UDC: 355(497.11)+623.437/.438
DOI: 10.5937/pnb29-58383
Review article

The Policy of National Security
(Политика националне безбедности)
Year XVI vol. 29
No. 2/2025
pp. 47-67

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UNMANNED AUTONOMOUS VEHICLES: CHALLENGES IN DEVELOPMENT AND MILITARY APPLICATIONS AND THE NEED FOR NEW COMPETENCIES OF MILITARY PERSONNEL [***]

(Translation in *Extenso*)

Abstract

The development of unmanned autonomous vehicles represents one of the most dynamic directions of contemporary technological evolution, with increasingly widespread applications in the civilian and primarily the military domain. Although *unmanned and autonomous vehicles* are often used interchangeably, this paper highlights their essential distinction and the importance of integrated decision-making capabilities for achieving full autonomy. Modern trends in the production of sensors,

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[***] The paper is a result of research conducted in the project of the Ministry of Defence of the Republic of Serbia: Design of an expert system based on artificial intelligence for assessing the situation on the battlefield (BA-TT/1/25–27).

communication, and power components have enabled the development of complex systems for environmental perception, path planning, and motion control, significantly influencing the transformation of concepts in military operations. The paper analyzes the historical development of unmanned autonomous vehicles, the levels of their autonomy, and their impact on the execution of modern military operations. Considering the pace of technological advancement and achievements, an even more intensive use of autonomous systems can be expected in future armed conflicts, which imposes the need to define the required knowledge and competencies for military personnel involved in their development and operational use. These competencies include mechatronics, automatic control, guidance, artificial intelligence, deployment tactics, and logistical support. The paper recognizes the need to enhance military education by integrating technological innovations and developing new academic programs to train personnel capable of creating, maintaining, and efficiently operating unmanned autonomous systems in a dynamic security environment.

Keywords: Unmanned Autonomous Vehicle, Control system design, Guidance system design, Military application of Unmanned Autonomous Vehicle, Military education.

INTRODUCTION

An unmanned vehicle (UV) is a vehicle controlled without a human operator on the vehicle itself, i.e., the vehicle is controlled from a suitable control station based on an appropriate communication link and various sensor systems. On the other hand, the unmanned autonomous vehicle functions without a human crew and conducts specific driving functions without direct human intervention by using advanced sensory systems and decision-making algorithms, environment recognition, and planning the movement path. Therefore, even though unmanned vehicles and autonomous vehicles are often used as synonyms, it should be stressed that unmanned vehicles are also autonomous, i.e., vehicle autonomy depends on the integrated ability of independent movement and decision-making on planning the movement path.

In the last years, with the development of the production technology of electronic and energy components, the field of research and examination of unmanned, and above all, autonomous vehicles experienced significant progress, which enabled the development of sophisticated systems of environment perception, direction and control of the vehicle, and thus the more efficient application of autonomous systems in different fields, including transportation, industry, agriculture, and above all, military use. Therefore, designing and developing guidance systems of autonomous vehicles is becoming quite a significant direction in scientific research papers (Wang 2023, 4; Gao 2021, 10; Huang 2022; Boretti 2024).

The development of highly sophisticated systems significantly impacted the change in the structure of conducting military operations. For example, using drones significantly improves the possibilities of movement reconnaissance and sudden attack on the opposing forces, unmanned autonomous vehicles contribute to higher mobility during operations of passage of ordnances, logistical equipment, and transport of the wounded. In contrast, the armed autonomous vehicles generated significant steps forwards in the evolution of contemporary military operations, carrying along numerous advantages in terms of efficiency, security, and the ability to conduct the most complex tasks in high-risk conditions for human crew (Đorić i Glišin 2023; Miljković i Beriša 2023).

The classical development of military education in Europe is, above all, linked to the famous considerations of von Clausewitz (Clausewitz 2021), in which the war is defined as the continuance of politics with different means and the development of the Prussian model of officer training and introduction of war games, in whose defining Helmuth von Moltke played a decisive role (Himmel 2024). In France, the work of Antoine-Henry Jomini (Rapin 2023, 1) in the period following the Napoleon wars and the foundation of the academy in Saint-Cyr, which fosters an approach to officer education through humanistic education and rigorous military training, stands out. The education of officers in the former Union of Soviet Socialist Republics (USSR), above all, included rigid military training and ideological education, and the foundation of this system can be found in the works of Mikhail Frunze (Frunze 2019). On the other hand, the establishment of the hegemony of the United States of America (USA) in the Western hemisphere contributed to the development of learning through discipline, engineering skills, and the theory of fast decision-making in combat (observe-orient-decide-act loop) (Boyd 2011). In the former Socialist Federal Republic of Yugoslavia (SFRY), the intensive impact on military education was made by the concept of total defense and protection (*Strategija opštenarodne odbrane i društvene samozaštite* 1987), which examined the method of frontal and guerrilla war.

The dynamic environment and fast technological development of weapons and military equipment that characterize modern conflicts also condition intensive changes in military education. In this segment, several directions can be noticed, such as fast adjustment to the new security challenges and threats through the process of continued improvement of curriculum and training (Arquilla 2021), digitalization of military training and intensive use of simulators working in virtual reality (Arquilla 2021), the application of neuro-sciences for better decision-making and experimental use of the "brain-computer" interface (Brose 2020), the preparation for hybrid and asymmetric warfare through improvement of the training concept and development of leadership skills for raising the level of psychological endurance of soldiers, officers and NCOs (Singer 2009). In this way, the concept of "lessons learned" is established and applied in the planning of contemporary military operations, which also influences the development of modern theories of military education.

The subject of this research is the application of unmanned autonomous vehicles in modern combat and non-combat operations and their development, as well as the consideration of necessary knowledge from modern technologies for designing, exploiting, and maintaining these systems. Given that the unmanned autonomous vehicles represent complex mechatronic systems, for them to be used properly in modern combat operations, the military staff developing and using them must know the fields of complex system management, mechatronics and mechanic transmission systems, as well as designing and development of artificial intelligence algorithms, to conduct optimal processing of signals gathered via various sensors in real-time and the use of unmanned autonomous vehicles on a tactical and operational level.

This paper is organized in the following order: After introductory deliberations, in the second chapter, a brief historical overview of the development of unmanned vehicles and their basic classification is presented. The developed levels of the unmanned vehicle's autonomy are analyzed in the third segment of this paper. In contrast, the aspects of the influence of these vehicles on conducting modern military operations are presented in the fourth chapter. In the fifth chapter, the challenges in designing the control and guidance systems are identified, while in the sixth chapter, the necessary competencies of the military staff in terms of the use and development of such systems to provide an adequate response to the new security challenges and threats are deliberated. Finally, in the concluding segment of this paper, suitable conclusions are defined, and directions for further research are suggested.

DEVELOPMENT AND TYPES OF UNMANNED VEHICLES

The development of unmanned vehicles began with systems that enabled remote control without absolute autonomy in the guidance system. Even in the 1930s of the 20th century, the first examples of simple remote-controlled platforms emerged, predominantly used for military and industrial purposes. The Soviet and German radio-controlled tanks were used in high-risk missions, such as munition transport and handling explosive ordnance. Even though technologically primitive, these systems present conceptual predecessors of the modern unmanned solutions, stressing the potential of the dislocation of the human factor from directly dangerous combat situations.

The second phase represents the second half of the 20th century, during which the unmanned system concepts broadened to partial or complete autonomy. The turning point was reached with the development of the mobile robot *Shakey* at Stanford University at the end of the sixties. This system, equipped with a camera and ultrasound sensors, represented the first mobile robot capable of independent data processing and decision-making based on the environment's perception, making it the predecessor of modern autonomous vehicles.

The intensive development of autonomous systems started at the beginning of the 21st century, and above all through projects such as the *Grand Challenges*, initiated by the Defence Advanced Research Projects Agency (DARPA) of the United States of America. This initiative strongly incentivized the improvement of the sensory systems and the development of sophisticated navigation, control, and path planning algorithms. The results of this research set the technological foundation for contemporary autonomous platforms, both in civilian and military use.

By different operational tasks and conditions, different forms of unmanned autonomous vehicle propulsion systems were constructed. The basic classification includes four types, whose basic characteristics are provided in the following segment.

Vehicles with wheels represent the most widespread type of unmanned systems. Their popularity comes from the simplicity of their construction, efficiency in movement on flat and well-maintained surfaces, and the lower complex of the control system. They rely on the rotational movement of the wheels connected to the undercarriage, while the number of axles and the powertrain configuration depend on the requirements for maneuverability and stability (Rubio 2019, 16).

Tracked vehicles – use tracks that provide a big contact surface with the ground, thus increasing the traction force and stability. The independent drive of each track enables precise control and high maneuver capability on uneven and challenging terrains. These systems are distinguished by high robustness, thus making them suitable for combat and reconnaissance tasks in harsh conditions (Zou 2018, 110).

Legged vehicles – these systems imitate the movement of animals by using a series of actuators and joints that enable dynamic balancing and movement on inaccessible terrains. The high level of mobility makes them especially efficient in urban environments and when performing tasks that demand overcoming obstacles and stairs (Zhao 2023,11).

Hybrid vehicles combine propulsion systems (wheels, tracks, and/or legs) to achieve maximum adjustment and performance. These systems represent a compromise between different types of mobility and enable operations in diverse and changeable conditions, even though technologically most demanding, hybrid systems enable a high level of flexibility upon use (Zou 2018, 110).

AUTONOMY LEVELS OF UNMANNED VEHICLES

Contemporary autonomous vehicles are based on integrating different propulsion and sensory systems, including the global navigation satellite system, radar systems, *LiDAR* systems, and other technologies that enable efficient perception and interaction of the vehicle with the environment in which it is located. The typical function of autonomous vehicles can be divided into three basic categories: environment perception, seeking an optimal movement route and making other decisions, and controlling the propulsion actuators to follow the desired trajectory and implement the decisions made. These three components can be perceived as the functions of the sense of sight, brain, and limbs of a human being, and they are implemented by designing suitable systems of guidance and control.

To better understand the development until now and the directions of future research, it is essential to further examine and analyze the concept of autonomy in detail. As previously mentioned, autonomy, in the context of unmanned vehicles, refers to the level at which the vehicle can function independently from human intervention. A generally accepted and widely recognized unmanned vehicle classification system defines six levels of driving autonomy, starting from level 0 (no autonomy level) to level 5 (complete autonomy), which can be explained in more detail in the following way (Sethi 2024):

Level 0: No autonomy. At this level, the vehicle functions completely based on the operator's guidance without autonomous capabilities. The vehicle can provide some technological assistance to the operator, such as various warning systems.

Level 1: Autonomy with the operator's assistance. This category of vehicles includes basic functions of autonomy that provide limited assistance to the operator. These are the systems, such as automatic speed control or assistance in maintaining the tasked trajectory, and the systems for controlling the speed and brakes. However, the operator remains completely in charge of control and guidance over the vehicle.

Level 2: Partial autonomy. Vehicles can conduct more complex tasks by combining two or more autonomous functions, such as maintaining the tasked trajectory or adaptive speed regulation. The vehicle can control the movement and speeding/slowing down in specific conditions, but the operator must be ready to intervene at every moment.

Level 3: Conditional autonomy. This level represents a significant step towards genuine autonomy. Vehicles with level 3 autonomy can conduct all driving tasks in specific, limited conditions, such as driving along a defined trajectory. The driver must not constantly monitor the surroundings, but be ready to take over the guidance when the vehicle asks for that.

Level 4: High autonomy. Vehicles can perform autonomously in the majority of movement scenarios, even if the operator does not respond to the demand for intervention. However, their operation can be limited to specific fields and projected operational domains.

Level 5: Complete autonomy. The vehicle is completely autonomous and capable of conducting all movement tasks in all conditions manageable by the human operator. No human intervention is needed.

This specter of the level of autonomy emphasizes the increasing sophistication and complexity of unmanned autonomous vehicles, i.e., the control and guidance systems, through which the desirable level of autonomy is achieved. While lower levels offer operator assistance, advanced research focuses on reaching higher levels of autonomy to realize challenging tasks in complex environments. Even though achieving complete autonomy (Level 5) is still in the development process, the current scientific research is focused on the improvement of the performance and abilities of vehicles at levels 3 and 4 in complex and challenging scenarios in realistic environments, which demands the projection and application of advanced guidance and control algorithms.

ASPECTS OF THE INFLUENCE OF UNMANNED VEHICLES ON MILITARY OPERATIONS

One of the key aspects of autonomous vehicle applications in the military is the ability to take up tasks previously deemed highly risky for the human crew. These tasks were, in the beginning, primarily linked to the use of unmanned vehicles in the field of reconnaissance and monitoring the opposing forces. Such systems, such as *QinetiQ TALON* (Army Technology 2020) or *Milrem THeMIS* (Milrem n.d.), possess sensors that act in different parts of the electromagnetic spectrum for the reconnaissance of the combat layout and early warning of enemy maneuvers. Moreover, small unmanned vehicles can be used for ruins and tunnel reconnaissance during operations in urban environments. Another aspect of the use of unmanned vehicles, which has been increasingly used in recent years, refers to the use of armed versions of such systems directly in combat actions (the Russian Uran-9 [СКБ МОРФ n.d.]) or *Milrem Robotics Type-X* [Milrem Robotics n.d.], as well as in the self-destruction missions (the Ukrainian *Ratel-S Global Defense News Army Recognition Group*

[GDNARG] 2024, for anti-tank warfare). Another aspect of using unmanned autonomous vehicles also refers to the conduct of logistical tasks (supply of ammunition, medical equipment, etc.), especially when the risk to the human crew is high. Additionally, unmanned vehicles can be equipped with electronic warfare devices and, as such, can be used in missions of electronic jamming of opposing forces or electronic protection of one's own forces.

All previously mentioned applications of unmanned vehicles in combat and non-combat tasks of the army bring along changes in the operational and tactical actions and procedures. In cases of attacks, using these vehicles in the initial phases of offensive actions enables reduced risk exposure of the personnel during advancement towards the enemy positions, as well as support to classic armored and mechanized units. Using unmanned vehicles in coordinated attacks on one target (attack of the unmanned vehicles swarm) enables efficient use of force to destroy enemy high-profile targets (bunkers, command centers, etc.). With all that, one should not ignore the psychological effect on the enemy morale when fighting unmanned autonomous systems. When conducting defensive combat actions, unmanned vehicles can be used on duty on the first line for efficient use of forces and for assessing the combat situation, the strength of the enemy's forces, and the enemy's maneuvers. Besides, using these systems reduces the possibility of tactical surprise of the enemy forces, while the self-destructing unmanned vehicles enable all forms of anti-tank fighting. The advantages of the use of unmanned platforms in reconnaissance missions against enemy forces reflect, above all, the increased combat endurance of these systems on the battlefield because these systems are complex to uncover, as well as the fact that they acquire and process information on the enemy forces in real-time, which is extremely significant for the commander's decision-making and the conduct of combat actions. In the logistical sense, combat platforms enable better protection of the forces upon supply of ammunition and other logistical needs to the units in direct combat contact, as well as the possibility for extracting the wounded and injured from the direct combat contact. As one of the most complex contents of combat actions stands urban warfare and, thus, unmanned platforms can be used as fire support to one's forces in narrow passages and streets, as well as the elements of reconnaissance of the combat layout of the enemy stationed in buildings and passages before the appearance of one's forces. Due to fast adjustment to changeable conditions of conducting combat actions (enemy activity, change of weather conditions, or specific tasks that call for precise navigation through harsh terrain), unmanned platforms enable high flexibility in planning and conducting operations.

However, the transition to unmanned autonomous systems introduces challenges regarding the security of use, ethics, and tactics. Namely, unmanned platforms are vulnerable to electronic jamming and deception, and interference with the connection to the command station can disrupt control of their work. Besides that, the opponent's possibility of taking control over the unmanned system represents a special challenge in its use and demands improvement of cyber system security. Moreover, unmanned vehicles of small dimensions are sensitive to direct hits from infantry weapons and have limited autonomy of work due to their relatively small capacity of energy capacity. The probability of correct classification of targets upon automatic detection and target classification is not entirely secure, which means there is a possibility of wrong target classification (for example, a civilian vehicle can be detected as a military vehicle). At the same time, failure of unmanned platforms can happen in critical moments of a mission. From an ethical standpoint, unmanned autonomous vehicles dehumanize combat actions and, thus, raise the issue of whether such systems can make decisions on the death or wounding of the enemy. The question of responsibility for mistakes of these combat systems remains open: Can the commander, programmer, or operator of an unmanned system be held responsible for any civilian casualties and damage to civilian infrastructure?

Based on the previously said, we can stress that autonomous vehicles are transforming military tactics and operations, thus enabling faster, more secure, and more efficient task completion while setting new challenges in security, regulation, strategy, and warfare tactics.

CHALLENGES IN THE DESIGN OF GUIDANCE AND CONTROL SYSTEMS

From a technical development standpoint, designing the guidance-and-control system for the unmanned autonomous vehicle implies various challenges. In contrast, both systems have special tasks at the desired level of autonomous movement. The guidance system is in charge of the perception of the environment and planning the trajectory. It collects and processes data from integrated sensors of the vehicle to create a model of the surroundings and determine the optimal route of movement for different scenarios of autonomous movement. This system secures key data for the guidance system, including information on the vehicle position, obstacles, and dynamic changes in the environment. The main reasons for the design and implementation of the guidance system include data processing in real-time, the accuracy of perception of the environment and enemies in unfavourable conditions, and decision-making in complex situations. On the other hand, the control system is responsible for conducting the task instructions from the guidance system. Based on the planned trajectory, it controls the actuator components (control, propulsion, and brakes) so that the vehicle closely follows the tasked trajectory. The key challenges include precise regulation of speed and direction, robustness in variable load conditions, and system resilience to unforeseen disturbances. Moreover, the control system must be resilient to malfunctions and ensure the vehicle's stability in all working regimes. These two autonomous movement systems' connection and efficient integration are essential for the safe and reliable functioning of unmanned vehicles.

Challenges in designing the guidance system

Achieving a high level of autonomy of movement sets significant challenges upon design of the guidance system of an unmanned vehicle, especially for complex tasks of autonomous movement with a high level of perception of the environment, such as moving along the task trajectory, moving towards the task coordinates in space, following a leader moving before or after the vehicle, detection, recognition and avoiding obstacles upon movement, recognition of enemy forces and assessment of threat, etc. Realizing such systems demands precise cognition of the current position of vehicles in space, as well as cognition of the environment and elements of interest located in the surroundings. Data integration from different types of wide-frequency sensors and the projection and implementation of sensor data processing algorithms in real-time are often needed. So, for example, upon moving along the task trajectory or towards a task coordinate in space, integration and processing of data acquired from inert sensors and global positioning sensors are needed. In contrast, following the leader, detection, recognition, and avoiding obstacles require applying optical, laser, and/or radar sensors. Moreover, in detecting and following the defined trajectory, autonomous vehicles must be able to function in environments in which the trajectories are not clearly defined and where different obstacles might impose limitations on the vehicle's sensor field of view. The key challenge in designing guidance algorithms is the generation of the optimal trajectory of the vehicle in dynamic and unpredictable environments, with minimization of energy consumption, as well as the noise in the sensor data. Besides that, bearing in mind the demands for acting in real-time, optimization of the computing complexity of the algorithm is necessary because computationally demanding algorithms demand big resources of the realization hardware, which raises the price of the unmanned vehicle. Moreover, guidance systems sometimes demand additional functionalities, such as human movement and pose recognition, or recognition of movements and formation of other unmanned vehicles, complicating the system's design and realization. The previously mentioned challenges stress the need for a guidance system that uses robust algorithms and can adjust to changeable environmental conditions and unexpected disturbances.

Challenges in designing the control systems

Designing the unmanned vehicle control systems sets high demands, above all, because of its complex dynamics and kinematics of movement, as well as the most often changeable interaction of driven actuators with the field, leading to the effect of slipping of the drive wheels/tracks and/or lateral and longitudinal sliding of the vehicle. Non-linear effects, time-varying parameters, and the impact of changeable loads and different terrains complicate the precise modelling of vehicle movement. Thus, control systems must be robust to different disturbances, unfamiliarity, and non-stationarity of the plant model.

Besides robustness, the demand for high performance during autonomous movement is also imposed. This means the movement control system must ensure the precise following of the reference trajectory, stability, and fast reaction to environmental changes. However, achieving high performance often demands complex algorithms, which introduces a challenge in balancing the realization's complexity and the system's efficiency. Too complex algorithms can be computationally demanding, which complicates their implementation on hardware with limited resources.

Another essential aspect is the energy efficiency of the designed control system. Namely, unmanned vehicle control algorithms should ensure stability and precision and minimize energy consumption, especially for electric vehicles with limited battery sources. This implies intelligent control strategies that reduce unnecessary energy consumption through optimizing the use of powertrains and reducing unnecessary vehicle acceleration and breaking.

Based on the previously stated, it can be concluded that the control system should satisfy the trade-off between robustness, performance, complexity, and energy efficiency to ensure safe, stable, and economical autonomous movement of unmanned vehicles in different working conditions. Thus, it is clear that, in the majority of cases, standard industrial control methods cannot provide for satisfactory system characteristics, i.e., the development of suitable control systems demands the application of advanced control techniques, such as adaptive, robust, and intelligent control.

THE NEED FOR NEW COMPETENCIES OF THE MILITARY PERSONNEL

Unmanned autonomous systems are available in the market, but procurement of the systems and their components is, in the majority of cases, perceived as procurement of arms and military equipment, which demands the acquisition of special permits and *end-user* certificates and can, therefore, be the subject of restrictions or technological limitations upon delivery. Access to key military technology, armament, and military equipment (including, among other things, the unmanned autonomous systems) can be limited in crises. Thus, the procurement of these systems represents a strategic security risk. As an alternative to importing already developed equipment and technology imposes independent production of these technologies, in which the key role is played by the highly educated expert professional military personnel, which possesses the necessary knowledge in the field of projection of unmanned autonomous platforms and maintenance and efficient use in combat and non-combat situations. One of the necessary steps in ensuring that the professional personnel are ready to dedicate themselves to solving the issue of designing and exploiting these complex systems, and above all, unmanned autonomous platforms, is the modification of the existent or definition of new study programs in military schools and the Academy by the imposed challenges.

One of the fundamental contemporary theories in higher education is defining the necessary competencies for suitable personnel (Dragoo 2016, 2; Dyson 2019, 2). Applying such an approach is also necessary upon setting the demands for the knowledge of future officers for conducting the entry-level duties, i.e., defining the study program structure for military schools and academies. In the previously described context of accelerated development and the use of unmanned autonomous systems in military operations, the Military Academy of the University of Defense in Belgrade must examine the emerging challenges, modify the existing ones, and suggest new study programs. As previously mentioned, the unmanned autonomous platforms represent complex systems whose projection, maintenance and use demand additional knowledge from the field of electrotechnical and computer engineering (designing the guidance and control algorithms for these vehicles, as well as the methods and techniques of data processing from different sensors located on these vehicles, application of techniques of artificial intelligence for their autonomous movement upon conducting missions and tasks, understanding the method of functioning of such systems and their efficient application) and machine engineering (designing the power unit, as well as transmission elements and materials that enable sufficient protection of these vehicles, as well as understanding of machine construction of vehicles, which ensures their more efficient use). It can be concluded that, upon graduation, the future officers should possess the abilities to analyze, synthesize, and predict solutions and possible consequences, as well as to master the methods, procedures, and processes of logical thinking to solve the development, maintenance, and exploitation of unmanned autonomous platform issues. Additionally, bearing in mind the complexity of autonomous systems and their accelerated technological advancement, it is necessary to develop the communication abilities of graduated cadets, not only regarding their close working and social environment but also the broader academic and scientific community, to ensure passing and improvement of knowledge and skills in this field.

Based on these needs for the education of highly proficient professional personnel, we can identify the following essential fields that should complement the existing curricula and study programs:

Mechatronics and autonomous systems – Unmanned vehicles are complex mechatronic systems combining mechanical structures, actuators, sensory systems, and computational control. Officers must gain basic and advanced knowledge in this field to understand the vehicle's principle of functioning and its efficient control.

Advanced automatic control techniques – due to the complex dynamics and kinematics of autonomous vehicles' movement, classical control techniques are often insufficient. It is necessary to introduce content regarding robust and adaptive guidance, trajectory optimization algorithms, and artificial intelligence for making decisions in real time.

Advanced systems of guidance and navigation – precise positioning of unmanned vehicles require a combination of several technologies, including GPS, inertial navigational systems, and other methods of defining the vehicle's position. The future officers must understand how these systems function, the principles of data fusion, and the methods of optimal trajectory generation.

Sensory data processing and artificial intelligence – autonomous vehicles use various environment perception sensors. Thus, educating officers in processing and analyzing data collected by sensors operating in different parts of the electromagnetic spectrum and in developing and implementing artificial intelligence algorithms, especially machine learning for object recognition and real-time decision-making, is particularly interesting.

Tactical use – tactical applications of unmanned vehicles demand that, besides possessing technical knowledge, future officers understand the abilities and advantages of unmanned autonomous systems compared to conventional weapons. This implies new strategies and reconnaissance tactics, logistical support, combat operations, and integration of autonomous platforms with the existing weapons systems.

Besides the defined professional-specialist and applied knowledge, additional attention must be given to developing highly motivated personalities of future officers and developing their leadership skills in their direct working environment. To fulfil this goal, it is necessary to reevaluate the role of army morale, military psychology and other fields of military social sciences to implement knowledge and develop a highly motivated personality of officers, as well as provide answers to ethical challenges of the application of new technologies, above all artificial intelligence, which is extremely pronounced in unmanned autonomous systems.

Accordingly, it is evident that, shortly, the Military Academy is expected to accredit new study programs, and one of the imperatives of developing new curricula is the identification of new technological challenges and security threats, as well as defining the necessary knowledge of military personnel, as part of responding to them, to defend the independence and autonomy of the Republic of Serbia.

CONCLUSION

In this paper, the use and challenges in the development of unmanned autonomous vehicles are analyzed. Besides that, the military personnel's knowledge is also identified for designing, exploiting, and maintaining these systems. The fundamental aspects of tactical and operational use in military operations and the development directions of unmanned autonomous vehicles were examined through the prism of designing vehicle guidance and control systems. Regarding the necessary competencies of the military personnel, we can conclude that it is necessary to develop different multidisciplinary and interdisciplinary knowledge to understand and use all the benefits of autonomous systems and ensure the improvement of the existing capabilities. By that, knowledge and experience acquired during this research will represent the basis for modifying existing and implementing new study programs within the military education systems.

Further research directions will refer to the challenges of designing expert systems for support in military decision-making based on artificial intelligence, which will improve the capabilities of autonomous systems and define the competencies of future officers necessary for confronting future challenges and threats to security.

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БЕСПОСАДНА АУТОНОМНА ВОЗИЛА: ИЗАЗОВИ У РАЗВОЈУ И ВОЈНОЈ ПРИМЕНИ И ПОТРЕБЕ ЗА НОВИМ КОМПЕТЕНЦИЈАМА ВОЈНОГ КАДРА***

Резиме

Развој беспосадних аутономних возила представља један од најдинамичнијих праваца савремене технолошке еволуције, са све широм применом у цивилном, а пре свега војном домену. Иако се термини беспосадно и аутономно возило често користе као синоними, овај рад указује на њихову суштинску разлику и значај интегрисане способности доношења одлука за пуну аутономију. Савремени трендови у производњи сензорских, комуникационих и енергетских компоненти омогућили су развој сложених система за перцепцију окружења, планирање путање и управљање кретањем, што је нарочито утицало на промену концепта извођења војних операција. У раду се анализира историјски развој беспосадних аутономних возила, нивои њихове аутономије и утицај на извођење савремених војних операција. Имајући у виду тренутну брзину технолошког развоја и достигнућа, може се очекивати још интензивнија употреба аутономних система у наредним ратним сукобима, што намеће потребу за дефинисањем потребних знања и компетенција војног кадра који ће се бавити развојем и употребом истих. Потребна знања

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*** Научни чланак је резултат рада на пројекту Министарства одбране Републике Србије: Пројектовање експертског система заснованог за процену ситуације на бојишту (ВА-ТТ/1/25–27).

укључују области мехатронике, аутоматског управљања, вођења, вештачке интелигенције, тактике употребе, логистичке подршке и других. Рад препознаје потребу за унапређењем војног образовања кроз модификацију постојећих и развој нових студијских програма за образовање кадрова способних за развој, одржавање и ефикасну експлоатацију беспосадних аутономних система у динамичном безбедносном окружењу.

Кључне речи: Беспосадна аутономна возила, Пројектовање система вођења, Пројектовање система управљања, Војна примена беспосадних возила, Војно образовање.

* This paper was received on April 22, 2025, and accepted for publication at the Editorial Board meeting on May 14, 2025.