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RUSSIAN ROBOTICS: A LOOK AT DEFINITIONS, PRINCIPLES, USES, AND OTHER TRENDS

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Introduction

Robots have been used in combat in one form or another since at least World War II, and they have also seen use in local conflicts of the last century. However, these robotic devices were simpler in form than those of today. Their integration with other devices was simply not possible. Now the paradigm has changed. The current robotization of combat operations involves devices that are powered with digital and artificial intelligence (AI) command and control devices. With the addition of such technologies, new ways to use robotics have appeared, such as the integrated use of robotics with nonlethal weapons, along with new ways to execute (and potentially control) missions autonomously. Initially the special and essential attribute for using robots was their ability to help minimize end strength personnel losses in combat, which continues to motivate developments. However, today robotic devices are being outfitted with kinetic components that can destroy an opponent's force from air, land, and sea. And, as a closer examination of their capabilities has revealed, robots may be becoming so advanced and autonomous that humans are losing command and control over them.

Russia's military has developed numerous robotic capabilities, to include the following: combat vehicle fire systems; multiple-launch rocket systems; radiological reconnaissance; logistic transport; use in space; crewless ships and submarines; and robotic swarms and group interactions, among many others. Military leaders have ascertained that there are mechanisms in place to ensure control over these assets which are to be used only in limited situations. Russian plans to use robotics in numerous operations may indicate, however, that their use may not be as limited as predicted. In the military sphere, where quickly seeking advantage takes center stage to outdo opponents.

The following summary first offers several ways that Russian theorists have defined a robot, starting in 1991. Second, the analysis compares Russian and U.S. approaches to employing robotics (from a Russian perspective) as well as tasks and principles of their use. Third, some of the uses of robotics in Russia are detailed, focusing on descriptions in military periodicals—in urban environments, in conjunction with engineer support, in unmanned aerial vehicle (UAV) use, with artillery, and their use in Syria. Fourth, legal and organizational issues of contention are examined that affect robotic use worldwide and regarding Russia. Fifth, the numerous problem areas are covered that Russia has encountered in its development of robotic capabilities, followed by a few conclusions. There are two appendixes. Appendix One lists some robotic employment principles and Appendix Two offers some photos of robots under development in Russia along with their operating parameters (and several not shown in the photographs).

Russian Definitions of Robots

Russian military authors understand that finding the correct terminology for a robot is difficult, since technology keeps evolving and changing robotic capabilities. A toy radio-controlled car, a batch-produced model drone, and even a smart missile are all sometimes described as robots. It would be rational, in the opinion of one group of authors, to "refer to a system with artificial intelligence possessing a high or total level of autonomy (independence) from a human as a robot."[1] There have been a few military definitions of a robot. In 1991, for example, Colonel A. A. Korabelnikov stated that robots would be classified by equipment type: combat, combat support, special-technical support, and logistic support robots. He offered the following definition:

> It would appear that the military robot represents a set (system) of military equipment outfitted with information-measurement and actuation systems and an automatic control device intended for performing combat missions or comprehensive support missions both with man's direct involvement as well as with a wired-in instruction.[2]

An expanded discussion of the definition of a robot took place in a 2016 article in Russia's *Independent Military Review,* which included three earlier definitions. First, the article offered a definition from the *1983 Military Encyclopedic Dictionary*, which defined a robot as follows:

> Automatic system (machine) equipped with sensors which receive information from the environment, and with actuating mechanisms, is capable, with the aid of a control unit, of performing in a purposeful manner under changing situations. A characteristic feature of robots is the capability partially or entirely to perform the functions of a human operator. Robots are employed in conditions of relative inaccessibility, in environments which are dangerous or harmful to man, etc. Industrial robots—automated manipulators—are the most common.[3]

Second, the 1989 *Polytechnic Dictionary* stated that "A robot is a machine with anthropomorphic (humanlike) behavior that partially or fully performs human functions in its interaction with the surrounding world."[4] The newspaper article noted that first-generation robots are controlled devices and the most widespread. Second-generation systems are semi-autonomous devices, while the transition to third-generation combat robots, autonomous devices, requires self-learning systems that involve artificial intelligence with advanced technologies of navigation, visual identification, weaponry, independent power sources, camouflage, and other technologies.[5] A third definition, from the 1995 *Interpretive Dictionary of the Russian Language*, stated that "A robot is an automation carrying out actions similar to human actions."[6]

In 2015, Igor Denisov, deputy general director of the Advanced Research Foundation, noted that robots are "remote-controlled platforms and systems that make decisions automatically

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[1] No author provided, Roundtable of Independent Expert Analysis Center, "Combat Robots in Future Wars: Experts' Conclusions. Russian Experts Predict an Explosive Increase in the Utilization of Robotic Systems on the Battlefield," *Nezavisimoye Voyennoye Obozreniye (Independent Military* Review), 4 March 2016.
[2] A. A. Korabelnikov, "Military Robots," *Voennaya Mysl' (Military Thought*), No. 6 1991, pp. 43-47.
[3] N. V. Ogarkov, main editor, *Military Encyclopedic Dictionary*, Moscow: Military Publishing House, 1983, p. 636.
[4] Roundtable of Independent Experts, 2016.
[5] Ibid.
[6] Ibid.

and systems that make decisions in conditions of less than full knowledge of the environment."[7] An ideal robot is a totally autonomous system that thinks like a person and resolves tasks like a person, but right now it is hard to describe a military system like that. They currently are systems that operate under human control, either directly or by functions that acquire decisions from automated systems.[8]

But robots are clearly under development to become more autonomous in Russia. In an article in Russia's *Army Journal* in 2017, author A. Kalistratov, in an article titled "Robots! Into Battle!" noted that "A military robot (military robotic asset) is an automated device that replaces a human in hostilities to preserve life or to operate in conditions beyond human capabilities, for military purposes: reconnaissance, doing battle, mine clearing, and so on."[9] Another 2017 article in the same journal defined a robot as "a mechanized complex capable of assimilating information from its environment and on the basis of that performing defined actions either autonomously or with an operator at a control panel."[10] It noted that a robot is composed of systems such as communication devices, sensors that assimilate and process information on the environment, control devices, and drives and propulsion mechanisms of various types. Robots incorporate elements of artificial intelligence and provide a degree of autonomy. It is expected that by 2025 the proportion of robots in the army's weaponry and hardware structure should reach 30 percent.[11]

Finally, the **most recent definition of a robot** was found in a 2019 article in *Military Thought* that stated it is:

> A complex technical system with artificial intelligence, which functions independently of a human being and which can execute any of a set of embedded functions, according to an algorithm (program) created by this system, considering the current condition of the system and the external environment.[12]

Other fields of interest for the development of robots are cybernetics, automated control systems, nanotechnologies, bionics, brain studies, and so on. It is expected that autonomous humanoid robots will be available somewhere in the 2020s-2030s.[13]

Russian Robotics: Important Tasks and Principles

Russian ground force analysts stated in 2019 that the nation's robotic force must not simply duplicate weapons that already exist but rather supplement them with new functions. For these

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[7] Aleksandr Kurennoy, Anatoliy Yermolin, and Aleksey Naryshkin, interview with Oleg Martyanov and Igor Denisov, "Innovations in Russian Robotics," *Ekho Moskvy Online*, 12 October 2015.
[8] Ibid.
[9] A. Kalistratov, "Robots, Into Battle! Military Robotic Devices in the Warfare of Today," *Armeyskiy Sbornik (Army Journal*), No. 10 2017, p. 36.
[10] S. Popov, "Robots in Fighting Formations," *Armeyskiy Sbornik (Army Journal*), No. 8 2017, pp. 88-94.
[11] Ibid.
[12] P. A. Dul'nev, N. P. Pedenko, S. N. Starovoitov, and S. A. Sychev, "On the Issue of Developing Ground Force Robots and Assessing the Effectiveness of their Combat Employment," *Voennaya Mysl' (Military Thought*), No. 7 2019, p. 151. The author would like to thank Dr. Harold Orenstein for his translation of this article.
[13] Roundtable of Independent Experts, 2016.

authors, the overriding priority was deciding what new functions to develop. The U.S. use of robotics, they note, involves five tasks: increasing the situational awareness of the human operator; reducing his load; improving logistics; optimizing maneuver on the battlefield; and providing protection and fire support. While all these areas are important, the analysts singled out as **Russia's most important task "increasing the role and improving the robotization of equipment, first and foremost, on-board fire resources," which is reflected in the creation of robotic strike complexes**—Vikhr, Uran-9, Soratnik, Nerekhta, and Platforma-M.[14]

In another 2019 article, different analysts discussed the formation of new (in make-up and capabilities) specialized assault subunits using robotic strike complexes (RTK). Functional systems of design were focused on information, support, control, destruction, mobility, protection, and support subsystems. After identifying tasks and goals for each, uncertainties were identified (conditions of employment, internal linkages, etc.), operational-tactical requirements developed, and assignments made to specific weapon systems. The projected level of technological development for the forecasted period must be taken into consideration as well. Military-economic assessments for alternative variants are made based on continued research. The authors ended their article noting the following:

> The creation of specialized assault subunits based on models of weapons and military equipment that have fundamentally new integration capabilities necessitates the development of new approaches to forming their weapons system that will ensure flexibility of employment, stability against enemy effects, and autonomy when executing combat tasks."[15]

The last three tasks are expanded below.

Flexibility of employment

P. A. Dul'nev and V. V. Korablin, also writing in 2019, wrote on the capabilities of robotic strike complexes. Military-grade robotic complexes, in their opinion, reduce losses and increase the effectiveness for resolving tasks and refurbishing outdated weapons. Increasing the strike capabilities of these RTK systems was emphasized. The Uran-9 is designed to destroy mobile and immobile targets, such as buildings and installations. Its modular structure includes 23- and 30-mm automatic guns, the 7.62-mm Kalashnikov tank machine gun, and an antitank missile system. The Soratnik strike RTK conducts reconnaissance and patrolling of important facilities. It uses interchangeable weapons, such as automatic grenade launchers, heavy machine guns, and the "Kornet" guided missile.[16]

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[14] P. A. Dul'nev, N. P. Pedenko, S. N. Starovoitov, and S. A. Sychev, pp. 148-149.

[15] V. G. Kovalev, S. A. Sychev, and O. I. Petrashko, "Methodological Approach to Validating Requirements for a Weapons System for a Military Robotic Assault Complex Subunit," *Vestnik Akademii Voennykh Nauk (Journal of the Academy of Military Science*), No. 4 2019, pp. 109-113. The author would like to thank Dr. Harold Orenstein for his translation of this article.

[16] P. A. Dul'nev and V. V. Korablin, "Problem Issues in the Selection of Weapons for Robotic Strike Complexes," *Vestnik Akademii Voennykh Nauk (Journal of the Academy of Military Science*), No. 1 2019, p. 129. The author would like to thank Dr. Harold Orenstein for his translation of this article.

The Vikhr strike RTK is designated for fire support during urban and reconnaissance operations and the destruction of important structures or lightly armored targets. It can issue targeting data for aviation and artillery and other strike RTKs. Its capabilities are determined by different combat modules: the Bumerang-BM that uses the 30-mm 2A42 cannon, RKTM coaxial tank machine guns (RKTM), and the Kornet antitank system; smaller dimension modules (perhaps the BMP-3) that carry two machine guns (12.7-mm and 7.62-mm) and an automatic grenade launcher; and the Au-220M "Baikal" combat module with a 57-mm automatic cannon.[17] One source noted that it is hard for an opponent to identify the Vikhr as a robotic device when it is among other military vehicles, such as traveling in a column. The device has four quadcopter UAVs that, one source noted, could be used for "kamikaze" attacks on high-value targets.[18]

A lighter strike RTK is the Nerekhta multifunctional modular RTK, a universal robotic platform on a tracked chassis. It has three variants, the fire support RTK (remote control 12.7-mm KORD machine gun or 7.62-mm Kalashnikov RKTM); reconnaissance RTK with artillery module; and RTK with a transport platform.[19]

Two final combat considerations are the Platforma-M RTK and Unikum systems. The former is designed for visual and technical reconnaissance, the detection and destruction of enemy equipment, and fire support of units involved in reconnaissance and patrolling. Weapons include a 7.62-mm RKTM and four RPG-26 antitank grenade launchers. These and other technical tactical requirements are determined by the fire tasks required, which include enumerating the types and nature of targets designated for destruction; determination of the range of destruction; and a determination of the totality of employment conditions. A problem task is determining when to open fire. Currently (2019) the decision to open fire is trusted only to a human who uses a remote-control method.[20]

The Unicum is a robotic group control system oriented on the mass employment of machines. For example, Unikum can control ten robotic complexes simultaneously. It can assign roles within a grouping, control a grouping, independently send robots to the most favorable positions, and search for a target. An operator is responsible for the attack of detected targets.[21]

Stability against enemy effects

In 2020, Russian military analysts noted that soon onboard artificial intelligence (AI) will be responsible for protecting ground combat systems from interference. Without protection, ground based robotic complexes (NRTK) cannot search, detect, and identify targets. Some of the information effects directed against NRTK include the placement of malware in software systems ahead of a robot's use; contaminating equipment with computer viruses; and generating false

[17] Ibid., pp. 129-130.
[18] Kalistratov, p. 40.
[19] Dul'nev and Korablin, pp. 129-130.
[20] Ibid., pp. 130-131.
[21] Dul'nev, N. P. Pedenko, S. N. Starovoitov, and S. A. Sychev, p. 149.

information commands, such as robot self-destruction ones.[22] To control such eventualities Russia is searching for an integrated protection system that would include five systems: intelligence and information exchange; weapons; protection; support; and mobility systems.[23] Protection systems must be responsive and possess anticipatory reaction capabilities, so that unbalanced situations are quickly identified and proper decisions made.[24] The authors concluded noting that "The idea of this approach provides protection control systems with the functional capabilities of a crew." Implementation rests with AI technology to use only resources needed for a specific situation; obtain new protection methods; and transfer experiences to other robotic devices. The effectiveness of an integrated protection system may not depend as much on a specific level of protection as on the "capability of restructuring, adapting to changing conditions, and self-organization."[25]

Autonomy when executing combat tasks

Full autonomy appears to be a goal but not a current capability of Russian robotics. For now, just the integration of crew and robotic capabilities appears to be the norm. Russian military analyst S. A. Sychev, who writes often on robotic issues, noted in 2019 that the employment of military robotic systems includes four principles: the principle of functional inequality and imbalance; the principle of structural and functional reconfiguration; the principle of functional integration; and the principle of synchronization of results.[26] Each is discussed at Appendix One.

It appears that these four principles are to be used to confront the correlation of the structure and functions of an opposing side's tasks and the situational context under consideration. Both sides are now using robotics and traditional force components. These principles help to create an understanding of how to develop organizational structures and determine the best methods for RTK employment. Combined arms formations equipped with both crew and robotic models of weapons and equipment are thus creating combat systems with new properties. Combat formations can function better in uncertain environments that have not been mapped with a crew and RTK combination, since they offer both combat and functional stability.[27]

The authors of this 2019 article noted, in regard to the classification of RTKs, that an RTK's "intellectualization" must be considered, since robotic devices (complexes, systems) are technical systems with elements of artificial intelligence. They function independently of humans and use algorithms to conduct functions. They take into consideration the system's current state and the external environment. Three varieties of RTK were noted: programmed, adaptive, and intelligent.

[22] P. A. Dulnev, V. G. Kovalev, D. N. Metelev, and S. A. Sychev, "An Approach to the Formation of Protection for Robotic Resources on the Basis of the Theory of Functional Systems," *Vestnik Akademii Voennykh Nauk (Journal of the Academy of Military Science*), No. 2 2020, p. 100. The author would like to thank Dr. Harold Orenstein for his translation of this article.
[23] Ibid., p. 103.
[24] Ibid., p. 102.
[25] Ibid., p. 106.
[26] S. A. Sychev, "Principles of Employing Combined Arms Ground Forces Formations Equipped with Military Robotic Systems," *Vestnik Akademii Voennykh Nauk (Journal of the Academy of Military Science*), No. 2 2019, pp. 101-107. The author would like to thank Dr. Harold Orenstein for his translation of this article.
[27] Ibid., p. 107.

The first operates according to a strict program assigned beforehand. The second is capable of self-adjustment under changing conditions. Some situational control is foreseen based on a set of known situations. The third is capable of self-organization of targeted actions under real combat conditions. The human's role is one of passive control and perhaps decision-making about the conduct of operations.[28]

The "effectiveness" of a robot often depends on a combination of the time for resolving a fire task and on the probability of a hit or target destruction, among other factors.[29] Thus, a typical RTK represents an aggregate of elements and, depending on the algorithm and other factors noted above, can perform final reconnaissance of targets; assessment of results of weapon employment; search and surveillance missions; patrols; communication and electronic intelligence collection; engineer reconnaissance of terrain; radiological reconnaissance; and weather reconnaissance, among other missions.

Specific Russian Robotic Use

Various branches of Russia's Armed Forces are employing robotic equipment. This section begins with two schematics from a 2017 Russian article in the journal *Armeyskiy Sbornik (Army Journal*). The **first schematic is of a potential separate robotic battalion of a combined-arms formation and a potential separate army regiment of robotic assets. The second schematic is a potential role for a separate army regiment of combat robots in a defensive operation**. That section is followed with examinations of Russian robotic use in urban operations, engineer and artillery applications, unmanned aerial vehicles (UAVs), unmanned underwater vehicles (UUV), and robotic uses in Syria. The section concludes with a variety of some specific robotic applications, such as their use as exoskeletons.

2017 Article in Armeyskiy Sbornik

Author A. Kalistratov wrote that for military purposes robots conduct reconnaissance, go into battle, perform mine clearing, and so on. They must also have artificial intelligence or substantial elements of it as part of the robotic complex. Kalistratov described several types of robots (listed in Appendix Two) and included in his article a proposed RTK organization at the battalion and regimental levels (figure 10 below). These units could be used as part of a covering force, to cover gaps in defensive positions, to block assaults, act as a reserve, prevent in-depth breakthroughs, secure freedom of maneuver, and offer use as an outer or inner encirclement element. Also listed was a schematic of a proposed RTK defense, figure 11, also attached.[30]

[28] Dul'nev, N. P. Pedenko, S. N. Starovoitov, and S. A. Sychev, p. 152.
[29] Ibid., p. 154.
[30] A. Kalistratov, "Robots, Into Battle!" *Armeyskiy Sbornik (Army Journal*), No. 10 2017, pp. 35-45.


ВОЗМОЖНАЯ СТРУКТУРА ОТДЕЛЬНОГО БАТАЛЬОНА БОЕВЫХ РОБОТОТЕХНИЧЕСКИХ СРЕДСТВ ОБЩЕВОЙСКОВОГО СОЕДИНЕНИЯ
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ВСЕГО В Б-НЕ 12 БОЕВЫХ КОМПЛЕКТОВ РОБОТОВ
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РОТА ТЕХНИЧЕСКОЙ ПОДДЕРЖКИ
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ПОДРАЗДЕЛЕНИЯ ОБЕСПЕЧЕНИЯ И ОБСЛУЖИВАНИЯ
ВОЗМОЖНАЯ СТРУКТУРА ОТДЕЛЬНОГО АРМЕЙСКОГО ПОЛКА БОЕВЫХ РОБОТОТЕХНИЧЕСКИХ СРЕДСТВ
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ВСЕГО В ПОЛКУ 36 БОЕВЫХ КОМПЛЕКТОВ РОБОТОВ
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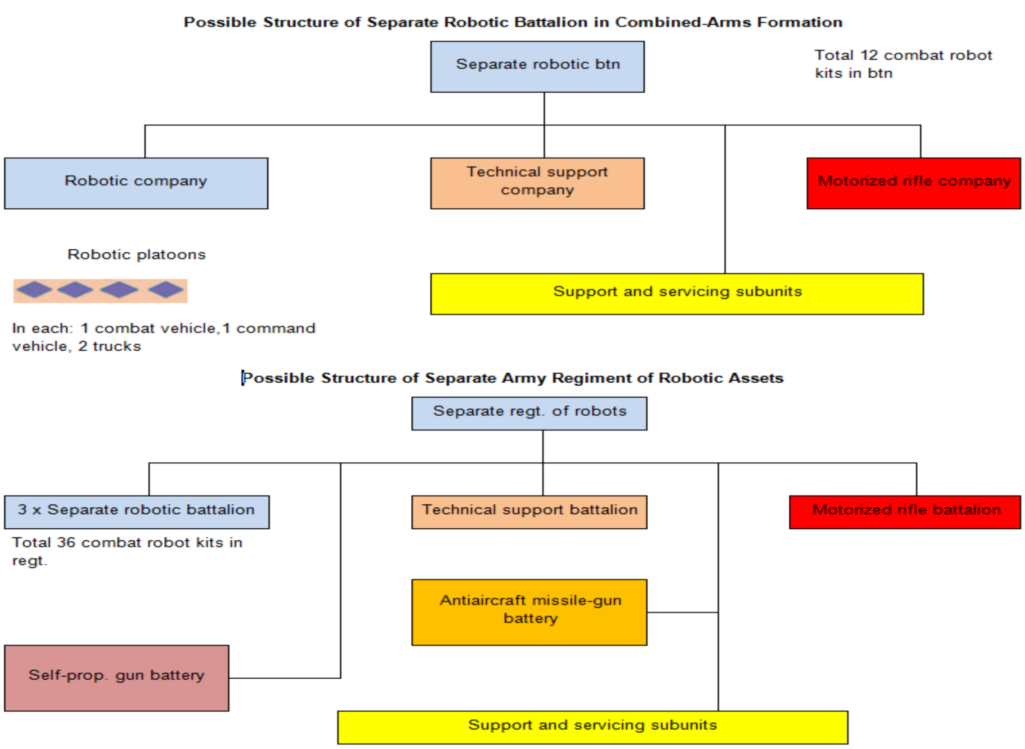
Possible Structure of Separate Robotic Battalion in Combined-Arms Formation
Separate robotic btn
Total 12 combat robot kits in btn
Robotic company
Technical support company
Motorized rifle company
Robotic platoons
Support and servicing subunits
In each: 1 combat vehicle, 1 command vehicle, 2 trucks
Possible Structure of Separate Army Regiment of Robotic Assets
Separate regt. of robots
3 x Separate robotic battalion
Technical support battalion
Motorized rifle battalion
Total 36 combat robot kits in regt.
Antiaircraft missile-gun battery
Self-prop. gun battery
Support and servicing subunits

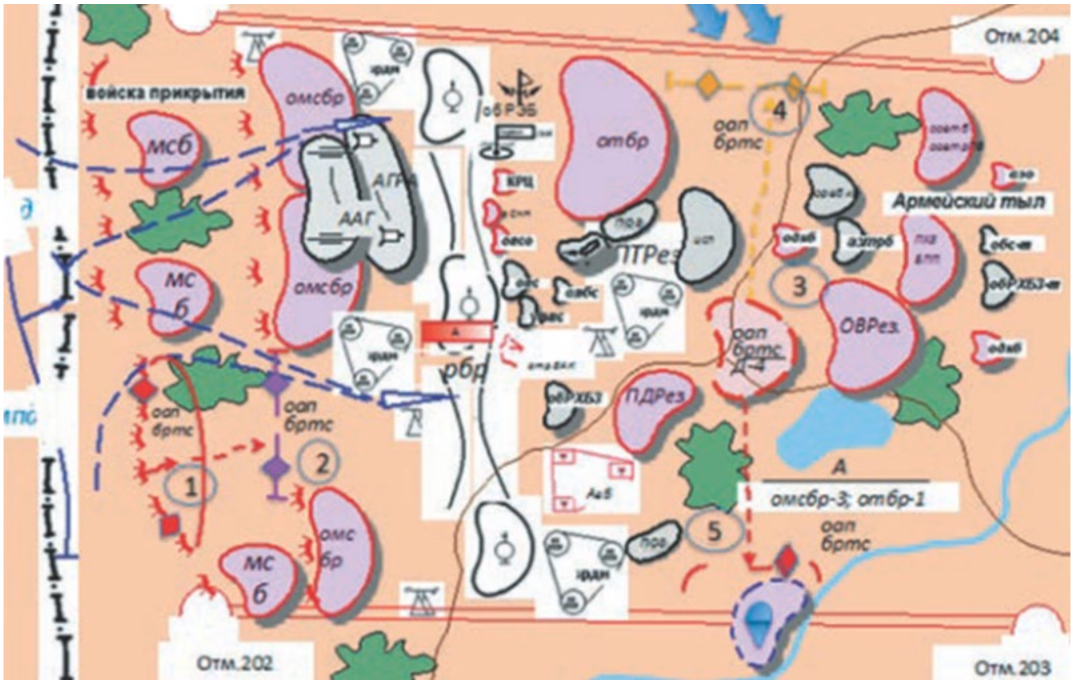

Figure 11. Possible place and role of separate army regiment of combat robots in defensive operation (option)

voyska prikrytiya = covering force
msb = motorized rifle battalion
oap brts = separate robot regiment
omsbr = separate motorized rifle brigade
AAG, AGR = artillery, artillery group
ombr = separate mechanized brigade
rbr = missile brigade
PTRez = (?antitank reserves)
OVRez = (?mineclearing reserves)
PDRez = (?airborne assault reserves)
Armeyskiy tyl = army rear

Robotic Use in Urban Operations

In 2017, P. A. Dul'nev discussed robotic use in urban operations in detail in an article for the *Journal of the Academy of Military Science*. Urban operations, he pointed out, are conducted at close quarters on several levels simultaneously (streets and squares, different floors of buildings, on rooftops, and underground). They lack a continuous front, with fighting turned into a series of isolated battles in small areas making forces vulnerable and requiring more security.[31] Experience gained from the fighting in Syria has helped advance Russia's use of robots in urban operations.

To capture urban structures, where the greatest loss of personnel occurs, robotic assault formations are important. RTKs formed into assault "detachments" are battalion sized, while assault "groups" are company sized. A detachment usually contains 2-3 assault groups, a reserve, a covering group, a fire support group, and an obstacle-clearing group (and on occasion a demolition group). Assault groups may include the following subgroups: penetration, fire support, ground reconnaissance-fire, air reconnaissance-fire, long-range air reconnaissance, command and control, logistics, and a reserve.[32] As a result, the following types of RTKs need to be developed in Dul'nev's opinion:

- Heavy RTK platforms: with tank-type armor protection to destroy highly protected enemy objectives and with bulldozer attachments to overcome mixed minefields.
- Medium RTK platforms: with BMP-type protection to cover flanks and hold captured regions as well as to provide fire support for heavy RTKs.
- Light RTK platform 1: with a weight up to 1000 kilograms, it has "anti-small arms" protection and can destroy unarmored equipment and defend command posts.
- Light RTK platform 2: with a weight up to 300 kilograms, it offers anti-shrapnel protection and can conduct audio-video reconnaissance of the enemy and terrain.
- RTK transport platforms: with a weight up to 100 kilograms, it can support operations by assault subunits.
- Multi-copter and airplane-type reconnaissance and recce-strike UAVs: they are designated to conduct reconnaissance and destroy small targets.[33]

An RTK-assisted attack would unfold with a recce-fire support subgroup of light RTKs, an air recce-strike group to destroy enemy fire resources (mortars, heavy machine guns, etc.), and a long-range reconnaissance group of UAVs for surveillance. Artillery fire would cover the advance of a penetration subgroup of heavy RTKs that conduct direct fire against opponents. RTKs

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[31] P. A. Dul'nev, "The Employment of Robotic Complexes During the Assault of a Town (Fortified Area)," *Vestnik Akademii Voennykh Nauk (Journal of the Academy of Military Science)*, No. 3 2017, p. 27. The author would like to thank Dr. Harold Orenstein for his translation of this article.

[32] Ibid., pp. 29-30.

[33] Ibid., p. 31.

would create passages through obstacles, and a fire support subgroup of medium and light RTKs would perform three missions: cover the penetration subgroup's actions; cover the advance of remote-controlled platforms advancing toward targets with explosives; and sweep the objective.[34]

Problems remain. Reconnaissance RTKs, the light platform 2, multi-copter/airplane-types, and recce-strike UAVs cannot detect underground lines of communication or identify in detail engineer obstacles, most importantly, mixed minefields. Further, cooperation among subgroups is still difficult since each RTK has a control system developed under a specific type of model. General requirements that still need work include the following:

- Maximum conformity, modularity, compatibility, and integration capability into existing and future structures
- Development of unified, jam-free communication channels and data transmission capabilities
- Integration into a unified system of tactical-level command and control, and outfitting RTKs with combat information control systems and "friend-foe" equipment
- Information exchange capabilities among RTKs and the ability to maintain stability against unsanctioned software effects from an enemy force.
- Provisions for the electromagnetic compatibility of military RTKs with other radiating objects, such as radio-electronic warfare resources.[35]

Another source, describing personnel working with minimal robotic assistance, noted that, initial positions are taken up some 200 meters from a building that is to be taken, and robotic devices are used for reconnaissance, detection, and even the engagement of enemy forces. Once a building is taken, a perimeter defense is organized to ensure any counterattack would not work. Nighttime seizures of buildings are more difficult. It was stressed that the first objectives to be seized are those that might entail the disruption of the entire enemy defensive system.[36]

Once underway, personnel are told to avoid movements along streets, where only fighting vehicles should advance. The authors stated that Article 230 of the *Ground Field Manual Part II* should be changed to reflect the following composition of an assault team:

- 3 motorized rifle (airborne, air assault) platoons
- 1 tank platoon
- 1 flamethrower squad (three flamethrower operators)
- 1 ZSU (self-propelled air defense mount, Shilka or Tunguska)
- 1 engineer obstacle-clearing vehicle

[34] Ibid., p. 30.
[35] Ibid., pp. 31-32.
[36] V. Podgorodetskiy, V. Litvinenko, and P. Sergeyev, "The Assault Team: Features of Combat Operations of Assault Teams in Urbanized Areas," *Armeyskiy Sbornik (Army Digest)*, No. 11 2018, pp. 19-25. It is unknown if the ZSU was for air defense or for destroying buildings, as the latter was used by Serbs in clearing Brcko.

- 1 UR 77 (mine clearing vehicle)
- 1 combat engineer platoon
- 1 medical team (physician and corpsmen)
- 1 technical support squad[37]

Another robotic combat vehicle under development is the Marker, which can provide reconnaissance and the destruction of an enemy target. It would be equipped with kamikaze drones, a rocket launcher, and machine gun.[38] Its modular design allows it to function as a combat vehicle, infantry support unit, or drone. It is designed to be fully autonomous, with the operator only providing target designation. The robot decides how to move to the target based on terrain type and obstacles to overcome and then selects the optimal type of weaponry. The Marker's open architecture offers developers the opportunity to test their own robotic components in it.[39] If used in swarms, their integrated use with UAVs and other weaponry would test any defense.

Engineer Use of Robots in Operations: Obstacle-Clearing and Reconnaissance

Engineers robotics are used in a variety of operations, but especially during assaults on urban terrain. It is their job to clear obstacles and ensure troop movement. Assault engineering robots are usually based on a tracked chassis and equipped with a 12.7 mm machine gun and grenade launcher. Main operating equipment includes excavating equipment and either a multipurpose bucket or hydraulic hammer.[40] These robots are maneuvered from mobile control points or a portable remote-control panel. They can use explosives or conduct mechanical breaching of brickwork or concrete obstacles. Robotic missions can be performed under fire and in conjunction with armored and motorized infantry units in the main attack. They get into position when preparatory fire begins, and a technical support element advances with required support materials. Breaches are marked. Mobile control points move behind the robots to advance mission fulfillment.

Robots are initially attached to the assault party and if that advance slows, then they are attached to the assault breaching party. The robot moves behind tanks and fighting vehicles and moves in front when the latter confront obstacles.[41] For obstacles up to 1.5 meters high, bulldozer equipment is used. For obstacles over 1.5 meters high, excavator equipment with a multipurpose bucket is used along with bulldozer equipment. For strong building structures, hydraulic hammers are used. A pavement breaker is used against extra strong material (steel load beams, bars, etc.).

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[37] Ibid.

[38] No author provided, "Russia's Marker's Robotic Combat Platform to Complete Testing by the End of 2021," https://maps.southfront.org/russias-marker-robotic..., accessed 13 January 2021.

[39] Dmitriy Strugovets, "Vitaliy Davydov: They Will Replace Live Warriors with Terminators," *RIA Novosti Online*, 21 April 2020, as reported by Mr. Charles Bartles in the Foreign Military Studies Office publication *OE Watch*, August 2020, p. 4.

[40] N. V. Babin, O. N. Ivanyushenko, and N. N. Magdalinov, "Several Aspects for the Combat Use of Engineering Robot Technical Complexes during Assaults and Obstacle Clearing," *Voennaya Mysl' (Military Thought*), No. 6 2019, p. 145.

[41] Ibid., p. 147.

One other piece of equipment is called haulage gear, where a thimble hook for hauling removes obstacles with a winch. Usually, one robot is assigned to each assault party.[42]

Another Russian article on engineer trends noted ways to improve ground complexes, unmanned aerial vehicles (UAVs), and unmanned underwater vehicles (UUV). Ground complexes should develop ways to survey road conditions and the type of obstacles before them; ways to develop module complexes capable of being assembled for carrying out certain tasks; and ways to develop self-propelled control systems, such as self-moving mines that can move about the area and exchange information with other mines.[43]

UAVs are tasked to estimate if terrain is passible so that robotic routes can be planned; to uncover mine fields and neutralize explosive items along troop movement routes; and to conduct mine-laying with precision. Work is required on increasing flight distances and time in the air, countering adversary electronic warfare capabilities, improving load-carrying capacity, and improving UAV swarm tactics.[44] UUVs are used to reconnoiter water obstacles to be negotiated and to offer a 3D profile of the bottom of an underwater crossing, to include installing markers for clearing mines and other issues.[45]

The following efficiency factors were noted in relation to the use of robotics (in general):

- Up to 50 percent of engineering support will be accomplished with robotic assistance
- Robotics will raise the efficiency of dangerous ground missions by 1.6 to 1.8 times and reduce casualties among personnel by 30-35 percent
- UUVs will improve unit efficiency by 25 to 35 percent when conducting reconnaissance.[46]

UAV Use

Russia classifies UAVs as robotic devices that have civilian and military uses. For civilians, UAVs help with land registry, trips to a bank or store, examining pipeline damage, delivering pharmaceutical drugs to remote populated areas, and disposing of nuclear waste, with the latter in the hands of FEDOR anthropomorphic robots. Flight altitudes and the command and control of UAVs in areas of aircraft congestion must be sorted out. Oleg Martyanov, the Head of the National Robotics Technology and Base Elements Development Center, noted that the Taiga Project UAV work, done in cooperation with the Aeronet UAV Developers Association and Tomsk Oblast Administration, is analyzing the market for oil customers such as Gazprom, Lukoil, and Rosneft,

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[42] Ibid., pp. 148-149.
[43] M. A. Moklyakov and A. M. Bylenkov, "Present-Day Development Trends in Engineer Troops Robotechnology," *Voennaya Mysl' (Military Thought),* No. 4 2019, pp. 43-44.
[44] Ibid., p. 46.
[45] Ibid., p. 47.
[46] Ibid., pp. 46-47.

and for banking and search and rescue organizations such as Rosseti, the Ministry of Extraordinary Situations, Sberbank, and others.[47]

In the military, a 2017 report noted that micro-robots and miniature drones will be equipped with Reset digital communications and video transmission systems. This 30-gram microchip provides secure radio channels with high throughput. It can transmit at distances up to 400 meters in urban environments and up to 1 kilometer in woodlands. Reportedly the system's signal cannot be silenced by means of electronic warfare or be hacked, as signals are encrypted using an algorithm that changes frequency ranges and alters the radiation patterns on antennas.[48]

A 2018 report noted that UAVs and ground-based robots are replacing forward air controllers. The AI-equipped UAV will guide aircraft with precision based on the combined use of four factors: a laser rangefinder, a high-resolution video camera, a thermal imager, and a navigation system. The robot determines the type of target in front of it and the AI determines the type of weapon to use. It has a friend and foe system as well. Data will be transmitted directly to a command post or to an airplane.[49] Another 2018 report noted that Russia is developing a solar-powered UAV (no name provided) with a wingspan of 50 meters, or nearly the length of Russia's White Swan Tu-160 bomber. The increased lift will enable it to increase its payload fivefold. It will cruise at altitudes of up to 30 kilometers and be capable of flying for an unlimited time and over unlimited distances. It can remain over a designated point in the stratosphere for months and thus is an excellent alternative to satellites. Uses for this UAV include monitoring the Earth's surface and the condition of pipelines, relaying communication signals, and monitoring space objects. Problems that remain include creating large-capacity batteries that recharge in daytime and are used at night. Energy-efficient solar panels are needed as well.[50]

A report on adversary drone swarms listed concerns of some Russian analysts. Small or miniature UAVs could produce substantial damage, since they could conduct reconnaissance rather effectively, vector precision-guided munitions to important targets, and attack targets themselves. Or, acting as decoys, they could "uncover" air defense systems, enabling electronic warfare systems to scan the frequencies on which radars and C2 systems operate. If frequencies are discovered, false beacons or dummy frequencies could be inserted into an opponent's systems.[51]

In 2019, an important interview on UAVs involved Vitaly Lopota, leader of the Sector for Programs on Robotics Engineering at the ERA Military Innovation Technopolis. Initially he

[47] Ilya Morozov, interview with Oleg Martyanov and Igor Denisov, "Oleg Martyanov: Anthropomorphic Robots Have Good Prospects in the Army. The Head of the National Robotics Technology and Base Elements Development Center Talked about the Development Trends of Domestic Robots," *Interfax-AVN* Online 16 May 2019.
[48] Andrey Kruglov and Aleksey Ramm, "Military Micro-Drones protected against Interference: Russian Developers Have Created Ultra-Compact Secure Communications System for Robots," *Izvestiya Online*, 21 December 2017.
[49] Bogdan Stepovoy and Aleksey Ramm, "A Robot Will Guide Aircraft with High Precision. Forward Air Control Officers Are to be Replaced by Artificial Intelligence," *Izvestiya* Online, 10 August 2018.
[50] Sergey Valchenko, "Giant 'Solar' UAV to be Built in Russia. Electric Drone to Have Wingspan Almost as Big as Tu-160 Strategic Bomber's," *MK Online*, 6 June 2018.
[51] Mikhail Goldreyer, "The UAV swarm: Concerns and Reality," *Arsenal Otechestva Online*, 1 February 2018, No. 1, pp. 86-87.

discussed an aerobot, a research platform on a quadrocopter multi-rotor UAV that is equipped with artificial vision and powerful on-board computer systems. The aerobot is a flying laboratory designed to research high-speed operations in various degraded conditions (absence of auxiliary navigation signals or global navigation GPS systems, limited optical visibility, limited space due to forests, residential facilities, etc.). Interest in multi-copters was due to their maneuverability at low speeds, hover capability, and ability to take off and land vertically.[52] Another innovative option is to place both optical devices and multifunctional software-supported radar stations (RLS) on UAVs and land-based robots. Optics are not able to distinguish enemy positions concealed in buildings or behind natural obstacles or "see things" or "discern" objects through fog. The desired range for RLS is 5 to 8 kilometers.[53]

Experience demonstrates that the optimum altitude for video camera and thermal imaging for long-range UAVs is up to 300 meters and for short-range UAVs up to 1,000 meters. A UAV target run should be made from the direction of the sun. UAVs should be launched from the forward edge into friendly rear territory to hide its launch position. When it gains altitude it should be turned toward the enemy. A high degree of reconnaissance, communications, and command and control assets is needed. Electro-optical systems enable detection and surveillance up to 6-8 kilometers.[54] UAV tasks include not only reconnaissance and target designation but also control over the results of troop actions, communication retransmission, and other uses.[55]

Drone strike operations were rehearsed in 2019 and reported in the paper *Izvestiya.* The order of attacks on adversary targets were, first, headquarters and communications centers, and then transport infrastructure, the approach of reserves, and frontline air defense systems. UAVs are deployed in attack groups (numbers vary and include Granat, Zastava, Eleron, Orlan [tested in Syria], and Leyer UAVs), with one of the lead vehicles conducting visual reconnaissance at 1-1.5 kilometers above the ground, followed by a second one carrying the Leyer-3 radio electronic warfare assets to suppress enemy ground communication equipment, and closing with a third UAV that relays information to the base from a height of 4.5 to 5 kilometers.[56]

The Russian Forpost UAV surpasses the Orlan in reconnaissance capability with a flight range that exceeds 250 kilometers to the Orlan's 100 kilometers. It is fitted with two cameras, one being infra-red that allows for around the clock use. A Forpost-M version is undergoing testing that will carry precision-guided bombs with a load capacity in excess of 100 kilograms.[57] The

[52] Yuriy Avdeyev interview with Vitaliy Lopota, "ERA Multi-Copter Pilotless Vehicles: The Defense Ministry is Actively Participating in a Program for Advanced Development of Unmanned Aviation Vehicles," *Krasnaya Zvezda (Red Star*), 29 March 2019.
[53] *Krasnaya Zvezda (Red Star*) interview with Vladimir Ivanovskiy*,* reported in *Russia Today Online*, 5 March 2020.
[54] R. Nikitenko, "Ground Troops: To Assist the Scout: Study of Robotic Reconnaissance Complex Capabilities," *Armeyskiy Sbornik* (*Army Journal*) Online, No. 5 2019, pp. 24-31.
[55] O. V Milenin and A. A. Sinikov, "The Role of Aerospace Forces Aviation in Modern Warfare: Unmanned Aerial Vehicles as a Development Trend in Military Aviation," *Voennaya Mysl' (Military Thought*), No. 11 2019, p. 54.
[56] Aleksey Ramm and Bogdan Stepovoy, "Military Rehearses Drone Strike Actions for the First Time," *Izvestiya*, 7 November 2019, as reported by Les Grau in the Foreign Military Studies Office publication *OE Watch*, January 2020, p. 22.
[57] Ibid.

Forpost-M, one 2018 report noted, has a "Russian-made strapdown inertial navigation system that allows the drone to fly without the use of GLONASS or GPS global systems," which offers advantages when flying in enemy air defense and electronic warfare sectors. It can reach speeds of more than 200 kilometers per hour and stay airborne for up to 17 hours. Its maximum altitude is 5,000 meters and weights more than 450 kilograms.[58]

Also, in 2019 the Altius UAV carried out its first flight and is able to conduct patrolling operations for 48 hours at up to 12,000 meters. Its operational range is about 10,000 kilometers. It has ultralong range radar and optoelectronic systems so that it can conduct all-around observation of water surfaces and airspace from great distances. Finally, the massive Okhotnik (Hunter) strike drone was mentioned in 2019. It weighs 20 tons, is 19 meters long, and has a wingspan of 14 meters. It can carry both cruise missiles and guided aerial bombs.[59] Other sources implied that the Okhotnik will eventually be armed with hypersonic weapons and be used to expand a fighter's radar field and thus target designation for long-range aviation.[60]

UAVs can be used in search and rescue missions, electronic warfare, information confrontations, air defense, terrain engineering, control over forces, and cargo drops. They can be used as temporary reconnaissance strike- and fire-loops as well. If placed in the first wave of an attack, they can draw fire from an adversary's air defense system, thereby exposing them for destruction by the second wave of combat aircraft. Short-range UAVs were used in an experiment due to their relatively low vulnerability from adversary air defense systems and ability to perform reconnaissance and fire destruction missions.[61]

The preliminary use of UAVs for reconnaissance and strike actions diminishes the risk of piloted aircraft from getting hit. UAVs are distributed by task. UAV "directors" for an operation take part in defining the combat formation used and its parameters, to include UAV types, degree of destruction required, sortie rate, and execution by stage.[62] To control UAV assets, a ground-based robot-technical system has been developed to replace/work with forward observers. The system consists of the following subsystems: information processing and command; control over the system; combat aircraft control; a power supply system; and an executive-technical system. It

[58] Aleksey Ramm and Bogdan Stepovoy, "Drone Attack: Military Preparing to Adopt the First Russian Attack Drone," *Izvestiya*, 24 July 2018, as reported by Les Grau in the Foreign Military Studies Office publication *OE Watch*, January 2020, p. 23.
[59] Ibid., Ramm and Stepovoy, "Military Rehearses…"
[60] See Victor Butkevich, "Colonel Baranets Spoke about Equipping the S-70 Hunter with a Hypersonic Dagger," *Polit-Rossiya*, 11 May 2020; and Oleg Falichev, "Will the Hunter Be Able to Hunt?" *Voyenno-Promyshlennyy Kuryer (VPK)*, 13 April 2020, as reported by Ray Finch in the Foreign Military Studies Office publication *OE Watch*, June 2020, p 3.
[61] A. V. Ananyev, S. V. Filatov, and A. G. Rybalko, "The Joint Use of Piloted Aviation and Reconnaissance-Strike Unmanned Aerial Vehicles of Short Range," *Voennaya Mysl' (Military Thought*), No. 4 2019, p. 27.
[62] A. V. Ananyev, S. P. Petrenko, and S. V. Filatov, "An Evaluation of a Path for Organizing Control of Unmanned Aerial Vehicle Formations in Combat Support of Piloted Aircraft," *Voennaya Mysl' (Military Thought*), No. 1 2019, p. 79.

is launched into action either in autonomous automated mode using a timer or through remote control.[63]

There were also numerous innovative and creative methods for employing UAVs. First, in an article on the Grom UAV, the device was described as equipped with a turbojet engine that is launched from the Smerch multiple rocket launcher system. It will be used for reconnaissance purposes.[64] The article did not note how many UAVs could be launched simultaneously.

Second, and perhaps most creative, was a method of making UAVs appear to be just another flying creature. Russian scientists made a UAV that closely resembles a polar owl. It was produced by servicemen of the ERA Technology Park. The UAV can remain airborne for 40 minutes with a flight range of 20 kilometers and, of course, appears as nature and not a UAV. Armed with a laser range finder and video monitoring instruments, it weighs five kilograms and can be controlled by one person. Made of composite materials, it is hard to view on radars.[65]

Third, the Karnivora strike UAV has a creative method to capture an opponent's UAV. The Karnivora has a wingspan of 5 meters, a take-off weight of 40 kilograms, and a speed of 150 kilometers an hour. It can loiter for 10-15 hours, can monitor an area up to 150 kilometers in operator mode or 500 kilometers in autonomous mode, and has day and nighttime camera capabilities. Karnivora has two modes. It can either intercept an opponent's UAV by casting a net to seize quadcopters and then deploy a parachute to lower the drone to earth; or employ its strike mode, which can include the use of fragmentation grenades, antitank aerial bombs, or anti-personnel fragmentation charges and aerial bombs. There were plans to test it in Syria.

Fourth, a creative method was to pair UAVs with the AZK-7 acoustic complex that measures the sound of artillery and mortar fire. This increases the establishment of the precise location of a target, even those 15 kilometers away. The equipment takes bearings, determines the location of acoustic signals, and forwards information to command centers.[66]

Fifth, the KYB self-detonating UAV utilizes a creative method of flying to a target "regardless of the targets covertness or the relief of the local terrain, at both low and high altitudes" at high speed and explodes, acting as a suicide UAV. It can achieve speeds of 130 kilometers per hour and fly for 30 minutes. It has a maximum payload of three kilograms, a body length less than one meter, and a wingspan of 1.2 meters.

Finally, the Central Military District created separate UAV units as part of artillery troops. Having such units offers artillery troops a method to adjust fire in a real-time mode after detecting enemy command posts up to 12 kilometers away through radio waves. [67] The Russian military

[63] M. A. Gudkov, V. N. Lukyanchik, and V. N. Melnik, "A Ground-Based Robo Technical Complex for the Forward Aviation Gunner," *Voennaya Mysl' (Military Thought*), No. 6 2019, pp. 151-152.
[64] No author or title provided, *Interfax* (in English), 8 January 2019.
[65] No author provided," Experts Assess Russian Drone Shaped Like a Polar Owl," *Rossiyskaya Gazeta Online*, 25 June 2019.
[66] Eastern Military District Press Service, "Reconnaissance Troops of Eastern MD Formation Augmented with Latest AZK-7 Acoustic Measurement Complexes," *Ministry of Defense of the Russian Federation (*in English*),*
[67] No author or title provided, *Interfax* (in English), 6 March 2019.

base in Tajikistan has such a new UAV battalion, according to the Central Military District. UAVs with the unit are Orlan-10, Leer-3, Eleron, Granat, and Takhion. It is not known if the battalion is associated with the artillery units there.[68] Another report noted that the Forpost UAV will be included in the detachment, offering a long-range capability.[69]

Of interest was that in 2020, trials of the VM Dan M UAV with an MGTD-125E engine took flight. The main components of the UAV were printed on a 3D printer. The flight lasted 19 minutes, reached a maximum speed of 676 kilometers per hour, and attained an altitude of over 2,000 meters. Its takeoff weight was 370 kilograms.[70]

Countering an Opponent's UAVs

To counter an opponent's UAVs (or airborne robots, from a Russian perspective), several systems have been promoted. Most fall into the classification of electronic warfare (EW) or sniper/air defense artillery fires. First, EW systems include equipment such as the Borisoglebsk-2, which has an expanded frequency electronic intelligence collection and suppression capability that it uses to suppress enemy UAVs.[71] Another EW system, the Krasukha-4, in conjunction with the Pantsir-S1 surface-to-air missile system, is said to have provided a protective dome over forces for a radius of several tens of kilometers against enemy UAVs in exercises.[72] The Central Military District noted that it utilizes the Zhitel, Silok, Lesochek, and other EW complexes to combat enemy UAVs.[73] A featured segment on Russia's *Zvezda TV* promoted the "Repellent" anti-UAV vehicle, which creates a "solid, impenetrable" electronic barrier.[74] The system supposedly can block UAV movement with "invisible walls" at any altitude in a radius of 30 kilometers. The system detects radio signals emitted by drones.[75] Finally, the Valdai UAV counter system locates radio emission sources, detects targets and identifies their types, intercepts control channels and global navigation system data, and issues target designations to other counter means.[76] The system can operate in bad weather and both in daytime and nighttime. Strategic Missile Troops deputy head Dennis Sakhnov stated that the system can detect and down any type of UAV.[77]

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[68] No author or title provided*, Interfax* (in English), 13 March 2019.
[69] Central Military District Press Service, "Russian Military Base in Tajikistan Reinforced by UAV Battalion," *Ministry of Defense of the Russian Federation* (in English), 14 January 2019.
[70] No author provided, "Russia Tests Dan Jet UAV," *Lenta.ru,* 16 September 2020.
[71] No author provided, "VVO's Amur Combined Formation Received the Latest EW System'Borisoglebsk-2': The System has an Expanded Frequency Band for Electronic Intelligence Collection and Electronic Suppression Equipment," *TASS*, 9 January 2019.
[72] Tatyana Vorobyeva, "Servicemen in Urals Cover Command Post against 'Swarm' of UAVs," *Rossiyskaya Gazeta Online*, 13 February 2019.
[73] Yuriy Gavrilov, "The Robot Does Not Fear War: Many Unmanned Combat Assets Have Undergone Battle-Hardening in Syria," *Rossiyskaya Gazeta Online*, 20 August 2018.
[74] No author or title provided, *Zvezda TV*, 21 April 2019.
[75] Ibid.
[76] No author or title provided, *Izvestiya Online,* 3 April 2019.
[77] No author provided, "Russia's Strategic Missile Troops Have Deployed the New Valdai Unmanned Aerial Vehicle Jamming System for the First Time in an Exercise in Tver and Novgorod Region," *Zvezda TV*, 4 April 2019.

Second, there are developments underway to shoot down enemy UAVs. The Moscow Aviation Institute has developed a combat UAV armed with an automatic gun. It weighs 23 kilograms, can stay airborne for 40 minutes, has a wingspan of 3 meters, and is armed with a 12-mm automatic carbine.[78] Another report noted that sniper pairs were involved in repelling UAVs during exercises.[79] Snipers first are warned by radar sites that an opponent's UAV is inbound, and they then advance to positions from which to conduct visual surveillance. The snipers in one exercise conducted fire up to 1.5 kilometers away.[80] The 57-mm Derivatsiva-PVO anti-aircraft artillery system is designed to combat cruise and air-launched missiles, UAVs, and helicopters.[81] The system's electro-optical detection and sighting system offers a 360-degree view to monitor individual sectors. It can detect "a small-dimension drone through thermal imagery at a range of at least 700 meters" and can use its optics to identify aircraft up to 6.5 kilometers away. Airborne targets can be engaged at up to 4.5 kilometers and the rate of fire of the 57-mm automatic cannon is 120 rounds per minute. The system has five types of rounds, the main one being a multipurpose projectile that can "be remotely programmed to detonate alongside a target."[82]

In a similar manner, the Strela-10 portable antiaircraft missile system crew destroyed UAVs in a Western Military District exercise. The integrated use of EW and PVO was based on experiences gained in Syria.[83] The Buk-M3 ZRK anti-aircraft missile system can be used to shoot down UAVs[84] as can the Zu-23/30M1-4 artillery piece, which is a mobile system with the name SAMUM (meaning Ultramobile Upgraded Multirole Artillery Piece). It has two variants. The artillery variant can engage targets at altitudes of 1.5 kilometers and a range of 2.5 kilometers, while the missile variant can engage targets at a range of 6 kilometers and an altitude of 3.5 kilometers. The latter is equipped with Igla or Verba MANPADS-type surface-to-air guided missiles.[85]

Another method to attack UAVs is a system such as the Ataka-DBS automated system, which is designed to identify drones and intercept their penetration. It blocks communication and satellite navigation channels and causes the UAV to lose connection, forcing it to either return to its point of launch or make an emergency landing. It suppresses control channels in civilian bands from 2-6 GHz. The system prevents video observation and industrial espionage by establishing a

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[78] No author or title provided, *RIA Novosti*, 15 March 2019.
[79] No author provided, "Unmanned Aerial Vehicle Combat Subunits Repel Hypothetical Combat Drones Attack in Exercise in Rostovskaya Oblast," *Ministry of Defense of the Russian Federation (in English),* 30 January 2019.
[80] Russian Federation Ministry of Defense Information and Press Service Directorate, "Eastern Military District Snipers in Buryatia Learn to Destroy the Aggressor's Unmanned Aerial Vehicles," *Ministry of Defense of the Russian Federation (in English),* 10 June 2019.
[81] No author provided, "Derivatsiva-PVO Advanced Antiaircraft Artillery System Undergoes State Testing in 2019," *Ministry of Defense of the Russian Federation (in English),* 8 March 2019.
[82] Aleksandr Grigoryev, "Rapid-Fire 'Flyswatters' for Hostile Drones," *Yezhenedelnik Zvezda*, 15 March 2019.
[83] No author or title provided, *Ministry of Defense of the Russian Federation* (in English*),* 14 March 2019.
[84] No author provided, "Buk-M3 ZRK Teams in Kursk Oblast Repelled a Massed Unmanned Vehicle Attack," Z*vezda TV Online*, 7 February 2019.
[85] Irina Dronina, "Russia Develops Drone Killer," *Nezavisimoye Voeynnoye Obozreniye Online*, 7 January 2019.

no-fly zone for unsanctioned drones. Detection is possible up to 1.5 kilometers and suppression at 1 kilometer.[86]

Unmanned Underwater Vehicles (UUV)

In September 2017, the Defense Ministry's Main Directorate for Research and Development (GUNID, whose deputy head is Roman Kordyukov) ran trials off the coast of Syria of the Galtel submarine robot. This is a yellow, torpedo-shaped device that is known as a robotic unmanned underwater vehicle (UUV) that can move in circles or a spiral and is not connected to wires or cables. Developed at the Vladivostok-based Institute of Marine Technology Problems, the Galtel system is composed of two UUVs, with each having an endurance of 24 hours and a range of up to 100 kilometers, a remote-controlled submersible, and a control center. The Galtel has photo and video capability and a side-scan sonar. In 2019, the Galtel system conducted more tests in Syria's coastal waters. The system orients underwater based on elements of hydroacoustic navigation systems. The system sets out coordinates and a reference point can be fixed with the help of the underwater beacons, since GPS and GLONASS signals do not penetrate to the bottom. The Galtel system includes an unmanned television guided underwater vehicle and two autonomous unmanned submarines with an autonomous cruising range of up to 24 hours and up to 100 kilometers.[87]

Another UUV is the Glidel, an autonomous reconnaissance device with stealth capability. It is not active-search like Galtel, but a passive-search device.[88] Data from the device is received in the Galtel's control room. It was noted that the underwater drone can survey four square kilometers in just over 12 hours, has a remotely operated camera capable of operating at depths up to 300 meters, and identified the Institute's lead designer as Vladimir Kostenko.[89] Alexander Mironov, head of the Main Department of Research and Technological Support of Advanced Technologies at the Russian Defense Ministry, stated that sea robotics would be demonstrated on Lake Komsomolskoye at Army 2017.[90]

The Morskaya Ten is a multifunctional instrument designed to collect and process large amounts of data in the world's oceans. It can loiter autonomously for up to six months in the water. The research and design projects for UUV's are located in the following areas: control systems and algorithms—26; mechanical engineering—16; marine technologies—14; medical RTK—9; and space—5.[91]

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[86] No author provided, "Roselektronika Holding Company Developed a New Automated System for Countering Unmanned Flying Vehicles," *Oruzhiye Rossii*, 23 March 2019.
[87] Viktor Sokirko, "Russia's Defense Will Be Reinforced with a Whole Arsenal of Underwater Robots," *Vzglyad Online*, 21 February 2019.
[88] *Zvezda TV*, 3 September 2017.
[89] Timur Alimov, "How the Russian Federation's First Robot Submarine in Syria Was Organized," *Rossiyskaya Gazeta* Online, 8 September 2017.
[90] *Interfax* (in English), 28 July 2017.
[91] Oleg Falichev, interview with Sergey Popov, "The Honor of the Iron Uniform," *Voyenno-Promyshlennyy Kuryer* Online, 7-13 June 2017.

In 2018, Russia's Klavesin-2 UUV was designated the 2R52. It is larger and heavier that the Klavesin-1. The -2 looks like a miniature submarine and has a diving depth of 6 kilometers and a range of 50 kilometers. It can carry sonar sets, electromagnetic sensors, and video cameras.[92] Russian deep-water equipment allows it to look for missing submarines, build underwater pipelines for hydrocarbon shipments, and construct fiber optic communication systems on the ocean floor.[93] UUVs can move at depths of over 1000 meters at high speed and remain invisible. It will have a nuclear propulsion unit.[94]

The existence of a nuclear-powered underwater drone, the Poseidon, is a creative method that Russia, in their opinion, can use to offset the advantages of the U.S.'s Prompt Global Strike Weapon. The Poseidon would be armed with a nuclear warhead of two megatons and would target an opponent's aircraft carrier group or the shore-side installations of cities. A nuclear reactor provides power and offers unlimited range and a speed of 200 kilometers per hour. President Vladimir Putin stated that the drone travels at "extreme depths, intercontinentally, at a speed multiple times faster than the speed of submarines, cutting-edge torpedoes, and all kinds of surface vessels…"[95] News agency *TASS* quoted a source that stated 32 such drones would be on combat duty. Two submarines in the Northern Fleet will each carry eight drones and two submarines in the Pacific Fleet will do the same. It was noted, however, that 16 drones will also be in the Barents Sea region.[96]

Finally, a comment is warranted about what Russia describes as the sea-bottom based nuclear missile "Skiff" that appears to have robotic relevance. Whether the concept is a real one or one aimed at just intimidating opponents is unknown, but the description of the missile system is fascinating and an interesting additional deterrent to an already expanding number of Russian missile systems.

Of primary concern is whether this is a new version of the "Dead Hand" system known as Perimeter from the Cold War days, which was described so well by David Hoffman in the book by that name. Can the Skiff system be launched individually or in mass (how many are there and where are they?) if the football/suitcase code system is unable to function and administer release codes? Hoffman's Perimeter/Dead Hand weapon did just that. Knowledge of the system was based on an interview with Russian missile expert Valery Yarynich after the demise of the Soviet Union. Regarding the Yarynich interview:

> It outlined how the 'higher authority' would flip the switch if they feared they were under nuclear attack. This was to give the 'permission sanction.' Duty officers would rush to their deep underground bunkers…if all communications were lost [with Kremlin leaders], then the duty officers in the bunker could launch the

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[92] Nikolay Surkov and Aleksey Ramm, "The Army: unmanned Submersibles Will Master the Crimea. Feodosiya Has Become the Main Range for Testing the Latest Naval Robots," *Izvestiya* Online, 15 May 2018.
[93] *Interfax* (in English), 22 February 2018.
[94] *Interfax* (in English), 1 March 20. 18.
[95] No author or title provided, *The Independent Barents Observer* (in English), 14 January 2019.
[96] Ibid.

> command rockets. If so ordered, the command rockets would zoom across the country, broadcasting the signal 'launch' to the intercontinental ballistic missiles.[97]

Thus, Perimeter was a type of "Dead Hand" system (as if rising from the grave) that would launch rockets that literally "threw down" the codes to intercontinental ballistic missiles, enabling their launch without receiving the codes from Moscow if all communications were lost. The discussion of the Skiff system implies the potential use of a system similar to but unlike Perimeter. Skiff, lying on the seabed, works in the following manner via remote control:

> Upon receipt of the launch command a partial inflation allows the container to assume the quality of a roly-poly toy, i.e., it assumes a vertical position. It then continues to inflate, and the container begins to surface. An opinion exists that the missiles are expelled from the container using solid-fuel boosters at a depth of 50 meters, as this occurs in submarines.[98]

The missile reportedly can remain in stand-by mode for a long period of time and upon command attack ground or sea targets. Reports are that the Sarov submarine released the missile. The submarine's nose section had an expanded diameter in its torpedo launch section and also had ballast tanks. The latter compensated for the weight of the missile when it was off-loaded and thereby helped maintain stability.[99] Thus while the missile system is not "robotic" in the sense of moving on land or in the air, it "comes alive" upon remote command and is able to fulfill the functions of a robotic-type asset, to include the ability to move to other locations.

Since the Skiff is a one-time launch vehicle, it would make no difference if the missile launched from the surface instead of below it. A significant advantage is gained when the Skiff is placed on alert on the seabed of the Arctic shelf, since flight time to the U.S. would be shortened. The flight time from the Arctic, one article noted, would offset the flight time of any medium-range ballistic missiles that the U.S. would put in Europe. Of concern was that the missile would need to remain for a decade or longer in an ocean environment without any technical servicing. Reports are that the missile was first tested in 2008.[100] As one article noted:

> Skiff is a ballistic missile, which can remain in standby mode on the sea or ocean bottom so that when it is needed it can be fired on command to strike ground and naval targets. Its installation is accomplished from a submarine. And this is important, as indeed it is the main element in providing for the covertness of such an installation.[101]

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[97] David E. Hoffman, *The Dead Hand*, Doubleday, 2009, p. 422.
[98] Vladimir Tuchkov, "The Skiff Missile: For the USA and England This is More Frightening than the Tsirkon. A Strategic Weapon with a New Basing Principle is Ready for Combat Alert," *Svobodnaya Pressa (Free Press)*, 24 November 2017.
[99] Andrey Riskin, "Senator-General Bondarev Adds Sea Bottom-Based Missiles to the Country's Nuclear Triad," *Nezavisimaya Gazeta (Independent Newspaper) Online*, 22 November 2017.
[100] Tuchkov.
[101] No author provided, "A Strike from the Depths of the Sea: Secrets of Project Skiff," *Pravda.ru (Truth.ru)*, 22 November 2017.

Skiff is probably a modification of the Sineva or Layner sea-based intercontinental ballistic missiles, since all three were developed at the Makeyev Center. Its placement on the seabed bottom was probably assisted by the Lasharik, an AS-12 deep-diving nuclear device able to dive to 6 kilometers. The system is deemed to belong in the category of nuclear deterrence weapons.[102]

Occasionally, information about the Skiff still appears in the press. In 2019, for example, there was a report that mini submarines bearing the name Skiff were designed in the Akademik Makeyev State Missile Center jointly with the Rubin Central Design Bureau (TsKB), with the design being to inflict surprise strikes from the ocean depths. Initially the article repeated what was already known about the Skiff, that it is not a submarine but rather a bottom-based ballistic missile. It lies on the ocean bottom for long periods of time and upon receipt of a command can strike a target at ranges beyond 300 kilometers. The report then added information that was more concerning. It noted that "even if a potential enemy pin points the area in which a Russian submarine positions the 'Skiffs,' they can be repositioned at significant distances and only then lie in wait on the bottom."[103] That is, it appears that the system can change its position on its own prior to its use. The article did not explain how it would reposition its start position but noted that when first deployed, Skiff emits a sound like the operation of a submarine power plant, which gives the submarine a chance to depart the area. Skiff then becomes noiseless and lies in wait of commands.[104] Thus, in 2019 new elements were added to the system's capabilities. If a real capability, it is important to ascertain where they are located in oceans or seas, and how many of these systems there are. If some are stationed next to the U.S. or other nations, they could easily be in range of the U.S. with their strike capabilities. This would be a new and asymmetric way to guarantee Russia's concept of "equal security."

Artillery Use of Robotics

Not much has been written on a general robotic system designed to support artillery. However, several separate pieces have appeared. First, in 2016 it was noted that the Koalitsiya-SV was a first step toward the robotization of artillery systems. The system has an unmanned combat section and a process of aiming and loading the gun without human involvement. In the "firestorm" mode, the system fires several shells from the same gun at different angles, but they all reach the target at the same time.[105]

Second, there was a 2019 discussion of suggested robotic technical systems (RTS) designed to carry out Missile and Artillery Ground Force (GF MF&A) tasks. Artillery RTSs consist of four to six robot self-propelled artillery pieces and one mobile control post. The artillery pieces are based on a caterpillar chassis that can proceed at speeds of up to 45 kilometers per hour over most terrain and up to 50 kilometers per hour on highways. Each artillery piece should consist of the following modular pieces and aim to fire up to 15 rounds per minute:

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[102] Tuchkov.
[103] Viktor Sokirko, "Russia's Defense Will Be Reinforced with a Whole Arsenal of Underwater Robots," *Vzglyad Online*, 21 February 2019.
[104] Ibid.
[105] No author provided, "New Artillery Systems Will Be Robotic," *TASS*, 18 November 2016.

- 120mm artillery piece
- Automated ammunition storage for 60 rounds
- A gun aiming control system
- A loading control system
- A loading initiation system
- And an automatic fuse setter.[106]

If firing separately, the entire number of rounds (60 x 6 pieces) would be expended in 24 minutes (at 15 rounds per minute for each piece).[107]

In addition, the systems include unmanned self-propelled artillery pieces with remote control homing, firing, and navigation components and a remote-controlled self-propelled antitank missile system. UAVs offer reconnaissance capabilities in support of artillery pieces, as described above. Long-and medium-range UAVs such as Forpost support missile systems and large-caliber multiple rocket launch systems (MRLS), while short-and close-range UAVs such as Orlan-10 and Eleron-3SV support artillery and some MRLS. Ground-based reconnaissance RTSs are required for security, movement routes, and other tasks.[108]

Third, in 2020 the Defense Ministry announced that the Southern Military District will be armed with the latest 2S19M2 "Msta-SM" artillery. These robotic guns have enhanced fire range and accuracy features that still require a crew. The guns use "smart" highly precise projectiles. The system includes an automated guidance and fire control component on each of the howitzers. A satellite navigation system has been added to the artillery mounts, so the exact location of the gun is known. The article added that:

> Each armored vehicle has obtained the capability to automatically exchange information with the battalion and battery command post and artillery radars and to obtain and transmit information about each shot. If necessary, one can even guide it remotely from the command post. It only remains for the crew to confirm opening fire.[109]

Robotics in Syria

The use of robotic systems was tested often under combat conditions in Syria. For example, one blogosphere report noted that a "high-technology" assault had utilized Russian robots along with Syrian infantry and Russian artillery under the control of an UAV and the Andromeda-D

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[106] S. V. Zyuzin, S. A. Umerenkov, and S. V. Shadrin, "The Prospects of Using Military Robo Technical Systems in the Missile Forces and Artillery of the Ground Forces," *Voennaya Mysl' (Military Thought*), No. 12 2019, p. 114. pp. 117-118.
[107] Ibid.
[108] Ibid., p. 114.
[109] No author provided, "The Devil's 'Msta'" Robotic Artillery Mounts Will Arrive in Russia's South," *Ivestiya*, 27 November 2020.

battlefield command and control system.[110] Another system tested was the Skarabey, a small robotic platform on wheels with a high-resolution video camera, a microphone, and a heat sensor. It is used in tunnel searches since it is only 15 centimeters high and with an electronic motor it is almost noiseless.[111] Other reports of robotic use in Syria included the Uran-9, which is a reconnaissance robot, tank-killer, and mobile fire support asset; Uran-6, a mine-clearing robot; the Nerekhta, which can be produced as an artillery reconnaissance module or transport module; and the Soratnik, an unmanned armored vehicle used as a fire support or mobile relay robot or for mine-clearing terrain or evacuating wounded.[112]

A 2019 article in the Russian journal *Military Thought* discussed the use of UAVs in Syria. In a single flight, a UAV might have conducted aerial reconnaissance, designated targets, controlled air strikes, or adjusted artillery fire. They assisted in the control of ceasefire regimes, delivering humanitarian cargo, and performing other tasks. On one occasion they assisted in the creation of a 3D simulation of the city of Palmira. Cameras, radio, and integrated multi-tiered technical reconnaissance, television, and infrared video cameras were used. Most were short-range UAVs used by commanders in sectors, although medium and long-range units were used to reconnoiter the entire territory of Syria. Problems associated with Russia's UAV deployment in Syria consist of the following:

- The difficulty of identifying the military facilities, personnel concentrations, and equipment of an adversary
- The dynamically changing surface situation
- The need to carry out aerial reconnaissance in mountainous and desert terrain as well as in populated areas
- The adversary's use of every available means to hit UAVs
- Using UAVs in the same air space as piloted aircraft.[113]

It was noted that UAVs should be used in conjunction with aircraft and artillery and should fly at altitudes where they cannot be visually detected or heard, spending only a few minutes over adversary facilities. UAV efficiency depends on ensuring the prompt processing of data and using UAVs jointly with other reconnaissance forces and assets. Of course, combat in Syria also exposed the need to counter adversary UAVs since insurgents either purchased light-class UAVs at retail or bought spare parts and made them.[114]

Defense Minister Sergey Shoygu, speaking at a conference in 2018, stated that UAVs had allowed Russian troops to take control of the situation throughout Syria. Daily, up to 70 UAVs

[110] Nikita Volchenko, "Syria Has Become a Test Range for Testing the Latest Developments of Russia's Defense Industrial Complex," *Vzglyad Online*, 3 February 2017.
[111] Yuriy Gavrilov, "The Robot Does Not Fear War: Many Unmanned Combat Assets Have Undergone Battle-Hardening in Syria," *Rossiyskaya Gazeta Online*, 20 August 2018.
[112] Ibid.
[113] Milenin and Sinikov, p. 55.
[114] Ibid., p. 56.

carried out operations, with Forpost and Orlan-10 UAVs used most frequently.[115] The Orion-E UAV, Russia's largest UAV with a weight of over a ton, was spotted in Syria. It has a wingspan of 16 meters and is 8 meters long. Its maximum payload is 200 kilograms with a flight speed of between 120-200 kilometers per hour. It can climb to an altitude of 7,500 meters and can operate for 24 hours before landing. It was spotted with two small bombs suspended beneath the fuselage in a video, so it may be Russia's first strike UAV.[116]

However, there apparently have been numerous shoot-downs of Russian UAVs in Syria. One Russian article noted that among the use of Orlan-10, Forpost, Eleron, and Granat UAVs, some 23 (specific type not listed) have been shot down. Most of these losses occurred in 2018. It is thought that some of the salvaged parts were then turned into drones by ISIS and used for attacks on the Khmeyshim Russian military air base.[117]

The commander of the Southern District, Colonel General Aleksandr Dvornikov, noted that UAVs are used often at Russian training bases. They have monitored potential areas liable to flood in the district; assessed target destruction and corrected artillery fire on the district's ranges; accompanied patrols and monitored the state of military facilities; and used infrared photographic and video modules to detect camouflaged targets including at nighttime.[118]

Exoskeletons, chemical reconnaissance, and so on

Russia has invested in several types of robotic equipment. One of those is the use of exoskeletons for civilian, special, and military purposes. Tasks include working with heavy equipment and rigging and loading operations. The exoskeleton takes the strain off a soldier's musculoskeletal system. The system was reportedly tested in Syria in 2017. It was also noted that inventors have considered using flamethrowers on drones, especially small ones.[119]

The third generation Ratnik (Sotnik) combat equipment set will be equipped with mini-robots and drones, a module for evaluating a fighter's physiological status, and an active exoskeleton. The drones will be contained in a container no larger than the magazine of a semi-automatic rifle. A fighter will have 3-4 such drones and the ability to launch them for reconnaissance purposes during urban or forest combat. The drone connects to the communications system of Ratnik for video observation. The fighter controls flight on his tablet, and images can be transmitted to an entire group participating in the operation. The UAV is of the helicopter class and is so small that it can be affected by wind. Its range is just 150 meters. The exoskeleton allows for speeds up to 20 km/h. The Ratnik system's power supply is only good for 3-4 hours. Future versions of Ratnik also envision a modular helmet with a visor which includes data on the position

[115] Ibid., p. 57.
[116] No author provided, "They Tested the Latest Russian Unmanned Vehicles in Syria: 'Orion-E' Drones Attacked Fighters' Positions Two Days Ago," *Moscow MK*, 6 April 2019.
[117] No author listed, "Russia Lost Several Tens of Unmanned Vehicles in Syria," *Avia.Pro*, 2 January 2019.
[118] Southern Military District Press Service, "In Winter Training Period Southern Military District UAVs Spent More than 5,000 Hours in the Air," *Ministry of Defense of the Russian Federation (*in English*),* 5 May 2019.
[119] Maxim Skokov, "Several Exoskeletons Are Being Created for the Russian Army," *RIA Novosti*, 28 September 2020, as reported by Les Grau in the Foreign Military Studies Office publication *OE Watch*, November 2020, p. 11.

of units on the battlefield, a friend or foe identification system, and a guidance system for precisely directing weapons to targets.[120]

A robotic complex is under development in the Russian chemical warfare units. The complex will be composed of ground units and UAVs. It will conduct reconnaissance of battlefield conditions to determine if areas are contaminated for Chemical, Radiological, and Biological units. It will work to mitigate the consequences of an adversary's use of mass destruction weapons. The complex will also be used in peacetime to handle chemical accidents in the civilian sector.[121]

Vitaliy Davydov, deputy General Director and Chairman of the Fund for Advanced Research's (FPI) Scientific-Technical Council, discussed the FEDOR[122] robot in 2018. He stated that it is a robotic platform with human-like or anthropomorphic traits. FEDOR researchers are experimenting with numerous technologies, such as artificial vision, autonomous navigation, adaptive control systems, high precision actuating arms, and so on. These technologies may be applied to not just FEDOR but numerous robotic systems: UAVs, quadrocopters, autonomous self-propelled platforms, and unmanned submersibles. Missions determine the type of requirements for a robot. The FEDOR for the State Corporation for Atomic Energy (Rosatom) could differ from the FEDOR for the State Corporation for Space Activities (Roskosmos).

The "Spasatel (lifeguard)" project will be part of Rosatom but other consumers, such as the Emergency Ministry, will develop variants of the technologies for their own purposes. It is designed for use in emergency situations, mostly civilian, when accidents occur. The contractor for the Spasatel project was the Android Technology (Androidnaya Tekhnika) Science-Manufacturing Association.[123]

In 2017, a *Military Thought* article discussed tasks before electronic warfare specialists to disable adversary UAVs and other robotic controls. Operators will use special software to disorganize foreign robotic parameters, while simultaneously protecting friendly control systems from UAV and robotic weapon jamming. Electronic warfare specialists were instructed to know the types of foreign employments, the equipment functioning order and guidance systems of foreign nations, their weapon control systems, and the processes involved with disorganizing UAVs and robot controls. Key capabilities to be attained were revealing foreign equipment points of failure, employing electronic warfare in order to disorganize foreign UAVs and robotic control, and identifying reconnaissance and software tasks for use against foreign electronic assets.[124]

[120] Aleksandr Stepanov, "Ratnik: Third Generation Equipment Set Will Arrive in Line Units by 2025," *Rossiyskaya Gazeta Online*, 15 March 2019.
[121] No author provided, "State of the Art Robotic System Being Created for Radiation, Chemical, and Biological Defense Troops," *Ministry of Defense of the Russian Federation*, 9 January 2018.
[122] Fedor is a Russian humanoid robot that replicates movements of a remote operator and can perform some actions autonomously. Originally intended for rescue operations, it was sent on an experimental mission to the International Space Station in 2019. FEDOR is a Russian given male name and an acronym for "Final Experimental Demonstration Object Research." Source is *Wikipedia*.
[123] *RIA Novosti* interview with Vitaliy Dvydov, *RIA Novosti*, 12 December 2018.
[124] S. V. Golubev, S. V. Plotnikov, and V. K. Kiryanov, "Training Electronic Warfare Specialists to Counter Foreign Armies' Unmanned Aerial Vehicles and Robotics," *Voennaya Mysl' (Military Thought)*, No. 4 2017, pp. 74-80.

In 2018, it was noted that fully robotic multiple-launch rocket systems would be available in a few years, adding that many operations (but not all!) will happen without human input.[125] Also Russian sappers would be armed with "death robots," a new mine system that can find and destroy enemy armor. A TM-83 antitank mine is mounted on a robotized platform. The system has a friend or foe recognition system and acts as a kamikaze robot, searching out enemy armor and firing a missile at it. It does so when a seismic sensor registers ground vibration and switches the mine to combat mode, activating an infrared detector that seeks out the vehicles heat emissions. The system then fires a weapon that creates an 80 mm-diameter hole in the armor from 50 meters.[126]

In 2020, a *Military Thought* article discussed Russia's disorganization concept and linked it with robotics. Similar to the 2017 article (two of the three authors were the same writers of the 2017 article) on training EW operators, the authors again discussed the need to acquire the necessary skills to disorganize robotic complexes in foreign armies. The article repeated the notion that operators must be familiar with foreign army control systems, their vulnerable links, and the best radio-jamming targets to make decisions on the employment of such skills.[127] Thus it is clear that Russia's military is closely following robotic advances in other armies so that its operators will not only train properly but be prepared for potential conflicts with foreign forces.

Robots and the Laws of Warfare: How Russia is Approaching the Topic

Nations everywhere are examining robotic use and for good reason. As a recent article in *The Economist* titled "Battle Algorithm" noted, while important, robotics must be used with caution: "Robots are cheaper, hardier, and more expendable than humans. But a machine capable of wandering the battlefield, let alone spilling blood on it, must be intelligent enough to carry that burden."[128] Others think machines, not a machine, will wander the battlefield. "Wars of the future will be between autonomous robots able to combine in groups and units," stated Russian Vyacheslav Pshikhopov, director of the Southern Federal University Research Institute of Robotics and Control processes.

Autonomous robots will undoubtedly possess a measured dose of artificial intelligence (AI) with the requisite skills—perception and navigation and co-ordination with other agents—to carry out activities. However, AI can introduce bigger problems than it can cure. Algorithms imbedded in robots clearly enhance their coordination of effort and the precision of strikes but can cause serious problems regarding the law and ethics of robotic use if they escape operator/algorithm control. They would violate Issac Asimov's first law of robotics, which is that the robot shall not harm humans.

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[125] No author or title provided, *Interfax* (in English), 8 June 2018.

[126] Aleksandr Kruglov and Aleksey Ramm, "New Mines Will Seek Out the Adversary on the Battlefield," *Izvestiya Online,* 13 April 018.

[127] S. V. Golubev, V. K. Kir'lanov, and M. V. Zhirnov, "A Model for Organizing the Military-Professional Training of Radio-Electronic Warfare Specialists to Execute the Tasks of Disorganizing Command and Control Systems of Foreign Armies by Means of Robotic Resources," *Voennaya Mysl' (Military Thought*), No. 2 2020, pp. 155-156. The author would like to thank Dr. Harold Orenstein for the translation of this article.

[128] No author provided, "Battle Algorithms," *The Economist*, 7 September 2019, p. 71.

The laws of warfare require proportionality and necessity. Will a robot's software be able to choose a target, explain why, and, more importantly, to know if its choice was made in accordance with the laws of war? Will its response to engagements be proportional and based on necessity? A dangerous scenario that might evolve was described as follows:

> Able to think faster than humans, an AI-enabled command system might cue up missile strikes on aircraft carriers and airbases at a pace that leaves no time for diplomacy and in ways that are not fully understood by its operators. On top of that, AI systems can be hacked and tricked with manipulated data.[129]

It is not known if software can be developed that imbeds such protective and vital considerations into robots, software that: controls actions in line with the laws of war, prevents deception, allows for diplomacy, and forestalls events, for example, where robots might inadvertently fire on friendly forces. Further, will control be possible over the interconnected AI systems of robots that choreograph combat, or will decisions be made so rapidly that they are beyond the capabilities of human cognition to control the future automated battlefield? Software that calculates probabilistic interactions on battlefields faster than humans may even allow robots to overtake decision-making. This might include decisions involving a political chain of events resulting from specific moves.[130]

There are reports that the Chinese have named robotic decisions that move faster than human cognition as a "battlefield singularity" issue, while some U.S. strategists have dubbed such actions as "hyperwar." Each describes a battlefield out of human control, whether on the ground, at sea, or in the air. It is impossible at this time, for example, to know what software imbedded in drones of various nations will do—act autonomously or allow for remote control.[131] Such potential catastrophic scenarios should also, it seems, be included when conducting AI-assisted robotic battlefield simulations and war games in the U.S. That would be prudent. Only with prior planning can forces comprehensively prepare for such eventualities. Peacetime opportunities are available to develop counters or blocks to keep such scenarios from ever occurring.

Russian authors understand well the implications of a robot powered by AI. One 2018 report noted that automated systems and robots "have the ability to learn from their own experiences and perform actions beyond the scope of those intended by their creators."[132] Such systems could operate independently from its creators or operators and complicate the task of determining responsibility. These independent actions could even vary from country to country since "**algorithms can be biased, for example, in the process of self-learning, they can absorb and adopt the stereotypes that exist in society or which are transferred to them by developers and make decisions based on them**."[133] But if programmers are made liable for the actions of

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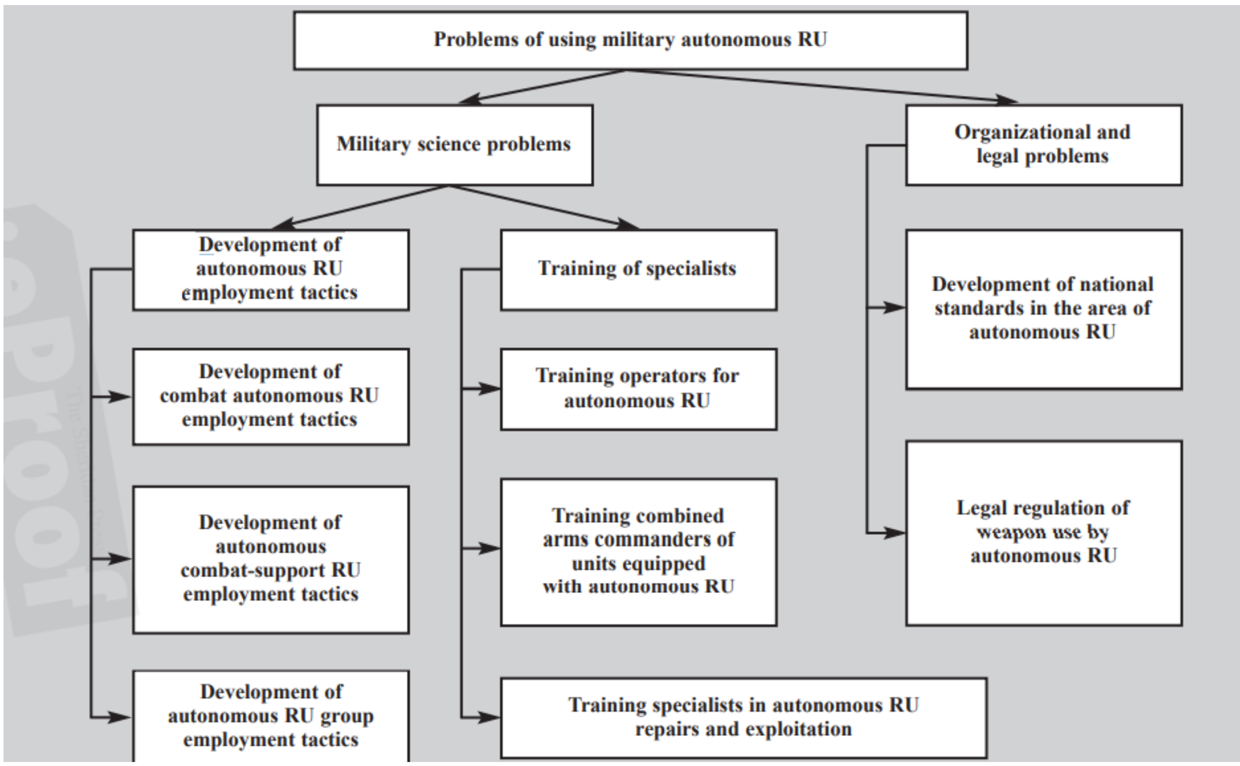
[129] No author provided, "Mind Control," *The Economist*, 7 September 2019, p. 16.
[130] "Battle Algorithms," pp. 72-73.
[131] Paul Schare, "Are Killer Robots Inevitable?" *Wired*, June 2020, p. 56.
[132] No author provided, "The Ethical and Legal Issues of Artificial Intelligence," *Russian International Affairs Council* (in English), 23 April 2018.
[133] Ibid.

specific systems and the system does something catastrophic (take out another nation's capital), does liability even matter in such cases?

Another Russian article has stated that its decision-makers are against imposing an international ban on the threat of so-called "killer robots."[134] In line with that decision, Russia continues to discuss the building and employment of autonomous military robot technical systems. The goal is to create a "Concept for Developing Autonomous Military Ground-Based Robot Technology." In a *Military Thought* article, the following military-science and organizational-legal problems of autonomous robot-technical units (RU) were offered in a schematic:[135]



The authors noted that the use of autonomous RU would offer the following advantages:

- Considerably improve jamming immunity in RU
- Increase RU range limited only by the size of the power unit
- Fewer mistakes by human operators
- Fewer operators and demands on them
- Potentially able to integrate large numbers of RU
- Eliminate man-machine dialogue and delays
- Expand the set of areas for RU use.[136]

[134]*The Moscow Times* Online, 16 August 2018, citing a *Kommersant* business daily.
[135] N. A. Rudianov and V. S. Khrushchev, "Conceptual Issues for Building and Employing Autonomous Military Robotechnical Systems," *Voennaya Mysl' (Military Thought)*, No. 6 2019, p. 57.
[136] Ibid., p. 59.

There was no discussion of problem issues.

In a 2019 *Interfax* article, experts at the 3rd Central Scientific Research Institute of the Russian Defense Ministry stated that the military must develop "methods for analyzing situations, scene identification, and target identification as applied to the functions of ground-based robotic systems."[137] The experts suggested "introducing in military robotics intellectual systems for making decisions at command stages, including group, autonomous movement, and use of equipment according to its purposes, including weapons."[138] Thus, the Defense Ministry appears to support the concept of equipping robots with intellectual systems that enable them to use weapons independently, a dangerous step.

Ground Force and UAV Problems

Ground force robotic problems were addressed in 2015. The problems are traced to the diversity of methods and models used to justify the need for developing robot units. Methodologically, models are constructed in an arbitrary fashion with no reference to the system where it is to be applied. Thus, there is a misunderstanding between developers and users that needs to be fixed. How to train operators, ensure system reliability (ability to confront various electromagnetic and other radiations), rectify incomplete or uncertain data inputs from the robot to the operator, and limiting manpower losses are all areas that need to be improved. Second, special algorithms need to be developed so that operator efficiency can be magnified. Subtasks must be sorted out according to function (attack to kill, reconnaissance, mobility maintenance, protection, support, etc.), which may be the most difficult phase of robot operations, since some operations require a group of operators working together. Energy resources are currently easily depleted, so more work is required in that area. Further, remote control of ground force robots was limited to line of sight.[139]

Robotic use of artificial intelligence introduced several problems. Technical system feedback could come from anomalous or irregular changes in the situation for which an intelligent robot-driven unit is not prepared. Referred to as "unbalanced situations," they are caused not only by situational uncertainty but also by a deficiency of information for decision-makers, the speed of information flows when data is available, and the emergence of sudden interference from outside sources such as noise.[140] Perhaps many of these 2015 problems have been rectified, especially with the creation of the ERA Technopolis and other organizations designed to address such issues.

Regarding UAV problems, a 2018 article noted that for the past five years (since 2013) there have been at least 600 in-warranty failures. These were due to: low quality of material used

[137] No author or title provided, *Interfax* (in English), 6 February 2019.
[138] Ibid.
[139] L. N. Ilyin, P. A. Dulnev, and V. G. Kovalyov, "Problems in the Creation of Ground Robotics for the Ground Forces," *Voennaya Mysl' (Military Thought)*, No. 11 2015, pp. 65-71.
[140] Ibid.

(1 percent); commercial component defects (80 percent); faults in design (9 percent); assembly faults (3 percent); and other cases (7 percent). The main reasons for such malfunctions were the violation of maintenance rules, equipment complexity, firmware faults, intensive use in tough environments under special conditions, and personnel that were insufficiently trained. It was also noted that up to 80 percent of UAV components were imported, resulting in repair complexity.[141] It was not stated if these parts were imported from Israel, China, or the U.S. This prompted the following list of priorities in 2018:

- Developing and analyzing the results of operations and repairs
- Forming UAV technical maintenance bodies in the Ground Forces' large units and formations
- Specifying the functions of mobile repair shops
- Organizing unmanned aircraft specialist training
- Working out maintenance documents
- Working out recommendations for operations under specific conditions
- Seeking Russian analogs for foreign components
- And increasing control over the quality of commercial components.[142]

In 2019 a significant problem during RTK exploitation was eliminating delays when firing. Another problem was the technical maintenance of such weapons, especially cleaning them and thought was given to mechanizing the cleaning of barrels. Other support task issues requiring attention were eliminating malfunctions and repairing RTK under field conditions.[143]

Conclusions

There is no overarching commentary on robotics that indicate the absolute direction in which Russian robotics are heading. General Staff Chief Valery Gerasimov mentioned robotics in five of his seven presentations at the Academy of Military Science but offered no specific direction other than the growing importance of UAVs in 2017 and 2019. Here are his assessments:

- 2013: Precision weapons, weapons based on new physical principles, and robotics are being introduced into military affairs.[144]
- 2014: Special attention is required in the areas of robotics, telecommunication infrastructure, and strategic deterrence and aerospace forces.[145]

[141] A. V. Novikov, V. V. Zevin, and I. A. Rasshchepkin, "Problems in the Exploitation of Robo Technical Complexes of Military UAV Significance in the Armed Forces of the Russian Federation," *Voennaya Mysl' (Military Thought*), No. 7 2018, pp. 82-83.
[142] Ibid., p. 84.
[143] Dul'nev and Korablin, p. 134.
[144] V. V. Gerasimov, "Principal Trends in the Development of the Forms and Methods of Employing Armed Forces and Current Tasks of Military Science Regarding their Improvement," *Vestnik Akademii voennykh nauk (Journal of the Academy of Military Science)*, No. 1 2013, p. 26. Dr. Harold Orenstein translated all the Gerasimov presentations below from Russian to English.
[145] V. V. Gerasimov, "The Role of the General Staff in the Organization of the Country's Defense in Accordance with the New Statute on the General Staff," *Vestnik Akademii voennykh nauk (Journal of the Academy of Military Science)*, No. 1 2014, p. 21.

- 2017: The employment of various types of robotic complexes will increase the effectiveness of troop operations and ensure a substantial reduction in personnel losses. A substantive feature of contemporary military conflicts is the increasing employment of the latest robotic complexes and unmanned aerial vehicles with varied designations and actions.[146]
- 2018: The principal features of future conflicts will be the extensive employment of precision weapons and other types of new weapons, including robot technology.[147]
- 2019: Gerasimov underscored specific directions for strategy's development, and singled out the use of military robotic complexes, especially UAVs.[148]

Gerasimov's focus on robotics and their future use will undoubtedly lead to new correlation of forces (COF) assessments among Russian theorists. That is an important consideration for planners to take into consideration. The development of UAV swarms and integrated Unicum robotic formations on the ground will affect COF in many ways. Unikum, as mentioned in the analysis, can control ten robotic complexes simultaneously. It can assign roles within a grouping, control a grouping, independently send robots to the most favorable positions, and search for targets.

The COF factor is reflected (but not named) in the models under creation and in the following discussion:

> One more prospective trend to support the achievement of superiority [that is, an advantage in COF] over an enemy in future military conflicts is the employment of fundamentally new types of weapons, which include military robotic systems and resources equipped with weapons based on new physical principles…At present, individual models of robotics are already being employed to carry out tasks of limited complexity, e.g., for operations from ambushes and as fire support resources. Soon it is proposed to implement their group employment both independently and in cooperation with combined arms formations.[149]

[146] V. V. Gerasimov, "Contemporary Warfare and Current Issues for the Defense of the Country," *Vestnik Akademii voennykh nauk (Journal of the Academy of Military Science)*, No. 2 2017, p. 10.
[147] V. V. Gerasimov, "The Influence of the Contemporary Nature of Armed Struggle on the Focus of the Construction and Development of the Armed Forces of the Russian Federation. Priority Tasks of Military Science in Safeguarding the Country's Defense," *Vestnik Akademii voennyh nauk (Journal of the Academy of Military Science)*, No. 2 2018, p. 18.
[148] V. V. Gerasimov, "The Development of Strategy under Contemporary Conditions: Tasks for Military Science," *Vestnik Akademii voennykh nauk (Journal of the Academy of Military Science)*, No. 2 2019, p. 9.
[149] S. I. Pasinchik, A. V. Garbardt, and S. A. Sychev, "Prospects for the Development of Methods of Combat Operations of Combined Arms Formations at the Tactical Level," *Vestnik Akademii Voennykh Nauk (Journal of the Academy of Military Science)*, No. 1 2020, p. 41. The author would like to thank Dr. Harold Orenstein for his translation of this article.

Another Russian focus has been UAVs. Innovative options for UAVs include the placement of both optical devices and multifunctional software-supported radar stations (RLS) on them, which enable the exposure of fighters concealed in buildings, fighters hiding behind natural obstacles, and the ability to "discern" objects through fog. An important UAV discussion centered on the order of attacks against adversary targets, first, headquarters and communications centers, and then transport infrastructure, the approach of reserves, and frontline air defense systems. UAVs are deployed in attack formations/groups much like ground force assault formations. While the numbers of UAVs involved may vary (and include Granat, Zastava, Eleron, Orlan [tested in Syria], and Leyer UAVs), it was noted that lead vehicles would conduct visual reconnaissance at 1-1.5 kilometers above the ground, followed by a second wave of Leyer-3 radio electronic warfare assets to suppress enemy ground communication equipment, and closing with a third UAV flight that relays information to the base from a height of 4.5 to 5 kilometers.[150]

Also of concern is Russian planning to conduct autonomous robotic group employment tactics. Many analysts in other nations seriously doubt that robots can be taught to fight with proportionality and necessity in mind. For example, what if swarm tactics were used as a form of robotic cyber operations—would such an attack option know when to cease work? Proportionality and necessity may currently be beyond reach of other capabilities as well, such as cyber ones.

Finally, it was noted that combined arms formations today at the tactical level will be conditioned by the creation of robotic ground force formations that employ precision weapons, radio-electronic warfare resources, information and command and control systems, and other capabilities for different functional purposes. The discussion above has underscored that the role of robotic units in such operations is growing quickly, whether it be under urban conditions or on the open battlefield. It was noted that robots will be placed around the country's exterior as sentries who will guard it borders, which are too huge to man with people. It is unknown if this will be accomplished through the use of sensors or if it will rely on, from Russia's perspective, "increasing the role and improving the robotization of equipment, first and foremost, on-board fire resources."

Limitations on robotic developments exist for several reasons, to include internal equipment problems and legal issues. But this has not kept Russia from further exploring their potential use. In fact, the nation's leaders have been quick to ignore discussions of limiting the use of so-called killer robots. The military leadership understands well the importance and spreading use of robotic systems in the militaries of potential opponents and do not want to be limited in the application of their own robotic developments to the contemporary battlefield.

It should be expected that in the coming months, both at the ERA Technopolis and elsewhere, that substantial improvements will be made in the algorithms and artificial intelligence components that are driving robotic improvements. The use of Russian military robotic systems has been codified in several documents, such as the *Concept for the Employment of Military*

[150] Aleksey Ramm and Bogdan Stepovoy, "Military Rehearses Drone Strike Actions for the First Time," *Izvestiya*, 7 November 2019, as reported by Les Grau in the Foreign Military Studies Office publication *OE Watch*, January 2020, p. 22.

Robotic Complexes for the Period up to 2030.[151] The concept's main objective is to provide the means of armed warfare with a new quality that increases the effectiveness of combat mission execution and lowers the loss of personnel through improving control means, communication and navigation assets, video surveillance, photography (thermal imaging), and other related equipment.[152] This concept was approved by the Russian General Staff on 22 August 2014 and resulted in the establishment of a more limited and quicker target program for the *Creation of Advanced Military Robotics up to 2025*.[153]

Thus, the interest in robotic systems and the creation of new models by scientific research institutes continues to expand in Russia's military. It is to be expected that the targeted programs under examination will be highlighted in the coming years and their progress and effectiveness tabulated. Russia's robotic use will require the continued attention of the West to ensure not only that their use is in line with international law but that they have not developed specific or asymmetric robotic capabilities against which the West has not contemplated a response—but needs to in the immediate future.

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[151] Andrey Petrochinin, interview with Sergey Anatolyevich Popov, "We Are Working on Military Robotics to Unique Russian Standards," *Oriyentir Online*, 1 April-30 April 2017, pp. 16-20.
[152] V. Lukyanchik, O. Bunin, and D. Koryakin, "Air Controller with Artificial Intelligence: Forward Air Controller Ground Robotic Complex for Controlling Army and Ground Attack Aviation," *Armeyskiy Sbornik*, No. 7 2018, pp. 26-33.
[153] Ibid.

APPENDIX ONE: ROBOT EMPLOYMENT PRINCIPLES

S. A. Sychev, in his article above titled "Principles of Employing Combined Arms Ground Forces Formations Equipped with Military Robotic Systems," listed four employment principles. They are described here.

The "principle of functional inequality and imbalance" is used when facing an opponent with an equal or superior level of technological development. The use of RTK helps achieve functional imbalance in four ways: accomplishing tasks normally associated with high losses of personnel; using groups of RTK to gain an advantage in the speed of using the reconnaissance-destruction cycle; the joint use of RTK capabilities; and the use of RTK in inaccessible or limited access areas.[154]

The "principle of structural and functional reconfiguration" offers design, structural, and functional flexibility when various and dissimilar robotic resources are integrated. This principle is achieved in two ways: with the creation of a formation that redistributes robotic resources or creates new elements while a task is being carried out; and the centralization of command and control of robotic resources with diverse tasks and the redistribution of their functional load depending on the situation.[155]

The "principle of integration" involves effects produced from using multifunctionality, joint autonomy, and integrated responses. Multifunctionality involves combining several functions into a single formation, such as the creation of a recce-strike complex, where reconnaissance, C2, and fire destruction are integrated to shorten the reconnaissance-destruction cycle. Joint autonomy is implemented with the synchronization of information within a group of varied robotic resources that can correct the sequence of their actions when executing a task. Exchanging information within a group of RTK (when any of the systems on one RTK fails) helps increase their later survivability. Algorithms can achieve responses under complex, changing situations that human capabilities cannot handle.[156]

The final principle was the "principle of synchronization," where embedded algorithms enable the synchronization of results at the software level. They achieve the following three results: ensuring the optimization of robotic actions under specific situations; forecasting potential enemy threats and warning the RTK about them in a timely fashion; and automatically updating priority goals in accordance with developing situations.[157]

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[154] S. A. Sychev, "Principles of Employing Combined Arms Ground Forces Formations Equipped with Military Robotic Systems," pp. 102-103.
[155] Ibid., p. 104.
[156] Ibid., p. 105.
[157] Ibid., pp. 106-107.

APPENDIX TWO: ROBOT TYPES AND PARAMETERS

This list of robotic developments in Russia is designated by year. There are several descriptions of systems that are repeated from one year to the next, but they are listed anyway for reference purposes.

2017

Galtel: In September, the Defense Ministry's Main Directorate for Research and Development (GUNID, whose deputy head is Roman Kordyukov) ran trials off Syria of the **Galtel** submarine robot. This is a yellow torpedo-shaped device that is a robotic unmanned underwater vehicle (UUV) that can move in circles or a spiral and is not connected to wires or cables. Developed at the Vladivostok-based Institute of Marine Technology Problems, the Galtel system is composed of two UUVs, with each having an endurance of 24 hours and a range of up to 100 km, a remote-controlled submersible, and a control center. The Galtel has photo and video capability and a side-scan sonar. The Grachyonok anti-sabotage vessel is where the Galtel's control center is located.

Glidel: Another UUV is the **Glidel**, an autonomous reconnaissance device with stealth capability. It is not active-search like Galtel, but a passive-search device.[158] The underwater drone can survey four square kilometers in just over 12 hours and has a remotely operated camera capable of operating at depths up to 300 meters. The institute's lead designer was identified as Vladimir Kostenko.[159] It was also noted by Alexander Mironov, head of the Main Department of Research and Technological Support of Advanced Technologies at the Russian Defense Ministry, that sea robotics will be demonstrated on Lake Komsomolskoye at Army 2017.[160]

Koalitsiya-SV: Another important armament is the 2S35 Koalitsiya-SV self-propelled artillery complex, whose specifications "essentially represent a combat robot capable of automatically executing fire missions with minimal human involvement."[161]

Nerekhta: This combat robot is designed at the Degtyarev Plant, with three modules—combat, artillery reconnaissance, and transport. Various modifications allow for its arming with the 12.7mm Kord Machinegun, the 7.62mm Kalashnikov machinegun, the AG-30m automatic grenade launcher, or even an anti-tank missile. In October it was announced that the Nerekhta system was recommended for service with the Russian Army. It is to be used as a scout, a sapper, and a supporting mechanism for the infantry. Oleg Pomazuyev, head of the Innovation Research Department at the Main Research Directorate for the Russian Defense Ministry, made this revelation.

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[158] *Zvezda TV*, 3 September 2017.
[159] Timur Alimov, "How the Russian Federation's First Robot Submarine in Syria Was Organized," *Rossiyskaya Gazeta* Online, 8 September 2017.
[160] *Interfax* (in English), 28 July 2017.
[161] No author provided, "Pilot Batch of Koalitsiya-SV Artillery Complex Will Go to the Troops," *Ministry of Defense of the Russian Federation*, 8 October 2017.

Soratnik: Produced by the Kalashnikov Group, this is a fire support, reconnaissance, evacuation, and ammo or fuel support vehicle. With speeds up to 40 kilometers per hour, it can reach 10 kilometers from remote control or radio line of sight. It can carry 7.62 mm and 12.7mm machineguns, a 30mm AG-17A grenade launcher, and a 40mm automatic grenade launcher.

Uran-9: This complex is designed at the 766 UPTK company for reconnaissance, fire support, and anti-tank warfare. It can destroy targets at 5 km in daytime and 3 km at night. It is armed with a 30mm 2A72 automatic gun, a 7.62mm machinegun, Shmel-M flamethrowers, and an Ataka complex armed with guided anti-tank missiles.[162] A later report stated that the Uran-9's 30-mm cannon has a firing rate of 350-400 rounds per minute and can accommodate 4 Ataka antitank missiles. All systems have had trial runs in Syria, the article noted.[163]

Vikhr and Morskaya Ten: The Vortex or Whirlwind (**Vikhr**) and Sea Shadow (**Morskaya Ten**) were discussed further. **Vikhr** is based on the BMP-3 with a remote-controlled armament module that includes a 57-mm or 30-mm cannon, automatic grenade launcher, and machine gun. The maximum speed is 60 kph. It was noted that the main task is creating automated control system software. The **Morskaya Ten** is a multifunctional instrument designed to collect and process large amounts of data in the world's oceans. It can loiter autonomously for up to six months in the water.[164]

Another description of **Vikhr** noted that it is a reconnaissance-strike robot system, weighing 14.7 tons with significant firepower and maneuverability. Controlled by an operator, the robot has good off-road movement to include water obstacle crossing capability. It can fire while stationary and on the move. The module (clearly not the entire vehicle weighing tons) has been observed on a Su-25 ground-attack plane and on a Ka-52 helicopter. The system's turret rotates 360 degrees. Once locked onto a target it can track it and fire on it until the target is destroyed.[165]

A 2017 article in Armeyskiy Sbornik (Army Journal) listed the following types of robots:

- **Vikhr**: Irina Zayko was one of its developers.
- **Prokhod-1:** This is a heavy robotic mine clearing complex based on the T-90 tank.
- **Mars:** This is a robotic tracked amphibious transport platform, that can be airdropped by parachute and carry up to 500 kilograms of cargo at 35 kph on land and 5 kph on water.
- **Spetsialist:** This is a forward area tracked robotic platform, an infantry type vehicle that can deliver ammunition, water, food, and medical supplies to the front line and evacuate casualties on the way back.

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[162] No author or title provided, *Interfax* (in English), 24 March 2017.
[163] Yuriy Gavrilov, "Defense Ministry Will Choose Combat Robot for the Army," *Rossiyakaya Gazeta* online, 23 August 2017.
[164] Ibid.
[165] Ruslan Melnikov, "Video Has Appeared Showing Tests of the Heaviest Russian Combat Robot," *Rossiyskaya Gazeta Online,* 23 April 2017.

- **Khishchnik**: This is a zoomorphic robot resembling a spider the size of a large dog that can traverse rough terrain carrying payload and armed with a 12.7-mm Kord machine gun, seek targets autonomously, and engage them on command from its operator.
- **Shnek:** This is a miniature robotic platform, weighing about 15 kg. It has off-road mobility and is armed with four mortars with thermobaric rounds.
- **Tigr:** This is an armored vehicle, fitted with the same control packages as the Uran-9.
- **Boyets:** This is a robotic wheeled platform with a 30-mm automatic grenade launcher.
- **MRK-27BT:** It is armed with a 7.62-mm Pecheneg, 2 RShG-2 assault rocket grenade launchers, and 2 Shmel infantry rocket launchers with a control range of 500 meters.[166]

2018

BMP-3: Georgiy Zakamennykh, general director of the Burevestnik Research Institute, stated that the **BMP-3** will become a robot with an AU-220M 57-mm weapon unit, firing 80 rounds a minute. This is because the gun can be controlled remotely.[167]

Klavesin-2: This is an unmanned underwater complex (UUV) with the designation 2R52. It is larger and heavier that the Klavesin-1. The -2 looks like a miniature submarine and has a diving depth of 6 km and a range of 50 kilometers. It is able to carry sonar sets, electromagnetic sensors, and video cameras.[168] Russian deep-water equipment allows it to look for missing submarines, build underwater pipelines to convey hydrocarbons, and put fiber optic communication systems on the ocean floor.[169] UUVs can move at depths of over 1 km at high speed and remain invisible. It will have a nuclear propulsion unit.[170]

Kobra: The **Kobra** 1600 robotic system was designed for remotely defusing explosive devices. It uses television cameras and detachable equipment and can be controlled by cable for four to eight hours at a time. It can cross barriers up to 160 mm high and water up to 120 mm deep.[171]

Nerekhta: The electronic magazine *Armeyskiy Standard* noted that the **Nerekhta** multirole robotic system has completed testing. Its unique drones can function as transporter, support vehicle,

166 A. Kalistratov, "Robots, Into Battle!" *Armeyskiy Sbornik (Army Journal*), October 2017.
167 Tatyana Vorobeva, "BMP-3 Infantry Fighting Vehicles Will Become Robots," *Rossiyskaya Gazeta* Online, 1 June 2018.
168 Nikolay Surkov and Aleksey Ramm, "The Army: Unmanned Submersibles Will Master the Crimea. Feodosiya Has Become the Main Range for Testing the Latest Naval Robots," *Izvestiya* Online, 15 May 2018.
169 *Interfax* (in English), 22 February 2018.
170 *Interfax* (in English), 1 March 2018.
171 *Interfax* (in English), 8 August 2018.

reconnaissance system, sapper robot, combat platform, or adjuster of artillery fire. It can reach a speed of 32 kph.[172]

Soratnik: The system is used as a reconnaissance and relay, patrolling and demining, and obstacle removal robot. Aleksey Krivoruchko, general director of the Kalashnikov Concern, said the robot can operate in passive mode up to 10 hours. It can operate with other automated assets, including UAVs.[173]

TM-83: These antitank mines are placed on special robotized platforms. The mines will have friend or foe recognition systems and the robots that carry them will be small with high terrain mobility. The mine switches to combat mode via seismic sensor vibrations and when activated, seeks heat emissions from an engine. If no target is detected in three minutes, the TM-83 returns to standby mode.[174]

UAVs: There are several UAVs that have parameters listed in publications. The **Okhotnik** heavy attack-reconnaissance UAV was produced at the Novosibirsk Aircraft Plant. It is being designed by the Sukhoy Design Bureau (KB) and has speeds of up to 1,000 kilometers per hour. The **Altius-O** medium-class attack UAV has concluded its flight tests. It can hover for 48 hours and carry up to a ton of payload. Its flight range is 10,000 kilometers with speeds between 150-250 kph. Its service ceiling is 12 kilometers.[175]

Uran-9: This robot's main function is combat reconnaissance and fire support. It has its own air defense, the Igla-S guided antiaircraft missiles. It can fire from behind cover as it has a boom that can reach a height of 3.7 meters. Due to its limited weight it has weak protection, which can be overcome with reactive and active protection modules.[176] The **Uran-9** has a system warning against laser radiation, and the system puts up a smokescreen from which the laser is coming. The multifunction robot was developed by the 766 Production and Fabrication Directorate.[177] The system can target personnel, antitank and weapon assets, and low-flying, low-velocity aerial targets such as helicopters and UAVs of the tactical level.[178] Flaws in the Uran-9's performance in Syria included management, mobility, firepower, reconnaissance, surveillance functions of the

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[172] Darya Fokina, "Nerekhta Combat Robot to be Put into Commission with Russian Army," *MK* Online 29 June 2018.
[173] Nikolay Grishchenko, "A Video Clip of the 'Soratnik' Combat Robot's Field Tests Has Appeared," *Rossiyskaya Gazeta* Online, 19 January 2018.
[174] Alexander Kruglov and Aleksey Ramm, "New Mines Will Seek Out the Adversary on the Battlefield," *Izvestiya* Online, 13 April 2018.
[175] Aleksandr Sharkovskiy, "Drone Autonomy is Becoming Dangerous: Out-of-Control Unmanned Aerial Vehicles May Attack Their Own Facilities," *Nezavisimaya Gazeta* Online, 2 July 2018.
[176] Anton Valagin, "Uran-9 Heavy Robot Battle Caught on Video," *Rossiyskaya Gazeta* Online, 2 February 2018.
[177] Vladimir Shcherbakov, "Americans Shocked by Shoygu's New Robots. Moscow's Decision to Include Combat Robots in 9 May Parade Occasions Fit of Panic in the West," *Nezavisimoye Voyennoye Obozreniye* Online, 27 April 2018.
[178] *Zvezda TV* Online, 7 May 2018.

robot, an inability to fire on the move, and a lack of ability to conduct reconnaissance and determine targets at distances of more than two kilometers.[179]

UR-15: This is a self-propelled rocket-launcher demining system codenamed “Meteor” (nickname “Dragon Gorynych”). It will be robotic and provided with armor protection. The range is 200-500 meters and creates a passage 6 meters wide and 80 meters in length. Reloading takes 40 minutes.[180]

Vikhr and MRP-100 Platform: The Geodeziya Research Institute Federal State Enterprise hosted a demonstration of the **Vikhr** robotic system. The **Vikhr** software was reportedly created by the Signal Research Institute Science and Production Corporation Joint Stock Company, according to deputy head Denis Barabin. The system facilitates robotic system movements while following a route while independently identifying and avoiding obstacles, moving by beacon, and moving in convoy. Aleksey Bogachev, head of the Advanced Developments Department of the ROKAD NTTs, developed the **MRP-100 platform**. The latter creates a ground pressure of .1 kilogram per square centimeter when moving, has a load-bearing capacity of 100 kilograms (with options for 300 and 500 kilograms), and a current speed of 7 kph with a future speed of 25 kph.[181]

Robots without specific characteristics: Kalashnikov tested the **Nakhlebnik** combat module. A **Kungas** multi-role robotic system was tested but it did not specify if it was attached to Kalashnikov.[182] Russia announced the creation of the **Argo** and **Platforma-M** robots, with the latter used by the Pacific Fleet’s military police in a counter-terrorism exercise in 2016.[183] The Armata unmanned tank will be named the **Tachanka-B**.[184] Uralvagonzavod (UVZ) General Director Aleksandr Potapov stated this was possible in February, and two years ago UVZ deputy director Vyacheslav Khalitov mentioned the possibility.[185]

2019

Galtel: The robotic system **Galtel,** an intelligence collector and sapper, was tested in Syria’s coastal waters. It orients itself underwater based on elements of a hydroacoustic navigation system. The system sets out coordinates and a reference point can be fixed with the help of the underwater beacons, since GPS and GLONASS signals do not penetrate to the bottom. The **Galtel** system includes an unmanned television guided underwater vehicle and two autonomous unmanned submarines with an autonomous cruising range of up to 24 hours and up to 100 kilometers.[186]

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[179] Mikhail Moshkin, “Will it be Possible to Make a Real Combat Robot from the Armata,” *Vzglyad* Online, 22 June 2018.
[180] Aleksandr Kruglov and Aleksey Ramm, “Dragon Gorynych Will Join Combat Formations; Development of a Unique Robot for Remote Mine Clearance Has Begun,” *Izvestiya* Online, 29 June 2018.
[181] Yuriy Avdeyev, “The Robots are Attacking: The Creation of Medium-Class Military Robot Systems Has Entered Research and Development,” *Krasnaya Zvezda (Red Star*) Online, 11 September 2017.
[182] *Interfax* (in English), 6 March 2018.
[183] *Interfax* (in English), 15 March 2018.
[184] Anton Valagin, “Russian Unmanned Tank is Named Tachanka,” *Rossiyskaya Gazeta* Online, 19 June 2018.
[185] Mikhail Moshkin, “Will it be Possible to Make a Real Combat Robot from the Armata,” *Vzglyad* Online, 22 June 2018.
[186] Viktor Sokirko, “Russia’s Defense Will Be Reinforced with a Whole Arsenal of Underwater Robots,” *Vzglyad Online*, 21 February 2019.

Marker: A **Marker** ground robot platform is under testing, with components associated with synthetic vision and group command and control.[187]

Paladin: This combat robot complex was displayed by High-Precision Complexes Holding Company (part of Rostec) at the Army-2019 forum. Basic hardware is the Dragun unmanned fighting module on a robotized BMP-3 chassis. It has two 100-mm and 30-mm guns and can operate in both autonomous and remotely controlled modes. Sergey Abramov, Rostec Industrial Director, said the complex can perform fire support, hold bridgeheads, break through lines of enemy defense, and transport personnel.[188]

Poseidon: The Russian UUV **Poseidon**, previously codenamed **Status-6** and **Kanyon** by NATO, is said to have speeds of 200 kph. The UUV's path to a target will not be a straight line but rather is a constantly changing route.[189]

Poverkhnost: This smart minefield contains explosive charges that can identify ships, other vessels, and submarines by their magnetic field or acoustic footprint. Its AI system decides which target to blow up and when.[190]

Sarma and Vityaz: The **Sarma** robot will initially operate on classic batteries.[191] The Malakhit Design Bureau oversees two departments that are associated with maritime robotics. Igor Denisov, Deputy General Director of the FPI, noted that Russia is working on the **Sarma** Project, a super-autonomous unmanned submersible. The submersible has energy autonomy and a cruising range of 10,000 kilometers. It has civilian use as well. The **Vityaz** Project is under testing. It is a super-deep-sea submersible with self-sufficient days of use and a design depth of 12 kilometers.

Sfera and Skarabey: These are miniature wireless examination systems, meant to collect and transmit audio and video data from areas that are difficult to access or dangerous for humans. **Sfera** contains four video cameras and is equipped with a system of vertical positioning. It is remote-controlled and weighs no more than 610 grams. It has a 20-minute battery from no less than 50 meters.[192] It can destroy an explosive device with a mass of up to one kilogram of TNT equivalent. The **Skarabey** and **Sfera** reconnaissance and surveillance systems can be thrown several meters onto a hard surface, or to the top floor of a building or into the ruins of a destroyed building. The **Skarabey** has a 45-minute power supply. The devices can offer information about hidden enemy fighters or hidden explosives.[193]

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[187] Ilya Morozov, interview with Oleg Martyanov and Igor Denisov, "Oleg Martyanov: Anthropomorphic Robots Have Good Prospects in the Army. The Head of the National Robotics Technology and Base Elements Development Center Talked about the Development Trends of Domestic Robots," *Interfax-AVN* Online, 16 May 2019.
[188] *TASS*, 24 June 2019.
[189] *Rossiya 1 Television*, 4 January 2019.
[190] No author provided, "Russia to Complete Testing of Naval Mine System," *Izvestiya* Online, 4 March 2019.
[191] Yuriy Gavrilov, "A Robot with a Machinegun. The Complexes for the Army Are Needed in Peaceful Life," *Rossiyskaya Gazeta* Online, 16 May 2019.
[192] *Interfax* (in English), 18 January 2019.
[193] Pavel Gerasimov, "Multilift for Robot Sapper and Other Engineering Innovations," *Krasnaya Zvezda (Red Star*) Online, 21 January 2019.

Skiff: Mini submarines designed in the Akademik Makeyev State Missile Center jointly with the Rubin Central Design Bureau (TsKB), bear the name **Skiff,** with the purpose being to inflict surprise strikes from the ocean depths. Essentially, the article notes, the **Skiff** is not a submarine but rather a bottom-based ballistic missile. It lies on the ocean bottom for long periods of time and upon receipt of a command can strike a target at ranges beyond 300 kilometers.[194]

Uran-6: This mobile robotic mine clearance system has four video cameras. It can precede an operator by up to 800 meters. The robots console can be carried on the back of an operator with the use of an exoskeleton frame. The EO-1 passive exoskeleton was tested in Syria. The multi-lift transport system loads the Uran-6 onto a Kamaz truck, according to Vitaliy Kushnir, deputy chief of the Engineering Troops Directorate Combat Training Department.[195]

UAVs (all citations from 2019):

Orlon-10 carries munitions on board and can conduct operations at a distance of up to 100 km. It has been used in Syria and can stay in the air for up to 14 hours, rising to a height of 5 km. It can independently conduct electronic or visual reconnaissance and detect target coordinates by collecting signals of cell phone and wireless devices. Newer models have 12 high-resolution cameras. They are usually deployed in attack groups along with other UAVs. **Orlan-10** and **Forpost** were used to support the Northern Fleet for the first time. Missions included escorting a large group of warships to provide reconnaissance to detect potential enemies and to assure missile strike precision. Airfield bases located near the Arctic can be used to base the UAVs.[196] A peacekeeping use of UAVs involved the **Orlan-10**, a four-drone system that can conduct reconnaissance up to 100 kilometers from the ground control station. It is equipped with secure telemetry and a command channel, a two-state jam-resistant encoding, and a secure channel of transmission of photo- and video information. It conducts reconnaissance deep behind defensive lines of warring sides for peacekeeping forces.[197] Another article noted that the **Orlan-10** has a launch weight of 14-18 kilograms and can carry a payload of five kilograms. It can attain a speed of 170 kilometers per hour and transmit pictures from 120 kilometers.

Some UAVs are for specific reconnaissance use. An unnamed UAV was described as a helicopter class UAV armed with a radio reconnaissance station. It can conduct intelligence collection at an altitude of 4.5 kilometers and has an operational radius of 100 kilometers.[198] Other UAVs, such as **Altair**, have specific reconnaissance and strike operations. Under development since 2015 by the Kazan-based Simonov Design Bureau, it is designed to be a reconnaissance and strike UAV. It is made of composite materials with only the engine mounts metallic. It has optics and a lateral-scan radar, and few weight limitations in terms of light modes (the craft itself is said to weigh six

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[194] Viktor Sokirko, "Russia's Defense Will Be Reinforced with a Whole Arsenal of Underwater Robots," *Vzglyad Online*, 21 February 2019.
[195] *Zvezda TV*, 20 January 2019.
[196] Aleksey Ramm and Aleksandr Kruglov, "Northern Fleet Unmanned Aviation Regiment Carried Out an Operation to Track a Group of Warships," *Izvestiya*, 5 January 2019.
[197] No Author or title provided, *Interfax* (in English), 23 January 2019.
[198] Aleksey Degtaryev, "In Russia They Developed a Drone Able to Carry Out Intelligence Collection within a Radius of 100 Kilometers," *Vzglyad Online*, 20 April 2019.

or seven tons). The need for such a system was motivated by Russia's combat experience in Syria, where each offensive operation depended first on aerial reconnaissance using UAVs. It is uncertain when the **Altair** will be deployed.[199] One report noted that its payload is two tons, and that the craft is capable of flying 10,000 kilometers and able to climb to 12 kilometers, with an autonomous flight of two days.[200] Other Western reports have stated it is now only a reconnaissance UAV.

The **Okhotnik S-70** is designed to be a strike UAV. Developed by the Sukoy Company, it is designed to be a heavy stealthy reconnaissance-strike UAV. Its takeoff weight is 25 tons, of which 2.8 tons is weaponry. At low altitude it can achieve a supersonic speed of 1,400 kilometers per hour and a flight range of 5,000 kilometers. It is limited in its maneuverability (it has no vertical tail assembly).[201] The Central Military District reported that UAVs were used as reconnaissance strike and fire complexes with the employment of aircraft and artillery systems. The operator's control panel can simultaneously command and control four other drones.[202]

Since 2015, **Granat-1, Granat-4,** and **Zastava** UAVs have been in the Far East and now **Orlan-10s** are there. The latter are deployed in detachments of three UAVs, with the first collecting intelligence at an altitude of 1-1.5 kilometers; the second carries EW equipment and is located higher; and the third operates at altitudes of 4.5-5 kilometers and retransmits video and other data to the base. **Orlan-10s** can carry a bomb payload and be equipped with day and night cameras, thermal imagers, and stay in the air up to 14 hours.[203]

Russia reportedly has three UAVs under development for **use** in the Arctic. The **ZALA** Arctic UAVs can perform missions that ensure maritime safety navigation, perimeter protection, and coastline and territorial water monitoring. The **ZALA 421-08M** and **421-16Ye** systems can work in sub-zero temperatures to conduct reconnaissance operations. They are fitted with automatic identification systems that can detect and identify (name, dimensions, heading, speed) ships at distances up to 100 kilometers. **ZALA** incorporates its own GIRSAM alternative navigation system. Other systems, such as the VRT 300 Arctic Supervision vehicle, a helicopter-type UAV, whose coaxial contra-rotating rotors increase stability in strong winds, is under development, weighing 300 kilograms and able to use a payload weighing 70 kilograms. Finally, the **Triada** convertiplane is an aircraft/helicopter hybrid with a vertical takeoff and horizontal landing capability. It has a range of between 80 and 1,600 kilometers. It can photograph objects up to 5 kilometers and can stay airborne for eight hours.[204]

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[199] Dmitriy Yurov, "The 'Altair's' Appearance: What the New Russian Strike Unmanned Air Vehicle Will Be Like; *Izvestiya* Has Learned Additional Details of the Future Vehicle," *Izvestiya Online*, 12 January 2019.
[200] Viktor Sokirko, "Twenty-Ton Drone: The Russian Okhotnik Scoffs at the American Lightning: USA Has Fearfully Categorized the State-of-the-Art Russian Stealth Strike Drone as a Fighter Aircraft," *Svobodnaya Pressa*, 28 January 2019.
[201] Andrey Borisov, "A Powerful Appetite: Russia is Developing the Heaviest Strike Unmanned Vehicle. What is Known About It?" *Lenta.ru*, 13 February 2019.
[202] Yuriy Gavrilov, "There Are Methods against Drones. Military Personnel Learn to Combat Hostile Unmanned Aerial Vehicles," *Rossiyskaya Gazeta Online*, 14 May 2019.
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Robotic vehicles, left to right: AER, Uran-9, Vikhr, Sorotnik, Mars, Uran-6

Fig. 1. Assault engineering robot (AER)

Рис. 3. Боевой многофункциональный робототехнический комплекс «Уран-9»

Ground Troops' Vikhr robotic complex

Рис. 8. Многофункциональный робототехнический комплекс разминирования «Уран-6»

Top set of six photos, left to right:

Assault Engineer Robot: N. V. Babin, O. N. Ivanyushenko, and N. N. Magdalinov, "Several Aspects for the Combat Use of Engineering Robot Technical Complexes during Assaults and Obstacle Clearing," *Voennaya Mysl' (Military Thought*), No. 6 2019, p. 145.

Uran-9: V.T. Bebeshev, D. N. Metelev, "Provision of the Comprehensive Security for Ground-based Military Robotic Units," *Voennaya Mysl' (Military Thought*), No. 2 2021, p. 120.

Vikhr, Sorotnik, and Mars (last two in bottom layer, left to right): A. Kalistratov, "Robots, Into Battle! Military Robotic Devices in the Warfare of Today," *Armeyskiy Sbornik (Army Journal*), No. 10 2017, Vikhr p. 40, Sorotnik and Mars p. 41.

Uran-6 (last photo on the right, bottom layer): M. A. Moklyakov and A. M. Bylenkov, "Present-Day Development Trends in Engineer Troops Robotechnology," *Voennaya Mysl' (Military Thought),* No. 4 2019, p. 46.