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NEW STRATEGY CENTER

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Cover: Ukrainian soldier with a drone, source: Associated Press
Drone, source: Ukrainian General Staff Facebook

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Introduction

The ongoing Russia`s war against Ukraine has brought the integration of artificial intelligence (AI) in military systems to the forefront of modern warfare. Both Russia and Ukraine leverage AI to enhance the operational capabilities of unmanned aerial vehicles (UAVs) and other military technologies, aiming to achieve tactical and operational advantages in a rapidly evolving battlefield environment.

In recent years, the Russian Federation has prioritized the development of AI-driven autonomous systems, including drones, to improve efficiency and flexibility in combat. AI integration allows for a high degree of autonomy in intelligence gathering, targeting, and decision-making, enabling operations in high-risk or inaccessible areas while reducing personnel exposure. These systems also optimize resource allocation and accelerate tactical responses through real-time analysis of large datasets.

Conversely, Ukraine has rapidly adopted and adapted AI-enabled drones to counter Russian advances, leveraging a decentralized and innovative approach that combines off-the-shelf technologies with military applications. Ukrainian forces use AI-driven UAVs for reconnaissance, artillery targeting, strikes, demonstrating remarkable adaptability and resourcefulness in integrating cutting-edge technologies under wartime conditions.

This research examines the contrasting strategies, technological advancements, and operational implications of AI integration in the UAV programs of both sides, shedding light on its transformative impact on doctrinal approach, battlefield dynamics, and the broader trajectory of AI in warfare.

A soldier of the Ukrainian Armed Forces says hello to a robot dog[1]

[1] What can the new AI drones created during the great war do? 09.01.2025, https://www.radiosvoboda.org/a/shtuchnyy-intelekt-na-poli-boyu-dronova-viyna/33269380.html

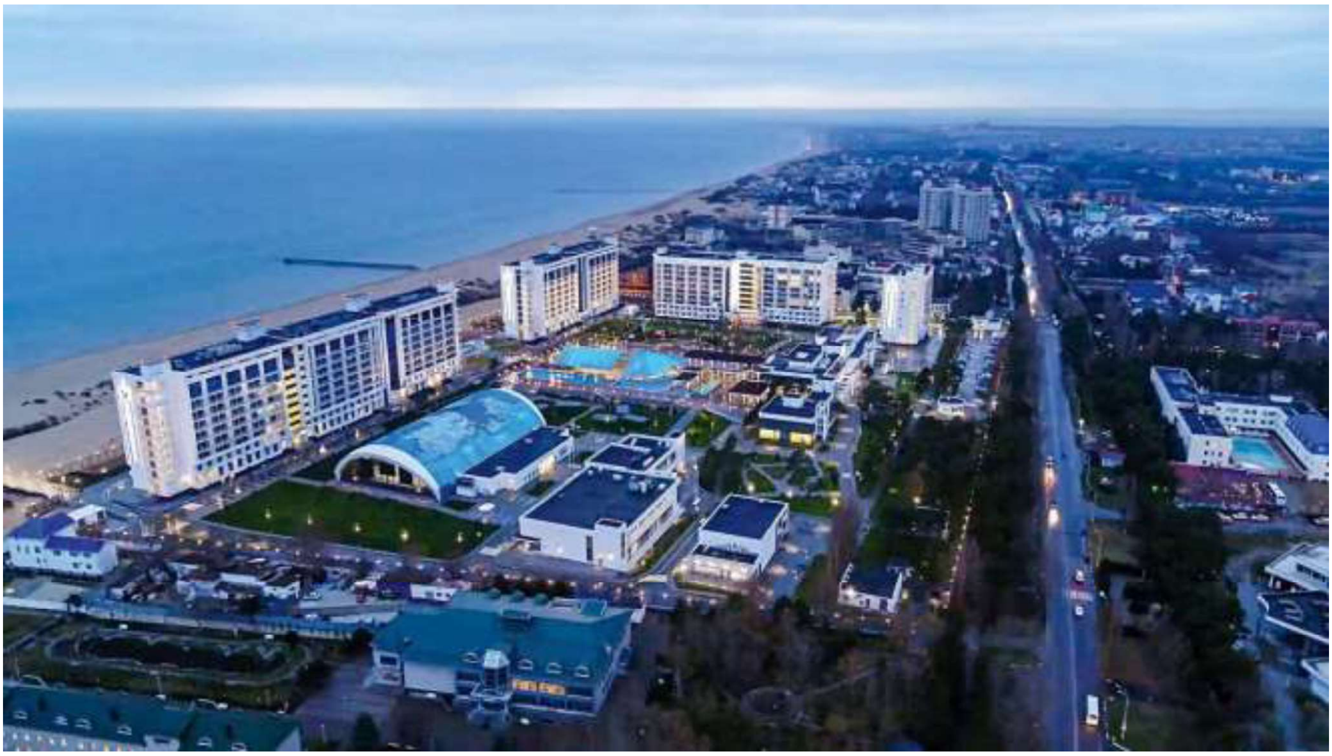
Trends in the Development of AI in Russian Military Sphere

The origins of artificial intelligence development in Russia can be traced back to the mid-20th century, deeply entwined with the Soviet Union's relentless push to strengthen its military prowess[2]. By the 1960s, as the concept of cybernetics gained traction within defence circles, the Soviet military turned its focus to neural networks, recognising their potential for strategic applications. In 1969, Colonel-Engineer Viktor Bokaryov made a significant contribution to this emerging field with his publication *Cybernetics in the Military Domain*[3]. This work delved into the theoretical possibilities and practical challenges of creating artificial intelligence systems, with particular attention to the intricate dynamics of human-machine interaction in the context of warfare. Bokaryov's analysis underscored the complexities of integrating AI into military operations, a concept that was revolutionary at the time but would come to define much of modern military strategy. The Soviet exploration of AI during this period laid the groundwork for Russia's present-day advancements, as the country continues to build upon its long-standing tradition of leveraging cutting-edge technology to bolster its strategic edge. Today, the legacy of these early efforts can be seen in Russia's ongoing quest to incorporate AI into its military systems, from drones to electronic warfare platforms.

In 2017 Russian president Vladimir Putin emphasized the global significance of AI, declaring it the future of both Russia and humanity. This statement underlined its critical role in maintaining military and technological superiority. He literally told: «The country that achieves leadership in creating artificial intelligence will be the ruler of the world»[4]. Russian Ministry of Defense hosted its first conference on AI in 2018, addressing challenges and identifying opportunities. The event resulted in directives to accelerate research and foster collaboration among government agencies, academia, and industry[5].

[2] Advanced military technology in Russia Capabilities and implications / Samuel Bendett et al. *Russia and Eurasia Programme*. URL: https://www.chathamhouse.org/sites/default/files/2021-09/2021-09-23-advanced-military-technology-in-russia-bendett-et-al.pdf.
[3] Cybernetics in the Military Domain (Кибернетика и военное дело), V.Bokaryov, 288 c., 1969, Moscow.
[4] Putin: The country that creates artificial intelligence will become the ruler of the world, https://eadaily.com/ru/news/2017/09/01/putin-strana-sozdavshaya-iskusstvennyy-intellekt-stanet-vlastelinom-mira
[5] «Defense Ministry: Artificial Intelligence technologies are being actively implemented in the Russian Armed Forces», https://tass.ru/armiya-i-opk/5034769

In the same 2018, Russia inaugurated the military technology park Technopolis ERA in Anapa, in the Krasnodar region, cementing artificial intelligence as one of its eight core research priorities[6].



Military Innovation Technopolis ERA in Anapa, Russia, source https://dfnc.ru

By 2024, the facility had grown into a significant innovation hub, hosting 19 research companies and collaborating with over 250 partners. Its focus spans diverse areas, including technical vision, nanotechnology, AI modelling, and more[7]. As for now, Technopolis ERA solidified its role as a key player in Russia's AI development with a strategic partnership agreement signed alongside the Federal Centre for the Applied Development of Artificial Intelligence and the Ministry of Defence's Department for AI Technologies Development. This trilateral agreement outlined a broad scope of collaboration, including the preparation of expert opinions, standardization efforts, and regulatory frameworks for AI integration. The initiative also prioritised fundamental and applied research into AI systems, such as the creation of advanced software and hardware platforms and decision-support systems underpinned by artificial intelligence[8].

In 2021, the 46th Central Research Institute (46th CRI) was designated as the primary organization responsible for the development and integration of military AI

[6] Building better security for wider Europe, European Leadership Network.
URL: https://www.europeanleadershipnetwork.org/wp-content/uploads/2023/11/Russian-bibliography.pdf.

[7] Denis Manturov visited the Military Innovation Technopolis ERA in Anapa, https://www.kommersant.ru/doc/5886051

[8] Residents of Innopolis ERA were exempted from taxes for 10 years, https://www.ng.ru/economics/2024-02-15/4_8950_facilities.html

technologies. By 2022, a specialized department within the Ministry of Defense was established to oversee AI-related initiatives[9]. That same year, Defense Minister Shoigu approved the "Concept for the activities of the armed forces of the Russian Federation in the development and application of weapons systems using artificial intelligence technologies" (a non-public document), formalizing AI's role within Russia's military strategy[10].

Russian military AI research spans a diverse range of applications. In 2015, the Strategic Missile Forces Military Academy proposed a mathematical model for an automated logistics management system tailored to mobile units. This system reduced the decision-making cycle by nearly 50%, streamlining information collection, processing, and analysis. By 2018, neural network-based models were deployed to predict the operational lifespan of missile system components, ensuring optimized maintenance schedules and sustained combat readiness[11]. In 2021, advanced automated systems for missile facility protection were introduced, incorporating robotic firing complexes powered by neural networks for target identification and engagement. Systems such as *Dym-SK* demonstrated the ability to operate autonomously or under human control, blending precision with adaptability to meet evolving threats[12].

The large-scale production of unmanned aerial vehicles underscores AI's integration into the Russian military. By 2023, approximately 140,000 UAVs were produced, with projections for up to 1.4 million units by 2024[13]. However, despite high production volumes, Russian UAVs often face quality issues, reducing their battlefield effectiveness. In these conditions, artificial intelligence can increase the efficiency of drone use by automating the processes of target detection, target qualification, and destruction. AI-driven UAVs can identify enemy positions, track movements, and deliver targeted attacks. Over time, improvements in AI technologies may enable UAVs to operate with greater autonomy, enhancing their ability to adapt to changing combat conditions and execute missions with minimal human intervention.

Despite progress, Russian UAV operations remain semi-autonomous. While the concept of *swarm* drone tactics is frequently discussed in Russian media, current

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[9] Department for artificial intelligence created in the Ministry of Defense of the Russian Federation, TASS, 17 Aug. 2022, https://tass.ru/armiya-i-opk/15492531

[10] Commentary by Russian Foreign Ministry spokesperson M.V. Zakharova on the activities of the Group of Governmental Experts of States Parties to the Convention on Certain Conventional Weapons on lethal autonomous weapons systems, Ministry of Foreign Affairs of the Russian Federation, 23 Aug 2022, https://www.mid.ru/ru/foreign_policy/news/1827203/

[11] Stefanovich, Dmitry, 'Artificial Intelligence and Nuclear Weapons', Russian International Affairs Council, 6 May 2019, https://russiancouncil.ru/en/analytics-and-comments/analytics/artificial-intelligence-and-nuclear-weapons

[12] Biryulin, Roman and Andreev, Dmitry, 'Russia's undeniable argument', Red Star, 17 Dec. 2021, http://redstar.ru/bespornyj-argument-rossii

[13] Putin says Russia is ramping up drone production tenfold, 19.09.2024, https://www.reuters.com/world/europe/putin-says-drone-supplies-russian-army-increase-tenfold-2024-2024-09-19/

systems still rely heavily on operator input. Coordination between drones requires significant manual effort, and fully autonomous swarm systems remain under development. Experimental semi-autonomous systems are being tested to allow UAVs to share data, communicate, and coordinate actions more effectively. However, achieving full autonomy in such systems continues to be hindered by technical complexities and field conditions.

Ground-based robotic systems also benefit from AI advancements. The *Shturm* program[14], for example, is developing robotic tanks based on the T-72B3 to complement and, in some cases, replace traditional crewed platforms like the T-90 or new T-14 *Armata*. These robotic tanks will be equipped with AI for target recognition, decision-making, and real-time action adjustment. Variants include configurations for urban combat, fire support, and thermobaric missile deployment. However, these systems face significant challenges, particularly in autonomy. Without human crews, the reliability of components and maintenance becomes a critical issue, as field repairs are often impractical in intense combat scenarios. Despite these limitations, robotic platforms have the potential to perform high-risk missions, particularly in urban environments where threats to personnel are heightened.

While Russia continues to push for greater autonomy in its unmanned systems, significant technical hurdles remain. Fully autonomous drones and robotic platforms must navigate complex environments, recognize objects and terrain, and make decisions independently. These requirements demand advanced sensor systems and AI-based vision technologies, which are costly and resource-intensive to develop. Consequently, human control remains a crucial component in deploying these systems, offering flexibility and adaptability in unpredictable battlefield scenarios.

Despite these challenges, Russia's sustained investment in AI technologies reflects its commitment to reshaping modern warfare. By integrating AI into UAVs, EW systems, and ground-based robotics, the Russian military is enhancing its operational effectiveness and preparing for the evolving demands of future conflicts.

Technological Integration of AI in Russian UAVs

Russian UAVs designed for automated target acquisition and tracking demonstrate advanced technological architecture aimed at improving mission efficiency. These platforms leverage AI-driven systems to analyze battlefield conditions, prioritize objectives, and execute tasks with precision. A detailed

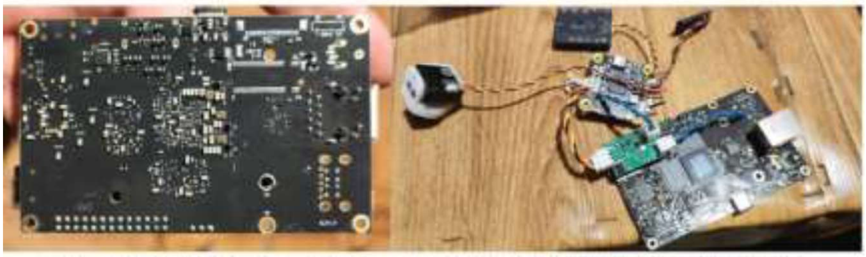
[14] Robotic complex "Shturm": preparation for testing is underway, "Voyennoe Obozrenie", 19.03.2022, https://topwar.ru/193694-robototehnicheskij-kompleks-shturm-idet-podgotovka-k-ispytanijam.html

examination of their design and operational frameworks reveals their current capabilities and provides insight into the future trajectory of their development[15].

Russian UAVs are equipped with the high-performance Rockchip RK3588 system-on-chip (SoC), developed by Chinese manufacturer Fuzhou Rockchip Electronics Co., Ltd[16]. This SoC delivers the computational power necessary for high-demand operational tasks, making it a critical component of the drones' performance capabilities. Its architecture features an octa-core CPU that combines ARM Cortex-A76[17] cores for high performance with Cortex-A55[18] cores optimized for energy efficiency, ensuring a balance between processing power and operational endurance.

The SoC integrates a Mali-G610 MP4 GPU[19], designed to manage complex visual processing tasks such as video analytics and real-time visualization. Central to the drone's artificial intelligence capabilities is the neural processing unit (NPU), capable of achieving up to 6 trillion operations per second (TOPS). This NPU is purpose-built for deep learning applications, enabling the UAV to perform advanced tasks like object detection, classification, and tracking. The system's low-latency processing allows for near-instantaneous decision-making, reducing reliance on operator input and enhancing mission effectiveness in dynamic environments.

Foxeer TRX1003 ELRS 900 Receiver **Main Circuit Board with Rockchip RK3588**



Backside of Main Circuit Board **Wiring and Flight Controller Setup** [20]

[15] Serhiy Flesh. A Russian drone with target acquisition and autotracking from the Kursk bridgehead. Telegram. https://t.me/serhii_flash/4172
[16] Rockchip RK3588, URL: https://www.rock-chips.com/a/en/
[17] Frumusanu A. Arm's Cortex-A76 CPU Unveiled: Taking Aim at the Top for 7nm. *AnandTech: Hardware News and Tech Reviews Since 1997*. URL: https://www.anandtech.com/show/12785/arm-cortex-a76-cpu-unveiled-7nm-powerhouse.
[18] A closer look at ARM's new Cortex-A75 and Cortex-A55 CPUs. *Android Authority*. URL: https://www.androidauthority.com/arm-cortex-a75-cortex-a55-breakdown-770380/.
[19] ARM Mali-G610 MP4. *GadgetVersus*. URL: https://gadgetversus.com/graphics-card/arm-mali-g610-mp4-specs/.
[20] Serhiy Flesh. A Russian drone with target acquisition and autotracking from the Kursk bridgehead. Telegram. https://t.me/serhii_flash/4172

The drone's AI systems leverage advanced deep learning algorithms to identify and acquire targets in real time by processing data from onboard cameras. Once a target is detected, the system transitions to tracking mode, employing neural networks optimized for rapid computation. This allows the UAV to predict the target's trajectory based on its speed and direction, adjusting its flight path dynamically to maintain visual contact and ensure mission success.

The integration of the Rockchip RK3588 SoC further enhances the drone's operational capabilities. This system supports high-speed interfaces, including HDMI, Ethernet, and USB 3.1, enabling seamless integration with a variety of sensors and communication systems. The SoC's ability to handle large data streams with minimal latency ensures reliable transmission of high-resolution video and other critical data. Additionally, compatibility with deep learning frameworks like TensorFlow Lite, ONNX, and Caffe allows the UAV to deploy diverse AI models tailored to operational requirements, such as reconnaissance, surveillance, and precision strikes.

Advanced sensor systems onboard the UAV enhance environmental mapping, target identification, and navigation accuracy. For long-range operations, the drone employs a Foxeer TRX1003_ELRS_900 receiver operating in the 900 MHz band. This receiver, utilizing the ExpressLRS[21] protocol, ensures low-latency communication over distances exceeding 10 kilometers, even in electronic warfare-contested environments. Although specific details of the onboard cameras remain undisclosed, the RK3588 SoC suggests the use of high-performance imaging systems capable of infrared and thermal imaging, providing critical functionality in low-visibility conditions such as night or fog.

Camera data is processed directly on the RK3588, where convolutional neural networks (CNNs) perform real-time object recognition and automate decision-making. These systems enable the UAV to classify objects, such as vehicles or personnel, and adjust its actions autonomously based on mission objectives. This seamless integration of advanced AI, high-speed communication, and sensor technology allows Russian UAVs to execute complex missions with precision and adaptability in dynamic combat scenarios.

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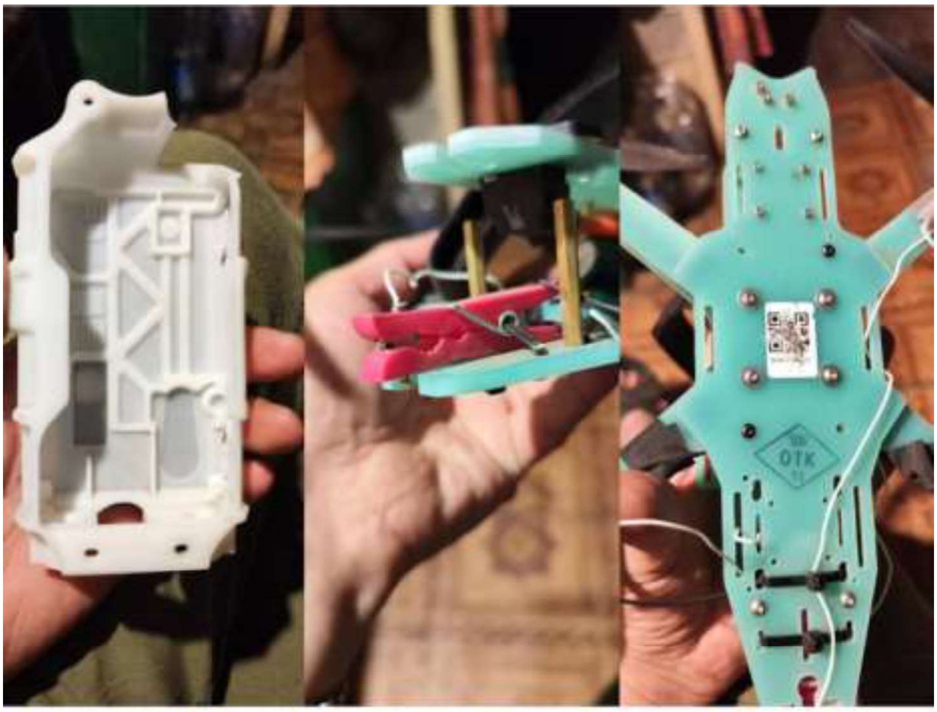
[21] GitHub - ExpressLRS/ExpressLRS: ESP32/ESP8285-based High-Performance Radio Link for RC applications. *GitHub*. URL: https://github.com/ExpressLRS/ExpressLRS.



1. **3D Printed Drone Frame**
2. **Servo Motor for Gimbal or Mechanical Adjustments**
3. **Main Drone Frame with Propeller mounts and Quality Control Markings**

[22]

The UAV’s electronic modules include a flight controller tasked with ensuring stabilization and precise maneuvering during operations. This controller interacts with onboard sensors such as accelerometers, gyroscopes, and magnetometers to continuously monitor the drone’s orientation, velocity, and position. Servo mechanisms, mounted on auxiliary boards, stabilize cameras and other sensors, maintaining steady focus on moving targets even under dynamic conditions. The flight controller works in coordination with the Rockchip RK3588 neural processing unit (NPU), processing GPS and inertial measurement unit (IMU) data to achieve precise trajectory adjustments and flight stability, ensuring optimal performance in mission-critical scenarios.

The propulsion system utilizes brushless DC motors, a reliable and highly maneuverable standard in UAV design. Electronic speed controllers (ESCs) precisely regulate motor rotation speeds, enabling the drone to execute sharp maneuvers and maintain accurate tracking of designated targets. To support the high energy demands of the RK3588 SoC and advanced onboard electronics, the UAV is powered by lithium polymer (LiPo) batteries. An onboard battery management system (BMS) ensures the safe operation of the power supply by preventing overcharging, overheating, and excessive discharge, preserving operational integrity in extended missions.

[22] Serhiy Flesh. A Russian drone with target acquisition and autotracking from the Kursk bridgehead, Telegram. https://t.me/serhii_flash/4172

A hallmark of this UAV is its autonomous capability, driven by AI-powered systems for target acquisition and tracking. The integrated RK3588 NPU supports modern neural networks like YOLO[23] and SSD, enabling real-time object detection and tracking. Advanced motion-prediction algorithms allow the UAV to anticipate target trajectories, continuously adjusting its flight path to maintain focus. Autonomy is further enhanced by the ability to operate independently when communication with the operator is disrupted by electronic warfare (EW) measures, significantly increasing resilience against adversarial interference.

Recent advancements in the UAV's capabilities were demonstrated in October 2024[24], with videos circulating on Telegram showcasing a newly developed machine vision and AI system. This system, designed to monitor the airspace ahead of the drone, detects incoming threats such as anti-aircraft drones and enables evasive maneuvers. The technology demonstrates exceptional military potential by analyzing and predicting the trajectories of hostile objects, allowing the UAV to evade them with minimal delay[25].

The UAV's cameras, equipped with wide-angle lenses, continuously scan the forward airspace to provide comprehensive coverage and minimize blind spots. This design ensures the timely detection of threats. In testing, the system effectively identified objects marked as potential threats, highlighting its ability to distinguish dangerous targets from less critical ones. Advanced classification algorithms enable the system to analyze and categorize objects in real time based on features such as shape and velocity. This capability, combined with high-speed image processing, allows the drone to react to emerging threats swiftly, maintaining its operational effectiveness in contested environments.

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[23] Drone-YOLO: An Efficient Neural Network Method for Target Detection in Drone Images. *MDPI*. URL: https://www.mdpi.com/2504-446X/7/8/526.
[24] Sergiy Flesh. Testing a system for drones based on AI and machine vision, Telegram. https://t.me/serhii_flash/4172
[25] UAV Detection Using Reinforcement Learning. *MDPI*. URL: https://www.mdpi.com/1424-8220/24/6/1870.


[26]

The UAV's onboard algorithms classify objects in its field of view as "threatening" or "safe" based on characteristics such as shape, motion, and thermal signatures. A critical feature of this system is its visualization interface, which highlights marked objects and provides real-time feedback to operators or autonomous AI systems. This interface allows operators to quickly assess the situation and make decisions when manual control is active[27]. For fully autonomous operations, the marking system integrates seamlessly with AI classification algorithms to facilitate rapid evasive maneuvers. Changes in camera angles and flight trajectories, as observed during testing, confirm the UAV's ability to actively avoid detected threats rather than merely monitoring them. The integration of evasion algorithms ensures synchronized operation between machine vision and maneuvering systems, enabling precise alterations to the flight path in response to identified dangers.

The UAV's high-resolution cameras provide broad-area coverage, allowing for accurate threat identification under various environmental conditions, including low light and adverse weather. These cameras reduce blind spots through wide-angle lenses capable of detecting subtle environmental changes and adapting sensory equipment accordingly. This capability is vital for countering high-speed threats like missiles or

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[26] Sergiy Flesh. Testing a system for drones based on AI and machine vision, Telegram. https://t.me/serhii_flash/4172

[27] Machine learning approaches to intrusion detection in unmanned aerial vehicles (UAVs). URL: https://www.researchgate.net/publication/383345559_Machine_learning_approaches_to_intrusion_detection_in_unmanned_aerial_vehicles_UAVs.

hostile UAVs. Advanced image-analysis algorithms process camera data in real time, segmenting frames into active motion zones and static backgrounds to optimize computational efficiency. Infrared cameras further enhance detection by identifying thermal signatures, making the system particularly effective during nighttime or low-visibility operations. Stereo cameras contribute three-dimensional spatial imaging, enabling precise distance, direction, and speed assessments of potential threats.

The UAV's evasion system operates autonomously, employing machine-learning algorithms to predict the trajectories of incoming threats.[28] Optical flow analysis evaluates positional changes across frames, allowing the UAV to adjust its trajectory dynamically. Trajectory-prediction algorithms calculate potential collision points, ensuring timely and effective evasive action. These algorithms consider optimization parameters such as battery charge, available airspace, and the UAV's speed to maximize efficiency during maneuvers. The advanced evasion capabilities, demonstrated in recent testing, leverage machine-learning models trained on extensive datasets to recognize hostile object behaviors and respond accordingly. For example, the UAV autonomously selects optimal evasion routes based on the threat's speed and trajectory, ensuring continuous mission execution.

Under critical conditions, the system activates specific safety protocols designed to preserve operational integrity. For instance, low battery levels trigger preemptive actions such as returning to base or initiating a controlled landing to prevent mission failure. These protocols also account for flight stability and external threats, enabling the UAV to prioritize safety while maintaining operational readiness. During emergencies, such as electronic warfare interference or physical damage, the UAV relies on its AI-driven autonomy to avoid danger and continue its mission without operator input.

[29]

[28] A Review on IoT Deep Learning UAV Systems for Autonomous Obstacle Detection and Collision Avoidance. *MDPI*. URL: https://www.mdpi.com/2072-4292/11/18/2144.
[29] Sergiy Flesh. Testing a system for drones based on AI and machine vision, Telegram. https://t.me/serhii_flash/4172

The system’s ability to analyze both external environmental data and internal operational parameters ensures that all maneuvers are optimized for mission success or threat avoidance. Critical-situation algorithms, such as automated termination protocols, display warnings like "LAND NOW" on the interface when low battery or other mission-critical issues arise. These safeguards, driven by data from onboard sensors and processors, enhance the UAV's resilience in complex and contested environments, allowing it to adapt and complete its objectives despite unpredictable challenges.

Autonomy in Russian Robotic Systems

The Russian Armed Forces have prioritised robotic and autonomous systems in their modernisation efforts, integrating these technologies into operations, tactics, and procedures. Promoted as "force multipliers" to enhance combat effectiveness and reduce personnel risks, these systems are a cornerstone of Moscow's strategy to address manpower and logistical gaps. However, questions persist about their reliability and real-world effectiveness. Many systems remain developmental or fail to meet the Kremlin’s bold claims. While these technologies reflect Russia’s push for innovation, their practical impact on military capability remains uncertain, particularly in the context of the ongoing Russian war against Ukraine.

Since 2021, the Russian Ministry of Defense and its military-industrial complex have focused on analyzing the operational experience of these systems in combat conditions and formulating theoretical foundations for their future impact on warfare. Particular emphasis is placed on the integration of artificial intelligence, which has become a central component in the development of robotic systems. AI-based systems aim to enhance autonomy, accuracy, decision-making speed, and adaptability to changing combat conditions.

Modern developments, such as the *Marker*, serve as test platforms for cutting-edge technologies [30]. The *Marker* is equipped with computer vision sensors, powerful processors for processing large data volumes, and neural network systems for autonomous decision-making. It can operate both as part of a swarm and independently, analyzing the environment and optimizing its actions.

[30] Shalnov A. Combat robot *Marker*: characteristics, photos, effectiveness against “Abrams” and “Leopards”. Tsargrad TV channel, URL: https://m-nn.tsargrad.tv/news/boevoj-robot-marker-harakteristiki-foto-postavki-dlja-russkoj-armii-v-zonu-svo_710194.

The *Marker* robotic complex[31]

Its height and width do not exceed 160 centimeters, enhancing maneuverability in challenging terrain conditions and making it harder for adversaries to target. The angled design of its frontal armor plates increases the machine's survivability against potential impacts. Additionally, the rear of the *Marker* features mounts for RPGs, allowing it to transport part of the infantry's ammunition load. The robot can be equipped with either tracked or wheeled platforms, providing versatility depending on the terrain. The *Marker's* range is between 600 and 1,000 kilometers, depending on the surface type and operating conditions. Its hybrid engine, combining diesel and electric drives, allows for efficient energy use and reduced fuel consumption.

One notable feature of this combat robot is its ability to integrate with a sight, enabling it to automatically aim its weapon at the same point as the soldier. The *Marker* can analyze the situation, determine target priority, and choose the optimal firing position, though the final decision to open fire is always made by a human. Equipped with cameras and thermal imagers, the robot continuously monitors its surroundings,

[31] Russian “terminators” arrived in the SVO zone: how combat robots will change the tactics of Donbass defense, Komsomolskaya pravda, 3.02.2023, https://www.kp.ru/daily/27461.5/4716203/

plans routes, and avoids obstacles. Additionally, capabilities for detecting and attacking drones are being developed, though these functions are currently in the conceptual stage.

The *Marker's* armament includes a 12.7 mm *Utes* machine gun and a block for two RPG-26s, which can be supplemented with anti-tank missile modules. After firing a grenade launcher, the system automatically discards the used tube, preparing to load the next munition. This ensures high combat speed and efficient reloading.

The Russian military-industrial complex is also focused on the development of autonomous robotic platforms. One such project is the *Shturm* robotic tank program based on the T-72B3 tank platform[32]. This strategy aligns with the need for cost-effective solutions to meet the demands of modern warfare, particularly compared to the more expensive T-14 *Armata* tanks. The robotic T-72B3 is designed as a viable alternative to the *Armata* through the integration of AI for more autonomous and efficient combat operations.

The main objective of the *Shturm* program is to create an autonomous platform capable of performing combat operations independently. The integration of AI allows for real-time processing of large volumes of data received from numerous onboard sensors, enabling the identification and prioritization of targets. This approach significantly enhances combat effectiveness, as AI enables automated decision-making, allowing the tank to operate autonomously even in intense combat situations. Each robotic vehicle can function within a network, where AI algorithms coordinate actions and respond rapidly to changes on the battlefield, thereby significantly increasing the operational efficiency of these platforms.

The choice of the T-72B3 platform for this project is also driven by its reliability and cost-effectiveness. With its proven combat history, the T-72B3 has established itself as a dependable machine, and its modernization into a robotic platform allows the Russian army to conserve resources while maintaining high combat potential. AI technologies and automation enable these tanks to be more flexible and adaptive to the conditions of intense combat, particularly in complex urban environments, where increased mobility and autonomy play a crucial role. The ability to maneuver in confined spaces and respond autonomously to changes in battlefield conditions opens new tactical opportunities for the deployment of robotic tanks.

The *Shturm* program includes several configurations of robotic vehicles, each equipped with specific weapon systems tailored to perform distinct combat tasks. One configuration is equipped with a 125-mm D-414 cannon, a 7.62-mm Kalashnikov machine gun, and a protection system against anti-tank grenades and mines. This version, with a shortened barrel and increased maneuverability, is ideally suited for

[32] Andrei_bt. The robot has been officially confirmed - Shturm. *LiveJournal*, https://andrei-bt.livejournal.com/949786.html

urban combat, where the ability to operate in confined spaces is critical. AI systems providing autonomous navigation enable this configuration to avoid obstacles and strike targets with high precision, relying on both pre-programmed algorithms and real-time data processing.

Combat vehicle *Shturm*, variant

Another configuration is designed for close combat and is equipped with rocket-propelled grenades and machine guns. This version of the robotic machine can destroy enemies in well-fortified positions, which is especially useful in urban warfare. AI algorithms allow the machine to independently identify targets and make decisions about using its grenade launcher based on threat assessments and the tactical situation. With autonomous decision-making capabilities, such platforms can function as direct combat units and provide support to personnel units, facilitating advances in dangerous zones.

Yet another variant of the tank is equipped with dual 30-mm automatic cannons with large ammunition reserves and an additional machine gun. This modification is intended for fire support and can simultaneously engage multiple targets, including enemy personnel and lightly armored vehicles. Thanks to AI, fire control systems continuously adjust aiming, ensuring high accuracy depending on the target type and distance. The ability to autonomously operate weaponry enables these robotic tanks to effectively act in combat situations without constant human intervention, enhancing their combat efficiency and allowing operators to focus on strategic management.

Another configuration of the *Shturm* platform is designed for delivering powerful strikes over large areas and is equipped with large-caliber thermobaric rockets. AI analyzes battlefield data, identifying priority targets and coordinating actions with other units to maximize strike efficiency. The AI's ability to analyze and prioritize targets makes these thermobaric systems particularly effective for breaking through enemy defensive lines and securing territorial control.

AI algorithms in these robotic platforms perform not only navigational functions but also tasks related to target recognition and elimination. Advanced computer vision algorithms allow the tanks to autonomously identify, classify, and prioritize targets based on the level of threat or specific mission objectives. These algorithms continuously process data from sensors to monitor enemy actions, adjust weapon targeting, and optimize attack tactics. The ability to track and attack multiple targets independently or transmit data to other units increases operational efficiency in complex combat conditions, particularly in situations requiring rapid response.

Despite their high level of autonomy, these robotic platforms retain the option for remote control, providing an additional layer of oversight and safety. Operators can manage the tanks remotely from specialized combat vehicles, also based on the T-72B3 platform. This allows operators to supervise autonomous actions while relying on AI to perform routine tasks such as navigation and reconnaissance. Moreover, the AI system integrated into the combat vehicles provides tactical recommendations to operators, enhancing coordination between manned and autonomous platforms and ensuring cohesive unit actions overall.

The strategic implications of developing such autonomous platforms could profoundly influence combat tactics and strategy. Robotic AI-enabled tanks can act as the first wave in offensive operations, breaching defensive lines and targeting key objectives. Their ability to operate without pause allows for sustained pressure on the enemy, providing an advantage in prolonged engagements. AI supports operational cohesion, enabling autonomous platforms to conduct complex attacks in coordination with other units.

AI-Optimized Drone Charging System from Power Lines

Charging UAVs from high-voltage power lines is a promising approach to extending drone operational capacity, addressing the problem of limited battery life[33]. The integration of artificial intelligence technologies for energy harvesting from power lines can significantly enhance UAV autonomy, enabling them to perform longer missions without the need to return to base for recharging. The use of AI in this system

[33] Arévalo, P., & Jurado, F. (2024). Impact of Artificial Intelligence on the Planning and Operation of Distributed Energy Systems in Smart Grids. Energies. https://www.mdpi.com/1996-1073/17/17/4501

is especially important in military contexts, where the duration of drone operations behind enemy lines depends on the efficiency of autonomous charging systems. Since access to conventional charging infrastructure is limited, the ability to recharge from power lines on-site provides a significant tactical advantage. With AI managing the process, drones can continue performing tasks in the field without interrupting operations to return to base. Moreover, this autonomy enables swarms of drones to coordinate their activities in the field: AI analyzes the charge level of each drone, directing them to the nearest power lines for recharging, thus maintaining operational continuity and increasing territorial coverage.

For Russian military drones operating in field conditions, the integration of such a system is a crucial step in expanding combat capabilities and operational potential. An AI-based charging system includes a suite of technologies working together, with every component - from energy collection and conversion to distribution - controlled by AI algorithms to ensure precision and safety during the charging process, particularly in managing dynamic risks such as interference or component failures.

Russia is implementing projects in this area[34]. In particular, we are talking about the *Treugolnik* (Triangle) system developed by the *Laboratoria Budushchego* (Laboratory of the Future)[35]. The main idea of the project is to place a special gripper mechanism on power lines, which allows receiving drones and placing them on a platform for charging. This innovative solution opens new perspectives for the charging and use of drones.

At present, the progress of Russian developers in developing such systems is not yet clearly defined, and there are no concrete results of their practical testing. Therefore, let's look at a successful project in this area on the example of researches of Department of Mechanical and Electrical Engineering, University of Southern Denmark[36].

A key technological challenge in enabling charging from power lines is how to efficiently and safely harvest energy from lines transmitting alternating current (AC) at high voltages, which can reach hundreds of kilovolts (kV). Direct contact with power lines is hazardous and could disable the drone; therefore, non-contact methods such as inductive or capacitive coupling are employed.

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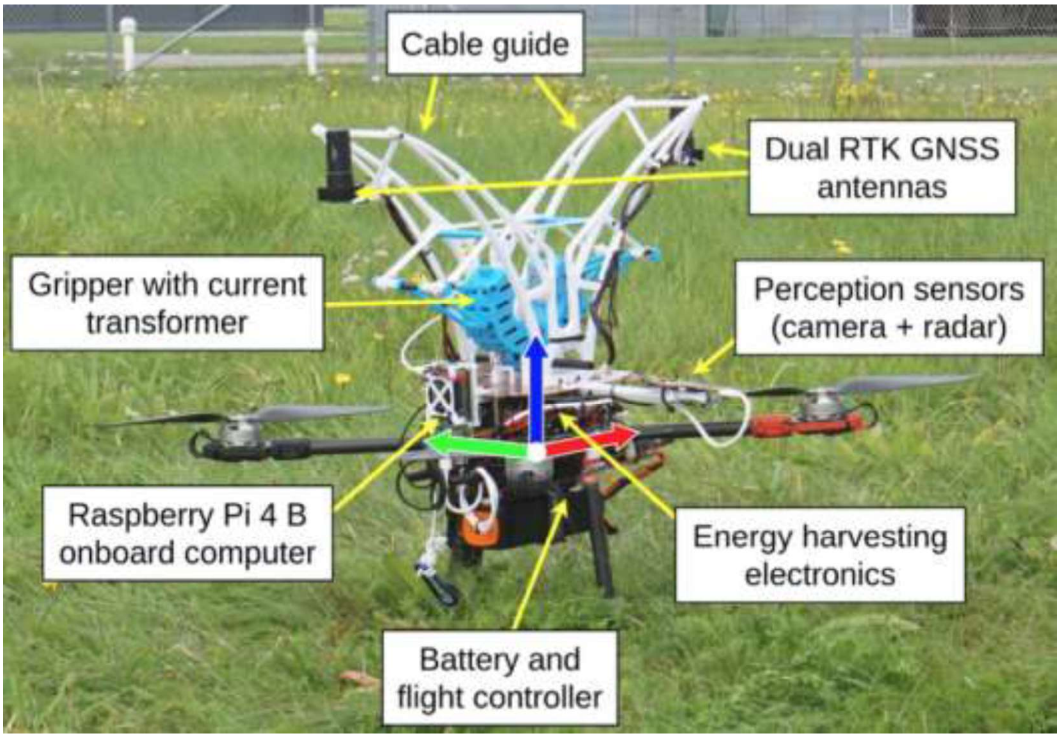
[34] Treugolnik (drone charging station), https://www.tadviser.ru/index.php/%D0%9F%D1%80%D0%BE%D0%B4%D1%83%D0%BA%D1%82:%D0%A2%D1%80%D0%B5%D1%83%D0%B3%D0%BE%D0%BB%D1%8C%D0%BD%D0%B8%D0%BA_(%D0%B7%D0%B0%D1%80%D1%8F%D0%B4%D0%BD%D0%B0%D1%8F_%D1%81%D1%82%D0%B0%D0%BD%D1%86%D0%B8%D1%8F_%D0%B4%D0%BB%D1%8F_%D0%B4%D1%80%D0%BE%D0%BD%D0%BE%D0%B2)

[35] Laboratoria Budushchego (Laboratory of the Future), https://www.tadviser.ru/index.php/%D0%9A%D0%BE%D0%BC%D0%BF%D0%B0%D0%BD%D0%B8%D1%8F:%D0%9B%D0%B0%D0%B1%D0%BE%D1%80%D0%B0%D1%82%D0%BE%D1%80%D0%B8%D1%8F_%D0%B1%D1%83%D0%B4%D1%83%D1%89%D0%B5%D0%B3%D0%BE

[36] Autonomous Overhead Powerline Recharging for Uninterrupted Drone Operations. *arXiv.org*. URL: https://arxiv.org/abs/2403.06533.



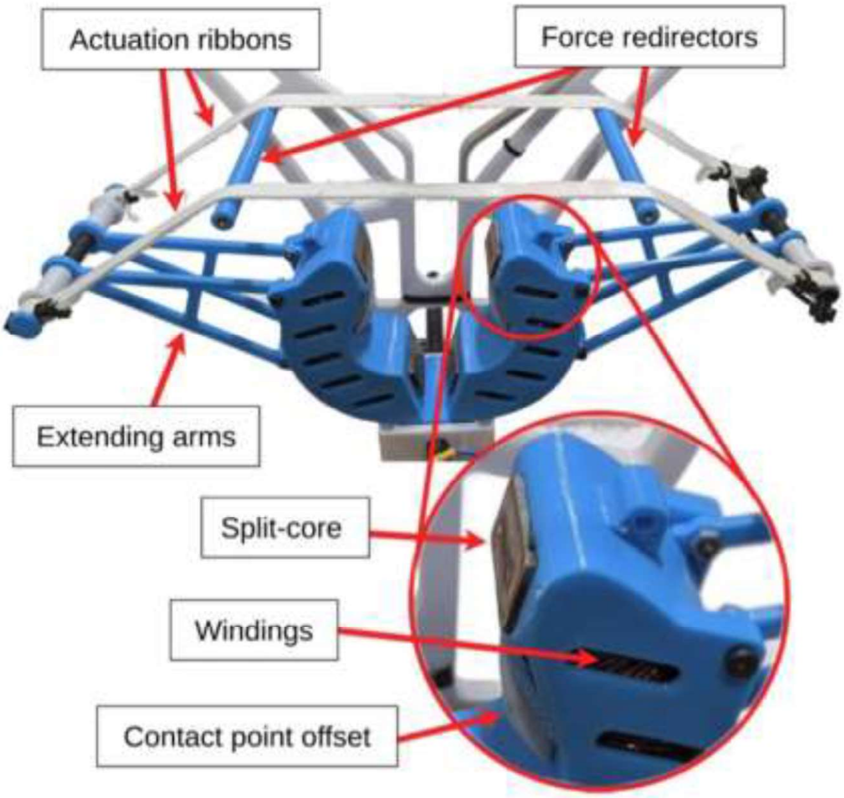
Components of a self-charging drone[37]

The inductive method uses the magnetic field generated around the power lines; when the drone is at a safe distance, this field induces a current in specialized onboard coils. This current is rectified and stored in the battery. In the capacitive method, energy is transferred via the electric field created between the power lines and the drone. Although capacitive coupling is less efficient, it is used when physical proximity to the power lines is critical, but the inductive method is insufficiently powerful. Regardless of the method, energy from the power lines requires conversion and voltage regulation to be used by the drone's onboard systems. The conversion process involves specialized AC-DC rectifiers and DC-DC converters that lower the voltage to a level suitable for battery charging.

AI manages energy conversion, adjusting the output voltage from the power lines and modulating the conversion rate to avoid overloading. The AI-controlled power management system (PMS) not only ensures safe charging but also regulates energy distribution among various drone components - from sensors to communication systems. The PMS continuously monitors the battery charge level supplied by the power lines and the condition of energy conversion components. When the battery reaches full charge, AI automatically reduces input power or halts charging to prevent overcharging, which could negatively impact battery longevity. Additionally, the PMS optimally

[37] Autonomous Overhead Powerline Recharging for Uninterrupted Drone Operations. *arXiv.org*. URL: https://arxiv.org/abs/2403.06533.

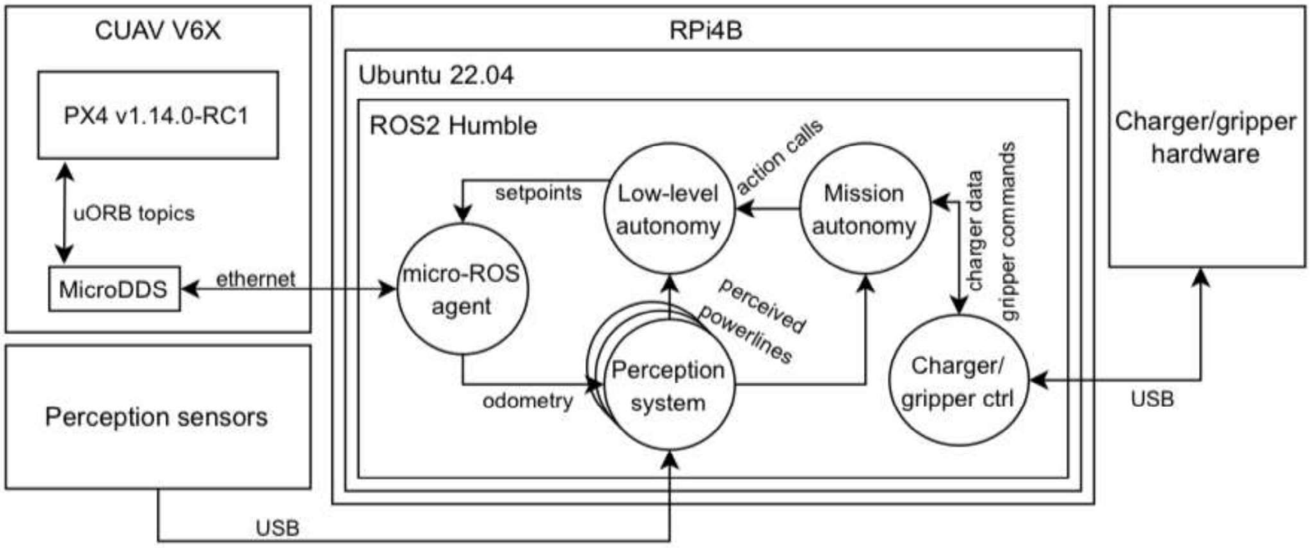
distributes energy among critical drone systems, ensuring uninterrupted operation even during charging.



Components of the gripper mechanism

Charging from power lines requires precise drone positioning near the lines, as excessive proximity can lead to electrical discharges or component damage. AI controls this process by processing data from GPS, cameras, LIDAR, and inertial measurement units (IMUs), enabling the drone to accurately determine its position and maintain stable hovering near the power lines. Furthermore, computer vision systems ensure the automatic identification of power lines, critical for the safety and stability of the charging process. Such precise positioning is essential not only for optimal energy collection but also for drones using specialized capture mechanisms for charging. In cases of physical attachment to the power lines, the drone uses insulated clamps, requiring advanced insulation systems to protect against high-voltage discharges.

As electromagnetic fields around the lines can fluctuate due to external factors such as grid load changes or weather conditions, AI dynamically adjusts the energy collection process. By processing electromagnetic field parameters in real-time, AI can alter the energy collection rate or reposition the drone to a better location, ensuring a stable charging cycle. If AI detects voltage drops or increases in the field, it can adapt charging parameters to prevent component damage or overheating, which could result in system failure. AI monitors the temperature of critical elements, such as inductive coils, voltage converters, and the battery, and activates cooling systems as needed to reduce overheating risks. If the temperature reaches a critical level, AI halts the charging process until temperatures normalize, preventing harm to the drone's operational capacity.



Computational system diagram showing the connections and data flow of the autonomous system[38]

Batteries must not only have high energy density to support prolonged flight but also be compatible with high-voltage energy harvesting. Lithium-ion (Li-Ion) and lithium-polymer (Li-Po) batteries are suitable for such drones due to their high energy density and rapid charging capabilities. Li-Ion batteries provide stable power, ideal for drones conducting long surveillance or reconnaissance missions. They can maintain consistent output over extended periods but are sensitive to overcharging and overheating. To prevent damage, the AI-controlled battery management system (BMS) regulates the charging process and continuously monitors parameters such as voltage, current, and temperature. Li-Po batteries are more flexible in design and can be manufactured in various shapes and sizes, advantageous for compact drones. They can sustain high discharge currents, making them suitable for drones requiring high energy pulses during maneuvers or combat operations. However, they are also prone to thermal runaway during charging. To mitigate this, AI regulates battery temperature during charging and, if necessary, reduces current or activates cooling systems.

[38] Drone Infrastructure Inspection &Interaction Group. Autonomous Overhead Powerline Recharging for Uninterrupted Drone Operations - ICRA 2024, 2024. *YouTube*. URL: https://www.youtube.com/watch?v=C-uekD6VTIQ.

The development of UAV technology with AI in Ukraine

The development of unmanned aerial vehicle technologies with artificial intelligence in Ukraine is taking place within the framework of active collaboration between government institutions and private technology companies working on creating advanced military solutions. In 2023, the BRAVE1 cluster was established - an initiative launched by the Ministry of Digital Transformation of Ukraine in cooperation with the Ministry of Defense, the General Staff of the Armed Forces of Ukraine, the National Security and Defense Council, the Ministry of Strategic Industries, and the Ministry of Economy. The goal of this cluster is to unite the efforts of the state and the technology sector to accelerate the development of innovative military technologies, including UAVs with artificial intelligence. The cluster supports the development of such technologies aimed at enhancing the efficiency of the Ukrainian Armed Forces, ensuring personnel safety, and providing Ukrainian military personnel with an advantage on the battlefield. BRAVE1's achievements include the development and testing of various types of drones, including reconnaissance, strike, transport drones, and drone sappers, as well as the development of artificial intelligence-based software that automates processes such as detection, target identification, and threat avoidance.

Recently, BRAVE1 conducted trials of three key technologies of strategic importance for the frontlines: drone swarms, guided munitions, and robot dogs[39]. These cutting-edge developments enable the effective use of drones in combat conditions and enhance autonomous actions on the battlefield.

Drone swarm technology allows a single operator to control an entire group of UAVs that act as a single autonomous unit. During the tests, it was demonstrated how drones within a swarm perform tasks, coordinating their actions to complete combat missions. Thanks to AI capabilities, each drone in the swarm can analyze its surroundings, make real-time decisions, and adjust its flight path, avoiding enemy obstacles and attacks. The swarm technology is a significant step toward increasing the autonomy and efficiency of missions, as a group of drones can independently cover large areas, ensuring timely detection and response to threats.

[39] Fedorov, New technologies for the frontline tested by Brave1: drone swarm, guided munitions and robotic dog, Telegram. https://t.me/zedigital/5012

Ukrainian drone`s swarm, video screenshot[40]

Guided munitions for drones have become an essential tool for improving target accuracy. These munitions are equipped with self-guidance systems that allow them to automatically adjust their trajectory during flight. This significantly reduces the risk of misses and ensures maximum effectiveness in combat missions of bomber drones. Thanks to these developments, drones can strike even moving targets with high precision, which is particularly important in the dynamic conditions of the frontlines. Guided munitions demonstrate adaptability and flexibility, enhancing the efficiency of military operations and reducing risks for operators.

[40] Together with Brave1, the Ministry of Defense, the Ministry of Digital Transformation, the General Staff, and the National Guard, we tested new Ukrainian developments - swarms of drones and guided munitions, 30.10.2024, https://www.youtube.com/watch?v=yTG6mJO6oHo&t=3s&ab_channel=Ukrinform

Ukrainian guided munitions for drones, video screenshot[41]

Robot dog technology, already used by the armed forces of the United States and other countries, performs logistical and reconnaissance functions in challenging terrains. The robotic dog can move autonomously, covering up to 10 kilometers on a single charge, ensuring its efficiency in long-term tasks. It is used to deliver ammunition and conduct reconnaissance in hard-to-reach areas, significantly expanding the logistical capabilities of units. The robot dog technology is suitable for use in various weather conditions, providing reliable delivery and data collection even in complex combat situations. Ukrainian developers are already collaborating with an American company to further integrate this solution into the Ukrainian army.

[41] Fedorov, https://t.me/zedigital/5012

Ukrainian robot dog, video screenshot[42]

The BRAVE1 cluster also facilitates the development of artificial intelligence technologies for autonomous data analysis and decision-making under limited operator control. Ukrainian developers are creating computer vision and machine learning algorithms that enable drones to automatically identify targets and determine optimal evasion routes in air defense conditions. Thanks to self-learning capabilities, UAVs can improve their effectiveness with each mission, collecting data and enhancing their ability to recognize threats. For example, algorithms used for object recognition allow UAVs to instantly analyze incoming images, identify objects that may pose a threat, and adjust their flight paths to avoid potential danger.

Among the achievements of Ukrainian companies working in this field are technologies such as stereo cameras for three-dimensional object analysis, which allow for more accurate assessment of distances to targets and evasion from attacks, and infrared cameras, enabling drones to operate effectively in low-light conditions or during nighttime operations. Additionally, neural networks are used to recognize objects with high precision and make optimal decisions based on data analyzed from sensors and cameras.

[42] Fedorov, https://t.me/zedigital/5012

Ukraine actively invests in the development of drones capable of operating independently of operators, carrying out operations even in remote and inaccessible areas. On the battlefield, this is crucial, as drones equipped with artificial intelligence can timely detect and neutralize threats, reducing risks to personnel. AI algorithms, such as predicting the trajectories of threatening objects and performing evasive maneuvers, enable drones to automatically evade attacks and provide operational data to command.

Ukrainian Armed Forces have already adopted the AI-powered drone, called *Saker Scout*[43]. This drone independently recognizes and records the coordinates of enemy vehicles (even camouflaged ones) and immediately transmits the information to the command post for decision-making.

AI-powered drone *Saker Scout* drone, source: Ministry of Defense of Ukraine

Along with air drones, AI and machine vision is being integrated into ground robotic platforms. There are automated turrets that are aimed at targets on a certain perimeter and operate in a given sector. In 2024, the companies in Ukraine also started developing interceptor drones that can stay on course on a moving target, such as an enemy drone, and attack it. Along with the integration of artificial intelligence into hardware, the trend of developing AI-based information systems continues. Artificial

[43] Ukrainian Forces Get an AI-Powered Saker Scout Drone, and Its Algorithms Can Solve an Important Problem, 04.09.2023, https://en.defence-ua.com/weapon_and_tech/ukrainian_forces_get_an_ai_powered_saker_scout_drone_and_its_algorithms_can_solve_an_important_problem-7842.html

intelligence helps to remotely detect mines, collect and analyze data from the battlefield[44].

Conclusions

The Russia-Ukraine war has highlighted the critical role of artificial intelligence in modern military systems. Both sides have integrated AI to enhance the effectiveness of unmanned aerial vehicles and other technologies, seeking tactical and operational superiority in an increasingly dynamic and technology-driven battlefield.

The evolution of artificial intelligence in Russia's military sphere represents a deliberate, long-term strategy to enhance operational capabilities and maintain strategic parity in modern warfare. Building on a foundation established during the Soviet era, Russia's AI research has progressed to incorporate cutting-edge technologies across diverse applications, from UAVs to robotic ground platforms.

Russia's focus on AI as a "force multiplier" reflects its intent to overcome manpower and technological disparities, particularly in high-risk combat environments. Institutional investments, such as the establishment of Technopolis ERA and the 46th Central Research Institute, underscore a systematic approach to advancing AI research and applications. Additionally, strategic frameworks, including the Ministry of Defence's AI strategy, highlight Russia's commitment to embedding AI into all aspects of military operations.

Notable achievements include the integration of advanced AI technologies in UAV systems, which enable autonomous target acquisition, tracking, and real-time decision-making. The adoption of high-performance components, such as the Rockchip RK3588 SoC with a neural processing unit, and the development of imaging systems with machine-learning algorithms have enhanced UAV mission efficiency and resilience in challenging environments. However, technical limitations, such as suboptimal autonomy and reliability in battlefield conditions, continue to hinder the full potential of these systems, necessitating human oversight in complex missions.

In the realm of robotic ground platforms, systems like the *Marker* and *Shturm* exemplify Russia's advancements in autonomy, machine vision, and adaptive combat capabilities. Modular and cost-effective designs, such as the T-72B3-based *Shturm* tanks, reflect a pragmatic approach to balancing operational autonomy with resource constraints. Despite these developments, many platforms remain unproven or fall short

[44] AI weapons of the Armed Forces of Ukraine and swarms of drones: what will the defense of the future look like and is war without people possible, 17.01.2025, https://internetua.com/shi-zbroya-zsu-ta-royi-droniv-yakoua-bude-oboronka-maibutnogo-ta-csi-mojliva-viina-bez-luadei?utm_source=ukrnet_news

of ambitious expectations, with reliability and maintenance challenges persisting under combat conditions.

Emerging innovations, such as AI-optimized drone charging systems utilizing power lines, further demonstrate Russia's focus on operational sustainability. These systems leverage non-contact energy harvesting methods and AI-driven power management to extend UAV endurance and operational range. While promising, the practical implementation of such systems faces significant hurdles, requiring extensive research, prototyping, and field trials.

Overall, the integration of artificial intelligence into Russia's military operations signifies a transformative shift in its strategic approach to modern warfare. AI technologies enhance decision-making, target recognition, and operational efficiency, providing the potential for sustained offensive operations and improved coordination between manned and unmanned units. However, the successful realization of these capabilities will depend on addressing technical limitations, ensuring system reliability, and maintaining consistent investment in innovation.

Ukraine’s advancements in AI-driven UAV technologies reflect a strategic commitment to modernizing military capabilities. Initiatives like the BRAVE1 cluster have accelerated innovation through collaboration between government and private sectors, ensuring a coordinated approach to addressing battlefield challenges.

AI serves as a force multiplier in Ukrainian UAVs, enabling autonomous target detection, threat avoidance, and real-time decision-making. Key innovations include drone swarms for coordinated operations, guided munitions for precision strikes, and robotic land systems for logistics and reconnaissance. Advanced AI algorithms and tools, such as computer vision and predictive modeling, enhance situational awareness and operational adaptability.

A focus on autonomous UAV operations reduces human risks while improving mission efficiency and effectiveness. While technical and operational challenges remain, continued investment in research, international collaboration, and field testing will be critical for sustaining progress.

Ukraine’s AI-powered UAVs provide a significant tactical advantage, improving situational awareness and operational flexibility. These advancements position Ukraine as a leader in next-generation military technologies, with the potential to shape the future of modern warfare.

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