, https://www.gazeta.ru/army/2020/10/31/13340929.shtml (accessed 9 Jul. 2021).

to counter unmanned aircraft systems (UAS) and capabilities, attention should be paid to technologies and skill sets for detecting tactical drones that have small infrared and electromagnetic signatures and can evade current air tracking systems.

Research, development, testing, and prototyping of UGVs has climbed higher on the defence ministry's priority list over the past few years, and a broad range of systems have advanced through the technology development cycle and been used for ISR, demining, breaching operations, and other combat support tasks. While attending the Army 2020 International Military-Technical Forum, for instance, Defence Minister Shoigu described seeing 'robots that are installed on heavy hardware, robots that can do mine clearance', and robots that 'effectively have neural networks of control, artificial intelligence elements'. This technology, according to Shoigu, can pose 'a serious threat and represents a serious weapon today'.[269]

Some of Russia's UGV projects, like the unmanned version of the T-14 Armata tank and the Soratnik mid-sized combat UGV, end up as demonstrators of advanced robotics technologies, and while these particular prototypes are not mass-produced, the technical data and testing results inform their redevelopment or even their redesign in new roles.[270] Other systems, like the Nerekhta and Marker UGVs, serve as a test bed for AI applications.[271] The Advanced Research Fund, for example, has used the Nerekhta UGV to test collaborative behaviour with other UGVs or UAVs, while the Marker UGV served to test computer vision, autonomous movement and navigation, and swarming technologies.[272]

While progress in AI applications for UGVs, and particularly the larger combat UGVs, has seen some setbacks, Russia is not alone in this. US, Chinese, and many other scientists and developers have also had to contend with the challenges of autonomous ground navigation, mobility in complex terrain, communication in a contested electromagnetic spectrum, and coordination with humans and other unmanned systems. The US military, for example, has had a number of programmes dedicated to the development of remotely-controlled and semi-autonomous robotic vehicles meant to provide logistical or fire support to dismounted soldiers, which ultimately failed to progress beyond the testing and experimentation phase.[273]

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269 Interfax (2020), 'Defense Industry; Russian Defense Ministry Plans to sign Major Contracts on Robots, Drones before Year-End – Shoigu'.
270 CNA (2020), 'Russian military prepares for robotic and AI-enabled smart combat systems', *Artificial Intelligence in Russia*, Newsletter 17, 18 December 2020, https://www.cna.org/CNA_files/PDF/DOP-2020-U-028818-Final.pdf (accessed 9 Jul. 2021).
271 Atherton, K. D. (2019), 'Is this Russia's gateway drone to better armed robots?', C4ISRNET, 31 July 2019, https://www.c4isrnet.com/unmanned/2019/07/31/is-this-russias-gateway-drone-to-better-armed-robots (accessed 9 Jul. 2021).
272 RIA Novosti (2017), 'Iron Guard: Russia's most dangerous fighting robots', 15 October 2017, https://ria.ru/20171015/1506649786.html (accessed 9 Jul. 2021); Фонд перспективных исследований [Advanced Research Foundation] (undated), 'Marker: Experimental Robotic Platform', https://fpi.gov.ru/projects/fiziko-tekhnicheskie-issledovaniya/marker (accessed 9 Jul. 2021).
273 In 2011, for example, the Army cancelled a Lockheed Martin programme to build a heavy six-wheeled robot meant for hauling gear and countering improvised explosive devices (IEDs), known as the Multi-Function Utility/Logistics and Equipment Vehicle, because it was too heavy to be transported on helicopters or move and navigate effectively to help with anti-IED missions; in 2015, the Marines cut the cord on the Boston Dynamics-built Legged Squad Support System or LS3, a robotic mule that proved too noisy, giving away the position of the troops.

The Russian military, however, tends to move faster than the US military when it comes to testing new technologies in operational conditions – arguably exhibiting a higher risk tolerance in the event of accidents or failures, or possibly a lower regard for what is ethical or permissible under the laws of war. In 2018, for example, the Russian military sent the Uran-9 – an armoured UGV the size of a small tank – for its first 'near-urban combat' mission in Syria, where it encountered some problems, including repeated communications outages and failing to fire effectively while on the move.[274] These challenges and delays in delivering the promised UGVs to the force have led some analysts to conclude that such systems can only be used in a limited capacity in combat, primarily for ISR missions. Such assessments fall far behind Russia's ambitions to deploy these systems as part of combined arms formations, in manned-unmanned operations, and with increasingly autonomous functions.[275]

Information superiority and cyber warfare

Russian strategists see information warfare as a central tenet of contemporary conflicts, and while thinking and approaches to information warfare are continuously evolving, there is a general consensus that information superiority could play a key role in the outcome of wars.[276] Some scholars argue that Russian strategists have come to view AI-enabled information warfare as a 'strategic war-winning asset in peer-state conflicts'.[277] According to this view, as militaries leverage AI to 'exponentially increase the power of information warfare', AI will usher in 'the third revolution in military affairs'.[278] Former deputy minister of defence Yury Borisov has articulated a somewhat less revolutionary view, stating that the development of AI will allow Russia to more effectively contest the information environment and win cyber wars.[279]

While it is well known that Russia relies on cyber warfare to advance and support its military, political, and strategic objectives, it remains to be seen exactly how the integration of AI, and more specifically, ML-based automation could augment existing Russian capabilities in cyber warfare. Generally speaking, as a recent report from the Center for Security and Emerging Technology's CyberAI project explains, 'machine learning could improve discovery of the software vulnerabilities that enable cyber operations, grow the effectiveness

274 Konaev, M. and Bendett, S. (2019), 'Russian AI-enabled Combat: Coming to a City Near You?', War on the Rocks, 31 July 2019, https://warontherocks.com/2019/07/russian-ai-enabled-combat-coming-to-a-city-near-you (accessed 9 Jul. 2021).
275 Tuchkov, V. (2021), 'Искусственный интеллект за рычагами танка' [AI behind the controls of a tank], VPK-news.ru, 11 January 2021, https://vpk-news.ru/articles/60333 (accessed 9 Jul. 2021).
276 Barrie and Hackett (2020), 'Russia's Military Modernisation', p. 37.
277 Thornton, R. and Miron, R. (2020), 'Towards the 'Third Revolution in Military Affairs'', *The RUSI Journal*, 165(3): pp. 12–21, https://doi.org/10.1080/03071847.2020.1765514 (accessed 9 Jul. 2021).
278 Ilnitsky, A. (2019), 'Искусственный интеллект – это и риски, и возможности' [Artificial intelligence is both risks and opportunities], *Красная звезда* [*Red Star*], 3(125), 24 June 2019, http://redstar.ru/iskusstvennyj-intellekt-eto-i-riski-i-vozmozhnosti (accessed 9 Jul. 2021).
279 TASS (2018), 'Ministry of Defense of the Russian Federation: the development of artificial intelligence is necessary for the successful conduct of cyber warfare', 14 March 2018, https://tass.ru/armiya-i-opk/5028817 (accessed 28 Jul. 2021).

of spearphishing emails that deliver malicious code, increase the stealthiness of cyber operations, and enable malicious code to function more independently of human operators'.[280]

In December 2015, for example, Russian attackers executed the first known cyberattack on an electric grid, hitting three power companies in Ukraine.[281] Although the attackers used automated systems to conduct reconnaissance within the network and delete data, the attack was 'decidedly manual', and 'each manual attack at each substation required a distinct human operator'.[282] During a 2016 attack on Ukraine's power grid, however, the malicious code CRASHOVERRIDE could automatically find circuit breaker controls, switching them on and off and creating a blackout. This attack offers insights into the increasing role of automation in offensive cyber operations and its significance expands beyond Ukraine, as 'the creators of CRASHOVERRIDE had developed an automated weapon that they can easily adapt for electrical grids all over the world, and that they could use, in theory, to generate blackouts at the flip of a switch'.[283]

Looking ahead, developments in ML have the potential to make cyber operations more efficient, far-reaching, and widespread, while shielding the identity of the perpetrators and making it more difficult to defend against incursions. AI can be used to automate, accelerate and scale synthetic accounts and content, or, as one senior adviser to the Russia military has put it, to 'supplement the information space with a large volume of artificially created data' and 'virtual truth'.[284] In this sense, technological advances in AI have the potential to 'hyperpower Russia's use of disinformation'.[285] For the US and NATO, technical solutions buttressing cyber defence are necessary, but are also unlikely to be sufficient in countering the broader effects of Russian information warfare, which expand beyond the cyber realm, threatening to erode public trust in democratic institutions and deepen social divisions.

Implications for the US and NATO

The strategic shift from counterinsurgency operations in the Middle East to the new era of great power competition against China and Russia marks the end of operations in permissive environments where US and allied forces have enjoyed essentially uncontested technological superiority and freedom of manoeuvre across the different domains and the electromagnetic spectrum. The rising popularity of the Joint All-Domain Command and Control (JADC2) concept across the US

280 Buchanan, B., Bansemer, J., Cary, D., Lucas, J. and Musser, M. (2020), *Automating Cyber Attacks: Hype and Reality*, Center for Security and Emerging Technology, November 2020, https://cset.georgetown.edu/publication/automating-cyber-attacks (accessed 9 Jul. 2021).
281 Zetter, K. (2016), 'Inside the Cunning, Unprecedented Hack of Ukraine's Power Grid', *Wired*, 3 March 2016, https://www.wired.com/2016/03/inside-cunning-unprecedented-hack-ukraines-power-grid (accessed 9 Jul. 2021).
282 Buchanan, Bansemer et al. (2020), 'Automating Cyber Attacks: Hype and Reality', p. 10.
283 Ibid.
284 Loser, A. (2018), 'Военный искусственный интеллект' [Military Artificial Intelligence], *Арсенал Отечества* [*Arsenal of the Fatherland*], 24 January 2018, https://arsenal-otechestva.ru/article/990-voennyj-iskusstvennyj-intellekt (accessed 9 Jul. 2021).
285 Polyakova, A. (2018), *Weapons of the weak: Russia and AI-driven asymmetric warfare*, Brookings, 15 November 2018, https://www.brookings.edu/research/weapons-of-the-weak-russia-and-ai-driven-asymmetric-warfare (accessed 9 Jul. 2021).

Department of Defense over the past three years reflects this reality, as do the investments in enhancing EW capabilities and modernizing command, control and communication networks.[286]

This multi-domain approach, the push toward connectivity between sensors and shooters from all of the military services, and the changes to command and control are meant to offset the sophisticated anti-access/area denial capabilities of potential adversaries, including Russia's more advanced systems. But closer attention to how Russia envisages using some of these new technologies could help reveal gaps in current thinking and potentially improve the overall strategy for dealing with a potential Russian threat.

For example, Russia sees EW as an asymmetric way to counter high-tech opponents. This suggests that EW could be integrated with deception and reflexive control techniques not only for a greater but for a qualitatively different tactical, operational and psychological impact from that which EW can accomplish on its own. A Russian EW contingent using AI-enabled systems to debilitate the opponent's frequency and communications capabilities, disorganizing the command and control, could also alter the correlation of forces on the battlefield. In this sense, tactical applications can have operational, if not strategic, effects.

Russia has repeatedly demonstrated innovation in drone tactics – using tactical drones to provide near-real-time intelligence and targeting information for supporting artillery units.

The US and some of its NATO allies have also taken steps to deal with the growing threat from UAS technologies, including investments in counter-UAS capabilities. Here, it is worth noting that Russia has repeatedly demonstrated innovation in drone tactics – using tactical drones to provide near-real-time intelligence and targeting information for supporting artillery units. In July 2014, Russian forces used this technique to destroy four Ukrainian army brigades.[287] While passive air defence measures could have minimized the damage from such an attack, continued evolution and innovation of tactical drone tactics, including AI-enabled swarming capabilities, will require an equal if not greater degree of adaptability and ingenuity on behalf of the US and NATO.

Now, because AI is a new technology that may fail when confronted with tasks and environments different from those for which it was trained, Russia's experience testing its high-tech weapons in near-operational and combat conditions in Syria and Ukraine is also consequential. Even the struggling Uran-9

286 Hoehn, J. R. (2021), 'Joint All-Domain Command and Control: Background and Issues for Congress', Congressional Research Service, 18 March 2021, https://www.everycrsreport.com/files/2021-03-18_R46725_abfcb7206003f102672346d3034be6e232a262fd.pdf (accessed 9 Jul. 2021); US Department of Defense (2020), *C3 Command, Control, and Communications Modernization Strategy*, September 2020, https://dodcio.defense.gov/Portals/0/Documents/DoD-C3-Strategy.pdf (accessed 9 Jul. 2021).
287 Edward, A., Guelfi, E. A., Jayamaha, B. and Robison, T. (2020), 'The Imperative for the U.S. Military to Develop a Counter-UAS Strategy', *Joint Force Quarterly*, 97(2): pp. 4–12, https://apps.dtic.mil/sti/pdfs/AD1099501.pdf (accessed 9 Jul. 2021).

provided key insights into capabilities, limitations and changes needed before this system can be integrated into the force. Data collected during experiments and testing in near-operational conditions can prove imperative for training new AI algorithms, while the experience Russian soldiers now have in operating and working alongside these advanced systems is important for future advances in human–machine teaming.

Finally, the US and some NATO allies are also investing in R&D related to counter-autonomy and counter-AI technologies, including as part of efforts to buttress their cybersecurity measures. The amalgamation of technical and psychological elements in Russia's approach to information warfare, however, presents a challenge that extends beyond what technological solutions alone can solve.

As a whole, there are good reasons to question Russia's ability to develop the modern AI algorithms that fuel sophisticated EW systems, to scale prototypes of heavy combat drones and unnamed ground combat vehicles, or to use AI-enabled information and cyber warfare to cause strategic effects. Russia, however, does not need to be an AI superpower to successfully employ AI-based technologies and capabilities against US and NATO interests.

A holistic understanding of Russian military AI developments must pay close attention to how AI-enabled systems fit within broader Russian military thinking about the strategic, operational, and tactical approaches to modern warfare. The emphasis on how new technologies may be used is therefore equally consequential to the technological advances themselves.

07 Conclusions and policy recommendations

It is paramount to ensure realistic assessments of Russian military capabilities, and to ultimately craft a balanced and flexible policy response.

Understanding how Russian military innovation works is critical for determining its impact for the US, NATO, and their partners, as well as potentially guiding future procurement choices. The Kremlin leadership has made the choice to pursue military innovation in specific technologies in order to give itself an advantage against the perceived conventional military superiority of great power competitors. This approach is compounded by Russia's sense of great power status and its perception of being in a conflict with the West and NATO in particular, and is reinforced by its wider foreign policy aspirations.

Military technology innovation enables Russia's way of war and feeds new concepts of operation and military thought around future warfare. Despite systemic impediments to innovation, the Russian military-industrial complex ('OPK') remains a formidable machine able to structure a fully-fledged military-industrial base in entire segments, and to adapt them to the operational needs of the armed forces.

It is therefore paramount to ensure realistic assessments of Russian military capabilities, focus attention on the most pressing developments while keeping tabs on future innovation, and ultimately craft a balanced and flexible response. Potential policy pathways include:

Ensure realistic assessments of Russian military capabilities

— There are potential dangers in both overhyping and downplaying Russia's advanced systems. It is true that some systems could have a major operational impact in the near future, potentially proving damaging to Western interests. Yet inflating the danger from existing and future capabilities could lead to erroneous policy being made, and ultimately to poorly informed procurement choices by Western armies. Different dangers lie in underestimating some developments that may pass under the radar of policymakers.

— Complacency is also a dangerous posture. Despite the weaknesses and constraints discussed above, there is a tendency among Western policymakers to underplay Russia's emerging military technology because of ongoing challenges within the OPK and the perception that Russia is not as technologically advanced as the West or China. Such convictions, however, suggest a failure to imagine how Russia could deploy advanced technologies and capabilities in innovative and disruptive ways.

— Good policymaking should start with establishing a precise threat credibility through careful analyses and balanced assessments of Russian systems. This includes careful assessments of signals and messages originating from the Russian leadership and the military-industrial complex. For example, some advanced systems are at different stages of development (Burevestnik, Poseidon); for others, progress is uncertain and probably overstated both by Russia and by Western analysts (semi-hypersonic systems); and others are still in search of a specific mission (anti-satellite systems).

— When looking at each 'advanced' weapon and technologically-enabled asymmetric system, it is important to put them into the context of current procurement plans, production capabilities, actual deployment and active service entry. In addition to the systems themselves, it will be important to observe and analyse how they are adapted in operational praxis.

— Developments and technologies should be analysed and assessed within the broader context of Russia's strategic ambitions, potential threats to Western interests, and the willingness to use these new and advanced systems in combat situations. Russia appears to be less risk-averse when fielding and implementing new military technology compared to Western armies, and the lessons learned inform both scientific progress and operational art.

What should NATO and its allies be concerned about?

- The most disquieting systems, as far as NATO is concerned, are those that amplify nuclear missions, strategic conventional systems, dual-capable systems, and asymmetric non-military applications. More generally, Russia's willingness to take risks, fail, and try again may lead to significant advances and potential breakthroughs in selected areas.
- Western planners should avoid the temptation to match Russian capabilities. In many respects, new weapons systems have emerged as 'asymmetric' and relatively low-cost responses to Western – and primarily American – conventional superiority.
- Specifically, the advanced strategic systems are designed to circumvent ballistic missile defence, while sub-strategic systems appear designed to counteract US dominance in aerospace and naval power. Consequently, attempting to develop and deploy like-for-like systems could be wasteful.
- Continued improvement and integration of longer-ranged combat drones within Russia's command and control systems will lead to greater efficiency of Russian forces in combat. While Russian development of concepts for a mixed unmanned ground vehicle (UGV)-manned unit is years away, continued experimentation in that space may present the Russian defence ministry with improved tactics in countering NATO's high-tech and precision-guided munition response.
- Continued Russian experimentation with unmanned aerial vehicle–UGV teaming could result in improved situational awareness and battlefield information analysis. Furthermore, the development of deep-diving autonomous maritime vehicles may present dangers to NATO's submarine force and operations in the long term.
- Russia's experience in testing high-tech weapons in near-operational and combat conditions could give it an edge in data collection for the training of more resilient artificial intelligence (AI) algorithms and human–machine teaming. Technical solutions that buttress cyber defence are necessary, but are unlikely to be sufficient to counter the psychological elements and societal effects of Russia's AI-enabled information warfare.

Craft a balanced and flexible response

- The fact that Russia is developing a particular system or technology does not mean the US and NATO should replicate it. Russian advanced systems are designed to perform specific functions aimed at lessening, and ideally nullifying, US and NATO conventional advantages (especially in the aerial and naval domains). Nevertheless, Russia is also pursuing experimental pathways to innovation that are not dictated by the need to outmatch Western military systems. It cannot be excluded that Russia will develop novel weapons systems and supporting infrastructure independent of the trajectory of weapons development in the West.

- It is therefore not advisable to develop countermeasures to every Russian military technology in every domain – for instance regarding hypersonic gliding vehicles. Policymakers should also avoid messaging a Western 'capabilities gap' with Russia, as that could further vindicate Moscow's position and lead to an emboldened Kremlin.
- In addition to pursuing technologies central to 4IR (Industry 4.0), responses could also exploit low-cost, relevant technology in selected domains. In particular, adapting and upgrading existing systems able to threaten the supporting infrastructure that enables Russia's new capabilities might be one more cost-effective and efficient way of responding to new threats.
- Countermeasures could target existing Russian weaknesses in specific areas (such as infrastructure and support) as well as across different levels of the kill chain (for instance in the area of sensors and sensor data analysis, as well as command and control). Suppressing Russian enablers in a kill chain's critical nodes would be an efficient way to limit potential asymmetric advantages. This would help disrupt and degrade the enabling military infrastructure that give these systems such potential.
- In areas where the US and NATO already possess technological superiority, for instance in autonomous systems or C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance), the focus should be on integrating and scaling these capabilities throughout the alliance to ensure interoperability as well as on hardening these systems to adversarial attacks and disruptions, including with the use of new technologies.
- Policy responses should also signal dominance and the intent to use advanced systems to match Russia's, as well as to increase sanctions against specific segments of the OPK – mainly against high-precision engineering capacity and electronic components – as part of a credible attrition strategy. However, the Western response must not lead to self-deterrence against a more militarily assertive Russia.

Put the 'red' back in red-teaming

- Russian advanced military systems are procured and fielded to implement Russia's way of war. Understanding Russian intentions regarding such systems from the Russian perspective is key to successful military planning.
- Western policymakers should think in terms of Russia's vulnerabilities, not just strengths. Western military concepts therefore need to evolve to account for Russia's own ability to recover and operate in conditions that are less than ideal, especially in contested environments.

- Another important aspect of red-teaming is looking at the sustainability of Russia's military innovation, modernization plans and overall defence spending. It remains paramount to understand which currently developing technologies will become future threats to Western interests, as well as to explore how innovation will meet the future operational needs of the Russian armed forces.

Demand accountability and transparency from Russia

- The development of advanced military systems in Russia increases unpredictability as well as the risk of miscalculation by the US and its allies. Recent examples include the Nyonoksa radiation accident in August 2019 (see also Chapter Three) and anti-satellite weapons testing. These events are a reminder that Russia is continuously innovating in domains that require more transparency and accountability – especially because experimenting with such could also put civilian lives at risk in peacetime.
- As Russian restraint is no longer a certainty, it is important to include such weapons systems in discussions on risk-reduction. For instance, strategic systems such as Sarmat and Avangard should be systematically raised in future arms control discussions.

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Cover image: An MDP-01 unmanned aerial vehicle on display at the Kalashnikov pavilion on Sunday 22 August 2021 during the Army 2021 Expo in Moscow, Russia.
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