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CONTENT/SADRŽAJ

A Message from the Editor-in-Chief

Serbian Journal of Engineering Management is a scientific journal, published by School of Engineering Management and Society of Engineering Management of Serbia. The Journal is cathegorized by the Ministry of education, science and technological development of the Republic of Serbia. From 2020 the Journal indexed in EBSCO databases. This international Journal is dedicated to the wide scope of themes in engineering management and industrial engineering and is published semiannualy. The papers are presented in English, Serbian and other former Yugoslavian languages.

Themes included in the journal are: Engineering management, Industrial engineering, Project management, Strategic Management, Logistics, Operations management, Production systems management, Quality control, Quality management, Entrepreneurship, Risk management, Human resources management, Financial management, Information systems, High technologies management, Environmental management, Maintenance management, Creative industries management, Security management, and Marketing.

Editorial board is consisted of distinguished academics from various countries dedicated to establishing the highest academic standards and promoting engineering management principles in Serbia.

Information on the journal in English and Serbian can be found at the journal web page: https://fim.edu.rs/en/serbian-journal-of-engineering-management/.

Prof. Dr. Vladimir Tomašević, FRSA

Reč urednika

Serbian Journal of Engineering Management je naučno-stručni časopis, koji izdaje Fakultet za inženjerski menadžment i Društvo inženjerskog menadžmenta Srbije. Časopis je kategorisan od strane Ministarstva prosvete, nauke i tehnološkog razvoja. Časopis je takođe od 2020. indeksiran u EBSCO bazama. Ovaj međunarodni časopis je posvećen temama inženjerskog menadžmenta i industrijskog inženjerstva i izlazi dva puta godišnje (u januaru i julu). Zastupljeni jezici su engleski, srpski, kao i jezici država bivše SFRJ.

Teme zastupljene u časopisu su: inženjerski menadžment, industrijsko inženjerstvo, upravljanje projektima, strategijski menadžment, logistika, menadžment operacija, menadžment proizvodnih sistema, kontrola kvaliteta, upravljanje kvalitetom, preduzetništvo, upravljanje rizikom, upravljanje ljudskim resursima, finansijski menadžment, informacioni sistemi, menadžment u visokotehnološkim industrijama, menadžment životne sredine, menadžment održavanja, menadžment kreativnih industrija, bezbednosni menadžment i marketing.

Uredništvo časopisa čine istaknuti naučnici iz različitih zemalja sveta koji su posvećeni postavljanju visokog akademskog standarda i promocije principa inženjerskog menadžmenta u Srbiji.

Informacije o časopisu i poziv za autore, na srpskom i engleskom jeziku, nalaze se na web stranici časopisa: https://fim.edu.rs/istrazivanje-i-saradnja/naucno-strucni-casopis/.

Prof. dr Vladimir Tomašević, FRSA

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Kvantna bezbednost i 6G kritična infrastruktura

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Apstrakt: Sredinom 2030-ih na polju odbrane i komunikacija nacionalne bezbednosti kvantni računari i 6G veštačka inteligencija će imati prevalst. 6G komunikacija je prihvaćena u različitim mobilnim poređenjima podataka koja se prenose spektralnim tehnologijama. Ljudsko telo postaje deo mrežne arhitekture 6G. Skup mrežnih čvorova ili nosivih uređaja, ugrađeni senzori ili nanodi prikupljaju poverljive informacije koje se razmenjuju u više svrha, kao što su zdravlje, statistika i bezbednost. Važan deo nove paradigme 6G biće inteligentne reflektujuće površine, kvantna teleportacija, kvantno šifrovane poruke, 6G holografija, distribuirana knjiga, 6G bezbednosne pretnje. 6G bežični standardi omogućiće brzu Internet komunikaciju u vremenskom pojasu u realnom vremenu sa podacima od 1TB u sekundi. Mreže radio frekvencija, THZ komunikacije, molekularne komunikacije i kvantne komunikacije dramatično će poboljšati brzine prenosa podataka.

Ključne reči: 6G kvantna bezbednost, kvantna metrologija, kvantna teleportacija, 6G šifrovane poruke, 6G holografija, ljudske veze 6G ere, 6G bezbednosne pretnje, 6G harmonija,

Quantum Security and 6G Critical Infrastructure

Abstract: In the mid 2030-s in the field of defense and national security communications the quantum computers and 6G artificial intelligence will have domination. 6G communication is accepted in a variety of mobile data comparts transmitted through spectral technologies. The human body becomes a part of the 6G network architecture. A set of network nodes or wearable devices, embedded sensors or nanodes collect confidential information that is exchanged for multiple purposes, such as health, statistics, and safety. An important part of the 6G new paradigm will be intelligent reflective surfaces, quantum teleportation, quantum encrypted messaging, 6G holography, distributed ledger, 6G layer security threats. The 6G wireless standards will allow real-time time zone high-speed internet communication with 1TB data per second. The radio frequency networks, THZ communications, molecular communications, and quantum communications will dramatically improve data rates.

Key words: 6G quantum security, quantum metrology, quantum teleportation, 6G encrypted messaging, 6G holography, human-bonds 6G era, 6G security threats, 6G harmony,

1. Introduction

A single quantum computer is more powerful than all supercomputers in today's world. In theory, if quantum computing is fully mastered, it will be very dangerous to the state critical infrastructure, due to the very difficult nature of protecting networks, databases or artificial intelligence. Armed conflicts can be fought on a larger scale than ever before and faster than humans can understand the threat to national security. It is now the subject of ongoing debate in the world of standards such as immutability, privacy protection, transparency, verifiability, anonymity, and the functionality of quantum technologies. The cyber attacks on existing artificial intelligence systems; the implementation of artificial intelligence in conventional military wars is a greater overall threat to national security.
Cyber attacks against individuals, businesses and governments for destruction in such a way that puts a great strain on artificial intelligence databases. The pace of operation and engineering challenges of quantum mechanics and the rapid development of quantum computers double the number of qubits on quantum computer processor chips every six months.

2. Review

6G warranty for hyper-connected world

6G is considered to be a complete connecting fabric, the nodes of which range from satellites to the interior of the human body. This ultra-dense network of heterogeneous nodes often provides tons of highly confidential information.The 6G will have a password to enter the connection of the world. These combinations of billion devices and nodes on the land, in the marine, and space providing a high bandwidth, high density and cloud intelligent security functions (Ylianttila et al., 2020). 6G containers are grouped into pods, each pod consists of multiple containers on a single quantum machine.The 6G traffic gateway (Boixo et al., 2014) and container technology meet the needs of security functions with ultra fast restart, with enhanced utilization, and storage.

The performance constraints of common internet of things - IoT devices, the offload of computing, storage, and network features to other nodes will increase and eventually become a common place feature of 6G. A reliable and low latency throughput is estimated, it is natural that a variety of 6G calculations will be both off-load from the terminal to the IoT network and off-load from the network to the network. Specific terminals or data centers of customer facilities in factories, smart cities, and smart hospitals.

Quantum Computing Security

A cyber attack on a top secret database or on a power grid database can result serious infrastructure damage and massive human casualties (Kline and Salvo, 2019). A large-scale cyber attack can cause more damage than the use of hard-force by conventional methods of weaponry. Code-breaking and public-key encryption vulnerabilities make users more susceptible to cyberterrorism threats. Cybersecurity could be a threat to quantum computing (Table 1). A vulnerable cyberattack that does not send a message to the optical particles of the network using quantum.

Table 1. Quantum Security in 6G Architecture

Quantum Security in 6G Architecture
Wide-area trust management across multiple trust domains
Privacy trust systems protection
AI anonymization
High network scalability and different forms of active malicious attacks
Artificial intelligence dynamically adjust physical layer security algorithms
Access security (inbound, outbound gateway endpoint security
Cloud security edge cloud central cloud
Automation vision based on full visibility
Leverage AI to provide complete end-to-end real-time protection
Challenging characterized by high network scalability

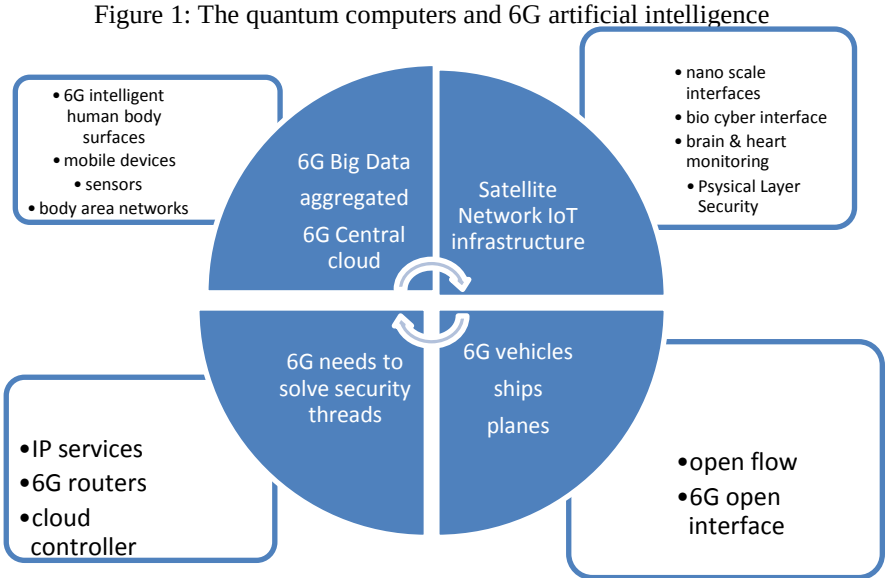
(Source: author)

The implications of artificial intelligence and quantum computing are enormous. The enormous capabilities and vulnerabilities of intelligence in these two fields over cyber warfare can be exploited as a big advantage among new battlegrounds in cyberspace. The purpose of the efficient feedback control is to adapt the idle time to a given value for learning the change of the traffic dynamics by the constitutive intelligence. The capabilities of these threads, whether passive or active, help to identify and protect the artificial intelligence against cybersecurity attacks. The importance of this process is the ability to effectively manage multiple current threads while simultaneously performing high-traffic tasks such as data transfer.

6G artificial intelligence

Quantum computers exist in multiple "states" at once, exploiting the unique qualities of subatomic particles rather than manipulating bits. Quantum computers can manipulate these particles to perform many calculations at the same time, which speeds up solving complex problems such as cracking encryption. More companies are using machine learning and other tools to build algorithmic trading systems that learn from data without resorting to rule-based systems (Merat and Almuhtadi, 2015).

Figure 1: The quantum computers and 6G artificial intelligence



(Source: author)

The evolution of artificial intelligence and quantum computing in modern warfare will also have an impact on security (Allen and Chan, 2018). The digital artificial intelligence must resist the future attacks to secure cyberspace. The artificial intelligence can harm as a weapon. However, the current encryption measures will be outdated. With the adoption of data scientists, advances in cloud computing, and access to an open-source framework for the artificial intelligence (Figure 1) quantum computing machine learning model, big banks are already developing self-learning algorithms.

Traditional algorithms are created by programmers and quant strategists, but these algorithms, based on if/then rules, use machine learning to learn the best trading patterns and pass them on to machines to automatically update the algorithms without human intervention. Instead of using mathematical complexity to encrypt messages, it relies on certain rules of quantum physics. With quantum information, you can't copy it or cut it in half, and you can't even see it without changing it. This allows for much more secure encryption than it is today.

6G quantum internet

Quantum internet will demonstrate the integration of the first of both sub-systems, pushing the frontier of technologies for both end nodes such as trapped ion qubit, diamond NV qubit, neutral atomic quantum bit and quantum rare earth-based memory repeaters, atomic gas. This makes the leap from a simple point-to-point connection to the first multi-node network. The major possible features for memory-based quantum repeaters.

Performance constraints of common IoT devices, increased offloading of computing, storage, and network features to other nodes, will eventually result in a common place feature of reliable and low latency 6G. This ultra-dense network of heterogeneous nodes often provides very sensitive information. It is natural that the various 6G calculation will be both loaded from the terminal to the IoT network. 6G is considered to be a complete connecting the nodes from satellites (Björnson, 2019) to the human body or to the smart customer facility as hospital, factory or smart city.

The 6G potential technologies

Cyberattacks on a top secret databases and power grid databases can cause serious damage to infrastructure and to massive human casualties. The main cause of cyber attacks can be traced back to software that guarantees system errors, rather than other causes such as hardware intelligence. This type of failure can result in problems such as firewalls or security programs, which can lead to repeated task management errors and incorrect threads in the soft process (Gyongyosi and Imre, 2019). A new

6G cyber security technologies (Table 2) will make users more susceptible to quantum computing cyber threats against code-breaking vulnerability and public key encryption.

Table 2. The 6G potential technologies

The 6G potential technologies
New meta data commands
The cross layer design breaks the end to end principle
High precission synchronisation
Multiplex advanced network functions
Multipath transmission
New network protocol architecture
New internet architecture
Cannot guarrantee future application delivery contrains such as deterministic throughput, metric or security details or ultra low latency
Distributed artificial inteligence
Communication catching control
Local patterns sent to central cloud
Obtaining global model
New classification ITU International Telecommunication Union
The evolution of connectivity ultra-high speed, large capacity, and low latency
Development of new frequency bands including terahertz frequency
Providing ultra-low energy and ultra-low cost communications
6G devices-connectivity

(Source: author)

The impact of artificial intelligence and quantum computing of cyber warfare can be exploited as a major advantage among new battlefields in cyberspace. The large-scale cyberattacks can cause more damage than the use of hard force by conventional weapon methods. The purpose of efficient feedback control is to adapt the idle time to a given value to learn changes in traffic dynamics by cognitive intelligence (Latva-aho and Leppänen, 2019). High-traffic tasks data transfer protection can effectively manage multiple threads. The firewall is excluded because of either passive or active attacks that can be initiated within the security. The functionality of these threads helps simultaneously to identify and protect artificial intelligence from cyber security attacks perimeter.

Quantum teleportation

The easiest way to understand the concept of the quantum Internet is through the concept of quantum teleportation. The possibility of a space-based quantum internet where satellites continuously broadcast entangled photons down to the Earth's surface. In quantum teleportation, two people who want to communicate share a pair of intertwined quantum particles.

Through a series of operations, the transmitting side can transmit any quantum information to the receiving side. It can't do faster than the speed of light, but it's a common misconception. The central research question is how best to distribute these intertwined pairs to people distributed around the world.

Hand in hand with hardware development, quantum internet industry partners have verified elementary safe quantum cloud computing platform verified by a large-scale simulation of the pan-european quantum Internet (EU, 2015). The design of the blueprint architecture is providing fast and reactive control when used in the real world.

Quantum encrypted messages

A space-based quantum internet is a new type of computer based on quantum physics could break modern cryptography (Bernstein and Lange, 2017). In quantum encrypted messages, the shared key is discarded and everyone is alerted about the compromised an ultra-secure communication network. The current artificial intelligence systems are starting to see data breaches from unknown sources because of insecure centralized servers that hold valuable information. An artificial intelligence will be used not only to implement complex problem solving and reasoning skills like humans, but also weapon systems that can have fully autonomous capabilities. If this growth pattern continues, qubit processors will be able to decipher the one of the most widely cryptographic system, the Rivest–Shamir–Adleman tool.

The singularity of a quantum superposition, where the quantum properties of an object occupy multiple states at once, and these quantum states are shared among multiple objects. The future 6G internet are based on these quantum principles. The quantum internet of the future, quantum internet, platforms, quantum ecosystems (Durak et al., 2019), computers and networks, sensors will utilize qubits of quantum information that can take an infinite number of values.

According to the forecast by the International Telecommunication Union (ITU), global mobile data traffic will reach 5 zetabytes by 2030. In 2018, Finland announced the 6G flagship program, the British and German governments invested in 6G potential technologies such as quantum technology, and the United States began research (National Quantum Computing Centre, 2019) on Terahertz-based 6G mobile networks. Autonomous driving will operate the global mobile data traffic and intelligent connection network in next decade.

Three-dimensional 6G environment

An analytical framework designed for two-dimensional wireless communication, derived from probability geometry and graph theory readjusted into a three dimensional environment used in 6G network devices in different applications and 6G communication (Table 3).

Table 3. 6G HARMONY

6G HARMONY
Distributed trust
Cyber Psychical Security
Terraherz Technologies
4D imaging and image projection
Automatic Orchestrated Transceiveres
Haptic Remote Telepresence
Full Spectrum fotonic Processing
Proactive Decissions Making
Non Device Centric Communication
Consent and Privacy Preserving
Support for Ambient Novel Sharing
Small Data AI
Distributed Learning
Informations offering
Data Sharing

(Source: author)

Considering to achieve network optimization of the three dimensional equipment it leads to the realization of advanced beamforming 6G architecture. Some of these notable technologies have been already incorporated these three dimensional schemes are satellites, unmanned aircraft or underwater communications.

Holographic 6G communication

The holographic communication allows transmitting virtual vision of people, events using real sight haptic touch techniques. The environment of holographic technology may implement to the abolition of the open system interconnection network model and the adoption of the inter-layer communication

system design. Such research has led to the creation of a hybrid communication technology that extracts various physical quantities and distributes them to the desired receiver via a safe 6G quantum internet channel.

Holograms are three dimensional technologies that manipulate the rays emitted from an object and capture the resulting interference patterns using a recording device. In fact, just sending a three dimensional image without stereo sound is not enough to depict the face-to-face presence characteristics. In the 6G era (Saad et al., 2019) reconfigution is utilized on the development three dimensional configuration platform used for multiple physical presence. The holographic data and images require consuming reliable 6G network links.

The following aspects of holographic communication are related to the human-bonds 6G era. Focused on a human-corporate 6G bond technology communication using an access to a physical features share and express physical phenomena. As a result, such new techniques facilitate the diagnosis of diseases, the detection of emotions, the collection of biological features and remote interaction with the human body. The design of communication systems that mimic human senses requires interdisciplinary research cooperation.

6G Distributed ledger

Blockchain can provide authentication and access control through optimization of privacy storage data sharing mechanism, ensure integrity, traceability monitoring of characteristic data such as keys in distributed computing architecture, and provide classic encryption.

A distributed system has been developed by the open internet, where the participants are freely separated and become a part of a distributed system. This leaves the trust issues in the end of the system to verify the trust of a service or participant. The traditional solutions are based on the third parties that certify and validate the accuracy of the service.

In many cases, parties cannot agree to a single 3rd trusted party. In practice many 3rd parties are used in parallel to weaken the overall security. Currently, the distributed ledger is a consensus with many alternative mechanisms that can support on trust between all parties. In the distributed ledger is ideal when deterministic facts are immutable.

A 6G distributed ledger will automatically trigger the trust network function based on the evaluated relationship. These autonomous ledger trusts will be able to generate smart contracts. The 6G ledger trust can utilize for different parties long-term operation improvement to facilitate a quality or reliability. A 6G distributed ledger will apply a definitive data into a dynamic trust relationships handled for the definitive responses.

6G Psysical Security Thread

The physical layer security technology is located between the body sensor or hub node. Security algorithm 6G high network scalability, heterogeneous devices in various forms of malicious attacks. Unconfirmed data sets can identify individuals as thresholds and determine whether they are as clear as they are today. This is a major unanswered issue for many digital technologies in different sectors, such as smart healthcare, industrial automation. Furthermore, the theoretical method for developing the maximum achievable secret capacity and secret rate of the physical layer security algorithm is very different from the approach adopted in the conventional system.

The intelligent reflecting surface consists of an array of units that can be used to change the phase, amplitude, or frequency of the incident signal. Typically, the intelligent reflecting surface signals are sent to different antennas. The intelligent reflect surface send a beamformed signals of legitimate users. Attackers inject eavesdropping directly by exploiting the internal lines of malicious software and configuration parameters.

Passive attacks such as eavesdropping on authentication keys, user-specific keys, and short-term session keys can also be easier because they are in vulnerable locations. The algorithm must have high power efficiency and the ability to operate in multi-user scenarios. In particular, the artificial fill signal generation characteristics of these modulation techniques are the most important advantages in

providing physical layer security technology (Panayirci et. al., 2020) as compared to conventional approaches.

6G security protocol

When it comes to data confidentiality and integrity, state-of-the-art encryption itself is considered difficult, but the design of traditional authentication and key distribution in the future is questionable. These many proposals have survived decades of attacks, which are believed to be safe even in classical and quantum settings. Replacing modern asymmetric cryptography with post-quantum secure schemes will cost both the communication and operational efficiency of the network.

The 6G security protocol to provide keyless generates secure communication channels through maximization of secret rate, distributed and coordinated in the network. The 6G symmetric encryption of physical layer security technology can also utilize the unique features of wireless channels to co-generate encrypted communication scenarios. The 6G physical layer security technology based key generation solution is fully distributed and does not rely on fixed parameters designed by a particular entity, but rather on radio channels. To meet the expected performance and functionality of the 6G architecture, research is needed to identify the correct application of post-quantum secure cryptography.

3. Conclusion

Quantum communication using the principles of quantum mechanics will ensure the global security architecture. The quantum computing security paradigm brings a new strategy to client data scenarios of 6G connectivity, privacy laws and data sharing and preventing agreements. The 6G security network environment, combined with the trend of artificial intelligence will take the new constraints of the network dynamic topology and algorithms network security.

The behavior of 6G intelligent physical layer will be dynamically activated. This approach allows communication in terms of low energy consumption and long battery life, complete customization and distributed artificial intelligence structure. Quantum key distribution channels can share keys without the possibility of stealing data.

The future intelligent 6G wireless privacy protection applications will use the different privacy data before privacy sending to the artificially designed final output. The local or national authorities responsible for security will not be able to court with 6G sensors and haptic internet data. An artificial intelligence supported on the quantum computing has a t impact on harmful cyber attacks warfare and will significantly increase the number of threats. The 6G communication security strategy can lead to the definition of new technologies (Arafa et. al., 2019) such as network node computing and energy resources, mobility, network node density, frequency spectrum utilization. Understanding quantum computing artificial intelligence has essential parts like technological advances of artificial intelligence.

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Uticaj sukoba u Nagorno-Karabahu 2020. na percepciju borbenih dronova

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Apstrakt: Upotreba borbenih dronova je aktuelna više od jednog veka. Tek poslednjih godina smo svedoci kako se evolutivni proces sa napretkom tehnologije pretvorio u pravu revoluciju. Sukob u Nagorno-Karabahu 2020, predstavljao je jednu od prekretnica u pogledu primene ove distruptivne tehnologije u borbene svrhe. Kao nikada do sada masovna upotreba borbenih dronova nije presudno uticala na ishod jednog konflikta. Zbog značaja koji pomenuti sukob predstavlja izvršena je SWOT analiza mogućnosti primene borbenih dronova u lokalnim konfliktima. Izvedeni zaključci mogu pomoći kako u razumevanju ishoda sukoba tako i u definisanju pravca kojim će se kretati dalja primena ovih borbenih sistema u budućnosti.

Keywords: UCAV, Nagorno-Karabakh, konflikt, SWOT

The impact of the Nagorno-Karabakh conflict in 2020 on the perception of combat drones

Abstract: The use of combat drones has been existing for more than a century. Only in recent years have we witnessed how the evolutionary process with the advancement of technology has turned into a real revolution. The conflict in Nagorno-Karabakh in 2020 was one of the turning points in the application of this ditruptive technology for combat purposes. As never before, the mass use of combat drones has not decisively influenced the outcome of a conflict. Due to the importance of the mentioned conflict, an SWOT analysis of the possibility of using combat drones in local conflicts was performed. The conclusions drawn can help both in understanding the outcome of the conflict and in defining the direction in which the further application of these combat systems will progress in the future.

Keywords: UCAV, Nagorno-Karabakh, conflict, SWOT

1. Introduction

Armed conflicts around the world in the last few decades imply an increasing use of unmanned aerial vehicles. Massiveness and possibilities of application have led to a real revolution in redesigning something we consider the battlefield of today. Robotic platforms are slowly taking precedence on the battlefield, and their combination with other systems provides the parties to the conflict with new, hitherto unserved ways of military engagement. The use of unmanned combat aerial vehicles (UCAV) or combat drone with the appropriate strategy can largely compensate the lack of combat aviation or make a state that does not represent military force a potentially respectable adversary. With the relatively low cost of the system, UCAV are becoming the subject of interest of a growing number of countries. Of course, systems that are intended to efficiently detect and neutralize combat drones are also beginning to attract a lot of attention.

Drones, in general, are engaged in the implementation of the so-called Dirty, Dull and Dangerous activities (Szabolcsi, 2018; Austin, 2010). What is noticeable is that their role in conflicts is gradually changing, from the role of reconnaissance that is supervision of the territory or the so-called "Dull" missions' activities to direct combat application within the so-called "Dangerous" missions (Austin, 2010).

UCAVs have been used throughout history in numerous conflicts, but it can rightly be said that the conflict in Nagorno-Karabakh in 2020 represents a turning point when analyzing the application of this combat system. Prior to the mentioned conflict, during the past few years, there was a sporadic application of these systems on numerous battlefields by numerous armies or armed formations. For example, the Yemen rebel group Houthi has repeatedly attacked civilian and military facilities in Saudi Arabia with relatively primitive, but extremely effective systems in terms of reputation and political repercussions (Muhsin, 2019). The use of unmanned aerial vehicles by the conflicting parties in Syria was relatively unnoticed. On the intricate Syrian battlefield, the Israeli and Turkish systems caused great damage to manpower and equipment to both government forces and their collation partners. Russian units stationed in Syria, which provide assistance to government forces, were not spared from drone attacks, and the attackers were Syrian rebels (Urcosta, 2020).

2. Review of the problem

A brief history of the Nagorno-Karabakh conflict

Nagorno-Karabakh or Artsakh is a self-proclaimed state of 4,400 km2 on the border of Europe and Asia in the unstable geostrategic region of the Caucasus. The conflict for independence of Nagorno-Karabakh began in 1988, when the ethnic majority Armenians, with the help of the Socialist Republic of Armenia, decided to secede the territory that was part of the Socialist Republic of Azerbaijan and create an independent state. The conflict, which caused great destruction and numerous human casualties, ended in 1994 with the formation of an autonomous region that covered 20% of the territory of Azerbaijan (Schiop, 2016).

During 2008 and 2014, more intense conflicts erupted, as the solution offered by the OSCE Minsk Group did not bring lasting peace and a solution to the conflict, but only an immediate cessation of hostilities. The most intense conflict broke out between April 2 and 5, 2016. During the Four-Day War, about 200 people were killed on both sides. The Azerbaijani side achieved certain minimal territorial gains, but a far more important consequence of the Four-Day War is the awareness of Azerbaijan that they can regain the areas occupied by the Armenians by military means (Bayramov, 2016). During the conflict, Azerbaijan successfully used several types of combat unmanned aerial vehicles such as "IAI Harop" (kamikaze UCAV), "ThunderB", "Orbiter 2M", "Aerostar", "Hermes 450" and "Heron-1". On the other hand, the Crane combat drone, used by Armenian forces had more modest capabilities than the aircraft used by the opposing side (Urcosta, 2020). The four-day war and the lessons learned from it by the Azerbaijani side were the foundation of what would happen four years later.

Prelude to the conflict

After the end of the 1994 conflict and the armistice, which did not result in a sustainable peace agreement, it was certain that a ruthless arms race would begin between Armenia and Azerbaijan, because the question was not whether the conflict would occur, but when and under what circumstances. As time went on, that race gained more and more intensity. During 1999, the completion of the Baku-Supsa and Tbilisi-Ceyhan pipelines in 2006, as well as the commissioning of the Baku-Tbilisi-Erzurum gas pipeline in the same year, enabled Azerbaijan to export its natural resources outside Russia, which led to economic empowerment in Azerbaijan (Güneylioğlu, 2017).

Thanks to abundant oil reserves, Azerbaijan's military spending increased from $175 million in 2004 to $3.1 billion in 2011. If we look at the defense expenditures from the GDP hourly, Azerbaijan set aside 6.2% for those purposes in 2011, while at the same time Armenia's expenditures amounted to around 4.1%. It is important to point out that although the Azerbaijani Armed Forces have doubled their military potential, the Armenian side has enjoyed the benefits of its military cooperation with Russia, from which it has received superior systems in certain segments from its rival. At the same time, Armenia has secured the presence of some 3,000 Russian soldiers at the Gyumri military base on its territory, as well as the missile command center as a result of cooperation between the Armenian Armed Forces and the Russian 102nd military base in that country (German, 2012).

At the same time, it should be noted that Russia has been trying all these years to preserve the frozen conflict without the interference of the West, primarily the United States. It even actively tried to appease Azerbaijan by insisting on diplomatic negotiations that would resolve the status of the disputed Nagorno-Karabakh region, and did not refrain from selling military weapons and military equipment to

Azerbaijan, despite good relations with Armenia, a member of the Collective Security Treaty Organization (CSTO) which is a counterpart to the NATO pact (Güneylioğlu, 2017).

The Velvet revolution that engulfed Armenia in 2018, led to the gradual rapprochement of Armenia with the west, and such development of situation was not well accepted by Russia. The newly elected Armenian Prime Minister Nicole Pashinian tried to apply a balanced approach towards the EU and Russia. Unfortunately, events such as the arrest of the arrest of CSTO Secretary General Yuri Khachaturov on July 26, 2018 for trying to overthrow the constitutional order did not meet with Moscow's understanding. This has led to serious problems in terms of military cooperation between Armenia and Russia (Makarov, 2018).

During 2010, Azerbaijan and Turkey signed two important agreements - the Strategic Partnership and Mutual Assistance Agreements as a kind of response to the agreement allowing the presence of Russian troops on Armenian territory, as well as the agreement on the establishment of the Turkish-Azerbaijani Strategic Cooperation Council. These agreements enabled the strengthening of military-technical cooperation between the two countries, as well as the possibility of providing military assistance if any of the signatory states is attacked by a third party (German, 2012).

The focus of the Armenian side was on strengthening air defense and procuring ballistic missiles as a means of deterring a potential attempt by the opponent to conquer the disputed area militarily. The idea of procuring ballistic missiles was to target power plants and other infrastructure in the event of a renewed conflict, which would thwart the long-term trend of Azerbaijan's economic development. Armenia was counting on Azerbaijan to have a lot to lose if it decided to launch military operations against the breakaway region (Güneylioğlu, 2017).

Table 1. Military spending by Azerbaijan and Armenia in USD millions (2000 – 2016)

Country	2000	2002	2004	2006	2008	2010	2012	2014	2016
Azerbaijan	255	311	470	1130	1653	1382	2728	2770	1932
Armenia	147	142	180	260	354	385	362	413	423

(Source: Babayev, 2019)

Table 2. Military spending by Azerbaijan and Armenia in USD millions prior 2020. Nagorno-Karabah war

Country	2017	2018	2019	2020
Azerbaijan	1530	1710	1790	2270
Armenia	430	500	640	640

(Source: Sarukhanyan, 2020)

On the other hand, Azerbaijan was buying large quantities of arms not only from Russia, but also from other countries especially Israel and Turkey. Between 2006 and 2019, Azerbaijan obtained 825 million US dollars' worth weapons from Israel. Those export arrangements included very sophisticated systems such as surface-to-air missile system, anti-tank missiles, loitering munitions and what it was most important large quantity of various types of UCAVs (Pérez, 2020). Turkih export of arms to Azerbaijan was approximately 123 million US dollars in the first nine months of 2020 before the fighting began. Most of the procurement was combat drones, rocket launchers, and various types of ammunition (Toksabay, 2020).

Azerbaijan realizes that sophisticated weaponry is the key to potential success in attempt to regain lost territories during 1988-1994 war. In Table 3 and Table 4, both sides modern arsenal of missiles, UCAVs and rockets is presented prior to 2020 war (Shaikh and Rumbaugh, 2020). Only partial look on data presented in Table 3 and Table 4. demonstrate how huge is the disparity when we compare arsenal of modern military combat drones owned by conflicting nations.

Table 3. Armenian armament (missiles, UCAVs and rockets)

Weapon	Notes	Number	Origin	Purchased / Introdused
9K79 Tochka-U (NATO: SS-21Scarab)	Ballistic missile, 120 km range	4 launchers	Soviet Union	/
Iskander-E (NATO: SS-26 Stone)	Ballistic missile, 300 km range	8 launchers / 25 missiles	Russia	2016.
SS-1C Scud B	Ballistic missile, 300 km range	8 launchers / 24 missiles	Soviet Union	/
X-55	Reconnaissance UAV	Unknown	Armenia	2014.
HRESH	Loitering munition	Unknown	Armenia	2018.
Krunk	Reconnaissance UAV	Unknown	Armenia	2011.
Orlan-10	Reconnaissance UAV	Unknown	Russia	2020.
BM-30 Smerch	300 mm MLRS, 90 km range	6 launchers	Russia	2015-2017.
NORINCO WM-80	273 mmMLRS, 120 km range	4-8 launchers	China	1999.
TOS-1A	220 mm MLRS, 6-10 km range	Unknown	Russia	2016.
BM-21 Grad	122 mm MLRS	Unknown	Russia	1995-1996.

(Source: Shaikh and Rumbaugh, 2020)

Table 4. Azerbaijan armament (missiles, UCAVs and rockets)

Weapon	Notes	Number	Origin	Purchased / Introduced
LORA	Ballistic missile, 280 km range	4 launchers / 50 missiles	Israel	2017-2018.
9K79 Tochka-U (NATO: SS-21Scarab)	Ballistic missile, 120 km range	3-4 launchers	Soviet Union	/
EXTRA	Guided missile, 150 km range	6 launchers / 50 missiles	Israel	2005-2009.
Bayraktar TB2	Tactical UAV	Unknown	Turkey	2020.
Harop	Loitering munition	50	Israel	2014-2016.
Orbiter 1K	Loitering munition	80	Israel	2016-2019.
Orbiter 3	Loitering munition	10	Israel	2016-2017.
SkyStriker	Loitering munition	100	Israel	2016-2019.
Hermes-900	Tactical UAV	2	Israel	2017-2018.
Hermes-450	Tactical UAV	10	Israel	2008-2013.
Heron	Tactical UAV	5	Israel	2011-2013.
Aerostar	Surveillance UAV	14	Israel	2007-2012.
Searcher	Reconnaissance UAV	5	Israel	2011-2013.
Antonov AN-2	Converted to UAV	Unknown	Soviet Union	/
BM-30 Smerch	300 mm MLRS, 90 km range	30-40 launchers	Russia	2003-2005.
T-300 Kasirga	300 mm MLRS, 120 km range	20 launchers	Turkey	2015-2016.
Belarusian Polonez	300 mm MLRS, 200 km range	10 launchers	Belarus	2017-2019.
TOS-1A	220 mm MLRS, 6-10 km range	36 launchers	Russia	2011-2017.
T-300	300 mm MLRS	20 launchers	Turkey	2015-2016.
T-122	122 mm MLRS	40 launchers	Turkey	2010-2014.
T-107	107 mm MLRS, 11 km range	30 launchers	Turkey	2010-2013.
RM-70	122 mm MLRS	30 launchers	Czech Republic	2016-2018.

Source: (Shaikh and Rumbaugh, 2020)

Conflict

The conflict over Nagorno Karabakh 2020 began on September 27, 2020 with the attack of Azerbaijani units on Armenian positions under the pretext that it was a response to the bombing of villages from the territory of Karabakh by the Armenian side (Ergun and Aliyev, 2020). The conflict that lasted for 44 days ended on November 10, 2020, with the acceptance of the peace agreement. About 4,000 people were killed during the conflict on both sides, mostly on the Armenian side, due to the massive use of UCAVs in war operations (Westad, 2021). Under the peace agreement signed by Russia, Azerbaijan and Armenia, Azerbaijan will retain control of the areas it regained control of during the conflict, as well as seven neighboring territories occupied by Armenia during the conflict that ended in 1994. Armenian military units have pledged to leave Nagorno-Karabakh and neighboring territories. This agreement should enable the return of displaced people during past conflicts in this area (ACAPS, 2020).

Five reasons significantly influenced Azerbaijan to start its military actions. These reasons include a lack of progress on peace talks, the consolidation of the Azerbaijani military, the ineffectiveness of the OSCE's Minsk Group, Turkey's desire to become a regional power and Russia's suspicion of the new Armenian authorities who have occasionally expressed pro-Western rhetoric. The conflict was certainly preceded by a kind of tacit agreement between Russia and Turkey by which each side would satisfy some of its aspirations (Ergun and Aliyev, 2020).

The UCAVs at the disposal of the Azerbaijani side played a key role in this conflict. Their widespread use provided an opportunity for Azerbaijani forces to carry out surgically precise attacks far from the front lines and to detect, monitor, and destroy all those targets that pose a danger to the development of the situation on the battlefield. Unmanned combat aerial vehicles were integrated with the air force, artillery units, but they are also very often used independently to attack certain targets. According to available data, the combat drones contributed to the destruction of numerous combat systems at the disposal of the Armenian forces. Their penetration into the background of Nagorno-Karabakh weakened Armenian supply lines and logistics. 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 key advantages of combat unmanned aerial vehicles over manned aircrafts are reflected in lower costs (financially and humanly), and this is undoubtedly one of the reasons for the mass use of unmanned aerial vehicles in the war around Nagorno-Karabakh in 2020. The price for Turkish Bairaktar TB2 UCAV is about five million US dollars. On the other hand, a modern fighter jet costs several tens of millions of dollars. The possibility of carrying a large amount of ammunition by fighter planes cannot be compared to TB2. But on the other hand, lower procurement and maintenance costs, as well as the lack of a man in the cockpit, have led to the loss of UAVs being more easily compensated (Ho, 2020). In the first days of the war, Azerbaijan used obsolete An-2 planes that were turned into drones as bait for Armenian air defense systems. Since the air defense unit would reveal its position by acting on the bait plane, Azerbaijan would send drones to detect the targets and then the observed targets would be acted upon by armed UCAVs or kamikaze UCAVs (Dixon, 2020). Armored vehicles, together with other ground combat systems represent easy target for unmanned aerial systems (UAS) in the absence of mobile and self-propelled air defense systems, electronic warfare systems and anti-UAS systems. Combat drones have to execute intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) missions in order to obtain the necessary information for the precise operation of various artillery weapons (Kasapoglu, 2020).

The most modern air defense systems available to the Armenian side were the S-300PT and PS series and the 9K37M Buk-M1 and they were not capable to detect, identify and track slow-moving targets such as combat drones. It should be noted that Armenia has export versions of these air defense systems with somewhat limited possibilities, especially in terms of plot fusion (Gressel, 2020). Azerbaijani military has effectively used UAS, to deal with the Armenian air defenses. Laser-guided smart munition system played a main role in the suppression of enemy air defenses (SEAD) campaign. In the first two weeks of the ongoing clashes, the Azerbaijani Armed Forces destroyed some 60 pieces of Armenian air defenses (Kasapoglu, 2020).

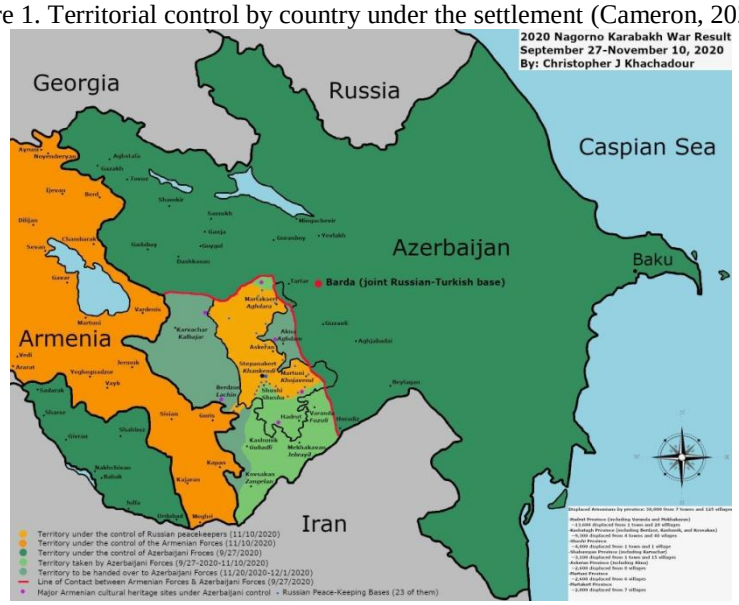
The Armenian side in the conflict did not have electronic jammers that could interfere with the signals connecting the UCAVs with their guidance stations. Just before the end of the conflict, Russia used the

Krasukha electronic warfare system from its military base on the territory of Armenia, Giumri, in order to prevent Azerbaijani reconnaissance in the depths of Armenian territory. It is important to note that in such circumstances, Azerbaijani forces relied on Israeli kamikaze Harop drones, with relatively reduced efficiency since they do not require a guidance link (Gressel, 2020).

Back in 2010, Azerbaijan acquired the ultralight reconnaissance drone Orbiter from Israel, followed by orders for the larger Elbit Hermes 450 and IAI Searcher aircraft, which were used for reconnaissance purposes. When the potentials of the UCAVs were considered and their application was mastered in the middle of the decade, heavier UCAVs with greater flight autonomy were purchased - IAI Heron and Elbit Hermes 900. In the conflicts of 2016 and 2020, these combat drones were actively used for reconnaissance and fire control (Yermakov, 2020). The Israeli Harop loitering munitions (or kamikaze UCAV) prove to be very efficient system. Harop main features are great autonomy, with, or without human interaction, and anti-radiation capabilities which proved to be very useful during the attacks on Armenia Air Defense units (Kasapoglu, 2020). Azerbaijan has also come into possession of a number newer kamikaza drones models such as the Aeronautics Orbiter 1K, the Elbit SkyStriker and the Turkish kamikaze quadcopter STM Kargu (Yermakov, 2020).

During June 2020, shortly before the outbreak of the conflict, information began to circulate about the purchase of the Turkish UCAV Bayraktar TB-2 by Azerbaijan. During September, the first recordings made during the operation of these combat systems were published, which seriously calls into question the ability of the Azerbaijani units to fully master the use of this system for a short time. Based on the testimony of Russian units that carried out electronic jamming of these UCAVs near their base in Armenia, there are indications that the combat drones were operated by Turkish units during the conflict (Frew, 2021). It seems that Turkish engineers have made a good unmanned aerial vehicle from what is available on the market, but far from the levels of the most developed countries in that field. The aircraft is distinguished by good flight duration, the ability to carry munitions in the form of MAM-L and MAM-C guided mini-bombs, an anti-tank missile and a 70-mm rocket, but it is also characterized by a small range and the absence of satellite communications channel (Yermakov, 2020). According to the data of the defense world net, the losses of the Armenian side caused by the UCAVs of Azerbaijan are estimated at about 1 billion dollars in technology. The destroyed equipment includes 84 tanks, 27 infantry fighting vehicles, 5 radars, 25 multiple launch rocket systems, 32 howitzers, 155 different types of vehicles, 18 air defense systems, etc. (Rakesh, 2020).

Figure 1. Territorial control by country under the settlement (Cameron, 2020).



Shift in combat drone perception as a result of the Nagorno-Karabakh conflict in 2020

The Nagorno-Karabakh conflict in 2020 largely affected the situation on the arms and military equipment market. During the conflict, the Armenian side placed its hopes in ties with Russia, an obsolete weapon and a strategy to deter a potential attack, while on the other hand, the Azerbaijani side has been investing in modern weapons, primarily drones, for years. It should be noted that investing in drones without proper tactics of use does not mean much, and the Azerbaijani side possessed both the

technique and the appropriate strategy. What resonated in military circles was a demonstration of how a small country that is not known as a world power can do on the battlefield with the mass use of drones. There are fears that some currently frozen conflicts could come to life if one of the conflicting parties comes into possession of the technology used during the Nagorno-Karabakh conflict (Roblin, 2020).

Countries such as Ukraine, Estonia, Belarus, Armenia, Azerbaijan, and Kazakhstan have shown interest in using UCAVs developed with their own production capacities. It is worth noting that many NATO members possess insufficient tactical attack drones in their arsenal (Hambling, 2020). Faced with war on its own territory, during 2019, Ukraine signed a $69 million deal with Turkey to buy six Baykar TB2s and showed interest in starting its own production of the combat drones (Bershidsky, 2020).

Analyzing the outcome of the conflict in the instinctual Karabakh, British military officials came to the conclusion that they needed cheap UCAVs like the ones used by the Azerbaijani side in the conflict. They also expressed the belief that the mentioned use of combat drones was crucial for the outcome of this conflict (Sabbagh, 2020).

The focus on brutal military power has been shaken in the eyes of India after the conflict between Azerbaijan and Armenia in Nagorno-Karabakh in 2020. Faced with growing tensions with Pakistan and China, India is becoming aware of the situation that it has a small arsenal of UCAVs intended for reconnaissance as well as loitering ammunition. India intends to focus on technologically complex combat systems that it is able to develop on its own, which would reduce dependence on foreign factors (Snehesh, 2020).

3. SWOT analysis of the applicability of combat drones in local conflicts

The presented SWOT analysis is the result of an analysis of the mass use of UCAVs in conflicts around the world with a focus on the conflicts over the past decade (war in Syria, war in Yemen, and finally conflict over Nagorno Karanbach in 2020). The mentioned conflicts, and especially the conflict between Armenia and Azerbaijan, demonstrated the extent to which combat drones can be crucial for the outcome of the armed conflict.

Strengths

Combat drones have low purchase and operation cost compared to other systems.The MQ-9 Reaper American combat UCAV has a purchase price of $ 6.48 million and an operating cost of close to $ 3 million. The hourly rate is $ 3,250 per hour. Compared to the MQ-9 Reaper, the fifth-generation F-35 Joint Strike Fighter is priced at $ 91 million per aircraft, its operating costs are $ 5 million and the cost per flight hour is $ 16,500 (McLean, 2014).

Using unmanned combat drones, it is possible to attack targets anywhere on the planet without putting the pilot in danger (Dowd, 2013). A standard manned fighter aircraft in the event of a crash not only endangers the pilot's life, but can cost the country diplomatic humiliation. Hiring UCAVs reduces potential political risk (Qaisrani et al., 2016).

UAS are capable of performing different types of missions. These include Intelligence, Surveillance, Reconnaissance and Strike mission. In the near future, the mentioned missions will probably be expanded to Resupply, Combat Search and Rescue, refueling and Air Combat missions (Rudaski, 2014). Improving UCAV performance can certainly affect the withdrawal from use of some older manned combat aircraft. Table 5. shows the characteristics of some of MALE and HALE class drones in terms of ceiling, flight endurance and speed (Adamski, 2020). It is noticeable that UCAVs are characterized by extremely high flight endurance.

Table 5. MALE and HALE classes of military drones characteristics

UCAV	Ceiling [ft]	Flight Endurance [h]	Maximum Airspeed [kt]
Global Yabhon	50 000	40	740
Mantis	50 000	36	555
MQ-1B Predator	25 000	40	222
MQ-9 Reaper ER	50 000	42	444
Wing Loong	23 000	20	281
Jabhon-United 40	26 000	100	200

(Source: Adamski, 2020)

Combat drones have the ability to fly at extremely low altitudes, which makes them a very difficult target for the enemy (Szabolcsi, 2020). In the analysis of the conflict in Nagorno Karabakh in 2020, it is noticeable how much this characteristic of military drones in combination with low flight speed was an obstacle for the Armenian Air Defense.

Weaknesses

Combat drones have a lower ability to carry combat payload compared to manned combat aircraft. They are also limited in terms of the weight and size of the sensor, which primarily refers to the possibility of carrying radar with a longer range. UCAVs are very slow and their engines are very noisy, which greatly facilitates their detection. Their low speed causes greater exposure to enemy fire, but it can also be considered an advantage when considering the possibility of detecting the aircraft with less modern radar systems.

The drones are also limited by the weather conditions during the operation, whether they are extreme temperatures, fog, rain, wind, etc. (Yaacoub et al., 2020). Dynamic weather conditions have a great influence on the behavior of the aircraft itself (Shahzaad, 2021). During military operations in Nagorno-Karabakh, the presence of UCAVs was noticeably lower during bad weather.

Enemy combat drone detection techniques include: Audio detection, Video detection, Motion detection, Thermal detection, Radar detection and RF Detection. Anti-drone countermeasures include modern laser systems such as: Advanced Test High Energy Asset (ATHENA), Rafael Drone Dome, Boeing Compact Laser Weapons System (CLWS) and others (Yaacoub et al., 2020). Table 6. presents various countermeasures against drones, and their limitations (Guitton, 2021).

Table 6. Countermeasures/limitation against drones

Countermeasure	Effect on target	Limitations/vulnerability
Direct fire	Destruction	Size of drone; Number of targets; Visibility.
Hunting drones	Destruction	Number of targets; Visibility; Inherent drone weaknesses; Deployment time
Missiles	Destruction	Costs
Laser weapons	Destruction	Atmospheric conditions; Smokescreens; Target's coating
Microwave weapons	Disabling	Sealing of electronics
Electronic jamming	Disabling /Control taking	Sealing of electronics
Defending drone swarm	Destructions/Disruption	Lack of accurate response; Deployment time

(Source: Guitton, 2021)

During the conflict in Nagorno Karabakh, the Russian S-300, Tor, and Osa missile systems proved ineffective in the fight against Azerbaijani UCAVs, primarily due to the inability of their radars to detect drones produced by Israel and Turkey (Shahbazov, 2020).

Opportunities

There are expectations that world spending related to research, development and procurement of UCAVs will increase from 11.1 billion dollars in 2020 to 14.3 billion by 2029, which represents adoption by almost 30 percent (Harper, 2020). Israel, the United States, and China are the leading manufacturers of combat drones (Chamola et al., 2021). The United States has supplied UCAVs exclusively to NATO members for many years. From 2018, India becomes the first non-NATO country to procure sophisticated American equipment. Israel is the largest exporter of military drones in the world. Israel's contractual obligations are accounted for 41 percent of all drones reported between 2001 and 2011. China is increasingly present as an exporter of combat drones thanks to its liberal export policy. Their biggest customers are countries like Pakistan, Iraq, Nigeria, and others (New America, 2020).

During 2018 in Syria, the Russian base Hmeimim came under attack by low-tech home-made combat drones made by Syrian rebels (Sly and Zakaria, 2018). Although no major damage was caused, the mentioned attack is proof that even with the help of simple drones made without the use of high technology, the desired goal can be achieved. There is a large offer of equipment on the market today that can be used to make modern drones. For example, Turkish UCAVs are made from commercially available components from various manufacturers - electronic circuits are made in Great Britain, aircraft engines in Austria, and optoelectronic equipment is of Canadian origin (Yermakov, 2020).

The purchase of combat drones from foreign sources has the consequence that the countries that have been using the mentioned solutions for many years are starting to develop their own models and thus improve their defense industry. As a result of military cooperation with Israel, for example, Azerbaijan managed to independently develop the Zerbe (Strike) drone, which is irresistibly reminiscent of the Israeli Orbiter 1K (Shiriyev, 2016). UCAVs can serve as a quick and effective response to a potential threat. Whether it is reconnaissance of the movements of enemy units, or surgically precise strikes on targets both on the front line and far behind the lines of enemy forces.

The latest conflict in Nagorno-Karabakh has shown that combat drones can also be a powerful weapon of propaganda. Numerous UCAV strikes have been publicly broadcast online or via billboards in the Azerbaijani capital Baku (Shaikh and Rumbaugh, 2020). Every moment of destruction of either military equipment or attacks on soldiers in the trenches was accurately recorded, and brutal footage of individual strikes was even created from several different angles in high resolution. Footage of combat drone strikes on Armenian infantry units trying to help wounded comrades who were already victims of the previous attack was often broadcasted. It should have created the impression that there is no hope that you can hide from the blow that can happen at any moment and from which there is no effective protection.

Threats

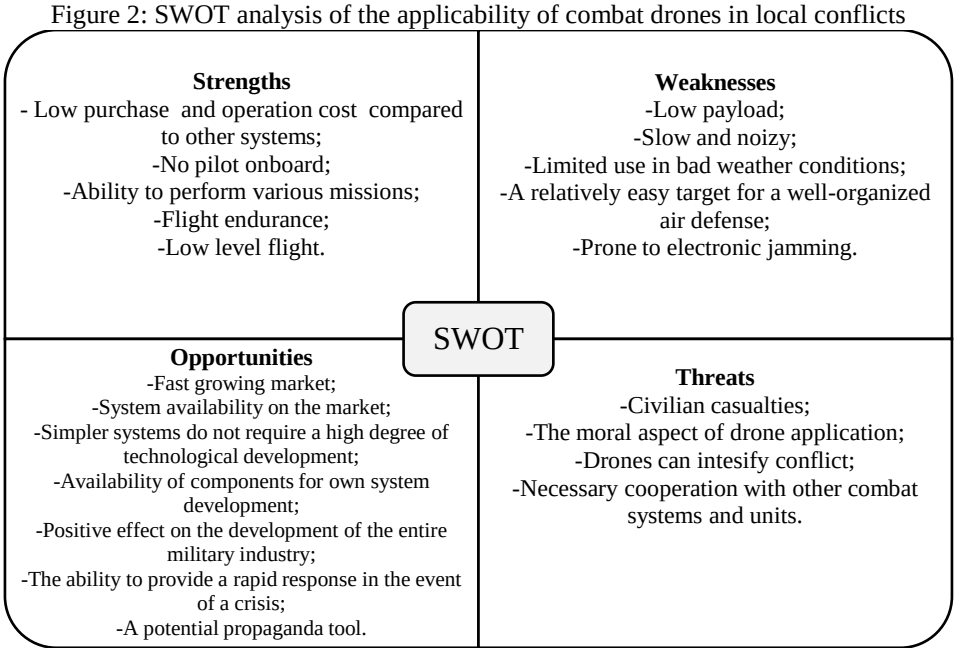
The use of UCAVs in conflicts around the world often results in numerous civilian casualties, despite high-quality sensors that can accurately monitor the situation on the ground. So when it comes to even individual military operations, civilian casualties are numerous. Thus, according to research by human rights organizations, 1,141 people were killed in US drone attacks targeting 41 people (Vacca and Onishi, 2017).

The conflict in Nagorno Karabakh in 2020 was characterized by the intensive application of the so-called “loitering munition” systems. Loitering munition represents some form of hybrid between drone and guided missiles. These systems have the ability to stay in the air for a longer period of time before hitting the target, giving the operator time to choose the target and the time when the target will be attacked (Slijper, 2017). Some loitering ammunition systems can autonomously attack targets without human control, which imposes moral dilemmas regarding the use of such combat systems. It should be noted that low cost loitering munition or “kamikaze drones” can be used in the form of swarm, and in that situation there are currently no effective protection against this type of threat from the air (Gettinger, 2017).

Today, countries that own UCAVs have the opportunity to apply this low cost technology far more aggressively towards countries that do not have the mentioned technology. Nine countries have used drones for military purposes to this date, while at least twenty countries are working intensively on

their development (Parker, 2018). However, it is important to point out the fact that no matter how much armed drones may be an advantage over the enemy, they alone cannot achieve the set goal without cooperation with other combat systems and units. This is especially evident when the enemy uses various means to fight drones intensively and effectively.

Figure 2: SWOT analysis of the applicability of combat drones in local conflicts



4. Conclusion

Every day we are witnessing more and more mass use of drones for military purposes. Many countries are transforming from importers of foreign technology into renowned manufacturers of their own systems. Taking into account the relatively low cost of the systems, as well as their high efficiency, this use is gradually moving away from sporadic to mass application.

The conflict in Nagorno-Karabakh in 2020 showed us how the dominance of combat drones on the one hand and the lack of certain combat systems on the other can be reflected in the final outcome of the conflict. During the conflict, Azerbaijani combat drones destroyed a large number of Armenian armoured vehicles. The purchase price of one combat drone and one tank used during the conflict is more or less similar. However, no immediate conclusions should be drawn that armored mechanized units no longer have their place on the modern battlefield. On the contrary. Nevertheless, if you don't have quality air defense systems, if you don't have electronic warfare (EW) capabilities, things just can't work the way you want. To paraphrase an orchestra without a couple of musicians is still an orchestra, but the music it performs loses its quality. The whole world watched as a relatively modest military force, through the mass use of drones for various purposes, inflicted extremely great losses to the other conflicting side in manpower and technology.

The role of drones in the war ranged from directing artillery fire at enemy positions, reconnaissance missions, and attacks by armed drones on enemy targets, all the way to constant use of loitering ammunition systems. The war in Syria was a testing ground for some new technologies. The war in Nagorno Karabakh 2020 was a mere materialization of everything that was learned regarding the application of combat drones on the modern battlefield. Carefully analyzing the conflict as well as its consequences, it is concluded that the conflict in Nagorno-Karabakh in 2020 represents a turning point when it comes to the use of UCAV and that the consequences of that conflict will largely affect the perception of combat drones as a combat system in years to come.

The paper focused exclusively on the contribution of combat drones to the achievement of war objectives without a deeper analysis of cooperation with other systems and units.

Future research will focus on selecting the specific type of aircraft that can provide the country's military with the most opportunities for investment in a given geopolitical situation.

5. Literature

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Upravljanje cirkularnom ekonomijom u poslovnim organizacijama primenom digitalnih tehnologija

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Apstrakt: Upravljanje cirkularnim ekonomskim modelom u poslovnim organizacijama širom sveta zavisi od pojave inovacija u tehnologiji, organizacionim formama i poslovnim modelima. Stepen cirkularnosti jedne poslovne organizacije u značajnoj meri zavisi od razvoja digitalnih tehnologija u istoj. U stvarnom dinamičnom poslovnom okruženju, digitalne tehnologije omogućavaju iskorišćenje potencijala cirkularnih strategija za poboljšanje efikasnosti resursa i produktivnosti. Primenom digitalne tehnologije u poslovnim organizacijama moguće je izvršiti monitoring procesa tranzicije linearnog ekonomskog modela na cirkularni ekonomski model. Stoga, cilj ovoga rada jeste da se izvrši pregled razvijenih digitalnih alata, koje je moguće koristiti za praćenje cirkularne ekonomije na nivou jedne poslovne organizacije, a u svrhu poboljšanja procesa donošenja odluka u analiziranoj oblasti.

Ključne reči: cirkularna ekonomija, poslovna organizacija, monitoring, digitalne tehnologije.

Circular economy management in business organizations using digital technologies

Abstract: The circular economic model management in business organizations around the world depends on the emergence of innovations in technology, organizational forms and business models. The level of circularity of a business organization largely depends on the development of digital technologies. In a real dynamic business environment, digital technologies can be applied to capture the full potential of circular strategies for improving resource efficiency and productivity. By applying digital technology in business organizations, it is possible to monitor the process of transition of a linear economic model to a circular economic model. Therefore, this paper aims to review developed digital tools, which can be used to monitor the circular economy at the level of a business organization, in order to improve the decision-making process in the analyzed area.

Keywords: circular economy, business organizations, monitoring, digital technologies.

1. Introduction

In recent years, there has been an increase in the world population, which has resulted in increased consumption of resources in order to meet various human needs. The current model of production and consumption of products intended for widespread use is not considered sustainable. The reason for this is that today, resources from nature are excessively consumed, especially those whose capacity is limited to create final products, which, after the phase of use, are mostly disposed in an unsatisfactory way. Such a model of production and consumption is called a linear economic model, which can be most simply defined as a one-way flow of energy and materials. This model is based on a "take-make-dispose" philosophy (Pagoropoulos et al., 2017). The linear flow of energy and materials contributes to the emergence of negative pressure on the Earth's ecosystems. In order to avoid current environmental problems that endanger the environment, it is necessary to change the current model of production and consumption of goods.

Furthermore, it can be concluded that the main reasons for the increase in ecological footprint are increased extraction of raw materials from nature and the increased amount of generated waste. Thus,

measures that will transform these two phases of the product life cycle must be defined at the global level. The concept of the circular economy (abbr. CE) is defined as an appropriate measure for changing the current model of production and consumption of goods. Namely, there is no evidence of the launch of term CE, but according to the literature review, it can be concluded that CE is the first time mentioned in 1990 by scientists Pearce and Turner (Pearce et al., 1990). At that time, the CE was not recognized as a concept that can influence the achievement of sustainable development. Over the last decade, this concept has gained attention because people have set themselves up aware of the fact that transformations of the present economic model are necessary. The expression of CE can be implemented in the entire economy, and it includes all products and services in different sectors, so it is challenging to find its single definition.

The concept of CE is defined as an alternative to the linear economy model. The CE promotes the urgency of closing materials loops, i.e., it promotes the transformations of resources' function. The generated waste becomes a valuable material that can be used in a completely different manufacturing process of a new products. That leads to the conclusion that the CE represents a way to integrate the economy and the waste management system.

The principles of the CE are based on the 4Rs concept (reduce, reuse, recycle, recover) and the 6Rs concept (reuse, recycle, redesign, remanufacture, reduce, recover) (Winans et al., 2017). The CE's ideology is that the products during their life cycle needs to be repaired, reused, improved, but not permanently disposed, because, in that way, a potential resource would be lost, i.e., secondary raw material would be lost.

In this research it is recognized that the concept of the CE can be implemented on a different level: macro (countries), micro (business organizations), and nano (products). On the macro level, implementation of the CE implies the adoption of legislation to regulate activities in this area at the national level. Then, implementation of the CE on the micro-level requires changes in business models from the business organizations. Thus, the global transformation of the linear economic model requires business organizations to develop, implement, and integrate a system that supports the CE. On the nano level, the CE considers activities concerning with design of products and the first measure from waste hierarchy, that is, activities covered by waste prevention as the most preferred option in the whole waste management system.

Business organizations represent the key to the countries economy, so it is considered they have a substantial role in the implementation of the CE.

This review provides an initial exploration of the intersection of two trends: circular economy and digital technologies. The motivation for this research lies in the fact that it is necessary to measure and monitor the circularity level of business organization. It is considered that monitoring of circularity can be carried out through monitoring and evaluation of various indicators that are still at an early stage of development. Circularity indicators accompanied by digital technologies can measure the circularity level in the business organizations. That is the reason why software tools and internet applications that can be used for that purpose are reviewed in the following chapters.

2. Monitoring of circular economy

Implementation of CE is not limited to certain materials, products or sectors so its monitoring is a challenging task. The main reason for that can be explained by the fact that circularity indicators are in at the initial stage of development.

Monitoring of the CE is performed by indicators, which should primarily include trends in the protection of the economic value of products, materials, and resources but also trends in the reduction of waste generation. In this review paper, monitoring is identified as systematic measurement, testing and evaluation of circularity indicators of one business organization.

Based on data published by the European Commission, during monitoring of the CE, the following activities are considered (European Commission, 2018):

- reducing the need for extraction of new resources through simultaneous minimization of negative impact on the environment,

- social behavior of people described by the awareness of citizens and their engagement in the CE's adaption,
- business operations, so-called eco-innovation operations, which stimulate changes and adaptations of a business model in accordance with the principles of CE.

Implementation of the CE model in a business organization is not an easy process. If the management of an organization wants to apply the CE into its business, it is necessary to change business models completely, adapt strategies, and develop workforce skills through the simultaneous adoption of national legislation that enables and supports the application of the CE.

The management of one business organization needs to understand its circularity level, so it is necessary to develop and implement circularity indicators. The business organizations need metrics in which the application can facilitate the adoption of a circularity strategy. First of all, systematic changes are needed at the global level. Those changes will enable the management in the business organizations, to determine the level of circularity uniformly. Namely, it is necessary to develop a methodology on the global level by which business organizations will have a common approach for measuring and monitoring circularity performance. In addition to solving differences in circular metrics' scope and level, a common framework for measuring circularity at the organization level should solve differences caused by position in the value chain or product life cycle (Kristensen et al., 2020).

The product life cycle is an essential segment of the economy because it describes all the stages of a product. The concept of this cycle occurs when products are developed, introduced to the market, then grow actively, reach maturity and, finally – decline. All mentioned is described by the following phases of the life cycle (Komninos, 2002):

- extraction phase of resources required for the production process,
- design phase,
- production phase,
- the phase of distribution of finished products,
- the phase of product use by consumers,
- product disposal phase, in a waste form.

To make it easier to monitor circularity indicators in all phases mentioned above, it is necessary to apply digital technologies. Thus, it is increasingly recognized that the monitoring framework of the CE must include different software tools and internet applications. With the help of digital technologies, it is possible to perform systematic monitoring of CE. Namely, to determine the exact level of circularity of the business organization in which the assessment is performed.

3. The possibility of using digital technologies to support circular economy in business organizations

The basic concept of CE is based on the assumption of the efficient use of resources in the production process. The fundamental principles of CE are established on the increase of the product or service value, while reducing the amount of waste generated or at least bringing that amount to a minimum. The product should be designed in a way that generated waste material can be reused or recycled at all stages of the product life cycle.

As the twenty-first century is the century of information technologies, it is logical that innovations in communications technology and materials use technologies and production processes that contribute to the development of the CE concept. Namely, it is considered that the concept of CE would not be applicable since technology could not support its ideas (Radivojević, 2018).

The possibility of CE implementation leads to increased investment in research and development, and consequently, in the development of technologies that enable the application of the CE's concept. The global industry is mostly entering the era of digitalization and artificial intelligence, and the impact of smart manufacturing on market competitiveness is growing. Computer Integrated Manufacturing (abbr. CIM) is a system that integrates and manages all activities in the production process using information technology such as computers, networks, and communications. CIM represents the process of production automation and the integrated flows of information and materials (Regodić & Cvetković,

2011). Implementation of the CIM system would significantly improve the circular economic model's application because its progress would be monitored more easily.

Also, in the coming period, significant support in the development of indicators for measuring the organization's circularity can be models developed using advanced computational methods, such as artificial intelligence (abbr. AI).

AI can enable innovation in a circular economy in three primary ways (Ellen MacArthur Foundation, 2019):

- design circular products, components, and materials,
- operate circular business models,
- optimise circular infrastructure.

It is possible to develop a universal methodology for determining a business organization's circularity using smart and AI technologies. In that way, it is possible to create an opportunity to support circularity indicators globally. As already mentioned, if the management of an organization wants to apply CE in its business, it is necessary to change the business model completely, and that includes the application of digital technology that supports CE.

3.1. Software tools and internet applications to support, promote and develop CE

CE is a regenerative economic system in which production resources, waste, waste emissions, and energy outflow are significantly reduced by slowing down, rounding, and extending energy and material cycle in the production. As this economic system is innovative, it must follow innovations from other areas, such as smart technologies.

There is no universal methodology for determining the circularity of a business organization, but developing software tools to support, promote, and develop CE has begun. For that reason, this chapter provides an overview of currently developed software tools/internet applications, which can be used to monitor CE. This overview is shown in table 1.

Table 1. Overview of analyzed software tools/internet applications for CE monitoring

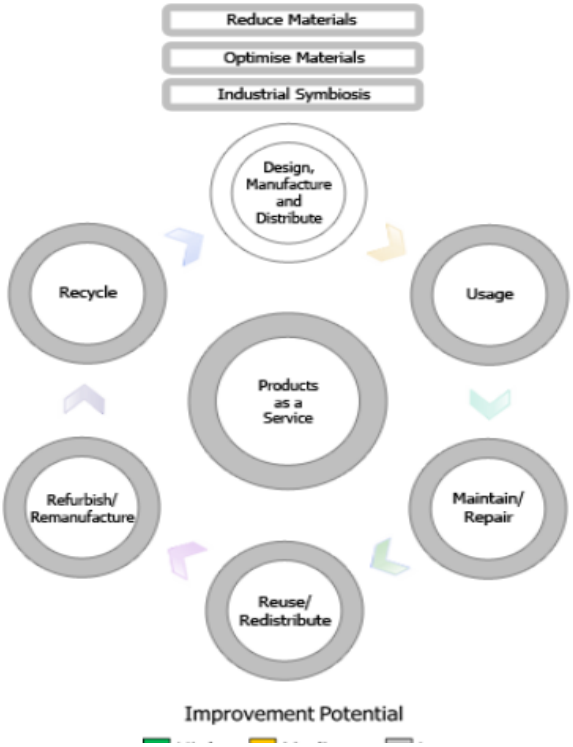
Acronym	Name	Author	Year of tool development
CET	Circular Economy Toolkit	Evans & Bocken	2014
CC	Circular Calculator	IDEAL&CO Explore	2016
CTI	Circular Transition Index	WBCSD	2020
/	Circulytics	Ellen MacArthur	2020

Based on a systematic review of the literature and research of relevant articles, studies, and reports on the CE, four software tools/internet applications which can be used for business organizations have been identified, in order to monitor the CE systematically.

3.1.1. Circular Economy Toolkit

Circular Economy Toolkit or so-called CET was developed at the University of Cambridge. CET is an online tool for assessing activities that have the potential to improve the circularity of a business organization (Evans and Bocken, 2014). By using this tool, organizations can determine each phase of a product life cycle, with low, medium, or high chance for improving of circularity. The analysis is conducted online using a questionnaire containing thirty-three questions about specific activities in the organization. The analyzed phases are shown in Figure 1.

Figure 1. Overview of activities analyzed using CET



(Source: Circular Economy Toolkit, 2020)

5.1.2 Circular Calculator

Circularity calculator (abbr. CC) is a tool that helps a business organization to understand how strategic decisions are made, when developing and designing products affect the degree of circularity of the material flow and its potential retention of material value. CC shows the degree of circularity of a different material flows, which depends on whether the materials are reused, remanufactured or recycled.

The analyzed calculator is available at www.circularitycalculator.com. It allows modeling of different conceptual solutions and business models in order to explore and compare different scenarios and their impact on overall circularity, recycling rate, and retent potential (Janik and Ryszko, 2019 12; Moraga, 2019).

5.1.3 Circular Transition Index

The Circular Transition Index (abbr. CTI) can determine the degree of transition to the CE in business organization and it has been developed by the World Business Council for Sustainable Development.
The CTI offers business organizations insights into their CE performance. With this tool, the business organization's management can identify circular opportunities and linear risks to improve company longevity and resilience (WBCSD, 2020). Therefore, CTI can serve to set a baseline and monitor progress on circular transition in business organizations.

World Business Council for Sustainable Development has launched the methodology for determining the transition indicators to the CE on the market in the form of internet applications that can be accessed via the internet address: www.ctitool.com

With the CTI methodology, it is possible to determine the company's circularity by defining indicators, classified into three groups (WBCSD, 2020):

- close the loop (% circular inflow, % circular outflow, % water circularity, % renewable energy)
- optimize the loop (% critical materials, % recovery type), and

- value the loop (circular material productivity).

Through the assessment via CTI, value chains that are essential to accelerating the transition to the circular economy can be identified.

5.1.4 Circulytics

Circulytics, like other tools, supports the transition of a business organization to the CE model regardless of industry, complexity, and size. Through the assessment of material flows, Circulytics helps to measure the circularity of business organization. Tool Circulytics reveal the extent to which a business organization has achieved the circularity of its services or products. That assessment can be achieved by using a wide range of currently available indicators, promoted by the English Ellen MacArthur Foundation. One of these indicators is a well-known Material Circularity Indicator (abbr. MCI).

This tool is the most innovative in this area because it (Ellen MacArthur Foundation, 2020):

- measures entire circularity of business organization,
- supports decision-making and adoption of strategies for the CE,
- displays advantages and highlights the areas for the improvement of CE,
- delivers information about circular economy performance.

5.2 Comparision of the analyzed software tools/internet applications

In the previous section, all relevant references related to the identified software tools and internet applications, which can be used to determine the circularity level in the business organizations, are analyzed.

In order to facilitate the comparison of the identified tools, table 2 has been created.

Table 2. Comparison of analyzed software tools/internet applications

Criterion	Software tools/Internet applications			
	CET	CC	CTI	Circulytics
Basic principles of the CE				
Waste reduction	X	X		X
Reuse	X	X		X
Recycling	X	X	X	X
Recovery	X	X		X
Aspects of sustainable development				
Economic aspect	X	X		X
Ecological aspect	X	X	X	X
Social aspect				X
The level of use of tools				
Material			X	X
Component				X
Product / Service	X	X		X
Method of using digital technologies				
Software tools			X	X
Internet applications	X	X	X	X

As can be seen from table 2, this analysis proposes several criteria that can be used to compare the quality of the considered tools and applications. When conducting the comparison, it was identified which criteria are taken into account during the evaluation of circularity in business organizations, using analyzed tools/applications.

The criteria related to the implementation of a circular economic model in the organization are classified into four groups.

The first group of criteria is focused on the application of the 4Rs concept as basic principles of the CE, which includes:

- reduction (prevention) of waste generation at the source,
- reuse of products,
- recycling of waste, and
- waste energy recovery or utilization.

The next group of criteria applies to aspects of sustainable development. According to these criteria, it is discovered which aspects (social, environmental, or economic) are considered when determining circularity.

The third group of criteria is a group that determines whether the software or internet application can be applied for evaluating the circularity at the product level, its component, or its constituent materials. Within the last group, the method of digital technologies usage was analyzed, more precisely whether the level of circularity in a business organization is determined using a software tool or an Internet application.

The analysis found that all tools, except the CTI tool, support the 4Rs concept as the CE's fundamental principle. Regarding the aspect of sustainability, all tools used during the determination of circularity include the environmental aspect, and the economic aspect is taken into account by all tools except CTI. In contrast, the social aspect of sustainable development in its work considers only the tool Circulytics. The analyzed tools can mainly be applied at the product level. The format for determining the circularity depends on the author, so the CET and CC tools are available online via an Internet application. In addition to the Internet application, CET and Circulytics are available to users through software, which is not free. Namely, the user has to pay to download them.

After reviewing all the criteria, it is concluded that the best is to use Circulytics in a business organizations because only with this tool all the criteria are met and with it, the management of the organization would have an insight into its current level of circularity.

4. Conclusion and further research

Defining and determining the performance of CE, i.e., determining the level of circularity in business organizations is one of the critical problems of achieving sustainability through the CE because there is no uniform way to monitor or carry out benchmarking of the CE. The main goal of this review was the analysis and comparison of developed digital tools for the support of CE at the business organization level.

Based on a systematic review of the literature, four software tools/internet applications have been identified that can be used to monitor CE: CET, CC, CTI, and Circulytics. During the comparative analysis of these tools, the criteria related to the implementation of the CE principles, aspects of sustainability, level of application, the format of determination, but also the criteria related to the organizational and operational aspects for the implementation of circularity tools have been taken into account.

After reviewing all the criteria, it is concluded that Circulytics stands out as a software tool/internet application because only with this tool, all the criteria are met. Circulytics is a digital measurement tool that gives a completely comprehensive picture of the organisation’s circularity in all business operations (Ellen MacArthur Foundation, 2020). Circulytics was developed by the English Ellen MacArthur Foundation, which means that this foundation aims to compensate the lack of regulations in the field of the CE through the development of a methodology that assesses how well the organization is transforming from a linear to a circular business model.

Future research in this area will be focused on conduction a case study based on analyzed software tools/internet applications. It is important to find a way to determine the level of circularity of one business organization using the best-identified tool - Circulytics.

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Upravljanje medicinskim otpadom

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Apstrakt: Upravljanje medicinskim otpadom je od velikog značaja za ljude i životnu sredinu. Neodgovorno upravljanje i klasifikovanje medicinskog otpada može dovesti do ugrožavanja životne sredine i prouzrokovati zdravstvene rizike kako kod zaposlenih, tako i kod pacijenata. Tradicionalno odlaganje otpada na deponije predstavlja najučestaliji obilk odlaganja otpada kod nas, iako autori vide najefikasnije rešenje u spaljivanju kao naprikladijem metodu ili integrisanom metodu hijerarhijskog upravljanja od faze nastanka do tretiranja otpada, što donosi ekonomsku prednost i smanjenje rizika potencijalnih šteta. Da bi se živelo u skladu sa okolinom, problem zbrinjavanja otpada se mora prepoznati kao jedan od važnih zadataka svih struktura koje učestvuju u njegovom stvaranju i zbrinjavanju.

Ključne reči: medicinski otpad, menadžment, upravljanje, zdravstvo, životna sredina.

Medical waste management

Abstract: Medical waste management is of great importance for people and the environment. Irresponsible management and classification of medical waste can lead to environmental hazards and cause health risks to both employees and patients. Traditional waste disposal on landfills are the most common form of waste disposal in our country, although the authors see the most efficient incineration solution as a more appropriate method or an integrated method of hierarchical management from the generation stage to waste treatment, which brings economic advantage and risk reduction potential damages. In order to live in harmony with the environment, the problem of waste disposal must be recognized as one of the important tasks of all structures involved in its creation and disposal.

Key words: medical waste, management, administration, health, environment

1. Introduction

The different types of global hazards facing the modern world can be divided into two basic ones: pollution and the creation of waste material that is released into the environment. At the same time, it means excessive consumption of natural resources that cannot be renewed. In modern society, almost everything, material, apparatus or object will become waste after a short or long time.

The increase in the quality of life, the development of technologies and the use of non-returnable packaging have caused the quantities of waste to increase day by day and threaten if they are not adequately disposed of. Their consequences are incalculable, which are slowly but surely endangering the conditions for a safe life. And while nature reuses its waste in the process of circulating matter and energy, man has created a series of synthetic materials that cannot be included in this process. They are accumulating, disturbing the balance in nature and becoming an economic, ecological and health problem of today, and they set the task of special care for waste in front of the society.

The amount of waste generated is related to the technological development and economic power of a country. Economically developed countries generate more waste, so today they face serious problems of waste disposal and management.

Developing countries generate smaller amounts of waste than developed countries, but they also have problems with harmful effects on human health and the environment because they do not have regulated waste collection and disposal systems.

The growth of living standard, the increase in the number of inhabitants, the development of technology, economic and non-economic activities and the use of non-returnable packaging have caused the amount of waste to increase day by day. In addition to municipal household waste, there are other human activities in which not only municipal but also various types of hazardous waste are generated.

2. Medical waste management

2.1. Hazardous waste

By place of origin, waste can be: municipal waste originating from households or similar in characteristics and content to household waste, technological or industrial waste generated in industry and crafts, packaging waste, construction waste generated by construction, maintenance and removal of buildings, and electrical or electronic waste. Special emphasis is placed on medical waste generated during the provision of health care or in scientific research. By properties, waste is divided into inert or non-hazardous and hazardous waste.

Hazardous waste began to be talked about more seriously in the late 1970's and early 1980's, following the events in the city of Love Canal in New York State. The city was built on a landfill for chemical and industrial waste, so the whole area was contaminated with more than 200 different chemicals, of which 10% were potentially mutagenic, teratogenic and carcinogenic.

The frequency of abortions or children born with chromosomal aberrations and a number of other diseases among citizens has warned the world that chemical waste should be treated as a separate category. In the early 1980s, hazardous waste was first officially defined in the United States. Hazardous waste is considered to be substances that have flammable, reactive, explosive or corrosive properties. (Jakšić et al., 2001)

Waste is also dangerous if it contains substances that are toxic (toxic) or infectious (infectious), carcinogenic, mutagenic and teratogenic. Hazardous waste can be in a solid state or in the form of a liquid, while toxic gases are classified as air pollution. However, hazardous waste is also considered to be substances that have the properties of releasing harmful gases by chemical or biological decomposition, ie in the processes of processing and disposal. Waste that can be classified as hazardous requires special methods of treatment and disposal, and this category of waste also includes waste in the provision of health care (McKay, 2002).

2.2. Medical waste

The generation of waste is a consequence of all human activities, including health. Waste generated during the provision of health care can be divided into two groups of waste, municipal and hazardous waste. Municipal waste contains: paper and cardboard packaging, glass, food scraps and other common waste generated in the administration, kitchens and laundries. Hazardous medical waste contains elements of chemical and biological danger, whether they are in solid, liquid or gaseous state (Alagoz and Kocasoy, 2008)

Its properties are: harmfulness, toxicity, carcinogenicity and infectivity, and that is why hazardous medical waste differs from municipal waste. The amount of hazardous waste compared to the total amount of waste generated in health care institutions is not large, but it certainly requires, like any other type of hazardous waste, special treatment.

It is an unacceptable, but realistic, fact that medical waste from health institutions (clinical and / or hospital centers, health centers and regional clinics) is transported without special markings by vehicles of the utility company with other municipal waste and disposed of at the city landfill without prior treatment. Needles and sharp objects that have been in contact with blood and body fluids are not separated in specially designed boxes for biorisk waste in some health care institutions (Jakšić et al., 2001).

2.2.1. Hazardous medical waste

According to the place of origin, within hazardous waste, we single out a group of hazardous medical waste. Medical or health waste is waste that is generated during the protection of human health. The largest producers of medical waste are large health care institutions, ie clinics, health centers, hospitals, diagnostic and research laboratories, morgues, autopsy centers and transfusion and dialysis centers.
Smaller producers are smaller health units such as private specialist and dental clinics, acupuncture and chiropractic clinics, home care institutions for the disabled, addiction reduction centers for addicts and funeral services. (Jakšić et al., 2001). According to the Ordinance on medical waste management, medical waste is a special type of waste that is produced in health care institutions.

It is a heterogeneous mixture of municipal, infectious, pathological, pharmaceutical, and laboratory waste, disinfectants and packaging, as well as radioactive and hazardous chemical waste. Hazardous medical waste contains toxic, harmful, carcinogenic and infectious substances and according to its properties and place of origin is divided into: pathological waste, infectious waste, sharp objects, pharmaceutical waste, chemical waste, pressure vessels and radioactive waste.

2.2.2. Safety and health aspects related to medical waste

Medical waste does not account for a large part of the total environmental pollution, but it is potentially among the most dangerous types of waste, because it can lead to infections and poisoning. Pollution coming from health facilities can be very dangerous to the health and ecosystem in which that waste is stored. Inadequate management of hazardous medical waste, from handling within facilities providing medical and veterinary services to final disposal, poses a very high risk, both for the health of staff handling it, patients and the environment in general.

In the process of handling medical waste, medical and non-medical employees are exposed to the risk, primarily of injury, if the used sharp objects are not safely packed. The World Health Organization estimates that due to inadequate medical waste handling, about 20 million people worldwide are infected with hepatitis B, C and HIV each year.

Those who search for waste in containers and landfills are also exposed to this risk. The population can be exposed to the risk of medical waste in a direct and indirect way, through various routes of contamination: inhalation, penetration through the skin and ingestion. It is estimated that about 80% of waste produced in hospitals is actually infectious waste. Risks of hazardous medical waste are: infectious diseases (AIDS, viral hepatitis B and C, intestinal infections, respiratory infections, blood infections, and skin infections); effects of radioactive substances (carcinogenic, mutagenic, teratogenic, and reproductive health toxins); poisoning or intoxication.

All persons who may come into contact with medical waste are exposed to potential health risks, namely: medical and non-medical staff of health care institutions, patients inside and outside health care institutions and their visitors, employees of utility companies handling and transporting waste, employees at landfills, including those who search for waste, the population, and especially children if they play with objects that can be found in the waste outside of health care facilities (Hossain, et al., 2011)

The introduction and implementation of adequate procedures for minimizing the risk of medical waste primarily protects the health of the population and reduces the negative impact on the environment. The first step in the management system is to identify potential risks. Possible ways of transmitting the disease are: direct contact, contact with vectors (flies, insects, field mice, rats, dogs, cats), aerobic transmission, polluted water and polluted environment (Herceg and Lukić, 2009).

Table 2. Type of medical waste, mode of infection and diseases caused by inadequate medical waste management

TYPES OF WASTE	INFECTION TYPE	DISEASES
Feces	Fecal oral intestine, food, water, insects, dirty hands	Salmonellosis, shigelosis (dysentery), hepatitis A, entrocolitis (viral and bacterial), parasitic diseases
Sputum, dust	Respiratory - droplet, by inhalation	Tuberculosis (TB), viral and bacterial pneumonia
Blood, body fluids	Infusion systems, transfusion, injuries skin and mucous membranes, fresh contaminated waste	Human immunodeficiency virus (HIV), acquired immunodeficiency disease (AIDS), hepatitis VHB virus, VHC
PUS	Contact with food	Skin infections, alimentary toxicoinfections
Genital secret	Contact with fresh contaminated waste	herpes genitalis, candidiasis, clamidiasis, AIDS
CSF	Syringes, needles, containers	Meningitis (viral and bacterial)
Urine	Contaminated objects, water, food	Urinary tract infections
Blades, needles	Injury, stab incidents	Hepatitis: VHB, VHC, HIV, AIDS, pyodermas
unprotected mixed medical waste	Vectors: flies, cockroaches, mice, rats, birds, stray dogs and cats	Intestinal infections, injuries and infections

2. 2.3. Packaging for hazardous medical waste

Disposal of medical waste begins in wards, clinics, institutes, laboratories, dispensaries, dressing rooms, surgical rooms and other parts of health care institutions. It is necessary to ensure sorting and separate collection at the place of origin. Waste is sorted and collected at the place of origin in packaging adapted to its properties, quantity, and method of storage, transportation and processing, in a way that protects the environment and those who professionally handle waste. General (inert, non-hazardous) medical waste that is similar to municipal waste is disposed of as municipal waste, because it does not pose a risk to health and the environment. Packaging, such as plastic bags, cardboard boxes, containers and containers, must be made in such a way that its characteristics (color, shape, size) enable and facilitate the classification of hazardous medical waste at the place of origin (Bdour et. al., 2007). A Packaging for storage must be marked "hazardous medical waste", with an indication of the type of waste. The packaging has specific markings: red for infectious waste, red with a black band for pathological waste, yellow for chemical waste, green for pharmaceutical waste, and black and blue for municipal waste.

2.2.3. Technologies for hazardous medical waste disposal

Disposal of waste from health care institutions is a complex system that involves its classification at the place of origin, collection, transportation, storage and treatment. By its composition, inert medical waste does not pose a direct danger to the health of people who handle it during collection, primary and secondary storage, and final disposal. Still, it poses a big problem given its volume and quantity. The correct way of managing this type of waste implies its classification at the place of origin into specialized containers for paper, glass, metal, etc. (Dowell et al., 2001). Earlier analysis and research noted that 77.36% of waste from health facilities is disposed of in landfills. In that waste, municipal waste is represented with 62.78%. This type of waste would be adequately disposed of if it was separated from potentially infectious waste at the place of origin. Thus, there are hazardous types of waste from health institutions at local municipal landfills: medicines, disposable materials, sharp objects, substrates and biological materials, and others (Radenovic, 2008).

Unfortunately, the final destination of waste is not only landfills, but also rivers, groundwater and the sea, because 8.87% of the total amount of hazardous medical waste and various chemicals and even radioactive contrast agents are annually discharged into the sewage system from medical institutions. (Grabara and Dima, 2014).

Each health care institution should elaborate in detail the method of sorting medical waste: its initial storage, roads, methods, persons in charge and time plan for waste collection, as well as transport to the place of secondary storage, duration of secondary storage, keeping records of types and quantities of waste, and its marking (Grose et al., 2012).

Hazardous medical waste should undergo a pre-treatment procedure before final disposal. Medical waste should be stored secondarily in a separate, marked, fenced and covered area, provided only for that purpose, and which must be structurally adapted for easy cleaning and disinfection.

3. Medical waste management in Serbia

Following the principles of the overall waste management system, a medical waste management system is being developed, which is based on a hierarchical way of acting, from the control of the place of origin to the place of final disposal. Avoiding waste is definitely a priority. Since this is not always possible, the waste needs to be: sorted, properly pre-treated, and transported in a special way, finally processed and the remains properly disposed of (Ugrinov and Stojanov, 2011). The final treatment method must be the one that will produce the least risk to human health and the environment. The implementation of the overall waste management system enables the disposal of medical waste with less financial resources, because large quantities of medical waste could be disposed of within the technological and municipal waste. Waste from health care institutions should be sorted and collected at the place of origin in packaging adapted to its properties, quantity, method of storage, transport and processing, so as to protect employees in health care institutions, employees who manage waste, citizens and the environment. Highly infectious waste requires heat or chemical sterilization in the area where the waste is produced before it is mixed with other infectious waste.

Hazardous medical waste (blades, highly infectious waste, other and potentially infectious waste, pharmaceutical waste, genotoxic, amalgam waste from dental practice, hazardous chemical waste and other chemical waste) should be kept in boxes or packaging that clearly state the characteristics and features category of waste and which provide adequate protection for persons from health care institutions who come into contact when handling the specified packaging (Tamplin, 2005). Disinfectants should not be disposed of in a sanitary landfill and should be transported in the prescribed manner.

Before disposal, it should be treated with inertization, ie the waste is pressed and lime or cement is added to it. Disinfectants must not be encapsulated as they are corrosive. Encapsulation of waste involves sealing in metal or plastic containers, and plastic foam, bituminous sand, cement mortar and/or clay material are added to the waste (Tanaskovic, 2007). Medical waste generated in health care facilities is transported to a pre-determined location within the health care facility before disposal, transport or transfer to an authorized person for these activities. The place must be a closed room that meets the following conditions: to be under the supervision of a waste management officer, to be spacious enough to receive the maximum amount of waste of different categories that must be stored separately, to prevent physical access to unauthorized persons and pests and to have provided a suitable refrigerated waste compartment that requires storage in cold rooms.

The room or landfill must be equipped with fire extinguishers and inert absorbent material to localize any spilled liquids (chemicals). If the final treatment of medical waste is carried out by the health institution where the waste is generated, the treatment is carried out in accordance with the conditions of the environmental permit or waste management permit issued by the institution.

In order to avoid the risk of disease transmission from medical waste, precautionary measures should be established, as well as training or education of health and other personnel handling waste in the direction of: acquaintance with the rules of medical waste disposal, classification of waste according to source and method of sorting, waste sorting. the place of its origin, the use of protective equipment, the manner of closing the packaging (bags, bottles, containers) as soon as they are filled with waste, careful transport of medical waste to the disposal site, packaging that must be visibly marked and appropriate hand washing after contact with medical waste. (Rakočević, 2010)

Waste management in the Republic of Serbia is regulated by a large number of regulations that directly or indirectly regulate this area (Radenovic, 2008). The complexity and importance of regulating this

area indicates the fact that a set of laws in the field of protection has been adopted environments that are fully compliant with international regulations. Waste management is regulated by large number of regulations that directly or indirectly standardize this area:

1. Law on Ratification of the Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal (Officiallist FRY, international agreements, no. 2/99)
2. Law on Environmental Protection (Official Gazette of the Republic of Serbia, No. 135/04)
3. Law on Waste Management (Official Gazette of RS No. 36/2009),
4. Law on Health Care (Official Gazette of the Republic of Serbia, No. 107/05)
5. Law on Protection of the Population from Infectious Diseases (Official Gazette of the Republic of Serbia, No. 125/04).
6. Law on Production and Trade of Toxic Substances (Official Gazette of the Republic of Serbia 101/05, other law).
7. Law on Medicinal Products and Medical Devices (Official Gazette of the Republic of Serbia, No. 84/04).
8. Law on Transport of Dangerous Goods (Official Gazette of the FRY 24/94, Official Gazette of Serbia and Montenegro 1/03 Constitutional Charter)
9. Law on Waste Management (Official Gazette of the Republic of Serbia, No. 25/96,)
10. Rulebook on the manner of handling waste that has the properties of hazardous substances (Official Gazette of the Republic of Serbia, No.
11. 12/95)
12. Ordinance on the conditions and manner of classification, packaging and storage of secondary raw materials (Official Gazette of the Republic
13. Serbia, no. 55/01)
14. Rulebook on the manner of destruction of drugs, auxiliary drugs and medical devices (Official Gazette of the FRY, no.
15. 16/94, 22/94, Official Gazette of Serbia and Montenegro 1/03 Constitutional Charter)

3. Conclusion

Medical waste, due to its composition and negative impact on the environment and human health, requires a team of experts who are trained to manage and steer that species waste. Furthermore, they should be responsible for transferring their knowledge to the staff of the institutions which medical waste produces. On the other hand, it is the institutions that produce it, and logically, they should be responsible for proper waste management.

In total environmental pollution, medical waste does not occupy a large part, but is potentially among the most dangerous types of waste, because it can lead to outbreaks of infection and poisoning. It is common for each country to dispose of medical waste with the help of domestic regulations. International legislation has provided a good basis for drafting domestic regulations that are not fully implemented in Serbia. Serbia does not pay enough attention to the issue of medical waste disposal.

The odds are that medical waste disposal will not get the connotation of an important topic in the near future for a long time, despite the extreme importance to take into account the significance of this issue before the consequences of its neglect begin to be felt. The opinion of the author of this paper is that the problem of medical waste disposal can be solved by adequate application legislation, as well as greater interest of the scientific and professional public, which can affect the awareness of citizens about the importance proper management of both other and medical waste streams.

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Analiza protivoklopnih raketnih sistema primenom hibridnog modela AHP – VIKOR metoda višekriterijumskog odlučivanja

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Apstrakt: U radu je prikazan izbor najboljeg protivoklopnog raketnog sistema, kao značajnog naoružanja čiji je osnovni zadatak neutralisanje tenkova, oklopnih borbenih i neborbenih vozila na različitim daljinama gađanja. Složenost problema uslovljena je različitim taktičko-tehničkim karakteristikama protivoklopnih raketnih sistema i specifičnim uslovima njihove primene uslovili su primenu modela višekriterijumskog odlučivanja. Izbor najpovoljnijeg protivoklopnog raketnog sistema realizovan je primenom hibridnog modela AHP – VIKOR. Primenom metode AHP izvršen je proračun težinskih koeficijenata kriterijuma. Metodom VIKOR izvršen je izbor najpovoljnije alternative (protivokolopnog raketnog sistema). Na osnovu dobijenih rezultata definisan je skup kompromisnih rešenja na osnovu kojih donosilac odluke može odlučiti o izboru najboljeg protivoklopnog raketnog sistema.

Ključne reči: AHP metoda, VIKOR metoda, protivoklopni raketni sistemi, višekriterijumsko odulučivanje, naoružanje

Analysis of anti-armor missile systems using the hybrid model AHP - VIKOR method of multi-criteria decision-making

Abstract: The paper presents the selection of the best anti-armor missile system, as a significant weapon whose basic task is to neutralize tanks, armored combat and non - combat vehicles at different firing distances. The complexity of the problem is conditioned by the different tactical and technical characteristics of anti-tank missile systems and the specific conditions of their application have conditioned the application of the model of multi-criteria decision-making. The selection of the most favorable anti-armor missile system was realized using the hybrid model AHP - VIKOR. Using the AHP method, the values of the criterion coefficients were calculated. The VIKOR method was used to select the most favorable alternative (anti-armor missile system). Based on the obtained results, a set of compromise solutions was defined, on the basis of which the decision maker can decide on the selection of the best anti-armor missile system.

Keywords: AHP method, VIKOR method, anti-armor missile systems, multi-criteria decision-making, weapons

1. Introduction

The development of weapons and military equipment, and with them the development of armored vehicles, directly influenced the development of anti-armor means. Tactics of modern combat operations require successful anti-armor operations in all conditions at medium and long distances, with the aim of maximizing the effects on the target. Anti-armor missile systems (AAMS) usually perform fire tasks by direct shooting, while there are also modern AAMS that realize fire tasks by indirect shooting. This type of weapon is most often found in infantry (Radovanović et al., 2017) and artillery anti-armor units (Randjelović and Kokelj, 2010).

Most armies of the world have several different models of anti-armor missile systems in their weapons, due to their different characteristics, which expands the range of their possible use. The requirements for the characteristics that armies place before AAMS manufacturers are different. The goal is to create a model based on which the best AAMS would be determined in accordance with the requirements of the Serbian Army.

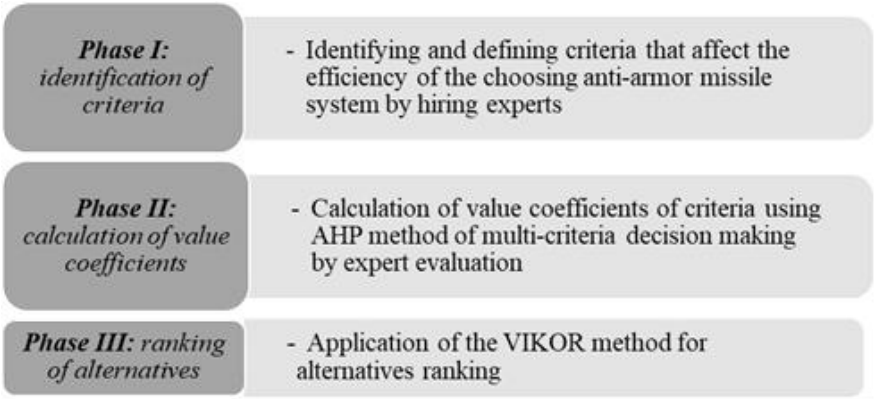
A large number of domestic and foreign authors in different literature deal with the issue of choosing an anti-armor system using the method of multi-criteria decision-making. The AHP method was used to select the second and third generation anti-armor missile system (Radovanović et al. 2019). For the purpose of introducing AAMS into operational use in the Serbian Armed Forces (SAF), an analysis based on MCDM was performed (Jokić et al., 2017). Through research works, a comparative analysis of ATACMS (Army Tactical Missile System) and the medium anti-armor system Javelin (David, 1995) is performed in order to equip the units. Using numerical analysis of tactical-technical and combat characteristics, the selection of the most efficient AAMS is realized (Radovanović et al., 2018).

The selection of the most favorable anti-armor missile system was made using the AHP method. (Randjelovic et al., 2019). Comparison of anti-armor missile guidance systems depending on which generation of anti-armor systems they belong to (Ramakrishna et al., 2018). By comparative analysis of weapons and military equipment of the US Army and other armies of the world, a comparison of basic combat characteristics was realized (Gordon et al., 2015). The complexity of choosing the most favorable alternative (anti-armor missile system) conditioned the use of multi-criteria decision-making methods, namely the hybrid model (Komazec et al., 2019; Tešić et al., 2018), which consist of two AHP methods (*Analytical Hierarchical Process*) and VIKOR method (*VIšekriterijumsko Kompromisno Rangiranje - Multi-criteria Compromise Ranking*).

2. Problem description

The paper presents a model that determines the most favorable alternative that is the most efficient anti - armor missile system. The hybrid model (Dwimas et al., 2019), applied when solving the problem of choosing an anti-armor missile system, was defined by a combination of the AHP - VIKOR method (Wass and Suprapto, 2020; Petrović et al., 2017) and was defined through three phases. Figure 1 shows the stages of model realization. The decision-making process on the selection of the most efficient AAMS is realized by ranking the offered alternatives and selecting the most favorable alternative. The definition of value coefficients was realized by expert evaluation using the AHP method, developed by Thomas Saaty (Saaty, 1980), while the VIKOR method developed by Serafim Opricović (Opricović, 1986) was used to select the most favorable alternative.

Figure 1. Decision support model



Identification and definition of criteria that influence the selection of the best anti-armor missile system was realized in the first phase of the model by expert evaluation. In the second phase, the initial decision matrix was defined using expert evaluation, and the value coefficients of the criteria were calculated using the AHP method using the Expert choice 2000 software. In the third phase, the best anti-armor system was selected using the VIKOR method.

The paper does not describe the methods used because they are known methods that are often used to select the most favorable alternative for multi-criteria decision making.

3. Forming the decision matrix and calculating the value coefficients of the criteria

Multi-criteria optimization selects the best anti-armor missile system for use in anti-armor infantry units. The first phase of the model is to define the criteria that influence the selection of the most favorable alternative. The criterion defines the quality and represents a measure for comparison during the selection of an anti-armor missile system. Criteria are expressed by a criterion function that for the best alternative should reach the global maximum, depending on the constraints that represent the possibility of achieving the goal. Defining criteria and their weighting coefficients is a very important phase in the decision-making model. When defining the criteria for the selection of an anti-armor missile system, it is necessary to include all relevant characteristics of the system to be optimized.

The analysis of the literature in the field of shooting theory, ballistics, the analysis of the literature of experts in this field, as well as the collected experiences of the members of the Serbian Army defined the criteria for selecting the best anti-armor missile system.

Penetration (f1) is a combat feature that has a significant impact on the performance of anti-armor actions. Higher penetration enables successful penetration and neutralization of the target. (Jokić et al., 2018) Modern projectiles for anti-armor missile systems mostly have tandem-cumulative warheads that enable penetrations both active and active-reactive armor protection, which is an advantage over classic projectiles with cumulative action. It is expressed in millimeters (mm) and the ability to penetrate explosive reactive armor (ERA). Penetration is a characteristic that is directly related to the caliber of an anti-armor missile, because a larger caliber achieves a higher penetration. The higher the penetration of the AAMS, the greater are combat capabilities of the anti-armor missile system. This criterion requires maximization.

The effective range (f2) represents the distance expressed in meters (m), at which the target is expected to be hit. Greater effective range provides the ability to conduct anti-armor actions over longer distances, which directly affects the increase of safety and protection for the operator. The modern way of conducting combat operations requires that anti-armor missile systems also have the ability to shoot at short distances in order to be able to perform combat operations as successfully as possible. Greater effective range increases the efficiency of the anti-armor missile system. (Randjelovic et al., 2019) The stated criterion requires maximization.

The price of an anti-armor missile system (f3) (Jokić et al., 2018) is an economic characteristic expressed in dollars ($). By designing AAMS, it is necessary to ensure the realization of the required combat requirements at the lowest cost, but this must not be achieved at the detriment of combat and operational characteristics. The price of an anti-armor system has a significant impact on the decision-maker because the funds for the procurement of the system are usually limited, and it is necessary to choose the most efficient system with the lowest possible price. This feature requires minimization.

The mass of an anti-armor missile system with an anti-armor missile (f4) is a very important combat characteristic and has a direct impact on mobility and the ability to transmit fire.). Mobility represents the ability of the weapon to quickly change the firing position, a quick transition from marching position to combat and vice versa, and the ability to switch to greater distances. The weight of the tool directly affects mobility. This criterion expresses the requirement for minimization that is systems of lower mass are more suitable for use. The mass of AAMS and rockets is expressed in kilograms and directly affects the number of servers (Radovanović and Stevanović, 2020).

Projectile efficiency (f5) is a characteristic that directly affects the firepower of the weapon. The basic parameter that affects the efficiency of the projectile is the caliber. Modern anti-armor systems mostly use tandem - a cumulative warhead with preload. The tandem warhead is intended to penetrate the active armor of modern tanks and armored vehicles, which explodes when a missile strikes. The first warhead of tandem warhead is intended only to activate the active armor, and the second penetrates the armor of the vehicle. Anti-armor missile systems that use thermo-baric warheads (a destructively flammable warhead, whose purpose is to destroy fortified objects) have a wider range of capabilities

and increase the efficiency of the system. (Radovanović et al., 2019) Projectile efficiency is a criterion that is linguistic and is expressed by qualitative assessments. Qualitative assessments are translated into quantitative ones using a bipolar scale and hiring experts.

The guidance system (f6) is a characteristic of the anti-armor missile system that determines the affiliation to the generation of anti-armor systems. MCLOS (Manual Command to Line of Sight) are systems with manual guidance and belong to the first generation anti-armor systems. SACLOS (Semi-Automatic Command to Line Of Sight) is a system with semi-automatic guidance and belongs to the second generation anti-armor systems. Generation III "fire and forget" anti-armor systems are the technological peak and the most sophisticated means. After the launch of the rocket, there is no engagement of any operator or device outside the rocket. (Randjelovic et al., 2019) Qualitative assessments have been translated into quantitative ones by applying the bipolar scale and hiring experts.

The possibility of shooting from closed premises (f7) is a combat characteristic of anti-armor missile systems that has a direct and positive impact on the performing of anti-armor actions in the urban environment. Anti-armor systems that have the ability to shoot from closed rooms are more efficient than systems that do not have this feature, because in addition to maneuvering space, they can also perform anti-armor actions in urban environments. (Ranđelović et al., 2019) The stated characteristic is expressed linguistically, and after that it is translated into quantitative data by applying the bipolar scale.

The minimum firing range (f8) is a combat characteristic that directly affects the efficiency of the anti-armor system and the performance of anti-armor actions in the urban environment at short distances. The shorter shooting distance enables more efficient solving of fire tasks in an urban environment, which is characterized by limited space. (Radovanović et al., 2018) The stated criterion requires minimization and is expressed in meters (m).

After defining the criteria, in the second phase of the research, the calculation of the value coefficients of the criteria was performed by applying the AHP method of VKO and hiring experts. Table 1. shows the value coefficients of the criteria.

Table 1. Value coefficients of the criteria

criteria	***f1***	***f2***	***f3***	***f4***	***f5***	***f6***	***f7***	***f8***
w	0.341	0.239	0.166	0.079	0.091	0.046	0.016	0.016

4. Selection of the most favorable alternative using the VIKOR method

In the third phase of the model application, the VIKOR method of multi-criteria decision-making was used. Data on alternatives were taken from existing literature sources, while certain data were obtained by different measurement and evaluation methods. Table 2. shows the initial decision matrix, where all alternatives are evaluated according to all criteria, while Table 3. shows the normalized decision matrix. Qualitative assessments are translated into quantitative ones via a bipolar scale, after which their normalization is performed.

Table 2. Initial decision matrix

	f1	*f2*	*f3*	*f4*	*f5*	*f6*	*f7*	*f8*
a1	1000 + ERA	4000	95 000	45.2	very effective	"fire and forget"	Yes	60
a2	650+ERA	2200	80 000	36	very effective	SACLOS	No	150
a3	800+ERA	3750	93 000	93	very effective almost extremely effective	SACLOS	No	65
a4	1250+ERA	4300	101 000	24.5	very effective	SACLOS	No	75
a5	1200+ERA	5500	90 000	29,2	absolutely the most effective	SACLOS	Yes	100
a6	900+ERA	2000	83 500	24.5	extremely effective almost absolutely the most effective	SACLOS	Yes	90
a7	670	4000	128 000	38	least effective	SACLOS	No	70
a8	900+ERA	600	150 000	15.8	effective	SACLOS	Yes	25
a9	750 + ERA	2000	207 000	22.3	less efficient	"fire and forget"	Yes	75
a10	700 + ERA	2500	210 000	28.8	extremely effective	"fire and forget"	Yes	200

Table 3. Best and weakest values of alternatives for all criteria

	f1	*f2*	*f3*	*f4*	*f5*	*f6*	*f7*	*f8*
f*	1250.00	5500.00	80000.00	15.80	0.900	0.90	0.90	25.000
f-	650.00	600.00	210000.00	93.00	0.100	0.50	0.30	200.000

Table 4. Normalized decision matrix with calculated values for Si and Ri

w	*0.341*	*0.239*	*0.166*	*0.079*	*0.091*	*0.046*	*0.022*	*0.016*		
	f1	***f2***	***f3***	***f4***	***f5***	***f6***	***f7***	***f8***	***Si***	***Ri***
	wi*Dij									
a1	0.142	0.073	0.019	0.030	0.046	0.000	0.000	0.003	0.313	0.142
a2	0.341	0.161	0.000	0.021	0.046	0.046	0.022	0.011	0.648	0.341
a3	0.256	0.085	0.017	0.079	0.034	0.046	0.022	0.004	0.542	0.256
a4	0.000	0.059	0.027	0.009	0.046	0.046	0.022	0.005	0.212	0.059
a5	0.028	0.000	0.013	0.014	0.000	0.046	0.000	0.007	0.108	0.046
a6	0.199	0.171	0.004	0.009	0.011	0.046	0.000	0.006	0.446	0.199
a7	0.330	0.073	0.061	0.023	0.091	0.046	0.022	0.004	0.650	0.330
a8	0.199	0.239	0.089	0.000	0.068	0.046	0.000	0.000	0.642	0.239
a9	0.284	0.171	0.162	0.007	0.080	0.000	0.000	0.005	0.708	0.284
a10	0.313	0.146	0.166	0.013	0.023	0.046	0.022	0.004	0.733	0.313

The values required for further calculation are read from the last two columns of Table 4:

S*	**S-**	**R***	**R-**
0.108	**0.733**	**0.046**	**0.341**

Table 5. Calculated values for QSi, QRi, Qi (v=0.5), Qi (v=0.25) and Qi (v=0.75)

	QSi	*QRi*	*Qi(v=0.5)*	*Qi(v=0.25)*	*Qi(v=0.75)*
a1	0.329	0.326	0.327	0.326	0.328
a2	0.863	1.000	0.932	0.966	0.897
a3	0.695	0.711	0.703	0.707	0.699
a4	0.167	0.042	0.105	0.074	0.136
a5	0.000	0.000	0.000	0.000	0.000
a6	0.541	0.518	0.530	0.524	0.536
a7	0.867	0.961	0.914	0.938	0.891
a8	0.854	0.654	0.754	0.704	0.804
a9	0.960	0.807	0.884	0.845	0.922
a10	1.000	0.904	0.952	0.928	0.976

According to the obtained values of QSi, QRi and Qi for each action (Table 5), three independent rankings can be formed (Table 6). According to the QSi criterion, the best alternative is a5, and according to the QRi criterion, also a5 as well as according to Qi (v = 0.5).

Table 6. Rang alternativa na osnovu veličina QSi, QRi, Qi (v=0.5), Qi (v=0.25) i Qi (v=0.75)

	QSi	*QRi*	*Qi(v=0.5)*	*Qi(v=0.25)*	*Qi(v=0.75)*
a1	3	3	3	3	3
a2	8	10	9	10	9
a3	5	6	5	6	5
a4	2	2	2	2	2
a5	1	1	1	1	1
a6	4	4	4	4	4
a7	6	9	8	9	7
a8	7	5	6	5	6
a9	9	7	7	7	8
a10	10	8	10	8	10

If an alternative is in the first position on such a compromise ranking list, it still does not mean that this alternative is considered the best. In order for an alternative to be adopted as the best, according to the VIKOR method, it must be first on the compromise ranking list and meet two conditions: condition C1 and condition C2.

The first alternative on the compromise ranking list for the value v = 0.5, must have a "sufficient advantage" over the alternative from the next position. “Advantage” is calculated as the difference of measures Qi for the value v = 0.5. Alternative a' has a "sufficient advantage" over the following a" from the ranking list, if fulfilled:

$$Q(a') - Q(a'') \geq DQ, \quad (1)$$

$$DQ = \min\left(0.25; \frac{1}{m-1}\right) \quad (2)$$

where the values are:

DQ – “sufficient advantage” limit (Pamučar, 2016)
m – number of alternatives,

Condition C1 is not met because Q(a4) – Q(a5) = 0.105 < DQ = 0.110

Alternative a4 enters a set of compromise solutions since the first alternative a5 does not have a "sufficient advantage" over the second-ranked alternative a4. Other alternatives do not enter the set of compromise solutions because alternative a5 has a sufficient advantage over them.

Condition C2 is met as alternative a5 has a “sufficiently stable” first place according to all three criteria (it has the first position in the ranking list QR, QS and Q).

The final solution is defined by a set of compromise solutions that include alternatives a5 and a4. This gives freedom to the decision maker to choose two alternatives that is that the most favorable alternative is a5, and as the first backup alternative, alternative a4 is suggested.

5. Conclusion

This paper presents the application of the AHP - VIKOR model in the selection of an anti-armor missile system based on the characteristics they possess. The paper presents the stages of application of the multi-criteria decision-making model. Criteria were defined and their value coefficients were calculated using the AHP method and hiring experts. The selection of the most favorable alternative was performed using the VIKOR method. The set of compromise solutions consists of two alternatives, which achieves objectivity in solving the problem of choosing the best AAMS according to the given criteria. When solving this problem, it is possible to change the criteria and their value coefficients depending on the specific requirements of the decision maker.

Through future research, the presented model could be used to solve other research problems. Other more modern methods of multi-criteria decision-making can be used to solve the problem of choosing the best anti-armor system.

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Sistem kriznog menadžmenta u Evropskoj uniji - kako radi?

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Apstrakt: Put razvoja Evropske unije kao nadnacionalne organizacije u kojoj prevladava jedinstveni politički, ekonomski i bezbednosni prostor na evropskom kontinentu, nije bio jednostavan i lak. Dugo godina ideološki tvorci evropske zajednice tragali su za nadnacionalnim modelom koji bi istovremeno odgovarao izazovima vremena, osiguravao ekonomski prosperitet, unutrašnju stabilnost, mir i sigurnost u Evropi. Takođe, takva organizacija je trebala imati svoju ulogu u međunarodnom poretku. U evropskoj politici i nauci postoje razlike u mišljenjima o tome da li EU trebala da razvije sistem upravljanja krizama ili ne. Potreba da EU razvije svoje sposobnosti na polju spoljne i bezbednosne politike uticala je na uspostavljanje sistema upravljanja krizama kakav poznajemo danas. Zahvaljujući tome, Evropska unija je danas važan faktor u svetskoj bezbednosti, posebno kroz vojne i civilne operacije menadžmenta upravljanja krizama.

Ključne reči: Evropska unija, ZSBP, krizni menadžment

Crisis management system in European Union - how it works?

Abstract: The European Union's development path as a supranational organisation in which a single political, economic, and security space on the European continent prevails was not simple and easy. For many years, the European community's ideological creators have been looking for a supranational model that would simultaneously meet the times' challenges and ensure economic prosperity, internal stability, peace, and security in Europe. Such an organisation should have had a role in the international order. In European politics and science, there have been differences of opinion on whether the EU should develop a crisis management system or not. The need for the EU to develop its capabilities in foreign and security policy has influenced the establishment of the crisis management system as we know it today. Thanks to that, the European Union is an important player in world security, especially through military and civilian operations.

Keywords: European union, CFSP, Crisis management

1. Introduction

The European Union's history represents a period that began in 1952 with the founding of the first major European supranational economic community - the European Coal and Steel Community. In Europe, two more supranational communities were established in 1958 - the European Economic Community and the European Atomic Energy Community, which is 1967, together with the European Coal and Steel Community, united into European Communities. In 1993, the European Economic Community, becoming one of the three pillars of the European Union, became part of it as the European Community, and ten years later, with the expiration of the Treaty of Paris, the functions of the European Coal and Steel Community became part of the European Community. Hence the EU. The European Atomic Energy Community has continued to exist as an independent supranational organisation. However, the EU's commitment to establishing a single crisis management system has been significantly influenced by other factors, including:

- the interest of EU member states in strengthening the international role and influence of the EU in protecting their interests in the world,
- the interest of the members and the EU as a whole in preserving international peace, security, spreading democracy, respect for human rights, freedom of movement of people, goods and capital in Europe and the world, and

- the aspiration of European nations for greater security autonomy on European security issues than the USA /NATO.
- In formulating the security and foreign policy and the EU's approach, the thesis was that:
- European security is indivisible and a key condition for European prosperity in all other areas;
- The European Union is necessary to build European autonomous capabilities that will enable it to strengthen the security of the Union and its members in all its forms and to protect the common values, fundamental interests, and independence of the Union;
- in addition to European security, the basic interest of the EU is the maintenance of peace and international security following the principles of the UN Charter and the principles of the OSCE;
- developing and strengthening EU cooperation with other subjects of European and international security, the basic way of strengthening European security, and
- The European Union is a global actor, and in addition to economic ones, it must have the political and security capabilities to fulfil such a role.

With the entry into force of the Lisbon Treaty (EU, 2007), on 1 December 2009, the Union's security and international action capacity has been significantly strengthened and expanded. In addition to the Union's existing security capabilities, established during previous periods, the EU has established additional mechanisms and institutions for joint external action in the Lisbon Treaty.

2. Common Foreign and Security policy

In the first years after establishing the European Communities, it was necessary to harmonise and coordinate its foreign policy. The formal concretisation of the principle of the European Economic Community members' joint foreign policy followed only through the Single European Act - SEA, signed in 1986, which entered into force on July 1, 1987. This act, which is essentially a revision of the Treaties of Rome on the European Economic Communities, among other things, in Part III entitled "Provisions of the Treaty on European Cooperation in the Field of Foreign Policy", Article 30, item 1, provides: "… Members of the European Communities shall jointly seek to formulate and implement a European foreign policy ". Further provisions of this document, also in Part III, set out the objectives, principles, principles, and institutions of the communities responsible for coordinating and encouraging cooperation in the field of common foreign policy, political and economic security.The most significant result of numerous ideas and discussions on ways to affirm and strengthen the role of the future Union in European security and international political and security scene, held at intergovernmental conferences during the formation of the EU, was the establishment of the Common Foreign and Security Policy - CFSP and its incorporation into the Union (Eliassen, 1998). The special section of the founding treaty of the EU, Chapter V - "Provisions on the Common Foreign and Security Policy", defines the role, goals, and tasks of the CFSP. In the first paragraph, Article J.1 states: "The Union and its Member States shall establish and pursue a common foreign and security policy, guided by the provisions of this Chapter and covering all areas of foreign policy and security (Eliassen, 1998).

The main goals of the CFSP are:

- protection of the common values, fundamental interests, and independence of the Union;
- strengthening the security of the Union and its Member States in all its forms;
- preserving peace and strengthening international security following the principles of the UN Charter and the principles of the Helsinki Final Act and the Paris Charter on European Security and Cooperation;
- promotion of international cooperation, and
- developing and strengthening democracy, the rule of law, and respect for human rights and fundamental freedoms.

EU Member States undertake (Article J.1, paragraph 4) to actively support the CFSP and refrain from any activity contrary to its interests. The key definition of the content of the CFSP is given in the first paragraph, Article J.4: "The common foreign and security policy covers all issues related to the security of the European Union, including the long-term definition of a common defence policy which could, in due course, lead to a common defence (Eliassen, 1998). First, the new Treaty strengthens, expands, and significantly more functionally networked competencies and relations of key EU institutions in the field of CFSP and external action. Namely, this Agreement expanded and strengthened the existing bodies and authorities and established new structures to support the EU institutions in

implementing the CFSP/CSDP and external action. For the continuity and unity of the Union's appearance on the international scene and the continuity and strengthening of the CFSP and CSDP of the Union, the introduction of a permanent electoral function is essential, the President of the European Council (EU, 2012a) and High Representative of the Union for Foreign Affairs and Security Policy/Vice-President of the Commission (EU, 2012b). Secondly, in addition to the CFSP and CSDP, as the basic pillars and sources of political and military-security capabilities of the Union, the Lisbon Treaty introduces another instrument for strengthening its capabilities on the international stage is The Union, with external action (EU, 2012c).

The objectives of the Union's common foreign policy and action under the Treaty of Lisbon (point 2, Article 21, General Provisions on the Union's external action, Chapter V) are:

- preserving the values, fundamental interests, security, independence, and integrity of the Union;
- strengthening and supporting democracy, the rule of law, human rights, and the principles of international law;
- maintaining peace, preventing conflicts, and strengthening international security following the objectives and principles contained in the United Nations Charter, as well as the principles of the Helsinki Final Act and the Paris Charter, including those relating to external borders;
- supporting long-term economic and social development, as well as environmental protection in developing countries, to eradicate poverty;
- encouraging the integration of all countries into the world economy, which includes the gradual elimination of obstacles to international trade;
- contribution to the development of international measures for the preservation and improvement of the quality of the environment and long-term management of the world's natural resources, to ensure long-term development;
- assisting the population, countries, and regions facing natural disasters or caused by human factors;
- Improving the international system based on enhanced multilateral cooperation and good governance of world affairs.

The European External Action Service (EEAS) has been set up to assist the High Representative of the Union in carrying out his duties in foreign policy and external action (EU, 2012d). The EU Foreign Affairs Service's organisation and functioning shall be determined by the Council of the EU, on the proposal of the High Representative, and after consultation with the European Parliament and the Commission's consent. In addition to the concretisation of goals and institutional arrangement of external appearance, ie. The Lisbon Treaty provisions on the expansion of existing and the establishment of new concepts and clauses on cooperation and mutual relations of members, such as the concept of closer cooperation and clauses on solidarity, on mutual assistance in defence against aggression and, establishing permanent structures of cooperation. Under the Lisbon Treaty, similar to the previous ones, the CFSP remains an area of cooperation between the Member States in which specific rules and procedures apply (EU, 2012d). The provisions on the Union's competencies in the field of CFSP (first paragraph, Article 24, Chapter 2, Chapter V of the Treaty) state: "The Union's competences in the field of the common foreign and security policy cover all areas of foreign policy as well as all the security of the Union, including the progressive establishment of a common defence policy that may lead to a common defence ". The common foreign and security policy is determined by the European Council and the Council of the EU, which, as a rule, decide unanimously in these matters unless otherwise regulated by the Treaty (Item 1, paragraph two, Article 24). Also, the same point regulates that the CFSP is implemented by the High Representative of the Union for Foreign Affairs and Security Policy and the member states following the treaties. In the area of CFSP, acts that have legal force over the members cannot be adopted, i.e., the Court of Justice of the EU has no jurisdiction regarding compliance with provisions in this area, except for the functioning of Union institutions (Article 40 TEU) following Article 275 of the Treaty on the Functioning of the EU.

In addition to defining the general direction of activities and systematic strengthening of cooperation between members, it is now clearly emphasised that the Union adopts decisions in the field of CFSP, which determine the actions and attitudes of the Union towards a certain issue (occurrence) and manner of implementation (Article 25). That is, the new provisions (Article 28, item 1) unequivocally regulate: "When the international situation requires operational action of the Union, the Council shall adopt the necessary decisions". The High Representative of the Union and the Ministries of Foreign Affairs of the Member States are responsible for coordinating the implementation of the Union's positions and

decisions (Article 32). It can be noticed that the new provisions of the EU Treaty sought to increase the degree of participation of members in creating EU positions in the field of CFSP, but also responsibility for the implementation of decisions, although, as stated, such decisions can not legally have legal force with members. Although the new wording of the Treaty provisions increases the direct involvement of members and responsibility in the creation and implementation of the CFSP, the lack of "communitarianism" in the field of CFSP has not been overcome by this EU Treaty, so it remains a possible weakness of the Union in the future. Especially from the aspect of unity and firmness in taking actions in the field of CFSP and CSDP. The role of the Political and Security Committee - PSC in the CFSP has not changed significantly. In addition to monitoring the international situation concerning the CFSP and, in this regard, giving advisory opinions and proposals to the Council and the High Representative of the Union, according to Art. 38 of the Lisbon Treaty on the EU, this body "under the leadership of the Council and the High Representative, conducts political control and control of the strategic directions of crisis management operations", defined in Article 43 of the Treaty. Thus, the CFSP represents a broad framework of cooperation between EU member states to strengthen the capabilities, responsibilities, and influence of the Union on the European and global political and security scene. As stated, during the two decades of CFSP development, it has established appropriate common sub-policies, institutions, and means (capabilities) for a much more independent response of the Union to the challenges and threats to European security, greater influence in global political and security issues and a more unified approach. In all aspects of international relations.

An important step in creating the full range of EU crisis management capabilities, including conflict prevention, is the European Council's decisions at the Feira (Portugal) meeting, 19-20. June 2000 (EU, 2000a). In addition to analysing the course of realisation of the "Main Goal" of developing military capacities and recommendations for further work on that issue, clear guidelines for strengthening the Union's civilian capacities were adopted at this Summit. That is, the justification of the establishment of the Civil Committee (CIVCOM) was confirmed (EU, 2000b).

As part of the EU's new political-security crisis management structure, the "Civilian Headline Goal" and mechanisms for centralising and managing non-military crisis management resources have been identified. It was concluded that the EU has significant resources for civilian aspects of crisis management, while, on the other hand, the international community is very scarce with such resources. However, although respectable, the members' civilian capacities should be centralised at the Union level voluntarily and further developed. Four priority areas have been identified to develop joint civilian capacities: police (police forces), the rule of law forces, civil administration forces, and civil protection forces. Also, members should have in high readiness and appropriate joint forces to provide civilian assistance. The Civil Committee is in charge of concretising the activities on the development of civilian capacities.

Within the EEAS, a special department, namely, the Crisis Response and Operational Coordination Department, was established to organise the foreign policy of the EU in the field of crisis management. One of the leading objectives of the EU has been to ensure a secure and stable international order that is based on the rule of law and supported by multilateralism. To realise this objective, the EU has selectively employed civilian and military crisis management instruments. Also, through 139 delegations and offices operating worldwide, the EU has been able to follow crises closely to shape its foreign policy accordingly and made its presence felt in the host countries. The instruments employed by the EU in crisis management can be grouped into four different categories following the context that is in focus. The focus situation may be one among the following four scenarios: peace or no armed conflict; escalation; armed conflict; post-conflict phase (Major et al., 2011). Instruments that can be employed in the first and the fourth phases share similarities, whereas there are convergences in instruments that can be deployed in the second and the third phases. For instance, instruments including peace-building, common financial structures, political missions, small-arms control, special representatives, and security sector reform (SSR) can be used both in a context where there is peace or no conflict and in a post-conflict context. In this regard, these instruments serve both crisis-prevention and peace-building purposes. They also have a stabilising impact aiming to remove the crisis's causes in the pre-incidental or post incidental stage of a crisis (Gjozinska, 2014). Likewise, CSDP operations, groups of friends, military rapid-response forces, peace enforcement, and peacekeeping can be used both in a context where the conflict's escalation occurs and in an armed conflict context. Thus, these instruments accomplish the dual purposes of mediation/intervention and conflict management. Unlike the above-mentioned instruments that can be used in different stages of a conflict, some instruments such as reconciliation and transitional justice can be employed—just in a post-conflict phase, with the

goal of peace-building. The EU has mostly utilised instruments that reflect the soft-power of the Union, such as economic instruments. Economic instruments include, on the one hand, financial assistance in the form of funds, whereas on the other, they include economic sanctions. The Union provides financial assistance to the third states and regions where poverty is perceived to be the leading factor to cause a potential crisis or conflict. Hence, the funding aims to eliminate poverty to contribute to stability in a given state or region. Through the employment of economic sanctions, the Union targets third states and their ruling regimes by punishing them for causing a change in their policies, such as human rights violations (Karakir and Karacasulu, 2016).

Table 1. Crisis Management Instruments Employed following Different Phases of Conflict Phases Context Instruments

Phase 1 Peace or no armed conflict	Crisis prevention: Common financial structures, disarmament and arms control, election observation, peace-building, political missions, sanctions, small arms control, special representatives, SSR
Phase 2 Escalation	Mediation/Intervention: Conflict resolution, CSDP operations, groups of friends, military rapid response forces, peace enforcement, peacekeeping, sanctions, special representatives.
Phase 3 Armed conflict	Conflict management: CIMIC, CSDP operations, friends, humanitarian aid, military rapid response forces, peace enforcement, peacekeeping.
Phase 4 Post-conflict phase	Peace-building: CIMIC, common financial structures, conflict mediation, CSDP operations, DDR, democracy promotion, economic reconstruction, election observation, groups of friends, international tribunals, peace-building, peacekeeping, police missions, political missions, reconciliation and transitional justice, small arms control, special representatives, SSR.

(Source: Major et al., 2011)

EU policy on crisis management has evolved through time. Many institutional changes took place to develop a more comprehensive and well-structured approach. Recently, the EU has adopted "principled pragmatism" for crisis management along with an existing large "toolbox." Since the 1990s, it has deployed more than 30 civilian missions and military operations on different continents, mostly in Africa, some of which have already been completed. The leading strength of the EU in crisis management is its capacity for offering efficient instruments within the framework of civilian crisis management. Civilian instruments are accepted as crucial to address political, social, and economic aspects of a conflict and find a sustainable and comprehensive solution accordingly. The EU has demonstrated a better performance in its civilian missions when compared with the leading international institutions like the UN, OSCE, and NATO. Particularly, the EU's economic instruments and police and the rule of law missions have successfully managed crises in various contexts. The other strength of the EU is related to multilateralism's prioritizations as a guiding principle for security building. The EU's multilateralism prioritisation can be observed in its close working relationships with the UN and other international organisations. Although the EU has made remarkable civilian contributions to conflict and post-conflict contexts, the EU response mechanism to crises suffers from many limitations. The first limitation is the lack of agreement among the EU officials on the definition of a "crisis." EU institutions cannot agree on what should be considered a crisis, which leads to misunderstandings and inefficiencies in the EU's responses to crises. The divergence in the definition of a "crisis" also results from a lack of unity on which instruments should be used in tackling the crisis. Another limitation concerning EU crisis management is related to the divisions among member states about their commitments to manage crises that may depend on their national interests. Decisions regarding CSDP are taken unanimously in the Union, but it has not been easy for EU member states to agree on a certain policy. In some cases, there may be little commitment by the member states due to a

lack of interest in the crisis region. There may also be tensions among member states on how to tackle the crises. Also, member states' policies may vary over whether "civilian" or "military" aspects of crisis management should be prioritised. Inadequate budget allocation for crisis management is another limitation. The Eurozone crisis has harmed EU member states' economies since the end of 2009. The austerity programs adopted by EU member states have, in turn, led to decreasing financial commitment by the member states to crisis management. For the EU to react more effectively to crises, an increase in funding for crisis management instruments is highly needed. Lastly, limited military capacity is considered to be among the weaknesses of the EU crisis response mechanism. The EU has widely been depicted as a soft-power that prioritises non-military foreign policy tools in responding to crises. Ukraine and the Middle East crises have demonstrated how critical military operation would be, and in this regard, the EU is under-resourced to respond to them (Karakir and Karacasulu, 2016).There are the preconditions to develop a Civilian Compact that would be a breakthrough compared to the past. This would be possible only by expanding the civilian capabilities and addressing the gaps of the previous plans. European institutions and member states should promote clear objectives and effective coordination between military and civilian forces. After the push on EU defence cooperation in 2017, it is time to give new momentum to the civilian sphere by highlighting the connections between internal and external security. The development of the Civilian Compact should aim to provide an efficient method to deal with the crisis, balance stability and democracy, and increase the areas involved. Looking at obstacles, the most difficult one is to win the support of the member states and European institutions. The goal should be to make the whole process more efficient by streamlining the decisions and integrating single member states' expertise. The role and mandate of each agency and the line of command should be clarified to create positive spillover effects. An endeavour of such complexity requires a specific budget, which could become another hindrance in the current European context. The project's efficiency should be improved by designing an evaluation system that considers both internal and external actions and effects. The Civilian Compact is, at the same time, a great opportunity and a challenge for the EU, especially with regards to the Mediterranean and the Sahel regions. On the one hand, the Union has been a sponsor of human rights since its establishment, and the missions developed under the Civilian Compact could enhance this role, with the EU being the leader for operations in the region. On the other hand, the Union has to work to guarantee its internal security, which is crucial to let the European citizens consider the EU to be regarded as a credible actor and understand its added value.

3. Crisis management and Response **(EEAS, 2020).**

A guiding principle of Lisbon Treaty provisions, which lie at the heart of the very purpose of the EEAS, is the desire to achieve a substantial increase in 'responsiveness' to the opportunities and challenges that exist beyond EU borders. Adequate EU action during external emergencies, which require ad-hoc decision making, is no exemption to this. Crisis response implies the immediate mobilisation of EU resources to deal with the consequences of external crises caused by human-made and natural disasters.

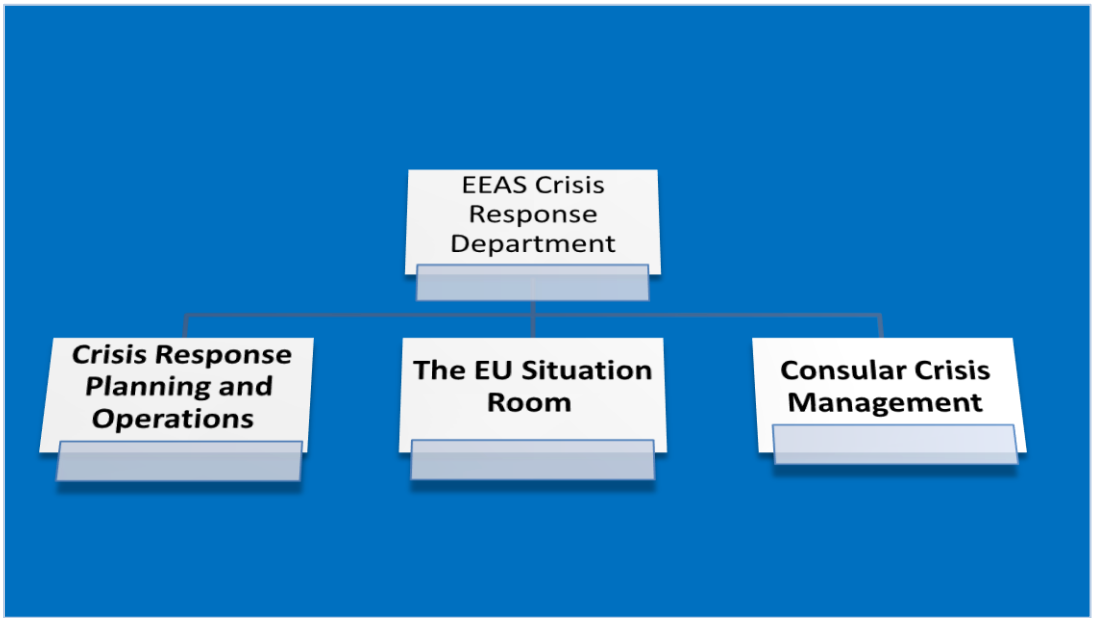
3.1. Crisis Response System

The EEAS Crisis Response & Operational Coordination Department is responsible for activating the **EEAS Crisis Response System** (Crisis Platform, EU Situation Room, and Crisis Management Board). Therefore, it plays a central role in ensuring both swift and effective mobilisation of actors and instruments across the EU system and the coherence of policies and actions throughout the various phases of the crisis life cycle. The EEAS Crisis Response System (CRS) covers crises that may affect EU security and interests occurring outside the EU, including those affecting the EU delegations or any other EU asset or person in a third country. It equally covers crisis occurring inside the EU if those have an external dimension. CRS ranges from prevention and preparedness to response and recovery, aiming to achieve a comprehensive EU crisis response and management capability. The CRS contributes to ensuring coherence between various aspects of crisis response and management measures, particularly in the security, political, diplomatic, consular, humanitarian, developmental, space-related, environmental, and corporate fields. The CRS secretariat is ensured by the EEAS Crisis Response Department, which plays a key coordinating role that facilitates translating the comprehensive approach into comprehensive action in crisis response and management.
The EEAS Crisis Response Department comprises the following three Divisions:

1. **Crisis Response Planning and Operations** is tasked with the overall planning, organisation, and coordination of crisis-related activities, including preparedness, monitoring, and response. In particular, the Division has the responsibility:
    - to assist the EU High Representative in his responsibility to ensure the coherence and coordination of the EU's external action specifically in the field of crisis management and response;
    - to undertake specific missions in crisis areas
    - to coordinate the work of the EU Crisis Platform
    - to closely follow developments in the world to enable the EEAS to respond to potential and emerging crises at short notice

2. **The EU Situation Room** is the EU's crises centre that provides worldwide monitoring and current situation awareness 24 hours a day, 7 days a week, all year round.
3. **Consular Crisis Management** assists in consular policies across the EU and coordinates actions in times of crisis.

Figure 1. EU Crisis Response Department



(Source: https://eeas.europa.eu/headquarters/headquarters-Homepage/412/crisis-management-and-response_en)

3.2. Crisis Platform

EU crisis response & management instruments are subject to different institutional and decision-making processes within and beyond the EEAS. To ensure that responses to emergencies are timely and adequate, effective coordination of the relevant crisis management instruments (civilian and military) is a key priority during the crisis cycle. The Crisis Platform – which comprises a range of services across the EU system and is chaired by the High Representative, the EEAS Executive General (ESG), or the EEAS Managing Director for Crisis Response – can be convened on an ad hoc basis and is a crucial mechanism that is activated to guarantee EU responsiveness during external crises. The Platform provides the EEAS and Commission services with clear political and/or strategic guidance to manage a given crisis.

Depending on the characteristics of a particular crisis, the EEAS Crisis Platform can bring together:

- Various EEAS crisis response/management structures: Crisis Management and Planning Directorate (CMPD), Crisis Response Department, EU Military Staff (EUMS), Civilian Planning and Conduct Capability (CPCC), Situation Centre (SitCen), EU Situation Room as well as relevant geographical and horizontal EEAS Departments.
- The EU Military Committee (EUMC).
- The relevant European Commission services (ECHO, DEVCO, FPI, etc.).

- The secretariat support is ensured by the EEAS Crisis Response Department, which performs an overall operational coordination function in support of the ESG, based on conclusions agreed at the Crisis Platform meetings.
- The unexpected onset of the 'Arab Spring' in early 2011 and its aftermath put the then recently established EEAS (at the new EU foreign policy system more generally) to its first major test. In that regard, the EEAS Crisis Platform played an important role and has since become an institutionalised element of crisis decision-making within the EU-system.

a. Crisis Response Cycle

Emerging and acute crises require swift responses to alleviate human suffering and avoid or prevent further escalation and instead strive to promote dialogue, reconciliation, and reconstruction and protect EU citizens. Unlike in other areas of foreign policy, the EU's capacity to meet the needs and challenges that (often unexpectedly) arise in natural and human-made emergencies crucially depends on its ability to take, in real-time, ad hoc decisions and actions. In short, when crises erupt – though they seldom follow a predictable pattern – immediate attention and coordination are required. Thus, the response is complementary to medium- to long-term measures and an integral part of a comprehensive approach that includes conflict prevention and peace-building, CSDP missions, or development programs.

3.4. The EU Situation Room

The EU Situation Room is the first point of contact for all information on crises. It is a permanent stand-by body that serves as a situation information hub for all relevant European institutions' stakeholders. It acts as the EEAS switchboard and embeds within situation reports or flash reports all crisis-related information provided, among others, by EU Delegations, EU Member States, EU CSDP Operations and Missions, EUSR teams, and International Organisations.
More specifically, the EU Situation Room:

- Monitors and reports on worldwide events on a 24/7 basis, focusing on topics and issues relevant for the EEAS and the EU as a whole;
- Liaises 24/7 with CSDP Missions and Operations through a Watchkeeping Capability, as well as with EU Delegations;
- Supports HRVP and relevant EEAS services, the Council, and cooperates closely with the Commission;
- Plays a role in the EU Integrated Political Crisis Response arrangements (IPCR) to support political coordination and decision-making in major, complex, inter-disciplinary crisis;
- Manages and develops relations with national crisis response and crisis coordination centres of EU Member States;
- Has regular contacts with other regional and international organisations' crisis centres, such as the UN Department for Peacekeeping Operations (UN DPKO), League of Arab States (LAS), African Union (AU), and the Association of Southeast Asian Nations (ASEAN).

3.5. Consular Crisis Management

Part of the EEAS Crisis Response Department, the Consular Crisis Management Division currently has two roles:

1. assisting the Presidency to coordinate consular policies across the EU (e.g. travel advice, issuance of consular guidelines);
2. to assist the Presidency and/or the Lead States to coordinate action in times of crises.

For normal consular work, Member States do not need the assistance of the EU. Consular assistance and protection are, after all, an exclusive national responsibility. However, not all EU citizens are represented in all third countries. The EU Member States are all present in only three countries: the US, Russia, and China. This means that in all other third countries, one or more Member States are not present. Article 23 of the TFEU gives any unrepresented EU citizen the right to obtain assistance from another Member State's consular services under the same conditions that the Member State assisting would give its citizens.

Conclusion

Although the implementation of crisis management began in the European Union only in the first decade of the 21st century, this was not an obstacle to developing a unified approach of that organisation. A realistic approach to the potentials and resources of the Union for active action in preserving the security of the European continent, but also global peace and security, influenced the new strategic approach to security reflected in the EU Global Strategy. Concerning the approach to resolving conflicts exclusively by military means, which was current in the period after the Second World War, a comprehensive approach to resolving a conflict situation represents a qualitative shift. Analysing the Common Security and Defense Policy of the European Union and the goals published in the Global Strategy, the European Union is committed to managing conflicts and stabilising the territory affected by them. The establishment of a European Union crisis management mechanism positions the EU as a global actor in security. The EU Crisis Management Mechanism is an effective segment of the CFSP and assures the international community that they have a reliable partner, especially in management emergencies. Apart from military crisis management, the EU is deeply committed to civilian crisis management which will be predominant in years to come.

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Uticaj industrijskih akcidenata u namenskoj industriji na bezbednost u Republici Srbiji

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Apstrakt: Bezbednost ljudi i imovine osnovna je premisa poslovanja svakog preduzeća. Bezbednost kao značajna funkcija menadžmenta organizacije, naročito dolazi do izražaja u preduzećima koja se bave proizvodnjom eksplozivnih i zapaljivih materija. U kategoriju bezbednosno rizičnih preduzeća spadaju i preduzeća namenske industrije. Ove konstatacije su se potvrdile u bliskoj prošlosti kroz nekoliko industrijskih akcidenata koji su imali ozbiljne posledice. Bezbednosna ugroženost ovih preduzeća se ogleda pre svega u osetljivosti pojedinih proizvodnih i tehnoloških procesa u pogledu mogućeg nastanka požara, eksplozija isticanja opasnih gasova i tečnosti, zatim u količinama i osetljivosti eksplozivnih i zapaljivih materija koje svakodnevno učestvuju u procesima proizvodnje. Uzimajući u obzir navedeno jasno se nameće zadatak preventivnog delovanja i sprečavanja nastanka akcidenata odnosno umanjenja efekata njihovog eventualnog ispoljavanja (ukoliko se dogode).

Suština ovog rada ukazuje na problematiku sagledavanja najkarakterističnijih industrijskih akcidenata koji su se dogodili u namenskoj industriji iz aspekta njihovih fenomenoloških obeležja, sa ciljem izvlačenja određenih zaključaka kao pouka. Kao najznačanija, obrađena su pitanja prevencije akcidenata i aktivnosti subjekata bezbednosti u pogledu preventive i otklanjanja posledica. Takođe izdvojeni su zaključci proizašli obradom ove veoma složene i u savremeno doba veoma aktuelne problematike, a koja zahteva punu pažnju svih subjekata bezbednosti u državi, kako bi se sprečile izuzetno opasne, pa čak i katastrofalne posledice po objekte bezbednosti u Republici Srbiji.

Ključne reči: akcident, bezbednost, eksplozija, preventiva, industrija.

Influence of industrial accidents in defense industry on security in the Republic of Serbia

Abstract: The security of people and property is one of the basic premises of the business of each company. Security as an important function of management of the organization, particularly evident in companies engaged in the production of explosives and flammable substances. In the category of security risk companies are the defense industry companies. Recently, these findings have been confirmed through several industrial accidents with serious consequences. Security vulnerability of these companies is reflected primarily in the sensitivity of certain production and technological processes in terms of exposure to destructive influences and possible occurrence of fire, explosion of a hazardous gases and liquids. Reasons for increased surveillance and a higher safety level can be found in the volume and sensitivity of explosives and flammable substances on a daily basis participate in the processes of production. Considering aforementioned clearly imposes the task of preventive action and preventing accidents and diminishes the effects of their possible manifestation (if they occur).

This paper considers the most characteristic of industrial accidents that have occurred in the defense industry from the point of view of their phenomenological characteristics, with a view to identifying the causes of these phenomena and take measures to correct them, in order to prevent repeated and similar events. As the most relevant, addressed the issues of prevention of accidents and safety activities of operators in terms of prevention and elimination of consequences. Also, paper presents singled out the conclusions derived by treating these very complex and in modern times most of the current problems, which requires the full attention of all security subjects in the country, in order to

prevent extremely dangerous and even disastrous consequences for security facilities in the Republic of Serbia and the destruction of valuable and scarce resources.

Keywords: Accident, Industry, Explosion, Safety, Environment

1. Introduction

In each area, including a work environment, where there are explosive and incendiary devices, there is a potential risk of possible occurrence of the effects of explosions and turbulent combustion, which would lead to endangering humans safety and property. In order to reduce these opportunities to a minimum, or its complete elimination and thereby increase the safety of humans and property, take all possible actions and measures which are the responsibility of certain organs of the Ministry of Defense in cooperation with the Ministry of Interior in charge of the Emergency Management Sector (Directorate of Risk Management).

The Ministry of Defense is required to undertake certain activities and measures to protect members of Serbian Armed Forces of the effects of explosion of the explosive devices. The protection measures and actions which are going to take and to extent will depend on the method and the way those will be made assessment of the security risk to humans and property from the effects of the explosion of explosive devices, and will also depend on how the content is objective and impartial. Therefore, the responsible service in the function of the Ministry of Defense finds the best mechanisms to evaluate the actual situation of vulnerability of humans and property from the effects of the explosion of explosive devices in the workplace. In these fields of work is possible then in a short period of time the crisis situation arise, unless there is constant vigilance and preparedness (prevention) to organize appropriate timely intervention.

Prevention of accidents and elimination of the consequences of accidents is particularly important in the field of defense industry, where the Ministry of Defense has a crucial role. This uniqueness is reflected primarily in the sensitivity of certain production and technological processes in companies of the defense industry in terms of the potential of fire, explosion of a hazardous gases and liquids, then the amount and sensitivity of explosives and flammable substances on a daily basis participate in the processes of production, deactivation and laboration various hazardous substances and finished products.

The aforementioned objects of the defense industry, in particular in the new era of more prominent asymmetric threats, particularly vulnerable to terrorist threats to the aspect, where the consequences of threats such facilities may be just as disastrous in terms of the classical industrial accident (the adversity) and the aspect of sabotage or diversion.

Possible accidents in the defense industry is not affected negatively only to members and assets of enterprises of the defense industry and the Ministry of Defense and the Serbian Armed Forces, but also can directly affect the entire population and infrastructure in their immediate environment and indirectly, the long term and the entire security community in the Republic of Serbia. Among other such violent activities endangering the security of facilities dedicated industries negatively affect the reputation of the security subjects and the country as a whole, because it suggests that security subjects are unable to preventive activities of detecting and preventing the occurrence of such phenomena.

2. Basic concepts of industrial accidents and safety

As a social phenomenon, science or theory, security is the subject of philosophical thought, and organizational sciences. For Thomas Hobbes security is the most fundamental value. There is no doubt that security is one of the most important human needs which satisfy other needs (freedom of individuals or social groups, the needs in the field of economic and other activities). Such a definition of safety is present in theoretical writings on management in organizations from the beginning of the last century, where it is treated as one of the basic conditions for the functioning of organizations (Kekovic and Nikolic, 2006).

Due to the complexity of the concept and the phenomenon of ubiquity, security is taken as cognitive and experiential framework for understanding the complex multidimensional risk today. At the same

time bearing in mind the legality of the appearance and change of the physiognomy of risk, the complexity of their causal links, latent and manifest the nature of hazards.

It is generally accepted that the concept of security today has become much more complex than it was during the "Cold War", and it is primarily due to the development of the globalization process. The concept of security today includes traditional (freedom from fear and from threats of physical violence) and new items (food safety, water safety, environmental protection, fear of the virus, terrorism). The United Nations say that the emphasis now is not only to protect the borders of a sovereign state, but also to protect from everyday worries. Today, people are more afraid of what would have to happen in a "free" and "secure" society of their completely militarily protected by the state, but from that to their territory could attack another country, or it could happen some cataclysmic event, such as a nuclear war. Today, new security risks related to income security and workplace, health care, environmental security and protection from violence, starvation or disease.

Development of technologies, rising competitive challenges in markets around the world, the struggle for natural resources and geopolitical dominance, increase in all types of crime and the emergence of new, intensifying the presence of various intelligence services and the increasing espionage in various segments of social, civil and economic activities, are some reasons which today more attention is paid to security segment especially in organizations engaged in economic activities.

It is no longer a question of whether the security management needs or not. Today this area is a matter of survival and is therefore the role of the security management all the more pronounced especially in areas where security management is not is a basic form of management, but also in function of preservation and growth of the organization, especially in those organizations which represent a very important factor in the economic security of the state (Talijan and Talijan, 2011; Vuruna et al., 2017).

Safe systems are those that are pre-protected, so that upon occurrence of certain incidents system remains protected. When it comes to performance and handling of ordnance, not only during the laboration, but also during handling, transport and storage, there is no absolute security, but it is set in relation to a particular danger or threat. Reaching a certain level of security, while laboration worker acquires additional security required for manipulating and working with resources.

Pyrotechnic safety system is an integrated set of organizational and tactical - technological measures and procedures aiming to the possibility of any damage and the result are reduced to an acceptable level in production plants and warehouses.

Security of the protected objects (for the manufacture, storage and transport of ordnance) and the reasons of protection are apparent and have a higher surface potential of the enormous harmful effects. Specifics of fire and explosion of ordnance in relation to other dangerous events only reinforce the reasons of protection:

- fires and explosions occur very quickly, without any prior warning signs, which would provide more time for rescue and evacuation,
- most of the explosions creates a very strong impactor, sonic, thermal effects in accordance with the purpose of ordnance - destroying and killing of,
- material destruction and damage caused during accidents are enormous,
- exact causes of fires and explosions usually can not be determined. As an aggravating factor in citizenship with complete ignorance and lack of understanding in all aspects of a dangerous weapon.

The accident, according to the standards of the European Union, is a sudden occurrence of a large emission, fire or explosion as a result of unplanned events within a particular industrial activity, which occurs within or outside the network including one or more of the chemicals (Group of authors, 2008). According to the Law for the Protection of Environment of Republic of Serbia, synonymous with the term "accident" is "crash", which comprises a sudden and uncontrolled event or series of events, which occurs non-controlled, spilling or scattering of dangerous substances in the production, transport, use, transport, processing, storage, disposal, or storage of long-term inadequately.

The causes of accidents are the subjective and objective character: inattention employees, force majeure, uncontrolled technical requirements, etc.

The technical and technological incidents can occur in (Becelic, 2008):

- installations for the production and processing of hazardous substances,
- plants that manipulate dangerous substances,
- storage of hazardous materials,
- traffic during the transportation of hazardous materials,
- landfills where they can find dangerous substances.

Basic features of technical and technological accidents are (Jeremic et al., 2008):

- accidents comes suddenly, usually at night and often in batches, accidents are quite unpredictable with respect to place, time, type and location, especially when it comes to an accident involving hazardous substances,
- have a lot of specifics, given the possibility of occurrence and the scope for people, working and living environment,
- quite frequently, and in addition to stopping the process of uncontrolled release of hazardous substances, result of repair is difficult and requires a long-term process,
- at the site where the accidents are mostly related to fixed installations and transport,
- security of chemical accidents in peace requires complex measures (monitoring, protection, removal of consequences) and reaction, namely response to the accident according to pre-defined protection plans.

Risk is the probability of occurrence of a certain harmful effect on humans, property or living and working environment in a given time, as a result of the realization of some danger or situations, or the occurrence of accidents. Acceptable risk is the accident with a high probability that it will occur, but with negligible consequences (Jovanovic, 2007).

When working with ordnance all elements of risk are defined in advance, or at least most of them, and have taken precautions in case of accidents is not the result or they are kept to a minimum. The biggest problem that occurs when laboration ordnance is a condition in which the employee is located. His psychological, physical, moral and spiritual condition can be decisive, because it is certainly more likely to be a fault in the system occur due to human error, but due to the cancellation of a machine. The level of psycho - physical quality and level of education of the people engaged in completely determines the complexity of work with ordnance.

In Table 1. are shown causes of the industrial accidents (Kekovic and Nikolic, 2006).

Table 1. Causes of Industrial Accidents

CAUSES OF INDUSTRIAL ACCIDENTS			
Unsafe conditions (insufficient lighting in the workplace, exposure to extreme temperatures, inadequate protection when working with machinery or hazardous materials, electrical installations)	**Unsafe actions** (negligence by workers, organizations and manufacturers)	**External causes** (fire, chemical emission, the emission of toxic gas or radiation, the error in the organization, the human factor, the abnormal operating conditions, the natural forces, external factors, errors in a software system)	**Internal causes** (equipment, toxic chemicals, hazardous materials, human error)

From the above it is clear that the danger to humans and the environment, and therefore by the state of human security, can cause various industrial accidents.

3. Importance of preventive activities

Production of arms and military equipment in the Republic of Serbia is proportional to the needs of the Army and the possible export business. Production that is harmonized organizational and technological means mixed and complex industrially technology (base - chemical, chemical - technological, electro - chemical, electrical, mechanical, etc.). Risks in such manufacturing processes are a reality and a duty to be reduced to a minimum.

Explosive substances which are used in the manufacture of armaments and military equipment (AMQ), which we believe to cause the greatest risk, during the actual manufacture and integration of, including the storage and use, can be classified into the following categories: explosive materials, propellants, rocket fuels (solid and liquid), the liquid oxidizers rocket propellant, pyrotechnic mixture (Jovanovic, 2007).

Basically, in terms of prevention of occurrence of accidents in the defense industry, as well as preventive activities in other areas of industry, represents a set of activities and measures that enable the prevention of emergency situations or harmful effects of industrial accidents caused by such disasters, and as such prevention represents a huge moral imperative (Berisa et al., 2015).

Effective prevention is always preferable, but reaction in the event of an accident, because it significantly reduces human suffering and economically more justified. Procedures and preventive measures to prevent the occurrence of miraculous situation and mitigate the effects can be: engineering - construction, urban - planning, economic, institutional and social.

Prevention is the set of measures and actions to be taken to a potential accident place to prevent and reduce the probability of accidents and potential consequences, and consist in an adequate spatial planning and zoning (determining the protection zone and the safety zone); making the analysis of the accident risk and giving opinions and approvals on them; selection of those technologies that allow a greater degree of protection, reducing transport needs of hazardous substances and reduce the emission of pollutants of living and working environment; timely elimination of all identified technical - technological defects; maintenance work - the technological discipline at the required level; comparative maintaining the patency of all the roads and passages within the hazardous installations; the application of technical means and equipment for detection and protection; control and monitoring and control system security; reviewing existing technology and improve its security; review the location of individual plants; reviewing and improving existing means of personal and collective protection and decontamination; reviewing the planning, training and practicing employed and cooperation with specialized authorities and organizations at all levels; information may be jeopardized through the middle and the media.

Prevention measures to prevent and reduce the possibility of an accident in the arms industry include measures in the design and construction (envisaged and implementing spatial planning, design and construction of facilities and installations); technical - technological measures (planned and implemented by selecting production technology, technological equipment, process control, etc.); fire protection measures (provided for in the security and protection, detection and identification of danger, warning, and response to danger); organizational measures (measures provided for the purpose of training and training people to manage and respond to accidents); other measures (protective outside the surveillance complex, notification, evacuation, emergency response, etc.). These measures can be viewed from the aspect of preventing further deterioration of the situation and reduce the risk but when it comes to accidents. The dimensions shown are in that it can be carried out in an explosion ordnance (EO) and the chemical contamination would be the following: panic prevented to avoid major accidents, and the result of; employees quickly and safely leave the danger zone or the object; the evacuation of injured workers being taken into account to avoid injury to rescuers; call the medical support and provide first aid to the injured; if as a result of the explosion appears to be the localized fire.

4. Entities security activities in the field of prevention and elimination of the consequences of industrial accidents

Basic security entities that act as a preventive and after the occurrence of accidents in plants of the defense industry are: 1) First of all the highest and direct managers (directors, managers drive leaders as individual technological units, etc.); 2) Qualified persons and groups in charge of safety at work, fire protection and environmental protection; 3) An executive authority from the composition intended for the company response of emergency (firefighting team, the rescue team, the medical team, the forces for the emergency evacuation of personnel and resources et al.); 4) Forces for emergency response in case of accidents are outside companies, which are part of the organizational units of the MoD and SAF or civilian structures, which have adequate forces (fire - rescue units, the forces of the Emergency Management Sector of Ministry of Interior, medical institutions, the crisis staffs local board, search and

rescue teams to detoxify people and decontamination agents, forces to block access to the site of accident - Ministry of Interior authorities, utility companies with appropriate equipment).

Accidents/emergencies can be prevented by applying appropriate preventive and corrective measures. In this sense, there are a number of procedures laid down in the relevant guidelines on the treatment of hazardous substances that act preventively so as to prevent unwanted situations.

Immediate preventive measures to prevent the fire would be: noted signs of prohibition, warning and danger in a prominent position; provide fire extinguishers and hydrants; regularly to control mobility of roads; all clearly marked fire roads; conduct regular staff training and assessment in the field of fire protection; in an obvious place to put a brief introduction of response in case of accidents (explosions, fires) with equipment which is necessary; on the fuel station, engine vehicle must be turned off while refueling; tanks cleaned regularly of a precipitate that results in filling the fuel, in the longer of the same; regular inspection apparatus for dispensing fuel (Kekovic et al., 2010).

Direct prevention measures when working with inflammable liquids and hazardous substances are (Markovic et. al, 2013) properly stored flammable materials; for storage use a secure, hermetic packaging in which there is no risk of breakage, spills, etc.; ensure safe transportation of fuel or other flammable liquids to the place of work; refueling (warehouses) carry out the prescribed protection measures; ensure that storage to be away from the place of work; dangerous substances should not be stored near heat sources; dangerous substances should not be stored in warehouses built of flammable material; dangerous substances should not be stored near combustible materials; the storage temperature maintained within the given range, depending on the type of hazardous substances; warehouse must have adequate ventilation; in an obvious place put a brief introduction of emergency response as well as information about the equipment that is necessary and empty container (adequately decontaminated) always kept separate from full containers.

Prevention measures in order to prevent occurrence of the explosion of munitions, explosive materials that include (Mladjan, 2009) every operation with a dangerous (explosive) substance has to be performed precisely at the prescribed technological process; workers must be physically and mentally healthy and trained (theoretical and practical) for the proper execution of work operations; in the workplace should be noted user operation; prescribe general measures of protection (electrical installation in the EX protection, use nosparking tools, adequate protective clothing and footwear, protective masks and other measures).

In case of emergency, which can directly cause any adverse effect on the safety and health of humans, the immediate superior of the drive in which there was an emergency interruption of the work process, turns off the power supply and act in accordance with the established plan. The most urgent is the rescuing of injured or endangered humans and given first aid. Then organize transport to health institutions where providing adequate health care. Then, provide material resources and performs normalization of working conditions. Very important is the rehabilitation of the environment if there is a substantial threat to her. First aid performed by employees of enterprises of the defense industry that have undergone appropriate training. If there is a need to invite and professional emergency services. For the rehabilitation of the consequences and bringing working conditions in normal operation formed special teams of trained persons in such situations.

Reaction accidental release the following (Cvetanovic, 2015): for the neutralization of hazardous materials that caused the chemical accident, use appropriate chemical substance for neutralizing them, which is situated in all the objects which may give rise to a chemical accident; use personal and collective protective equipment; act in accordance with a previously prepared response plans in case of accidents (for chemical accidents) - which must be displayed in all facilities in which may cause chemical accidents.

Reaction in case of spills of dangerous substances boils down to this: to prohibit access to the open flame and sparking tools; sprinkle spilled liquid with sawdust or sand yellow. When the dust (sand) and filled with liquid, pick up the shovel into containers or drums intended for it and upload the stored waste materials; in the event of a major spill notify the director, the manager, referent of fire protection (RFP), Department of FP, referent for the protection of the environment (RPE), and a referent for security and safety (RSS) and further treated according to their detailed instructions; act in accordance

with a previously prepared response plans in case of accidents (for spills of hazardous substances) - which should be installed in all buildings that may spill of hazardous materials.

Reaction in case of an explosion of hazardous materials is the following: if came to explosion (detonation), it is very important to prevent a panic that could lead to even bigger and fortunately consequences; workers need fast and safe way to leave the building in which the explosion occurred; after explosion immediately begin the evacuation of the injured people, and the take care to avoid injury to rescuers; call the ambulance, while providing first aid to the injured; if as a result of explosion of fire occurs, it should be localized and prevent them from turning into a new detonation; special attention to the fact that in case of fire and explosion release different toxic gases: carbon monoxide, nitrogen gas, hydrogen sulfide, sulfur dioxide and others, so that the rescuers and firemen must be equipped with appropriate means of personal protection (masks, clothing, etc.); act in accordance with a previously prepared response plans in case of an accident (explosion of hazardous materials and munitions) - that should be installed in all buildings which may explode ordnance.

5. Characteristic examples of industrial accidents in defense industry in the Republic of Serbia

According to the International Labor Organization in 2008, statistics occurrence of industrial accidents in the world 6,000 people a day, or 2.2 million people die each year due to accidents in the workplace or as a result of the outcome of occupational diseases. Out of this number, there were 350,000 deaths due to the occurrence of accidents in the workplace.

Various industrial accidents in the defense industry in the Republic of Serbia, and before that in the FRY is reflected in the following (Cvorovic, 1999):

- On June 23rd 1995 there was an explosion at the facility Vinifleks factory "Grmeč" in Zemun and on that occasion 11 workers died and 10 workers were injured;
- On June 21st 1996 due to fire in defense industry "Prva Iskra" in Baric claimed the lives of two workers;
- On December 3rd 1997, due to a fire in the defense industry "Milan Blagojevic" in Lucani have killed three workers and seven were injured;
- On May 29th 2006, there was an explosion in the defense industry "Prva Iskra" in Baric and on that occasion that killed three workers and injured three workers;
- On September 4th, 2009, four powerful explosions in the gunpowder department of defense industry "Prvi partizan" in Uzice, when handling powders, killing seven workers and thirteen workers were injured;
- On May 10th 2010, in a weaker explosion at a defense industry holding corporation "Krusik" in Valjevo were lightly injured two workers;
- On December 27 th 2010, there was a series of explosions caused by a fire at the facility for laboraciju ammunition in the defense industry "Sloboda" Cacak, no one was hurt but it caused great material damage;
- On September 21th and June 25th 2012, in the defense industry "Milan Blagojevic" in Lucani was an explosion on the presses for the production of double-base propellants, and on that occasion there was an injury to workers;
- On May 15th 2015, the defense industry holding corporation "Krusik" in Valjevo during testing lighter hand grenade explosion occurred and it was 7 injured workers;
- On February 28th 2017, at the Technical Repair Bureau of ammunition in Kragujevac there was a fire and explosion UBS prepared for overhaul, where killing 4 members and 25 members of the Bureau were injured and hospitalized.

Following analysis of all the above accident in the defence industry there is found that the majority of accidents result of the human factor, namely: non-compliance with workers defined technological procedures unconscientiousness and discipline in the performance of highly hazardous and charge operations, the transition to a routine for certain operations, and the absence of the required level of attention, lack of workflow control by direct supervisors, as well as by higher levels of management. In addition to these factors important role and those who are not a direct consequence of human factors, such as: insufficient elaborate security measures in particular technological procedures, certain working machines and drives do not provide a sufficient level of protection of the people, not provided clear and

effective procedures and procedures for the formation of accident, people not trained to the extent necessary to work in a safe manner, as well as procedures in accident and emergency situations.

6. Conclusion

The emergence of industrial accidents in the defense industry, particularly in the case of large-scale accident could have extremely negative effects and be dangerous to life and health, infrastructure facilities and resources, the living and working environment. There is no doubt that the effects of industrial accidents leave only short-term but especially long-term adverse effects on the environment and prevention is imperative in all serious considerations of industrial accidents. Preventive measures, as pointed out, should be given special attention and carry them continuously, continuously review and improve them. It is especially important to keep abreast of modern technical - technological solutions in the defense industry in the immediate environment and the world, to raise the level of protection and security of human and material resources and in accordance with its own normative, organizational, technical, material and financial capacities to plan and implement the same in own enterprises of the defense industry.

Experience in the field of potential causes and the danger of industrial accidents must be constantly exchanged the entire security society, ie. beyond the borders of national countries, and the same in the future procename install, optimize and improve the system, which contain processes and technologies for the production, storage and transportation of hazardous, especially explosive and flammable substances.

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Balans privatnog i profesionalnog života nastavnog osoblja na visokoškolskim ustanovama u uslovima pandemije virusa Covid 19

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Apstrakt: Pitanje ravnoteže između poslovnog i privatnog života nastavnog osoblja na visokoškolskim ustanovama postaje sve zanimljivije za istraživače zbog složenosti odgovornosti nastavnika koje uključuju ne samo nastavu i pripremu predavanja, već prvenstveno naučna istraživanja i pisanje naučnih radova, kao i razne administrativne dužnosti i eventualne menadžerske dužnosti (šefovi katedri, prodekani, itd.). Ova tema dobija na značaju ne samo u odnosu na žene na nastavničkim pozicijama u visokom obrazovanju, već i u celini pri privlačenju i zadržavanju talenata. Ovaj složeni problem je posebno očigledan u okolnostima katastrofe poput pandemije virusa COVID-19. Ovaj rad proučava stavove (u obliku intervjua) nastavnog osoblja - asistenata u nastavi, predavača (stranih jezika), docenata, vanrednih i redovnih profesora prema postignutom balansu poslovnog i privatnog života u periodu rada od kuće tokom vanrednog stanja u Srbiji od 16. marta do 18. maja, kada se većina visokoškolskih ustanova vratila na poluregularne načine rada na primeru Fakulteta za inženjerski menadžment, Beograd, Srbija. Iako je uzorak mali, može se zaključiti da su svi nivoi nastavnog osoblja imali poteškoća u održavanju ravnoteže između radnog i privatnog života tokom rada od kuće, posebno oni sa decom školskog uzrasta.

Ključne reči: Balans privatnog i profesionalnog života, nastavno osoblje, visokoškolske ustanove, pandemija Covid 19 virusa.

Work-life balance of teaching staff at higher education during COVID 19 pandemic

Abstract: The issue of work-life balance of teaching staff at higher education institutions is becoming more interesting for the researchers due to complexity in responsibilities of teachers which include not only teaching and preparation of lectures, but primarily scientific research and scientific papers writing, as well as various administrative and managerial duties (vice deans, department chiefs, etc.). This topic is getting importance not only in regard to women in higher education teaching positions, but to overall attracting and retaining talent This complex problem has been particularly evident in disaster circumstances such as the COVID-19 virus pandemic. This paper studies attitudes (in the form of interviews) of teaching staff - teaching assistants, lecturers (languages), assistant professors, associate professors and full professors towards the achieved work-life balance during period of working from home during the lockdown imposed in Serbia from March, to May when the most higher education institutions returned to semi-regular ways of operations on the example of the School of Engineering Management from Belgrade, the Republic of Serbia. Even though the sample is small, it can be concluded that all levels of teaching staff have had difficulties in maintaining work-life balance during the work from home, especially the ones with children of school age.

Key Words: Work-life balance, teaching staff, higher education institutions, Covid 19 pandemic.

Introduction

One of the most elucidated definitions of work-life balance has been the one by Campbell Clark (2000), who defines *work-life balance* as ‘satisfaction and good functioning at work and at home with a minimum of role conflict’. The expression *work-life balance* shows a remarkable phenomenon – the

separation of work and all other life roles, thus provoking the thought that work is not an integral part of life and that it is actually burdening factor on one's life. The term *work-life balance* has been accepted from the 1980's (Currie and Eveline, 2011; Gervais and Millear, 2016; Greenhouse and Beutell, 2008; Gregory and Milner 2008; Guest, 2002; Lockwood, 2003). The widely accepted phrase, at the beginning of scientific research, has been mainly focused on women, namely working women with children (Rafnsdottir and Heijstra, 2013; Adisa et al., 2021).

Human resources management policies at higher education institutions are in the last decade more focused on talent attraction and retention due to increasing competition between faculties and universities and the need for establishing the institutions as reputable, science, and innovation driven major factors for knowledge development and dissemination. One of the main centres of attention of those policies and practices is establishing work environment which provides its teaching workforce with the conditions for delivering excellent teaching and scientific results. Higher education teachers' workload is becoming more complex and includes demands that go well beyond the limits of teaching and scientific research (Castaneda and Isgro, 2013; Sallee, 2008), thus opening the question of balance between academic and private life of the higher education teachers.

The entirely new set of problems for human resource management policies and procedures for supporting achievement of work-life balance of academic staff at higher education institutions have emerged from the onset of the COVID-19 virus pandemic. Coronavirus Disease 2019 (COVID-19) caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has been identified in December 2019 in China, Hubei province - the city of Wuhan. The news on the virus has been globally spread from the beginning of January 2020. The virus has spread from China to other Asian countries (Japan, South Korea, and Singapore), United States, Western, and Eastern Europe, and South America. World Health Organization (WHO) declared pandemic on March 11. The Republic of Serbia was not an exception, and the first official case has been confirmed on March 6, 2020.

This research is aimed to observe attitudes of teachers in higher education institutions in various ranks towards the influence of imposed lockdown and shifting to online mode of teaching and other academic responsibilities on their work-life balance. The research has been performed as a case study of the School of Engineering Management and the attitudes have been collected in the form of semi-structured interviews. The participants have been interviewed in September 2020, when the effects of online classes from March to June 2020 have been evaluated and the plans for the next school years have been set. Main focus has been given to the elements that blurred the lines of work-life balance.

1. Work-life balance of higher education teachers in pandemic

Academic life is mainly consisting of teaching, preparation of lectures, students' mentoring, students' papers grading, scientific research and papers publishing, textbooks writing, preparation for and participation at scientific conferences, participation in academic and scientific bodies and organizations, participation in scientific projects, participation in professional and consulting projects, administrative work (various reports, analyses, participation in various scientific and administrative bodies), managerial work (chiefs of departments, vice deans, etc.) (Castaneda and Isgro, 2013; Misra, et al., 2012; Philipsen and Bostic, 2010; Sallee, 2008). The academics are evaluated and their advancement is first and foremost based on the number of publications in high impact academic journals (van den Brink, et al., 2013; Ylijoki and Ursin, 2013).

Private life is consisting of various roles: family life, raising the children, home chorus, taking care of elderly, friendships maintenance, emotional relationships, travel, leisure, hobbies, etc. The academic and professional responsibilities have been mounting during the last decade and are overflowing to private life. The thin line between academic and private life of the teachers is thus disappearing and already having hard times to balance work and other aspects of their life (Rapanta, et al., 2020). Commonly, the teachers at the higher education institutions work much more than traditional 40 hour working week (Castaneda and Isgro, 2013) and many factors affect the add to the amount of working hours of teaching staff.

The use of latest information technologies calls for teachers to be accessible to students almost 24 hours a day for the entire week, weekends included. Even when academics work from home for several days a week, they are available for students through information technologies (Currie and Eveline, 2011). In the last decade there are more research that found out that teachers carry various

responsibilities home, which is made possible by the expansion of information technology (writing scientific and professional papers, sources and literature search through digital databases, review of student papers), and that female teachers, particularly ones with children, tend to write scientific papers mostly at night (Currie and Eveline, 2011; Ryan and Peters, 2014; Koppes Bryan and Wilson, 2015).

The question that has great influence on work-life balance, not only of female academics, but male academics too is job uncertainty as academics take a long time for a permanent contract. (Fontinhaet al., 2018). One of the extremely important consequences of increasing responsibilities is elevated academics' level of stress, and also other health issues especially for female academics (Brazeauet al., 2020). Nevertheless, this issue is not exclusively associated to female academics; it is affecting male academics, too.

As in other countries, it is the same situation with the academics in the Republic of Serbia who have to follow rigorous requirements for academic advancement. There are not many research on this issue in the Republic of Serbia, nevertheless, some of the research in Serbia concluded that the attitudes of teachers on the balance of professional and private differ, women believe that they to a lesser extent achieve a balance of professional and private life and cannot complete all their job responsibilities during the forty-hour work week (Ilić-Kosanović et al., 2016; Ilić-Kosanović et al., 2017).

The spread of Covid-19 disease pandemic caused by a Corona Virus (Severe Acute Respiratory Syndrome Coronavirus 2 - SARS-CoV-2) from March 2020 compelled the most of the higher education institutions in most of the countries affected by the virus to transfer, most of their teaching to online forms. The pandemic also affected higher education institutions in the Republic of Serbia which had to transfer their teaching to online platforms after the State of emergency was announced on March 15, 2020 (Službeni glasnik, 2020) for the entire Summer semester with the exception of the exams that by *Serbian Law on Higher Education* (Republika Srbija, 2017) can be carried out exclusively at a higher education institution premises.

There is various research on the topic of influence of Covid-19 pandemic on the work life balance, especially in the case of working women under the lockdown circumstances (Rodríguez-Rivero et al., 2020; Aristovnik et al., 2020; Adisa et al., 2021; Möhring, et al., 2021) There is already conflicting research on the issues of possible disruption of work-life balance of the higher education teachers due to new forms of teaching (Parham and Rauf, 2020). One of the studies has shown that from 146 participants in the survey, total of 63.2% of female respondents have stated that their work-life balance has worsened and 33.3% that it has actually improved, while 44.8% of male participants have stated the same with the equal percentage of male participants stating the opposite (Ashencaen Crabtree, Esteves, Hemingway, 2020), while a study of academics in Austria, Switzerland and Germany has shown that actual satisfaction with work-life balance increased during the lockdown because of the flexibility of work without increased dissatisfaction of the female participants with children (Raabe et al., 2020).

The one of the central issues that has emerged from the situation is the need for new set of skills for teachers in higher education, not only because of adaptation to technological changes and the use of information technologies (Pažun and Langović, 2020), but also because the call for acquiring new teaching methods for new circumstances (Langford and Damsa, 2020). Some of the previous research has stated that completely new teaching style is required, with the need for almost theatrical skills (Mishra et al., 2020) in order to gather students' attention and interest in a course subject.

2. Research

The scope of study and data collection

Methodology and methods

School of Engineering Management, a private faculty located in Belgrade, the Republic of Serbia, is a part of the "University Union – Nikola Tesla", and has accredited undergraduate study programs *Engineering Management* and *Management*; master study programs *Project Management and Industry 4.0*, Engineering *and Management of Security Information Systems*, *Economics and Management of Energy*, with a novel accredited PhD program *Waste Management*. Due to Covid-19 pandemic, the School has started to realize online forms of teaching on March 23, a week after the announcement of

the state of emergency, using Zoom platform with the Google classroom as an additional mean for sharing information, teaching materials, and homework.

The objective of the empirical part is to examine the attitudes teaching staff - teaching assistants, lecturers (languages), assistant professors, associate professors and full professors towards the achieved work-life balance during period of working from home during the lockdown imposed in Serbia from March 23, to May 18. The interviews have been conducted from September 14th to 18th through semi-structured in person interviews and the answers have been recorded by the author.

Survey design

The interviewees have been given two closed questions:

1. Do you feel that the new situation affected their work life balance in a negative way?
2. Do you feel that the new situation affected their work life balance in a positive way?

After that, the participants have been given the opportunity to express their thoughts on the elements that are blurring the lines between private and professional (academic) life.

Description of the sample

For the purpose of this study, eighteen participants in teaching positions: Teaching assistant, lecturer (languages), assistant professor, associate professor, full professor have been interviewed. The demographical data of the sample are given at Table 1.

Table 1. Demographic variables (Source: author)

Code Name	**Scientific field**	**Position**	**Gender**	**Age**	**Status**	**Number of children currently living in the household**	**Age of the children**
P1	Engineering	Full professor	M1	43	S	0	/
P2	Humanities	Full professor	F	40	M	1	7
P3	Management	Full professor	M2	44	M	2	5,9
P4	Security studies	Full professor	M3	57	M	0	/
P5	Information technologies	Associate professor	F	41	M	1	8
P6	Engineering	Associate professor	F	55	M	0	/
P7	Management	Associate professor	F	49	M	2	8,8
P8	Engineering	Associate professor	M4	52	M	0	/
P9	Environmental engineering	Associate professor	F	42	S	0	/
P10	Chemical engineering	Assistant professor	F	40	M	1	2
P11	Economics	Assistant professor	M5	36	M	2	1,3
P12	Languages	Lecturer	F	46	M	1	4
P13	Languages	Lecturer	F	40	M	2	6, 9,
P14	Management	Teaching assistant	F	36	M	1	5
P15	Management	Teaching assistant	M6	41	M	2	1
P16	Security management	Teaching assistant	M7	28	S	0	/
P17	Industrial management	Teaching assistant	F	30	M	0	/
P18	Engineering management	Teaching assistant	M8	49	M	2	8, 8

As it can be seen at Table 1, ten participants have been female and eight male. Three participants have been single (one female and two male) and twelve participants have had children of school age. Four professors have been in the rank of full professor, five associate professors, two assistant professors, two lecturers (foreign language), and five teaching assistants.

3. Results

All of the participant teaching staff stated yes on the first question and no on the second. Nevertheless, the comments have shown different, not so strict, stance.

During the second part (unstructured) of the interview, they have had the opportunity to clarify their thoughts on work life balance disruptions. The first issue that emerged is the question of accessibility of information technologies, especially for the participants with partners working from home and the children going through online classes at primary and high schools. P7 have stated:

> 'For me the first problem regarding the IT was the fact that my daughters had online classes, luckily they could use one computer in their room, my husband is in teaching and used a desktop in our room, I used a lap top in the living room. If we didn't have classes at the same time it was doable, but if we all had something at the same time, the Wi-Fi signal would weaken and it was not going smoothly.'

The same technical situation has emerged for participants P2, P3, P5, P13, and P18, all who have had children of school age. They have used PC's, lap tops, tablets, and phones to be able to access to or to post materials, or have classes with various technical difficulties.

It should be stressed out that the adaptation to new forms of teaching regarding the technical skills and learning the new platforms and apps have not been the significant issue in disruption of work-life balance because the new tools (Zoom and Google Classroom) are user friendly. P9 has indicated:

> 'Honestly, I thought it would be a challenge for older professors, but it is very simple, understanding the mechanisms of those platforms takes minutes, not hours.'

The other situation that negatively affects the work-life balance of the participants with the children is organization of day to day activities. P2, P3, P5, P7, P13, P18 have similarly stated that the organization has been the key issue, because different work related and school related obligations have been scheduled at the same time, and even when they have been scheduled apart it has been very difficult to arrange breaks for meals or for family activities. Participant 17 has stated:

> 'Yes, it was difficult, my younger child is first grader and their classes would start on TV at 08.00, so I would prepare the breakfast for him early, and then my older child had classes from 11.00 and would ask for breakfast at about nine or ten, I would have my classes, then would help the children after 13.00 to download their homework sent by the teachers, and then I would prepare lunch, then we would have lunch break at about 15.00 and then continue with their homework and I with mine. My husband was home at about 17.00 and he would eat. Than I would send instructions for my students and give the children dinner and then at about eight I would gather homework form my children, photograph it and post it on their Google classroom. After nine or ten I would answer my students E-mails and help my children get ready for sleep. So my day would end at about 11.00.'

The participants with the preschool children have had another set of problems, the difficulty to watch over their children and work at the same time. Participant 12 has stated:

> 'My son has been pulled out the kindergarten for the duration of emergency situation, and it has been very difficult for me, because my classes [foreign language] are interactive and he couldn't eat or play without me. Every now and then I had to switch off the camera or tone.'

Similar problems have been stated by the participants P10, P14, P15 whose children of kindergarten age also stayed at home to avoid overcrowded kindergartens. P10 has stated:

> 'I can leave my child at kindergarten, but even it is tiresome sometimes to watch over a small child and work at a same time, I want to protect my child form potential illness and to take the burden off the kindergarten teachers, because there are parents that have to work and don't have any other options.'

Stress has emerged as an important issue. P4 have stated that the most stressful periods have been the weekends with complete lockdown when the time has been an asset, but the stress of it strongly influenced the organization of the activities. P17 (teaching assistant) have stated that even though the weekends should be time for leisure, it has been a time of difficulty of focusing on one activity. She has said:

> 'It sounds great, you know, you had a hectic week with online classes, sending materials, answering mails for my professor, and now you can read a book or watch some movie or just sit on a terrace and enjoy nice weather, but the lockdown situation itself brought such a confusion, I would prepare a book and a coffee to enjoy a terrace view and then I would start watching TV forgetting about my previous plan, and then I would be watching nice weather and being frustrated that my husband and I just couldn't go for a walk near the river and clear our heads a little bit'.

Participants without family obligations have shown some frustrations with innitial organization of their obligations and the need to acquire new technical knowledge fast (P1, P9, P16). Nevertheless, participants without family obligations have expressed more time for academic improvement (reading academic papers), as well as more time for private life (walks, watching films, reading books, cooking, gardening, etc.). P16 has stated:

> 'After innitial stress and, I can say confusion, I can use more spare time that I have to read literature that is not from my narrow field. You know, I lose evary day about one and half or two hours for travelling alone to and from work alone, so this is great now.'

Rank itself has proved not to be relevant, but additional duites (department chairs, vice deans, etc.) had major influence, as two full professors (P2 and P3), and one assistant professor (P7) have stated that other, administrative and managerial duties, especially "paperwork", like various analyses, and reports, esecially quality assessment reports, have had extremely negative impact on their work-life balance as they have been time consuming and the communication and cooperation between various professors has shown various difficulties.

4. Discussion

The first issue that connects various studies on the influence of Covid-19 pandemic on work-life balance of higher education teachers on all levels is the issue of higher education teachers' information technology skills adjustment that has been prerequisite for smooth transition to online teaching methods (Marinoni and van't Land, 2020; Ashencaen Crabtree et al., 2020; Langford and Damsa, 2020; Rapanta et al., 2020; Coman et al., 2020) as almost all higher education institutions had to promptly shift to online models of teaching. A research of Canadian teachers' attitudes toward technology before and during the pandemic has shown no significant difference in attitudes (Sokal et al., 2020), which is slightly surprising, but actually supports the thought that previous technologies' shrewdness (or the lack of it) of teaching staff assists in adjusting the new working conditions.

As one of previous studies conducted in Great Britain has shown that some of the participants have reported increased levels of stress due to disruption of their regular activities, that is especially burdening mothers with children, excluding some of the participants who appreciated new challenges that generated a need for more innovative solutions (Ashencaen Crabtree et al., 2020), we can see that the interviews conducted at our observed Institution got similar results.

Some of the research has been focused on increasing levels of stress and its relation, among others, to feelings of burnout, teaching competence, attitudes toward change of various ranks of university teachers (Sokal et al., 2021; Pyhältö et al., 2021; Shlenskaya et al., 2020) that have showed different levels of stress for various groups of teachers.

5. Limitations and scope of further research

This research includes the sample that is small, as it is a case study of a particular higher education institution, further research is desirable and this important issue calls for larger sample, structured survey and implementation of a variety of statistical methods.

6. Conclusion

The question of added value of online higher education classes and courses, their benefits and shortcomings for students and teachers alike, that is rising from the beginning of the 21st century, and that have become particularly important during last decade, because of the expansion of online learning programs and platforms, have had its trial in almost entire world with the emergence of Covid-19 disease pandemic caused by a Corona Virus (SARS-CoV-2) mainly from March 2020. The most of higher education institutions in Europe have had to transfer to online teaching forms in a matter of weeks or even days.

Many questions have been emerging since then: technological development and appropriate skills of teaching staff; teachers' and students' flexibility and swiftness in adaptation to new circumstances; organization of the teaching process; organization of exams; stress and worries of students and teachers alike, etc. Among them, the question of work-life balance of teaching staff during the compulsory online classes during the lockdowns has gained a real importance.

This paper have examined attitudes of teaching staff - teaching assistants, lecturers (languages), assistant professors, associate professors and full professors of the School of Engineering Management from Belgrade, the Republic of Serbia on the achieved work-life balance during working from home in the imposed lockdown in Serbia from March, to May 2020. In that period higher education institutions in Serbia transferred their education process to online forms.

Although this paper is focused on only one higher education institution, it can be concluded that all levels of teaching staff have had difficulties in maintaining work-life balance throughout the work from home, specifically the ones with children of school age.

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Primena zelenih alata u zelenom marketinškom pristupu

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Apstrakt: Zeleni marketing je promocija „zelenih“ ili ekološki prihvatljivih proizvoda kao potrošačke baze vrhunskog proizvoda. Podrazumeva čitav lanac životnog ciklusa proizvoda, sprečavanje ispuštanja zagađujućih materija u životnu sredinu i njihovo uklanjanje korišćenjem fitoremedijacije kao jednog od mnogih alata. Povećavanje socijalne zaštite povezalo je zdravstveno blagostanje sa održivim okruženjem i ekonomijom. Stoga povećani broj ekološki orijentisanih preduzetnika uključuje i zeleni marketing. Strateški cilj korporacija je podizanje svesti putem ekološki orijentisanih publikacija, ekološke maloprodaje, organskog ugostiteljstva/promocije, ekološkog uređenja, eko-konsaltinga itd. Dakle, zeleni alati, deo zelenog marketinga, promovišu i edukuju o emisijama ugljenika i zagađenje svakodnevnih aktivnosti potrošača i uticaj koji te aktivnosti imaju na krajnji proizvod. U kontekstu promena u poslovanju, zeleni marketing bi se mogao staviti u okvir razmišljanja životnog ciklusa. Uzimajući u obzir otpad kao konačni nusproizvod čak iu vitkoj proizvodnji, LCA uključuje nezaobilazne zagađivače ili proizvode, kao i sanaciju/fitoremediaciju radi smanjenja uticaja štetnih proizvoda.

Ključne reči: zeleni marketing, zeleni alati, LCA, sanacija/fitoremedijacija

Application of Green Tools in Green Marketing Approach

Abstract: Green marketing is a promotion of “green” or environmentally friendly products as a consumer base for the premium product. It implies the whole chain of a product’s life cycle, prevention of releasing pollutants into the environment and their removal using phytoremediation as one of many tools. Increasing social care linked health well-being with sustainable environmental and economy. Therefore, increased number of eco-minded entrepreneurs includes green marketing. A strategic goal of corporations is to raise awareness through environmentally minded publication, eco-friendly retail, organic catering/promotion, eco-friendly landscaping, eco-consulting, etc. Thus, green tools, part of green marketing promote and educate about carbon emissions and pollution consumers daily activities produce and the impact those activities have on the final product. In the context of the changes in business, green marketing could be put in the framework of life cycle thinking. Taking into account waste as a final by product even in a lean manufacturing, LCA includes unavoidable pollutants or products as well as the remediation/phytoremediation to decrease harmful product impact.

Keywords: Green marketing, Green tools, LCA, Remediation/Phytoremediation.

Introduction

Current environmental issues include human activities, therefore, an increasing number of academic disciplines including marketing have integrated green issues into their literature. Increasing concern for the natural environment, point towards a changed perspective of many businesses in an attempt to address society’s justifying concern (Polonsky, 1994). Green marketing is a promotion of “green” or environmentally friendly products as a consumer base for the premium product. Sustainable, eco-friendly, or “environmentally friendly” terms encounter increasing consumer approval (Campbel et al. 2015; Sarkar et al, 2012). Sustainability of green marketing in terms of environmental management is essential for social development. The illustration of green promotion is being done to substitute the products that are highly risky to the environment with those that are environmental friendly (Stanton

and Futrell, 1987). Green marketing involve different attribute in the organizational operation that are required to be changed such as: product change, manufacturing method change. Supply chain is very important and should be modified that these products or services be close to desires or needs of the customers. These activities of green marketing are aimed to make possible the satisfaction of the customers and contribute sustainable environment. (Alhamad et al. 2019)

Next in this case is that environmental activities are rarely incorporated into corporate evaluative criteria. Many companies are using traditional business measures as are, profits, ROI, market share, and so on, to evaluate the success of green initiatives. Another, are just using more humane reasons. Companies have realized that doing stuff to be part of green initiative gives them a strategic opportunity and start position in market. When we are considering green marketing, many people lean to understand incorrectly, on specific individual activities, such as promoting green product characteristics or designing ecologically products that are less harmful for environment. Nevertheless, these activities are strategically important and necessary to the success of a greening program. Green marketing is a holistic, integrated approach that continually reevaluates how firms can get corporate objectives and meet consumer needs while minimizing on a long-term ecological harm. (Polonsky et al., 1994; Polonsky et al., 2001)

Marketing Mix of Green Marketing

Every company has its own marketing mix. Some of them are using 4 P's and some 7 P's of marketing mix. The 4 P's of green marketing are that of a conventional marketing but the challenge for marketers is to use 4 P's in an innovative way.

Standard 4 P s for marketing is product, price, promotion and place:
(1) Product. The ecological objectives in planning products are to reduce resource consumption and pollution and to increase conservation of limited resources (Kellerman, 1978).
(2) Price is a critical and important factor of green marketing mix. Most consumers will only be prepared to pay additional value if there is a perception of extra product value. This value may be improved performance, function, design, visual demand, or taste. Green marketing should take all these facts into consideration while creating price.
(3) Promotion. There are three types of green advertising:

(I) Relates product/service and the biophysical environment;
(II) Advocates a green lifestyle by highlighting a product or service;
(III) Campaigns with a focal point to a corporate image of environmental responsibility.

(4) Place. The choice of where and when to make a product available, will have significant impact on the customers. Very few customers will go out of their comfort zone to buy green products. When looking through the literature there are several suggested reasons for firms increased use of Green Marketing. Five possible reasons are as follows:

(I) Organizations perceive environmental marketing to be an opportunity that can be used to achieve its objectives.

(II) Organizations believe they have a moral obligation to be more socially responsible. Government force firms to become more responsible.

(III) Competitors' environmental activities pressure firms to change their environmental marketing activities.

(IV) Cost factors associated with waste disposal, or reductions in material usage forces firms to modify their behavior.

(V) As resources are limited and human wants are unlimited, it is important for the marketers to use the resources efficiently without waste as well as to achieve the organization's objective. So green marketing is predictable.

There is one question, how should companies handle the issues associated with green marketing. They must always keep in mind that consumers are in many cases unlikely to compromise on traditional product attributes and consumer’s needs are always in a first place, such as convenience, availability, price, quality and performance. In other words, green products must have big attributes against non-green products to satisfy concerns from the huge majority of consumers. It's even more important to realize, that there is no green marketing strategy that is right for every company. The strategies that should be used under different market and competitive conditions range from the relatively passive and silent "lean green" approach to the more aggressive and visible "extreme green" approach. (Ginsberg et. al., 2004). A good presentation of a product provides the opportunity for the consumer to get as one

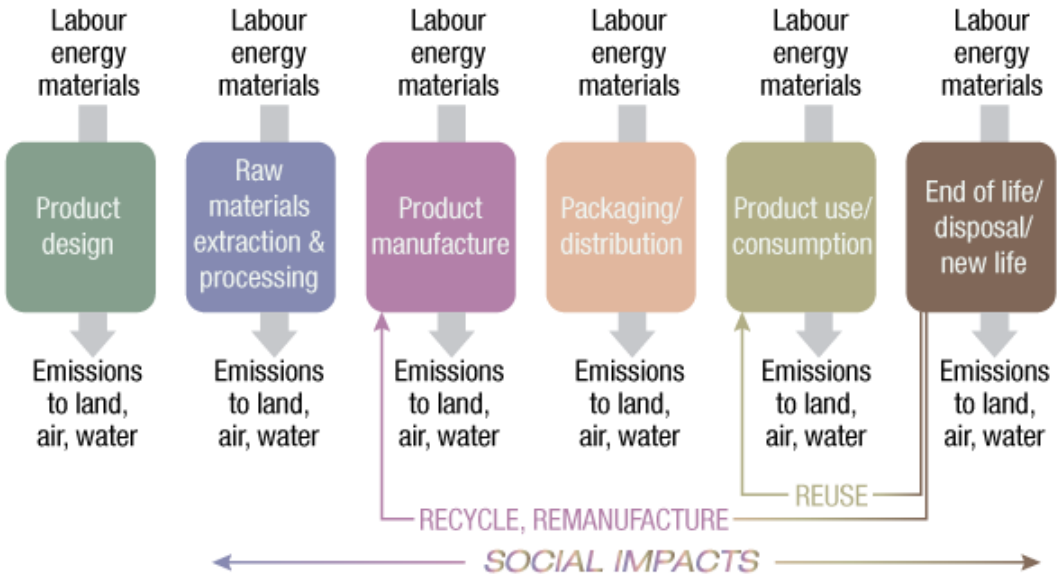
with businesses showing environmental responsibility. The presentation policy aims to create an environmentally friendly firm image in the eye of the consumer and give environmental messages, how much the product is important to consumers (Boztepe, 2012).

There is growing interest among the consumers in the world for protection of environment. Worldwide evidence indicates people are concerned about the environment and are changing their behavior for it. As we now said, green marketing has impact for growing market for sustainable and socially responsible products and services. There is high number of nonprofit organizations in the world whose aim is to protect the environment. (Tiwari et al., 2011).

Green technology towards green marketing

Life-Cycle Technology: Rather, right or wrong, firms are more and more held responsible for the environmental impact of their products and its ingredients across the whole life-cycle of product. For vertically integrated firms, this makes sense, because they control much of the value chain. (Martin Chartern Joint Coordinator, the Centre for Sustainable Design, UK (Ottman, 1998). The case study conducted in Italy provided useful insights in the application of LCA from the environmental aspect. The LCA is show to be very useful tool in decision making process (Fig. 1). Therefore includes entire supply energy consumption and a material properties and volume (Peano et al., 2015).

Figure 1. LCA application benefits

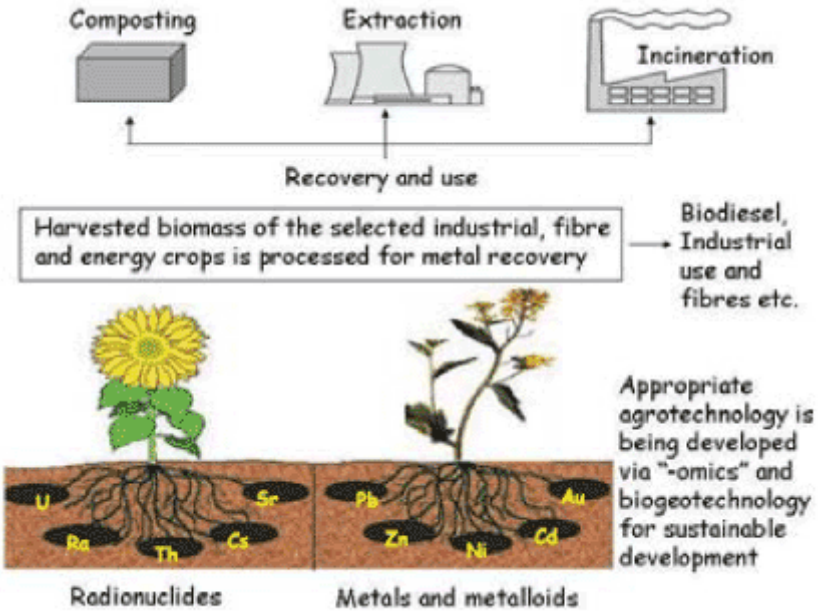


(Source: www.lifecycleinitiative.org)

Nowadays, green new technology brings products without a harmful impact on nature and the environment (Karjaluoto et al., 2009). Life cycle assessment (LCA) has related to product, process, or activity associated all the materials, emission and pollution released into the environment. This involves complete spectrum of environmental effects assigned to the final product. Taking into account waste as a final by product even in a lean manufacturing, LCA includes the remediation/phytoremediation as well as the effect of any pollutants or products on the assessment of product impact. (Chandra et al., 2018)

To provide environmentally friendly products, there is a need for an ecologically sound economy and organic agriculture to boost human potential towards an intact, functioning, and healthy environment. The risk of environmental pollutions is very high, therefore the use of microorganisms (Idi et al., 2015) and plants (Rungwa, et al., 2013; Nikolic and Stevovic, 2015; Nikolic and Tomasevic, 2020) to clean up contaminated environment presents an excellent solution. Application of both suitable photosynthetic bacteria and plants can eliminate pollutants such as pesticides, heavy metals, dyes, crude oil, etc. (Idi et al., 2015; Nikolic and Stevovic, 2015). Bioremediation and phytoremediation are natural, biological therefore an eco-friendly and efficient method of harmful contaminants elimination (Fig. 2).

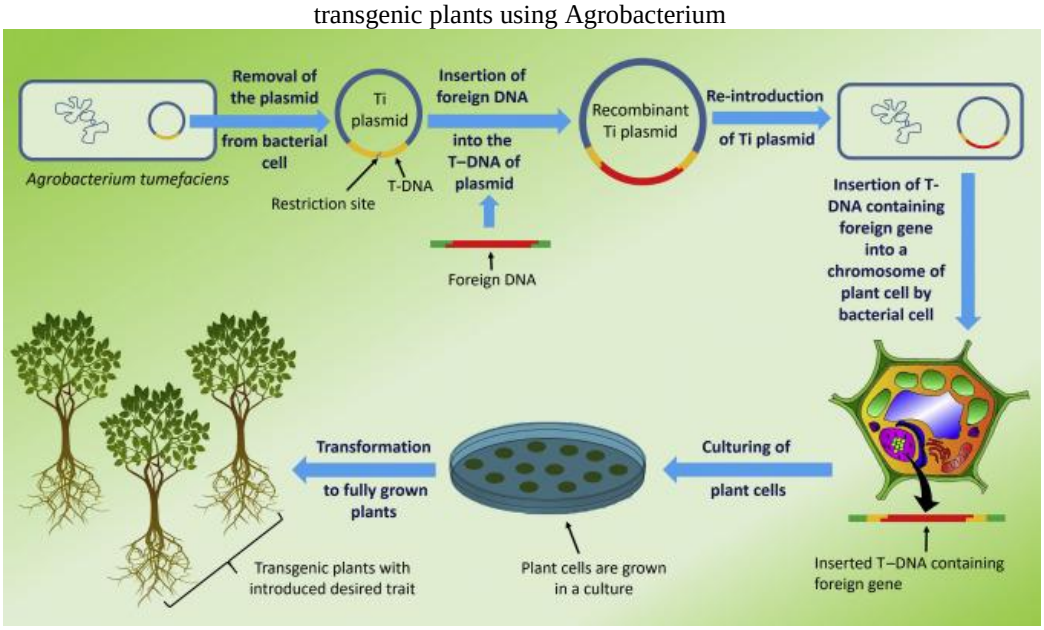
Figure 2. Phytoremediation as a green technology



(Source: Gratão et al., 2005)

Phytoremediation has become one of the most applicable, therefore cost-benefit and sustainable techniques for removal, sequestration, and/or detoxification of pollutants such as metals and metalloids (Cd, Co, Cu, Pb, Zn, Se, As, and Hg) from soil and water environments. Moreover, this plant-based method includes both conventional plant species and transgenic plants. Transgenic plants have become very popular among scientists because of their unique capability to remediate polluted environments where conventional plants fail. The benefits of green technologies especially phytoremediation reflect the genetic ability of plants to remove pollutants from soil. The unique properties of hyper accumulator plants are presented with a group of native or foreign/introduced genes (Nikolic and Tomasevic, 2020). Gene manipulation as a wide accepted engineering method brings ecologically friendly products contributing to green marketing (Fig. 3).

Figure 3. The transgenic plants' development showing major steps involved in the generation of transgenic plants using Agrobacterium



(Gunarathne et al., 2019)

Conclusion

Going towards sustainable development, there is necessity for products improvement through promotion of green marketing, as well as green tools applications. To provide environmental-friendly products, there is a need for an ecologically sound economy and organic agriculture to boost human potential towards an intact, functioning and healthy environment. The paper shows that path to create eco-products include assessment of a product LCA together with phytoremediation, identified as one of the most applicable, therefore cost-benefit and sustainable techniques for removal, sequestration, and/or detoxification of wide range of pollutants from soil and water environments.

Make green thinking became part of almost every company culture. Companies embraced a green way of doing business and take part in a green initiative as a strategic opportunity and start position on the market. Taking into consideration all above mentioned, green marketing incorporate promotion, technologies and assessment as a whole to bring safe and healthy products to customers.

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Guidelines for the Preparation of Papers for Publication in the Serbian Journal of Engineering Management

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The paper should be written using MS Word for Windows (on Serbian Cyrillic, Latin or English – UK keyboard). The length of work should not be more than 10 pages including text, diagrams, tables, references, and appendices.

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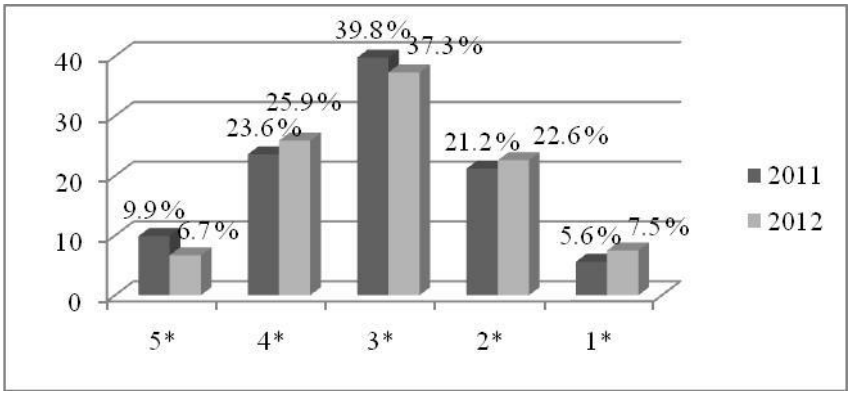
Figure 1: Accommodation units according to the structure of hotel capacities in 2011 and 2012, written in the form of percentage



Source: (The Ministry of Finance and Economy, 2013)

The title and number of the table should be presented above the table as centred

Table 1: Accommodation units according to the structure of hotel capacities in 2011 and 2012, written in the form of percentage

Category	2011	2012	Number of accommodation units (2011)	Number of accommodation units (2012)
5*	**9,9**	**6,7**	1452	990
4*	**23,6**	**25,9**	3486	3911
3*	**39,8**	**37,3**	5895	5636
2*	**21,2**	**22,6**	3102	3420
1*	**5,6**	**7,5**	1133	1132
total	100	100	15068	15089

Source: (The Ministry of Finance and Economy, 2013)

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Rad pisati koristeći MS Word za Windows (tastatura za srpsku ćirilicu, latinicu ili engleski jezik - UK). Dužina rada treba da bude najviše 10 strana uključujući tekst, slike, tabele, literaturu i ostale priloge. Format stranice je **A4.** Koristite **2 cm** za donju i gornju marginu, a **2,5 cm** za levu i desnu marginu. Razmak između redova u okviru jednog pasusa je jedan, dok je razmak između paragrafa dvostruki. Za formatiranje teksta preporučuje se korišćenje fonta **Times New Roman.**

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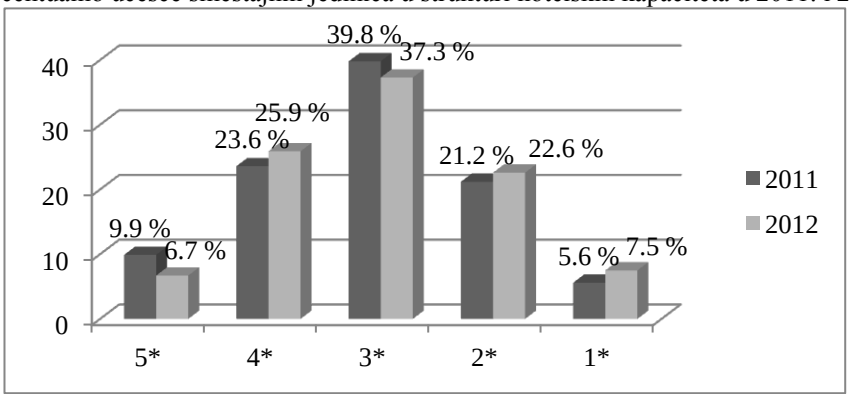
U prvom redu na prvoj strani treba napisati naslov rada na srpskom jeziku (16 pt). Ispod naslova rada treba ostaviti mesto za navođenje ime(na) autora, nazive institucija autora onako kako je naznačeno u ovom Obrascu. Nakon institucije poslednjeg autora, ostaviti jedan prazan red i u sledećem napisati kratak sažetak (10 pt). Nakon sažetka sledi pregled ključnih reči. Nakon prikazanog naslova rada, sažetka i ključnih reči na srpskom jeziku, potrebno je i na engleskom jeziku naznačiti prethodno navedeno.

Numerisane podnaslove prvog nivoa treba formatirati korišćenjem fonta 12 pt boldovano, a podnaslove drugog nivoa 10 pt boldovano. Tekst, kao i spisak literature treba formatirati korišćenjem fonta 10 pt.

3. Grafički i tabelarni prikazi i formule

Sve ilustracije, bez obzira da li su dijagrami, fotografije, grafikoni nazivaju se slike. Naziv i broj slike treba prikazati na sredini reda iznad slike.

Slika 1: Procentualno učešće smeštajnih jedinica u strukturi hotelskih kapaciteta u 2011. i 2012. godini



Izvor: (Ministarstvo finansija i privrede, 2013)

Naziv i broj tabele treba prikazati iznad tabele na sredini reda.

Tabela 1: Procentualno učešće smeštajnih jedinica u strukturi hotelskih kapaciteta u 2011. i 2012. godini

Kategorija	2011.	2012.	Broj smeštajnih jedinica (2011)	Broj smeštajnih jedinica (2012)
5*	**9,9**	**6,7**	1452	990
4*	**23,6**	**25,9**	3486	3911
3*	**39,8**	**37,3**	5895	5636
2*	**21,2**	**22,6**	3102	3420
1*	**5,6**	**7,5**	1133	1132
ukupno	100	100	15068	15089

Izvor: (Ministarstvo finansija i privrede, 2013)

Pošaljite svoj rad, uključujući tabele, slike itd, kao jednu datoteku. Pored toga, treba dostaviti sve slike i tabele (koje se unose u crno-beloj tehnici) kao posebne fajlove u JPF ili TIFF formatu sa najmanje 300dpi rezolucije.

Formule treba centrirati na stranici sa numeracijom, kao u narednom primeru. Preporučuje se formatiranje redova sa formulama u Microsoft Word-u (MathType).

$$\mathrm{PVo} = \frac{\mathrm{FVn}}{(1+\mathrm{i})^{\mathrm{n}}} \qquad (1)$$

4. Zaključak

U zaključku autori treba da sumiraju rezultate do kojih su došli u istraživanju.

Literatura

Prilikom navođenja literature, treba se pridržavati uputstva APA sistema navođenja literature. Za više informacija pogledajte *Publication Manual of the American Psychological Association* (6th ed.).

Prilikom citiranja unutar teksta, kada u rečenici spominjete autora i navodite njegove reči, onda posle imena autora treba navesti godinu izdanja citiranog teksta u zagradi, a na kraju rečenice potrebno

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Knjiga sa jednim autorom:
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Kada imamo više autora navodimo ih sve, s tim što pre poslednjeg prezimena dodajemo i, odnosno &, ako imamo više od sedam autora, navodimo prvih šest, zatim pišemo pišemo tri tačke, i na kraju poslednjeg autora.

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Knjiga, prevod dela:
Primer: Spic, E. H. (2011). *Umetnost i psiha: studija o psihoanalizi i estetici.* (A. Nikšić, prev.). Beograd: Clio.

Knjiga sa urednikom ili priređivačem, zbornik radova:
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Primer: Đurković, M. (ured.) (2007). *Srbija 2000-2006: država, društvo, privreda, Beograd:* Institut za evropske studije.

Rad u zborniku radova:
Primer: Čerović, S. (2012). *Savremeni koncepti strategijskog upravljanja turističkom destinacijom.* Naučni skup sa međunarodnim učešćem "Turizam: izazovi i mogućnosti", Trebinje.

Rad u časopisu sa jednim autorom:
Primer: Harish, R. (2008). Brand Architecture and its Application in Strategic Marketing. *The Icfai University Journal of Brand Management,* 7(2), 39-51.

Rad u časopisu sa dva autora:
Ako članak na koji se pozivate ima DOI broj, treba ga dodati referenci.

Primer: Tew, C. & Barbieri, C. (2012). The perceived benefits of agritourism: The provider’s perspective. *Tourism Management,* 33(6), 215-224. doi:10.1016/j.tourman.2011.02.005

Rad u časopisu sa više od dva autora:
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Članak iz novina sa navedenim autorom:
Primer: Mišić, M. (1. feb. 2012). Ju-es stil smanjio gubitke. *Politika,* str. 11.

Članak iz novina bez navedenog autora:
Primer: Straževica gotova za dva meseca. (1. feb. 2012). *Politika,* str. 10.

Teza-štampana verzija:
Primer: Dewstow, R. A. (2006). *Using the Internet to enhance teaching at the University of Waikato* (Unpublished master's thesis). University of Waikato, Hamilton, New Zealand.

Dokumenta ili baze podataka sa interneta, privatne ili zvanične internet stranice kojima se zna autor:

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