USE OF UNMANNED AERIAL VEHICLES INTEGRATED INTO THE C4IRS SYSTEM IN MODERN COMBAT OPERATIONS

Marko Radovanovic[1], Aleksandar Petrovski[2] , Zeljko Jokic[3], Aleksandar Aleksic[4]

[1] University of Defence in Belgrade, Military Academy, Veljka Lukica-Kurjaka Street No. 33, Belgrade, Republic of Serbia, markoradovanovicgdb@yahoo.com

[2] University „Goce Delcev“, Military Academy „General Mihailo Apostolski“ Skopje, North Macedonia, aleksopetrovski@gmail.com

[3] University of Defence in Belgrade, Military Academy, Veljka Lukica-Kurjaka Street No. 33, Belgrade, Republic of Serbia, antras1209@gmail.com

[4] University of Defence in Belgrade, Military Academy, Veljka Lukica-Kurjaka Street No. 33, Belgrade, Republic of Serbia, aleksic.aleksandar1004@gmail.com

Received: 12th July 2022
Accepted: 20th July 2022

Professional paper

Abstract: *The development of weapons and military equipment conditioned the new model of conducting modern combat operations. The manner of conducting modern combat operations is characterized by the increasingly frequent and diverse use of unmanned aerial vehicles integrated into the C4IRS system in combat operations of the army. These aircraft are one of the most important types of weapons in modern combat operations. Anyone that has the technology can process the latest information from the field and safely passes that information to the command centre has a great advantage and a chance to cause great damage to units whose goal is to prevent further operational work. What is important is that UAVs must have some degree of self-protection through site selection action to reconnaissance and retreat routes. In case anyone is knocked down it would be acceptable to have the option to self-destruct vital and dataset parts, for technology and information protection.*

The paper presents the possibility of using unmanned aerial vehicles for various missions in combat operations, as well as a case study of their use in previous modern armed conflicts.

Key words: *UAV, UCAV, C4IRS, combat operation, command center*

1. INTRODUCTION

Modern combat operations require the use of the most sophisticated combat means in order to efficiently perform the assigned tasks. The use of unmanned aerial vehicles is an indispensable segment of modern combat operations. Due to its versatile use and different capabilities, it provides a wide range of capabilities to units equipped with this type of combat equipment. By applying unmanned aerial vehicles integrated into the C4IRS (Command, Control, Communications, Computers (C4) Intelligence, Reconnaissance and Surveillance (IRS)) system, it is possible to have a real-time image from the battlefield, which gives the decision maker the possibility of timely and efficient command of forces in the operation. Modern types of unmanned aerial vehicles are used in modern combat operations, from commercial to armed unmanned aerial vehicles. Both foreign and domestic authors have dealt with this topic. Milic et al. (2019) analyze the possibility of using drones in operations in urban environments. Radovanovic et al. (2020) shows the possibility of using civilian drones in the protection and monitoring of the land security zone. Adamski (2020) analyzes the effectiveness of UCAVs (unmanned combat aerial vehicles) used in modern armed conflicts. Jovic (2016) analyzes the combat use of drones in a counter-terrorist operation. Petrovski and Radovanovic (2021) analyze the use of dorns in cooperation with the C4IRS system for the needs of the army. Ilic and Tomasevic (2021) analyze the impact of the Nagorno-Krabah conflict on the perception of combat drones. Radovanovic et al. (2021) analyzes the possibility of implementing drones in mortar units in order to increase the efficiency of fire support units by applying a fire management system in cooperation with the C4IRS system. Bares performs interoperability modeling for the C4IRS system in a collective security system. Petrovski et al. (2019) analyzes the application of GIS in cooperation with the C4IRS system in geography for the needs of the military. Radovanovic et al. (2021) analyzes the selection of UAVs for the needs of military and police tactical units using the fuzzy AHP - VIKOR model of multicriteria decision making. Znidarsic et al. shows several types of drones and anti-drone means for implementation in the units of the Serbian Army. Petrovski and Toshevski (2016) present the application of GIS in geo-reconnaissance and C4IS for military purposes.

2. DEFINITION AND CLASSIFICATION OF UNMANNED AIRCRAFT

So far, there is no generally accepted definition of unmanned aerial vehicles as well as their classification, so the European Association of Unmanned Vehicles Systems - EUROUVS has defined the classification of unmanned aerial vehicles in relation to purpose (Bares,2001; German, 2012), flight altitude, flight duration, speed, Maximum takeoff weight - MTOW, aircraft dimensions, signal range, etc. (Arjomandi et al., 2006).

According to the model of control and management of unmanned aerial vehicles, they are divided into autonomous systems, self-control systems, radar or radio beam control systems, telecommand control systems and combined systems (autonomous, non-autonomous). In relation to flight altitude, take-off weight and maximum range, drones are divided into four categories (Agbeyangi et al., 2016):

- Category 1 (weight up to 1 kg, flight altitude up to 50 m, AGL - Above Ground Level, range up to 150 m);

- Category 2 (mass greater than 1 kg to 5 kg, flight altitude up to 150 m AGL, range up to 500 m);

- Category 3 (mass greater than 5 kg to 20 kg, flight altitude up to 300 m AGL, range up to 2500 m);

- Category 4 (mass greater than 20 kg, flight altitude greater than 300 m AGL, range greater than 2500 m).

Petrovski and Radovanovic defined the terms drone and UAV and their classification (figure 1). The term UAV has a broad meaning, it means with a motor that is remotely controlled by the operator or it is a means that has a certain level of autonomy (control is done using communication software, and often uses artificial intelligence and different types of sensors), which they can be used once or repeatedly and can carry deadly or non-lethal cargo, transmit data in real time, using as a WiFi station and ect. It is a synthesis of the means and devices necessary to manage it. They differ in purpose, construction characteristics (shape, dimensions, weight, payload, maximum flight altitude, maximum range, flight time, speed, etc.) of the environment in which they are used, the energy source with which they are driven. 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 a condition for application in defense and security (for the needs of the army and police - original purpose). agriculture, construction, traffic, trade, communication, science, medicine, research, architecture, video and photography, geology, forestry, mining, oceanography, environmental management, sports, mapping, etc. The term drone is more general than the term unmanned aerial vehicle, because all unmanned aerial vehicles can be called drones, while a drone does not necessarily have to be an unmanned aerial vehicle. (Petrovski and Radovanovic, 2021).

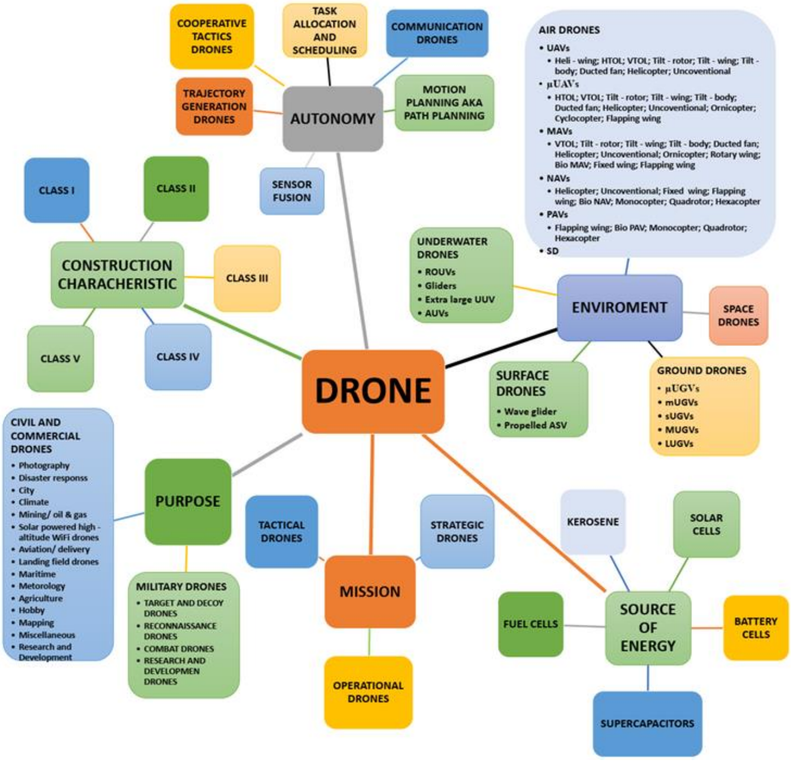

Figure 1. Classification of drones

Source: (Petrovski and Radovanovic, 2021.)

Based on the classification of unmanned aerial vehicles, it is concluded that the characteristics of unmanned aerial vehicles usually depend on their purpose. It is necessary to analyze the tactical and technical characteristics of unmanned aerial vehicles in order to consider their possibility of use in modern combat operations.

Military use of unmanned aerial vehicles can be classified into three groups: naval, land and air use, while for civilian purposes it can be used in various areas of human activity, such as. in geodesy (photogrammetry), agriculture, industrial production, civil protection, disaster management, critical infrastructure surveillance, environmental protection, police surveillance, protection and rescue of people, intelligence and security services, journalism, commercial activities and leisure.

3. COMBAT OPERATIONS

The planning and organization of any operation cannot be well done without information about the enemy, which can be collected using drones. The use of drones contributes to the successful performance of operations in the urban environment. The possibility of using drones in operations in urban environments is as follows: detection of nuclear, chemical and biological weapons; mine detection; electronic reconnaissance; anti-electronic action; communication relay; hyperspectral scanning, radar imaging, laser target marking, radar jamming, use of drones as combat stations and anti-drone systems, logistics stations, transport support, support to medical teams.

An operation is defined as a set of combat and / or non-combat activities, movements and other actions taken with a single idea, either alone or in cooperation with other defense forces, to achieve a general goal of varying importance. "

In order to successfully perform the analysis of the use of unmanned aerial vehicles in modern combat operations, it is necessary to consider the characteristics and factors of modern combat operations, which directly or indirectly affect the use of unmanned aerial vehicles.

Significant use of drones in combat operations began in the late twentieth century, so the NATO aggression on the FRY used different types of drones, while their more significant use was in the conflicts in Libya and Syria. The Nagorno-Karabakh conflict in 2020 (German, 2021) was one of the turning points in the application of this destructive technology for combat purposes. As never before, the mass use of combat drones has decisively influenced the outcome of an armed conflict. Unmanned aerial vehicles determine the strategy and tactics of military operations. (Ilic and Tomasevic, 2021) The following BPLs were used in this conflict: Krunk-25-1, Aerostar, Hermes, kamikaze-drone Heron, Harop, Orbiter 2M and Bajraktar TB2. The Turkish Bairaktar TB2 UCAV showed exceptional versatility during the conflict. In addition to target identification, tracking, and guidance, TB2s were armed combat systems capable of independently destroying targets (Shaikh and Rumbaugh, 2020).

The Nagorno-Karabakh conflict has clearly shown the effectiveness of the use of drones, which once again indicates a change in the tactics of armed conflicts as such. The airspace is completely dominated by unmanned aerial vehicles and we see that they underline the "line" to which armored vehicles can be "safely" used. In front of them, armored vehicles are absolutely undefended, even with built-in dynamic protection.

When armored vehicles fight an almost equivalent battle with ATGMs (anti-tank guided missiles), artillery and other anti-tank weapons, then they become powerless against UAVs attacks. First, because the UAVs hit from above on the most unprotected places of the tanks - in the thin upper armor of the turret and the engine compartment. Second, an unmanned aerial vehicle, especially if it is controlled remotely, has a certain degree of "artificial intelligence", which enables the identification of the target, the ability to maneuver and a high probability of destroying the target.

The drone itself is quite vulnerable to anti-aircraft protection systems due to its low speed and limited maneuverability. It can easily be shot down by portable anti-aircraft missile systems or even a large-caliber tank machine gun. Unmanned aerial vehicles capable of carrying out long-range attacks, such as the Turkish Bajraktar TB2, have a degree of protection, but even then there is the possibility of counter-action in the form of electronic warfare systems or other systems against unmanned aerial vehicles (C-UAV).

Russian troops in Syria thwarted attempts to attack the "Khmeimim" air base by efficient use of air defense systems and means specialized in the fight against UAVs and electronic warfare systems. In particular, the "Pantsir S1" and "Tor-M2" systems are mostly used for the destruction of unmanned aerial vehicles, other tasks are performed with electronic anti-drone rifles.

Among the most effective Russian electronic countermeasures against small BPLs, the Repellent, Sapsan-Bekas, Kupol, Rubezh-Avtomatika, Luch and Pishchal systems can be mentioned. The Repellent-1 anti-drone system is able to suppress or destroy swarms of reconnaissance, unmanned aerial vehicles, with very small surfaces and dimensions. The system is able to automatically detect and neutralize enemy reconnaissance drones at distances of 30 km, performing strong electronic interference with their control sensors or satellite navigation links. The system is able to detect drones via their control command transceiver signals, in all weather conditions.

The armed conflict on the territory of Ukraine is also characterized by the massive use of unmanned aerial vehicles by both the Russian armed forces and the Ukrainian army. Ukrainian forces mostly use the "Bajraktar TB2" unmanned aerial vehicle, while Russian forces most often use "outpost", "eagle-10" and "zala" unmanned aerial vehicles.

Unmanned aerial vehicles can be used to gather information by reconnaissance and aerial photography and to attack by destroying assigned targets with guided or unguided missiles in integration with the C4IRS system. The information obtained should be forwarded to the Force Command Center in a timely manner. The use of drones in combat operations provides a wide range of capabilities to the units that use them, by adding a wide range of accessories. Unmanned aerial vehicles provide an advantage during combat operations, because they provide support for making a quick decision to the field manager and the possibility of controlling a larger area of combat operations in the operation zone.

4. INTEGRATION OF C4IRS SYSTEM ON UNMANNED AIRCRAFT

C4IRS defines a Command, Control, Communication, Computer, Information, Reconnaissance and Surveillance system. The Arc-GIS platform is an enterprise information technology infrastructure, and as such, provides a horizontal, crosscutting technology that is very different from GIS technologies past niche usage (ESRI, 2005). One concept made a big step up in the usage of GIS for military purposes, especially military affairs. That is NCO which represents concept of Network-Centric Operations i.e., the use of the network to connect decision making across multiple defense domains and beyond. Therefore, NCO is about far more then war fighting. It connects war fighting to strategic intelligence, and with that to installation management. This frame is way beyond from the traditional defense and intelligence domain. Arc-GIS has a critical impact in each of the three concepts of NCO:

- Intelligence, Surveillance, Reconnaissance - ISR
- Command, Control, Communications, Computers, and Intelligence - C4I
- Precision engagement – PE.

The C4IRS domain supports timelier and better decisions by using a variety of tools to analyze, assess, and plan actions. Arc-GIS bolsters C4IRS capabilities by providing a common spatial context and the tools to provide decision makers, commanders, and war fighters with a distributed, scalable, decision support environment (Nagy, 2004).

The development of military commanding and management technique systems seen in recent years has been made possible primarily by the development of microelectronics, the rapid decrease in size of IT tools, the enormous increase of their capacity, and the integration of their capabilities into a single system. This is applied by maneuvering robot aircrafts, unmanned flying devices and by all other armament managing, deployment managing systems, which are, on the one hand in an interactive contact with the environment, and direct interactively the given object, on the other (Nagy, 2004). Nowadays all elements of managing systems are integrated into a combat vehicle, which forward commands to the managing staff of the vehicle and send back reports. Based on reports, a close to real-time combat value can be worked out, which in the case of traditional tools would be slow, cumbersome procedure full of uncertainties, requiring human resource.

In the many armies, the Commercial Joint Mapping Toolkit (C/JMTK) provides the Mapping, Charting, Geodesy, and Imagery (MCG&I) functionality for C4IRS mission applications. The toolkit is being deployed to support both legacy mission applications and new systems being developed throughout the Department of Defense (DoD) Command, Control, and Intelligence (C2I) Community (Thomas and Jonnson, 2007; ESRI, 2006).

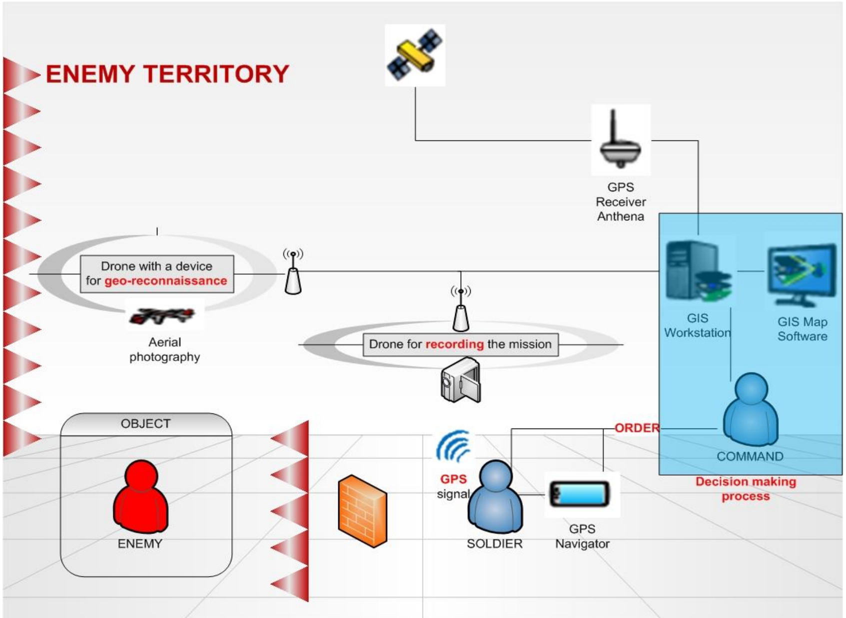

Figure 2. Model of Geo-reconnaissance and commanding (GRC) information system in UAV
Source: (Petrovski A. and Mihajlo T. defined this model - figure 2)

5. THE IMPORTANCE OF THE INTEGRATED C4IRS SYSTEM FOR PERFORMING MODERN COMBAT OPERATIONS

The importance of C4ISR has grown as global economic, territorial, and resource competition has increased. Its importance to mission success today lies in C4ISR's function as a technological and strategic nerve center that integrates the operational side of military forces – platforms, troops, weaponry, and other assets – with intelligence, tactical networks, and analytical tools to provide command and control leaders with situational awareness and predictive analytics for effective decision making. Understanding the environment and making good decisions quicker than an adversary is the fundamental capability that C4ISR provides (http://defense-update.com/events/2005/summary/LIC-c4sec.htm).

C4ISR systems are becoming increasingly important for mission success. Read on to learn how the changing nature of warfare is informing the DoD's overarching strategy for maintaining military dominance on today's battlefield. Today's environment also requires the collective capabilities and efforts of multiple organizations. Unfortunately, traditional C4ISR systems weren't built with interoperability in mind—in the past, they were designed to meet mission-specific requirements and to solve a particular set of problems facing an organization. This specialized functionality limited the DoD's ability to communicate from one system or platform to another, and information remained stovepiped within missions (https://www.baesystems.com/en/productfamily/c4isr-systems).

The increasing breadth and depth of information, the accelerating speed with which information flows and weapons can be deployed, and the proliferation of interoperable digital devices have driven home the need for the DoD to develop and deploy more modern C4ISR capabilities. The "nervous system" of the military, the collection of subsystems used to maximize situational awareness, is referred to as C4ISR—command, control, communications, computers, intelligence, surveillance, and reconnaissance. C4ISR technologies are the bedrock of any mission, and the components must work in tandem to effectively enable the "muscle" side of the military—weapons, platforms, and troops. C4ISR networks collect massive amounts of data from multiple sensors, databases, and other sources worldwide. The data is fused, processed into usable information, and shared securely among authorized users.

Advancements in C4ISR capabilities are changing the nature of defense systems, battlefield strategies, and communications security worldwide, requiring innovative thinking and agile, expeditious development capabilities among USDoD partners and contractors. Maintaining the military dominance necessary to defeat adversaries and support allies across every domain – on the ground, at sea, in the air, and in space – demands a commitment to advancing C4ISR priorities within each branch of the DoD and across the integrated frameworks necessary to deliver the most pertinent capabilities effectively (https://www.defenseone.com/insights/cards/c4isr-military-nervous-system/).

While the DoD has signaled the development of C4ISR capabilities as a top priority, a number of obstacles must be overcome in the years ahead if it hopes to maximize innovation. C4ISR plays a key role in the military defense and operational stability of governments, businesses, and societies worldwide today, and indications are that it will only become more important moving forward, given its growing role in how decisions are made, threats are addressed, and agreements are enforced. The world's nations are in a race for C4ISR superiority – a significant national advantage – and the ability to lead through innovation could determine who wins.

The C4ISR Solutions teams at BAE Systems are conquering the complex emerging mission challenges across all domains – around the globe, below the sea, and out in space. From innovative command and control technologies and secure, adaptable communications systems to extended-range ISR sensors, high-velocity data analysis systems, cyber resilience solutions, and more, BAE Systems has developed proven C4ISR technologies for information dominance that will help secure an aware, protected, and resilient future.

The defense space often refers to these systems as either C4ISR or C5ISR. The difference between the two terms reflects advancing needs in military communication efforts. Effective communication systems are crucial to military operations across every branch, mission, and training regimen. Success is driven not only by combat and force but through the gathering and dissemination of intel across military personnel.

Beijing's determination to dominate in the information warfare arena has led to the country's fast adoption of C4ISR technologies. In fact, this rapid procurement and development are predicted to make the Asia Pacific region the largest market for C4ISR tools by 2025. C5ISR includes those 7 components in addition to an 8th element and 5th "C"--cyber-defense (https://www.adsinc.com/news/c4isr-vs-c5isr-what-is-the-difference). Without this element, C4ISR did not address the threat of cyber security risks. Today, an effective C5ISR system must protect against threats related to intelligence and information warfare, as well as sensitive data leaks and breaches.

The benifits of C5ISR systems are becoming increasingly important for mission success. Read on to learn how the changing nature of warfare is informing the DoD's overarching strategy for maintaining military dominance on today's battlefield. The key to effective C5ISR is optimizing the functionality and interoperability of land, sea, air and space systems to rapidly turn data and intelligence into mission-winning action.

How Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) solutions are simplifying the complex—turning data into knowledge? And knowledge into action. Today's environment also requires the collective capabilities and efforts of multiple organizations. Unfortunately, traditional C4ISR systems weren't built with interoperability in mind—in the past, they were designed to meet mission-specific requirements and to solve a particular set of problems facing an organization. This specialized functionality limited the DoD's ability to communicate from one system or platform to another, and information remained stovepiped within missions (https://www.northropgrumman.com/c4isr/).

Adversaries are highly adaptive and threat environments are becoming increasingly complex. Fifth Generation C5ISR is a joint battle management system that can gather data, understand it, and communicate freely with each and all of its components. The "nervous system" of the military, the collection of subsystems used to maximize situational awareness, is referred to as C5ISR—command, control, communications, computers, cyber, intelligence, surveillance, and reconnaissance. C5ISR technologies are the bedrock of any mission, and the components must work in tandem to effectively enable the "muscle" side of the military—weapons, platforms, and troops. C5ISR networks collect massive amounts of data from multiple sensors, databases, and other sources worldwide. The data is fused, processed into usable information, and shared securely among authorized users.

As discussed in Chapter 4, previously clear distinctions between C4ISR and combat systems are blurring; this trend is likely to increase with the advent of network-centric operations. Sensors onboard on UAV's are often integral parts of combat systems, but data shared with other units can cue other sensors and can fuse with other data to create a more complete picture or add to a commander's situational awareness.

While the DoD has signaled development of C4ISR capabilities as a top priority, a number of obstacles must be overcome in the years ahead if it hopes to maximize innovation. The army has put forth a new construct for its strike forces that enables more effective forward deterrence and rapid response. A key aspect of this construct is the need for flexible, adaptive command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems (https://www.northropgrumman.com/c4isr/). To assist development of this capability, the Army started to examine C4ISR for carrier, expeditionary, and strike and missile defense strike groups, and for expeditionary strike forces. This report provides an assessment of C4ISR capabilities for each type of strike group; recommendations for C5ISR architecture for use in major combat operations; promising technology trends; and an examination of organizational improvements that can enable the recommended architecture.

Effective communication systems are crucial to military operations across every branch, mission, and training regimen. Success is driven not only by combat and force but through the gathering and dissemination of intel across military personnel. These new systems will significantly improve tactical operations. On the battlefield, nine times out of 10 we have to improvise our plan and we need to move, and move quickly. If we can get the network up in minutes [versus hours], it enables us to move that much faster.

Beijing's determination to dominate in the information warfare arena has led to the country's fast adoption of C4ISR technologies. In fact, this rapid procurement and development is predicted to make the Asia Pacific region the largest market for C4ISR tools by 2025 (https://www.nap.edu/read/11605/chapter/9). This systems can show us volumes of data on fires, logistics, or friendly and enemy force locations, yet we don't have one system that brings the entire picture together. We have constantly evolving software, but some tools require too many clicks or permission levels for warfighters to actually find their best features. We have great communications inside combat and tactical vehicles, but they each come with their own monitors and other hardware, creating a challenge for operators in tight quarters.

C4ISR is a terrific example of where an acronym helps avoid repetition. After all, who wants to say Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance more times that you must? 'C4ISR' helps us put together arguably the most important elements of the infrastructure of global national security into a single, memorable term. Supported by "Cyber Defense" elements in future events this system will be a leader in gettering information in the world and the future creation of new perspectives of living.

6. CONCLUSION

The use of unmanned aerial vehicles equipped with modern technical devices (high resolution cameras, infrared and thermal cameras, microphones, various types of sensors, guided and non-guided missiles and other accessories) integrated into the C4IRS system significantly increases the efficiency of units engaged in combat operations. The use of this sophisticated technology enables timely and accurate information about the event in real time, as well as the destruction of the target without risk to humanity, while transmitting the situation to the battlefield command center. Unmanned aerial vehicles can still be used to deliver medical supplies and other necessary combat and non-combat equipment to units in the area of operation.

The use of unmanned aerial vehicles in combat operations, regardless of limitations, increases the efficiency and effectiveness of the units engaged in the operation, and also increases the protection and reduces the risk to the engaged personnel. Based on the tactical and technical characteristics of unmanned aerial vehicles, it is possible to realize various tasks.

Today's environment also requires the collective capabilities and efforts of multiple organizations. Unfortunately, traditional C4ISR systems weren't built with interoperability in mind—in the past, they were designed to meet mission-specific requirements and to solve a particular set of problems facing an organization.

Further research should be focused on the integration of the modern C5ISR system to the combat systems of the army and the advantages that the mentioned system provides to units during the execution of a modern combat operation in a different environment.

ACKNOWLEDGEMENTS

This paper was written as part of the scientific research project funded by the Military Academy of the University of Defence in Belgrade, number: VA-DH/1/21-23 "Uticaj savremenog okruzenja na izvoDjenje borbenih dejstava u urbanim sredinama" ("Influence of contemporary environment on the conduct of combat activities in urbanspaces")

REFERENCES

Adamski, M. (2020). Effectiveness analysis of UCAV used in modern military conflicts. Aviation, Vol. 24, No. (2).

Agbeyangi A., Odiete J. and Olorunlomerue A. (2016). Review on UAVs used for AerialSurveillance, Journal of Multidisciplinary Engineering Science and Technology, Vol. 3, No. 10, ISSN 2458-9403

Arjomandi A., Agostino S., Mammone M. (2006) Classification of Unmanned AerialVehicle, Report for Mechanical Engineering class, University of Adelaide, Adelaide,Australia,

Bares M. (2001). Interoperability Modeling of the C4ISR Systems, Paper presented at the RTO SCI Symposium on "System Concepts for Integrated Air Defense of Multinational Mobile Crisis Reaction Forces", held in Valencia, Spain, 22-24 May 2000, and published in RTO MP-063.

ESRI (2005) GIS for Defense and Intelligence.

ESRI (2006) GeoRover Tools for ArcGIS.

German, T. (2012). The Nagorno-Karabakh Conflict between Azerbaijan and Armenia: Security Issues in the Caucasus, Journal of Muslim Minority Affairs, Vol. 32, No. (2).

Ilic, D., Tomasevic, V. (2021). The impact of the Nagorno-Karabakh conflict in 2020 on the perception of combat drones, Serbian Journal of Engineering Management, Vol. 6, No. (1)

Jovic, Z. (2016). Combat engagement of drones in USA counterterrorist operations. Bezbednost, Beograd, Vol. 58, No. (3).

MiliC A., Randjelovic A., Radovanovic M. (2019), Use of drones in operations in the urban environment, 5 th International Scientific conference Safety and crisis management – Theory and practice Safety for the future – SecMan 2019, Belgrade: Regional Association for Security

Nagy, P., (2004). GIS in the army of 21st century, Hungary.

Petrovski A. and Radovanovic M. (2021). Application of detection reconnaissance technologies use by drones in collaboration with C4IRS for military interested, Contemporary Macedonian Defence, Vol. 21, No. 40.

Petrovski A. and Toshevski M., (2016) Gis in Army: Application of GIS in Geo-Reconnaissance And C4IS in Army Purposes, 2nd International Scientific Conference GEOBALCANICA, Skopje.

Petrovski A., Taneski N., Bogatinov D., Geography in Geospatial Intelligence - C4IRS and Cyber Security, 5th International Scientific conference Safety and crisis management – Theory and practice Safety for the future – SecMan 2019. Belgrade.

Radovanovic M., Milic A., Randjelovic A., (2020). Mogucnost upotrebe dronova u zastiti Kopnene zone bezbednosti, 15. Medjunarodna konferencija rizik i bezbednosni inzenjering, Visoka tehnicka skola strukovnih studija u Novom Sadu i Fakultet tehnickih nauka, Novi Sad.

Radovanovic M., Petrovski A., Znidrasic V., RanDjelovic A., (2021) Application of the fuzzy AHP -VIKOR hybrid model in the selection of an unmanned aircraft for the needs of tactical units of the armed forces, Scientific Technical Review, Vol. 71, No. 2.

Radovanovic M., Samopjan M. and Petrovski A., (2021). Possibility of Implementation of Drons in Mortar Units in Order to Increase the Efficiency of Fire Support Units, 24.

Medjunarodna DQM konferencija Upravljanje kvalitetom i pouzdanoscu ICDQM -2021, Prijevor.

Rangoa A., Laliberteb A., Jeffrey E., (2009). Unmanned aerial vehicle-based remotesensing for rangeland assessment, monitoring, and management, Journal of Applied Remote Sensing, Vol 3, ISSN 1931-3195.

Shaikh, S. and Rumbaugh, W. (2020). The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense. CSIS.

Thomas, S. and Johnson, K. (2007). GIS enabled modeling and simulation (GEMS), MAK TECHNOLOGIES INC CAMBRIDGE MA,

Vanya L. (2000). Military GIS and Their Application During Training and Education. Presentation material, Budapest ZMNE.

Znidarsic V., Radovanovic M., Stevanovic D. (2020) Modeling the organisational implementation of a drone and counter-drone operator into the Serbian Armed Forces rifle section, Vojno delo, Vol. 72, No. 3.

http://defense-update.com/events/2005/summary/LIC-c4sec.htm

https://www.baesystems.com/en/productfamily/c4isr-systems

https://www.defenseone.com/insights/cards/c4isr-military-nervous-system/

https://www.adsinc.com/news/c4isr-vs-c5isr-what-is-the-difference

https://www.northropgrumman.com/c4isr/

https://www.nap.edu/read/11605/chapter/9