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Characteristics of combat drones used in current military operations

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Abstract. In the current context of the Russian-Ukrainian conflict, it has been proven that the drone without human personnel on board (Unmanned Vehicle - UV), whether airborne, maritime or land, represents a formidable weapon of the combat forces. Depending on the basic characteristics, dimensions, load capacity, speed, range, flexibility, ease of operation and costs, these combat means present real advantages in achieving operational objectives, regardless of the category of forces to which they belong. The objective of this paper is the theoretical approach, with an applicative impact in the military operational sphere, resulting in the identification of important directions in the development of the combat capability of UV.
Keywords: unmanned aerial vehicle, unmanned surface vehicle, unmanned underwater vehicle, unmanned ground vehicle, first person view, combat drones

1. Introduction

In the past, tanks and airplanes influenced the outcome of armed conflicts. Later, nuclear warheads and intercontinental ballistic missiles shaped the doctrines of the great powers, preventing their use by belligerent states. The emergence of unmanned vehicles marked the beginning of a new era, that of remote control and command, and UVs became state-of-the-art equipment [1].

In the current geopolitical context, in which armed conflicts are increasingly based on technological superiority, UV is a determining factor in obtaining strategic advantages. The rapid development and evolution of this field requires military forces to invest heavily in autonomous systems and solutions integrated with artificial intelligence in order to remain competitive in armed conflicts.

Essentially, UVs perform the same functions, starting from providing information, surveillance, reconnaissance and ending with the neutralization of enemy equipment or human personnel.

The use of UV in armed conflicts proves to be very effective since, with low purchase prices (a few hundred dollars), expensive combat equipment (tanks, artillery pieces, radio-location stations, military equipment and weapons depots, etc.) worth millions of dollars can be neutralized.

UVs can be classified by operating mode, degree of autonomy, control mode, operational role, dimensions [1], [2], [3], [4].

According to the operating environment, UVs are divided into four categories, as seen in Table 1.

By size, UV can be: nano ($m < 0.25$ kg); micro (0.25 kg $< m < 2$ kg); small (2 kg $< m < 25$ kg); medium (25 kg $< m < 150$ kg); large ($m > 150$ kg).

By autonomy, UVs are: very short range ($A < 5$ km); short range (5 km $< A < 50$ km); short range (50 km $< A < 150$ km); medium range (150 km $< A < 640$ km); long range ($A > 640$ km).

Table 1. UV classification according to operating environment

Category	Type	Operating mode	Scope
Air (UAV)	Vertical Landing (VTOL)	Autonomous Semi-autonomous Remote controlled	surveillance, reconnaissance, transport, attack, mapping
	Horizontal Lading (HTOL)		
	Hybrid		
Sea (UMS)	Surface (USV)	Autonomous Semi-autonomous Remote controlled	surveillance, monitoring, anti-mine
	Underwater (UUV)	Autonomous (AUV) Remotely (ROV)	research, mine detection, offshore inspections
Land (UGV)	With wheels	Autonomous Semi-autonomous Remote controlled	research, defuse, transport, patrol
	With tracks		
	Robotic (EOD)		
Space (ASV)	Satellites	Autonomous Semi-autonomous Remote controlled	surveillance, inspection, research, exploration
	Planetary rovers		
	Orbital vehicles		

According to the control mode, UVs can be: with direct control, via radio waves (LOS); with control beyond the visual line (BVLOS); with satellite control; with complete autonomy (programmed mission).

According to their operational purpose, UVs can be:

- FPV, equipped with a video camera that transmits images in real time to the operator (on a monitor or special glasses);
- ISR, for surveillance and reconnaissance;
- fight / attack;
- logistics and transportation;
- search and rescue;
- industrial monitoring;
- scientific research;
- detection and neutralization.

2. Peculiarities of military UAVs

2.1 General considerations

An UAV used for military purposes is a military aircraft, autonomously guided and/or remotely controlled, equipped with sensors, target designators, offensive ammunition or electronic transmitters, with the role of interfering with enemy targets and/or destroying them [5], [6].

The UAV, generically called a drone, is a self-contained system that includes equipment necessary for operation and control and consists of three essential elements [5]: the vehicle itself (1); the ground control-monitoring system (2); the two-way connection between the UAV and the ground system (3).

Due to the conduct of military operations in various armed conflicts around the world (e.g. Vietnam, Iraq, Afghanistan, Ukraine, etc.), military drones have been developed, improved and adapted, in particular, for the purpose of gathering information, surveillance and aerial reconnaissance.

The current state of UAVs is characterized by rapid evolution driven, in particular, by advances in AI, sensors, autonomy, communications, and integration into civil and military operations. Thus, AI has the potential to produce a force multiplier effect by optimizing human capabilities and adding superior capabilities to low-cost military systems. For example, a low-cost drone is harmless against an F-35 fighter system, but a swarm of drones can neutralize or destroy such high-tech systems [1].

Used for military purposes, UAVs must perform two basic functions, flight and navigation. For flight, the drone needs a power source and devices that provide lift. For navigation, the drone is equipped with controllers that allow the operator to use remote controls for launch, navigation and landing.

The operator can communicate with the drone directly, via radio waves (high reliability over short and medium distances), via Wi-Fi (control from a phone or tablet, with internet access), via 4G/5G cellular networks (practically without distance limitation, being used in BVLOS drones), via satellite (offers global coverage, being used in military and offshore applications), autonomously (by pre-programming, the operator having partial control over the drone) and hybrid (uses combinations of communications, used in professional drones).

Most aerial drones are equipped with video cameras that transmit real-time images to the operator's command and control center. Some UAVs can also fly automatically on a predetermined path using obstacle detection/collision avoidance sensors and GPS navigation. A common implementation of this function is the return-to-home function [1], [8].

2.2 Representative types of UCAV

Combat aerial drones are used for reconnaissance, surveillance, electronic warfare, precision explosive strikes or loitering missions.

According to NATO, unmanned combat air systems are grouped into three basic classes, as shown in Table 2.

Table 2. NATO UAS Classification [9]

Class	Category	Normal Employment	Normal Operating Altitude	Normal Mission Radius	Primary Supported Commander	Example Platform
Class III (> 600 kg)	Strike/ Combat	Strategic/ National	Up to 65,000 ft	Unlimited (BLOS)	Theatre	Reaper
	HALE	Strategic/ National	Up to 65,000 ft	Unlimited (BLOS)	Theatre	Global Hawk
	MALE	Operational/ Theatre	Up to 45,000 ft MSL	Unlimited (BLOS)	JTF	Heron
Class II (150 kg – 600 kg)	Tactical	Tactical Formation	Up to 18,000 ft AGL	200 km (LOS)	Brigade	Hermes 450
Class I (< 150 kg)	Small (> 15 kg)	Tactical Unit	Up to 5,000 ft AGL	50 km (LOS)	Battalion, Regiment	Scan Eagle
	Mini (< 15 kg)	Tactical Sub-unit (manual or hand lunch)	Up to 3,000 ft AGL	Up to 25 km (LOS)	Company, Platoon, Squad	Skylark
	Micro (< 66 J)	Tactical Sub-unit (manual or hand lunch)	Up to 200 ft AGL	Up to 5 km (LOS)	Platoon, Squad	Black Widow

HALE – High Altitude Long Endurance; MALE – Medium Altitude Long Endurance; MSL – Mean Sea Level; AGL – Above Ground Level; JTF – Joint Task Force

The MQ-9 Reaper, considered the most advanced in the world, is a remotely piloted vehicle operated by the USAF and allows remote operation by a specific crew consisting of two operators, the pilot and the sensor and weapons guidance operator (Figure 1). It is a medium altitude tactical drone, armed with Helfire missiles and guided bombs, has a wingspan of approximately 20 m and provides precision strikes.

Figure 1. UAV MQ-9 Reaper (USA) [5]

By using the MQ-9 Reaper in the area of joint multinational operations, it is possible to achieve: reconnaissance in enemy territory; close air support; launching missile strikes on enemy positions; destroying tanks, armored vehicles, shelters, fuel depots; causing significant damage to enemy warships; combat search and rescue of pilots from downed aircraft; monitoring convoys and offensive operations; clearing routes; identifying targets; controlling high-precision weapon systems [10].

The RQ-4 Global Hawk, operated by the USAF, is one of the most advanced unmanned military aerial platforms in the world, with a long range and is designed for surveillance, reconnaissance and intelligence gathering (Figure 2). The RQ-4 Global Hawk is a high altitude strategic drone, is unarmed, has a wingspan close to that of an airliner (~ 40 m) and covers very large areas, regional or continental.

Figure 2. UAV RQ-4 Global Hawk (USA) [11]

The Heron model, operated by the IDF, is a MALE military reconnaissance, monitoring and intelligence gathering drone, has a wingspan of approximately 16.5 m and is one of the most widely used UAV platforms for strategic and operational surveillance, especially in the maritime domain (Figure 3).

The Hermes 450, operated by the IDF, is a MALE tactical military surveillance drone, used primarily for reconnaissance, monitoring, and operational support (Figure 4). With a wingspan of approximately 10.5 m, it is significantly smaller than the Heron or Global Hawk, being optimized for tactical missions and low operating costs.

Figure 3. UAV Heron (Israel) [12]

Figure 4. UAV Hermes 450 (Israel) [13]

Next, the aerial drones used in the Russian-Ukrainian military conflict are mentioned. Thus, Ukraine uses drones for surveillance, reconnaissance and attack, as seen in Table 3.

Among the aerial drones mentioned in the table above, the Turkish-made Bayraktar TB2 (Figure 5) is a medium-altitude, long-endurance drone designed for surveillance and precision strikes. With a wingspan of 12 m, the drone falls into NATO Class II and has proven to be very effective in targeting armored vehicles, artillery, and supply lines.

Table 3. Aerial drones used by Ukraine in the Russian-Ukrainian conflict [14]

Drone type	Country of origin	Functions
Bayraktar TB2	Turkey	Military ISR, targeting, strike missions
Phoenix Ghost	USA	Military ammunition, surveillance
WB Group Warmate	Poland	Military ISR, Loitering
RAM II	Ukraine	Military surveillance
Spectator-M1	Ukraine	Military reconnaissance, search, rescue
UJ-22 Airborne	Ukraine	Military intelligence, search, rescue
Punisher	Ukraine	Hitting military targets
Leleka-100 (stork)	Ukraine	Military and commercial reconnaissance, surveillance, target acquisition
Athlon Avia A1-CM Furia	Ukraine	Military reconnaissance, surveillance
R18	Ukraine	Military surveillance, search, cargo delivery
Autel Evo II	China	Commercial photography, videography, inspection, mapping
DJI Mavic Series	China	Commercial photography, videography, search, rescue
Golden Eagle	USA	Commercial surveillance
Skydio X2	USA	Commercial search, inspection, salvage, mapping
PD-1 (People's Drone)	Ukraine	Military reconnaissance, monitoring
WB FlyEye	Poland	Unknown military
Quantum System Vector	Germany	Commercial ISR
RQ-20 Puma	USA	Military ISR
Tupolev Tu-143 Reis	USSR	Military reconnaissance, surveillance
Mini-Bayraktar	Turkey	Military reconnaissance, surveillance
Switchblade 300	SUA	Military reconnaissance, surveillance, target acquisition
Switchblade 600	SUA	Military ammunition

Figure 5. UAV Bayraktar TB2 (Turkey) [15]

In turn, the Russian Federation uses a wide range of aerial drones in military operations in Ukraine, for surveillance, reconnaissance, electronic warfare and direct attacks, as shown in Table 4.

Among the aerial drones mentioned in the table above, the Orlan-10 (Figure 6) stands out, which is part of an integrated complex equipped with launch and recovery systems, a ground control segment and interchangeable payloads. With a wingspan of 3.1 m, the Orlan-10 is launched using a collapsible catapult and is recovered using an attached parachute. The drone is equipped with electronic warfare capabilities, differentiates between friendly and enemy information transmission means, has the possibility of mounting interference transmitters and can establish areas for cellular jamming.

Also, the Iranian Shahed-132 model, used extensively by Russian forces under the name Geran-2, is a Kamikaze drone, designed to dive into the target with an explosive charge, making it a powerful weapon for attacking fixed positions, infrastructure and enemy force concentrations.

Table 4. Aerial drones used by the Russian Federation in the Russian-Ukrainian conflict [14]

Drone type	Country of origin	Functions
Zala	Russia	Military ISR, Kamikaze
Shahed136 (Geran-2)	Iran	Military kamikaze
Mohajer 6	Iran	Military ISR, Air-to-ground attack
Orlan-10	Russia	Military ISR, jamming
Orion	Russia	Military ISR, TA, battle damage assessment
KBLA-IVT	Russia	Military air target, reconnaissance
Forpost	Russia	Military ISR
Zala Aero	Russia	Military ISR
Granat-4	Russia	Military ISR
Orlan-30	Russia	Military reconnaissance, surveillance
E95 (E95M)	Russia	Military air target, reconnaissance
Zastava	Russia / Israel	Military reconnaissance
Tachyon	Russia	Military reconnaissance
Eleron-3	Russia	Military ISR, Kamikaze

While Ukraine is researching the effects of integrating AI as quickly as possible into the operation of combat drones, Russian specialists from CCBR have managed to create the Joker FPV model (Figure 7), an invisible UAV, resistant to jamming specific to electronic warfare in standby (hibernation) mode, which is activated after a while after launch, to be quickly activated later in order to fulfill the mission.

Figure 6. UAV Orlan-10 (Russia) [16]

Figure 7. UAV Joker FPV (Russia) [5]

2.3 Trends and prospects of the use of combat aerial drones

Given the importance of drones in future military operations, several NATO countries have equipped their armies with small drones for individual use.

Small drones, generically called "pocket drones" (Figure 8), have, in the two-drone configuration, some particularly important characteristics, such as [17]:

- they are shaped like a mini-helicopter, up to 20 cm long, they are efficient and silent;
- 3 cameras can be installed on a drone in the system, in a frontal, lower and 45° inclined position;
- the operating time of each drone is a maximum of 25 minutes, and the charging time of a battery is 25 minutes;
- The drones are equipped with IR video cameras and sensors necessary for transmitting digital data at a distance of approximately 1.6 km;
- the system allows for field reconnaissance up to distances of 20-25 km.

Training a military operator to manually operate such a system takes no more than 30 minutes. Before launch, the operator must digitally enter the coordinates for the pocket drone's flight.

Figure 8. Pocket drone [18]

Figure 9. Aerial drone swarms [19]

The Russian-Ukrainian military conflict also allowed for the early deployment of complex missions using multiple drones simultaneously. In the future, with the help of AI, drone swarm attacks will be possible (Figure 9), meaning that multiple UAVs will be able to network, coordinate, and cooperate in the air to achieve attack objectives on targets [5].

Last but not least, China recently revealed its intention to build, within 20-30 years, a space aircraft carrier, called Luanniao (Figure 10), which can deploy unmanned fighter jets capable of launching missiles from the edge of the Earth's atmosphere [20]. With a wingspan of 684 m and a fuselage length of 242 m, the triangular Luanniao aircraft carrier will have a takeoff weight of 120,000 tons, significantly greater than any current aircraft.

Figure 10. Luanniao space aircraft carrier (China) [20]

Luanniao, part of the Nantianmen project developed by AICC 10 years ago, will be able to carry 88 Xuan Nu unmanned fighter jets, highly maneuverable stealth aircraft capable of launching hypersonic missiles.

3. Peculiarities of military UMS

3.1 General considerations

A maritime drone is an unmanned aerial vehicle or vessel that operates autonomously or remotely on the surface of the water or underwater. The terminology used for maritime drones may differ depending on the mode and environment of operation (surface or submerged).

In general, maritime drones are classified by operating environment and size. Thus, NAVSEA divides USVs and UUVs into four classes, as shown in Figures 11 and 12.

To cover the full range of maritime drones, NATO has adopted the term MUS (Maritime Unmanned Systems), while the EDA uses the term UMS (Unmanned Maritime Systems). However, these terms also refer to air, land or space systems involved in maritime operations [22].

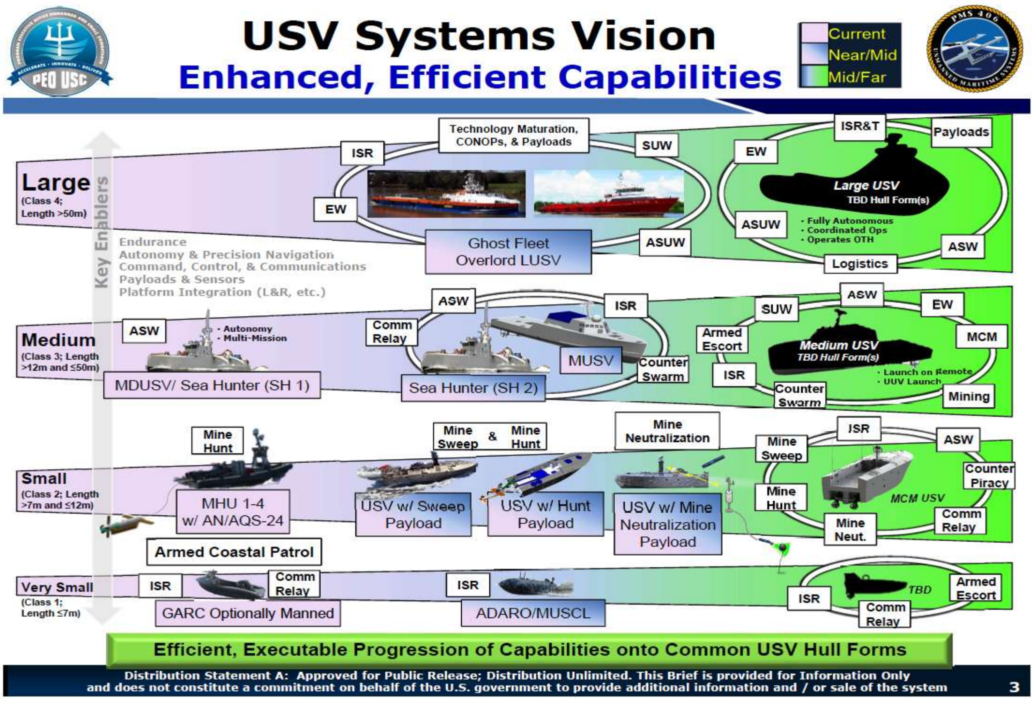

Figure 11. USV classification according to NAVSEA [21]

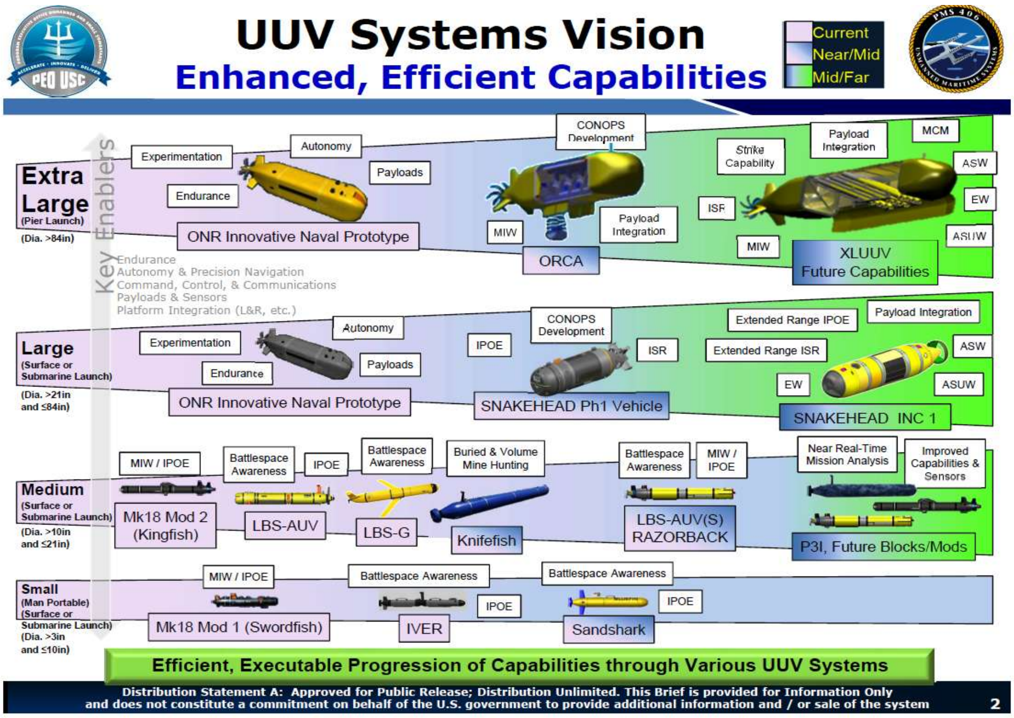

Figure 12. UUV classification according to NAVSEA [21]

3.2 Representative types of USV

The first remotely controlled military USVs with explosives on board were tested in World War I, but the results were not promising, so their development stagnated. USV development resumed after 2000, so that in 2005 Israel launched the Protector drone, a motorboat equipped with a light machine gun, in the Peach Gulf area (Figure 13).

Figure 13. USV Protector (Israel) [22]

Figure 14. USV Sea Hunt (USA) [23]

In 2016, the DARPA agency, responsible for developing emerging military technologies, proposed the Sea Hunt trimaran, a fully autonomous Class III anti-submarine USV prototype (Figure 14). Originally intended for surveillance, the model allows for adaptation to additional tasks such as intelligence gathering or countering sea mines.

In the context of the recent escalation of military conflicts in the world, the development of USV accelerated after 2020. Thus, in 2020 Turkey develops the prototype armed USV ULAQ, and in 2022 launches MARLIN, the first autonomous USV used for electronic warfare (Figure 15). The MARLIN model is capable of carrying and launching new generation surface-to-surface guided missiles, has low cost, medium range and high firepower, being able to attack targets both on land and at sea.

Figure 15. USV MERLIN (Turkey) [24]

Since the beginning of the large-scale attack on Ukraine by the Russian Federation, the warring parties have developed and perfected kamikaze maritime drones.

Ukraine, due to the fact that its fleet was destroyed at the very beginning of the Russian invasion, was forced to find alternative solutions for maritime counter-offensive. Thus, Ukraine is currently building the fourth generation of autonomous kamikaze-type maritime drones (Figure 16).

Generation 1 (2022), which appeared shortly after the invasion, consisted of improvised prototypes based on modified ski jets, loaded with explosives and guided remotely.

Generation 2 (2023), considered a stage of professionalization, brings to the Black Sea theater of military operations the Magura stealth maritime drone and Mamai, a fast maritime drone with the ability to hit targets at long distances.

Generation 3 (2024), considered an advanced stage, is being developed by the SBU, it is notable for the Sea Baby maritime drone, with a load capacity of up to 2000 kg of explosives and an autonomy of approximately 800 Mm. The model is capable of operating in difficult hydro-meteorological conditions and destroying large marine structures.

Generation 4 (2025), still being adapted and refined, is distinguished by the use of AI. Maritime drones of this generation are capable of launching small aerial drones (FPV), which are immune to electronic jamming thanks to fiber optic control and can attack extremely distant targets.

Figure 16. Kamikaze maritime surface drones (Ukraine) [25]

Figure 17. Kamikaze surface maritime drones (Russia) [25]

The Russian Federation has developed less of its own maritime drones (Figure 17) as it continues to rely on its own fleet of traditional warships. The first kamikaze maritime drone, named Oduvanchik

(Dandelion), is being developed by the Russian Federation in 2023 and has capabilities similar to those of the Ukrainian Sea Baby.

3.3 Representative types of UUVs

Military underwater drones are autonomous or remotely operated systems used by naval forces for complex underwater missions such as: detecting and neutralizing sea mines; surveillance and reconnaissance; protecting offshore infrastructure; mapping the seabed; damaging/destroying enemy submarines; special operations and sabotage.

The REMUS series of maritime drones consists of autonomous underwater vehicles designed by OSL, initially manufactured by WHOI, and later by Hydroid Inc. and is intended for mine clearance, seabed mapping, port infrastructure defense, and search/recovery (Figure 18). The REMUS series of maritime drones is designed to have low cost, common software, and the ability to be operated using a single laptop.

Figure 18. UUV REMUS 600 (USA) [26]

A remarkable technological innovation occurred in 2016, when the Boeing company launched Echo Voyager, capable of operating for months thanks to a hybrid rechargeable power system and a modular payload compartment, and capable of being launched and recovered without a support ship (Figure 19).

Considered one of the most advanced UUVs in the world, the Orca XLUUV (Figure 20) is an autonomous, diesel-electric submarine developed by Boeing for the United States Navy. Designed for long-duration unmanned missions, the model extends its underwater range for surveillance, mine clearance, and payload delivery.

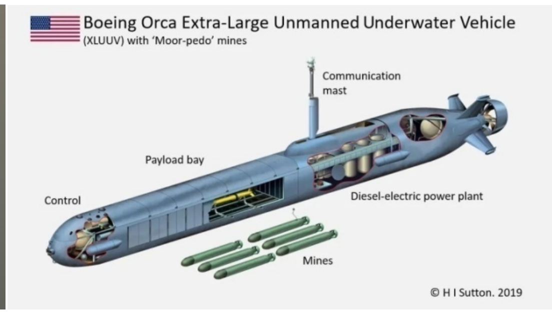

Figure 19. UUV Echo Voyager (USA) [27]

Figure 20. UUV XLUUV (USA) [28]

Regarding remote-controlled underwater marine drones, Pluto Plus, developed by the Gaymarine company, allows the safe identification and neutralization of sea mines, without endangering the teams of divers trained for neutralization/detonation (Figure 21).

In the conflict between the Russian Federation and Ukraine, the use of underwater maritime drones is reduced due to limited underwater communications, complex navigation, and high production costs.

In 2023, Ukraine will launch its first underwater maritime attack drone, called Marichka (Figure 22), with the role of destroying ships, coastal infrastructure and submarines. Not yet used operationally, the model can be adapted for the transport of military/civilian utilities or for reconnaissance.

Figure 21. UUV Pluto Plus (Italy) [29]

Figure 22. UUV Marichka (Ukraine) [30]

In December 2025, Ukraine uses the Sub Sea Baby underwater drone, capable of destroying naval and port targets, to damage a Russian Klio-class submarine docked at the Novorossiysk naval base.

The Russian Federation is still in the strategic development phase of UUVs, notable for the Poseidon model (2018), which is nuclear-powered and capable of carrying both conventional and nuclear warheads.

3.4 Trends and prospects for the use of maritime combat drones

The trends and prospects of surface maritime drones are strongly influenced by the current armed conflicts in the world, especially in the Black Sea, and by the accelerated technological advances of recent times.

One of the directions of work concerns the implementation of multi-domain drone systems, which consists in coordinating and controlling several types of drones. Ukraine continues to innovate in asymmetric warfare strategies so that, in 2025, the developer ToviTechNet launches the Ursula micro-aircraft carrier, 1 m long, capable of carrying an FPV drone (Figure 23). The Ursula model, designed for transporting and launching FPV attack and reconnaissance drones, can navigate in difficult-to-reach areas, such as rivers or swampy areas.

Figure 23. USV Ursula (Ukraine) [33]

Figure 24. UMV Triton (USA) [33]

In the USA, the company OceanAero has developed the hybrid model Triton, one of the most advanced in the world, capable of operating both on the surface and submerged (Figure 24). The model is designed for surveillance, reconnaissance, intelligence gathering, mine neutralization and anti-submarine operations. Triton has a foldable sail and is completely covered with solar panels, which gives it an autonomy on the surface of up to 3 months, and by folding the sail, it can operate underwater for 5 days.

In turn, underwater maritime drones, although they were developed more for civilian purposes, in the current context of armed conflicts in the world, underwater space is becoming strategic from a military point of view.

In 2022, China will launch its first unmanned drone carrier, an 88-meter-long USV that can carry up to 50 small drones that can be deployed by air or sea, on the surface or submerged. With the help of

AI, the network of small UUVs can conduct naval blockades, naval reconnaissance activities and naval mine countermeasures operations.

Boya Gongdao Robot Technology in Beijing has successfully built the Robo-Shark, a 2.2 m submersible capable of underwater surveillance and anti-submarine operations (Figure 25). The model has a speed of 10 Nd and a structure made of three joints that mimic the movement of a fish, thus greatly reducing the acoustic footprint of the propulsion system.

Figure 25. UUV Robo-Shark (China) [31]

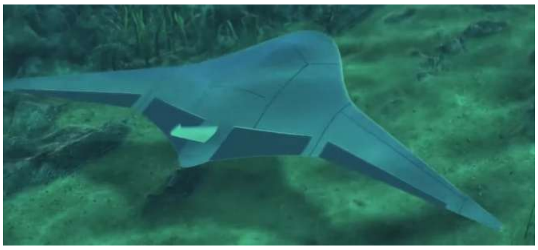

Figure 26. UUV Manta Ray (USA) [32]

In 2024, the American company Northrop Grumman launches the Manta Ray submersible maritime drone based on the biology and movement of the manta ray (Figure 26). The model can operate autonomously for long periods of time and is used in logistics operations.

4. Peculiarities of military UGVs

An UGV is a robotic device that operates on land, without human personnel on board, is remotely controlled or semi-autonomously and is used to perform dangerous, routine or dirty tasks.

Used for civil, logistical or military purposes, through the functions of surveillance, reconnaissance, research and transport of materials, UGVs act as terrestrial counterparts of UAVs. For this reason, the two types of UVs frequently operate together.

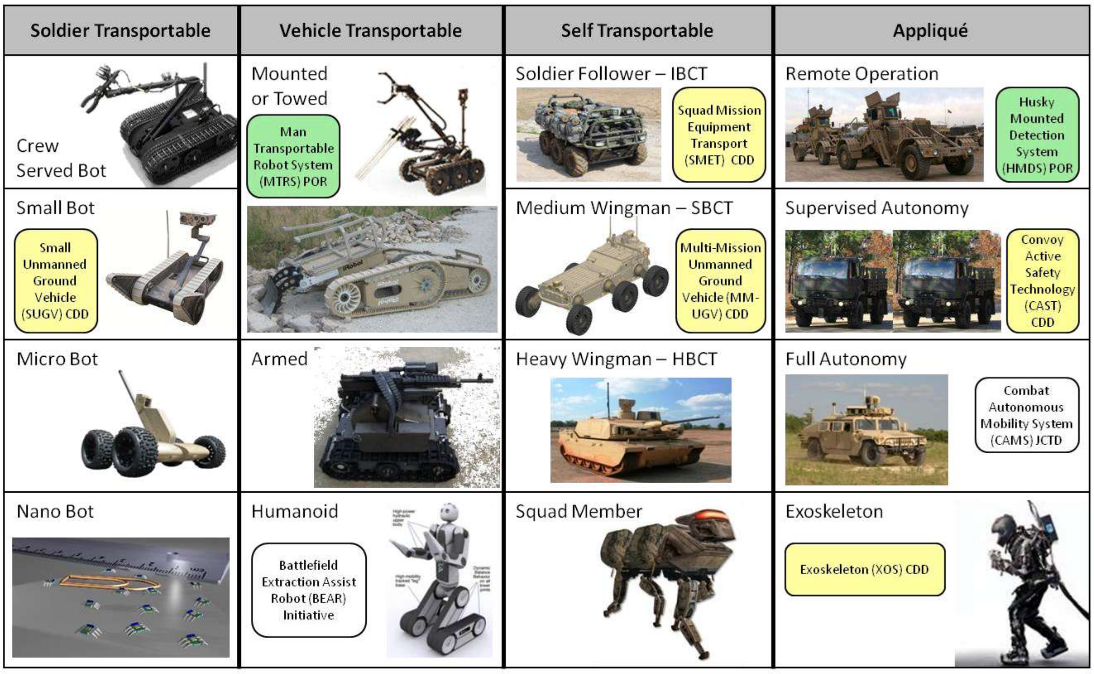

Figure 27. DoD Army UGV Campaign Plan [34]

There is no universal classification of UGVs, as they can be differentiated by dimensional characteristics, weight, mode of locomotion and degree of armament. From the point of view of locomotion, some observations can be made. Wheeled land drones, although energy efficient, are not suitable for off-road terrain. Tracked land drones are effective on off-road terrain but consume a lot of energy, are noisy and have a low speed of travel. Robotic land drones are equipped with legs and are suitable for any type of rough terrain but are slow, consume a lot of energy and are mechanically complicated, due to the need to maintain balance and stability.

In the USA, TRADOC, responsible for recruiting, training, and educating soldiers, as well as developing military doctrine, organizations, and equipment, has adopted a single overall strategy through the ICD program, which aims to develop modular, interoperable, coordinated, and collaborative unmanned resources across combat functions (2010-2035). The first effort was the development and use of UGVs, as shown in Figure 27.

In recent decades, UAV technology has evolved rapidly and had a major impact in several areas, including operational military logistics. Logistic drones have demonstrated that they present clear advantages (speed of delivery, transport efficiency, risk reduction, adaptability to different combat scenarios, reduction of costs required for logistical support) in terms of transporting resources (ammunition, food, medicine, essential equipment) to combat and support structures.

In the war in Ukraine, Ukrainian UGVs have been actively used on the front line since 2023 to perform essential functions such as transporting weapons and explosives, remotely destroying mines, mining operations, establishing blockade zones, or evacuating wounded soldiers (Figure 28).

Figure 28. Multifunctional robot Vepr (KNLR-E) (Ukraine) [35]

In turn, the Russian Federation has created the URAN family of robotic devices for the ground forces (Figure 29). Thus, the URAN-6 is used for mine clearance, the URAN-9 is a multi-role device used for reconnaissance, attack and counter-terrorism, and the URAN-14 is designed for firefighting in hazardous and hard-to-reach environments.

Figure 29. Autonomous systems from the URAN family (Russia) [36]

The trends and prospects of UGV use in military operations are influenced by the evolution of AI, the development of sensors and the need for automation in hazardous environments. Challenges in the future evolution of UGVs relate to the development of drone swarms, miniaturization, building cheap drones, integration with other UV categories or the development of fully autonomous ground drones.

To minimize the loss of logistical resources during the transport of military equipment, NATO is looking for solutions regarding the organization and safe movement of fully autonomous land vehicles, individually or in columns, supported by aerial drones (Figure 30).

In military search and rescue operations, the use of small drones in narrow spaces is not effective, which is why specialists are trying to robotize insects and turn them into cyborgs by attaching electronic chips, mini-video cameras and sensors. Other specialists are focusing on entomology, trying to take control of insects by transmitting electronic signals to their antennae (Figure 31). Thus, by attaching different types of sensors, cyborg insects are able to detect movement, organic heat or carbon dioxide emissions. Cyborg insects are also effective for detecting chemical or biological threats.

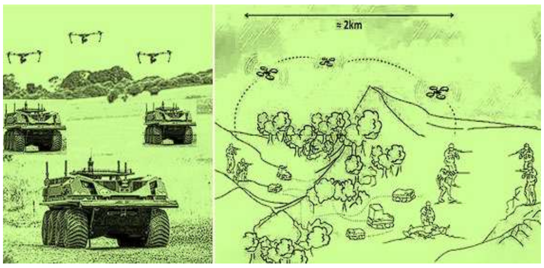

Figure 30. AtlasPro system (USA) [35]

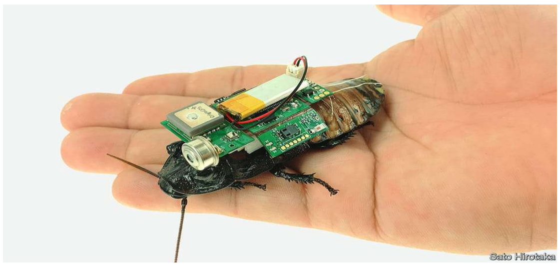

Figure 30. Cyber-beetle (China) [37]

5. Conclusion

Analyzing the efficiency and effectiveness of the use of UV in recent armed conflicts, it can be concluded that unmanned drones, regardless of the category they belong to, are of major importance in the processes of preparing and conducting military operations as they facilitate the observation of the movement of enemy forces, allow the reduction of the number of soldiers in the operational theater, the precise hitting of targets or the reduction of human casualties. Moreover, it has been proven that the use of cheap UVs, worth a few hundred dollars, can lead to the destruction of advanced combat equipment, worth millions of dollars.

However, it should not be overlooked that, in parallel with the accelerated growth of UV construction, massive investments are needed in anti-drone systems and the development of the necessary technologies for combating and neutralizing them.

In the future, the use of AI for coordination, the development of the drone swarm concept, the miniaturization and integration of all categories of drones into a single command, can greatly expand their capabilities and operational possibilities.

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