ULOGA BESPOSADNIH ZEMALJSKIH PLATFORMI U ZAŠTITI SNAGA PEŠADIJSKIH JEDINICA U NAPADNOJ OPERACIJI

Marko Radovanović[1] Aleksandar Petrovski [2] Željko Jokić [3] Aner Behlic[4]

Rezime: Razvoj savremenog naoružanja i vojne opreme kao i potreba za što većim stepenom zaštite ljudi u borbenim operacijama doprineo je razvoju autonomnih i bespilotnih sistema. Navedeni sistemi poseduju značajan stepen primene u oružanim snagama zbog širokog spektra upotrebe. Implementacijom ovih sistema u pešadijske jedinice povećavaju se elementi otpornost i zaštita snaga na viši nivo. Besposadna zemaljska vozila u napadnoj operaciji mogu se upotrebiti za aktivnosti izviđanja, prepada, otkiravanja i uništavanja neeksplodiranih sredstava, evakuacije povređenih i obolelih, transporta, vatrene podrške, i drugih. U radu su prikazane mogućnosti i karakteristike različitih vrsta besposadnih zemaljskih platformi i izvršena je analiza njhiove upotrebe u borbenim operacijama i uloga u zaštiti snaga pešadijskih jedinica u napadnoj operaciji. Definisane su prednosti koje ova vozila pružaju pešadijskim jedinicama, a zaključak predstavlja predlog autora za implementaciju zemaljskih besposadnih vozila u pešadijske jedinice oružanih snaga.

Ključne reči: bespilotni sistemi, autonomni sistemi, dron, veštačka inteligencija, besposadna zemaljska vozila, borbena operacija, zaštita snaga.

THE ROLE OF UNMANNED GROUND PLATFORMS IN THE PROTECTION OF INFANTRY UNITS IN AN OFFENSIVE OPERATION

Abstract: The development of modern weapons and military equipment as well as the need for the highest possible degree of protection of people in combat operations contributed to the development of autonomous and unmanned systems. The mentioned systems have a significant degree of application in the armed forces due to a wide range of uses. By implementing these systems in infantry units, the elements of resistance and force protection are increased to a higher level. Unmanned ground vehicles in an offensive operation can be used for activities of reconnaissance, raids, clearing and destruction of unexploded ordnance, evacuation of the injured and sick, transport, fire support, and others. The paper presents the capabilities and characteristics of various types of unmanned ground platforms and analyzes their use in combat operations and their role in protecting the forces of infantry units in an offensive operation. The advantages that these vehicles provide to infantry units are defined, and the conclusion represents the author's proposal for the implementation of unmanned ground vehicles in infantry units of the armed forces.

Key words: unmanned systems, autonomous systems, drone, artificial intelligence, unmanned ground vehicles, combat operation, force protection.

1. INTRODUCTION

Modern large-scale combat operations require the use of the most sophisticated combat assets for the efficient execution of assigned tasks. The use of unmanned aerial vehicles and unmanned ground vehicles is an indispensable segment of modern combat operations. Due to their various uses and different capabilities, they provide a wide range of possibilities to units equipped with this type of combat equipment. At the end of the 20th century, there was the development of automated mobile platforms without human crew (Unmanned Vehicles - UVs) [1]. The purpose of unmanned platforms is the complete or partial replacement of humans in crisis areas and situations (civil or military operations). Their development and application have been given increasing importance in recent years,

[1]Captain, MSc, University of defence, Military academy, Belgrade, Veljka Lukića Kurjaka 33, e-mail: markoradovanovicgdb@yahoo.com
[2]Lieutenant Colonel, PhD, University "Goce Delchev" - Shtip, Military academy "General Mihailo Apostolski", Skopje, e-mail: aleksopetrovski@gmail.com
[3]Lieutenant Colonel, MSc, University of defence, Military academy, Belgrade, Veljka Lukića Kurjaka 33, e-mail: antras1209@gmail.com
[4]Second Lieutenant, BIH military engenering unit, e-mail: kadet.aner.behlic@yahoo.com

and they represent assets of essential importance in all branches of the economy, due to technological progress in the areas of sensor and actuator components, signal processing and guidance (navigation) and control algorithms, and due to the potential capabilities of these platforms . A special group of automated platforms consists of unmanned ground vehicles (UGVs) designed for movement on prepared or unprepared terrain. The development of driverless vehicles was initially based on automating the movement of existing human-driven vehicles. However, due to the increase in economy, mobility and maneuverability, today unmanned vehicles are designed as a special class of vehicles with wheels or tracks, with fully automated movement functions and, most often, independent control of the drive wheels [2]. Unmanned ground vehicles continue to improve in terms of intelligence, mobility and reliability. The US military uses over 3,000 such vehicles. The tasks of these vehicles range from security, logistical support to the detection and neutralization of explosive devices.

The development directions of unmanned ground platforms go towards maximum system autonomy and the development of energy-sustainable solar-powered platforms. In the paper, certain ground unmanned vehicles are presented, their classification is performed and the capabilities of the mentioned vehicles during modern combat operations are presented. Unmanned ground vehicles have a wide range of possible uses during military combat operations, such as reconnaissance, raids, detection and destruction of unexploded ordnance, evacuation of the injured and sick, transportation, providing fire support to forces in a combat operation, and others.

In modern combat operations, different types of drones are used, from commercial ones to armed combat drones and combat unmanned ground vehicles UGVs that transmit data from the battlefield to the command center and provide fire support to maneuver units. The use of various types of drones in modern combat operations is increasing, especially for reconnaissance, detection, surveillance and targeting of targets on the ground. There are certain characteristics that must be met in order for drones to be effective in combat and meet the requirements of modern warfare.[3]

Unmanned vehicles should provide efficient and effective execution of tasks in combat operations without risk to personnel, by replacing soldiers in certain missions and thereby providing safety and security for soldiers in high-risk zones. Their application is particularly important when conducting combat operations of the army in urban areas, when maneuvering space is limited and when there are a significant number of restrictions on the use of soldiers in high-risk zones in urban areas. However, their application is possible in different environments where they provide significant combat capabilities to forces in combat operations.

There is a large number of works dealing with the problem of drones. Milić et al. analyze the possibility of using drones in operations in the urban environment.[4] Radovanović et al. show the possibility of using civilian drones in the protection and monitoring of the terrestrial security zone.[5] Adamski analyzes the effectiveness of combat drones used in modern armed conflicts.[6] Jovic shows the combat use of drones in a counter-terrorist operation.[7] Petrovski and Radovanović analyze the use of mandrels in cooperation with the C4IRS system for the needs of the military.[8] Ilić and Tomašević analyze the impact of the conflict in Nagorno-Krabakh on the perception of combat drones.[9] Radovanović et al. analyze the choice of an unmanned aerial vehicle for the needs of tactical units of the army and the police by applying the fuzzy AHP - VIKOR model of multi-criteria decision-making.[10] Mahajan analyzes the application of drones in construction.[11] Mitka and Mouroutsos classified drones according to purpose.[12] Choi et al. in their work they propose a multiple transmitter system composed of transmitter coils of different sizes for charging drones.[13] Gupta et al presented a classification of unmanned aerial vehicles and analyzed the model of an unmanned aerial vehicle with its components.[14] Žnidaršič et al. shows several types of drones and anti-drone assets for the purpose of implementation in units of the Serbian Armed Forces.[15] Wrzosek analyzes the challenges of modern command and future military operations.[16] Horyń and Tomasik analyze territorial defense forces in hybrid warfare in light of the experience of the conflict in Ukraine.[17] Selmy analyzes the use of drones in search and rescue operations.[18] Watts and others analyze drones in remote sensing and science. [19] Radovanović et al. show the application of unmanned ground vehicles in urban areas during military combat operations.[20]

2. TERM OF DRONE

Until now, the terms drone and unmanned ground vehicles do not have one generally accepted definition. unmanned ground vehicles in the general sense are characterized as drones. the definition of the term drone and the detailed classification of drones (figure 1) were made by petrovski and radovanović (2021) [8].

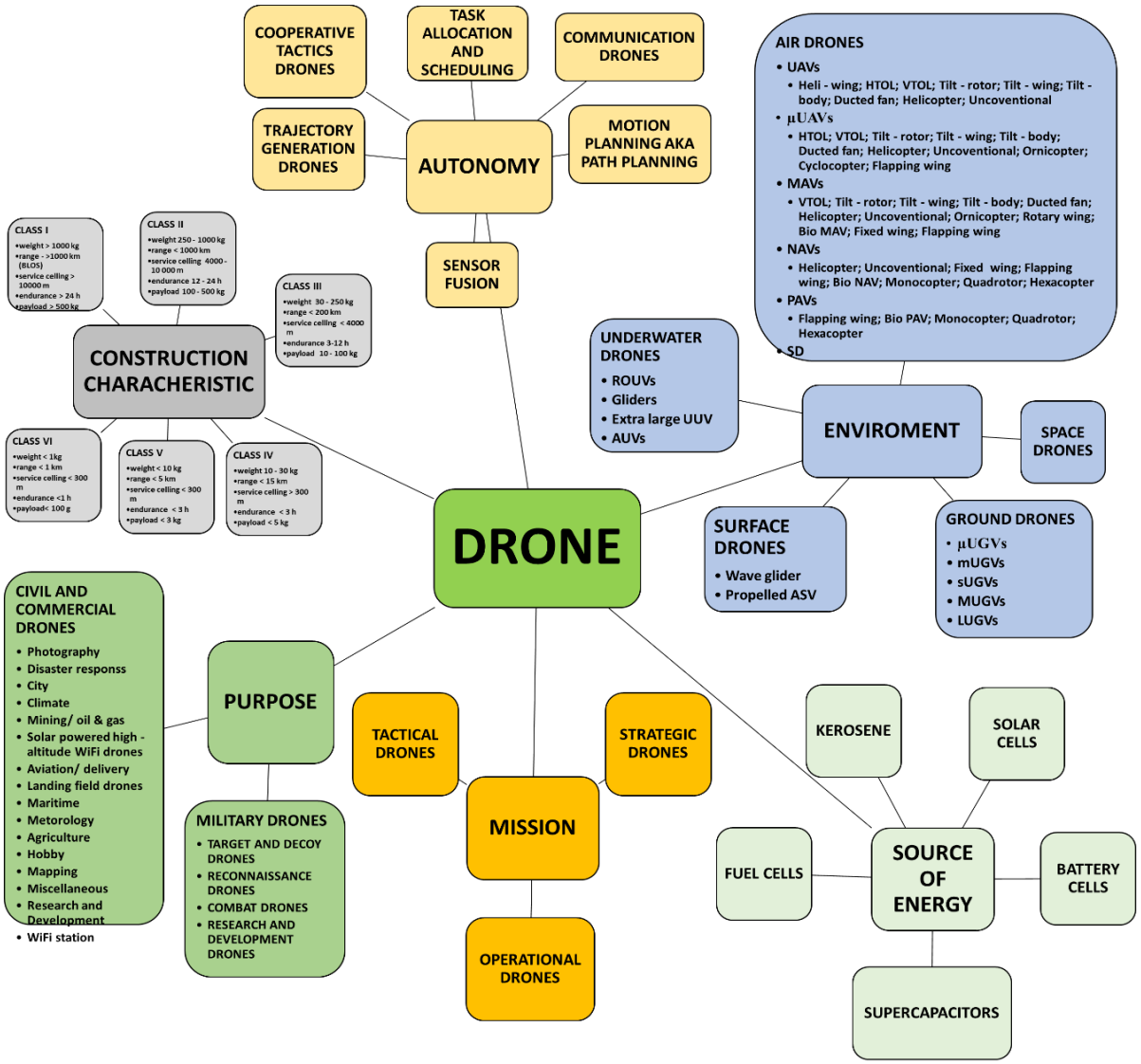

Figure 1: Classification of drones [8]

A drone has a broad meaning and represents means with a motor that are remotely controlled by an operator or means that have a certain level of autonomy (control is carried out using communication software, and artificial intelligence[21] and various types of sensors are often used), and which can be used once or repeatedly and can carry lethal or non-lethal payloads and transmit data in real time. It represents the synthesis of means and devices necessary for its management. They differ in terms of purpose, construction characteristics (shape, dimensions, weight, payload, maximum flight height, maximum range, flight time, speed, etc.), the environment in which they are used, and the energy source that drives them. Depending on the purpose, they can be used in different environments such as land, water, air and space, and a wide range of possibilities has created the conditions for application in defense and security (for the needs of the army and the police - the

original purpose), and they are also used in agriculture, construction, traffic, trade, communication, science, medicine, research, architecture, video and photography, geology, forestry, mining, oceanography, environmental management, sports, mapping, etc. A drone or unmanned ground vehicle UGV is a means that does not have a pilot, that is, it is controlled remotely or has a certain level of autonomy. The term drone is more general than the term unmanned aerial vehicle and unmanned ground vehicle because all unmanned aerial vehicles and unmanned ground vehicles can be called drones, while a drone does not necessarily have to be an unmanned aerial vehicle.

3. THE ROLE OF UNMANNED GROUND VEHICLES IN ATTACK OPERATIONS

Unmanned ground vehicles (drones) differ in their characteristics depending on the platform and purpose or practical use.[4] When classifying unmanned ground vehicles, it is necessary to thoroughly look at all aspects that can have an impact on different understandings of these means. In order to classify unmanned vehicles as accurately and precisely as possible, the methods of analysis, synthesis and classification were used. Today there are several different divisions of unmanned ground vehicles depending on the institution that classified them into different categories. They are most often classified in relation to the environment in which they are used, purpose, construction characteristics, in relation to the task and the source of energy that drives them. Figures 2 and 3 show different types and types of unmanned ground vehicles.

The use of unmanned ground vehicles improves the elements: efficiency, effectiveness, economy, security, safety and security of the unit, creates opportunities for reconnaissance, detection and destruction of mine and explosive devices, the possibility of evacuating the injured and sick, transport capacity and increases firepower.[15]] The mentioned vehicles can be armed (combat) whose purpose is to provide fire support to the ground forces in an operation and non-combat whose main purpose is to provide logistical support to units during combat operations. These vehicles can have an integrated GIS (geographic information system) and be integrated into C4 - C6IRS (Command, Control, Communications, Computers, {Combat, Cyber} Intelligence, Reconnaissance and Surveillance) systems, which significantly increases the combat capabilities of both unmanned vehicles and and the units that use them in different operations. The ability of unmanned ground vehicles mainly depends on their mobility and maneuverability and is considered one of the most important factors in their development, because vehicles that have the ability to pass over all types of terrain reduce the probability of the vehicle getting stuck.

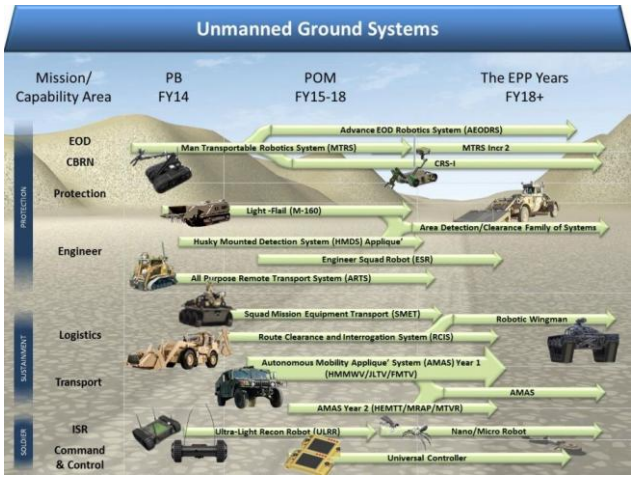

Figure 2: Unmanned Ground Systems

Figure 3. Different types UGVs

The basic characteristics of modern military operations are: multidimensionality, precision, non-linearity in time and space of execution, distributed content, simultaneity in action, integration of forces, interoperability and respect for international humanitarian law in the use of military force [22],

which is why the use of drones in modern offensive operations integrated into the command-information system (C2-C6ISR) of great importance for the successful execution of that type of operation [23], and is particularly reflected in the use of these assets in the protection and provision of fire support to infantry units in offensive operations.

Based on the available data during the execution of a special military operation on the territory of Ukraine (offensive operation), there is a significant use of unmanned aerial vehicles, while there is little available data on the use of unmanned ground vehicles. On the basis of which it can be concluded that unmanned ground vehicles have not yet taken the most important place in modern combat operations, unlike unmanned aerial vehicles. However, the development and improvement of combat operations and the wide range of capabilities that unmanned ground vehicles possess will place them in an indispensable segment in the armament of modern and well-equipped armed forces.

Recent technological advancements enabled the development of different-size unmanned ground vehicles (UGV) to support a variety of disaster-relief and combat missions. While these systems are to be used in small numbers with no coordination or even awareness of each other in most cases, some applications could benefit from utilizing (smaller-size) UGVs in quantities, featuring a swarming behavior. Among these possible applications are operations in an urban area, which due to its complexity represents a challenging multidimensional environment for ground warfare. [24]

Transporting supplies and combat equipment in offensive operations by infantry and ground forces is often a major challenge for soldiers and units. Due to the physical limitations of the soldier, the mass of additional equipment and heavy weapons represent a limitation for the soldier when performing offensive operations. The use of unmanned vehicles with integrated GIS and different types of command and information systems (C2, C3ISTAR, C4ISR, C5ISR, C6ISR, etc.) integrated into the mentioned vehicles significantly increases their autonomy, and thus the efficiency in the combat attack operation . These vehicles [25] have the ability to transport additional equipment, evacuate the wounded, fire support to units (integrated: small arms, multi-barrel grenade launchers, anti-armor systems, anti-drone systems), security and protection of borders and critical infrastructure facilities, logistical support and force protection, can be used for the removal of mine explosives. it is also possible to integrate the system.

With unmanned ground vehicles in offensive operations in different areas when there is a network for data on the very function of all these systems with the help of connecting to the infrastructure of smart cities, there are opportunities and advantages in using that information, which increases the mobility of units and makes them more efficient. When these vehicles are used as combat stations, it is possible to integrate machine guns, grenade launchers, anti-tank systems, and even mortars, which when connected to GIS, command information system and infrastructure of smart cities significantly increase the combat capabilities of infantry units in offensive operations of the army.

Due to the complexity of conducting offensive operations of the army, the application of unmanned ground vehicles is of extreme importance for providing fire support and protection of infantry units in combat operations. These vehicles are usually smaller in size than classic combat vehicles, and they have exceptional firepower and approximate combat capabilities, and they have significantly better maneuverability, which makes them a logical solution when equipping army infantry units. Certain unmanned vehicles are designed so that they can pass through standard doors and have the ability to move up stairs, which is very important when clearing and occupying residential buildings, evacuating the wounded and delivering ammunition and combat equipment in a limited urban space, such as for example residential buildings and residential blocks.

There are models of unmanned ground vehicles that are designed for the detection and removal of mine explosive devices, which significantly protects human and material resources and increases the safety and security of soldiers and equipment, especially infantry units during the execution of an army attack operation.

Models intended as mortar carriers are equipped with a specially designed support system for the safe transport and use of mortars, additional combat equipment and missiles, which increases their maneuverability and combat capabilities and provides the possibility of rapid deployment on different terrains. The main purpose of these models is to provide fire support to maneuver units. Their

integration into the command and information system, that is, into the C4ISR system, significantly increases the fire and combat capabilities of units in modern combat operations.

Unmanned vehicles that are equipped and intended for the extraction of the wounded and the transport of combat equipment should enable logistical support for the forces in the operation in high-risk zones and increase the protection of transport to a higher level and ensure the safe transport of material assets through the zone of military operation.

4. CHARACTERISTICS OF UNMANNED GROUND VEHICLES SIGNIFICANT FOR THE PROTECTION OF INFANTRY UNITS IN OFFENSIVE OPERATIONS

A large number of unmanned ground vehicles with different characteristics and different applications (in agriculture, medicine, architecture, construction, transport, meteorology, photography, security, etc.) can be found on the market. The requirements of the armed forces for optimal unmanned ground vehicles for use in various combat operations are very uneven in terms of their tactical-technical characteristics and economic characteristics. Based on the above, it is necessary for the decision-maker to define the goal and requirements of choosing the most optimal solution (unmanned ground vehicle) which, according to its tactical-technical and economic characteristics, would best meet the needs of the armed forces. In this paper, the focus is on defining the characteristics of these vehicles that have an impact on the protection of infantry units in an offensive operation.

All unmanned ground vehicles are equipped with different types of sensors that facilitate control by the operator or just the vehicle in the case of autonomous systems. On the market today, it is possible to find a large number of unmanned ground vehicles, with different characteristics and different purposes (application in agriculture and water management, medicine, transport, architecture, construction, meteorology, photography, army, police, telecommunications, mining, energy, geodesy, etc.) . Modern unmanned ground vehicles are equipped with various advanced technological solutions to make vehicle management as easy as possible for the operator. In the further part of the work, six characteristics were defined that have a significant impact on the decision-maker when choosing the most favorable solution (UGV) for the implementation and equipping of infantry units with unmanned ground vehicles.

Mobility autonomy integrates several different features of unmanned ground vehicles such as remote control range; a time limit on the use of unmanned ground vehicles that depends on the type of energy that powers the unmanned ground vehicle. When talking about the autonomy time, it represents the total time that the UGV can spend in operation without recharging, while the remote control range represents the maximum distance at which the vehicle receives a signal (RF, WiFi, etc.) from the operator. Greater autonomy of movement also increases the efficiency of the UGV and allows for a longer time of task realization, which is extremely important when the requirements are such that it is not possible to interrupt the task due to the replacement or replenishment of the energy source. The level of autonomy can vary from fully autonomous operation to full control by a remote operator. The difference in the concept of autonomy is the difference between automatic and autonomous systems.[26] The greater maximum range allows the use of UGVs at different distances and enables the use of UGVs deep in enemy territory, which is significant for maneuver units of the ground army. The greater maximum range also increases the protection of the operator from the effects of the enemy. Autonomy of movement is expressed in the unit of time (h) or the number of kilometers traveled.

Reliability is one of the most important exploitation characteristics of unmanned ground vehicles, which is expressed by the number of hours of operation without failure and expressed in percentages. Reliability is the ability of the UGV to provide the required functions under certain conditions of use and during a given period of time, while at the same time the values of the basic characteristics are within the defined limits. Here, it is important that the UGV functions in different conditions of use, at high and low temperatures, with strong gusts of wind and bad weather conditions, with dirty parts, in conditions of electronic, infrared, radio and WiFi interference, etc. Reliability is ensured by: construction and exploitation measures that are elaborated and implemented during design, construction and construction tests in different conditions, effective quality control of parts and

assemblies of the system, selection of suitable materials, protection from atmospheric influences, etc. The most effective is the use of combined composite materials and polymers. Greater reliability also increases the element of force protection in an offensive operation. Stoppages in the use of UGV result in interruption of activities.

The maximum mass of the useful load (carrying capacity) represents the additional equipment (additional useful load) that is placed on an unmanned ground vehicle, on the basis of which its type, purpose and class of belonging are characterized and expressed in kilograms. For the needs of the land army units, it is necessary for unmanned ground vehicles to be equipped with different types of cameras, sensors, weapons and other useful equipment, as well as to have the ability to transport different types of non-combat and combat equipment (ammunition, ordnance, medical equipment, wounded, etc.).[4]

The maximum speed is a characteristic that directly affects the effectiveness of the combat system, increasing the maximum speed increases the efficiency and effectiveness of the unmanned ground vehicle. A higher maximum speed directly affects the increase in maneuverability and tactical capabilities of unmanned ground vehicles, which also directly increases their efficiency. The higher speed provides the possibility of a faster response to the current situation and enables a faster maneuver with fire and movement during the execution of offensive operations. The mentioned characteristic is expressed in the distance traveled per unit of time (km/h) and is one of the most important criteria in the selection of unmanned ground vehicles.

Resilience is an important characteristic of unmanned ground vehicles and represents the possibility of survival of the combat system (UGV) on the battlefield in different conditions characterized by: enemy action from land, water and air; electronic, radio, WiFi and infrared signal jamming, etc. Greater resistance enables greater protection of infantry units during offensive operations of the army.

5. CONCLUSION

Unmanned ground vehicles continue to improve in terms of intelligence, mobility and reliability. Based on the presented definitions and classifications, it can be clearly seen that in just two decades, a high level of development of these systems with very complex tasks that can be performed in different environments has been reached. In this paper, special emphasis is placed on the characteristics of different types of unmanned ground vehicles, which can be used in offensive operations of the army, especially in infantry units.

By integrating GIS on unmanned ground vehicles that are networked with the command and information system (C2, C4ISR, C5ISR, C6ISR, etc.), the mobility, maneuverability, efficiency, fire and combat capabilities of the units are significantly increased in the offensive operations of the army.

The implementation of unmanned ground vehicles in army infantry units would significantly improve the effectiveness of ground army units in carrying out offensive operations on different terrains and environments, especially the introduction of combat armed unmanned ground vehicles. The mentioned vehicles would find the most significant use in reconnaissance and infantry units of the ground army, while unmanned ground vehicles equipped with stretchers for evacuating the wounded would be used in medical teams. Unmanned ground vehicles intended for the transport and transfer of various types of cargo would find their application in all branches of the Serbian Armed Forces and in certain services, which would significantly improve the operational and functional capacity of the aforementioned units. The use of the mentioned vehicles would significantly improve the element of force protection, which would raise the level of protection of infantry units of the ground army in an offensive operation to a higher level.

Further research should be focused on determining the impact of certain types of unmanned ground vehicles on the execution of army offensive operations in different environments and on the selection of the most effective unmanned ground vehicle for the needs of army infantry units by applying a certain multi-criteria decision-making model. This will create the conditions to determine priorities in the selection of equipment and assets (combat unmanned vehicles) through strategic

thinking and planning, and based on the observed performance and the possibility of training personnel to manage such systems.

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