

UNMANNED AERIAL VEHICLES AS AN ELEMENT OF AIR POWER

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Abstract: The growing use of drones for aerial reconnaissance, targeted strikes on enemy objectives, and to a lesser extent for air transport, has led to changes in the execution of military operations during armed conflicts in the 21st century. Drones are increasingly taking on the role of reconnaissance and strike aviation in air operations conducted by air forces. The authors of the paper focus on specific aspects of drone usage to determine whether all drones can be considered part of air power. They examine their differences through conceptual definitions and classifications, and compare their combat operations with those of traditional aviation. This comparison aims to assess whether all types of drones conduct aerial operations and thus contribute to air power. The paper does not provide specific historical examples of warfare or drone use but relies on established facts from open sources, which are cited in the literature at the end of the paper.

Key words: Drone, Remotely Piloted Aircraft (RPA), Air Power, Aerial Action, Anti-Aircraft Action, Electronic Warfare (EW), Counter-Electronic Warfare (Counter-EW).

1. INTRODUCTION

In modern warfare, there is an increasing tendency to reduce or completely eliminate the direct involvement of humans in combat operations on the battlefield through the development of remotely controlled weapon systems. The aim is to preserve the lives of military professionals, whose training is expensive and complex, and to eliminate human emotions, which, under the influence of a stressful environment, represent an unpredictable and deceptive factor in combat. Additionally, for public opinion in a society, sending machines to war and the loss of these machines, rather than humans, are more easily accepted, as the loss of machines does not have the same social and political effects as the loss and suffering of human lives. One of the achievements of modern technology that aligns with these objectives is drones. They are now used for various operations in the airspace, which were previously exclusively linked to aviation. They are used for aerial reconnaissance, for fire strikes on targets on land, water surfaces, and in the airspace, for electronic and counter-electronic operations, to establish communication for command functions during operations, for precise fire control during fire support by artillery-rocket units and/or aviation, and so on.

If we define air power as follows: „Air power encompasses the entire use of military air forces as a means of national power and security interests“ [1] then drones, as part of air forces, can be considered an element of air power.

However, if drones are viewed in the broadest sense of their categorization and classification, a great diversity in their purpose and capabilities for performing various flight tasks for military needs will be noticed. This diversity arises from their different characteristics and capabilities, which in turn leads to different methods of organizing and executing flight tasks.

2. CONCEPT AND CLASSIFICATION OF DRONES / REMOTELY PILOTED AIRCRAFT

Drones, unmanned aerial vehicles (UAVs), or remotely piloted aircraft (RPAs) are classified into a broad family of unmanned aircraft and are used as part of a system that includes a crew for control, as well as communication and remote control equipment for managing all aircraft functions. Drone flight does not always need to be under the control of a pilot-operator; it may also involve a certain degree of autonomy in executing specific flight phases. However, despite the technical capabilities that allow for such use, the current aviation regulations in the Republic of Serbia do not permit drone flights in airspace without supervision and the ability for the pilot-operator to take full control at any time via flight commands.

Due to their classification in the broad family of unmanned aircraft, various terms and interpretations can cause confusion, not only within the country but also internationally. In the

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Republic of Serbia, there are separate regulations for military [2] and civilian [3] unmanned aircraft, but the categories are similarly defined (with slight variation in categorization based on operational weight/maximum takeoff weight).

In English terminology, the terms "drone" and UAV (Unmanned Aerial Vehicle) are used, which generally refer to more complex unmanned systems. The aircraft itself is part of the UAS (Unmanned Aircraft System), a system that includes the operator on the ground and communication and control equipment. Russian terminology also views this category of aircraft as an unmanned platform, referred to as „БПЛА - Беспилотный летательный аппарат” [4].

Considering the complete system, including the aircraft and the pilot-operator, all the above terms will be used interchangeably for the purposes of this work, as they all represent a type of aircraft that requires modern and sophisticated equipment, as well as specially trained personnel for handling and operation.

„A military remotely piloted aircraft (RPA) is a military aircraft without a crew on board, powered by an engine, and controlled by an operator/pilot from the ground or executing a flight pre-programmed by the operator.” [2]

„A remotely piloted aircraft is an aircraft that does not carry a human operator, uses aerodynamic forces to generate lift, can fly autonomously or be remotely controlled, can be used for single or multiple missions, and can carry either lethal or non-lethal payloads.” [5]

Missiles and projectiles are not considered drones, but fall under the category of ammunition. Sports unmanned aircraft, with remote control, are defined and categorized by a special regulation, and are referred to as „Unmanned Aircraft.” [3]

Besides military and civilian drones, there is no unified global classification for them. Each country that produces and uses drones has its own categorization, but the criteria are generally similar or the same. Some of the most commonly applied criteria for classifying drones are based on weight or construction, which significantly reduces the diversity in their categorization at the global level.

- Classification based on weight:
 1. MICRO: less than 2 kilograms,
 2. MINI: from 2 kg to 20 kg,
 3. SMALL: from 20 kg to 150 kg,
 4. LARGE: over 150 kg. [6]
- Classification based on construction platform:
 1. Fixed-wing,
 2. Multicopter,
 3. Single rotor. [6]

Military unmanned aerial vehicles are most commonly classified by their speed, range, weight, and purpose based on specific tactical-technical (TT) characteristics of both the drone and the equipment that provides its special purpose.

For this paper, the classification of drones made by NATO can be adopted, which divides them into three categories based on weight: **mini** (small or micro), **tactical**, and **strategic**.

- **CLASS I (<150 kg) – Mini** (small or micro): There are different types of drones in Class I used for many informational, telecommunications tasks, as well as for command support tasks. They can be defined as any unmanned aerial vehicle flying at altitudes between 150 and 300 meters, with endurance of around two hours. Currently, rotor-based models dominate this category. [4]
- The most common civilian use is in commercial applications for recording various events, phenomena, objects, etc. In the military, they are used, in addition to command support, for

small-area reconnaissance and surveillance. However, due to their limited TT characteristics (sensitivity to meteorological phenomena, short range, low flight autonomy, and modest payload capacity), they cannot be compared to air operations – aerial reconnaissance from airspace, operational, and strategic-level reconnaissance; instead, they are primarily used for reconnaissance and surveillance to collect intelligence at the tactical level.

- **CLASS II (150–600 kg) – Tactical:** Tactical unmanned aerial vehicles include heavier platforms that fly at higher altitudes (from 3000 to 8000 meters). Unlike micro and mini unmanned aerial vehicles, which were previously mostly used for civilian/commercial applications, tactical UAVs are primarily used for military purposes. This group is often divided into six subcategories: *short-range*, *medium-range*, *long-range*, *high-autonomy*, and particularly popular long-range aircraft flying at medium altitudes (Medium Altitude Long Range - **MALE**). Long-range UAVs employ advanced technology to complete assigned tasks, usually including satellite links or other platforms as relays to overcome communication issues caused by the curvature of the earth between the ground station and the aircraft. A typical representative of the MALE subcategory is the MQ-1 *Predator*, which appeared in the mid-1990s. Initially an intelligence-gathering platform, it later evolved into an armed aircraft capable of carrying precision-guided missiles. Following the Predator philosophy, many countries have developed similar systems, leading to the appearance of numerous combat UAVs, the most famous being the American MQ-1 *Predator*, MQ-9 *Reaper*, MQ-1C *Gray Eagle*, China's *Wing Loong* and *Hongdu GJ-11*, Turkey's *Anka* and *Bayraktar TB2*, Iran's *Mohajer-6*, and Russia's *Orion*. [4]
- This category of RPAs is the most widely used in military applications, primarily due to their characteristics: long range, flight autonomy, complex but precise control, and good payload capacity (for reconnaissance, electro-optical equipment, and various weapons systems). Moreover, the ability to fly at altitudes above the range of ground-based air defense systems, small radar cross-section, low flight speed, and the ability to conduct precise operations allow these RPAs to avoid detection by ground-based air defense systems, especially older generations. Since attacking air defense systems and positions is highly sensitive and risky for manned aircraft crews, the use of this category of RPAs is highly valuable in military operations.
- **CLASS III (>600 kg) – Strategic:** Strategic unmanned aerial vehicles operate at higher altitudes and are characterized by greater range and endurance. However, there are two opposite construction approaches: on one hand, the RQ-4 *Global Hawk* with a turbofan engine and weights similar to jet fighter bombers, and on the other hand, solar-powered research aircraft like the *Pathfinder*, *Zephyr Electra*, *Lavochkin La-252*, and *PHASA-35*, which can stay in the air for months. [4]
- Although they perform their missions from airspace, similar to traditional aircraft (planes and helicopters), considering all the construction and aerodynamic specifics, as well as the fact that there is never a crew onboard, drones/RPAs/BL are distinguished from them primarily by being complex systems composed of six elements: **human factor, takeoff and landing, payload, control and management segment, aircraft, and communication/data link**. [4]
- **The human factor** is still the most important element of the system. Regardless of the level of automation, a human is always present to manage or control the tasks executed by the RPA, but the crew operates from a ground station, which is part of the control and management system for both the RPA and its weapons.
- **Takeoff and landing** are determined by the aerodynamic and construction characteristics of drones. Fixed-wing drones typically have additional equipment and more complex procedures for safe takeoff and landing. Large UAV systems require suitable runways and personnel for operation, along with ground aggregates, tow trucks, trucks, and other equipment. Smaller drones can be manually launched, while landing is done with a parachute. Most drones use a ramp system with a catapult for takeoff to achieve speed and necessary lift within a short distance. For landing, they may use a net or hook to catch a cable stretched across the runway.
- Rotary-wing drones have an advantage in this application as they do not require special equipment, and typically no specially designed infrastructure for takeoff and landing. Takeoff

and landing are performed via vertical maneuvers in small areas, sometimes even from the operator's hand. This is why they are often used when quick reaction times and takeoff are required.

- **The payload** may consist of reconnaissance, observation, communication equipment, various guidance sensors, or even different types of weapons and other cargo, showcasing all three forms of aerial operations (aerial firepower, reconnaissance from airspace, and, to a lesser extent, air transport).
- For reconnaissance and surveillance tasks, the payload comes in various sensor types. Predominantly used sensors are electro-optical cameras, infrared cameras, synthetic aperture radar, as well as laser rangefinders and illuminators, which are usually fixed to the aircraft structure. Depending on the category of the aircraft, it will determine the payload capacity and, consequently, the level of reconnaissance from airspace.
- Armed aircraft in the MALE subcategory are currently the most sought after due to the wide range of tasks they can perform with no unnecessary risk to personnel. Such armed UAVs represent multifunctional systems that can be used for reconnaissance from airspace, precise target location on the ground, automatic tracking of moving targets, battlefield intelligence preparation, artillery or airstrike corrections, effect assessment, guided missile strikes against ground and sea targets, and laser target designation for other laser-guided munitions (bombs and missiles).
- **The control and management segment** is often equated with the ground control station, which can be as small as handheld transmitters for the operator or large ground stations where multiple operators work for larger UAVs. The station generally consists of software and hardware that allows operators to communicate with the drone, remotely control the aircraft and its payload, and manage the entire flight, whether by setting parameters for autonomous flight or directly controlling the aircraft. This segment can be housed in containers, trailers, field vehicles, etc. For MINI class drones, their control is often done using cheaper devices, commercially available or often via smartphones.
- The autonomous operation mode of the drone involves the drone carrying out its mission without human operator intervention, following pre-planned routes and instructions. There are multiple levels of autonomy. At the lowest level, the operator remotely controls the aircraft throughout the flight, while at the highest level of full autonomy, the drone takes off, performs the aerial operation, and returns to the airport for landing, while the operator is on standby to adjust flight parameters or take control in case of an emergency.
- **Communication and data link** is a term that refers to the method of connecting one location to another in telecommunications for the purpose of transmitting and receiving digital information. The data link for an unmanned aerial system (UAS) is used to connect the drone to the ground control station. The data link consists of an *uplink* segment for transmitting commands from the ground to the autopilot, and a *downlink* segment for transmitting information from the autopilot to the ground station. Therefore, both the drone and the ground station must have appropriate modems that operate on the same frequency and are capable of sending and receiving information. Generally, there are three types of data links: *simplex* (one-way communication), *half-duplex* (two-way communication, but not simultaneously), and *full-duplex* (simultaneous two-way communication).[4] This is considered a „weak point” for all categories of drones, as disrupting this communication makes the drones inoperable. The focus in the production of military drones is on protecting communications and data links.
- **The aircraft** is considered a key component of the system. An unmanned aerial vehicle (UAV) can have fixed, conventional wings or one, two, or more rotors. Drones with conventional wings have an advantage in operational speeds and flight altitudes compared to rotor-based drones. They can also carry significantly larger payloads and achieve greater range because they have better aerodynamic surfaces and generate lift more easily. They can stay airborne for longer periods without landing. These drones are most commonly used for observation, reconnaissance, and collecting various types of data, but also for the efficient and precise deployment of firepower. Drones with rotors have a different application. Due to the rotors, they have the ability to take off, land, and hover in small spaces, while also being capable of

horizontal flight by controlling the rotors. They are more suitable for maneuvering at low flight speeds. Electric rotor drones can be ideal for search and rescue operations (locating the injured), assisting in natural disasters, and similar situations, as they can be quickly prepared and take off for a mission in a very short time (they do not require specialized airport infrastructure for takeoff). Their disadvantage is that they cannot achieve high horizontal flight speeds like fixed-wing drones, and their flight autonomy is limited because generating aerodynamic lift with rotors consumes more energy from the propulsion system (especially in the case of electric battery-powered engines). They typically carry smaller payloads and are noisier than other categories of drones.

- The uniqueness of drones and their differences depend on the characteristics of all six elements and are considered as the capabilities of the entire system, just as the technical and tactical characteristics are used to assess the capabilities of individual types of aircraft.

3. PURPOSE AND USE OF DRONES/REMOTELY PILOTED AIRCRAFT

Based on what has been discussed so far, it can be observed that the basic characteristics of a drone (weight, aerodynamic surface construction, range, altitude, speed, autonomy, or types of propulsion systems and production costs, etc.) are important design parameters by which drones differ. All of this provides the basis for choosing how to use them, or determining their purpose. The size of drones is probably one of the best and most visible ways in which we can distinguish them. The sizes of drones range from very small ones, known as nano drones, to large drones.

Nano drones or very small drones are designed to easily operate in small and inaccessible spaces (mostly indoors due to high sensitivity to weather phenomena). They resemble large insects in appearance. They have a small operational radius, usually a few hundred meters, rarely up to several kilometers, and can stay airborne for several tens of minutes. Their dimensions are up to 10 centimeters.

Medium-sized drones weigh up to 200 kilograms and have a significantly larger operational range. Their wingspan can be up to ten meters.

Large drones are mostly used for military purposes and resemble smaller aircraft. They have powerful enough engines and are designed to carry usable payloads. What is common to all drones is that their size and system element characteristics determine the specifics within each drone category. From these specifics, the method of use or impact deployment directly follows. This way, the purpose of drones can be defined, just like with conventional aircraft, meaning they can be:

- Reconnaissance drones
- Attack drones
- Multi-purpose (reconnaissance and attack) drones.

In accordance with the category and purpose, and according to the Doctrine of the Air Defense and Air Force, aircraft units of the Serbian Army conduct air action, anti-aircraft action, electronic and counter-electronic action.

Air action are operations aimed at destroying, neutralizing, or disrupting the enemy's forces in the airspace and on the ground. In general, air operations are divided into air fire operations, reconnaissance from the air, and air transport. **Air fire action** involve Air Force performing missile, bomb and firepower strikes against the enemy in the air, on the ground, and at sea to diminish the operational capabilities of the enemy forces and achieve the desired outcome. The main targets of air actions are delivery forces, support forces, command forces, aviation infrastructure, and enemy-controlled territory. **Air reconnaissance** is also categorized as an air action, as it uses specific aerial equipment integrated into modern air systems for action, often executed above the enemy's combat formations with high exposure to enemy countermeasures. **Air transport** is linked to the execution of combat operations and is a vital component of them: transporting parts of combat units and airborne assaults, which have immediate effects on the enemy and are directly related to different types of operations. [7]

Anti-aircraft action involves inflicting losses on the enemy's air forces in the airspace and on the ground, along with disabling their air infrastructure. The main carriers of anti-aircraft **action** are missile units and aviation units. The primary targets of anti-aircraft action are aircraft, airfields, fuel and munition depots, and observation and navigation systems. [7]

Electronic and counter-electronic action in the Air Defense and Air Force include combat actions in which special technical equipment is used for electronic reconnaissance of the electromagnetic spectrum and emitters, followed by appropriate electronic and counter-electronic actions. The targets of these actions are the enemy's electronic systems. These can include command and control systems, radar stations, air defense missile systems, aircraft guidance electronics, communication centers, electronic warfare systems, reconnaissance, television, radio and radio relay stations, command posts, and other systems that contain electronic elements or emit electromagnetic radiation. [7]

From the definitions of each of these types of operations, it can be concluded that every combat action involving drones has its designation within one of the operations carried out by other aviation units. Also, for all types of aircraft, it is characteristic that the Rules of Use for each type of aviation specify phases for conducting a combat flight, which ensures a unified tactic for using aircraft, despite differences in their technical characteristics and purpose. The phases of a combat flight for an aircraft are:

1. Phase – Start, takeoff, and assembly
2. Phase – Flight to the Target Area
3. Phase – Maneuver in Target Area and engagement
4. Phase – Return to the airfield
5. Phase – Dispersal and landing
6. Phase – Preparation for a new task.

For Class II and III drones, in line with their characteristics, the tactics used by other types of conventional combat aviation can be fully applied. They can plan, organize, and execute their combat flights following the same phases of combat flight. This allows crews to plan and organize the flight execution in the same manner as crews of other aircraft, ensuring that for each phase, the necessary calculations for the flight and safety measures are in place for the flight to be executed accurately and safely. However, for Class I drones, due to their characteristics, particularly their size, small range, and limited flight autonomy, the tactics used for other aircraft and higher-class drones do not apply. They are so small that operators usually carry them in dedicated bags/cases to the Target Area (TA), from where they take off (usually from the hand) without special preparation or organization for takeoff, as they typically do not operate from airfields. They only apply the third phase of the combat flight, as the operator brings them directly to the TA, where, once conditions are met, they are activated and sent to perform their mission, without the covered flight phase to TA and without a return to the airfield.

When considering Class I drones, regarding combat capabilities, specifically in terms of spatial, temporal, and firepower (effect deployment) capabilities, it is clear that the overall combat capabilities of Class I drones are significantly below those of higher-class drones and other aircraft, and are not on par with the combat capabilities of aviation units, which are the carriers of firepower and maneuvering capabilities in any modern military.

4. CONCLUSION

After the 1980s, there was rapid development in the fields of electronics, composite materials, manufacturing technologies (robotization in production), control systems, and computers, leading designers to focus on the development of multi-role military aircraft with ever-improving performance. The wide range of characteristics and increasing capabilities of this type of aircraft enable them to perform a broad spectrum of tasks by carrying various devices. By acquiring this type

of aircraft platform, significant savings are achieved in all areas, both technical and personnel-related, without diminishing air power.

This logic was also implemented in the design of remotely piloted aircraft, and from the very beginning of their development, the aim has been to integrate as many different electronic devices and systems as possible into the same aircraft platform to perform various tasks simultaneously. For example, it is common for modern drones to perform reconnaissance tasks from the air, provide fire support, conduct electronic jamming, and possibly execute other tasks essential for supporting military forces in modern operations (such as command, guidance, and correction of fire support, etc.). Considering that in modern armed conflicts it is crucial to have a thorough understanding of the enemy—both quantitatively and qualitatively, as well as their grouping, combat arrangement, and intentions—this type of aircraft has found its place in military use and has fully fulfilled its role in providing air support to ground forces.

The use of drones in air operations can be viewed in a broader temporal context, from the preparation phase to the completion of each operation, through several useful functions they perform, including:

- Intelligence gathering
- Battlefield visualization
- Fire action against ground and surface targets
- Assistance to crews in target identification
- Laser target designation
- Control and correction of strike effects
- Search in the CSAR⁴ operation.

If air power is defined in its broadest context as „The ability to project military power or influence through the control and exploitation of airspace, outer space, and cyberspace to achieve strategic, operational, and tactical objectives” [8] and considering the benefits and manner of drone use in military operations, then all drones can be considered elements of air power, regardless of their categorization, size, and method of use.

The fact that Class I drones, due to their characteristics, have a specific way of carrying out combat tasks, and that there is a certain mismatch with the tactics used in comparison to other drones and conventional aircraft, might raise the question of whether they should be categorized and used within the aviation branch?! However, if their use is viewed through the previously stated definition of air power, they certainly represent the exploitation of airspace to achieve and fulfill at least tactical objectives. Depending on the effects achieved, these tasks can have strategic or operational significance. When considering everything mentioned so far regarding the use, categorization, and classification of drones, it can be concluded that some categories of drones do not perform air operations characteristic of aviation units. However, through their specific method of use in military operations, all drones can represent a significant element of air power.

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