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ОРИГИНАЛЬНЫЕ НАУЧНЫЕ СТАТЬИ
ORIGINAL SCIENTIFIC PAPERS

CHARACTERIZATION OF Cu10wt.%Al INTERMETALLIC COATINGS APPLIED BY THE ATMOSPHERIC PLASMA SPRAYING PROCESS

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Summary:

The atmospheric plasma spray process is one of the procedures used for the deposition of coatings resistant to wear due to friction, erosion, cavitation and corrosion. In this paper, the APS process produced a Cu10wt.%Al intermetallic coating which is a reliable candidate for use in tribological environments because of a combination of low price and exceptional resistance to abrasion under different work conditions. The aim of this study was to investigate the mechanical properties and the structure of the Cu10wt.%Al intermetallic coating and develop an efficient method for repairing and improving light alloy resistance to wear. Many components of copper alloys tend to be degraded due to corrosive environment, friction, erosion and cavitation. Such components can be saved by surface engineering with the use of appropriate coatings on surface areas exposed to degradation. A typical microstructure of a coating for the APS process is lamellar, with micro pores, unmelted particles, inter-lamellar oxides and precipitates present in it. The mechanical properties of Cu10wt.% Al coatings were investigated by measuring the microhardness of coating layers using the $HV_{0.3}$ method while the

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bond strength was tested on a tensile machine. The morphologies of powder particles and the coating surfaces were analyzed on a scanning electron microscope (SEM). The analysis of the coating microstructure was carried out with the use of an optical microscope, and a share of micro pores was determined by analyzing the micrographs through an optical microscope (OM).

Key words: *wearing, intermetallics, erosion, corrosion, coatings, cavitation, Al, abrasives.*

Introduction

APS - atmospheric plasma spraying is one of the technological processes used to manufacture coatings with a thickness between 0.1 and 0.5 mm. Plasma spray technology is one of possible solutions to produce copper-based coatings because of afordable production costs and possibilities to produce coatings on parts of complex shapes. The APS process includes the injection of powder particles into a plasma jet, its melting or semi-melting, and then accelerating and collision with the substrate where powder particles are deposited, forming a coating (Mrdak, 2015a, pp.137-159), (Mrdak, 2015b, pp.46-67). The microstructure of plasma spray coatings is characterized by a lamellar structure with limited inter-lamellar bonding due to the presence of micro pores. The coating microstructure and its mechanical properties are influenced by a large number of process parameters which directly affect the phase composition and porosity content for a specific powder and a range of powder particles (Mrdak, et al., 2015, pp.337-343), (Mrdak, 2016a, pp.1-25), (Mrdak, 2016b, pp.411-430), (Vencl, et al., 2011, pp.1281-1288), (Vencl, et al., 2010, pp.591-604). Copper is a metal that is widely used in many applications because of its excellent thermal and electrical conductivity. The mechanical properties of copper can be improved by alloying. Some copper alloys such as Cu-Al, Cu-Si and Cu-Al-Fe are used for wider industrial applications, because they are quite resistant to wear and corrosion. Cu10wt.%Al alloys are widely used in the chemical industry thanks to their high corrosion resistance. In this alloy type, besides the α structure, there is the β structure as well. Wear resistant Cu10wt.%Al coatings are used on working parts to reduce damage due to friction, erosion, corrosion and cavitation (Bartuli, et al., 2007, pp.175-185). Cu-Al intermetallic coatings are good candidates for use in tribological environments because of a combination of low prices and exceptional resistance to abrasion under different work conditions. Optimum protection against wear of light metal substrates can be provided with effective application of thermal spray processes for coating

and powder depending on the working environment and working conditions (Sartale, Yoshitake, 2010, pp.353-360), (Wang, Seitz, 2001, pp.755-761). Intermetallic coatings or metal-ceramic composite coatings can be obtained by thermal spray powder spraying. Cu-Al intermetallic systems have been actively researched for use in aircraft, automotive, marine, construction, etc. The Cu-Al system have long been used for wheel bearings for planes and screws for ships because of its resistance to wear and corrosion (Sartale, Yoshitake, 2010, pp.353-360). Cu10wt.%Al powder marked Metco 445 is mechanically coated aluminum bronze which shows self-bonding for substrates during the thermal spray process as a result of the chemical reaction of the coated components which build intermetallic phases. The powder contains aluminum from 7.0 to 12.0 wt%Al (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco). Coatings have good resistance to friction and scuffing at low and moderate temperatures and excellent resistance to abrasion and cavitation. Testing of Cu10wt.%Al coatings to abrasive wear and sliding wear using the ring-on-disk method and a load of 150 g over the sliding speed of 4.5 cm/s showed that the abrasive coating wear is $0.52 mgm^{-1}$, and that sliding wear is $2.8x10^{-5}mm^3m^{-1}$. The main coating wear mechanism is plastic deformation (Limpichaipanit, et al., 2011, pp.123-126). Coatings machine easily and excellently. Typical components covered by Cu10wt.%Al coatings are: supports of bearings, sleeves of hydraulic presses, piston guides, air compressor seals, water pumps, turbine nozzles, etc. The presence of aluminum in bronze increases the resistance of the coating to corrosion because of the formation of a thin cohesive surface oxide which acts as a protective layer on the alloy rich in copper (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco). To understand better the reaction processes which occur between Cu and Al during the process of powder melting and the formation of intermetallic phases, it is necessary to know the Cu-Al equilibrium diagram. In the equilibrium phase diagram of Cu-Al, there are five stable intermetallic phases, i.e.: Cu_9Al_4, Cu_3Al_2, Cu_4Al_3, CuAl and $CuAl_2$ with two solid solutions Cu(Al) which are often described as α–Cu and Al(Cu) (ASM Handbook, 1992, Volume 3, Alloy Phase Diagrams, ASM International, Metals Park). Studies have shown that in the process of powder melting in plasma, due to the reaction of Al and Cu, various intermetallic phases are formed, such as: $CuAl_2$, Cu_9Al_4, Cu_3Al_2, Al_4Cu_9 (Altuncu, et al., 2012, pp.181-183). The main intermetallic phases which affect the wear resistance of the coating are Cu_9Al_4 and Cu_3Al_2. Plasma spray deposited Cu10wt.%Al coatings have a lamellar structure, with

present unmelted particles, precipitates, and inter-lamellar pores. According to the authors (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101) in the microstructure there are present intermetallic phases of $CuAl_2$ and Cu_9Al_4. The alloy base is a solid solution of α-Cu (90.6–100wt%Cu) and β-Cu (85.0- 91.5wt.%Cu). In the microstructure of the coating, there are not black oxide lamellae of Al_2O_3 oxide (Li, Sun, 2004, pp.92-101). Cu10wt.%Al coatings consist of a bright phase of copper and a dark phase of copper oxide Cu_2O. Copper oxide is primarily formed when temperatures ≥ 1000 °C and in the presence of oxygen, which occurs when using the plasma spray process (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101).

In this paper, plasma spraying at atmospheric pressure was used to deposit an aluminum bronze coating which contains 7.0 to 12.0 wt.%Al. The coating microstructure was analyzed with a light microscope and the coating surface was analysed with the SEM - scanning electron microscope. The aim of this study was to investigate the mechanical properties and the microstructure of the Cu10wt.%Al intermetallic coating and to develop an economically efficient method of depositing intermetallic coatings for improving resistance of worn aircraft parts made of Cu alloys exposed to a combination of corrosion and wear.

Materials and experimental details

The material on which layers of Cu10wt.%Al(7.0 to 12.0 wt%Al) intermetallic coatings were deposited was made of stainless steel X15Cr13 (EN 1.4024) in the thermally unprocessed state. Powder of the Sulzer Metco company labeled Metco 445 was used to produce the Cu10wt.%Al coating. The powder was manufactured using mechanical coating and spheroidization to a specific granulation density of 3.1-4.3 g/cm^3. The powder melting point is 1040 °C. Powder with granules in a range of 45 -106 μm was used for the experiment (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco). Figure 1 shows the (SEM) scanning electron photomicrographs of the Cu10wt.% Al powder particles morphology. The powder particles are approximately spherical in shape. The testing of the mechanical properties of the Cu10wt.% Al coating was done in accordance with the Pratt & Whitney standard (Turbojet Engine – Standard Practices Manual (PN 582005), 2002, Pratt & Whitney, East Hartford, USA). The bases on which were deposited layers of coatings for microhardness testing and evaluation of the microstructure in the deposited state are made of steel Č.4171 (X15Cr13 EN10027) in the thermally unprocessed state with the dimensions of 70x20x1.5 mm.

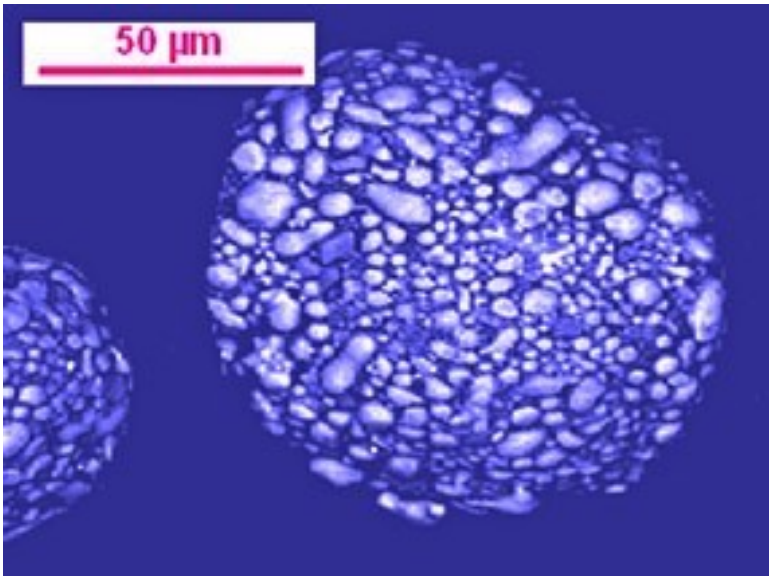

Figure 1 – (SEM) Scanning electron micrography of a Cu10wt.%Al powder particle
Рис. 1 – (SEM) Электронная микрография частиц порошка Cu10вес.%Al
Slika 1 – Skening elektronska mikrografija (SEM) čestice praha Cu10tež.%Al

The substrates for testing the bond strength are also made of steel Č.4171 (X15Cr13EN10027) in the thermally unprocessed state with the dimensions of Ø25x50 mm.The microhardness of layers was tested using $HV_{0.3}$ and bond strength tensile testing. The microhardness measurements were performed along the lamellae. Five readings of microhardness values of the layers were performed in the middle and at the ends of the samples while two extreme values were rejected. Out of three remaining values, the average value is shown. The bond strength was tested at room temperature with a tensile speed of 1cm/60s. Five specimens were tested, out of which two extreme values were rejected. Out of the three remaining values, the mean value of the bond strength is shown. The morphology of the powder particles and the surface of the deposited coating was examined using scanning electron microscopy (SEM). The microstructure of the deposited layers was examined on an optical microscope (OM). The share of micro pores in the coating was analysed by analysing 5 photos at 200x magnification. In this paper, the mean value of the share of micro pores in the coating is presented.

Cu10wt.%Al powder is deposited with the atmospheric plasma spray system of the Plasmadyne company and the plasma gun SG-100, with controlled plasma spray parameters. The plasma gun SG-100 consists of a cathode type K1083-129, anode type A 2083-175 and the

gas injector type GI 1083–130. Ar in combination with He was used as an arc gas, and the power supply was 40kW. The plasma spray deposition parameters of Cu10wt.%Al powder are shown in Table 1. Before the deposition process, the substrate surfaces were roughened with white aluminum oxide particles of the size 0.7-1.5 mm. Coatings were deposited on the test samples with a thickness of 0.45-0.5 mm.

Table – 1 Plasma spray parameters
Таблица 1 – Параметры плазменного напыления
Tabela 1 – Plazma sprej parametri

Deposition parameters	Values
Plasma current, I (A)	700
Plasma Voltage, U (V)	35
Primary plasma gas flow rate, Ar (l/min)	50
Secondary plasma gas flow rate, He (l/min)	12
Carrier gas flow rate, Ar (l/min)	5.6
Powder feed rate (g/min)	50
Stand-off distance (mm)	100

Results and discussion

The microhardness and the tensile bond strength of the coating had values characteristic for this type of coatings. The Cu10wt.%Al Intermetallic coating had an average microhardness of 176 $HV_{0.3}$. The measured average value of microhardness was higher than the value specified by the powder manufacturer - 158 $HV_{0.3}$ (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco), which indicates that a large share of micro pores was not present in the coating. This was confirmed by metallographic examinations of the coating layers. The mean value of the tensile bond strength measured on the samples with coated Cu10wt.%Al was 35 MPa. The coating was destroyed at the substrate / coating interface because of good bonding with the substrate. The measured values of the microhardness and the tensile bond strength of Cu10wt.%Al coatings were correlated with the microstructure of the deposited layers.

Figures 2 and 3 show the micrographs of a typical microstructure of the plasma spray coating.

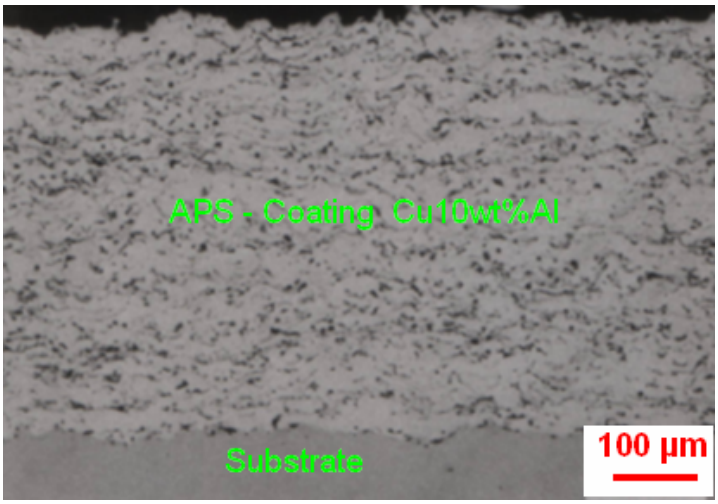

Figure 2 – (OM) Cu10wt.%Al coating microstructure
Рис. 2 – (OM) Микроструктура Cu10вес.%Al покрытия
Slika 2 – (OM) Mikrostruktura Cu10tež.%Al prevlake

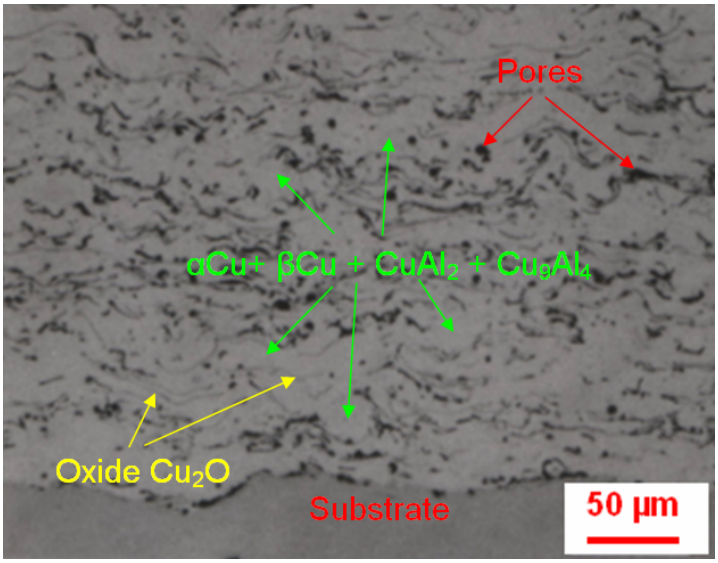

Figure 3 – (OM) Cu10wt.%Al coating microstructure
Рис. 3 – (OM) Микроструктура Cu10вес.%Al покрытия
Slika 3 – Mikrostruktura (OM) Cu10tež.%Al prevlake

The photomicrographs clearly show the interfaces of coating layers and the substrate. The substrate/coating interface is very clean indicating a very good bonding of the coating with the substrate, which indicates a good substrate surface preparation. Because of good surface preparation, the interface does not show the presence of corundum particles left from roughening, which resulted in good adhesion of the coating with the substrate. At the interface between the substrate and the deposited coating layers, there are no defects such as discontinuities of deposited layers, microcracks, macrocracks, coating peeling and separation from the substrate. Generally, the layers are uniformly deposited on the substrate. The coatings have a lamellar structure, inter-lamellar oxides and inter-lamellar pores. The microstructure of the coating showed that powder particles are uniformly and homogeneously distributed. Through the coating layers, coarse micro pores, micro cracks and macro cracks cannot be seen. The average share of micro pores in the coating layers was 8%. At a higher magnification, in Figure 3, we can see the light gray lamellae of oxide Cu_2O with a uniform distribution in the coating (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101) as well as micro pores in black. In the coating, unmelted powder particles were not detected, which indicates that powder particles had been deposited with the optimal deposition parameters. The Cu10wt.%Al coating base consists of solid solutions α-Cu and β-Cu rich in copper containing $CuAl_2$ and Cu_9Al_4 intermetallic phases (Hang, et al. 2008, pp.416-424), (Lee, Sun, 2004, pp.92-101).

Figure 4 shows a SEM photomicrograph of the surface of the Cu10wt.%Al intermetallic coating.

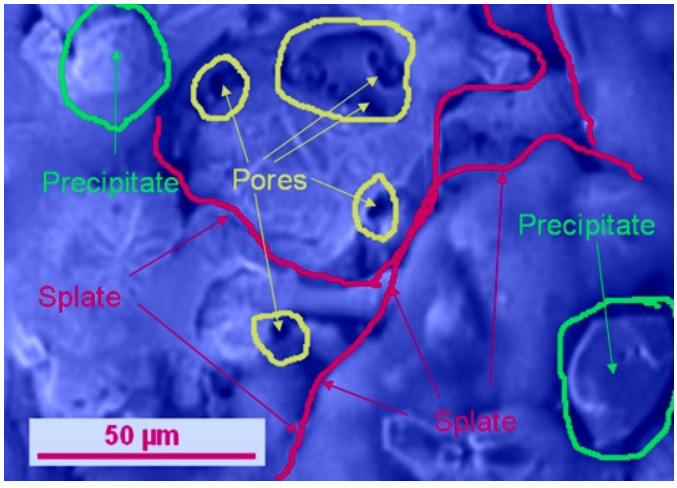

Figure 4 – (SEM) Surface morphology of the Cu10wt.%Al coating
Рис. 4 – (SEM) Морфология поверхности Cu10вес.%Al покрытия
Slika 4 – (SEM) Morfologija površine Cu10tež.%Al prevlake

The analysis of the surface morphology of the Cu10wt.%Al intermetallic coating shows complete melting and regular melting of powder particles on the previously deposited layer. The red lines in SEM micrographs mark boundaries between the melted particles. The molten powder particles formed thin discs - splates in a collision with the substrate. Thus formed shapes of deposited particles have good cohesive bonding with the previously deposited particles, indicating that the powder particles were deposited with the optimum deposition parameters. Coarse micro pores cannot be seen on the coating surface. SEM micrographs clearly show black micro pores surrounded by yellow color of a size up to 10μm. The coating surface shows precipitates formed as a result of the collision of molten droplets with the substrate. At the moment of the collision of molten droplets with the substrate, the ends of molten particles chip and solidify as precipitates in the deposited coating layers.

Conclusion

In this paper, the APS - atmospheric plasma spray process produced a Cu10wt.%Al intermetallic coating based on copper with a content of aluminum from 7.0 to 12.0wt.%Al. The coating deposited on the test samples had a thickness of 0.45-0.5 mm. We analyzed the mechanical properties and the microstructure of the coatings in the deposited state, which led to the following conclusions.

The Cu10wt.%Al intermetallic coating had good mechanical properties, with a microhardness value of 176 $HV_{0.3}$ which was above the value of 158 $HV_{0.3}$ prescribed by the powder manufacturer. The bond strength was 35 MPa. The microstructure is lamellar, consisting of lamellas of oxide Cu_2O formed by Cu oxidation in the process of deposition of the powder and inter lamellar pores with an average proportion of 8%.

The base of the Cu10wt.%Al coating consisted of solid solutions α-Cu and β-Cu rich in copper with $CuAl_2$ and Cu_9Al_4 intermetallic phases as a result of the thermal reaction between Cu and Al in plasma during melting and deposition.

Applying Cu10wt.%Al coatings on aircraft parts made of light alloys and exposed to a combination of corrosion and wear has significantly improved the efficiency and reliability of the parts in exploitation and also significantly reduced the costs of repair.

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ХАРАКТЕРИЗАЦИЯ ИНТЕРМЕТАЛЛИЧЕСКОГО ПОКРЫТИЯ Cu10вес.%Al НАНЕСЕННОГО ПЛАЗМЕННЫМ НАПЫЛЕНИЕМ

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ОБЛАСТЬ: химические технологии
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Плазменное напыление является одним из методов нанесения износостойких покрытий, устойчивых в т.ч. к истиранию, эрозии, кавитации и коррозии. В данной работе описан процесс создания интерметаллического покрытия Cu10вес.%Al, являющегося надежным кандидатом для применения в трибологических условиях эксплуатации. Преимуществом покрытия данного вида является сочетание низкой стоимости и повышенной стойкости к абразии в различных режимах эксплуатации. Цель данного исследования заключается в изучении механических свойств и структур интерметаллических покрытий Cu10вес.%Al и развитии эффективной методологии нанесения покрытия, а также в повышении износостойкости легких сплавов. Многие компоненты сплава меди в коррозийных условиях подвергаются кавитационному и эрозийному разрушению, но своевременная инженерия поверхности соответсвующим покрытием деградирующих слоев, поможет сохранить их. Типичная микроструктура покрытия напылением – ламеллярная, с микропорами, несплавленными частицами, межламеллярными оксидами и преципитатами. Испытания механических характеристик покрытия Cu10вес.%Al проводились методом $HV_{0.3}$ а испытания прочности соединений − методом растяжения. Морфология частиц порошка и поверхности покрытия испытаны методом электронной микрографии (SEM). Испытания микроструктуры покрытия проведены методом оптической микроскопии, а микропоры исследованы методом оптической микрографии (ОМ).

Ключевые слова: *износ, интерметаллиды, эрозия, коррозия, покрытие, кавитация, Al, абразия.*

Mrdak, M., Characterization of Cu10wt.%Al intermetallic coatings applied by the atmospheric plasma spraying process, pp. 949–965

KARAKTERIZACIJA INTERMETALNE PREVLAKE Cu10tež.%Al NAPRSKANE ATMOSFERSKIM PLAZMA SPREJ POSTUPKOM

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OBLAST: hemijske tehnologije
VRSTA ČLANKA: originalni naučni članak
JEZIK ČLANKA: engleski

Sažetak:

Atmosferski plazma sprej je jedan od postupaka koji se koristi za depoziciju prevlaka otpornih na habanje usled trenja, erozije, kavitacije i korozije. U ovom radu, APS postupkom proizvedena je intermetalna prevlaka Cu10tež.%Al, koja je pouzdana za primenu u triboloških okruženjima zbog kombinacije niske cene i izuzetne otpornosti na abraziju pri različitim uslovima rada. Cilj ovoga rada bio je da se izuče mehanička svojstva i struktura intermetalne prevlake Cu10tež.%Al i razvije efikasan metod za reparaciju i poboljšanje otpornosti lakih legura na habanje. Mnoge komponente od legure bakra imaju tendenciju da se degradiraju zbog korozivne sredine, trenja, erozije i kavitacije. Takve komponente mogu se spasti inženjerstvom površina sa primenom odgovarajućih prevlaka na površinama izloženim degradaciji. Tipična mikrostruktura prevlake za APS postupak je lamelarna u kojoj su prisutne mikropore, neistopljene čestice, međulamelarni oksidi i precipitati. Mehaničke karakteristike prevlake Cu10tež.%Al ispitane su merenjem mikrotvrdoće slojeva prevlake metodom $HV_{0.3}$ i čvrstoće spoja metodom ispitivanja na zatezanje. Morfologija čestica praha i površina prevlake analizirana je na skening elektronskom mikroskopu (SEM). Analiza mikrostrukture prevlake urađena je uz korišćenje optičkog mikroskopa, a udeo mikropora određen je analizom mikrofotografija sa optičkog mikroskopa (OM).

Uvod

Atmosferski plazma sprej (APS) jedan je od tehnoloških postupaka koji se koristi za proizvodnju prevlaka debljine između 0,1 i 0,5 mm. Plazma sprej tehnologija je jedna od mogućih rešenja proizvodnje prevlaka na bazi bakra zbog povoljnih troškova proizvodnje i sposobnosti da se proizvedu prevlake na delovima složenih oblika. APS proces uključuje ubacivanje čestica praha u mlaz plazme, njegovo topljenje ili polutopljenje, a zatim ubrzavanje i sudaranje sa podlogom, gde se čestice praha deponuju i formiraju prevlaku (Mrdak, 2015a, pp.137-159), (Mrdak, 2015b, pp.46-67). Mehaničke karakteristike i mikrostruktura prevlaka pod uticajem je velikog broja parametara procesa koji direktno utiču na fazni sastav i sadržaj poroznosti za određeni prah i raspon čestica praha (Mrdak, et al., 2015, pp.337-343), (Mrdak, 2016a, pp.1-25), (Mrdak, 2016b, pp.411-430),

(Vencl, et al., 2011, pp.1281-1288), (Vencl, et al., 2010, pp.591-604). Bakar je metal koji ima široku primenu u mnogim aplikacijama zbog svoje odlične toplotne i električne provodljivosti. Mehaničke osobine bakra mogu se poboljšati legiranjem, što karakteriše legure bakra. Neke legure bakra, kao što su Cu-Al, Cu-Si i Cu-Al-Fe, koriste se za širu industrijsku primenu, jer su prilično dobri materijali kada je u pitanju otpornost na visoko habanje i koroziju. Legura Cu10tež.%Al mnogo se upotrebljava u hemijskoj industriji radi velike otpornosti na koroziju. U leguri Cu10tež.%Al, pored α strukture pojavljuje se i β struktura. Prevlaka Cu10tež.%Al otporna na habanje koristi se na radnim delovima da smanji štetu usled trenja, erozije, kavitacije i korozije (Bartuli, et al., 2007, pp.175-185). Prah Cu10tež.%Al, oznake Metco 445, jeste mehanički obložena aluminijumska bronza koja pokazuje samovezivanje za substrate za vreme termo-sprej procesa kao rezultat hemijske reakcije obloženih komponenti koji grade intermetalne faze. Prah sadrži aluminijum od 7,0 do 12,0tež.%Al (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco). Prevlake imaju dobru otpornost na trenje i zaribavanje na niskim i umerenim temperaturama i odličnu otpornost na abraziju i kavitaciju. Ispitivanje prevlake Cu10wt.%Al na abraziono habanje i habanje klizanjem, gde se koristila metoda prsten - na - disku i opterećenje od 150 g pri brzini klizanja od 4,5 cm/s pokazalo je da je abraziono habanje prevlake 0,52 mgm^{-1}, a habanje klizanjem 2,8x$10^{-5}$$mm^3m^{-1}$. Glavni mehanizam habanja prevlake je plastična deformacija (Limpichaipanit, et al., 2011, pp.123-126). Prevlake se lako i odlično obrađuju mašinski. Tipične komponente na kojima se koristi Cu10tež.%Al prevlaka su: oslonci ležajeva, rukavci hidrauličnih presa, vođice klipova, zaptivači kompresora vazduha, pumpe za vodu, turbinske mlaznice i dr. Prisustvo aluminijuma u bronzi uvećava otpornost prevlake na koroziju usled formiranja tankog kohezivnog površinskog oksida koji deluje kao zaštitni sloj na leguri bogatoj bakrom (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco). Da bi se bolje razumeli procesi reakcije koji se dešavaju između Cu i Al za vreme procesa topljenja praha i formiranja intermetalnih faza, neophodno je znati ravnotežni dijagram Cu-Al. U ravnotežnom dijagramu faza Cu-Al postoji pet stabilnih intermetalnih faza, kao što su: Cu_9Al_4, Cu_3Al_2, Cu_4Al_3, CuAl i $CuAl_2$, sa dva čvrsta rastvora Cu(Al), koji se često opisuju kao α-Cu i Al(Cu) (ASM Handbook, 1992, Volume 3, Alloy Phase Diagrams, ASM International, Metals Park). Istraživanja su pokazala da se u procesu topljenja praha u plazmi, usled reakcije Cu i Al, formiraju različite intermetalne faze kao što su: $CuAl_2$, Cu_9Al_4, Cu_3Al_2, Al_4Cu_9 (Altuncu, et al., 2012, pp.181-183). Glavne intermetalne faze koje utiču na otpornost na habanje prevlake su Cu_9Al_4 i Cu_3Al_2. Plazma sprej deponovana Cu10tež.%Al prevlaka ima lamelarnu strukturu, sa prisutnim neistopljenim česticama, precipitatima i interlamelarnim porama. Po autorima (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101) u mikrostrukturi su prisutne intermetalne faze tipa $CuAl_2$ i Cu_9Al_4. Osnovu legure čini čvrsti rastvor α-Cu(90,6-100tež.%Cu) i β-Cu(85,0–91,5tež.%Cu). U mikrostrukturi pre-

vlake nisu prisutne crne oksidne lamerle oksida Al_2O_3 (Li, Sun, 2004, pp.92-101). Prevlake Cu10tež.%Al sastoje se od svetle faze bakra i tamne faze oksida bakra Cu_2O. Oksid bakra se, pre svega, formira kada je temperatura ≥1000 °C i prisutan kiseonik, što se dešava pri primeni plazma sprej postupka (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101).

U ovom radu plazma sprej postupkom na atmosferskom pritisku deponovana je prevlaka aluminijumske bronze koja sadrži 7,0–12,0 tež.%Al. Mikrostruktura prevlake je analizirana na svetlosnom mikroskopu i površina prevlake na skening elektronskom mikroskopu. Cilj ovoga rada bio je da se izuče mehanička svojstva i mikrostruktura intermetalne prvlake Cu10tež.%Al i razvije ekonomski efikasan metod deponovanja intermetalne prevlake za poboljšanje otpornosti pohabanih vazduhoplovnih delova od legura Cu izloženih kombinaciji korozije i habanja.

Materijali i eksperimentalni detalji

Materijal na kojem su deponovani slojevi intermetalne prevlake Cu10tež.%Al (7,0-12,0tež.%Al) bio je od nerđajućeg čelika X15Cr13(EN1.4024) u termički neobrađenom stanju. Za proizvodnju Cu10tež.%Al prevlake upotrebljen je prah firme „Sulzer Metco" sa oznakom Metco 445. Prah je proizveden metodom mehaničkog oblaganja i sferoidizacije na određenu granulaciju gustine 3,1 – 4,3 g/cm^3. Temperatura topljenja praha je 1040°C. Za eksperiment se koristio prah koji je imao raspon granulata od 45 do 106 μm (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco).

Ispitivanje mehaničkih karakteristika prevlake Cu10tež.%Al rađeno je prema standardu Pratt&Whitney (Turbojet Engine–Standard Practices Manual (PN 582005), 2002, Pratt & Whitney, East Hartford, USA). Osnove na kojima su deponovani slojevi prevlake za ispitivanje mikrotvrdoće i za procenu mikrostrukture u deponovanom stanju izrađene su od čelika Č.4171 (X15Cr13 EN10027) u termički neobrađenom stanju, dimenzija 70x20x1,5 mm. Osnove za ispitivanje čvrstoće spoja takođe su izrađene od čelika Č.4171(X15Cr13EN10027) u termički neobrađenom stanju, dimenzija Ø25x50 mm. Mikrotvrdoća slojeva ispitivana je metodom $HV_{0.3,}$ a čvrstoća spoja ispitivanjem na zatezanje. Merenje mikrotvrdoće izvršeno je u pravcu duž lamela. Urađeno je pet očitavanja vrednosti mikrotvrdoće slojeva u sredini i na krajevima uzoraka od kojih su odbačene dve krajnje vrednosti. Od tri preostale vrednosti prikazana je srednja vrednost. Ispitivanje čvrstoće spoja rađeno je na sobnoj temperaturi sa brzinom zatezanja 1 cm/60 s. Ispitano je pet epruveta od kojih su odbačene dve krajnje vrednosti. Od tri preostale vrednosti prikazana je srednja vrednost čvrstoće spoja. Morfologija čestica praha i površina deponovane prevlake urađena je skening elektronskom mikroskopijom, a mikrostruktura deponovanih slojeva ispitana je na optičkom mikroskopu. Analiza udela mikropora u prevlaci urađena je obradom 5 fotografija na uveličanju 200x. U radu je prikazana srednja vrednost udela mikropora u prevlaci.

Depozicija Cu10tež.%Al praha urađena je sa atmosferski plazma sprej sistemom firme „Plasmadyne" i plazma pištoljem SG-100, sa kontrolisanim plazma sprej parametrima. Plazma pištolj SG-100 sastojao se od katode tipa K 1083A-129, anode tipa A 2083-175 i gas injektora tipa GI 1083A-130. Kao lučni gas koristio se Ar u kombinaciji sa He i snaga napajanja do 40kW. Plazma sprej parametri depozicije Cu10wt.%Al praha prikazani su u tabeli 1. Pre procesa deponovanja površine substrata su hrapavljene česticama belog korunda veličine od 0,7 do 1,5mm. Prevlake su deponovane na ispitnim uzorcima sa debljinama od 0,45 do 0,5mm.

Rezultati i diskusija

Mikrotvrdoća i zatezna čvrstoća spoja prevlake imale su vrednosti koje su karakteristične za ovaj tip prevlake. Intermetalna prevlaka Cu10tež.%Al imala je prosečnu vrednost mikrotvrdoće 176 $HV_{0.3}$. Izmerena prosečna vrednost mikrotvrdoće bila je veća od vrednosti koju propisuje proizvođač praha 158 $HV_{0.3}$ (Material Product Data Sheet Aluminum Bronze Thermal Spray Powders Thermal Spray Powder Products Metco 445, 2012, DSMTS-0103.0, Sulzer Metco), što ukazuje na to da u prevlaci nije prisutan veliki udeo mikropora. To su potvrdila metalografska ispitivanja slojeva prevlake. Srednja vrednost zatezne čvrstoće spoja izmerena na uzorcima sa prevlakom Cu10tež.%Al bila je 35 MPa. Prevlaka je razorena na interfejsu supstrat/prevlaka zbog dobrog spoja sa substratom. Izmerene vrednosti mikrotvrdoće i zatezne čvrstoće spoja Cu10tež.%Al prevlake bile su u korelaciji sa mikrostrukturom deponovanih slojeva. Na mikrofotografijama se jasno uočavaju međugranice spoja slojeva prevlake i substrata. Međugranica između substrata i slojeva prevlake je izuzetno čista, ukazujući na izuzetno dobru vezu slojeva prevlake sa substratom, što govori o dobroj pripremi površine substrata. Zbog dobre pripreme površine substrata na interfejsu nisu prisutni ostaci čestica korunda od hrapavljenja, što se odrazilo na dobru adheziju prevlake sa substratom. Na interfejsu između substrata i deponovanih slojeva prevlake nisu prisutni defekti kao što je diskontinuitet deponovanih slojeva, mikropukotine, makropukotine, ljuštenje i odvajanje prevlaka sa substrata. Generalno, slojevi su ravnomerno deponovani na podlogu. Prevlake imaju lamelarnu strukturu, interlamelarne okside i interlamelarne pore. Mikrostruktura prevlake pokazuje da su čestice praha ravnomerno i homogeno distribuirane. Kroz slojeve prevlake ne uočavaju se grube mikropore, mikropukotine i makropukotine. Prosečan udeo mikropora u slojevima prevlake bio je 8%. Pri većem uveličanju (slika 3) jasno se vide svetlo- sive lamele oksida Cu_2O sa ravnomernom raspodelom u prevlaci (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101) i mikropore crne boje. U prevlakama nisu uočene neistopljene čestice praha, ukazujući da su čestice praha deponovane sa optimalnim parametrima depozicije. Osnova prevlake Cu10tež.%Al sastoji se od čvrstih rastvora α-Cu i β-Cu bogatih bakrom u kojima se nalaze intermetalne faze $CuAl_2$ i Cu_9Al_4 (Hang, et al., 2008, pp.416-424), (Li, Sun, 2004, pp.92-101).

Analiza morfologije površine intermetalne prevlake Cu10tež.%Al pokazuje potpuno topljenje i pravilno razlivanje čestica praha na prethodno deponovani sloj. Na SEM mikrofotografiji crvenom linijom su označene granice između razlivenih čestica. Istopljene čestice praha formirale su tanke diskove – splates u sudaru sa podlogom. Tako formirani oblici deponovanih čestica ostvaruju dobru kohezivnu vezu sa prethodno deponovanim česticama, ukazujući da su čestice praha deponovane sa optimalnim parametrima depozicije. Na površini prevlake se ne uočavaju grube mikropore. Na SEM mikrofotografiji jasno se vide crne mikropore, zaokružene žutom bojom veličine do 10 μm. Na površini prevlake uočavaju se precipitati koji su nastati kao posledica sudara istopljenih kapi sa substratom. U trenutku sudara istopljenih kapi sa podlogom dolazi do odlamanja krajeva istopljenih čestica, koji očvršćavaju kao talog u deponovanim slojevima prevlake.

Zaključak

U radu je atmosferskim plazma sprej procesom (APS) proizvedena intermetalna prevlaka Cu10tež.%Al na bazi bakra sa sadržajem aluminijuma od 7,0 do 12,0tež.%Al. Prevlake deponovane na ispitnim uzorcima bile su debljine od 0,45 do 0,5 mm. Analizirane su mehaničke karakteristike i mikrostrukture prevlaka u deponovanom stanju, na osnovu čega se došlo do određenih zaključaka.

Intermetalna prevlaka Cu10tež.%Al imala je dobre mehaničke osobine, čija je mikrotvrdoća od 176 $HV_{0.3}$ bila iznad vrednosti 158 $HV_{0.3}$ koju propisuje proizvođač praha, i čvrstoću spoja od 35 MPa. Mikrostruktura prevlake je lamelarna, a sastoji se od oksidnih lamela Cu_2O formiranih oksidacijom Cu u procesu depozicije praha i interlamelarnih pora sa prosečnim udelom od 8%. Osnova Cu10tež.%Al prevlake sastoji se od čvrstih rastvora α-Cu i β-Cu bogatih bakrom u kojima se nalaze intermetalne faze $CuAl_2$ i Cu_9Al_4 nastale kao rezultat termičke reakcije između Cu i Al u plazmi u toku procesa topljenja i deponovanja.

Primenom Cu10tež.%Al prevlake u remontu na vazduhoplovnim delovima od lakih legura izloženih kombinaciji korozije i habanja znatno se poboljšala efikasnost i pouzdanost rada delova u eksploataciji i smanjili se troškovi remonta.

Ključne reči: *habanje, intermetali, erozija, korozija, prevlaka, kavitacija, Al, abrazija.*

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FUZZIFICATION OF THE SAATY'S SCALE AND A PRESENTATION OF THE HYBRID FUZZY AHP-TOPSIS MODEL: AN EXAMPLE OF THE SELECTION OF A BRIGADE ARTILLERY GROUP FIRING POSITION IN A DEFENSIVE OPERATION

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Summary:

This paper presents the new way of fuzzification of the Saaty's scale. In this model of fuzzification, the confidence interval of fuzzy numbers that describes the comparison in pairs' degree is not determined before the comparison. It is defined (calculated) during and after the comparison, based on the degree of certainty of decision-makers/experts. Thus, the confidence interval can vary depending on the comparison, no matter if it refers to the same degree of comparison. Also, in group deciding, confidence intervals differ depending on the decision-maker/expert's opinion. Such explanation is supported by the new fuzzyficated Saaty's scale. The application of the new scale is shown in the hybrid fuzzy AHP-TOPSIS model when choosing firing positions of an artillery brigade group in a defensive operation. Finally, the impact of the degree of certainty on the final decision is analyzed, where it is demonstrated that this element affects output results. The impact is reflected in the change of the size of weight vectors, i.e. output results (the distance from the ideal alternative), as well as in the change of the rank of alternatives, but only at limit values.

Key words: *Fuzzy logic, Firing position, Hybrid model, TOPSIS, AHP.*

Introduction

Decision making is one of the most important management elements. It has been empirically proven that decision making makes even 92% of a manager's job structure (Čupić, Suknović, 2010, p.xxv). Considerable attention is paid to the decision-making process in military organizations. The reason for this can be found in the fact that a man is in the center of every decision, and it is not expected that all people respond equally to situations in which they find themselves, as expressed particularly in combat operations, where the consequences of wrong decisions can often be irreparable (Pamučar, et al., 2011a, p.3). In the Army of Serbia many decisions are made in the processes of planning, organization and preparation for the execution of missions and tasks. The useful tools which support the decision-making process are the methods of multi criteria decision making.

This paper presents a hybrid model, using the fuzzificated Saaty's scale and the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution). The paper is focused on the demonstration of a new way of fuzzification of the Saaty's scale used for comparison in pairs with varying a confidence interval depending on the comparison. The scale is used for obtaining criteria weight coefficients, while the TOPSIS method is used for the final ranking. This model is illustrated by an example of decision making during the selection of a brigade artillery group (BrAG) firing position area in a defensive operation. The example presents only one segment from a series of decisions that decision makers face in the preparation and execution of (military) operations.

Fuzzy logic and fuzzy sets

In conventional logic, belonging of an element to the given set is strictly defined, i.e., an element can belong or not belong to the set. In fuzzy logic, belonging of an element to the specific set is not precisely defined - the element can be more or less part of the set; therefore, it is closer to human perception than conventional logic (Pamučar, et al., 2011b, p.594). Fuzzy logic allows quantification of seemingly imprecise information, which is a very common situation when describing social phenomena.

The first step in designing fuzzy sets is defining the degree of the membership of an element x ($x \in X$) to the set A. This is described with the membership function $\mu_A(x)$, which in the classic theory has a value of 0 (does not belong) or 1 (belongs), while in a fuzzy set the membership

function can have any value between 0 and 1. So, it can be said that the closer the $\mu_A(x)$ is to 1, the belonging of the x to A is greater, and vice versa. Every fuzzy set is completely and uniquely defined by its membership function (Zadeh, 1965). A fuzzy set is defined as a set of ordered pairs

$$A\left\{\left(x,\mu_A(x)\right)\middle| x\in X, 0\le\mu_A(x)\le 1\right\}. \quad (1)$$

where:
– X is a universal set or a set of considerations based on which the fuzzy set A is defined;
– $\mu_A(x)$ is a membership function of the element x to the set A.

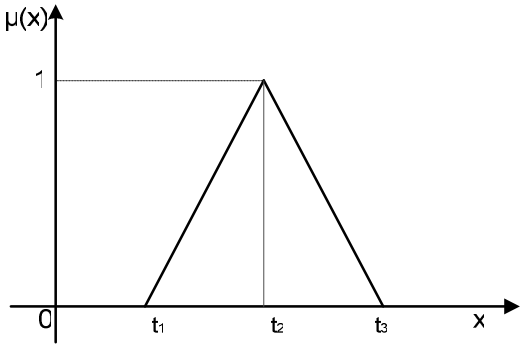
The membership function forms and the width of the confidence interval are usually selected on the basis of subjective assessment or experience, so that they best describe the phenomenon they represent. In practice, a variety of membership functions is used: triangular, trapezoidal, Gaussian, etc.

In this paper, triangular fuzzy numbers will be used. They will be presented in the form T = (t_1, t_2, t_3), where (Figure 1):

– t_2 is where the membership function of a fuzzy number has a value of 1;

– t_1 is the left distribution of the confidence interval of the fuzzy number T, and

– t_3 is the right distribution of the confidence interval of the fuzzy number T (Pamučar, 2011, p.45).



Picture 1 – Triangular fuzzy number T
Фигура 1 – Треугольное нечеткое число T
Slika 1 – Trouglasti fuzzy broj T

The membership function of the fuzzy number T is defined in the following way:

$$\mu_{\tilde{T}}(x)=\begin{cases}0, & x<t_1\\ \dfrac{x-t_1}{t_2-t_1}, & t_1\le x\le t_2\\ 1, & x=t_2\\ \dfrac{t_3-x}{t_3-t_2}, & t_2\le x\le t_3\\ 0, & x>t_3\end{cases} \quad (2)$$

For its final purpose, the fuzzy number $T=(t_1, t_2, t_3)$ is converted into a real number. Different methods are used for this procedure (Herrera, Martínez, 2000).

Fuzzification of the Saaty's scale

The Analytical Hierarchy Process method belongs to the group of light optimization methods. It is based on the interpretation of complex problems in a hierarchy, with an aim at the top and criteria, sub-criteria and alternatives at the levels and sub-levels of the hierarchy (Saaty, 1980). One of the key phases in the application of this method is the development of the comparison matrix by pairs, corresponding to every level of the hierarchy. A pairwise comparison is performed according to the data collected and by measuring them, as well as based on the beliefs, estimates or experiences of those who carry out the assessment (Čupic, Suknović, 2010). The main problem in the pairwise comparison is to quantify linguistically formulated selections or phrases (Kujačić, 2001). Different evaluation scales are developed for this purpose. Basic approaches in its development are: linear (Ma, Zheng, 1990) and exponential (Lootsma, 1988). Previous analyzes have shown that there is no ideal scale, but their quality varies from case to case (Triantaphyllou, et al., 1988). The standard for the AHP method presents the Saaty's scale, Table 1 (Saaty, 1980).

Table 1 – Saaty's scale for comparison in pairs
Таблица 1 – Шкала Саати парных сравнений
Tabela 1 – Saaty-jeva skala za poređenje u parovima

Definition	Standard values	Inverse values
The same importance	1	1
Low dominance	3	1/3
High dominance	5	1/5
Very high dominance	7	1/7
Absolute dominance	9	1/9
Intermediate values	2, 4, 6, 8	1/2, 1/4, 1/6, 1/8

The Saaty's scale is applied by decision-makers or analysts performing comparisons in pairs on the basis of semantic preferences from the left column of the Saaty's scale, or by direct association. Number values in columns two or three of Table 1, which correspond to the semantic preferences in the left column, are entered in the square comparison matrix.

$$A = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{12} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \end{array} \tag{3}$$

Since it is true that $a_{ji} = 1/a_{ij}$ and $a_{ii} = 1$ for every $i, j = 1, 2, \dots, n$, the matrix A is positive, symmetrical and reciprocal. The essential information on elements of preferences is located only in the upper triangle of the matrix, but all methods for its further analysis use the reciprocal value from the lower triangle (Bozanic, et al., 2013).

When applying the classic Saaty's scale, relations in the pairwise comparison are strictly defined. However, very often, when defining these values, one cannot be completely sure of the relations of the pairs compared. Therefore, in the literature there is an increasing number of papers which approach the fuzzification of the Saaty's scale in various ways ((Ray, Triantaphyllou, 1999), (Zhu, et al., 1999), (Chen, 2007), (Srđević, et al., 2008), (Gardašević-Filipovic, Šaletić, 2010), (Janacković, et al., 2013), (Rezaei, et al. 2014), (Janjić, et al., 2014) and others). Most authors use a predetermined interval of a fuzzy number in the fuzzification, i.e., preset the left and the right distribution of the most commonly used triangular fuzzy number T = (t_1, t_2, t_3). Some authors have recognized the necessity to leave the possibility of some uncertainty, such as in (Božanić, et al., 2011), (Božanić, et al., 2013), (Pamučar, et al., 2011c) (Pamučar, et al., 2012), (Pamučar, 2013) (Pamučar, et al., 2015), (Božanić, et al., 2015b), where the level of uncertainty for the whole scale is pre-defined, based on which the left and right distribution of the fuzzy number T are calculated. This level of uncertainty, i.e., the confidence interval, changes depending on the case or depending on the decision-maker.

On the basis of the Saaty's scale and the idea that the confidence interval of the fuzzy number does not always have to be identical, as shown in (Božanić, et al., 2011), (Božanić, et al., 2013), (Pamučar, et al., 2011c) (Pamučar, et al., 2012), (Pamučar, 2013) (Pamučar, et al., 2015), (Božanić, et al., 2015b), a new scale is defined, Table 2 (Božanić, Pamučar), (Božanić, et al., 2015a), (Božanić, et al., 2016). Defining this new fuzzyficated Saaty's scale has started from the assumption that decision

makers and analysts have a different degree of certainty γ_{ji} concerning the accuracy of comparisons in pairs. This degree of certainty differs from one comparative pair to the other. The value of the degree of certainty belongs to the interval $\gamma_{ji} \in [0, 1]$. In the cases when $\gamma_{ji}=0$, it is considered that the decision-maker/analyst has no data about this relationship, so it should not be used in the decision-making process, because it points to the absolute ignorance of the decision-making subject. The value of the degree of certainty where $\gamma_{ji}=1$ describes the absolute certainty of decision-makers and analysts in the defined comparison. The lower the certainty in the performed comparison is, the lower the element γ_{ji}.

Table 2 – Fuzzified Saaty's scale for comparison in pairs (Božanić, Pamučar), (Božanić, et al., 2015a), (Božanić, et al., 2016)
Таблица 2 – Фаззифицированная шкала Саати парных сравнений (Božanić, Pamučar), (Božanić, et al., 2015a), (Božanić, et al., 2016)
Tabela 2 – Fazifikovana Saaty-jeva skala za poređenje u parovima (Božanić, Pamučar), (Božanić, et al., 2015a), (Božanić, et al., 2016)

Definition	Standard values	Fuzzy number	Inverse values of the fuzzy number
The same importance	*1*	(1, 1, 1)	(1, 1, 1)
Low dominance	*3*	$\left(3\gamma_{ji}, 3, \left(2-\gamma_{ji}\right)3\right)$	$\left(1/\left(2-\gamma_{ji}\right)3, 1/3, 1/3\gamma_{ji}\right)$
High dominance	*5*	$\left(5\gamma_{ji}, 5, \left(2-\gamma_{ji}\right)5\right)$	$\left(1/\left(2-\gamma_{ji}\right)5, 1/5, 1/5\gamma_{ji}\right)$
Very high dominance	*7*	$\left(7\gamma_{ji}, 7, \left(2-\gamma_{ji}\right)7\right)$	$\left(1/\left(2-\gamma_{ji}\right)7, 1/7, 1/7\gamma_{ji}\right)$
Absolute dominance	*9*	$\left(9\gamma_{ji}, 9, \left(2-\gamma_{ji}\right)9\right)$	$\left(1/(2-\gamma_{ji})9, 1/9, 1/9\gamma_{ji}\right)$
Intermediate values	*2, 4, 6, 8*	$\left(x\gamma_{ji}, x, \left(2-\gamma_{ji}\right)x\right),$ $x = 2,\ 4,\ 6,\ 8$	$\left(1/\left(2-\gamma_{ji}\right)x, 1/x, 1/x\gamma_{ji}\right)$

By defining different values of the parameter $\gamma_{ji,}$, the left and the right distribution of fuzzy numbers change from comparison to comparison, according to the expression:

$$T=\left(t_1,t_2,t_3\right)=\begin{Bmatrix} t_1=\gamma t_2, & t_1\le t_2, & t_1,t_2\in[1/9,9] \\ t_2=t_2, & & t_2\in[1/9,9] \\ t_3=(2-\gamma)t_2, & t_3\le t_2, & t_2,t_3\in[1/9,9] \end{Bmatrix} \quad (4)$$

the value of t_2 represents the value of linguistic expressions from the classic Saaty's scale, which in a fuzzy number has a maximum membership $t_2 = 1$.

The fuzzy number $T=(t_1,t_2,t_3)=\left(x\gamma_{ji},x,\left(2-\gamma_{ji}\right)x\right)$, $x\in[1,9]$ is defined by the expressions:

$$t_1=x\gamma_{ji}=\begin{cases}x\gamma_{ji},\ \forall\ 1\le x\gamma_{ji}\le x\\ 1,\quad \forall\ x\gamma_{ji}<1\end{cases} \tag{5}$$

$$t_2=x,\ \forall\ x\in[1,9] \tag{6}$$

$$t_3=\left(2-\gamma_{ji}\right)x,\forall x\in[1,9] \tag{7}$$

The inverse fuzzy number $T^{-1}=(1/t_3,1/t_2,1/t_1)=\left(1\Big/\left(2-\gamma_{ji}\right)x,1/x,1\Big/\gamma_{ji}x\right)$, $x\in[1,9]$ is defined as follows:

$$1/t_3=1\Big/\left(2-\gamma_{ji}\right)x=\begin{cases}1\Big/\left(2-\gamma_{ji}\right)x,\ \forall\ 1\Big/\left(2-\gamma_{ji}\right)x<1\\ 1,\ \forall\ 1\Big/\left(2-\gamma_{ji}\right)x\ge 1\end{cases} \tag{8}$$

$$1/t_2=1/x,\ \forall\ 1/x\in\left[1,9\right] \tag{9}$$

$$1/t_1=1\Big/\gamma_{ji}x,\forall 1/x\in[1,9] \tag{10}$$

The defined scale is further used in standard steps of the AHP method, which is described in a number of papers (Saaty, 1980), (Lootsma, 1988), (Nikolić, Borović, 1996), (Srđević, Srđević, 2004) (Čupić, Suknović, 2010), (Karović, Pušara, 2010), (Devetak, Terzić, 2011), (Inđić, et al., 2014) and others.

Based on the pre-defined scale, decision-makers and analysts fill in the new, modified matrix:

$$A=\begin{array}{c}\\ C_1\\ C_2\\ \vdots\\ C_n\end{array}\begin{array}{c}\begin{array}{cccc}C_1 & C_2 & \cdots & C_n\end{array}\\ \begin{bmatrix}a_{11};\gamma_{11} & a_{12};\gamma_{12} & \cdots & a_{1n};\gamma_{1n}\\ a_{21};\gamma_{21} & a_{22};\gamma_{22} & \cdots & a_{2n};\gamma_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ a_{n1};\gamma_{n1} & a_{n2};\gamma_{n2} & \cdots & a_{nn};\gamma_{nn}\end{bmatrix}\end{array} \tag{11}$$

As it can be seen, the matrix is extended with the degree of certainty in the comparison made, whereby $\gamma_{ji}=\gamma_{ij}$, where $\gamma_{ji}\in[0,1]$. After the calculation is finished, the defuzzification can be performed using one of well-known methods. Some of well-known expressions for defuzzification (Seiford, 1996) are the following ones:

$$A=((t_3-t_1)+(t_2-t_1))/3+t_1 \tag{12}$$

$$A=\left[\lambda t_3+t_2+(1-\lambda)t_1\right]/2 \tag{13}$$

where λ represents the degree of optimism (Božanić, et al., 2015b). Also, it is possible to perform further calculations using fuzzy weight coefficients without defuzzification, which would be done at the end of the calculation of the criteria functions of alternatives.

The scale presented can be implemented in the classic application of the AHP method, where weight coefficients are calculated first, and then criteria functions are evaluated for every alternative studied. The scale is also suitable for the evaluation of criteria weights with the aim of later implementation of some other method.

The defined scale is also suitable for group decision making, which has recently become more and more popular. Involving experts greatly improves the quality of decisions made because knowledge and experience are collected and consolidated into a single unit. The most widely used approach in data collecting by experts is the Delphi method (Lootsma, 1988). The scale defined in this paper is applied in group decision making, as well as in the standard AHP method (more information in (Srđević, Zoranović, 2003) (Zoranović, Srđević, 2003)).

The TOPSIS method

The TOPSIS method was developed by Hwang and Joon (1981). This method consists in ranking alternatives by multiple criteria comparisons based on the distance from the ideal solution and the negative ideal solution. The ideal solution minimizes the cost type criteria and maximizes the benefit type criteria, while the negative ideal solution is reverse (Srđević, et al., 2002). The optimum alternative is the one that is the closest in a geometrical sense to the ideal solution, i.e., the farthest from the negative ideal solution (Srđević, et al., 2002).

The starting point of this method is the initial decision-making matrix.

$$P = \begin{array}{c} \\ \\ A_1 \\ A_2 \\ A_3 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & \cdot & \cdot & C_m \end{array} \\ \begin{array}{cccccc} w_1 & w_2 & w_3 & \cdot & \cdot & w_m \end{array} \\ \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdot & \cdot & r_{1m} \\ r_{21} & r_{22} & r_{23} & \cdot & \cdot & r_{2m} \\ r_{31} & r_{32} & r_{33} & \cdot & \cdot & r_{3m} \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot \\ r_{n1} & r_{n2} & r_{n3} & \cdot & \cdot & r_{nm} \end{bmatrix} \end{array} \tag{14}$$

With the decision-making matrix, the *n* alternatives and the *m* criteria are defined. The weight of the criteria w_i is joined to each criterion. Criteria weights should meet the following requirement:

$$\sum_{i=1}^{n} w_i = 1 \tag{15}$$

After defining the decision-making matrix, the TOPSIS method can be implemented. The application of the method can be divided into six steps:

– *First step*: normalization of the decision-matrix values:

$$x_{ij} = r_{ij}\left[\sqrt{\sum_{i=1}^{n} r_{ij}^2}\right]^{-1} \tag{16}$$

After the application of expression (16), a new dimensionless matrix is obtained:

$$P' = \begin{array}{c} \\ \\ A_1 \\ A_2 \\ A_3 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & \cdot & \cdot & C_m \end{array} \\ \begin{array}{cccccc} w_1 & w_2 & w_3 & \cdot & \cdot & w_m \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdot & \cdot & x_{1m} \\ x_{21} & x_{22} & x_{23} & \cdot & \cdot & x_{2m} \\ x_{31} & x_{32} & x_{33} & \cdot & \cdot & x_{3m} \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot \\ x_{n1} & x_{n2} & x_{n3} & \cdot & \cdot & x_{nm} \end{bmatrix} \end{array} \tag{17}$$

– *Second step*: multiplication of the normalized values and the criteria weight coefficients:

$$v_{ij} = x_{ij} w_j; j = 1, 2, ..., m \tag{18}$$

After the application of expression (18), a new matrix is obtained:

$$P'' = \begin{array}{c} \\ \\ A_1 \\ A_2 \\ A_3 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & \cdot & \cdot & C_m \end{array} \\ \begin{array}{cccccc} w_1 & w_2 & w_3 & \cdot & \cdot & w_m \end{array} \\ \begin{bmatrix} v_{11} & v_{12} & v_{13} & \cdot & \cdot & v_{1m} \\ v_{21} & v_{22} & v_{23} & \cdot & \cdot & v_{2m} \\ v_{31} & v_{32} & v_{33} & \cdot & \cdot & v_{3m} \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot \\ v_{n1} & v_{n2} & v_{n3} & \cdot & \cdot & v_{nm} \end{bmatrix} \end{array} \tag{19}$$

– *Third step*: determination of ideal solutions. The ideal and negative ideal solution are obtained using the following expression:

$$A^* = \left\{\left(\max v_{ij} \mid j \in C\right)\left(\min v_{ij} \mid j \in C'\right), i = 1, 2, ..., n\right\} = \left\{v_1^*, v_2^*, ..., v_m^*\right\} \tag{20}$$

$$A^- = \left\{\left(\min v_{ij} \mid j \in C\right)\left(\max v_{ij} \mid j \in C'\right), i = 1, 2, ..., n\right\} = \left\{v_1^-, v_2^-, ..., v_m^-\right\} \tag{21}$$

where: C is the set of benefit type criteria, and C' is the set of cost type criteria.

– *Fourth step*: determination of the distance of alternatives from the ideal solution.

$$S_i^* = \sqrt{\sum_{j=1}^{m}\left(v_{ij} - v_j^*\right)^2}, i = 1,2,...,n \tag{22}$$

$$S_i^- = \sqrt{\sum_{j=1}^{m}\left(v_{ij} - v_j^-\right)^2}, i = 1,2,...,n \tag{23}$$

– *Fifth step*: determination of the relative proximity of alternatives to the ideal solution. Determination of the distance from the ideal alternative is performed by applying the expression:

$$Q_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1,2,...,n \tag{24}$$

– *Sixth step*: ranking alternatives. Alternatives are ranked on the basis of the results obtained by applying expression (24). The best alternative is considered the alternative whose value Q_i^* is the highest, and vice versa.

Selection of a BrAG firing position area by using the hybrid FAHP-TOPSIS model

Description of the problem and defining the criteria

A brigade artillery group is a temporary formation of artillery units, formed at the tactical level. It is intended for artillery firing support of one's own forces in combat operations of a land forces brigade and territorial brigades (Vojni leksikon, 1981, p.72). A BrAG performs its tasks from firing positions (primary, suplementary, alternate, temporary). A firing position (FP) is a part of the land in the area of the operation, prepared and occupied or intended to be occupied by the artillery units for the execution of firing support (Vojni leksikon, 1981, p.658). An FP area of a BrAG is determined depending on its purpose, type of weapons and ammunition, targets of artillery firing support, combat, space, time and other conditions.

There are rules and regulations governing fundamental criteria of grouping artillery and its deployment into action, as well as a part of the conditions an FP area should meet in order to be selected as an alternative. However, in the available literature, this problem has not been fully developed, systematized, nor the method of selection of an FP area has been elaborated (neither criteria are precisely defined, nor their weight values and their relationship, nor the particularities of various

combat operations). Consequently, decision-makers usually have to select an FP of BrAG area relying on the acquired theoretical knowledge, experience and assessment in the specific situation. A number of criteria that influence the ranking and selection of alternatives indicate a possibility of applying multiple criteria methods.

For the purposes of the selection of the best firing position for a BrAG in a defensive operation, the following six criteria are defined (Kurtov, et al., 2014, p.708):

C_1 - "*distance from the ideal location for action*" - the ideal location is generally defined as 1/3 of the rank of artillery weapon from the front end of one's own forces;

C_2 - "*sheltering height*" - represents the height of the obstacles that allow hiding or masking combat effects from the survey instruments, electronic effects and enemy fire;

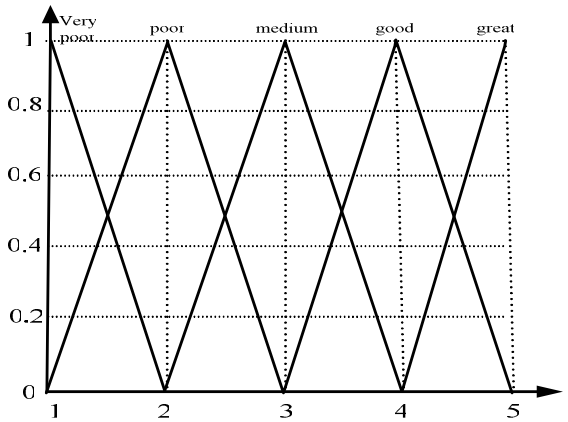
C_3 - "*masking conditions*" - terrain features that enable successful masking of the BrAG and movement of parts or the whole BrAG;

C_4 - "fortification *conditions*" - terrain features that allow successful fortification of artillery to enhance force protection;

C_5 - "c*onditions for maneuver*" – terrain features based on which the assessment of the possibility of fast moving to the following firing position is performed;

C_6 - "*average height difference between individual instruments*" - for successful actions, it is necessary for all individual instruments in BrAG artillery batteries to be located on the height difference less than 20m.

The values of the criteria C_1, C_2 and C_6 are described numerically and the values of the criteria C_3, C_4 and C_5 are described with fuzzy linguistic descriptors, Figure 2.



Picture 2 – Graphic display of the fuzzy linguistic descriptors
Фигура 2 – Графическое изображение нечеткого лингвистического дескриптора
Slika 2 – Grafički prikaz fuzzy lingvističkih deskriptora

The membership functions of the fuzzy linguistic descriptors are defined through the expressions:

$$\mu_{l_{VL}} = \begin{Bmatrix} 1, & 1 \geq x \\ 2-x, & 1 \leq x \leq 2 \end{Bmatrix} \tag{25}$$

$$\mu_{l_L} = \begin{Bmatrix} x-1, & 1 \leq x \leq 2 \\ 3-x, & 2 \leq x \leq 3 \end{Bmatrix} \tag{26}$$

$$\mu_{l_S} = \begin{Bmatrix} x-2, & 2 \leq x \leq 3 \\ 4-x, & 3 \leq x \leq 4 \end{Bmatrix} \tag{27}$$

$$\mu_{l_D} = \begin{Bmatrix} x-3, & 3 \leq x \leq 4 \\ 5-x, & 4 \leq x \leq 5 \end{Bmatrix} \tag{28}$$

$$\mu_{l_O} = \begin{Bmatrix} x-4, & 4 \leq x \leq 5 \\ 1, & x \geq 5 \end{Bmatrix} \tag{29}$$

Calculation of the criteria weight coefficients

The first step in defining the weight coefficients is to define the square comparison matrix. Two elements of the hierarchy (models) are compared using the Saaty's classic scale and by defining the degree of certainty of a given claim (according to expression 11). The degree of inconsistency of the given matrix is 0.08.

$$A = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 \end{array} \\ \begin{bmatrix} 1;1.0 & 4;0.2 & 6;0.2 & 5;0.4 & 2;0.5 & 9;0.2 \\ 4^{-1};0.2 & 1;1.0 & 3;0.6 & 5;0.9 & 3^{-1};0.4 & 6;0.5 \\ 6^{-1}:0.2 & 3^{-1}0.6 & 1;1.0 & 2;0.4 & 4^{-1};0.6 & 7;0.6 \\ 5^{-1};0.4 & 5^{-1};0.9 & 2^{-1};0,4 & 1;1.0 & 6^{-1};0.4 & 4;1.0 \\ 2^{-1};0.5 & 3;0.4 & 4;0.6 & 6;0.4 & 1;1.0 & 7;0.4 \\ 9^{-1};0.2 & 6^{-1};0.5 & 7^{-1};0.6 & 4^{-1};1.0 & 7^{-1};0.4 & 1;1.0 \end{bmatrix} \end{array}$$

The values of the matrix A are converted into fuzzy numbers by applying the fuzzyficated Saaty's scale (Table 2), so a new matrix A' is obtained.

$$A' = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ K_6 \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 \end{array} \\ \begin{bmatrix} 1 & \tilde{4} & \tilde{6} & \tilde{5} & \tilde{2} & \tilde{9} \\ \tilde{4} & 1 & \tilde{3} & \tilde{5} & \tilde{3}^{-1} & \tilde{6} \\ \tilde{6}^{-1} & \tilde{3}^{-1} & 1 & \tilde{2} & \tilde{4}^{-1} & \tilde{7} \\ \tilde{5}^{-1} & \tilde{5}^{-1} & \tilde{2}^{-1} & 1 & \tilde{6}^{-1} & \tilde{4} \\ \tilde{2}^{-1} & \tilde{3} & \tilde{4} & \tilde{6} & 1 & \tilde{7} \\ \tilde{9}^{-1} & \tilde{6}^{-1} & \tilde{7}^{-1} & \tilde{4}^{-1} & \tilde{7}^{-1} & 1 \end{bmatrix} \end{array}$$

The weight vector w of every criterion of the matrix A' is the sum of the linguistic expressions that describe the criteria in the same row of the matrix A', which is divided by the sum of all linguistic expressions that describe the criteria of the matrix A'.

After the calculation is performed, the weight vectors of the criteria are obtained:

$$w_i = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \\ w_6 \end{bmatrix} = \begin{bmatrix} 0.282; 0.393; 0.382 \\ 0.212; 0.159; 0.162 \\ 0.112; 0.093; 0.105 \\ 0.089; 0.060; 0.058 \\ 0.272; 0.269; 0.254 \\ 0.033; 0.026; 0.039 \end{bmatrix}$$

Ranking alternatives

The model is applied using the illustrative values of seven alternatives shown in the initial decision matrix and taken from (Kurtov, et al., 2014, p.709).

$$P = \begin{array}{c} \\ w_i \\ \\ A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 \\ w_1 & w_2 & w_3 & w_4 & w_5 & w_6 \\ \min & \max & \max & \max & \max & \min \end{array} \\ \begin{bmatrix} 1100 & 15 & \tilde{1} & \tilde{4} & \tilde{3} & 3 \\ 2000 & 23 & \tilde{4} & \tilde{3} & \tilde{4} & 6 \\ 3800 & 27 & \tilde{3} & \tilde{5} & \tilde{4} & 2 \\ 500 & 5 & \tilde{2} & \tilde{4} & \tilde{2} & 1 \\ 1850 & 32 & \tilde{5} & \tilde{1} & \tilde{3} & 4 \\ 3200 & 10 & \tilde{5} & \tilde{1} & \tilde{3} & 9 \\ 900 & 20 & \tilde{3} & \tilde{3} & \tilde{5} & 5 \end{bmatrix} \end{array}$$

The six-step TOPSIS method application results in the values of the distance of alternatives from the ideal alternative, based on which they are ranked:

$$\tilde{Q}_i^* = \begin{array}{c} \tilde{Q}_1^* \\ \tilde{Q}_2^* \\ \tilde{Q}_3^* \\ \tilde{Q}_4^* \\ \tilde{Q}_5^* \\ \tilde{Q}_6^* \\ \tilde{Q}_7^* \end{array} \begin{bmatrix} 0.578; 0.664; 0.658 \\ 0.597; 0.573; 0.574 \\ 0.410; 0.293; 0.300 \\ 0.538; 0.650; 0.647 \\ 0.611; 0.591; 0.598 \\ 0.276; 0.242; 0.252 \\ 0.748; 0.812; 0.802 \end{bmatrix}$$

Finally, defuzzification is performed by applying expression 12, and the final values of the distance of alternatives from the ideal alternative are obtained:

$$Q_i^* = \begin{matrix} Q_1^* \\ Q_2^* \\ Q_3^* \\ Q_4^* \\ Q_5^* \\ Q_6^* \\ Q_7^* \end{matrix} \begin{bmatrix} 0.633 \\ 0.581 \\ 0.334 \\ 0.612 \\ 0.600 \\ 0.257 \\ 0.787 \end{bmatrix}$$

Based on the obtained distances from the ideal alternative, it can be concluded that alternative seven (A_7) is the most appropriate alternative, i.e., alternative six (A_6) is the least favorable one.

Discussion and Conclusions

A practical example of the new scale demonstrated a possibility of using the hybrid fuzzy AHP-TOPSIS model, i.e., its performance in ranking the offered alternatives. In order to determine the differences between the application of the classic Saaty's scale and the scale demonstrated in this paper, a comparative overview of the output results is presented (Table 3).

Table 3 – Comparative summary of the solutions
Таблица 3 – Сравнительный обзор решений
Tabela 3 – Upredni pregled dobijenih rešenja

Alternatives	Classic Saaty's scale		Fuzzyficated Saaty's scale	
	Q_i^*	Rank	Q_i^*	Rank
A_1	0.664	2	0.633	2
A_2	0.573	5	0.581	5
A_3	0.293	6	0.334	6
A_4	0.650	3	0.612	3
A_5	0.591	4	0.600	4
A_6	0.242	7	0.257	7
A_7	0.812	1	0.787	1

Analyzing the output results, it can be observed that the rank of alternatives has not changed. However, the values obtained by applying the classic Saaty's scale and the fuzzyficated Saaty's scale are different. The differences between the alternatives A_1, A_4 and A_5 are significantly reduced, and the difference between the alternatives A_1 and A_5 is reduced more than twice. It is also evident that the difference between the alternatives A_3 and A_6 increased.

Although the differences shown are significant, there is no change in the rank of alternatives. However, it would be important to determine whether changes in the elements of the initial decision matrix may result in a change of the rank of alternatives when using the classic and fuzzyficated Saaty's scale. These changes will be presented with two examples.

Example 1: Changing the value of the alternative A_1 by the criterion C_2 in the initial decision-making matrix from 15m to 11m would lead to a different way of ranking alternatives (Table 4).

Table 4 – Comparative summary of the solutions with the change of the initial elements
Таблица 4 – Сравнительный обзор решений с изменением исходных элементов
Tabela 4 – Uporedni pregled dobijenih rešenja sa promenom početnih elemenata

Alternatives	Classic Saaty's scale		Fuzzyficated Saaty's scale	
	Q_i^*	Rank	Q_i^*	
A_1	0.646	3	0.611	2
A_2	0.574	5	0.582	5
A_3	0.295	6	0.336	6
A_4	0.648	2	0.610	3
A_5	0.592	4	0.601	4
A_6	0.242	7	0.257	7
A_7	0.811	1	0.786	1

In the mentioned example, it is noted that, when the classic Saaty's scale is used, the alternative A_1 is ranked as the third. However, when the fuzzyficated scale is used, it is ranked as the second, while the alternative A_4 switched the position with the A_1.

Example 2: Changing the value of the alternative A_5 by the criterion C_1 in the initial decision-making matrix from 1850 m to 1500 m would lead to a different way of ranking alternatives (Table 5). In the mentioned example, it is noted that when using the classic Saaty's scale the alternative A_1 is ranked as the second, while when using the fuzzyficated scale the alternative A_5 is ranked as the second, and vice versa.

Table 5 – Comparative summary of the solutions with the change of the initial elements
Таблица 5 – Сравнительный обзор решений с изменением исходных элементов
Tabela 5 – Uporedni pregled dobijenih rešenja sa promenom početnih elemenata

Alternatives	Classic Saaty's scale		Fuzzyficated Saaty's scale	
	Q_i^*	Rank	Q_i^*	Rank
A_1	0.667	2	0.636	3
A_2	0.573	5	0.580	5
A_3	0.290	6	0.331	6
A_4	0.654	4	0.616	4
A_5	0.661	3	0.661	2
A_6	0.241	7	0.256	7
A_7	0.813	1	0.789	1

Both examples show the importance of the degree of certainty of decision makers when ranking alternatives. Of course, the degree of certainty should not be the deciding factor in ranking, but an additional element that comes to the fore at the limit values. This can be analyzed through the already given examples.

If we consider the calculation with the values from the initial decision matrix, it can be noted that the rank of alternatives is identical when using both classic and fuzzyficated scale. In examples 1 and 2, the rank of alternatives has changed. If we continue and further reduce the value of the alternative A_1 by the criterion C_2 in the initial decision-making matrix from the original 15 m, and next 11m, to 10, new solutions would be obtained (Table 6).

Table 6 – Comparative summary of the solutions with the change of the initial elements
Таблица 6 – Сравнительный обзор решений с изменением исходных элементов
Tabela 6 – Uporedni pregled dobijenih rešenja sa promenom početnih elemenata

Alternatives	Classic Saaty's scale		Fuzzyficated Saaty's scale	
	Q_i^*	Rank	Q_i^*	Rank
A_1	0.641	3	0.605	3
A_2	0.574	5	0.582	5
A_3	0.295	6	0.337	6
A_4	0.648	2	0.609	2
A_5	0.592	4	0.602	4
A_6	0.242	7	0.257	7
A_7	0.811	1	0.786	1

Table 6 shows that, when using different scales, the rank of alternatives is identical again, except that the alternatives A_1 and A_4 switched their positions (which is considered to be expected because the characteristics of the alternative A_1 improved). The situation is similar in example 2. If the values of the alternative A_5 by the criterion C_1 in the initial decision-making matrix are reduced from 1850 m, and 1500 m, to 1400 m, the identical situation occurs as in the previous case (Table 7). The ranks of alternatives are identical applying either scale, except that there is the expected replacement in the rank of alternatives due to improving the alternative value by one criterion.

Table 7 – Comparative summary of the solutions with the change of the initial elements
Таблица 7 – Сравнительный обзор решений с изменением исходных элементов
Tabela 7 – Uporedni pregled dobijenih rešenja sa promenom početnih elemenata

Alternatives	Classic Saaty's scale		Fuzzyficated Saaty's scale	
	Q_i^*	Rank	Q_i^*	Rank
A_1	0.668	3	0.637	3
A_2	0.572	5	0.580	5
A_3	0.289	6	0.330	6
A_4	0.655	4	0.617	4
A_5	0.680	2	0.677	2
A_6	0.241	7	0.255	7
A_7	0.814	1	0.789	1

In all cases it can be observed that Q_i^* changes, i.e., that the differences between the alternatives increase/decrease depending on the degree of certainty of decision makers.

From all of the above mentioned, it can be concluded that the new fuzzyficated Saaty's scale improves decision making taking into account the degree of certainty of decision makers in the shown pairwise comparison. Considering the degree of certainty of decision makers, a change occurs in ranking alternatives at the limit values, thereby maintaining the decisive role of the comparison itself, which is the essence of the Saaty's scale.

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ФАЗЗИФИКАЦИЯ СКАЛЫ СААТИ И ОБЗОР ГИБРИДНОЙ МОДЕЛИ FUZZY AHP – TOPSIS: ПРИМЕРЫ ВЫБОРА ОГНЕВОЙ ПОЗИЦИИ БРИГАДНОЙ АРТИЛЛЕРИЙСКОЙ ГРУППЫ В ОБОРОНИТЕЛЬНЫХ ОПЕРАЦИЯХ

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Резюме:

В настоящей работе представлен новый метод фаззификации шкалы Саати. В данной фаззификации доверительный интервал нечетких чисел, описывающих степени парных сравнений не определен заранее − до начала процесса сравнения. Он вычисляется в течение и по окончании сравнения, на основании степени уверенности лица, принимающего решение (эксперта).

Таким образом, доверительный интервал может отличаться в сравнениях, несмотря на одинаковую степень сравнения. Доверительные интервалы также могут отличаться при групповом принятии решений, в зависимости от выбора решения эксперта. Данные положения поддерживаются новой фаззифицированной шкалой Саати.

Применение новой шкалы представлено в гибридной модели fuzzy AHP – TOPSIS, при выборе огневой позиции бригадной артиллерийской группы в оборонительной операции. В завершении произведена оценка влияния степени уверенности на конечное решение, и доказано, что данный элемент влияет на выходные результаты.

Влияние отражается в изменениях значений весовых векторов, то есть, выходных результатов (расстояние от идеальной альтернативы), а также на изменение ранга альтернатив, но только при граничных значениях.

Ключевые слова: *фаззи логика, огневая позиция, гибридная модель, TOPSIS, AHP.*

FAZIFIKACIJA SAATY-JEVE SKALE I PRIKAZ HIBRIDNOG MODELA FUZZY AHP – TOPSIS: PRIMER IZBORA VATRENOG POLOŽAJA BRIGADNE ARTILJERIJSKE GRUPE U ODBRAMBENOJ OPERACIJI

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OBLAST: matematika, operaciona istraživanja
VRSTA ČLANKA: originalni naučni članak
JEZIK ČLANKA: engleski

Sažetak:

Osnovu rada čini prikaz novog načina fazifikacije Saaty-jeve skale. U ovoj fazifikaciji interval poverenja fuzzy brojeva, kojima su opisani stepeni poređenja u parovima, nije određen pre samog procesa poređenja. On se definiše (proračunava) u toku i nakon poređenja, a na osnovu stepena uverenosti donosilaca odluka – eksperata. Tako se interval poverenja može razlikovati od jednog do drugog poređenja, bez obzira na to što se radi o istom stepenu poređenja. Takođe, intervali poverenja se razlikuju od jednog do drugog donosioca odluke – eksperta, kada je reč o grupnom odlučivanju. Ovakvo obrazloženje podržava nova fazifikovana Saaty-jeva skala. Primena nove skale prikazana je u hibridnom modelu fuzzy AHP – TOPSIS prilikom izbora vatrenog položaja brigadne artiljerijske grupe u odbrambenoj operaciji. Na kraju je analiziran uticaj stepena uverenosti na konačnu odluku, gde je dokazano da ovaj element utiče na izlazne rezultate. Uticaj se ogleda u promeni veličine težinskih vektora, odnosno izlaznih rezultata (udaljenosti od idealne alternative), kao i na promeni ranga alternativa, ali samo na graničnim vrednostima.

Ključne reči: *fuzzy logika, vatreni položaj, hibridni model, TOPSIS, AHP.*

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MODELING INTERNATIONAL NUCLEAR CHEMICAL BIOLOGICAL DEFENCE FORCES IN CASE OF CHEMICAL WEAPONS APPLICATION FOR TERRORIST PURPOSES

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Summary:

Accelerated technical and technological development of civilisation during the twentieth and the beginning of the twenty-first century has fundamentally contributed to an uneven distribution of total world resources. Such distribution of resources has led to frequent armed conflicts which resulted in the use of both conventional weapons and those of mass destruction. Unlike conventional weapons, this kind of weapons possesses specific characteristics that make it very attractive for terrorist purposes. The best example for this is the terrorist attack in March 1995, when the ,,Aum Sinrikjo" cult used sarin (toxic chemical from a lethal chemical weapons group) in the Tokio subway which resulted in 12 deaths and over 5,000 exposed to intoxication. This paper aims to present a model of using international nuclear chemical biological defence forces in case of the application of chemical weapons for terrorist purposes. Oppinions of CBRN experts were used for determining the criteria for the selection of a nuclear chemical biological defence forces model. The analytic hierarchy process (AHP) method was used to obtain optimal results. The obtained results can be used as a starting point for modeling nuclear chemical biological defence forces at international exercises with similar content.

Key words: *international forces, terrorism, CBRN units, weapons, nuclear, chemical.*

Introduction

Increasing disparities between rich and poor regions have created conditions for the application of the "asymmetrical method", where the fight against the rich uses everything available to individuals, organizations or countries. Terrorist groups are trying to procure and use weapons of mass destruction (WMDs). Events worldwide have brought terrorist attacks with WMDs into focus. There is hardly any global scientific, technical, political and economic gathering where new risks and threats to global and national securities are not a topic.

The danger of the use of WMDs for terrorist purposes is reflected in uncontrolled events in the form of explosions, fires, radiation, leakage and spillage of materials. Emergencies caused by using WMDs for terrorist purposes are unpredictable and can result in a large number of casualties, contaminated and injured. Also, material damage that can occur in these situations is not small. Fear and panic among the population can cause immediate collapse in traffic. These facts contribute to actualizing the problem of protection from the use of WMDs for terrorist purposes as well as a problem of an adequate response.

Chemical, biological, radiological and nuclear (CBRN) defense units, in most armies of the world, are intended for nuclear, chemical and biological (NCB) observation, radiological, chemical and biological (RCB) survey, laboratory analyses and RCB decontamination of sites targeted with WMDs in combat. In peace, in the event of the application of WMDs for terrorist purposes, these units would also have an important role in eliminating the consequences of the application of this weapon. Because more than one country could be affected by a terrorist act, an integrated approach of international CBRN forces to eliminating the consequences of WMDs usage becomes increasingly important. However, there are not enough data on how to model international CBRN defence forces in such situations.

This paper will analyze the use of international CBRN defence forces in eliminating the consequences of the chemical weapons application for terrorist purposes.

Presentation of chemical weapons usage for terrorist purposes

In the current conditions of global social changes and tendencies of treating terrorism as a global security problem, there is an increasing possibility of chemical terrorism, especially if it is taken into account that certain forms of chemical terrorism have already appeared. The USA Federal Agency for Emergency lists several reasons for this: the first - chemical agents are easier to produce than nuclear weapons or radioactive material, the second - 26 nations managed to develop chemical weapons, and another

12 are trying to do it, and the third - chemical agents are easier to transport and purchase. For the possibility of being used for terrorist purposes, chemical agents must have the following characteristics: they must be highly toxic by its unit weight, relatively resistant to various atmospheric conditions and possible to be mass-produced (Petković, 2009, pp.248-275).

Chemical means and toxic chemical agents may be used for terrorist purposes when terrorists carry out chemical contamination[1] of particular areas, the air, water or food, causing fear on a large scale.

A large number of toxic chemicals (TCs) when entering the human body manifest adverse effects, but not all are suitable for use in terrorist activities, because, after entering the body, chemicals must remain outside the sensory perception of the victim until the appearance of poisoning symptoms. General conditions to be met by TCs are their toxicity and favorable physicochemical properties, poor ability for detection and identification, and difficulty to provide first aid. A comparative review of the toxicity of some agents is shown in Table 1 (Lazarević, Radovanović, 2015).

Toxic chemicals from chemical weapons are an effective tool for terrorist purposes. Their advantages are that they can be used en masse, can cause rapid contamination of a large number of people and are easy to synthesize. The most important classes of highly toxic chemicals – poison gases are: nerve (sarin, soman, tabun, VX and F-poisons), Vesicant/Blister (sulfur and nitrogen mustard, lewisite), choking/pulmonary (phosgene and diphosgene) and incapacitating (psilocybin, mescaline, BZ, LSD 25) agents.

Table 1 – Comparative review of the toxicity of some agents
Таблица 1 – Сравнительный обзор токсичности некоторых соединений
Tabela 1 – Uporedni pregled toksičnosti nekih jedinjenja

Class of agent	Agent name	Origin	Dose (μg/kg)
Toxins	Botulinum toxin	bacteria	0.00003
	Tetanus toxin	bacteria	0.01
	Ricin	bacteria	0.02
	Diphtheria toxin	bacteria	0.2
	Koko toxin	frog	2.7
	Bufotoksin	frog	390
	Curare	plant	400
	Strychnine	plant	3000
Toxic chemicals	VX	synthetic	7.5
	Soman	synthetic	50
	Sarin	synthetic	63
	Tabun	synthetic	150
Incapacitating	LSD–25	synthetic	2
	ALD–52	synthetic	2
	BZ	synthetic	2.4
	DMHP	synthetic	60

[1] The term "chemical contamination" implies the presence of chemical agents in the form of droplets, vapors, fumes or gases in dangerous concentrations in a particular area, the air, the population, food and water or indoors.

For terrorist organizations, it is particularly important that chemicals are easily available and that they can be produced by simple chemical processes, known to every student of chemistry. This kind of terrorism can be performed not only with chemical war agents, but also with "ordinary" chemical compounds that are normally used in the production of chemical, petrochemical, pharmaceutical, oil and other industries. Pesticides, phosgene and chlorine were the chemical warfare agents of the First World War, and today there is a huge amount of these substances used in the chemical industry. In the so-called concealed terrorism, i.e. "Silent doing", chemicals are used or facilities damaged, which is subsequently declared as a chemical accident caused by human factor. Even poor terrorist organizations can easily obtain and use chemical weapons (Lazarević et al, 2003, pp.13-36).

Besides having several times higher efficiency than conventional weapons, they are impossible to be detected effectively and easily. Only a small number of TCs can be detected during their usage. Two of their properties, extremely convenient for terrorists, are their low purchase price and relative ease of purchase. "Chemical weapons proved their lethality even in the First World War, when millions of people were exposed to chemical weapons, among which there were even 90,000 victims" (OPCW, 1998).

It is characteristic of terrorists who are planning a chemical attack that they neither have help from outside nor there are authorities who can retain and prevent the execution of their terrorist activities. Religiously motivated sects, for example, are cut off from the outside world, and their leaders are charismatic and indisputable authorities. In 1986, a white racist Christian group known as „The Covenant, the Sword and the Arm of the Lord" (CSA), wanted to destroy the American administration and accelerate the return of the Messiah. Its members bought 30 gallons of cyanide in order to, according to the leader of the group Jim Ellison, poison the water supply in several major US cities, believing that God would direct death from cyanide only to selected individuals: non-Christians, Jews and black people in the capital. Although the desire for causing mass loss is one of the specific factors that may motivate terrorists to use chemical weapons as opposed to usual guns, hand grenades and explosive devices, there are other reasons for terrorists to apply chemical weapons (Willkinson, 1986).

Today it is easy to obtain chlorine, phosgene, and organophosphate toxic compounds which are used in agriculture. The lethal dose of this class poison is 10-50 times higher than the doses of toxic chemicals suitable for terrorist purposes and it amounts to 1.05 to 7 mg/kg, which for a man of 100 kg is about 0.4 grams. The third drawback is the safe use of TCs for the execution of terrorist acts. However, the level of technical complexity for the TC usage may be lower than, for example, the production of more complex explosive devices.

Chemical accidents usually occur in chemical industry plants due to technical and technological shortcomings and human factor, but also due

to possible diversion and sabotage of various terrorist organizations. Examples of previous accidents at chemical plants indicate potential catastrophic consequences for people and the environment, and a profile of today's terrorists who do not hesitate to recur to mass destruction indicates that the risk of terrorist attacks on chemical plants is real. Many incidents in the last years indicate the need to fight against terrorism. In the former World Trade Center, a bomb was placed in February 1993, and sarin was placed in the Tokyo subway in March 1995. The statistics presented by an American state representative based on the data of the Federal Bureau of Investigation (FBI) shows that the number of terrorist acts has decreased in recent years, but the number of victims has been growing dramatically. During 1994, 321 acts of international terrorism were reported, out of which 66 were committed against the United States. A year earlier there were 431 terrorist actions, out of which 88 were against the United States, with 109 deaths and about 1,500 injured, which was the highest number in the previous five years. This fact indicates that terrorists use modern weapons and tactics during their actions. Terrorists are increasingly giving up bombings and turning towards the use of more efficient means (Petković, 2009, pp.248-275).

The most difficult terrorist attack in which a chemical weapon was used took place on 20th March 1995 in the Tokyo subway. The attack was launched in a primitive manner, so that eight plastic bags out of eleven prepared were so damaged during drilling with sharpened umbrellas that sarin (purity of only about 30%) largely evaporated. This was the main reason why the outcome was "only 12 dead" and more than 5,500 seriously injured people. Many of these people still suffer from permanent nerve damage.

Presentation of the effects of a terrorist attack on a chemical facility

Let us assume that a chemical accident occurred in a chemical industry building due to a terrorist attack (at a chlorine-alkale complex), where 30 tons of chlorine were spilled from an above-ground tank, under the following conditions:

- pouring into a concrete receiving vessel - a protective pool, without chemical interactions and absorption of chlorine,
- wind speed at a height of 2 m above the ground is 2 m/s,
- wind direction 270 ° - Western,
- vertical stability of the atmosphere: isotherm,
- terrain: urban area, mainly low buildings,
- relief: flat terrain, open.

The "HESPRO"[2] software package for the evaluation and chemical situation prognosis gives the results shown in Table 2 (Luković, et al, 2004).

Table 2 – Data on a designed terrorist attack on a chemical facility
Таблица 2 – Данные о смоделированном теракте на объекте химической промышленности
Tabela 2 – Podaci o modelovanom terorističkom napadu na objekat hemijske industrije

ACCIDENT DATA	
Time and date of accident	19:00 21.07.2015.
Hazardous substances	chlorine
Quantity	30 t
The average thickness of the puddles	1.5 m
HOTSPOT	
Radius	9.9 m
Surface of evaporation	14.5 m^2
Speed of evaporation	2921.8 g/s
Converted into the fume phase	5.89 t
Time of natural decontamination	02:18 (hour:min)
PRIMARY CLOUD	
Depth propagation / surface area	3.5 km/5 km^2
SECONDARY CLOUD	
Depth propagation / surface area	7 km/40.3 km^2
OBSERVED POINT	
Distance from the hotspot / direction	2.00 km/90° (E)
The time and date of arrival of the primary cloud	19:15 / 21.07.2015.
Weather facts	9.9 s
The concentration of fumes	9.85 g/m^3
Inhalation doses	97.03 g s/m^3 (2.7 toxic dose)
HAZARDOUS SUBSTANCE DATA	
Hazardous substances	chlorine
Molecular weight	71 g/mol
Boiling temperature	-34°C
HAZARDOUS SUBSTANCE DATA	
Vapour pressure at 20 °C	680000 Pa
Median lethal concentration	360 mg/m^3
Maximum permitted concentration	3 mg/m^3
Limit values of emission	0.1 mg/m^3

[2] "HESPRO" - a software package for a quick evaluation and prognosis of chemical situations at chemical accidents (in the process industry facilities or in the transport of dangerous goods). It exists in the units of the Serbia Armed Forces and in other institutions of the Republic of Serbia.

Median threshold toxic dose	36000 mg/m^3
Density at the liquid phase	1380 kg/m^3
Specific volume	0.34 m^3/kg
Converts into the vapor phase at 30 °C	22.5 %
WEATHER DATA 19:00 21.07.2015.	
Wind (speed / direction)	2 m/s - 270° (3)
Temperature (2 m)	20°C
Vertical stability	Isotherm (neutral)

The obtained results are analyzed and the situation is assessed – the chemical situation is analysed.

The terrorist attack point is located approximately 2km to the west from the observed point, in a settlement with prevailing low buildings. The transportation infrastructure affects the propagation of TC vapor clouds, carrying them towards the observed point. The relative height difference compared to the observed point is small so it does not affect the propagation of clouds.

Meteorological conditions favourably influence the fume propagation. It takes TC vapor clouds 15 minutes and 20 seconds to get to the observed point, so that the personnel in the military facilities have enough time to take adequate protection measures, depending on the warning speed.

The local population has no shelter and the buildings are old so the windows do not have a required level of air-tightness. Since collective shelters are inadequate due to the conditions of the buildings, the local population is completely exposed, which causes the need for evacuation.

As the cloud approaches the observed point, and the buildings are not air-tight, evacuation is necessary. The population must be evacuated as soon as possible either to the north or to the south. The distance zone for the evacuation should be 10 km minimum from the accident spot, bearing in mind that the depth of propagation of the primary cloud is 3.5 km and that of the secondary cloud is 7 km. The evacuation can be carried out with or without vehicles, depending on the assessment, because the cloud reaches the observed point in 15 minutes and 20 seconds. It is safest to walk, but it is necessary for the population to gather as soon as possible and go towards the specified regions before the expiration of this time. The evacuation by vehicles will be difficult due to the increased frequency of traffic.

From the obtained results – the summary report, it can be concluded that chlorine produces a primary and a secondary cloud and that it takes 9.9 seconds of the inhalation of these vapors to receive 2.7 toxic doses at the observed point. The evacuation is necessary because the buildings are not adequate for protection.

Local residents have enough time to organize the protection through timely evacuation to safe regions. During the contamination event, all regular activities in the city would be cancelled, except providing building security. After 2 hours and 18 minutes, which is the time of natural decontamination of 30 tons of chlorine, residents can go back to their homes.

This situation happens when there is no decontamination of the place were an accident occurred. Its decontamination reduces the risk and the likelihood that people will inhale the subsequent fumes; they will be exposed only to those fumes that evaporated prior to decontamination.

The analysis of the assessed chemical event shows that these amounts of chlorine form zones of high contamination through the effects of primary and secondary clouds. After the formation of the primary cloud, a considerable amount of chlorine in the liquid form remains in the protective pool, so it is necessary to take measures for the elimination of accident consequences, by refilling into the spare tank, by blocking the evaporation surface, by neutralizing hazardous materials, etc.

CBRN service units

CBRN service units are organizational units, formed, equipped and trained individually or as part of other defense units to successfully carry out tasks and special NBC protective measures and protection from nuclear and chemical accidents (Rutić, 2009).

The implementation of WMDs, their huge power of destruction, speed of manifesting effects, the scale and diversity of effects and consequences on people and material resources requires the organization of NBC protection commands, units and institutions of the Serbian Armed Forces in order to reduce losses and preserve their operational and functional capabilities. This important protection of the Army of Serbia includes general and special measures for the protection of human power, material goods and resources from nuclear, chemical and biological events as well as the reduction of their consequences. The NBC protection content is shown in Figure 1 (Rutić, Milošević, 2015, pp.443-455).

General NBC protection measures are implemented by all members of the Army of Serbia in accordance with the tasks and responsibilities in assigned missions. General measures are realized by reconnaissance, use of equipment for personal and collective protection, force maneuvering dosimetry control, organization of control and protection services, and decontamination.

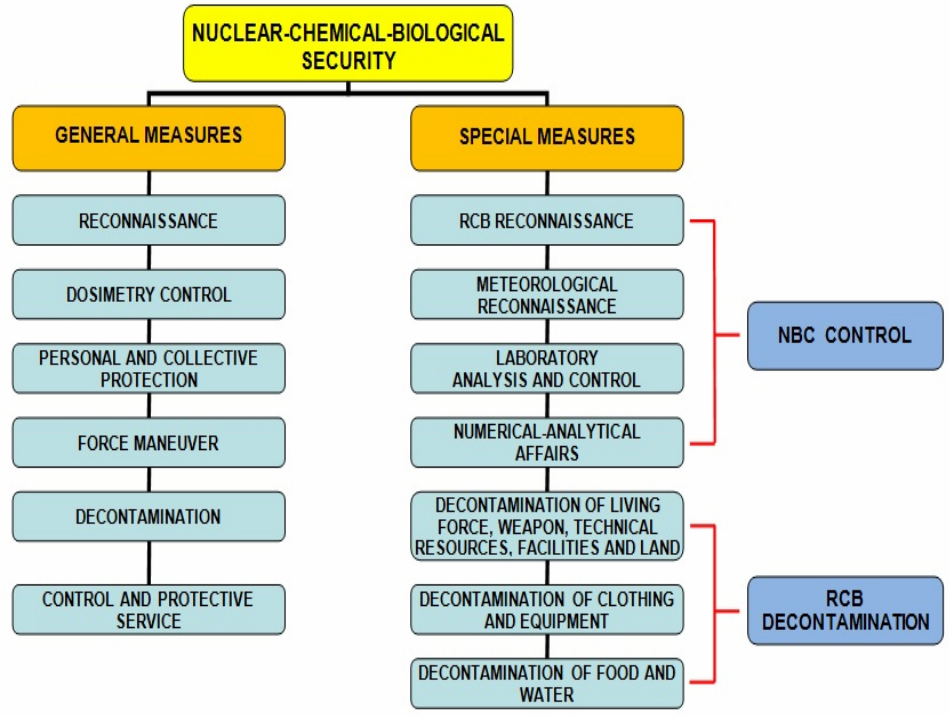


Figure 1 – Content of the CBRN protection measures
Рис. 1 – Список мероприятий по *РХБЗ*
Slika 1 – Sadržaji PNHB obezbeđenja

Special measures of NBC protection are carried out by specialized units and institutions of the Republic of Serbia. Special measures are carried out through nuclear-chemical-biological control and radiological-chemical-biological decontamination.

The CBRN service units of the armed forces of foreign countries are mainly designed for the realization of the same tasks as the SAF units. Units capabilities are directly related to the organizational structure and modern equipment for NBC protection, detection and identification of TCs and toxic industrial chemicals, detection and dosimetry of ionizing radiation, RCB decontamination and means and equipment for the purposes of carrying out laboratory testings and controls.

A comparative display of CBRN service units of foreign countries and the SAF, through the prism of means for RCB reconnaissance and protection, laboratory work and biological decontamination, is given in Table 3 (Indjić, 2014.).

In the analyzed countries, there are mostly CBRN service units at the rank of battalions with a similar organizational and formation structure.

Table 3 – Comparative display of the CBRN service units of the armed forces of foreign countries and those of the SAF
Таблица 3 – Сравнительный обзор отечественных и иностранных взводов *РХБЗ*
Tabela 3 – Uporedni prikaz jedinica ABH službe VS i stranih zemalja

RCB reconnaissance and protection means	Means for laboratory work	RCB decontamination means
1. Republic of Serbia		
Vehicle for RCB reccee: AR 55 RC without an NBC protection system. C detectors: CD M11B, ACD. Protection means: PO M-5, PM M-3, PG M-4.	Mobile laboratory LH M-3U, very modest capabilities.	Automobil tank for decontamination M-78: - Dc personnel – 192/h - Dc vehicle – 6 до 10/h - Dc route– 12000 m^2
2. Republic of Austria		
Vehicle for RCB reccee: „DINGO“ with complete NBC protection and IC sensors for reccee. C detectors: CAM, Drager, RAID. Protection means: similar as in the SAF.	The „DINGO“ vehicle contains: gas chromatograph, ionization and mass spectrometer, which determine DCM in a very short time. Information is instantly available.	Decontamination vehicle „ÖAF S-LKW“: - Dc personnel– 42/h - Dc vehicle – 4 до 8/h - Dc route– 2000 m^2
3. Republic of Slovenia		
Vehicle for RCB reccee: „SKOV HC 400“ with complete NBC protection. C detectors: CAM, RAID. Protection means: protective suits SARATOGA, other similar as in the SAF.	Mobile laboratory „PJRKBALAB“ with modern means for CBRN analyses, connected with the NRC alert system.	Decontamination system „Sanijet“ on m/v TAM: - Dc personnel– 60/h - Dc vehicle – 6-12/h - Dc route– 12000 m^2
4. Republic of Latvia		
Vehicle for RCB reccee: „PATRIA“ with complete NBC protection. C detectors: CAM, Drager, SVG2. Protection means: protective suits „Seintex“ and „Zodiac“.	Similar characteristics as in the SAF.	Device for group Dc – „PSDS-10“ and decontamination system „TS5/S“: - Dc personnel– 100/h - Dc vehicle – 10/h - Dc route– 1000 m^2
5. Republic of Italy		
Vehicle for RCB reccee: „VBR - NBC“ with complete NBC protection. C detectors: CAM, Drager, Toxi Rae. Protection means: „Drager“ for full protection from DCM.	Mobile system "GC-MS" for quick CBRN analyses, connected with the alert system. Automobile lab "Cyclone" for complete analyses of DCM in the field.	Decontamination system „Sanijet c.921“ on m/v IVECO: - Dc personnel– 50/h - Dc vehicle – 10/h - Dc route– 15000 m^2

The analysis of the CBRN service units in the Serbian Armed Forces and those from other countries leads to the conclusion that they have similar organizational structures (CBRN service battalions), but the considered foreign armies are better equipped with modern means for RCB reconnaissance and protection, RCB decontamination and laboratory analyses (except a small number of means for protection and decontamination).

Capabilities of CBRN service units

The SAF CBRN service units can remove consequences of chemical weapons usage for terrorist purposes through chemical reconnaissance, chemical decontamination and chemical analysis and control. The multinational exercise "Balkan response 2015" was carried out in 2015 at the CBRN centre (Krusevac) with a topic: "Rescue action in terms of contamination caused by terrorism action using weapons of mass destruction and accidents." The exercise aimed at presenting the training level and a model of joint reaction of civil and military structures in the prevention and elimination of radiological and chemical contamination due to effects of terrorism and WMDs accidents.

One of the aims was the improvement of interoperability, mutual understanding and training of NBC members from the countries in the region at the tactical level, governmental and non-governmental organizations and the Organization for the Prohibition of Chemical Weapons (OPCW) in a joint action for elimination of radiological and chemical contamination consequences, caused by the effects of terrorism and WMDs accidents.

At the exercise there were:

- members of CBRN service units of the armed forces of the Republic of Slovenia, Bosnia and Herzegovina, Montenegro, the Republic of Macedonia and the Republic of Austria,
- OPCW,
- representatives of the Republic of Serbia – members of Serbian Military Medical Academy, 246th CBRN Battalion, Training Command, CBRN Centre, Ministry of Internal Affairs Special Anti-Terrorist Unit, Police Department Krusevac, Ministry of Internal Affairs National Crime Technical Centre, Fire-rescue units, Department for Emergency Situations specialized units of Civil RCB Protection in Krusevac, Krusevac General hospital and the Red Cross of the Republic of Serbia. The exercise was attended by numerous observers from home and abroad.

The exercise was carried out as a representation of the reaction of civil-military structures through 31 suppositions, which was planed by the List of major events and suppositions. The realised activities focused on

the removal of terrorist attacks effects on the chemical industry facilities (chemical contamination of workers and the population, extensive damage). Another practiced scenario concerned the removal of consenquences caused by a terrorist "dirty bomb" and toxic chemicals, after which the OPCW carried out an investigation in the case of the alleged use of weapons of mass destruction.

The exercise was based on practicing work and coordination of all relevant institutions in the Republic of Serbia, which are included in a response to the crisis caused by the use of WMDs, with a special emphasis on the combined risk (chemical and radiological accident due to a terrorist act), large potential consequences for the population, material resources and the environment.

A survey of the organizational structure and equipment of CBRN units of the armed forces of the countries participating in the exercise "Balkan response 2015" points to certain differences which have a decisive impact on their overall capabilities while removing the consequences of a terrorist attack on the chemical industry facilities. The comparative capabilities of the CBRN units of the armed forces of the countries participating in the exercise "Balkan response 2015" are shown in Table 4.

Table 4 – CBRN units capabilities – participants of the „Balkan response 2015“ exercise
Таблица 4 – Возможности взводов *РХБЗ* − участников учений «Балканский ответ 2015»
Tabela 4 – Mogućnosti jedinica ABHO oružanih snaga zemalja učesnica vežbe „Balkanski odgovor 2015”

Engaging possibility	Type of engagement	SAF	Slovenian Army	Macedonian Army	Army of BiH	Military of Montenegro
Chemical reconnaissance	Detection	+	+	+	+	+
	Identification	+	+	+	+	+
	Remote reconnaissance	-	+	-	-	-
Sampling	Operational	+	+	+	+	+
	Forensic	-	+	-	-	-
Chemical decontamination	People	+	+	+	+	+
	The wounded and the sick	-	+	+	-	-
	Aircraft	-	+	-	-	-
	Vehicles and equipment	+	+	+	+	+
	Electronic instruments	-	+	-	-	-
	Land and buildings	+	+	+	+	+
Chemical identification	Spectrometric methods	-	+	-	-	-
	Classical chemical methods	+	+	+	+	+

International CBRN units model for a removal of chemical weapons consequences

In case that chemical weapons used for terrorist purposes cause chemical contamination of several countries (mainly bordering areas) or in case one country cannot solve this problem alone, international CBRN units can be involved for consequences removal (on request and in compliance with international agreements).

In order to realize the tasks of removing consequences, various CBRN international forces (CBRN IF) may be engaged. A decision-maker responsible for accident relief must choose adequate CBRN units out of existing alternatives in order to use the best possible solution (Inđić, et al, 2014, pp.23-41).

The paper discusses the employment of various CBRN units (for RCB reconnaissance, RCB decontamination and laboratory work), as well as temporary units (forces formed to implement a specific task and then to return to their original units). The resulting consequences, time and other parameters when using CW for terrorist purposes also influence the way of organizing CBRN IF.

The problem of selecting CBRN IF for removing CW consequences is defined as follows:

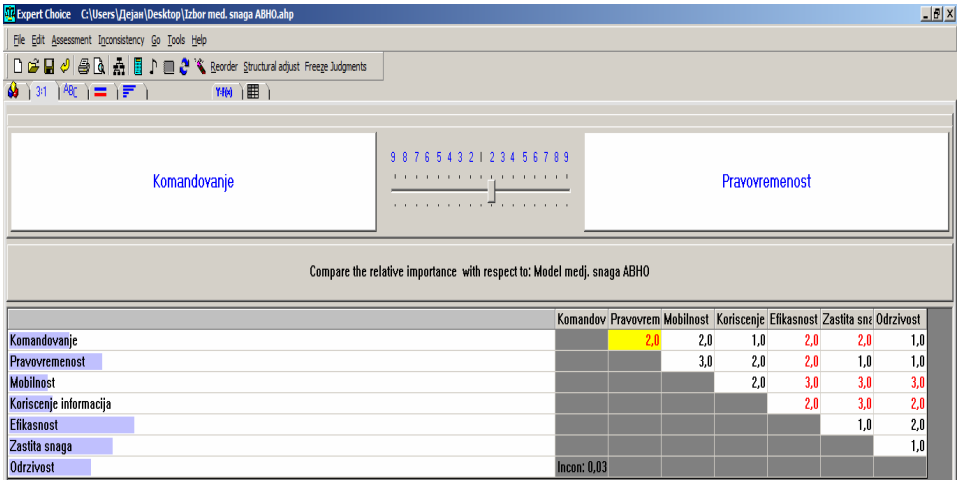
Level 1: choice of CBRN international forces (decision)

Level 2: attributes (decision criteria) are defined through the operational capabilities of forces:

- A1 - Leadership;
- A2 - Timeliness;
- A3 - Mobility;
- A4 - Use of information;
- A5 - Efficiency;
- A6 - Force protection, and
- A7 - Sustainability.

Then the attribute importance can be provided at the second level through the following matrix, Table 5:

Table 5 – Comparison of the attributes at the second level
Таблица 5 – Сравнение атрибутов на втором уровне
Tabela 5 – Upoređenje atributa na drugom nivou



where the index of inconsistencies is $CR = 0.03 \leq 0.10$.

Level 3: attributes (alternatives) are defined as:

- B_1 - CBRN IF 1 (one RCB reccee section; three RCB decontamination sections and one RCB laboratory section);
- B_2 - CBRN IF 2 (two RCB reccee sections; two RCB decontamination sections and one RCB laboratory section);
- B_3 - CBRN IF 3 (one RCB reccee section; two RCB decontamination sections decontamination and two RCB laboratory sections).

After entering the criteria for the selection of the CBRN IF into the programming package "Expert Choice", the results shown in Figure 2 are obtained. It can be seen that, in the selection of CBRN IF, a dominant criterion is power efficiency (0.228), which is understandable considering the type of WMDs applied (chemical weapons). It is followed by force protection (0.194), timeliness (0.168) and the force sustainability (0.153), which is also to be expected, taking into account the danger forces are exposed to during the removal of consequences incurred by CW. After that comes command (0.107), use of information (0.077) and mobility (0.073), which have a certain influence in solving this problem, but to a lesser extent compared to the previously mentioned criteria.

Of course, the extent of the consequences given in Table 2 must be considered and implemented when making a selection of alternatives in relation to the offered criteria.

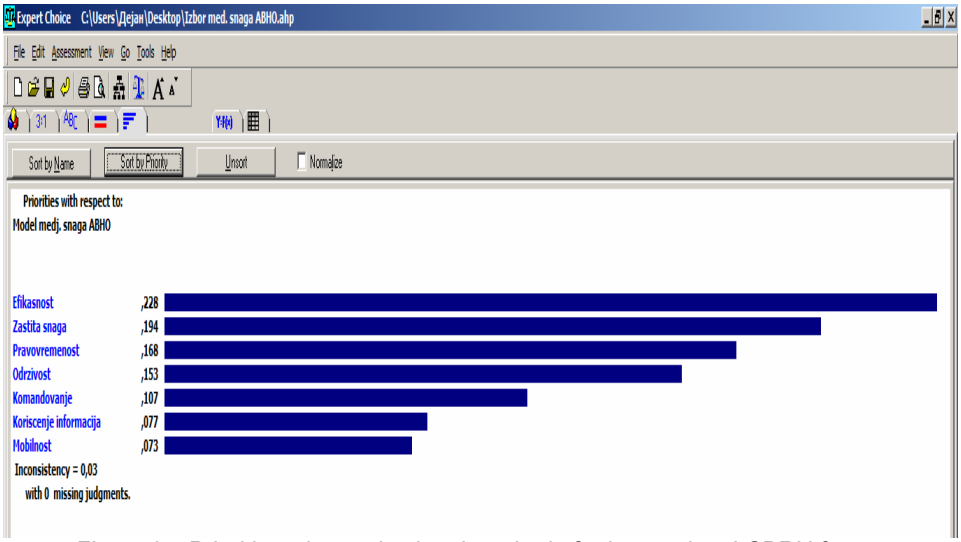


Figure 2 – Priorities when selecting the criteria for international CBRN forces
Рис. 2 – Приоритеты при выборе критериев международных войск РХБЗ
Slika 2 – Prioritet prilikom izbora kriterijuma međunarodnih snaga ABHO

The corresponding matrices of comparing the alternatives from the third level for each attribute and their priorities are presented from Table 6 to Table 12:

Table 6 – Matrix of the relevant importance of alternatives to attribute A_1 (Leadership)
Таблица 6 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_1 (Командование)
Tabela 6 – Matrica relevantne važnosti alternative u odnosu na atribut A_1 (komandovanje)

	B_1	B_2	B_3	Weight
B_1	1	5	3	0.109
B_2	1/5	1	2	0.582
B_3	1/3	1/2	1	0.309

where is: $CR = 0.00352 \leq 0.10$.

Table 7 – Matrix of the relevant importance of alternatives in relation to attribute A_2 (Timeliness)
Таблица 7 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_2 (Своевременность)
Tabela 7 – Matrica relevantne važnosti alternative u odnosu na atribut A_2 (Pravovremenost)

	B_1	B_2	B_3	Weight
B_1	1	3	2	0.169
B_2	1/3	1	1	0.443
B_3	1/2	1	1	0.387

where is: $CR = 0.02 \leq 0.10$.

Table 8 – Matrix of the relevant importance of alternatives in relation to attribute A_3 (Mobility)
Таблица 8 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_3 (Мобильность)
Tabela 8 – Matrica relevantne važnosti alternative u odnosu na atribut A_3 (mobilnost)

	B_1	B_2	B_3	Weight
B_1	1	3	1/2	0.163
B_2	1/3	1	2	0.540
B_3	2	1/2	1	0.297

where is: $CR = 0.00877 \leq 0.10$.

Table 9 – Matrix of the relevant importance of alternatives in relation to attribute A_4 (Use of information)
Таблица 9 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_4 (Использование данных)
Tabela 9 – Matrica relevantne važnosti alternative u odnosu na atribut A_4 (korišćenje informacija)

	B_1	B_2	B_3	Weight
B_1	1	4	3	0.122
B_2	1/4	1	2	0.558
B_3	1/3	1/2	1	0.320

where is: $CR = 0.02 \leq 0.10$

Table 10 – Matrix of the relevant importance of alternatives in relation to attribute A_5 (Effectiveness)
Таблица 10 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_5 (Эффективность)
Tabela 10 – Matrica relevantne važnosti alternative u odnosu na atribut A_5 (efikasnost)

	B_1	B_2	B_3	Weight
B_1	1	4	3	0.126
B_2	1/4	1	1	0.458
B_3	1/3	1	1	0.416

where is: $CR = 0.00877 \leq 0.10$.

Table 11 – Matrix of the relevant importance of alternatives in relation to attribute A_6 (Force Protection)
Таблица 11 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_6 (Защита войск)
Tabela 11 – Matrica relevantne važnosti alternative u odnosu na atribut A_6 (zaštita snaga)

	B_1	B_2	B_3	Weight
B_1	1	3	1	0.210
B_2	1/3	1	2	0.550
B_3	1	1/2	1	0.240

where is: $CR = 0.02 \leq 0.10$.

Table 12 – Matrix of the relevant importance of alternatives in relation to attribute A_7 (Sustainability)
Таблица 12 – Матрица релевантной значимости альтернатив по отношению к атрибуту A_7 (Устойчивость)
Tabela 12 – Matrica relevantne važnosti alternative u odnosu na atribut A_7 (održivost)

	B_1	B_2	B_3	Weight
B_1	1	5	4	0.100
B_2	1/5	1	1	0.466
B_3	1/4	1	1	0.433

where is: $CR = 0.00527 \leq 0.10$.

The process ends with the synthesis of the problem of choosing CBRN IF for the removal of consequences caused by the use of CWs for terrorist purposes. All given alternatives are multiplied by the weights of individual decision-making criteria, and the results are summarized thus giving the optimal alternative. In this case, it is the alternative B2 – CBRN IF 2 (0.496), followed by B3 (0.358) and B1 (0.145). The final procedure of applying the AHP method and the software package "Expert Choice" is shown in Table 13 and in Figure 3.

Table 13 – Synthesized table for the selection of the optimal alternative
Таблица 13 – Сводная таблица выбора оптимальных альтернатив
Tabela 13 – Sintezna tabela za izbor optimalne alternative

Criteria	Criteria weight	B_1	Weight x B_1	B_2	Weight x B_2	B_3	Weight x B_3
A_1	0.107	0.109	0.012	0.582	0.062	0.309	0.033
A_2	0.168	0.169	0.028	0.443	0.073	0.387	0.065
A_3	0.073	0.163	0.011	0.540	0.039	0.297	0.022
A_4	0.077	0.122	0.009	0.558	0.042	0.320	0.025
A_5	0.228	0.126	0.029	0.458	0.104	0.416	0.095
A_6	0.194	0.210	0.041	0.550	0.106	0.240	0.047
A_7	0.153	0.100	0.015	0.466	0.070	0.433	0.066
			0.145		**0.496**		**0.358**

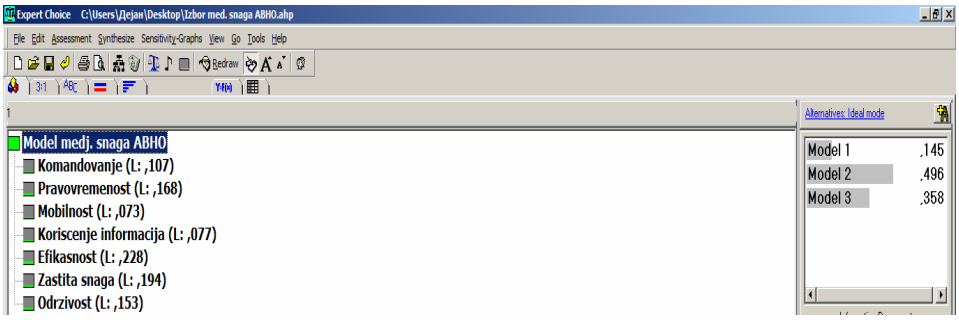


Figure 3 – Priority during the selection of a model of international CBRN forces
Рис. 3 – Приоритеты при выборе моделей международных войск РХБЗ
Slika 3 – Prioritet prilikom izbora modela međunarodnih snaga ABHO

On the basis of the selected model of CBRN IF (model 2) which would be engaged in solving the problem of the removal of consequences caused by the use of CWs for terrorist purposes, further activities would be implemented as follows:

– selected CBRN forces go to the place targeted by CWs as a part of the forces that carry out the removal of consequences,

– forces carry out chemical reconnaissance tasks on the place targeted by CWs (area of CW usage, access routes, chemical contamination marking, sampling, etc.),

– taken contaminated samples are analysed and based on that, the need for further engagement of the forces is determined, and

– if necessary, chemical decontamination of the place targeted by CWs is performed (primarily people, vehicles and structures, and then, if necessary, communication routes with the emphasis on the one for evacuation).

This paper does not specially consider time required to engage CBRN IF in the implementation of these tasks, because it is defined by the international standards of CBRN units (in this case, adequate equipment and force capabilities do not come into question).

Conclusion

As one of huge plagues of the twenty-first century, terrorism imposes a need for fast operation of the international community in its "eradication". Unfortunately, we are witnessing large-scale consequences terrorist acts may cause.

The paper presents a possible situation of chemical weapons application for terrorist purposes, its consequences and a way of creating international CBRN units for solving the problem. The engagement of international units is determined by the United Nations Charter, international agreements or other documents, but the time of their engagement can be a specific problem.

Of course, the paper starts from the fact that the engagement of CBRN IFs has all the necessary preconditions.

When solving the problem of the removal of consequences caused by CW usage for terrorist purposes, criteria for selecting international CBRN units (their operational capabilities) were determined first, and based on that alternatives (three unit models) were offered. After that, the analytic hierarchy process method was applied to find the optimal problem solution. The authors took the criteria values from CBRN experts engaged in the multinational exercise „Balkan response 2015“.

A precise implementation of the AHP method gave the following order of alternatives in the CBRN IF model:

- B_2 (second alternative) – 0.496 (first in rank),
- B_3 (third alternative) – 0.358 (second in rank),
- B_1 (first alternative) – 0.177 (third in rank).

From this, it can be concluded that the second alternative has the highest value (0.496), which is why it is the best (the most applicable). This option, model CBRN IF 2, presents a combination of two CBRN reccee sections, two CBRN decontamination sections and one CBRN laboratory section. It is the most applicable model for the created situation, since, due to short time of natural decontamination (approximately 2.5 hours), the foxus is on chemical reconnaissance and the laboratory analysis of samples. Decontamination is carried out to the necessary extent and in order of priority: personnel, equipment and materials, followed by evacuation routes.

The third alternative, model CBRN IF 3, which presents a combination of one RCB reconnaissance section, two RCB decontamination sections and two laboratory sections, has a value of 0.358 and is not far behind in comparison to the previous one. In it, the focus was on a quick analysis of the contaminated samples.

The first alternative, model CBRN IF 1, which presents a combination of one RCB reconnaissance section, three RCB decontamination sections and one laboratory section, has the lowest value 0.177 and is far behind compared to the previous two. This is understandable when taken into account that in this variant the focus was given to RCB decontamination which is not a dominant measure in the modeled situation.

It can be concluded that the engagement of international CBRN units for solving problems of chemical wepons use for terrorist purposes is possible and justified; there are, however, certain limitations that must be taken into consideration when deciding upon the engagement of these units.

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МОДЕЛИРОВАНИЕ МЕЖДУНАРОДНЫХ ВОЙСК РАДИАЦИОННОЙ, ХИМИЧЕСКОЙ И БИОЛОГИЧЕСКОЙ ЗАЩИТЫ ПРИ ПРИМЕНЕНИИ ХИМИЧЕСКОГО ОРУЖИЯ В ТЕРРОРИСТИЧЕСКИХ ЦЕЛЯХ

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ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Ускоренное технологическое развитие человеческой цивилизации двадцатого и начала двадцать первого века существенно повлияло на неравномерное ипользование мировых ресурсов. Такое распределение ресурсов способствовало разгоранию вооруженных конфликтов, в ходе которых используется, как конвенциональное оружие, так и оружие массового поражения. В отличии от конвенционального оружия, оружие массового поражения обладает уникальными характеристиками, подходящими для использования в террористических целях. Ярким примером применения оружия массового поражения является теракт в токийском метрополитене 1995 года, организованного сектой «Аум Синрике», последователи которой распылили газ зарин (фосфорорганическое отравляющее вещество,

причисленное к группе смертоносного химического оружия). В результате газовой атаки погибло 12 человек, а 5000 человек получили отравление различной степени тяжести. В данной работе представлен обзор моделей применения международных войск радиационной, химической и биологической защиты

при использовании химического оружия в террористических целях. При определении критериев выбора модели войск РХБЗ учитывалось мнение экспертов в области РХБЗ, а для получения оптимальных результатов применен метод анализа аналитических иерархических процессов. Полученные результаты могут быть использованы в качестве основы для моделирования войск РХБЗ в международных учениях по радиационной, химической и биологической защите.

Ключевые слова: *международные силы, терроризм, РХБЗ, оружие, ядерное, химическое.*

MODELOVANJE MEĐUNARODNIH SNAGA ATOMSKO-BIOLOŠKO-HEMIJSKE ODBRANE PRILIKOM PRIMENE HEMIJSKOG ORUŽJA U TERORISTIČKE SVRHE

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OBLAST: hemijske tehnologije
VRSTA ČLANKA: originalni naučni članak
JEZIK ČLANKA: engleski

Sažetak:

Ubrzani tehničko-tehnološki razvoj ljudske civilizacije, tokom dvadesetog i početkom dvadeset prvog veka, suštinski je doprineo neravnomernoj podeli ukupnih svetskih resursa. Takva raspodela resursa dovela je do čestih oružanih sukoba koji su imali za posledicu upotrebu konvencionalnog oružja, ali i oružja za masovno uništavanje. Za razliku od konvencionalnog oružja, ovo oružje poseduje jedinstvene karakteristike koje ga čine veoma atraktivnim za upotrebu u terorističke svrhe. Najbolji primer predstavlja teroristički napad u martu 1995. godine, kada je sekta ,,Aum Sinrikjo" u tokijskom metrou primenila sarin (toksičnu hemikaliju iz grupe smrtonosnog hemijskog oružja), zbog čega je umrlo 12, a intoksikovano preko 5.000 lica.

Cilj ovog rada je prikaz modela upotrebe međunarodnih snaga atomsko-biološko-hemijske odbrane (ABHO) u slučaju primene hemijskog oružja u terorističke svrhe. Prilikom određivanja kriterijuma za izbor modela snaga ABHO korišćeno je mišljenje eksperata, a za dobijanje optimalnih rezultata primenjena je metoda analitičkih hijerarhijskih procesa. Dobijeni rezultati mogu se koristiti, kao polazna osnova, za modelovanje snaga ABHO na međunarodnim vežbama sa sličnim sadržajem.

Ključne reči*: međunarodne snage, terorizam, ABH odbrana, oružje, nuklearno, hemijsko.*

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MONITORING THE EFFECT OF MOTIVATION ON MASTERING KNOWLEDGE AND SKILLS IN DISTANCE LEARNING SYSTEMS

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Summary:

This paper describes how motivational processes affect students from the point of view of acquiring knowledge and skills, transfering them and using them in distance learning systems. Research in the social-cognitive framework illustrates the flexibility of the system and adequate adjustment of motivational patterns. A model of motivational processes, based on research, is presented as a function of learning objectives.The didactic-methodical approach to teaching was changed and adapted parallelly with monitoring the impact of the motivational factor on cognitive task performance and on students' responses, i.e. with the motivational factor influence on the success or failure of the cognitive outcome and the learning process quality. This work investigated the influence of specific knowledge areas and the interests of students on understanding professional or scientific lectures. The implications in practice and interventions done through the design of software of distance learning systems were aimed at correcting the educational process.Two forms of prior knowledge (expert knowledge and general thematic knowledge) were checked at the start as entrance tests and a preparatory course. After problem solving, a feedback analysis was carried out to determine the effects of

prior professional knowledge, general thematic knowledge and interests on understanding and solving problems. The analysis of the results showed that for solving professional and technical tasks, prior knowledge of the domain, general thematic knowledge and interests were significant predictors of understanding and success.

Key words: *motivation, learning, cognitive functions, emotions, prior knowledge, distance learning, affectivity.*

Introduction

The educational process is a very complex and complicated process that involves the operation and interaction of many factors, the most significant ones being certainly course lecturers and participants, followed by other factors which in many ways can and should contribute to quality education. Among them are curricula, resources, forms of work, as well as factors related to personal characteristics of those who directly participate in the educational process, such as interests, openness, trust, etc., and, ofcourse, motivation. Motivation of participants in the educational process is an important precondition that can greatly contribute to a better realization of the educational process, so that better results are achieved as well as progress in learning. Therefore, motivation is one of the most important factors in the educational process because its presence can greatly facilitate and improve the teaching and learning process while its absence leads to devastating results.

Modern systems of education are increasingly based on newly developed techniques of learning, such as e-learning (EL), distance learning (DL), distributed knowledge centers, "cloud" systems, etc. In the future, it is also expected to see their further development and implementation as well as modern technological solutions for wider availability of education, specialization, teaching, training, etc. In these circumstances and this environment, methodological approaches to knowledge transfer must be adapted to the fact that there is no direct interaction, and that "on-line" lectures and consultations are replaced by specialized automated systems for learning, for example, Tutoring Systems (TS). Consequently, one of the leading challenges in the successful implementation of the concept of modern education is to recognize motivation, and how to keep up or increase the factor of motivation, and how to adjust the educational process to individual needs of course participants.

Adaptability, flexibility, understanding of individual characteristics and abilities of course participants are the characteristics that currently

favor "live" teachers more than automated tutoring systems (TS).The process of education realized by the principles of intelligent tutoring systems (ITS) must follow and analyze cognitive experiences, emotional experiences and motivational experiences which determine a reaction to do "something" or manage the process of learning. The strength of this motivation often depends on how strongor important certain stimuli (emotions) are.

Emotional states have an important role in decision making, and problem solving, and communication, and negotiation, and motivation; therefore, recognition of emotionsis essential for the development of an intelligent interaction between people and computers. Positive emotions which arise during the educational process have a strong positive impact on learning for two reasons. First, positive emotions in general allow more creative and flexible thinking processes, increasing motivation so that course participants work harder and quitmore rarely. Another reason is that students consciously want to retain and possibly increase the intensity of the positive emotional state (which in this case comes from the education system) thus maintaining concentration and motivation for learning. In the case of externally generated positive emotions that are not directly related to the learning process and an automated system, student are not necessarily motivated or focused on keeping concentration to learn. So there is less motivation. The positive effect of these emotions is therefore less strong, and can even turn into a negative one if emotions are too intense (deconcentration). R. Kvaščev discusses the following features of an individual who is well motivated in the educational process:

- Development of powerful motivation to learn,
- Well integrated personality,
- Self-confidence, emotional stability, self-control, independence,
- Developed strong character and super ego,
- Developed risk taking and tolerance to frustration, and
- Mastering the methods and techniques of learning.

Communication and Exchange of Information in the Process of Distance Learning

The main challenge for teachers and learners alike is how to teach learners to learn. This is particularly evident in the case of application systems based on information and communications technologies (ICT) and DL technologies. Flexibility, personalization and different learning styles can be combined, and learning can be

authentic, motivational and conceived as a part of a social process, creating an informal network of peer interactions. This leads to learning from each other (Punie et al, 2006). The process of learning, as much as it seems, is not isolated and limited to the world of ICT. An interaction with the environment is a constant. An additional reaction that developed through a new educational process is a human-computer interaction.

Technical achievements in the development of ICT technologies enable learning materials to be chosen in desired forms for learning. Choosing an appropriate methodological and didactic approach to learning in a combination with determined individual differences in learning, detection of emotional intelligence and emotional states, learners can raise their performances in learning, which should lead to increased motivation and improved efficiency of the educational process (Grimley, Riding, 2009, pp.1-24).

For example, if proofing goes in a wrong direction, how to correct it, or how to implement these corrections, but not in the traditional manner (not to discard all effort), i.e. without negative effects such as demotivation, deconcentration, resentment, etc.? Future DL technologies must have solutions for the development of higher cognitive functions for mathematical or information theories, including concepts of motivation, emotions, instincts, intelligence, imagination and intuition. The intention is to activate the mechanisms of instinctive knowledge that provide a basic understanding of the world (Perlovsky, 2007).

How learners react to knowledge extended by DL technology and how they manifest reactions through the process can be found out only from feedback information. Reactions can be presented in various forms: a sound context, a visual context or through problem solving, tests, etc. Feedback (as a confirmation of understanding the message meaning) is sent to a system or to a person whose work is commented (eg. employee performance in a business environment). The communication process involves a two-way communication, which is the main advantage of modern tutors, so that the learning process is raised to a higher level, providing immediate feedback like reactions of learners on the course material, reactions through problem solving, but also a reaction on the system itself. Based on feedback and identification of differences between learners in the approach to solving problems and coping with the material, the system will adequately respond to the individual needs of the user through tutors, and correct or build on, for example, proofing so that it guides the user to the conclusions, in accordance with the prior knowledge and applying a coherent chain of logic.

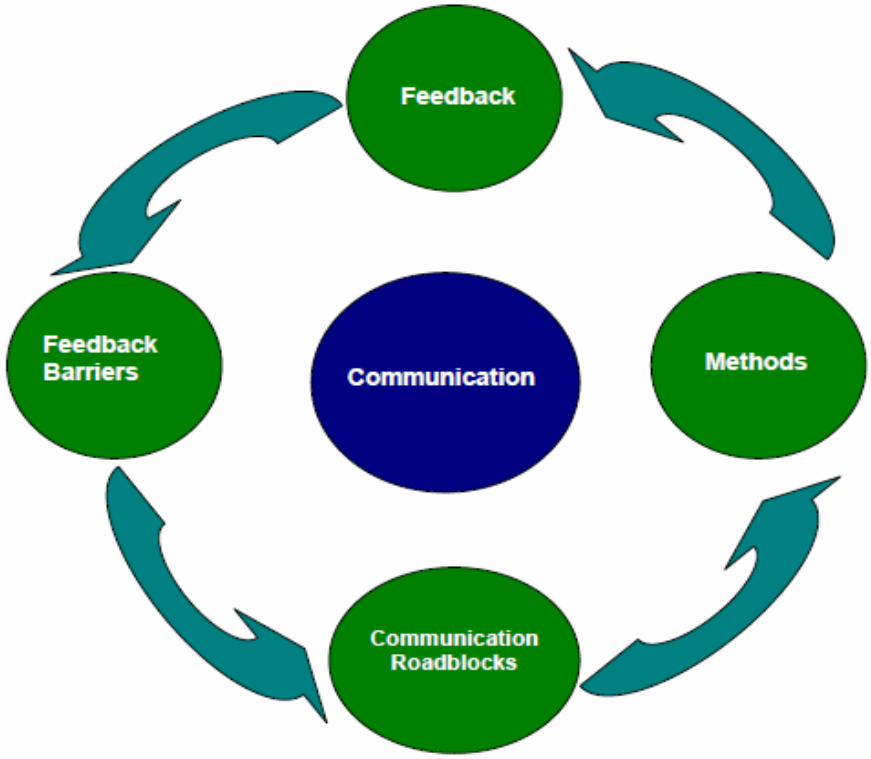

Figure 1 – Feedback cycle (Lawrence, Wiswell, 1995)
Puc. 1 – „Feedback“ цикл(Lawrence, Wiswell, 1995)
Slika 1 – „Feedback“ ciklus (Lawrence, Wiswell, 1995)

There are two types of feedback. The first is motivational feedback that stimulates the learner for something that has been done (praise). This reinforces good performance and increases the probability that it will happen again in the future. It must be given immediately after the completed task so that a person who is praised gains confidence and satisfaction of achievement. Another type of feedback is information feedback which advises the learner what to correct (improve). This points to a specific problem to be effectively solved. The best is to start with positive aspects that should encourage and motivate to continue the attempts to realize the educational process, notifyng the improvements. It must be stressed that too much negative feedback provokes defensiveness, and therefore may undermine the established flow of learning.

The analysis and discussion, in addition to providing examples of practical application of the results and solving methods, have a very important role in creating favorable conditions for the development of intrinsic motivation.

Motivation and Factors of Motivation

Every learning is associated with prior knowledge and personal life experience. The dominant learning methods are: practical, working, or manual activities, expressive actions, laboratory work, social activities, field work, and observation of natural phenomena. Human behavior is purposeful and this purposefulness determines motivation in human behavior. Motivation to learn can be internal or external. Every objective that satisfies motivated behavior, and is located outside the body, can be called an external motive, regardless of whether it also meets some internal needs. M. Paleksić believes that an external stimulus in the education process should be an enhancing effect, one that encourages the promotion, development and enrichment of personality. Improving functions ensure not only the preservation and improvement of acquired competences, but also the acquisition of new types of skills. External motivation is the result of imposed actions, and therefore brings more relief than real pleasure brought by intrinsic motivation.

The most well-known definition of intrinsic motivation was givenby E. L.Deci: Intrinsically motivated activities are those for which there is no apparent reward except the activity itself. People engage in activities for their own account, and not because these activities lead to an external reward. The very activity is the aim rather than the means.

The basic questions about intrinsic motivation are how to develop it with a help of a variety of educational, methodical and didactic resources, and how to encourage short-term motivation in order to develop long-term motivation.

In terms of the educational process, extrinsic motivation is:

- Focused on fulfilling the obligations in the educational process,
- Heavily influenced by external incentives or pressures,
- Leads to a surface approach to learning and to a fear of failure,
- The learning outcomes are not flexible and cannot be easily transformed into different contexts and fields of application.

The most common forms of extrinsic motivation are material rewards, grades, praise, awards, certificates, etc.

The intrinsic motivation:

- Reflects the personality,
- Arises from the interest for the field of study,
- Depends on the personal engagement in tasks that can be selected,
- Depends on one's own feelings of competence and self-confidence,
- Leads to an in-depth approach to learning and understanding of concepts,
- The learning outcomes are flexible and can be easily transformed into different contexts and fields of application (Lungulov, 2010, pp.294-305).

Modern research shows the importance of improving the impact of intrinsic motivation and intrinsic incentives, especially among students, sincethey are not properly developed although they considerably contribute to academic success and motivation for learning (Marić, Sakač, 2014, pp.63-79).

The learning process is accompanied not only by cognitive reactions but also by affective ones. From the viewpoint of gain in the educational process (the acquisition of knowledge and skills), affective reactions have a major impact on the motivational outcome (Lepper et al., 1993, pp.75-105). Previous studies mainly analyzed the influence of affective reactions on cognitive functions and processes. With the development of modern ITS, it became clear very quickly that the outcome of learning (among others) is in correlation with motivation, and that motivation is a function of emotional (affective) states. Keller`s theory confirmed that motivation of the course participant plays a crucial role in the learning process. Therefore, it is now the central problem in ITS research and development to determine the tutorial strategy which can appropriately make a balance and compromise between cognitive, motivational and affective reactions of learners. Consequently, knowledge of the impact of the phenomenon of affective learning has led to the identification of a need to understand the phenomena of "bad timing" as a short time of disconcerting and the influence of affective states on cognitive and motivational characteristics in the learning process (Grafsgaard et al., 2013, pp.159-165).

Research has confirmed that motivational factors cannot fit into any template. Depending on feedback, ITS must first sort the purpose - whether feedback has the purpose of increasing the overall efficiency of learning or solving a particular task. Positive "feedback" does not have the same effect (Boyeret al, 2008, pp.239-249). For example, a course participant without motivation due to low self-esteem can be encouraged to continue working with the DL system and the ITS system so that the system provides positive feedback (Tan, Biswas, 2006, pp.370-381). In contrast, some teaching tactics which require explicit security are best avoided for course participants who already have high motivation (Rebolledo-Mendez et al, 2006, pp.545-554). Studies have shown that students who had more control and corrections of affective states, experienced greater increase of self-confidence and achieved more in the learning process. With the ITC and the ITS through DL technology, teaching strategies can have a significant impact, not only on the success of pure cognitive learning outcomes, but also on an important motivational aspect such as self-confidence, which directly affects the environment of the educational process, and indirectly the achievement of learning process results.

During modeling and testing modern ITS with adaptive characteristics, it was observed that the course participants willing to face the challenge of problem-solving tasks were considerably more involved in the learning process. Also, the ITS adaptivity, i.e. adapting ITS strategies to the course participant motivation, is a promising direction for improving dialogue with tutoring systems, which directly affects the efficiency of the educational process (Ezen-Can, Boyer, 2015, pp.105-114). An example of a model of such a system for monitoring and controlling the process of motivation and self-confidence is presented through the scheme of the clarifications of ambiguities, doubts, and prejudices - theusual causes of uncertainty and motivation loss, Figure 2.

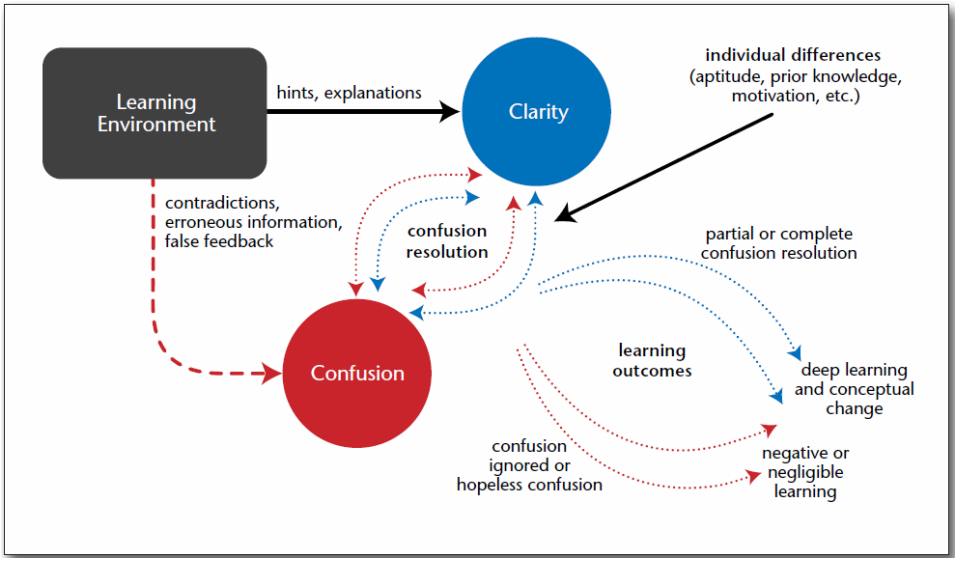

Figure 2 – Model of Confusion, Prejudice and Misunderstanding Induction and Resolution (Rus et al, 2013, pp.42-54)
Рис. 2 – Модель несоответствий, неточностей, сомнений, неясности, объяснений(Rus et al, 2013, pp.42-54)
Slika 2 – Model indukovanih nejasnoća, predrasuda i nedoumica, i razjašnjenje (Rus et al, 2013, pp.42-54)

Methodology of Research Work

Four dimensions of motivation can influence the improvement of the educational process: control, curiosity, challenge and trust (Lepper et al., 1993, pp.75-105). For this reason, this paper is an attempt to explore the relationship between emotional, motivational, intellectual, and psycho-physical characteristics of course participants and the interaction with the

tutorial system at defined time or thematic sessions (there are dialogue tutors, texttutors, combined tutors, etc.). For the research study, a group of students attending the first year of study was divided into two subgroups. The first subgroup was with a lower motivational factor, and the second one was with a higher motivational factor.

The underlying idea is to analyze the recordings of exercises during the course and the consultations taken by an improvised automated center for distance learning with a simulated tutoring system. The environment was created as an interactive workshop through audio-vido sessions (Skype) and text conversations (chat). Cognitive processes were monitored through exercises where the agents, teaching staff of the course, led the sessions. Affective reactions and behavioral changes were monitored by agents simulated by psychological-pedagogical staff of the college.

For a more detailed analysis, the sessions were recorded audio-visually. The speech analysis software was used to monitor the emotional states of the course participants. Emotions in speech are reflected through the variations of voice characteristics at three levels: (1) prosodic, i.e. suprasegmental level through specific changes in frequency, intensity and duration, (2) segmental level (changes in the quality of articulation) and (3) intrasegmentnal level (global voice quality, acoustic correlates as a form of the glottal pulse and the distribution of its spectral energy, variations in amplitude (shimmer) and frequency (jitter)). In the man-machine dialogue in which machines analyze the emotional reactions of users, using the ESR (Emotional Speech Recognition) algorithm, the key words are recognised in their answers as well as the level of satisfaction (based on the identification and classification of emotions), the dialogue is led and the answers given so as to successfully accomplish the initiated communication.

Software for the analysis of video clips, i.e. analysis and monitoring of gestures, facial expressions, movements, body postures and looks, confirmed the detected emotional states, and more accurately described the emotional reactions already detected through the speech analysis.

Figure 3 – The basic emotions (by Ekman)
Рис. 3 – Базовые эмоции (по Эксану)
Slika 3 – Osnovne emocije (po Ekmanu)

Figure 4 – Facial Expressions
Рис. 4 – Выражение эмоций на лице
Slika 4 – Facijalne ekspresije

The formation of subgroups

In order to understand and analyze the research results in a few steps, we determined the data which were to be viewed and which were essential in our analysis. Information technologies is the subject area in which testing was performed and the results analysed. The input data on the basis of which the students were divided into preliminary subgroups were: the entrance test results in the subject area, the compatibility of the curriculum of the previous level of education with the subject area and the results achieved in the previous level of education in the subject area.

Table 1 – Background Informationon the Course Participants–Prior Knowledge, Interest
Таблица 1 – Данные о слушателях курса – предзнания, интересы
Tabela 1 – Polazni podaci slušalaca kursa – predznanje, interesovanje

No	Student	Secondary school-orientation	Secondary school – professional subjects	Compatibility of curriculum (1-5)	The mean score in pro-fessional subjects	Success in the entrance test (max 30)	Sum
1	Student 1	Secondary School of Economics, Kikinda - Sales	Computers & IT x 3Computer-Aided trade E-business	3.50	5.00	22.0	30.50
2	Student 2	Technical School, Sombor - el. technicianof computers	Computers& IT IT in electrical engineering Computer programming x 4 Computers x 2 Computer data transmission Digital electronics	5.00	3.00	23.5	31.50

No	Student	Secondary school-orientation	Secondary school – professional subjects	Compatibility of curriculum (1-5)	The mean score in pro-fessional subjects	Success in the entrance test (max 30)	Sum
3	Student 3	Secondary School of Economics, Kula – Business Adm.	Computers & ITx 2	2.50	5.00	22.0	29.50
4	Student 4	Technical School Kula – Mech. tech. for computational construction	Computer programming x 2 Computer graphic design Automation and robotics	4.00	4.00	21.5	29.50
5	Student 5	Technical School, Sombor– technician of mechatronics	Computers & ITx 2 Computer programming Digital electronics Microcontrollers SCADA systems Measure transducers Programmable logical controllers Robotics	5.00	4.00	23.0	32.00
6	Student 6	High School, Apatin	Computers & ITx 4	4.50	3.50	18.0	26.00
7	Student 7	Technical School, Sombor– technician of mechatronics	Computers & ITx 2 Computer programming Digital electronics Microcontrollers SCADA systems Measure transducers Programmable logical controllers Robotics	5.00	3.00	21.0	29.00
8	Student 8	Secondary vocational school, Vrbas - Environmental protection technician	Computers & ITx 2 Automated data processing	2.50	5.00	15.5	23.00
9	Student 9	Secondary Vocational School, Crvenka - Food technician	Computers & ITx 2	2.00	2.00	22.0	26.00
10	Student 10	Politechnical Secondary School, Subotica - printing technician	Computers & ITx 3 Basics of graphic techn. x 2 Graphic design and letter design	3.00	2.75	20.0	25.75

No	Student	Secondary school-orientation	Secondary school – professional subjects	Compatibility of curriculum (1-5)	The mean score in pro-fessional subjects	Success in the entrance test (max 30)	Sum
11	Student 11	Medical Secondary School Sombor - physiotherapist	Computers & IT	2.00	3.00	16.0	21.00
12	Student 12	Secondary School of Economics Odzaci– Business technician	Computers & IT Business IT	2.50	3.50	12.5	18.50
13	Student 13	Agricultural school, Futog – veterinary technician	Computers & IT	2.00	4.00	13.0	19.00
14	Student 14	Technical School Sombor– Computer control systems	Computers & IT Computer graphics CAM technology CAM programming x 2 Design of tech. systems x 2	4.50	3.18	24.6	32.28
15	Student 15	Technical School Odzaci- Environmental protection technician	Computers & IT Automated data processing	2.50	3.50	21.6	27.60
16	Student 16	Secondary Vocational School St Sava, Sombor- Environmental protection technician	Computers & IT Automated data processing	2.50	3.50	14.4	20.40
17	Student 17	High School Sombor- humanities	Computers & ITx 4	4.50	3.00	18.0	25.50
18	Student 18	Technical School Sombor– Computer control systems	Computers & IT Computer graphics CAM technology CAM programming x 2 Design of tech. systems x 2	4.50	2.57	12.6	19.67
19	Student 19	Secondary School of Economics Kula – Business technician	Computers & IT Business correspondencex 2 Business IT x 2	3.50	5.00	20.0	28.50

The following data and activities were analyzed:

- inputs
- boundaries
- entropy
- state of cognitive balance
- feedback mechanism
- adaptation mechanism
- development path, and
- gradual finalization.

The candidates with fewer than 20 input points and with more than 35 input points (shadowed in Table 1) were not taken into consideration, in accordance with the previously mentioned "Tan & Biswas" and "Rebolledo-Mendez, Boulay & Luckin" research works. In the preliminary activities, before the start of the course, professional orientation (aptitude) and learning styles were tested. Subgroups of students who had more or fewer points than the arithmetic mean (27.5 points) were formed. The first subgroup consisted of the students with less motivation, i.e.:

- students with a smaller number of input points than the average (27.5),
- students for whom aptitude and competence tests do not point to be those who learn through research and whose learning leads to concrete and tangible results,
- students whose learning style is not logical.

Games, quizzes, and tests were used in the research for detecting competencies, skills, and enhance incentives to make it easier to assess the reactions in order to make a right decision on the selection of tutorials.

Corrective Changes of Subgroups

In mathematics, the problem solving strategy is analysed while in informatics the code is analysed. In the code analysis, the tutor can use either the cause-consequence model, i.e. queries and statements or just state whether it is accurate or not. The decision is made based on the information about the motivation and emotional state of the student. Table 2 and Table 3 give the template swhich show the problem solving flow as well as the statements of the student during the problem solving and their occurrence frequency.

In the communication (dialogue), there are queries, statements, declarations, etc., based on which the current state of the learning flow can be described (Greetings, prepared questions, affirmative question, direct question, information request, observation, correction, clear feedback, unclear feedback, explanation, other, Yes-No answer, answer, positive feedback, clarifications).

Table 2 – Students' dalogues, their features, sample statements and frequency of their occurrence
Таблица 2 – Диалог слушателей курса, характеристики, выражения лица и частотность их появления
Tabela 2 – Dijalog slušalaca kursa, karakteristike, uzorak iskaza i frekvencije njihovih pojava

Dijalogue	**Example**	**Distr. (%)**
Answer	*I am satisfied, but there is a lot of work at home*	43.28
Statement	*Personally, to me it is very interesting*	20.46
Confirmation	*Ok.*	20.20
Query	*How do I fix mistakes and fails?*	14.16
Clarification	*LiveChat messages*	0.90
The request for the feedback	*Is it clearer?*	0.50
Other	*I.e. laugh*	0.50

Table 3 – Excerpts from the corpus of dialogues with the tag: characteristics of communication
Таблица 3 – Выборка из корпуса диалогов с обозначенными характеристиками коммуникации
Tabela 3 – Izvod iz korpusa dijaloga sa oznakom karakteristike komunikacije

The Student made the coded program		
He received an error message after compiling the program		
Recognizable gesture		
Student	*What should I change first*	Query
Tutor	*Try here*	Statement
The Student changed the definition of a library		
After compiling the program again he received an error message		
Tutor	*Similar mistake*	Statement
Tutor	*Go back and add a mathematical library*	Statement
The Student changed the code		
Compiling executed successfully		
Student	*Is it a good order*	Query
Tutor	*Not consistently*	Statement
Student	*The name of the variable is*	Statement
The Student changed the code		
The Student ran the program successfully		
Tutor	*This is excellent*	Positive feedback
Tutor	*A couple of tasks are ahead of us*	Statement
A distinctive facial expression		
Student	*This is very interesting*	Statement
Tutor	*Try not to repeat the same mistakes in future tasks*	Statement
A new screen and a task		
A recognizable gesture		

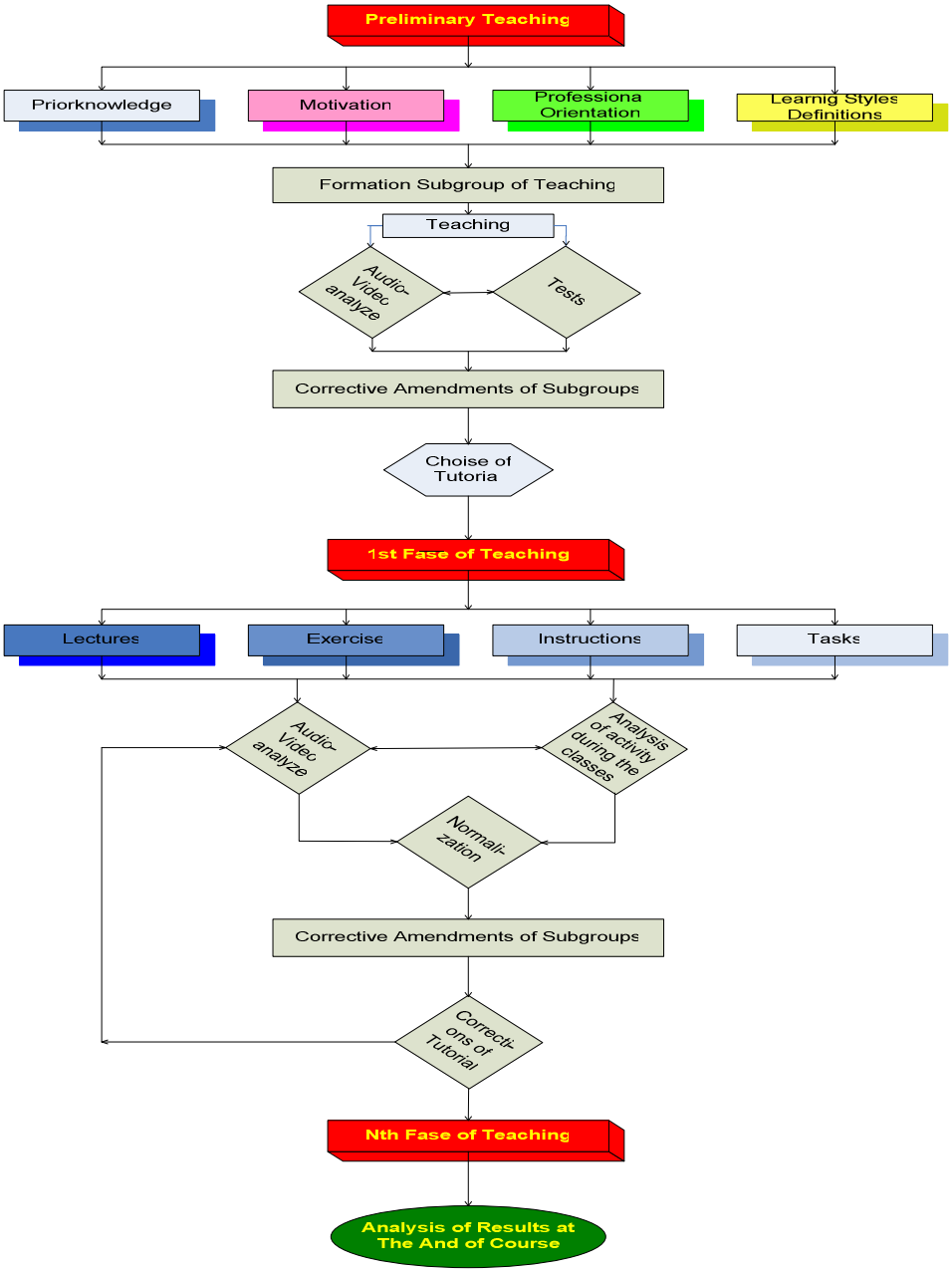

Figure 5 – Flowchart (SDL Diagram) of Forming Subgroups and Choice of Learning Environment, ITS
Рис. 5 – Процесс формирования подгруппы и выбор условий обучения, ITS
Slika 5 – Tok procesa formiranja podgrupa i izbira okruženja učenja, ITS

In our research, we were oriented to determine the data dominant in determining the ITS modules. The aim is to define an ITS module (determined by its basic characteristics, dynamics, type, and style of presentation) as early as possible (preferably at the start of the realization of the course - at the first class), and to implement individual corrections during the course on the assigned basic ITS model. In this way, we try to avoid changing a tutor model, which is often compared to the effect of changing a live lecturer, resulting in demotivation, fear, or insecurity.

So, all the reactions in characteristic situations are monitored, i.e. at which levels the characteristic reactions appear (type of emotions, intensity, rationality, motivation, etc.), and based on this information micro adjustments are carried out in the ITS module and the student subgroups, in accordance with the observed responses. Then the style and methods of work with individual subgroups are defined.

Further classifications are carried out based on the responses to tasks that come as "feedback", the reactions to erroneously solved tasks, the reactions to the advice that leads to the solution, and finally the reactions to the task when successfully solved. The aim is to analyze and review (based on feedback) which features should be implemented into tutorial learning systems, and to determine the standard deviation of the parameters of creating groups for which the system could successfully operate independently.

Creating Alternative Goals

The database of emotional algorithms and states is continuously upgraded and updated with models of behaviour and events for certain scenarios. The analysis of patterns for motivational groups in terms of timelines of events, types and intensities of students' emotional states and on the basis of the achieved results and goals, provides the system with the information about the events, i.e. which emotional change preceded the successful completion of a task. Also, if a student achieves targets B and C in time of communication (t), but fails in achieving target A, the system must compare the type and intensity of emotions which were present at that moment, so that it can create an algorithm of a successful scenario, as an alternative to failure. The goal of the system is not only the successful completion of the task at any cost, but also maintaining a fair duration and mode of communication. In the knowledge base, the system must contain phase algorithms as well. If the goal is hardly feasible, interphases are sought. Those interphases will ensure the successful implementation of training programs, i.e. through realizing targets B and C in a certain period of time, it is expected that target A will also be realized.

In our research, this represents a so-called normalization, a variation of the educational process regarding emotional states and achieved results, i.e. success (if the goal Ais unattainable, to redirect the flow of learning tothe goal B and create an alternative, i.e. the goal C, with the possibility of eventually achieving the goal A).

Research

Monitoring and analyzing multimodal affective expressions enable monitoring of verbal and nonverbal behavior. These analyses have given us a potential to detect more early affective consequences regarding the detected learning performances (activity, frustrations and meticulous learning) and affective outcomes in the context of tutoring. In terms of initial information, the same affective expressions can have different causes by depending on the context of tutoring.

The students were monitored during the sessions, by monitoring their engagement and effectiveness in solving problems, Table 4. In addition, all sessions initiated by students themselves were recorded (their number, length, quality, time frame, during the classes separately and the whole semester as well.

Table 4 – The records of sessions and activities by subject areas
Таблица 4 – Учет сессий и деятельности по образовательным областям
Tabela 4 – Evidencija sesija i aktivnosti po nastavnim oblastima

No	Student	Learning the subject material	Consultations (frequency)	Progress	Emotional changes	No sessions by subject area	Change in methodology during the session
1	Student 1	Partly	NO	Poor	Before the test	0	NO
2	Student 2	YES	YES-before the test	Independent	Before exercise classes	1	NO
3	Student 3	YES	YES	By consultation	At the occurrence of the problem	5	2x - efficiently
4	Student 4	YES	YES	By consultation	For each homework	7	3x - efficiently
5	Student 5	Partly	YES-before the test	Unsatisfactory	Before exercise classes	1	NO
6	Student 6	Partly	DA	By consultation	At the occurrence of the problem	5	3x - partially successful

No	Student	Learning the subject material	Consultations (frequency)	Progress	Emotional changes	No sessions by subject area	Change in methodology during the session
7	Student 7	Partly	YES-before the test	No progress	Before exercise classes	1	NO
8	Student 8	YES	YES	By consultation	For each homework	5	4x - partially successful
9	Student 9	Partly	YES	By consultation	At the occurrence of the problem	5	3x - partially successful
10	Student 10	NO	NO	Poor	Before the test	0	NO
11	Student 11	NO	NO	No progress	NO	0	NO
12	Student 12	Partly	YES – on demand	Poor	Before the test	2	NO
13	Student 13	Partly	YES-before the test	Poor	At the occurrence of the problem	1	1x - unsuccessful
14	Student 14	YES	YES – on demand	Independent	At the occurrence of the problem	2	NO
15	Student 15	NO	NO	No progress	NO	0	NO
16	Student 16	NO	NO	No progress	NO	0	NO
17	Student 17	NO	NO	No progress	NO	0	NO
18	Student 18	Partly	YES-before the test	No progress	Before the test	1	1x - unsuccessful
19	Student 19	YES	YES – on demand	Independent	NO	4	NO

During the sessions, there were corrective actions in order to adapt teaching (ITS simulation), in order to adjust to the level of prior knowledge, affective states, interests (whether a student joined the course because of intellectual curiosity or needs for a degree), style of learning in order to increase or at least preserve the initial level of motivation (starting enthusiasm).

Students who actively participated in the sessions maintained or increased the starting level of motivation, with occasional oscillations overcome by corrective adjustments of the educational process in accordance with individual needs and current affective reactions. The success of these students, regardless of the subgroup (S3, S4, S6, S8, S9) was better (Be) or much better (MB). The exception is Student 19 (S19), with the initial assessment of the success of the implementation of the educational process very good (VG), whose emotional state during the course was closest to neutral. With a constant level of motivation, high quality level of prior knowledge, adequate professional orientation, and exceptional activities in regular classes, he achieved a much metter (MB) result.

Students who did not actively use the simulated DL system experienced a drop in motivation, which was detected at the periods of reporting (normally before the mid-term test or the exam). Affective states developed during the semester, the length, and the frequency of sessions (with exceptions) did not provide the time or the opportunity for corrective actions in order to return to the initial motivational level or at least to improve it a little. Those students (regardless of the subgroup), finished the course with bad (B) results, worse than expected (WE) results or in a few cases, with the expected results (E) which were at the start of the course assessed as poor (P).

Table 5 – One Look at the Results Achieved Through the Monitoring of Motivational Factors During the Course Realization by a Simulated ITS
Таблица 5 – Обзор результатов и наблюдение за изменениями мотивационного фактора в процессе проведения курса, путем моделирования ITS
Tabela 5 – Pogled na ostvarene rezultate uz praćenje promena motivacionog faktora tokomrealizacije kursa kroz simulirani ITS

		Subgroup 1									*Subgroup 2*							
The Initial Prerequi-sites for Success	*Student*	S1	S2	S3	S4	S5	S7	S14	S15	S19	S6	S8	S9	S10	S11	S16	S17	S18
	Expected Success	VG	E	G	VG	E	E	E	G	VG	G	P	P	P	P	P	G	P
Flow of Motivation	*Positive or negative*	-	-	+	+	-	-	-	-	+	+	+	+	-	-	-	-	-
The Achieved Result	Relation to the Initial Estimate	B	E	MB	Be	B	B	WE	WE	MB	Be	Be	Be	WE	E	B	E	E

LEGEND:
E-Excellent; VG-Very Good; G-Good; P-Poor
B-Bad; WE-Worse then Expected; E- Expected; Be-Better; MB-Much Better

Conclusion

Negative emotions, poor skills, and inadequate environment of the educational process cause a drop in motivation. Without individualized corrective actions in the educational process, regaining motivation will not by itself lead to success; also, applying individualized corrective actions in the learning process without regaining motivation will have no effect.

In this study, it was observed that individual motivational expressions and actions during poblem solving increase the likelihood of raising self-efficacy and success in learning. The fact is, also, that this motivational tactics has a limited possibility to increase self-efficacy and gain in students who start the course with high quality and high initial self-efficacy.

The example of S19 student, a good course participant despite being a single case and not representative for the discussion, should be taken as a warning signal. Quality students with high abilities often think they do not need motivation or they do not appreciate the role of motivation, motivational sessions and tactics. In addition, it was noted during the sessions that the motivational components of curiosity and challenges hould be explored together with confidence and self-control in the context of the application of distance learningsystems.

Balancing and mainaining the environment of coupled cognitive and motivational functions has become a key issue in the theory of intelligent tutoring systems and systems of distance learning. Among other things, this work was guided by the idea to suggest how to determine the most efficient use of motivation in the context of feedback for students with problematic (affective) actions.

The research indicates that the application of ICT technologies and ITS in education in terms of adapting teaching strategies can have a significant impact not only on purely cognitive learning outcomes, such as the gain in knowledge and skills, but also on an important motivating aspect such as self-confidence.

The primary limitation of this study (similar to some previous research) comes from two drawbacks: 1st the absence of control groups, and 2nd an abundance of factors omitted or permitted to vary from a treatment to a new session appointment (Boyer et al, 2009, pp.111-136). These other factors (except those investigated) are probably responsible for the lack of a broader active participation and motivation of the course participants in the use of a simulated DL system. However, this work, among other things, reveals the breadth of the hypothesis of intelligent tutoring systems and their application in systems of distance learning, and may be the basis for future research and experiments.

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ВЛИЯНИЕ МОТИВАЦИИ НА ПРОЦЕССЫ ОВЛАДЕНИЯ ЗНАНИЯМИ, УМЕНИЯМИ И НАВЫКАМИ В СИСТЕМЕ ДИСТАНЦИОННОГО ОБРАЗОВАНИЯ

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ОБЛАСТЬ: образование, технологическое развитие
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной статье описано, каким образом мотивационные процессы влияют на слушателей курса системы дистанционного образования, в т.ч. на восприятие знаний, овладение ими и на применение знаний, умений и навыков. Социально-когнитивные исследования свидетельствуют о высокой степени приспособленности системы и соответствии применяемых мотивационных моделей. Модель мотивационных процессов в исследовании представлена с целью совершенствования дистанционной системы обучения. При наблюдении за влиянием мотивационных факторов на выполнение когнитивных задач, и по выражениею реакций слушателей курса, можно определить какие мотивационные факторы способствуют осуществлению положительных и отрицательных когнитивных результатов, в связи с чем, дидактические методы и приемы в процессе обучения периодически подвергались изменениям. Цель данной работы заключалась в исследовании влияния мотивационного фактора на овладение знаниями и профессиональными навыками, а также в наблюдении за проявленным интересом слушателей курса к научным лекциям. На основании выявления несоответствия мотивационных процессов с помощью дизайна программного обеспечения, разработанного для дистанционного образования, проводится корректирование условий и методов обучения. Сам процесс выявления основан на наблюдении роста знаний по сравнению с предварительными, так называемыми предзнаниями: 1. профессиональные предзнания и 2. общеобразовательные предзнания, проверенные вступительными тестами и на подготовительных курсах. В результате решения задач по данным вопросам проведен

анализ влияния профессиональных предзнаний, общеобразовательных знаний и заинтересованности учащихся на восприятие, понимание и решение задач и достижение результатов. Результаты проведенного анализа показали, что в успешном понимании и решении профессионально-технических задач общеобразовательные предзнания и заинтересованность учащихся играют ключевую роль.

Ключевые слова: *мотивация, обучение, когнитивные функции, эмоции, базовые знания, дистанционное образование, аффекты.*

PRAĆENJE UTICAJA MOTIVACIJE NA PROCESE APSOLVIRANJA ZNANJA I VEŠTINA U SISTEMU UČENJA NA DALJINU

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OBLAST: obrazovanje, tehnološki razvoj
VRSTA ČLANKA: originalni naučni članak
JEZIK ČLANKA: engleski

Sažetak:

U radu je opisano kako procesi motivacije utiču na slušaoce kursa sa stanovišta apsolviranja znanja, te prenosa i korišćenja znanja i veština u sistemu učenja na daljinu. Istraživanja, u socijalno-kognitivnom okviru, ilustruje prilagodljivost sistema i adekvatno prilagođavanje motivacionih obrazaca. Model motivacionih procesa predstavljen je u funkciji ciljeva učenja slušalaca kursa. Praćenjem uticaja motivacionog faktora na izvršavanje kognitivnih zadatka, te kako se oblikuju reakcije slušalaca kursa, tj. kako motivacioni faktor utiče na uspeh ili neuspeh i kvalitet kognitivnog učinka u procesu učenja, menjan je i prilagođavan metodičko-didaktički pristup nastavi. U ovom radu istraživan je uticaj znanja iz uže stručne oblasti, ali i interesovanja slušalaca kursa za razumevanje stručnog ili naučnog izlaganja. Implikacije u praksi i intervencija, kroz dizajn softvera sistema učenja na daljinu, usmerene su na korekciju obrazovnog procesa na konstatovanu neprilagođenost motivacionih procesa u okruženju učenja ili stručnog osposobljavanja, prateći kroz istraživanje dva oblika predznanja: stručno predznanje i opšte tematsko predznanje, koja su proveravana ulaznim testovima predznanja, te kroz pripremnu nastavu. Nakon rešavanja problemskih zadataka izvršili smo povratnu analizu utvrđivanja efekata stručnog predzna-

nja, opšteg tematskog znanja i interesovanja na razumevanje i rešavanje problemskih zadataka, te analizu ostvarenih rezultata. Za zadatke više stručno-tehničke orijentacije, predznanje iz domena opšte tematsko znanje i interes bili su značajni prediktori razumevanja i uspeha.

Ključne reči: *motivacija, učenje, kognitivne funkcije, emocije, predznanje, učenje na daljinu, afekti*.

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HYDROMETALLURGICAL PROCESSING OF NICKEL LATERITIC ORES

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Summary:

Nickel production is a very important activity for the European Union because nickel is a unique constituent of stainless steel. Europe has lateritic (oxidic) ore deposits along a very well-known belt starting from the Alps and ending to the Himalayas. The lateritic belt passes through western Balkans and Greece and continues through Turkey to Asia. The known lateritic deposits in Serbia are located in three different areas called: Zapadna Morava (Rudjinci, Veluce, Ba), Sumadija (Lipovac, Kolarevici, Bucje) and Mokra Gora, which have many natural resources such as forests, rivers, etc. Therefore, it is very important to understand and show hydrometallurgical treatments of lateritic ores via mining and metallurgy in different parts of the world. In this paper, several exploitation scenarios for hydrometallurgical treatment and benefication of lateritic ores will be shown: Direct Nickel Process, Ravensthorpe and Murrin Murrin in Australia and Meta Cobalt Nickel in Turkey.

Key words: *nickel, cobalt, lateritic ore, hydrometallurgy, autoclave.*

Introduction

Nickel is a naturally occurring, silvery-white metallic element widely used in over 300,000 products for catalysis, consumer, industrial, military, transport, aerospace, marine and architectural applications. Nickel has been used since ancient times. Because of its resistance to corrosion, nickel has been occasionally used historically as a substitute for decorative silver. Pure nickel was extracted by Axel Cronstedt from the ore niccolite (nickel arsenide, NiAs) in 1751. Because of its presence in copper ores, this element got its name from the German word 'kupfernickel' meaning Devil's copper. It is the fifth most common element on earth and occurs extensively in the earth's crust. In this work, different hydrometallurgical processes for the treatment of nickel laterite ores will be presented. Nickel is not a cumulative toxicant. Some people may show an allergy sensibility to nickel, affecting their skin (about 5 to 10 % in Europe).

As a result of high nickel production costs associated with traditional pyrometallurgical techniques and the depletion of high-grade sulfide ores, a renewed interest has developed concerning the production of nickel and cobalt by high pressure acid leaching (HPAL) of nickel laterites. More than one third of the world's nickel is nowadays produced from laterite ores (Bergmann, 2003, pp.127-138). Laterites account for two thirds of the world's nickel resources. It is therefore likely that increasing amounts of nickel will be produced from laterites. Since laterite type ores naturally occur close to the surface, economical open pit mining techniques are employed to recover the ore after the removal of the overburden (Whittington & Muir, 2000, pp.527-600). The laterite ore consists of fresh saprolite, limonite and nontronite. These ores represent various layers in the laterite bedrock. Limonite consists mainly of goethite, a hydrated iron oxide such as FeO(OH), HFeO2, or Fe2O3·H2O. This continues to a nontronite rich zone. Saprolite is the next layer, which is distinguished from its rich magnesium silicate content. The chemical analyses of a few chosen ores are shown in Table 1 (Stopić, 2004, pp.257-266)

Table 1 – ICP Analyses of the Average Content of Laterite Ore from "Rudjinci", Serbia and from "Silcrete", Australia
Таблица 1 – ICP Анализ среднего объема латеритных руд в «Руджинцы», Сербия и в "Silcrete", Австралия
Tabela 1 – ICP analize prosečnog sadržaja lateritnih ruda nikla u „Ruđinci" (Srbija) i „SIlcrete" (Australija)

Element	"Rudjinci", Serbia (wt %)	"Silcrete", Australia (wt %)
Si	25.33	17.40
Fe	14.90	26.42
Al	2.12	4.16
Cr	1.30	0.67
Ni	1.13	0.78
Co	0.05	0.05
Mg	3.22	1.70
Mn	0.37	0.25
Na	0.04	0.04
K	0.04	0.05

As shown in Table 1, the nickel content in oxidic ores amounts to between 0.78 and 1.13 wt. %. The main accompanying elements are silicium, iron, magnesium and aluminium. The above mentioned ores were investigated under high pressure conditions in an autoclave. The comparative analysis of different minerals shows a different content of important elements, what is very important for the choice of leaching.

Table 2 – Chemical composition of nontronite and limonite
Таблица 2 – Химический состав нонтронита и лимонита
Tabela 2 – Hemijski sastav nontronita i limonita

[%]	Fe	Al	MgO	Ni	Co
Nontronite	10-30	8-10	5-15	0.6-2	0.02-0.1
Limonite	40-50	7-9	0.5-5	0.8-1.5	0.1-0.2

Leaching Methods

In hydrometalurgical processes, three different methods are usually used: tank leaching, heap leaching and high pressure acidic leaching HPAL. Tank leaching uses a stirrer and reagents to get the reaction started. An overflow leads the suspension to another tank, where the pregnant solution and the slurry are separated by a solid/liquid separation process.

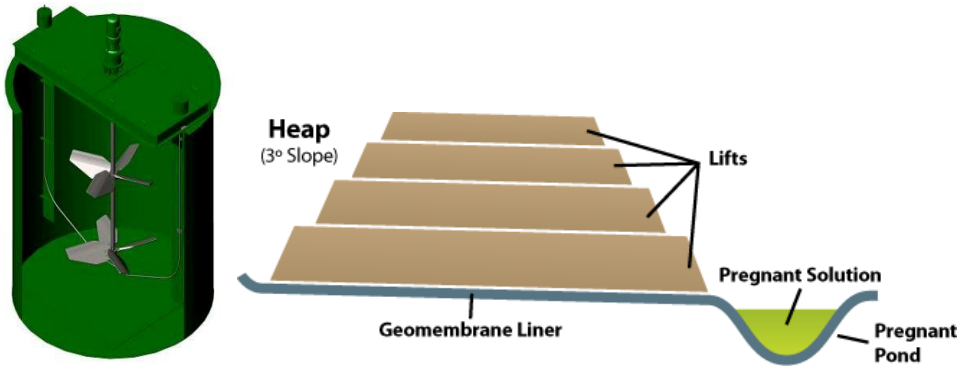

Figure 1 – Leaching under atmospheric pressure: tank (left) and heap (right)
Рис. 1 – Промывка при атмосферном давлении: в баке (слева) и в куче (справа)
Slika 1 – Luženje pri atmosferskom pritisku: u tanku (levo) i na gomilama (desno)

Heap leaching is a very slow process, where the acid is spread dropwise on a heap, slowly pouring to the bottom. Superiadi had some remarks about the following heap leaching processes (Superiadi, 2008, pp.25). During this reaction time, the used acid reacts with the minerals.

Table 3 – The most known heap leaching processes
Таблица 3 – Самые распространенные методы промывки руд в куче
Tabela 3 – Najpoznatiji procesi luženja na gomilama

Project	Owner	Country	Remarks
Caldag	European Nickel	Turkey	First Heap Leach project
Ravensthorpe	BHP-B	Australia	Part of flow sheet
Murrin-Murrin	Minara	Australia	Expansion of project
Piaui	Vale	Brazil	Being fast-tracked for production

Leaching under high pressure was performed in special devices (autoclaves). Slurred, crushed ore from the mine is conveyed to the processing plant to be pressure leached with sulphuric acid. The High Pressure Acid Leaching HPAL area receives the slurred feed, heats it up to 225-270°C and mixes it with hot concentrated sulphuric acid inside four titanium-lined autoclaves. Nickel and cobalt are dissolved into the solution.

$$NiO + H_2SO_4 \rightarrow NiSO_4 + H_2O \quad (1)$$

$$CoO + H_2SO_4 \rightarrow CoSO_4 + H_2O \quad (2)$$

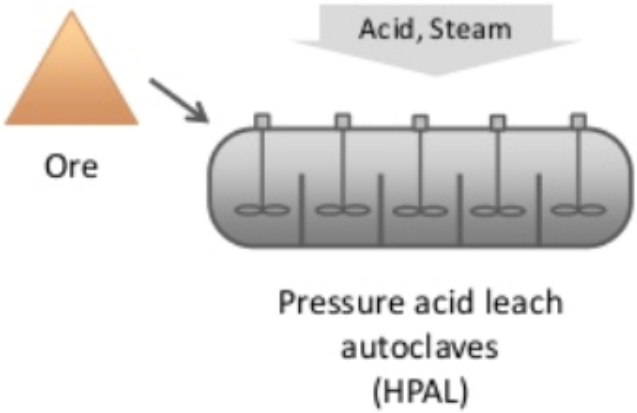

Figure 2 – High Pressure Leaching of nickel lateritic ores HPAL
Рис. 2 – Промывка латеритных руд под высоким давлением в автоклаве
Slika 2 – Luženje pri visokom pritisku u autoklavu

The hydrometallurgical processing of nickel lateritic ores begins with an acidic solution (Dry &Haris, 2012, pp.20-35). The dominant acid so far has been sulphuric acid, but research work has been published on the process using hydrochloric acid or nitric acid. Sulphuric acid, hydrochloric acid, and nitric acid are the three major mineral acids for the leaching of laterites. The comparative analysis has shown that both the chloride and the nitrate circuits examined have appreciably lower operating costs than the sulphate circuits. The dissolution kinetics of nickel lateritic ore in an aqueous acid solution of three metabolic acids, i. e. citric acid, oxalic acid and acetic acid was investigated in a batch reactor individually (Sahu et al., 2011, pp.251-258). The percentage of nickel leaching for different acids at the time intervals of 40, 80 and 120 hours at a concentration of 1M was studied. Oxalic acid was the most efficient leaching agent compared to the other two used acids. The maximum leaching efficiency was about 30% under the above mentioned conditions. Superiadi has performed a comparative analysis of different leaching processes for lateritic ores.

Table 4 – Comparative analysis of different leaching processes for lateritic ores
Таблица 4 – Сопоставительный анализ различных методов промывки латеритных руд
Tabela 4 – Uporedna analiza raznih procesa luženja za lateritne rude

Process	Main Feed	Electricity Require	Capital Cost	Operating Cost
HPAL	Limonite	Low	High	Low
Caron	Saprolite	Moderate	Very High	High
Heap Leach	Limonite	Very Low	Moderate	Low
Chloride Leach	Limonite Saprolite	Moderate	High	Low

The Caron process contains a thermal pretreatment and the final ammoniacal leaching. Therefore, this process needs more capital costs. This process is not a subject of this paper. HPAL, Heap Leach and Chloride leach have low electricity request and operating costs. The high pressure leaching process is considered in our previous publication (Stopić, 2011, pp.29-44). One detailed analysis of different

deposits confirms an advantage of the used HPAL-processes regarding the maximum leaching efficiency of nickel and cobalt (approx. above 90 %).

Table 5 – Comparative analysis of the leaching efficiency of Ni and Co
Таблица 5 – Сопоставительный анализ эффективности промывки никеля и кобальта
Tabela 5 – Uporedna analiza stepena luženja za nikal i kobalt

Process	Ore Type	Acid Req. (kg/tonne ore)	Leach Time	Ni Rec. (%)	Co Rec. (%)
Tank Leaching	Nontronite	856	5 h	92.8	77.0
	Limonite	907	24 h	85.2	87.0
Heap Leaching	Nontronite	462	144 days	83.9	55.2
	Limonite	560	534 days	65.5	57.1
HPAL	Nontronite	536	90 min	98.1	94.4
	Limonite	300	90 min	88.9	90.5
	Blend (Pilot Scale)	**315**	**60 min**	**90.0**	**97.0**

The study aims to compare three different hydrometallurgical processes for the treatment of nickel lateritic ores: Direct Nickel, Meta and Minara HPAL processes, as well as to point out a significance of the beneficiation processes in order to increase the leaching efficiency of nickel and cobalt.

Direct Nickel Process, Australia

The Direct Nickel Process was developed in Australia representing a revolution in nickel production and a frontier advance in the processing of lateritic oxidic nickel ores (McCarthy & Brock, 2011, pp. 2-11). The Direct Nickel Group from Australia has created a new, simple and efficient process for extracting nickel from oxidic ored from Indonesia, which will bridge the global nickel supply gap. Most steps in the verstaile flowsheet have been tested at a pilot scale. In 2007, a pre-feasibility study conducted independently by Kvaerner and studies by several independent experts confirmed its economic potential. The full process was demonstrated at a five tonnes a day scale.

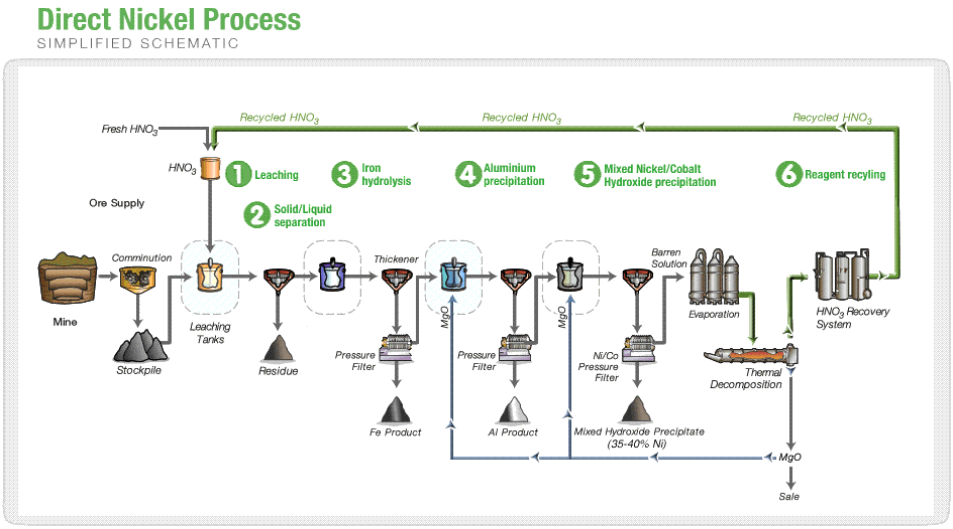

Figure 3 – Flowchart of the Direct Nickel Process
Puc. 3 – Схема операций Direct Nickel Proces
Slika 3 – Pregled operacija u „Direct Nickel Procesu"

The DNi Process leach is operated at atmospheric pressure at 110°C in 304 stainless steel tanks at temperatures below the boiling point. Leaching takes between 2 and 4 hours.

2. Insoluble residue is separated from the pregnant leach solution (PLS), which now contains most of elements such as Ni, Co, Fe, Al and Mg. The residue goes to a tailings disposal facility.

3. Iron Hydrolysis takes the pregnant leach solution and removes iron and chromium, making a hematite (Fe_2O_3) product at temperatures about 170°C. This is separated from the PLS by filtration at 50°C.

4. Aluminium is precipitated in two steps by MgO addition and filtered from the solution in a form of white product- aluminium hydroxide.

5. A Mixed Hydroxide Product (MHP) is precipitated using MgO and filtered out of the solution. This MHP (40-45 wt.% Ni, ~2% Co) is the final product from the DNI.

6. The barren solution is passed through a series of evaporation vessels and then through thermal decomposition where magnesium nitrate converts to MgO and NOx gases. These gases are recycled back to nitric acid and reused in the leach circuit. Some of the produced MgO is recycled back to aluminium precipitation and mixed hydroxide precipitation, the remainder is available for sale as a high quality magnesia product.

The process is environmentally friendly because almost all the reagent is captured and recycled. The mass of waste residues is less than half that of HPAL processes due to minimal disposal of reagent and

neutralization agents – and the production of saleable co-products. Valuable co-products are produced such as magnesium oxide. Maintenance costs are reduced by the low intensity of the process, and the simple materials of construction in comparison to titanium in an autoclave.

Ravensthorpe Nickel Project, Australia

Beneficiation is the process where a low-grade component of mineralization is separated from the rest and rejected, leaving a component with a higher grade to be treated in the leaching process. This is analogous to making a concentrate from a sulfide ore, but the concentration factor is much smaller for nickel laterite ores. A major difference between laterite (oxide) and nickel sulfide processing is that the sulfides ores are amenable to beneficiation producing high grade concentrates (10 to 26 % Ni). This reduces both the size of the processing facilities (especially the front end processing facilities) and overall processing costs for sulfides. Only a limited upgrading (by a factor of <3, but mostly < 2) can be carried out with laterite ores.

The combined Ravensthorpe Nickel Project RNP and Yabulu Refinery Expansion (BHP BILLITON 100%) was a US$ 1.4 billion project in regional Australia in 2004 that has produced high quality nickel metal and cobalt for global export markets. The Ravensthorpe orebody is distinctive in that it has a high silica content which enables the limonite ore to be upgraded to almost twice the mined grade through a beneficiation plant-a simple scrubbing and screening process to remove the barren hard silica (Adams, et al., 2004, pp.193-202).

The saprolite ore also upgrades but to a lesser extent. Limonite and saprolite are to be treated separately in two purpose-built beneficiation circuits, thereby increasing the nickel grade of the ore prior to leaching. The average grade of ore shipped from Berong has been greater than 1.5% Ni. The Ravensthorpe Nickel Project consists of 152 million tonne-resource of nickel laterite of the south coast of Western Australia. The project involves the mining and beneficiation of the nickel laterite ore, hydrometallurgical processing using Pressure Acid Leaching (PAL) technology and marketing of nickel and cobalt products. The project gives a PAL plant feed grade of 2.0 % Ni, produces 25,000 tonnes per annum of LME grade nickel metal cathodes and 1,900 tonnes per annum of cobalt sulphide by–products. Screening and classification processes are used to separate out the finer higher grade fraction from the coarse grade fraction from the Run of Mine ROM. The aim of the beneficiation circuit is to maximise Ni and Co recovery in the minimum weight fraction obtainable, while rejecting minerals containing quartz. The unit operations are: primary crushing, scrubbing, screening, cycloning, attritioning, classification, and thickening.

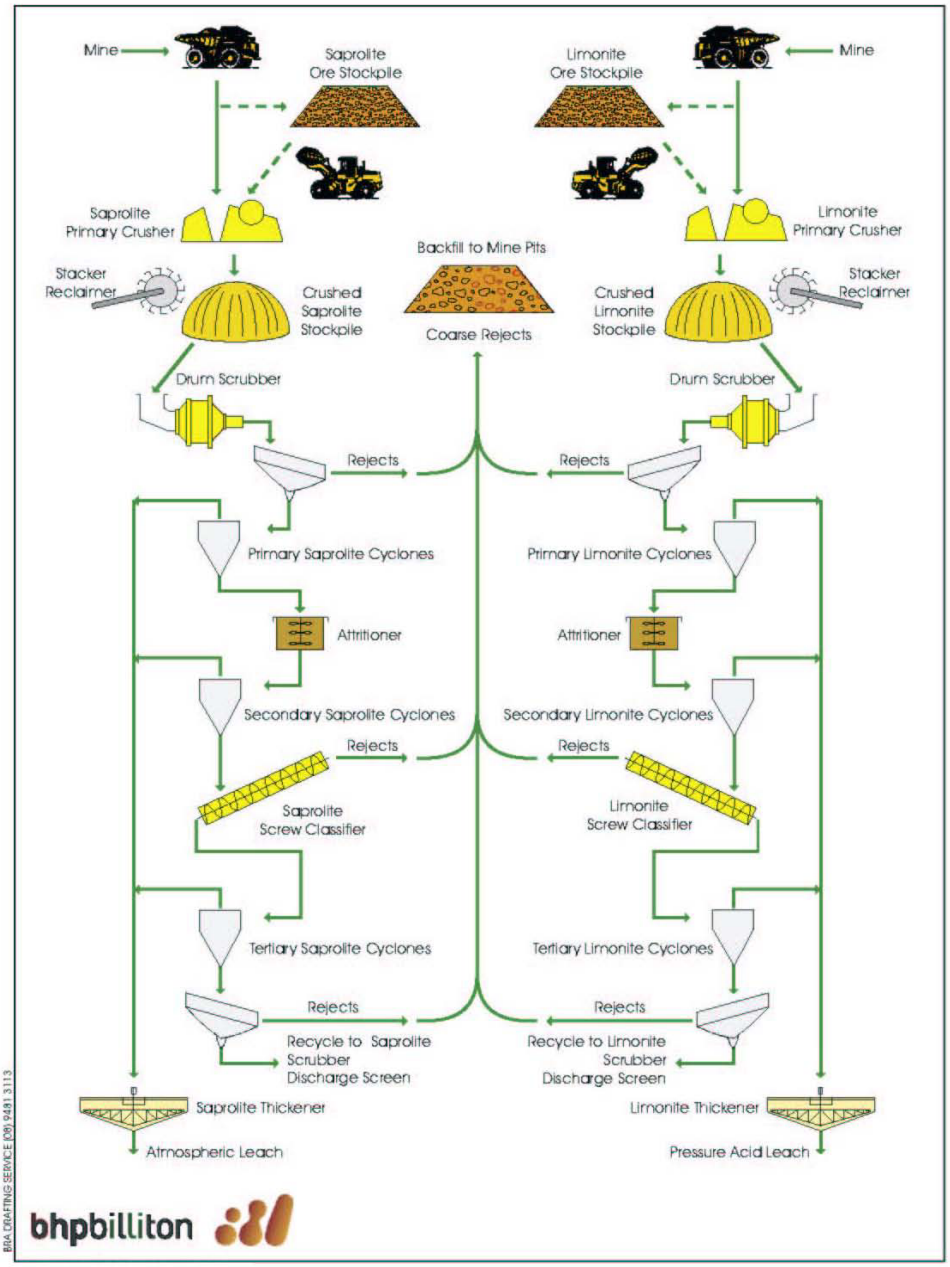

Figure 4 – Process Flow Chart for Ore Beneficiation (Ravensthorpe Nickel Project)
Рис. 4 – Схема “Ravensthorpe Nickel Project” обогащения руды
Slika 4 – Šema „Ravensthorpe Nickel Project” radi obogaćivanja rude

Meta Nickel Cobalt Process, Turkey

Meta Madencilik Ltd. Şti. was founded in 2000 by a group of professional engineers and it developed the Turkey's first nickel project. Meta has been carrying out the activities under the name of Meta Nikel Kobalt Madencilik Sanayi ve Ticaret A.Ş. since 2007. The Turkish "*Meta"* company is part of the "ZORLU Group", which is active in many different industries.

"*Meta*" has 3 project sites at which nickel and cobalt are extracted:

- Gordes nickel cobalt investment project
- Eskisehir nickel ore production & exploration project
- Usak nickel exploration project

All plants extract metals from the lateritic ore. The previous investigation of nickel extraction from lateric ores was performed under atmospheric pressure (Büyükakıncı & Topkaya, 2009, pp.33-38). The project area is located in Western Turkey, within the boundaries of Manisa Province, between Akhisar and Gördes Towns and around Fundacık - Çiçekli – Kabakoz and Kalemoğlu Villages. The mine site is 20 km away from the town of Gördes by an asphalt road and it is nearly 45 km from the town of Akhisar, 115 km from Manisa and 160 km from İzmir. The nearest state railway is about 40 km away.

A total of 230,000 tons of nickel ore has been produced from two open pits and 150,000 tons of ore have been exported to Greece, Macedonia and China since 2003. Approximately 80,000 tons of the remained nickel ore were stocked at the mine site, to be used during a trial production of the process plant, which is under construction. A world class laboratory was set up on the mine site in 2007, to conduct chemical analyses on the samples obtained from the exploration and drilling program. The following operations are used:

1) Ore Preparation → classification of ore particles

2) High Pressure Acid Leaching (HPAL)→ leaching method to extract nickel and cobalt

3) Primary Iron Removal & Re-Leach Area Solid Liquid Separation (CCD or SX)

4) Secondary Iron Removal (Secondary Neutralization)

5) MHP (Mixed Hydroxide Product) Precipitation-1

6) MHP (Mixed Hydroxide Product) Precipitation-2

7) Manganese Removal

8) Final Neutralization

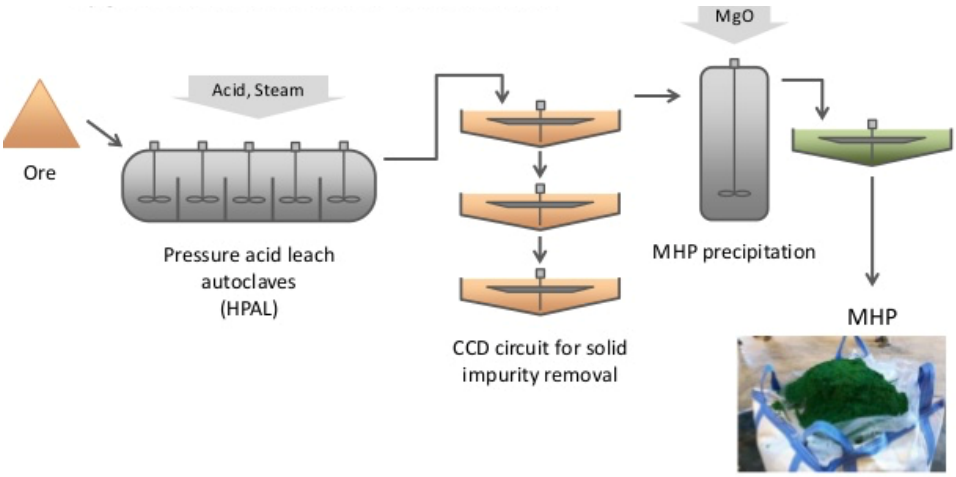

Figure 5 – Flowchart of the META Cobalt Nickel Process
Рис. 5 – Схема META Cobalt Nickel Process
Slika 5 – Šema za „META Kobalt Nikal Process"

For the following neutralization, calcium carbonate is used. After that, nickel and cobalt are recovered from the solution in 98 – 99 % yield by precipitation at 120 °C with hydrogen sulfide at a pressure of 1.1 MPa in a three-compartment, brick-lined autoclave in accordance with the following reaction:

$$NiSO_4 + H_2S \rightarrow NiS + H_2SO_4 \quad (3)$$

The final product has the following chemical composition of the mixed precipitate

Table 6 – Chemical composition of the final product
Таблица 6 – Химический состав конечной продукции
Tabela 6 – Hemijski sastav konačnog produkta

[%]	Ni	Co	Fe	Al	Mg	Mn
MHP-2	30-40	1.5-2	<0.5	1-2	1.3	0.8

The advantages of the META-process:
1) Capital expenditure and operational expenditure are relatively low
2) Sulphuric acid consumption is low
3) Reagent types and consumption is low
4) Metal extractions (Ni and Co) with respect to time are above 90 %

The disadvantages of this process are related to the precipitation process:
1) Low Mg concentration necessary (<4%)
2) Low Al concentration necessary (because Al is high acid consumer)

Murrin Murrin Project, Australia

Minara is the fully integrated nickel laterite producer in the world. The Murrin Murrin nickel-cobalt project, 60km east of Leonora, was commissioned by Anaconda Nickel Ltd. The project is now a joint venture between Murrin Murrin Holdings Pty Ltd, a wholly owned subsidiary of Minara Resources Ltd (60%), and Glenmurrin Pty Ltd, a wholly owned subsidiary of Glencore International AG (40%). It is based on the mining and processing of lateritic ore for the production of up to 40,000t/y of nickel and 2,500t/y of cobalt briquettes. After mining from the nearby open pits, the ore is delivered to the run of mine (ROM) pad, where it is sorted depending on its grade and blended to ensure consistent feed to the feed preparation circuit. The ore is then mixed with water to form slurry for processing in the High Pressure Acid Leach (HPAL) circuit. (four titanium autoclaves in a line).

The most important operations in the Murrin Murrin process contain:

1. mining and rehabilitation
2. ore preparation
3. High Pressure Acid Leach (HPAL)
4. solid/liquid separation-counter current decantation
5. solution neutralization
6. mixed sulfide precipitation
7. tailling neutralization
8. oxygen pre-leach of nickel and cobalt values
9. nickel and cobalt separation
10. nickel and cobalt refining
11. metal package

Mr. Johnston from Minara Resources reported he had finally laid the ghosts of the company's troubled past to bed, nearly 14 years after the first nickel was produced at its Murrin Murrin mine (Evans, 2013, pp.63). Murrin Murrin produces nickel and cobalt briquettes that easily meet the highest grade standards of the London Metals Exchange and are highly regarded and in strong demand from consumers around the world (http://www.minara.com.au/about/operations-overview/technology).

Conclusion

Hydrochloric, nitric and sulphuric acids were successfully used for the leaching of laterite ores. The dissolution kinetics of lateritic ores in an acidic solution of three metabolic acids confirmed low leaching efficiency of nickel and cobalt. Tank leaching, heap leaching and high pressure acidic leaching are mostly used for the hydrometallurgical treatment of lateritic ores. The Direct Nickel Proces, the Meta Cobalt Nickel Process

and the Murrin Murrin Process show a high potential for the production of nickel and cobalt. The application of HPAL for laterites is expected to continue - especially for large projects and high grade deposits. Regarding lower grade deposits, further development of the heap leaching process for small projects is expected. The beneficiation process of laterite ores was successfully performed in the Ravensthorpe plant in Australia in order to produce a nickel concentrate. Finally, nickel and cobalt have become essential materials in modern life.

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ГИДРОМЕТАЛЛУРГИЧЕСКАЯ ОБРАБОТКА ЛАТЕРИТНЫХ РУД НИКЕЛЯ

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ВИД СТАТЬИ: обзорная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Производство никеля представляет важную отрасль промышленности в Евросоюзе, так как никель является составляющим элементом в производстве нержавеющей стали. Европа обладает ресурсами оксидных руд, находящихся на большой территории от Альп до Гималаев, охватывая западную часть Балкан и Грецию, простилаясь через Турцию до Азии. Известные резервы латеритных руд находятся в Сербии, располагаясь в трех зонах: Западная Морава (Руждинцы, Велуце, Ба), Шумадия (Липовац, Коларевичи, Бучье) и Мокра Гора, представляющих собой природные ресурсы, такие как: лес, реки и пр. Очень важно понимать и оценить применение латеритных руд в области горной промышленности и металлургии в разных частях мира. В данной статье представлено несколько эксплуатационных сценариев латеритных руд в области гидрометаллургии: Direct Nickel Process, Murrin Murrin и Ravensthorpe в Австралии, и META Process в Турции.

Ключевые слова: *никель, кобальт, латеритные руды, гидрометаллургия, автоклав.*

HIDROMETALURŠKO TRETIRANJE LATERITNIH RUDA NIKLA

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OBLAST: hemijske tehnologije
VRSTA ČLANKA: pregledni članak
JEZIK ČLANKA: engleski

Sažetak:

Proizvodnja nikla je vrlo značajna aktivnost u zemljama Evropske unije, jer nikal je važan dodatak u nerđajućim čelicima. Evropa ima resurse oksidnih ruda duž dobro poznatog prostora koji započinje od Alpa i završava se na Himalajima. Ovaj opasač prolazi kroz zapadni Balkan i Grčku i nastavlja se kroz Tursku do Azije. Poznati depoziti lateritnih ruda u Srbiji smešteni su u tri zone: Zapadnoj Moravi (Ruđinci, Veluce, Ba), Šumadiji (Lipovac, Kolarevići, Bučje) i Mokroj gori, koje predstavljaju prirodne resurse, kao što su šume i reke. Lateritna ruda tretira se u rudarstvu i metalurgiji u raznim područjima sveta. U ovom radu biće predstavljeno nekoliko eksploatacionih scenarija preko hidrometalurškog tretiranja: „Direct Nickel Process", „Murrin Murrin" i „Ravensthorpe" u Australiji, i „META Process" u Turskoj.

Ključne reči: *nikal, kobalt, lateritne rude, hidrometalurgija, autoklav.*

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CATASTROPHES CAUSED BY CORROSION

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FIELD: Materials, Chemical Technology
ARTICLE TYPE: Review Paper
ARTICLE LANGUAGE: English

Summary:

For many years, huge attention has been paid to the problem of corrosion damage and destruction of metallic materials. Experience shows that failures due to corrosion problems are very important, and statistics at the world level shows that the damage resulting from the effects of various forms of corrosion is substantial and that, for example, in industrialized countries it reaches 4-5% of national incomes. Significant funds are determined annually for the prevention and control of corrosion. In the case of ignoring the problem of corrosion, in some cases the penalty is financial, whereas in other cases it is the loss of human lives.

This review presents several cases of failures in engineering structures and installations of catastrophic proportions, where corrosion was responsible for the occurrence of failures and the loss of hundreds of lives.

Key words: *catastrophe, failure, corrosion, corrosion pit, pesticide, explosion, pipeline, helicopter, aircraft.*

Introduction

Failures occur when a component or a structure is no longer able to withstand stresses imposed during exploitation. Usually, failures are related to stress concentration and they can occur for many reasons, including structural faults such as holes, notches and transitional curvatures of small diameters, cavities in the microstructure of materials as well as corrosive attacks, such as pitting, which generate local stress concentrations.

Based on the research and statistical data, it is possible to estimate the frequency of failure mechanisms (Table 1). It is evident that corrosion, in all its forms (general corrosion, pitting corrosion, corrosion in the gaps, stress corrosion cracking, corrosion fatigue), dominates with 42% when it comes to the frequency of failure mechanisms in engineering structures. Also, in aircraft structures, where the largest number of failures is a result of fatigue, corrosion is the cause of even a quarter of the total number of failures (Findlay, Harrison, 2002).

Table 1 – Frequency of failure mechanisms
Таблица 1 – Частота механизмов отказов
Tabela 1 – Učestalost pojave mehanizama otkaza

Failure mechanisms	Percentage of Failures	
	Engineering Components	Aircraft Components
Corrosion	**29**	**16**
Fatigue	25	55
Brittle fracture	16	-
Overload	11	14
High temperature corrosion	**7**	**2**
SCC/Corrosion fatigue	**6**	**7**
Creep	3	-
Wear/abrasion/erosion	3	6

Table 2 presents a few accidents caused by corrosion.

Table 2 – Overview of several characteristic accidents caused by corrosion
Таблица 2 – Обзор нескольких характерных несчастных случаев, вызванных коррозией
Tabela 2 – Pregled nekoliko karakterističnih nesreća prouzrokovanih korozijom

05/19/2015 Oil spills (Santa Barbara / California)

On one of the most biologically diverse coastlines in the United States, there was a discharge of 540 m^3 of crude oil. Investigations indicated the presence of serious corrosion. In the lower quadrant of the pipeline, the thickness of which was reduced by 45% due to corrosion, there was crack propagation.

11/17/2014 The fall of railway traffic lights (Newbury / England)

A train traveling at 180 km/h crashed into a railway traffic light that fell over two tracks. Corrosion caused almost a complete loss of the wall of the hollow pylon.

08/15/2014 Landing of a Jetstream away from the runway (England)

Immediately after landing, the left leg of the landing gear separated from the shackles. The aircraft slid off the runway into the grass. The results of the investigation showed that the failure had been caused by stress corrosion.

06/24/2013 Damage of a turbine engine (England)

During Airbus A330 running at the airport in Manchester, at a speed of 190 km/h, the right engine caught fire. The investigation showed that there had been a fracture of one of the turbine blades. The blade failed due to high cyclic fatigue initiated by corrosion pitting.

08/19/2000 The explosion of a gas pipeline (New Mexico)

Near the city of Carlsbad, New Mexico, there was damage to the pipeline company El Paso Natural Gas Company. The released gas ignited and 12 people got killed. In the pipeline there was evidence of the existence of damage caused by corrosion.

12/12/1999 Sinking of the tanker Erika (Bay of Biscay / France)

On 12 December 1999, the oil tanker Erika broke in two and sank in the Bay of Biscay. There were no casualties. However, the oil spill led to a great environmental disaster. The main cause of the accident was significant corrosion of the internal structure of the vessel.

08/21/1995 ASA Embraer crash (Georgia / USA)

While climbing to a height of 5,500 m, an Embraer turboprop airplane of the ASA airline company, on flight 529, lost a propeller blade. The plane crashed near Carrollton, Georgia, killing 8 and injuring 21 people. A broken blade failed due to high cyclic fatigue initiated by corrosion pitting.

10/04/1992 EL AL Boeing 747 crash (Netherlands)

A cargo plane Boeing 747-258F operated by El Al crashed on a residential block in a suburb of Amsterdam with 43 human victims. After a takeoff, engine No 3 separated from the right wing and hit motor No 4. The reason for separating the two right engines is damage on an internal safety pin in the compound of engine No 3 carrier and the middle spar of the right wing, caused by corrosion pits and fatigue.

04/22/1992 Explosion of sewer (Guadalajara / Spain)

In a number of explosions of gas in the city sewerage system, 8 kilometers of streets were destroyed. 252 people were killed, nearly 1,500 were injured and 15,000 people were left homeless. Corrosion of water pipes caused water leaks, which subsequently caused the corrosion of gas pipes and gas leak into the sewer.

04/28/1988 Aloha Boeing 737 plane crash (Hawaii)

While flying at 8,000 m above the ground, a large segment of the upper fuselage of the plane was literally torn off making a big hole in the passenger cabin. The aircraft inspection found separation, corrosion and cracks in the lap joints of the fuselage skin.

12/03/1984 Bhopal accident (Bhopal / India)

Toxic glas was released into the atmosphere from the Union Carbide India Limited (UCIL) pesticide plant in Bhopal in the state Madhai Pradesh. The official death toll is 2,259, while unofficially the number is much higher, about 8,000. The main culprit for this disaster is corrosion.

05/10/1974 Sikorsky S-61N helicopter crash (North Sea)

In May 1974, a helicopter Sikorsky S-61N PH-NZD crashed into the North Sea, where six people were killed. A fractographic analysis of blade No 3 found that the blades broke due to high cyclic fatigue initiated by corrosive pitting.

01/06/1974 Flixborough disaster (Lincolnshire / England)

A massive explosion rocked the Nypro plant in Flixborough, England. The explosion was caused by a burning vapor cloud formed by leaking cyclohexane from one of the reactors. The explosion and subsequent fire damaged the plant, which resulted in 28 deaths. The metallurgical tests showed that the critical crack in the reactor had been caused by stress corrosion.

12/15/1967 Demolition of the Silver Bridge (Ohio river / USA)

Point Pleasant bridge that connects West Virginia and Ohio, known as the Silver Bridge, collapsed on 15 December 1967. The accident resulted in 46 fatalities and 11 serious injuries. The disaster was caused by stress corrosion of the compound of the bridge construction and the bridge chain.

The article further presents in detail several catastrophic accidents, in which corrosion was responsible for the occurrence of failure and losses of human lives, from one to several thousand lives.

Aloha Boeing 737 plane crash

Structural damage to the plating on the Boeing 737 aircraft, operated by the US airline Aloha Airlines, which took place on 28 April 1988, undoubtedly contributed to the creation of awareness of aircraft aging. This aircraft suffered very serious damage caused by explosive decompression during flight. At 8,000 m above the ground, a large segment of the upper fuselage was literally torn off and it made a big hole in the passenger cabin (Miller, 1990).

Figure 1 – Simulation of the flight of an airplane Boeing 737 Aloha Airlines, Flight 243
Рис. 1 – Моделирование полета самолета Boeing 737 Aloha Airlines Flight 243
Slika 1 – Simulacija leta aviona Boeing 737 Aloha Airlines Flight 243

The crew landed the plane safely on the island of Maui in Hawaii. One flight attendant got killed, while 65 out of 94 survivors were injured. In the remaining structure of the aircraft, in several lap joints of the fuselage skin, in the holes of the upper row of fasteners, subsequent investigations discovered more cracks caused by fatigue (Wildey, 1990).

In the skin of the Aloha Boeing 737 aircraft, multiple damage was found in the form of cracks caused by fatigue which had led to the final structural damage. The report of the National Committee for Traffic Safety, made after the completion of the investigation in 1989, attributed the responsibility for the incident to the program of maintenance and detection of damage from corrosion. Earlier, in 1981, a similar plane suffered an in-flight break-up with more than one hundred fatalities. Investigations have indicated the existence of damage mechanisms to the fuselage skin panels caused by fatigue assisted by corrosion (http://www.corrosion-doctors.org/Aircraft/Aloha.htm).

Lap joints join large panels of the fuselage skin together and run longitudinally along the fuselage. Fatigue cracking was not anticipated to be a problem, provided the overlapping panels remained strongly bonded together. A review of other similar aircraft discovered separation, corrosion and cracks in the lap joints.

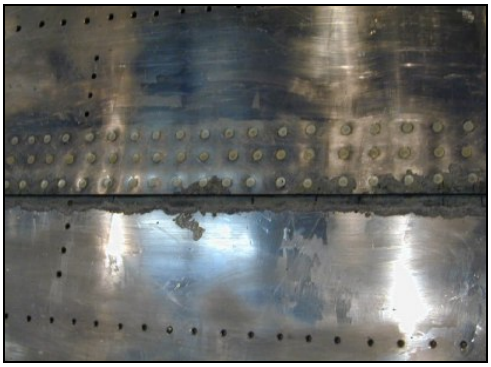

Figure 2 – Fuselage skin of the Boeing 737 Aloha
Рис. 2 – Обшивка фюзеляжа самолета Boeing 737 Aloha
Slika 2 – Oplata trupa aviona Boeing 737 Aloha

Figure 2 clearly shows that the corrosion process and subsequent extensive accumulation of corrosion products within the lap joints led to the creation of so-called "pillowing", which finally led to the separation of the contact surfaces and uplifted the fuselage skin panels above the surface of the rivet heads (Komorowski, 1996).

This accident drew attention of aviation inspectors to airplanes of somewhat older age. The Aloha plane had flown for 19 years in a very

unfavorable environment which is favorable for corrosion, typical for interislands aircraft. With an average flight duration of 20 to 40 minutes, the plane had 88,000 take-off-landing cycles.

El Al Boeing 747 crash

In October 1992, an El Al Boeing 747-258F cargo plane crashed on an apartment block in a suburb of Amsterdam with the loss of 43 lives and many injured.

About five minutes after the take off, engine No 3 and its pylon separated from the right wing in an outboard and rearward direction. Engine No 3 hit engine No 4, causing this engine and its pylon also to separate from the wing. Both engines and pylons fell into a lake about 25 km of Schiphol. During the engine separations, the wing leading edge was extensively damaged. This damage and loss of the two engines made control of the aircraft extremely difficult. An attempt was made to return to Schiphol, but tragically to no avail.

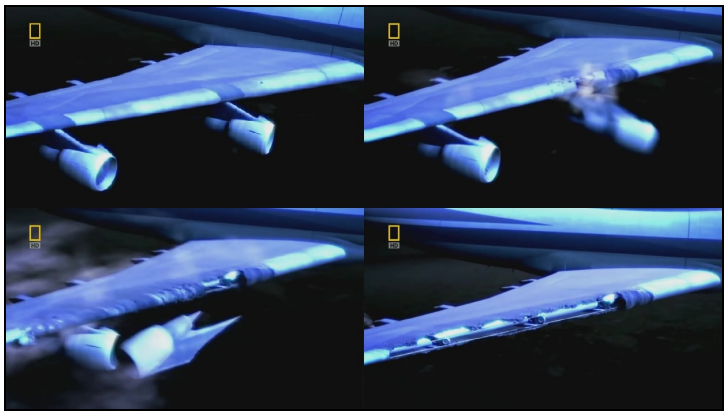

Figure 3 – Simulation of the El Al Flight 1862 crash in Amsterdam
Рис. 3 – Моделирование аварии самолета El Al Flight 1862 в Амстердаме
Slika 3 – Simulacija udesa aviona na letu 1862 avio-kompanije El Al u Amsterdamu

The investigation of the accident involved a variety of organizations, including manufacturers of aircraft and engines, the operator of the aircraft, airtraffic authorities, the National Aerospace Laboratory - NLR from Amsterdam, etc.

The NLR's Department of Structures and Materials was responsible for investigating the components connecting engine No 3 pylon on the right wing. It turned out that these components were the key to explaining this complicated accident (Wanhill, 2009).

A possible reason for the shearing away of the two right engines is damage to an internal safety pin of the mid spar (Figure 4) caused by corrosion pits and fatigue.

Pitting corrosion is defined as an extremely localized corrosion attack leading to the formation of corrosion holes (pits). Very small (limited) metal surfaces are subject to pitting corrosion, while the rest of the surface is in a stable, passive state, which leads to the creation of damage - spots, holes, pits, and craters. Pits are formed in the places of destruction of passive films on metal surfaces.

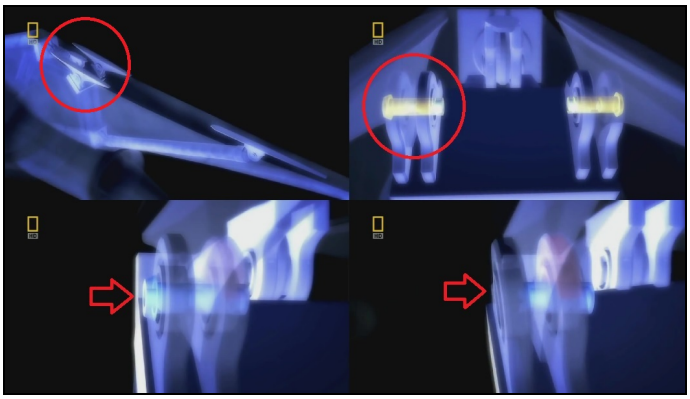

Figure 4 – Internal safety pin of the mid spar
Рис. 4 – Внутренний предохранительный штифт среднего лонжерона
Slika 4 – Unutrašna sigurnosna osovinica srednje ramenjače

The inboard and outboard pylon fittings and the partial fuse pin were made of AISI 4330M low alloy steel. The inboard pylon fittings were made of high strength steel 1517 – 1655 MPa, and the safety pin was made of medium strength steel 869 – 958 MPa. This design of the fuse pin had been used from 1982 and in a seven year period there were fifteen reports of cracked pins (http://www. corrosion-doctors.org/Aircraft/el-al.htm).

After this accident, Boeing introduced several changes for the pylon-to-wing connections, including a newly designed safety pin made of corrosion-resistant stainless steel.

Sikorsky S-61N helicopter crash

In May 1974, the helicopter Sikorsky S-61N PH-NZD crashed into the North Sea, and six people were killed. Figure 5 shows the crashed helicopter during its recovery from the water. All the main rotor blades were broken, but blade No. 3 was an exception because of low deformation at the fracture (indicated in Figure 5).

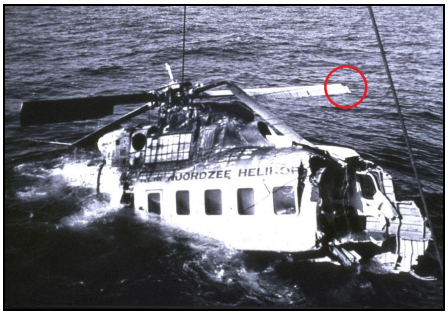

Figure 5 – Recovery of the helicopter Sikorsky S-61N PH-NZD from the North Sea
Рис. 5 – Извлечение вертолета Sikorsky S-61N PH-NZD из Северного моря
Slika 5 – Spasavanje helikoptera Sikorsky S-61N PH-NZD iz Severnog mora

Figure 6 shows a cleaned fracture surface of the blade spar No.3, made of aluminum alloy AA6061-T6. The spar is adhesively bonded to the sheeting in the form of a ribbed aluminum pocket, as shown in Figure 6b. The fractographic analysis determined the phases of the spar fracture and their order. The first phase was high-cycle fatigue initiated by corrosion pits on the spar lower surface under the bonded area (indicated by the red arrow in Figure 6b) (Wanhill, 2009).

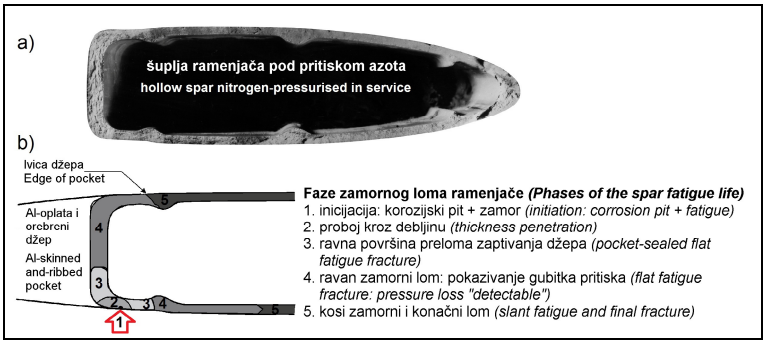

Figure 6 – Recovered blade spar fracture surface and the phases of the fatigue life
Рис. 6 – Поврежденная поверхность лонжерена лопасти и фазы усталости
Slika 6 – Oštećena površina preloma ramenjače lopatice i faze zamornog loma

Bhopal accident

Bhopal is probably the biggest industrial disaster in history. In the period between 1977 and 1984, the Union Carbide India Limited (UCIL) pesticide plant, located at a distance of 5-6 kilometers from the center of Bhopal, the state of Madhai Pradesh, was producing phosgene, monomethyl amine (MMA) methyl isocyanate (MIC) and the pesticide carbaryl, known as Sevin (http://www.corrosion-doctors.org/Pollution/ bhopal.htm).

In the night between 2 and 3 December 1984, there was a penetration of large amounts of water into the tank with methyl isocyanate (MIC), with over 40 tons of MIC. The addition of water into the tank caused a runaway chemical reaction, resulting in a rapid rise in pressure and temperature. Heat generated by the reaction, chloroform concentrations higher than normal and the presence of an iron catalyst caused by the corrosion of the stainless steel tank wall, resulted in the opening of the safety valve. Toxic gas composed of MIC, hydrogen cyanide, monomethyl amine, carbon monoxide and other chemicals was released into the atmosphere. The wind blew the cloud of gas and more than 500,000 people were exposed to toxic effects of its ingredients. The parts of the town with dilapidated houses surrounding the plant were most affected, and the victims were exclusively from poor communities. The official death toll is 2,259, while unofficially the number is much higher, about 8,000.

Figure 7 – Elements of the UCIL pesticide plant in Bhopal
Рис. 7 – Завод по производству пестицидов UCIL в Бхопале
Slika 7 – Elementi postrojenja za proizvodnju pesticida UCIL u Bopalu

As already mentioned, the immediate cause of the chemical reaction was the rush of 500 liters of water into the MIC storage tank. Many researchers and scientists have agreed that the corrosion of the pipelines and other safety equipment are the main culprit for this disaster. The following facts support this statement (Nitin, nd):

- MIC was stored in three double-walled stainless steel tanks, codenamed 610, 611 and 619. One of the third shift workers noticed that the pressure in tank 610 (the tank from which all MIC leaked) increased from 2 psi as it had been recorded one hour before, in the previous shift, to about 10 psi. Pressure increase for more than five times in an hour was not taken seriously because of the belief that the instrument for measuring pressure was faulty. Shakil Qureshi, the supervisor on duty, said later: "The instruments were often not working. They were corroded."

- How water entered the pipeline connected to the MIC tank made of stainless steel is a different story, but its entry inside the tank was related to improper maintenance of the valve between the pipeline and the tank. In this case, the valves were made of carbon steel which easily corrodes in acidic media, which actually happened in the factory. In addition, sliding back panels, which should have prevented the entry of water through faulty valves had not been installed.

- The exact sequence of events in the tank remained unexplained. The Carbide's report states that what happened was a unique combination of large amounts of water (120 to 240 gallons), chloroform in an amount greater than normal (a few percent instead of the maximum of 0.5%) and an iron catalyst, which led to a violent reaction in the MIC. The heat released by the reaction of water and MIC raised the temperature in the tank. At the same time, the reaction was accelerated by iron as a catalyst, resulting from the corrosion of the tank wall under the influence of high temperatures. The UCIL claimed that the corrosion rate was significantly increased due to the presence of an incredibly high level of chloroform. The rapid release of carbon dioxide in large quantities then helped to build up high pressures, which forced the foaming mass of chemicals out of the tank.

- The final blow was the fact that the tower designed to burn MIC was not usable due to the corrosion of a pipe which had not been replaced.

The explosion of a gas pipeline

On August 19, 2000, a 76 cm diameter natural gas transmission pipeline operated by the El Paso Natural Gas Company (EPNG) ruptured adjacent to the Pecos River near Carlsbad, New Mexico. The released gas ignited and burned for 55 minutes. Twelve persons who were camping under a concrete-decked steel bridge that supported the pipeline across the river were killed and their three vehicles destroyed. Two nearby steel suspension bridges for the pipeline crossing over the river were quite damaged. According to the EPNG, the damage amounted to $ 998,296.

The force of the rupture and the violent ignition of the escaping gas created a crater 16 meters wide and blew out three large pieces of the pipeline. All three ejected pieces showed evidence of internal corrosion damage, but one of the pieces showed significantly more corrosion damage than the other two. Corrosion pits were visible on the inside surface of this piece, and the pipeline wall was significantly thinned at several locations. A perforation of the wall was visible at one location. No significant corrosion damage was visible on the outside surfaces of the three pieces or on the two ends of the pipeline remaining in the crater (National Transportation Safety Board, 2003).

Figure 8 – The crater that was created in the explosion
Рис. 8 – Кратер, образованный в результате взрыва
Slika 8 – Krater koji je nastao prilikom eksplozije

Interconnecting pits were observed on the inside of the pipe in the ruptured area (Figures 9 and 10). Striations characteristic for microbiological corrosion were observed in these pits. A pit profile showed that chloride concentration in the pits increased steadily from the top to the bottom. Increased concentrations of chloride can be caused by some kind of microbial activity. All four types of microbes (sulfate reducing microbes that produce acid, aerobic and anaerobic) which may affect the corrosion process, were found in the samples collected from the pits in one piece from line 1103 with internal corrosion, discovered after the incident 630 m away from the place of explosion. Although the individual contribution of various microbes in the corrosion process could not be estimated, the damage morphology and the corrosion product analyses data suggest that microbiological activity contributed to the corrosion process (Nitin, nd).

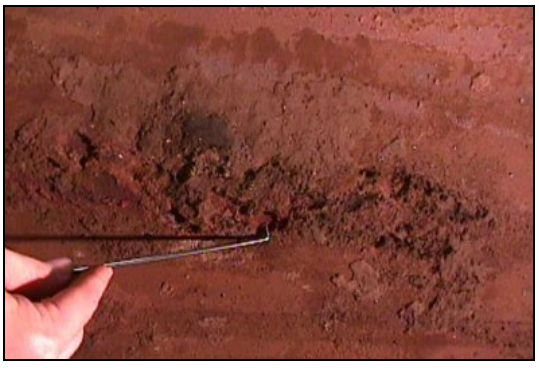

Figure 9 – Corrosion pitting on the inside of the pipe near the rupture site
Рис. 9 – Питтинговая коррозия на внутренней стенке трубы в зоне разрыва
Slika 9 – Piting korozija na unutrašnjoj strani cevi u zoni kidanja

The El Paso Natural Gas Company (EPNG) committed itself to spend $ 86 million on the replacement of 10,000 miles of the gas pipelines destroyed in the incident. Also, after this accident, the EPNG company developed a program to train staff on internal corrosion and implemented a program for integrity management which applies to 46,000 miles of the gas pipelines of the company. The EPNG identified 60 segments of the pipelines with the estimated risk of internal corrosion. These segments were inspected by non-destructive methods and internal corrosion was discovered on 8 pipelines. In the metallurgical laboratory of the company, on one of these lines, the experts found general internal corrosion which had reduced the thickness of the pipe wall for about 42% (https://abduh137.wordpress.com/2008/04/28/the-50-major-engineering-failures-1977-2007-part-3).

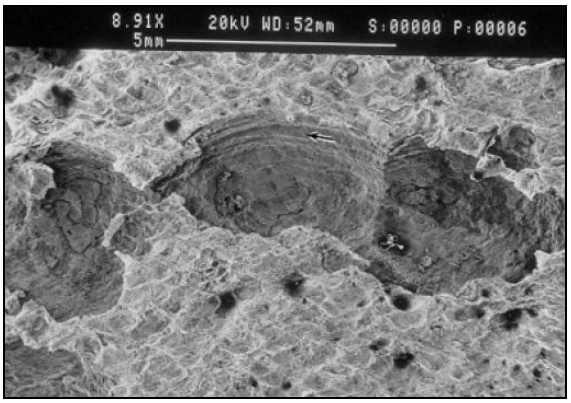

Figure 10 – Microscopic view of a corrosion pit in the Carlsbad pipeline
Рис. 10 – Микрографическое изображение питтингов на трубопроводе в Карлсбаде
Slika 10 – Mikrografski snimak korozivnog pita u cevovodu Carlsbad

Guadalajara sewer explosions

The explosions took place in Guadalajara on 22 April 1992, in the downtown district Analko. In a number of explosions of gas in the sewage system, 8 kilometers of streets were distroyed. Officially, by the Lloyd's of London accounting, 252 people were killed, nearly 1,500 were injured and 15,000 people were left homeless.

The sewer explosion was traced to the installation of the water pipe which had been placed above the gas installations several years before the explosion. The corrosion of the water pipes caused water leaks out of them, which subsequently caused the corrosion of the gas pipes and gas leaks in the sewers (Nitin, nd).

Figure 11 – Aftermath of the Guadalajara sewer explosions
Рис. 11 – Последствия взрыва канализации в Гвадалахаре
Slika 11 – Posledice eksplozije kanalizacije u Gvadalahari

Figure 12 – Corrosion pits in the water pipelines
Рис. 12 – Коррозийные питтинги на трубе водопровода
Slika 12 – Korozivni pitovi u vodovodnim cevima

The explosion in the Gaylord Chemical Corporation

On October 23 1995, at 15:55, at the Gaylord Chemical Corporation factory in Bagalusi, in Louisiana, there was a leak of yellow-brown steam out of the dome of the tank railway wagon. The tank contained a mixture of water and nitrogen tetroxide which is very toxic and corrosive. The initially formed "mushroom" of vapor had a diameter of 3-4 m. The staff of the factory notified the agency for emergency response and started the spraying of vapor by water from fire protection systems. Around 16:30 a fire crew arrived at the factory.

At 16.45, damage occured to the rear of the tank wagon, resulting in breaking of a part of the tank jacket and its rejection at about 350 m. At the same time, the tank wagon started to move, and after a 35 m ride, it derailed. A large red-brown cloud of steam was released from the tank. Vapors proceeded to go out through the hole in the tank wagon for the next 36 hours, until the chemical reaction was not put under control. Out of 4,710 people admitted to local hospitals, 81 were kept for treatment (http://www.corrosion-doctors.org/ProcessIndustry/Bogalusa-explosion.htm).

Prior to the accident on 12 October 1995, nitrogen tetroxide was decanted from the rail tank to a storage tank. While this transfer was taking place, the material from the storage tank was simultaneously

being transferred into the plant. At 09:00, the security system switched off the chemical reactor. The internal investigation into the cause of the security interruption of work of the chemical reactor revealed that nitrogen tetroxide had been contaminated by water. In order to prevent corrosion damage caused by the action of nitric acid, formed in the reaction of water with nitrogen tetroxide, the Gaylord management had decided to relocate the contaminated material from the tank wagon and the storage tank into the stainless steel cargo tank.

Overnight, between October 12 and 13, 1995, the measuring instrument showed that about 38,200 liters of the product were transferred from the storage tank into two cargo tanks. No other check was made on the storage tank or the cargo tanks to determine how much material had been transferred. When the transfer operation was finished, a material sample was taken from the transfer system. The sample contained a small amount of green liquid and foam. At 4:00 on 13 October, believing that the tank wagon was empty, factory employees poured water into it to dilute a – what was believed to be - small amount of residual material that had remained in the tank to push it along the transfering pipe. Measurements after the accident showed that only 1,900 liters of material had been transferred into the cargo tanks, while the testing of the tank wagon after the accident showed that the transfering pipes were corroded and that only a small portion of each pipe near the top of the tank remained intact.

On October 19, the material samples obtained from the tank wagon and the three cargo tanks were taken to the Vicksburg Chemical Company for a chemical analysis. On October 20, the Gaylord employees began the transfer of the remaining material from the tank wagon, and by 18:00 that day, the mesuring instrument indicated that 25,400 liters of the material had been transferred from the tank wagon to the cargo tank. At the end of the transfer, the sample of material taken from the transfer system showed the presence of a small amount of foam and green liquid. Measuring of the material transferred into the the cargo tank, conducted after the accident, revealed that only about 3,200 liters of the material had been transferred.

Water for cleaning and washing the tank wagon was poured into it with a fire hose. Adding water was stopped when the pressure in the tank wagon reached a value of 4-4.5 bar. Gaylord employees vented out steam and reduced the pressure in the tank. Later, in the evening of 20 October, the staff in charge started emptying the tank wagon into the factory sewage system. After 2 or 3 minutes, a large vapor cloud was released, and the unloading was stopped. On 21 October, the workers added water twice in order to dilute the material in the tank wagon and they vented the tank. Every addition of water resulted in an increase of pressure in the tank.

On October 23, the measuring instrument on the tank wagon showed that the internal pressure was 1.24 bar. At 12:54 p.m., the Gaylord company received the results of the chemical analysis of the material sample obtained from the tank wagon on October 19. The results indicated that the material

was nitrogen tetroxide. These results were unexpected because it was believed that on October 13 nitrogen tetroxide had been unloaded from the tank wagon and that the minimum residue had been diluted with water. The Gaylord staff concluded that there was an error in the Vicksburg Chemical Company during the chemical analysis and that the analyzed sample had not been the one taken from the material from the tank wagon.

Between 13:30 and 13:45 On October 23, the workers add more water into the tank wagon, and in 4-5 minutes the internal pressure increased from 1.2 bar to 5.5 bar, after which pouring water was stopped. Around 14:00, the pressure reached a value of 6.3 bar and began to decline slowly. At 14:30, the internal tank pressure was 3.8 bar. When one of the workers reused a fire hose and started pouring water again, the pressure increased to 7 bar, which was the maximum value of the measuring instrument. Water was turned off and the vapors were again vented. At 15:00, it seemed that the pressure was decreasing. However, at 15:30, the pressure was still over the limit and it began to rise again. At 15:55, yellow-brown vapor was observed leaking from the dome of the tank wagon. At 16:45, damage occurred to the rear of the tank wagon, resulting in the release of a huge red-brown vapor cloud. The examination conducted after the accident revealed a corroded opening 20 cm high and 170 cm wide at the head of the rear of the tank wagon, near the top of the tank. In addition, at least three distinctive horizontal bands of corrosion were found near the top of the interior tank wall, whereby one band was at the same level as the opening in the tank head (http://www.corrosion-doctors.org/ProcessIndustry/Bogalusa-explosion.htm).

Conclusion

Although the mankind made remarkable progress in the last century, there have been cases stemming from this development and leading to losses of human lives. Corrosion in itself is not important, but the consequences of corrosion failure may be very serious. This paper presents the events in which corrosion was responsible for the loss of human lives. The investigations showed that the described disasters were the result of a combination of legal, technological, organizational and human errors. It has also been shown how much control and prevention of corrosion are important in order to prevent both financial losses and losses of human lives.

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КАТАСТРОФЫ В РЕЗУЛЬТАТЕ ВОЗНИКНОВЕНИЯ КОРРОЗИИ

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ОБЛАСТЬ: материали, химические технологии
ВИД СТАТЬИ: обзорная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Проблема разрушения металлических материалов вследсдтвие возникновения коррозии привлекает большое внимание уже долгие годы. Опыт показал, что отказы инженерных сетей в результате воздействия коррозии являются важной проблемой, а согласно статистике мирового уровня выявлено, что ущерб от воздействия коррозии в промышленно развитых странах составляет 4-5% национального дохода. В связи с данной проблемой, на годовом уровне выделяются средства на предупреждение и контроль коррозийного воздействия. Игнорирование опасности от коррозии влечет за собой финансовые потери, а в отдельных случаях и человеческие жертвы.

В данной работе представлено несколько случаев масштабных отказов инженерных сетей и установок вследствие коррозийного воздействия, которые унесли сотни человеческих жизней.

Ключевые слова: *катастрофа, отказ, коррозия, очаг коррозии, пестицид, взрыв, трубопровод, вертолет, самолет.*

KATASTROFE IZAZVANE KOROZIJOM

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OBLAST: materijali, hemijske tehnologije
VRSTA ČLANKA: pregledni članak
JEZIK ČLANKA: engleski

Sažetak:

Problemu korozivnog oštećenja i razaranja metalnih materijala već godinama se posvećuje velika pažnja. Svetska statistika pokazuje da je šteta koja nastaje usled delovanja različitih oblika korozije ogromna i da, na primer, u industrijski razvijenim zemljama dostiže 4 do 5% nacionalnog dohotka. Za prevenciju i kontrolu korozije izdvajaju se znatna sredstva na godišnjem nivou. U slučaju ignorisanja problema korozije izriču se finansijske kazne, a može doći i do katastrofalnih posledica – gubitka ljudskih života.

U ovom članku predstavljeno je nekoliko slučajeva otkaza inženjerskih struktura i postrojenja katastrofalnih razmera, u kojima je korozija odgovorna za pojavu otkaza i pogibiju stotine ljudi.

Ključne reči: *katastrofa, otkaz, korozija, korozivni pit, pesticid, eksplozija, cevovod, helikopter, avion.*

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MITIGATION OF SAFETY VULNERABILITY OF PEOPLE AND PROPERTY FROM THE EFFECTS OF EXPLOSIONS OF EXPLOSIVE MATERIALS IN THE SERBIAN ARMY

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Summary:

The aim of the research is to provide proactive mitigation of safety risk to people and property of the effects of explosions of explosive materials in the Serbian Army based on a large number of relevant collected data. Achieving these research goals requires the use of appropriate methods and techniques for understanding and studying the existing theoretical and practical solutions as well as proposing new solutions in the area of interest. The research includes possibilities to mitigate risk to people and property from the effects of explosive material explosions. These possibilities aim at reducing danger, risk and threat to the population, their property and the environment, as well as at mitigating the consequences of possible emergencies. The following methods have also been discussed: avoidance, retention, reduction, division, transfer and reduction of hazards, risks and threats, where for each method a detailed theoretical explanation is provided with appropriate examples of good practice. The formulated hypothesis is also being proven, with the aim to – with a scientific objectivity towards one's own research results - accept or reject the proposed methods.

Key words: *threat, danger, army, property, explosive.*

Introduction

One of the properties of explosive materials is that in a short period of time, under certain external influences, through chemical decomposition, they create a lot of pressure and release a lot of energy in the form of heat or gases capable of performing mechanical work over the environment and thus achieve the effect of explosion[1]. This chemical process partially or completely damages or destroys the environment in a closer or farther area, causing casualties and damage to material goods. Therefore, explosive materials are considered to be one of potential causes of safety vulnerability of people and property from the effects of explosions of explosive materials. Above all, since it is known that the majority of the Serbian Army personnel are exposed to some form of danger, risks and threats from explosion effects of explosive materials that can occur in different forms and affect the functioning of the whole system, opportunities for mitigating these phenomena become significant.

Since the process of mitigation of safety vulnerability of people and property from explosive material explosions is complicated, complex and interdisciplinary, and since it is not fully defined in relevant literature, this paper tends to comprehensively and systematically deal with all the relevant issues (with appropriate examples from practice) which affect the modern process of mitigation of danger, risks and threats. By analyzing the views of several authors[2] who were engaged in risk management and experience guidance[3], we have searched for a solution closest to the subject area in order to ensure improvement in the field of increasing the safety of people and property which is important for mitigation of explosion effects of explosive materials in the Serbian Army.

Mitigation of safety vulnerability of people from the effects of explosions of explosive materials

Mitigation of safety vulnerability of people and property from the effects of explosions of explosive materials is a mental process built on early detection and acknowledgement of danger, risk and threat from

[1] Explosives (lat. Exploder - decay) are gaseous, liquid or solid chemical compounds or mixtures which decompose under the influence of specific activation energy with the release of large amounts of heat and heated gases the expansion of which leads to an abrupt increase of pressure in a very short time interval. Explosives are materials used for demolition, divided into initial (primary) and brisant (secondary) ones (Radovanović, 2011).

[2] The emphasis in this paper is given in (Mijalkovski, Đorđević, 2010) and (Keković, Nikolić, 2006).

[3] Acquired during the period of temporary work by Dejan Stojanovic as a protection of resources officer in the 4th brigade of Land Forces, Vranje.

explosive material explosions based on the assessment of locations in which explosive materials can be found. In the decision-making process, before an actual explosion of explosive materials has occured, personnel in charge[4] tend to determine a character of real or potential safety vulnerability of people and property from explosive material explosions in order to make proper decisions and thus provide optimal protection to all the members of the Serbian Army. This is why each assessment needs to be objective since wrong or unrealistic assessments can lead to wrong decisions and pose danger, risk and threat to all the subjects in the system.

The research of the safety vulnerability of people and property from explosive material explosions in the Serbian Army has led to the assessment[5] that danger, risks and threats from the effects of explosive material explosions, in a certain period of time and under certain circumstances, can have an effect on the entire safety situation in the Serbian Army. This is why the personnel from commands, units and institutions have to decide on how to react in critical situations. They make their decisions in accordance with the existing structure and jurisdiction of the management and the executive department of the system of defence, defined by the Constitution of the Republic of Serbia, the Law on Defence and the Law on the Army of Serbia. The decisions are made in order to reduce the level of danger, risk and threat of explosive material explosions to the minimum, or to a moderate level. Methods for mitigation of safety vulnerability of people and property from the effects of explosive material explosions are recommended for the purpose of reducing the possibility of explosions with a disastrous outcome.

The proposed methods to mitigate safety vulnerability of people and property from the effects of explosions of explosive materials are: avoidance, retention, impairment, division, transfer and reduction of hazards, risks and threats (Figure 1).

[4] Persons who are, in accordance with laws and regulations, authorized to govern or command military units (institutions), commands, units or institutions i. e. their personnel. Other persons in units (institutions) are subordinates. Superiors are those with higher ranks. If they are of the same rank or without ranks, a superior is the one on a higher level of duty, and if they are on the same duty level, the superior one is the one who has been promoted first (Pravilo službe Vojske Srbije / Service Regulations of the Serbian Armed Forces, 2008, p.10).

[5] The assessment of the situation of vulnerability of people and property from the effects of explosions of explosive materials in the Serbian Army, made in earlier assessment stages, has shown that the level of hazards, risks and threats from the occurrence of the effects of large explosions of explosive materials is high and as such is not acceptable for the Serbian Army (Stojanović, 2015, p.159).

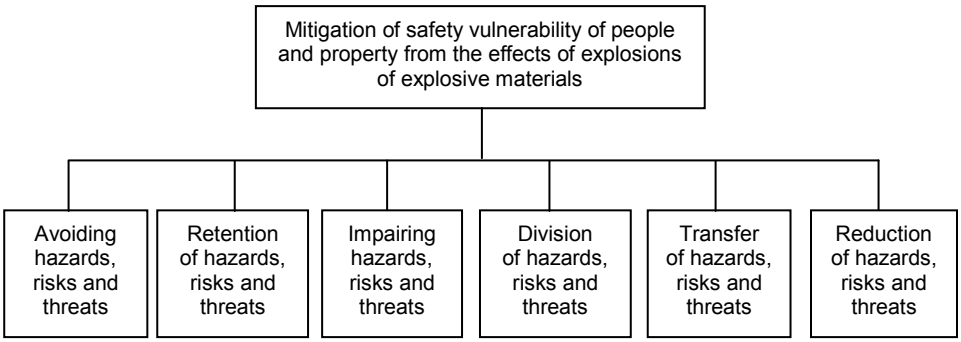

Figure 1 – Methods for mitigating safety vulnerability of people and property from the effects of explosive material explosions
Рис. 1 – Методы по предотвращению и смягчению последствий взрыва взрывчатых средств
Slika 1 – Metode za ublažavanje bezbednosne ugroženosti ljudi i imovine od efekata eksplozije eksplozivnih sredstava

In this case, mitigationof safety vulnerabilityof people and property from the effects of explosionsof explosive materials includes a theoretical treatment of certain methods applied in practice in a combination with several others (when they depend on each other) or individually when referring to a specific event. Which of the proposed methods will be applied in a particular period and to what extent will be a decision of the commander or other persons responsible for mitigating safety vulnerability of people and property from the effects of explosive material explosions at a critical moment. It is necessary to provide a continuous adjustment of planned methods to new conditions in order to mitigate potential hazards, risks and threats of unwanted events as much as possible and to prevent possible human casualties due to explosive material explosions.

Avoiding hazards, risks and threats

It is possible to put the mitigation of hazards, risks and threats by avoidance into practice only by avoiding an activity for which it is estimated that can lead to the explosion of explosive materials. This assessment is made by commanders of particular units or by the Ministry of Defence who observe to what extent the safety measures have been violated and can lead to potential dangers, risks and threats from explosions of explosive materials. After that, the decision is made to avoid certain activities in order to overcome the situation. It has to be kept in mind that avoiding the implementation of one activity may lead to a creation of other hazards, risks and threats from the occurrence of the effects of explosions of explosive materials. Therefore, the basic rule is

that it is best to put into practice an activity the damage of which is estimated to be of lower intensity, and avoid danger, risk and threat likely to cause damage of higher intensity. In some instances, this is the only possible practical alternative.

Example: There is a real danger, risk and threat from the effects of explosions on the *Combined-Arms training ground "Pasuljanske livade" due to unexploded ordnance that can be foundon the training ground around the Krcora hill, where targets are placed (while performing tactical exercises with live firing). The most acceptable method that mitigates any danger, risk or threat of explosion effects of explosive devices at the test site is to put a target in a safer place to avoid any form of danger, risks and threats of having effects of explosions of explosive materials.*

It should also be noted that the Serbian Army completely alleviates dangers, risks and threats by avoiding activities assumed to bea cause of unwanted events. In some cases this can be effective, but not practical for the functioning of the Serbian Army which represents defence system armed forces and the armed opposition to military and non-military[6] forms of en dangering the state security (Keković, Nikolić, 2006, p.421). Therefore, it is necessary to avoid only those forms of danger, risks and threats with assessed high probability of unwanted events occurrence during the effects of explosion.

Retention of hazards risks and threats

While working with explosive devices, individuals as well as entire teams are faced daily with virtually unlimited hazards, risks and threats mitigated by subconscious or conscious retention. If individuals or teams during the implementation of tasks in such work environment are not aware that they are exposed to hazards, risks and threats from the appearance of the effects of explosive material explosions, then in such situations they subconsciously react to danger, risk or threat, since the brain creates a defense mechanism that warns them against risk at a certain point and sends signals that they should be careful to avoid any unintended consequences. In such situations, danger, risk and threat are subconsciously retained, which in certain jobs (such as jobs with special working conditions[7] or, jobs that cannot be avoided due to their

[6] The strategic documents of potential challenges, risks and threats to national security are defined and may be of a military (aggression, armed conflicts, armed rebellion escalation of terrorism and other conflicts with the use of weapons) and anon-military nature (national and religious extremism, organized crime, corruption, natural disasters, industrial and other accidents and epidemics).

[7] Jobs with special working conditions include jobs with particularly difficult tasks, dangerous to life and health, harmful jobs, or jobs in which professional military personnel are exposed to specific efforts and increased risks.

importance) is not enough, so each activity needs to be consciously considered during work. In such a case, individuals or teamsaware of hazards, risks and threats do not want to accept them to the extent required from them in order to put the entire activity into practice, so they consciously postpone the activity when they estimate that their lives are in danger from the explosion of explosive materials, until the change of a decision. This is how a safety situation is created for the continuation of planned activities and the safety of people and property is increased.

Example: *An order was issued by the superior command thattargets should be placedon Krcor hill. When issuing orders, a superior is required to consider whether they can be carried out or not (Pravilo službe Vojske Srbije / Service Regulations of the Serbian Armed Forces, 2008, p.20). Targets are placed at designated places, and attention is subconsciously paid to movement areas and the place where targets are set. But if prudent thinking, perception and reasoning prevail, then it is easy to realize that the area in which the target is placed is very risky to stay in, because of unexploded projectiles which can be activated due to negligence and cause unwanted consequences. In such situations, an individual deliberately slows down the implementation of the task and points to the problem in order to change the decision or possibly correct it. In a situation where the decision is not changed, the task is subconsciously completed or consciously rejected because it threatens the safety measures. After wards, the explanation for such behavior and task rejection is given to the superior command.*

As a rule, hazards, risks and threats mitigatedby conscious retention result in unwanted events with relatively small human and material losses, and as such are favorable for the Serbian Army, while dangers, risks and threats mitigated by subconscious retention result in greater human and material losses and as such are not favorable for the Serbian Army. It is certain, however, that retention of hazards, risks and threats is not desirable in the case of severe hazards, risks and threats, and is acceptable only in a situation where the probability of occurrence of hazards, risks and threats is small (Karović, Komazec, 2010, p.237).

Impairment of hazards, risks and threats

Impairment of hazards, risks and threats from the occurrence of the effects of explosive material explosions can be put into practice only if the activity in the workplace is interrupted when the human body experiences too much physical and psychological stress. Practice has shown that most of damage caused by the explosion of explosive materials in the Serbian Army occurred due to the weakness of the human organism during increased physical and mental strain. Creating appropriate working

conditions and organizing living and working as intended, in line with the tasks and conditions of units and institutions of the Serbian Army, reduces the load on the human body. The load during working processes and the objective capabilities of the human organism are often in great discord which results in fatigue, tiredness, exhaustion, moodiness, tension and the lack of desire to work. Therefore, in areas where there is increased danger, risk and threat of the occurrence of the effects of explosionsof explosive materials, the following measures should be taken: making more frequent breaks, reducing work intensity and improving the functioning of the system by adapting the work process to real conditions (this can be achieved by adjusting the maximum speed of work to the workflow, adjusting the working temperature to the working conditions, reducing the noise to the permitted level, etc.). The Serbian Army has very responsible and complex tasks: to create a system functioning in the prescribed working conditions as well as to enable and motivate individuals to work in certain situations based on defined working conditions, thus preventing human and material losses.

In order to reduce threats, risks and hazards from the explosions of explosive materials, it is important for the commander or other persons responsible for making decisions in critical situations, to make decisions on the working process until the moment when the body fatigue appears due to in adequate working conditions. This is the way to reduce the number of accidents (frequency) or the amount of danger (intensity), because it is virtually impossible to fully prevent all losses.

Example: *One member of the military personnel did not make a right decision while clearing the remaining cluster bombs on mountain Kopaonik. On that day when he became an invalid, he had already destroyed 106 cluster bombs. There was one more, 107th, a fatal one which had a contactless, seismically activating fuze. If he had stopped working when experiencing fatigue due to in adequate working conditions, he would probably have both hands now. This is just one of many events having occurred in recent years.*

Therefore, in order to reduce hazards, risks and threats from explosions of explosive materials, it is important to recognize moments of too much physical and mental pressure and to stop work in order to reduce consequences from unwanted events, i.e. minimise material and economic losses.

Division of hazards, risks and threats

Mitigation of hazards, risks and threats by division is conducted by dividing hazards, risks and threats from explosion of exlosive materials into several partial, less dangerous hazards, risks and threats which are individually much easier to control. This is how unwanted events are

restricted in intensity and area so that human losses and material damage are kept to the minimum.

Example: *Instead of storing explosive materials in one warehouse (storage area) of larger capacity, it is better to store them in two warehouses of smaller capacity placed at a sufficient distance from one another*[8] *in order to prevent the effects of an adverse event which may occur in one warehouse to affect what is stored in the other one.*

The division is also carried out during some operational activities. It is essential that a Serbian Army unit planning to work with explosive materials consider the question of danger, risks and threats from the effects of an explosion and divide the activity into smaller partial operations.

Example: *In the Department of Operations of Unexploded Ordnance, the biggest problem for deminers is to assess the fuze condition, because they cannot see inside the fuze mechanism and the phase its arming is in. Aware of the importance and the responsibility for the work they do (in their case there is no second attempt), they are forced to perform the job slowly, with the division of their work into several partial operations. Therefore, the demining of unexploded explosive devices cannot be simultaneously operated by two or more men, but only by one at a time, and to a certain moment, after which that person is replaced. Another member of the team waiting for his turn to continue demining explosive devices assists the deminer, while the other team members are in the shelter. They use IT support from the headquarters to search the database for missiles and fuzes based on the information they get from the field. Deminers must be fully concentrated since any mistake could be fatal.*

In the process of decision making, breaking perceived dangers, risks and threats of the effects of explosive devices down into several partial hazards, risks and threats, or dividing them into several partial activities, is sometimes the only solution to avoid unwanted events.

Transfer of hazards, risks and threats

Mitigation of hazards, risks and threats from exlosions of explosive materials by transfer is obtained when hazards, risks and threats are transferred from one person to another person or to an organization. Hazards, risks and threats from explosions in the working environment are, therefore, transferred from one person, who is not certain of his or

[8] Inter-warehouse distances are distances between adjacent warehousesin which explosive materials are stored. The minimum permitted separation distances between the warehouses are those that effectively protect against transmission of the explosion from one warehouse to the adjacent one, where the presence of staff is not taken into account (Upustvo za rad skladišta ubojnih sredstava / Manual for ordnance warehouses, 2002, p.63).

her ability to accept hazards, risks and threats to the requested extent,to another person or organization ready to take responsibility in such a situation. Thisother person ororganization differs from the first one in the level of decisiveness, readiness and dedication. The one to whom the hazards, risks and threats of the explosion are transferred to consiously accepts responsibility that the one who they were transferred from wants to avoid, and therefore is trying to mitigate or fully eliminate the possibility of their occurrence in order to increase the safety of peple and property. The person accepting this needs to be more experienced and skilled in the field of hazards, risks and threats and ready to take full responsibility.

Example: *Artillery firing from a self-propelled 122 mm howitzer is taking place on the military training ground "Pasuljanske livade". A battery commander is in charge of firing. If the first projectile is unobserved firing, then the division commander as the most responsible and the most experienced officer, finds that a blunder has occurred and continues firing until an observed hit occurs. The commander of the division thus takes responsibility for the action and prevents occurrence of unwanted situations.*

Hazards, risk and threats from the effects of explosions of explosive materials are transferred to an organization by making an agreement or a contract on taking responsibility. One of the parties agrees to take responsibility in case of material damage or losses of human lives, which is sometimes inevitable. These agreements or contracts are concluded before the damage occurs (and must be realized in the stipulated period of time). This ensures that unexpected expenses or damage which occurred while performing the contracted activity, are reimbursed by the other party. In such situations, hazards, risks and threats are mitigated by transferring financial consequences of any explosive material explosions from the Serbian Army to some other organization. Organizations which accept these agreements first need to assess the frequency and intensity of possible risks they are taking, based on previous experience and accept all the conditions and actions in order the avoid the risk that has been passed on to them (Vujović, 2009).

Example: *The risk of explosions during demining of mines and cluster bombs left from NATO raids on Serbia was transferred from the engineering units of the Serbian Army to specialized companies and other organizations registered for these activities, with appropriate technical equippment and trained staff. Therefore, with a purpose of harmonizing activities related to humanitarian demining, the Mine Action Centre has been established in Serbia. The Mine Action Centre was founded in 2002, initially as a federal body within the Ministry of Foreign Affairs, and in 2003, by a respective government decision, it became a body at the republic level, first as a government department, and later as a separate organization. It investigates locations suspected of being*

contaminated by cluster munitions, landmines and other unexploded ordnance, develops projects for demining, submits them to donors or international foundations to ensure donations for their implementation, performs quality control of demining, performs international cooperation, ensures the implementation of international standards and the implementation of international agreements and treaties (Centar za razminiranje / Mine Action Centre, http://www.czrs.gov.rs/lat/o-nama.php).

At workplaces where hazards, risks and threats of the effects of explosive material explosions become increasingly common, many persons resort to transferring the decision-making process to another person or they resort to signing fixed-contract agreements with other organizations ready to take the risk for a certain amount of financial compensation.

Reduction of hazards, risks and threats

The most efficient way of mitigating hazards, risk and threats by reduction is to implement preventive actions to reduce the frequency or intensity of consequences in order to affect any possible occurrence of the effects of explosive material explosions in the working environment (Keković, Nikolić, 2006, p.421). Prevention represents a series of activites directed to reduce the likelihood of the adverse event occurrence, i.e. to reduce a possibility of its occurrence, and reduce its consequences in case it does occur after all. These are the main characteristics and tasks of prevention and the only way to purposefully conduct prevention and ensure safety of people and property. Prevention of hazards, risks and threats tends to reduce material losses and human casualties that the Serbian Army has been facing lately. This depends especially on hazards, risks and threats in work environments where explosives[9] are involved. It is the Serbian Army's interest to widely implement activities that lead to the increse of general safety and quality of life of its members and to reduce expences for remediation of damage. Some events occur despite the greatest efforts of the Serbian Army to predict future scenarios of occurrence of unwanted events. This is why it is necessary to undertake certain steps to reduce their intensity to the minimum. Preventive actions

[9] The timeline of unfortunate events in the industry for the manufacturing of explosive devices in recent years was as follows: May 29th 2006, an explosion in "Prva Iskra" in Baric claimed three lives while three workers were injured; on September 4th 2009, in four powerful explosions in the gunpowder department of "Prvi Partizan" Factory in Uzice, seven workers were killed and thirteen were injured; on May 10th 2010, in the detonation in the "Krusik" Factory in Valjevo two workers were slightly injured; on December 27th 2010, a series of explosions in the "Sloboda" Factory in Cacak caused significant material damage; on September 21st 2011, June 25th 2012, and September 30th 2015, workers were injured in explosions in the "Milan Blagojevic" Factory in Lucani (Stojanović, 2015, p.153).

are implemented in order to reduce the consequences. A significant preventive action would be to issue a set of provisions which regulate protection from explosions at the Ministry of Defenceand in the Serbian Army, which would successfully determine the rules of behavior in the working environment, and also avoid the slightest possibility of the occurrence of the effects of explosive materials explosion.

Accepting and implementing international, primarily European, as well as the national rules and regulations in the field of protection from the effects of explosive material explosions, will provide well-regulated prevention and a possibility for quick and appropriate interventions. The activities will also be directed towards issuing technical rules and regulations on the methods of mitigating damageand providing functional integrity of all services. Cooperation, coordination and availability of information will increase the speed and efficiency of reacting to the occurrence of the effects of explosive material explosions in the Serbian Army.

Example: *A few years ago, explosions of explosive materials with the disastrous outcome occurred in the industry for manufacturing explosives. Those in charge then improved the safety program which includes the implementation of rules on functioning of the industrial system for manufacturing and trade of explosive materials and thus prevented human casualties and material losses. The Regulations on Fire Protection at the Ministry of Defence and in the Serbian Army prescribe that in the premises where explosive materials are stored certain preventive rules and regulations should be apllied in order to prevent any kind of safety vulnerability of people and property in the working environment (Službeni vojni list/Official Military Gazette, 2015). This contributed to avoidance of human casualties, reduction ofthe amount of damage, and reduction of intensity of the damage that had already occurred.*

In places where explosive materials can be found, appropriate methods of conduct had been prescribed, which resulted in avoiding unwanted events with the disastrous outcome, while material damage was reduced compared to previous years.

Results of the research and the discussion

In accordance with the subject of research and available information, this paper sets a hypothesis:

- Certain methods for the mitigation of hazards, risks and threats from the occurrence of the effects of explosive material explosions in the Serbian Army are applied in order to increase the level of protection of people's lives and health, material goods and the environment.

In order to prove the hypothesis using the research results, a survey[10] was conducted online (https://docs.google.com/forms/d/1bGmu-PnrT4YgOIIBiNOQ34jcGOcVWa8ahwiyLuDxsfI/viewform?usp=sendform). The aim of the survey was to assess to which extent each method for the mitigation of the effects of the explosive material explosions was really present in the workplaces of the Serbian Army members and during the training of the Military Academy cadets. The survey was based on the information gathered on the views and opinions of the respondents. From the survey results (Figures 2-8) it can clearly be seen that out of 117 surveyed members of the Serbian Army, at the moment of the decision-making, a high percentage of them decided to mitigate a hazard, risk and threat from the explosion of explosive materials in one of the proposed ways.

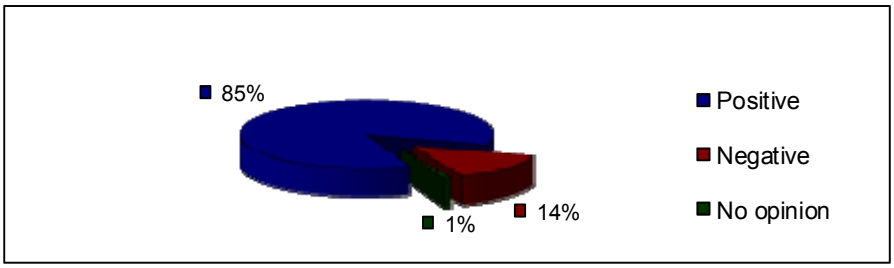

Figure 2 – Assessment of the avoidance of an activityfor which it is estimated to be able to lead to explosion of explosive materials
Рис. 2 – Оценка прекращениядеятельности, которая может привести к взрыву взрывчатых средств
Slika 2 – Ocena izbegavanja realizacije aktivnosti za koju se proceni da može dovesti do pojave eksplozije eksplozivnih sredstava

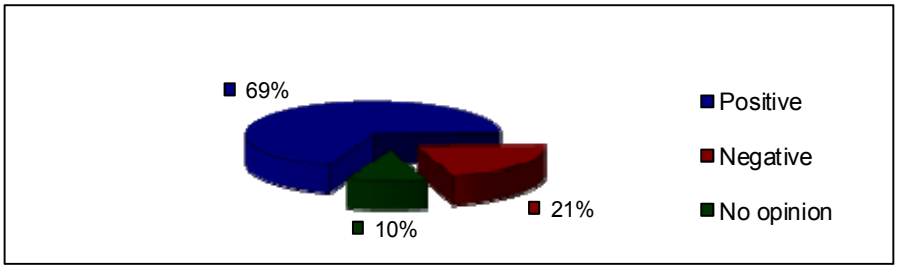

Figure 3 – Assessment of the mitigation of hazards, risks and threats from the effects of the explosion of explosive materials in a subconscious manner
Рис. 3 – Оценка смягчения опасности, рисков и угроз от взрыва взрывчатых средств, на подсознательном уровне
Slika 3 – Ocena ublažavanja opasnosti, rizika i pretnji od pojave efekata eksplozije eksplozivnih sredstava na podsvestan način

[10] From a large number of different definitions of the survey, the most acceptable is the Moser's definition: "The survey is a technical procedure for gathering factual material by combiningstatistical sampling with the method of interviews or questionnaires" (Mozer, 1962, p.5).

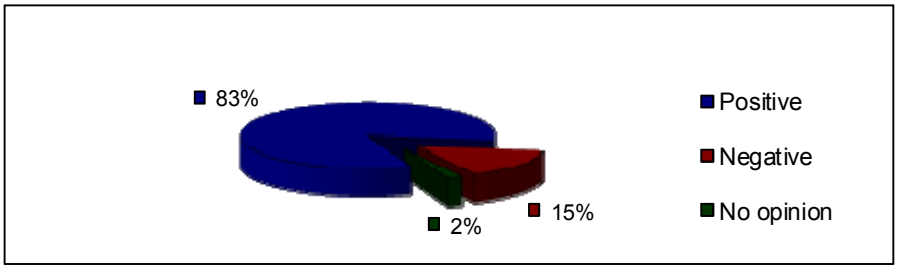

Figure 4 – Assessment of the mitigation of hazards, risks and threats from the effects of the explosion of explosive materials in a conscious manner
Рис. 4 – Оценка смягчения опасности, рисков и угроз от взрыва взрывчатых средств, на сознательном уровне
Slika 4 – Ocena ublažavanja opasnosti, rizika i pretnji od eksplozije eksplozivnih sredstava na svestan način

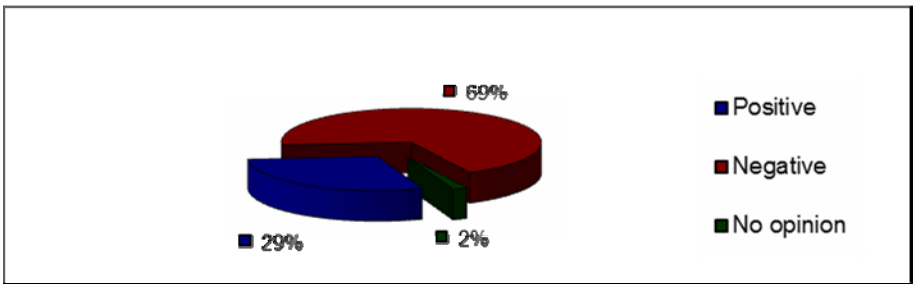

Figure 5 – Assessment of the transfer of hazards, risks and threats from the explosion of explosive materials to another party
Рис. 5 – Оценка переноса опасности, рисков и угроз от взрыва взрывчатых средствк третьим лицам
Slika 5 – Ocena prenošenja opasnosti, rizika i pretnji od eksplozije eksplozivnih sredstava na drugo lice

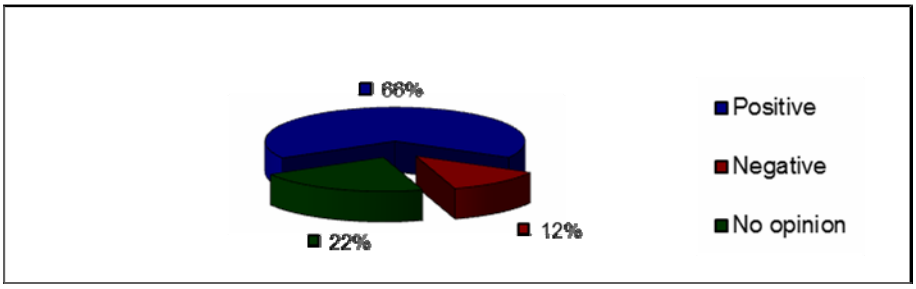

Figure 6 – Assessment of the division of hazards, risks and threats from the explosion of explosive materials into more smaller ones
Рис. 6 – Оценка разложения опасности, рисков и угроз от взрыва взрывчатых средств на составляющие
Slika 6 – Ocena raščlanjivanja opasnosti, rizika i pretnji od eksplozija eksplozivnih sredstava na više parcijalnih

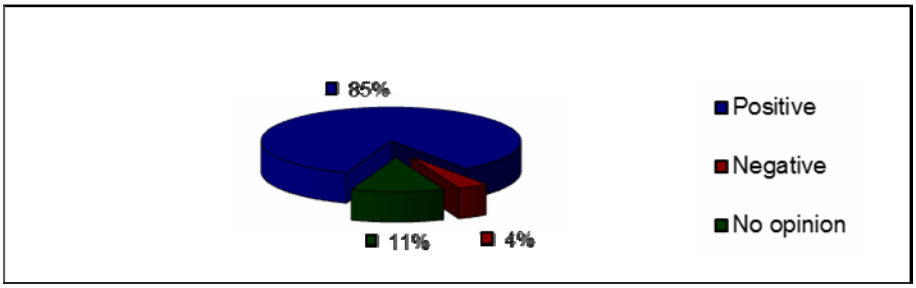

Figure 7 – Assessment of the termination of the work with explosive materials when the body fatigue is felt
Рис. 7 – Оценка прекращения работы с взрывчатыми средствами, при выявлении слабости в организме
Slika 7 – Ocena prestanka rada sa eksplozivnim sredstvima kada se primeti slabost organizma

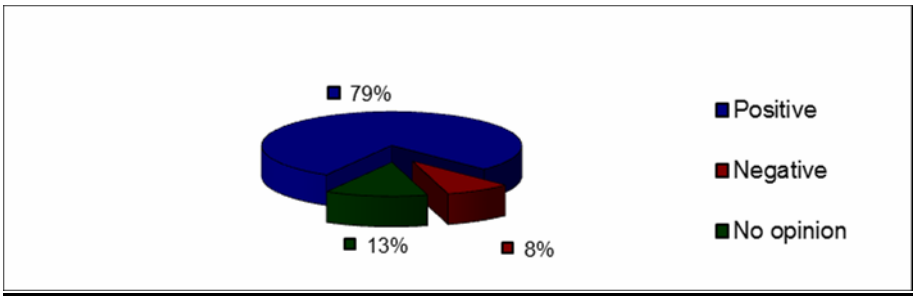

Figure 8 – Assessment of the reduction of hazards, risks and threats from explosive materials by implementing regulative provisions
Рис. 8 – Оценка снижения опасности, рисков и угроз от взрыва взрывчатых средств, в соответствии с регламентом
Slika 8 – Ocena smanjenja opasnosti, rizika i pretnji od eksplozivnih sredstava primenom pravilskih odredbi

A smaller number of the Serbian Army members, however, would not decide to mitigate the hazards, risks and threats from the explosion of explosive materials in any of the proposed ways. It is also important to note that a higher percentage of the Serbian Army members would not transfer the hazards, risks and threats to another person at a decision-making moment. They would complete the task on their own responsibility despite the awareness of the fact that they could bear certain consequences in case of making a wrong decision. Based on the views and opinions of the respondents to the survey, the set hypothesis is partially proven because the proposed measures for mitigation of hazards, risks and threats from the effects of explosive material explosionsat the decision-making moment are not applied at the requested level.

In order to reduce uncertainty in making timely and appropriate decisions in situations where there is danger, risk and threat from the effects of explosive material explosions, it has been suggested that this area be included in the training of Serbian Army members and cadets of the Military Academy. These research results could have applications in monitoring and training of the staff of the Serbian Army to make rational decisions in preventive activitiesin order to eliminate the consequences of any explosion of explosive materials. Lectures based on scientific knowledge would bea part of crisis management adapted to the curriculum at the Military Academy so that the members of the Serbian Army would be ready to respond to changes and challenges, which requires a constant ability to improve the process of mitigating safety vulnerability of people and property from the effects of the explosion of explosive materials in order to ensure optimal protection of the environment and increase the safety of people and property.

A detailed program for the mitigation of the safety risk to people and property from the effects of the explosion of explosive materials is a result of considering all alternative methods studied in the paper, dealing with the prevention from exposure to hazards, risks and threats of the effects of explosive material explosions. A collaborative use of these methods is a special contribution of this work to the community, especially to the members of the Serbian Army who are exposed to hazards, risks and threats of the effects of explosive material explosionson a daily basis. The methods discussed in this work should help employees who work with explosives or are in their immediate vicinity to rationally make the right decision based on their abilities and functions they perform. Unfortunately, practice has shown that not all decisions were appropriate in specific situations; hence invalids and those who got killed during cluster bombs clearing because they did not make the right decision in the given moment of decision-making. If they had applied the proposed methods for avoiding, retention, impairment, division, transfer and reduction of hazards, risks and threats there would have been fewer casualties and less property damage.

This problem has beenin the center of attention for the last couple of years when the effects of explosions of explosive materials were frequent, which indicates a high probability that they will occur in the future. Therefore, the results of this research should be applied in practice. Currently, this issue is not sufficiently considered for several reasons (such as ignorance, insecurity, lack of understanding, etc.) until the highest level of command in the Serbian Army takes greater care and responsibility for protecting people, material resources and the environment.

Conclusion

Members of the Serbian Army improve their abilities for the purpose of optimal defence of their physical and mental integrity, as a function of preserving the independence, territorial integrity and sovereignty of the country and its protection from external armed threats. During this complex process, they face many dangers, risks and threats of possible occurrences of the effects of explosive material explosions and mitigate them by making right decisions the results of which maintain the necessary safety. However, they sometimes fail to provide complete safety because at critical moments they consciously expose themselves to dangers, risks and threats, regardless of the possible outcome, which is why in the last few years some events with the disastrous outcome have occurred. For these reasons, members of the Serbian Army should enhance their knowledge in mitigating safety vulnerability, in order to bring danger, risk and the threat from explosions of explosive materials to the lowest possible level of appearance.

Based on the conducted survey on the views and opinions of a representative sample, it was found that the proposed methods to mitigate hazards, risks and threats of the effects of explosive material explosions are not sufficiently represented in the Serbian Army. Therefore, a solution has been proposed in order to increase the level of their implementation through acquiring relevant knowledge during the training of the Serbian Army members for the purpose of improving constructive reasoning, decision making and taking appropriate actions. The purpose of this would be to increase the safety of people and the property. Taking concrete actions to eliminate hazards, risks and threats from the appearance of the effects of explosions of explosive materials represents the future direction of activities of the Serbian Army in order to prevent negative consequences for particular areas in which explosive materials are located or in which they could be found. This matter will be dealt with in one of the next editions of the Military Technical Courier.

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СМЯГЧЕНИЕ УГРОЗЫ БЕЗОПАСНОСТИ НАСЕЛЕНИЯ И ИМУЩЕСТВА ОТ ПОСЛЕДСТВИЙ ВЗРЫВА ВЗРЫВЧАТЫХ СРЕДСТВ В ВООРУЖЕННЫХ СИЛАХ РЕСПУБЛИКИ СЕРБИЯ

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ОБЛАСТЬ: охрана окружающей среды и критический менеджмент
ВИД СТАТЬИ: обзорная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

На основании данного исследования представлены возможности смягчения угрозы безопасности населения и имущества от взрыва взрывчатых средств. Исследование проведено с целью определения мер по снижению опасности, рисков и угроз длянаселения, имущества и окружающей среды и смягчения последствий чрезвычайных ситуаций. В статье также подробно описаны следующие методы: профилактика, отсрочивание, снижение, распределение, перенос и уменьшение опасности, рисков и угроз, подкрепленные соответствующими практическими примерами. В процессе исследования, автор стремился доказать гипотезу с объективностью научного подхода к результатам собственных трудово применении представленных методов.

Ключевые слова: *опасность, угроза, войска, имущество, взрывчатые вещества.*

UBLAŽAVANjE BEZBEDNOSNE UGROŽENOSTI LjUDI I IMOVINE OD EFEKATA EKSPLOZIJE EKSPLOZIVNIH SREDSTAVA U VOJSCI SRBIJE

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OBLAST: zaštita životne sredine i krizni menadžment
VRSTAČLANKA: pregledni članak
JEZIKČLANKA: engleski

Sažetak:

Istraživanjem su obuhvaćene mogućnosti za ublažavanje bezbednosne ugroženosti ljudi i imovine od efekata eksplozije eksplozivnih sredstava koje imaju za cilj da smanje opasnost, rizik i pretnju po stanovništvo, njihovu imovinu i životnu sredinu, kao i da ublaže posledice moguće vanredne situacije. Razmotrene su sledeće metode: izbegavanje, zadržavanje, umanjenje, podela, prenos i redukcija opasnosti, rizika i pretnji. Svaka metoda je detaljno teorijski objašnjena, uz adekvatne primere iz prakse. Dokazivana je postavljena hipoteza koja ima za cilj da, prilazeći s naučnom objektivnošću vlastitim rezultatima istraživanja, prihvati ili odbaci predložene metode.

Ključne reči: *pretnja, opasnost, vojska, imovina, eksploziv*.

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APPLICATION OF MULTIPLE CRITERIA DECISION MAKING IN THE SELECTION OF DIGITAL FORENSICS SOFTWARE

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Abstract:

Nowadays there is almost no criminal offense in the investigation of which digital evidence does not play a key role. Constant increase of the capacity of media that store digital data leads to continuous increase of the time necessary to identify and copy (acquire) digital evidence. Selection of appropriate digital forensics software is gaining in importance.

Selection of adequate software includes a previous comparative analysis of two or more digital forensics software tools and an optimization process. The objective of the comparative analysis of these software tools is to determine and compare each of their realistic and comparable performances. Optimization aims to determine which of digital forensics software tools has better performances.

This paper shows one of possible variants of selecting digital forensics software, using the latest scientific achievements in support of decision making based on the analytic hierarchy process (AHP) method and the Expert Choice computer program.

Key words: *forensics software, digital forensics, expert choice, optimization, digital evidence, comparative analysis.*

Introduction

The implementation of a high-quality comparative analysis of standard digital forensics software is a very complex task. A qualitative analysis involves a larger number of the latest software programs to be analysed. Since commercial software is rather expensive (McClure, et al., 2002, p.614) this adds to the complexity of the problem.

In addition, there is a problem regarding professional usage and experience in working with selected software. In under-developed and developing countries, such as the Republic of Serbia, which consider using digital forensics, there are practically no certified digital forensic experts. This points to another significant problem.

Continuous development of digital forensics software and daily improvements of their characteristics through new software versions and generations make the results of these analyses "short of breath". This imposes a need to base the selection of the optimal digital forensics software on a preliminary analysis and a comparison of more digital forensics software tools of the latest generation, which is often not economically feasible and sometimes not even possible.

Such problems can be overcome in many ways. In this sense, there are the results of comparative analyses of digital forensics software published in the scientific literature and the results published in peer-reviewed journals with a long tradition of comparative analyses. Both methods have their positive and negative sides.

A positive characteristic of the results of comparative analyses of digital forensics software published in the scientific literature is comprehensiveness and scientific foundation while a negative side is that they are often not up-tp-date due to the development of new versions of software. A positive characteristic of the results of professional journals with a long tradition of comparative analyses of such software is the up-to-dateness of software choice while a negative side is a populistic approach to the analysis due to different educational profiles of readers.

A comparative analysis of standard software programs of digital forensics, viewed from the perspective of this study, is a function of defining elements and indicators necessary to optimize the selection of digital forensics software and to present the optimization process itself. In accordance with the prevailing opinion of the scientific and professional community, standard digital forensics software products are from American Guidance Software and Data Access as well as from German X-Ways, i.e. their digital forensics software tools named EnCase, FTK (FTK Imager) and WinHex. The problem of securing legal software necessary for comparative analyses is overcome by using their older test, demo, and lite versions ie. versions EnCase Enterprise v4, FTK v1.81.6 (FTK Imager 3.1.1.) and WinHex 18.5.

These versions of digital forensics software are limited in terms of some advanced features and scope of analysis but not in their primary functions which are identifying and copying (acquisition) of disks. These functions are also the subject of analysis.

Specifying the above digital forensics software also defines the alternatives for optimization. The first step in the optimization process is to determine the optimization objective. In the scientific and professional literature it is often stressed that EnCase, FTK and WinHex have similar features i.e. performances. In order to determine which of the above software programs has better performance, optimization is used to identify an alternative that, according to the established criteria, has better basic possibilities or primary performances. In this sense, the objective of optimization is defined as" Selection of Digital Forensics Software with better primary performances". In short, to optimize means to make the best decision when choosing between alternatives, comparing them with each other according to certain criteria.

The selection of criteria is determined by the optimization objective. In this case, criteria must be chosen to reflect performances. The operating software speed when performing functions that precede the analysis (of primary functions), expressed in the units of time, is certainly one of the most important performances. "Live disk" Identification speed for its preliminary analysis is important in taking emergency measures in a process such as making a decision on the detention of the suspect. On the other hand, the speed of making "live disk" copies for its detailed analysis is important in taking measures to detain the suspect, where the time available to collect evidence and submit it to the judge for preliminary proceedings is limited to 48 hours. Since today's disk capacity is measured in Terabytes (TB) and larger units of measurement, it is important to note that the process of disk copying may take considerable time. According to some authors, the length of time required to create copies of a disk, in addition to capacity, is affected by the speed at which the network cable transfers data contained on the disk (Simeunović, Ristić, 2013, p.1009).

A selection of digital forensics software tools for digital forensic investigation gains in significance due to the fact that digital forensics software preparation, including the selection of appropriate software, stands out as a new phase of digital forensic investigation that precedes and affects other phases: evidence collection and examination, analysis and reporting (Delija, 2015). Evaluation and selection of tools for digital forensic investigation is still a challenge and it is an insufficiently researched topic in the field of digital forensics. The selection of appropriate tools to be used for digital forensic investigation greatly influences the outcome in court. While the goal is clear - to obtain valid digital evidence acceptable in court, in practice it appears that this is not easy to achieve at all (Kaurin, Anucojić, 2012, p.715).

Comparative analysis of standard digital forensics software

Based on author's own experience, the optimization criteria are: (1) identification of the disk, and (2) copying the disk. Each of these criteria is evaluated using three sub-criteria: (1.1) time for the identification of the 1 GB flash disk, (1.2) time for the identification of the 4 GB flash disk and (1.3) time for the identification of the 8 GB flash disk, (2.1) time for copying the 1 GB flash disk, (2.2) time for copying the 4 GB flash disk, and (2.3) time for copying the 8 GB flash disk.

Based on the values obtained by testing the Digital Forensics software EnCase Enterprise v4, FTK v1.81.6 and WinHex 18.5, in terms of the time necessary to identify the flash disks of 1, 4 and 8 GB, it is evident that EnCase and WinHex software, under the same conditions (Table 1), identify the disk in less than one second, or give proportional values which remain the same when the disk capacity is changed (Table 2).

On the other hand, under the same conditions, FTK software takes some time to identify the disk, i.e. gives slow progressive values that grow with the increase of the disk capacity but at a smaller ratio compared to the disk capacity increase (Table 2).

Table 1 – Conditions of testing the digital forensics software: EnCase, FTK and WinHex, in terms of the time required to identify disks of 1, 4 and 8 GB
Таблица 1 – Условия, в которых испытаны программные обеспечения цифровой форензики EnCase, FTK и WinHex, с учетом времени, необходимого для идентификации накопителя 1, 4 и 8 GB
Tabela 1 – Uslovi u kojima su testirani softveri digitalne forenzike EnCase, FTK i WinHex, sa aspekta vremena neophodnog za identifikaciju diskova od 1,4 i 8 GB

Computer configuration:	***Windows edition – Windows XP Profesional (SP3)***
	System manufacturer – Acer
	System processor–Intel(R)Pentium(R)DualCPU E2220@2.4 GHz
	Installed memory (RAM) – 768 MB
	System type – 32-bit Operating System
Alternative:	***EnCase Enterprise v4***
	FTK v1.81.6
	WinHex 18.5
Criterion:	***identification speed disk***
Sub-criteria:	***flash disk Kingston DTI/1GB***
	flash disk SanDisk Cruzer Edge 4 GB
	flash disk Kingston DT101 G2 8 GB

Table 2 – Display of the values obtained by testing the digital forensics software: EnCase, FTK and WinHex, in terms of the time required to identify disks of 1, 4 and 8 GB
Таблица 2 – Изображение значений, полученных путем тестирования программного обеспечения цифровой форензики EnCase, FTK и WinHex, с учетом времени, необходимого для идентификации накопителя 1, 4 и 8 GB
Tabela 2 – Prikaz vrednosti dobijenih testiranjem softvera digitalne forenzike EnCase, FTK i WinHex, sa aspekta vremena neophodnog za identifikaciju diskova od 1,4 i 8 GB

No.	IDENTIFICATION DISK	EnCase Enterprise v4	FTK v1.81.6	WinHex 18.5	Difference		
					EC/FTK	EC/WH	FTK/WH
1	Kingston DTI/1GB 	< 00:00:01	00:01:02	< 00:00:01	61	0	61
2	SanDisk Cruzer Edge/4 GB 	< 00:00:01	00:03:50	< 00:00:01	229	0	229
3	Kingston DT101G2/8 GB 	< 00:00:01	00:05:01	< 00:00:01	300	0	300

It is important to notice that the values in Table 2 are not unique since all forensic software programs, to a lesser or greater extent, have special options that are automatically executed. Since it is not possible to deactivate all the options, the given values should be regarded only as an indication to select the right forensic software for a particular case.

When it comes to the differences in the values obtained by testing the EnCase and FTK software tools, expressed descriptively, it is evident that it is: "moderately to very important" in favour of EnCase software for the 1 GB (61 s) disk; "very important to extremely important" in favour of EnCase software for the 4 GB (229 s) disk and "extremely important" in favour of EnCase software for the 8 GB (300 s) disk. The case is identical when it comes to the difference between FTK and WinHex software, in favor of WinHex. Bearing in mind that EnCase and WinHex software tools give equal values when tested, regardless of the disk size, their values are "equally important". The aforementioned descriptive expression is necessary in order to adjust the difference of the results obtained by testing to the text assessment scale of Expert Choice program, which will be diskussed further on.

Based on the values obtained by testing the Digital Forensics software EnCase Enterprise v4, FTK Imager 3.1.1. and WinHex 18.5, in terms of time required to copy the flash disks of 1, 4 and 8 GB, it is evident that the EnCase software tool, under the same conditions (Table 3), with the increase of the disk capacity, gives first slow progressive values that grow with the disk capacity increase but at a smaller ratio compared to the disk capacity increase; with further disk capacity increase, its values become rapidly progressive and grow with the increase of the disk capacity at a greater ratio compared to the disk capacity increase (Table 4).

On the other hand, the FTK software tool, under the same conditions (Table 3), provides constantly accelerated progressive values that grow

with the increase of the disk capacity at a greater ratio compared to the disk capacity increase (Table 4).

The WinHex software tool, under these conditions (Table 3), changes the values identically to EnCase software; the only difference is that the progression and increase of these values are less pronounced with the disk capacity increase (Table 4).

Table 3 – Conditions under which digital forensics software tools -EnCase, FTK and WinHex- are tested, in terms of the time required to copy the disks of 1, 4 and 8 GB
Таблица 3 – Условия, в которых испытаны программные обеспечения цифровой форензики EnCase, FTK и WinHex, с учетом времени, необходимого для создания копии дисков 1, 4 и 8 GB
Tabela 3 – Uslovi pod kojima su testirani softveri digitalne forenzike EnCase, FTK i WinHex, sa aspekta vremena neophodnog za izradu kopija diskova od 1,4 i 8 GB

Computer configuration:	***Windows edition – Windows XP Profesional (SP3)***
	System manufacturer – Acer
	System processor–Intel(R)Pentium(R)DualCPU 2.4 GHz
	Installed memory (RAM) – 768 MB
	System type – 32-bit Operating System
Alternative:	***EnCase Enterprise v4***
	FTK Imager 3.1.1.
	WinHex 18.5
Criterion:	***the speed of making copies of a disk***
Sub-criteria:	***flash disk Kingston DTI / 1GB***
	flash disk SanDisk Cruzer Edge / 4 GB
	flash disk Kingston DT101 G2 / 8 GB

Table 4 – Display of the values obtained by testing digital forensics software tools -EnCase, FTK and WinHex - in terms of the time required to copy the disks of 1, 4 and 8 GB
Таблица 4 – Изображение значений, полученных путем тестирования программного обеспечения цифровой форензики EnCase, FTK и WinHex, с учетом времени, необходимого для создания копии дисков 1, 4 и 8 GB
Tabela 4 – Prikaz vrednosti dobijenih testiranjem softvera digitalne forenzike EnCase, FTK i WinHex, sa aspekta vremena neophodnog za izradu kopija diskova od 1,4 i 8 GB

No.	DISK DUPLICATION	EnCase Enterprise v4	FTK Imager 3.1.1.	WinHex 18.5	Difference		
					EC/FTK	EC/WH	FTK/WH
1	*Kingston DTI/1GB* 	00:01:34	00:01:22	00:01:28	12	6	6
2	*SanDisk Cruzer Edge/4 GB* 	00:04:50	00:06:00	00:05:45	70	55	15
3	*Kingston DT101G2/8 GB* 	00:13:49	00:14:44	00:11:22	55	147	202

The difference in the values obtained by testing the EnCase and FTK software tools, expressed descriptively, is the following: for the disk of 1 GB (12 s) it is "moderately important" in favor of FTK software; for the disk of 4 GB (70 s) it is "very important" in favour of EnCase software and for the disk of 8 GB (55 s) it is "moderately to very important" in favour of EnCase software.

The difference in the values obtained by testing EnCase and WinHex software, expressed descriptively, is the following: for the disk of 1 GB (6 s) it is "equally to moderately important" in favour of WinHex software; for the disk of 4 GB (55 s) it is "moderately to very important" in favour of EnCase software and for the disk of 8 GB (147 s) it is "very to extremely important" in favour of WinHex software.

The difference in the values obtained by testing FTK and WinHex software, expressed descriptively, is the following: for the disk of 1 GB (6 s) it is "equally to moderately important“ in favor of FTK software; for the disk of 4 GB (15 s) it is "moderately important" in favour of WinHex software and for the disk of 8 GB (202 s) it is "extremely important" in favour of WinHex software.

Optimizing Digital Forensics Software Selection

In the process of optimization, decision-makers have access to the latest scientific achievements in support of decision making. One of such developments is the analytic hierarchy process (AHP) method. This method was developed by Thomas Saaty in the early seventies in order to assist decision-makers in solving complex problems of decision making with multiple criteria and the presence of a large number of alternatives. The AHP method allows decision-makers to include a subjective attitude, experience, knowledge and intuition in decision making.

The AHP presents complex problems through a model in the form of hierarchy. Each level consists of several elements, where the elements of the same level are independent of each other but comparable. In today's conditions, the AHP method is applied by means of the Expert Choice 2011 computer program (hereinafter: EC 2011). This computer program was developed by a well-known manufacturer of computer programs, the Decision Support Software Company. It is such an important product that a part of the company was named later by this computer program - Expert Choice (Čupić, et al., 1992, p.131).

The process of using EC 2011 program includes the following phases: defining the objective; defining (generating) alternatives; defining criteria and sub-criteria (structuring the problem); comparing the criteria in relation to the objective (determining the influence of the criteria on the objective); comparing the sub-criteria with the criteria (determining the influence of the sub-criteria on the criteria); comparing alternatives in relation to the sub-criteria (determining the relative impact of each alternative on a particular sub-criterion); synthesis of the alternatives regarding the objective (aggregation of the solution) and a sensitivity analysis (Fakultet organizacionih nauka, 2015).

In the phase of defining the objective, it is necessary to enter a description of the previously defined objective "DIGITAL FORENSICS SOFTWARE SELECTION" into the relevant program window.

In the phase of defining alternatives, it is necessary to enter the data on the alternatives under consideration, or the names of the three leading digital forensics software programs selected based on the opinions of professional and scientific community, "EN CASE", "FTK" and "WIN HEX". A more detailed description of the objective is preferable in order to continually point to the purpose of optimization - "The comparison of the leading digital forensics software programs selected based on the opinions of professional and scientific community, in order to identify the one with better primary performances" (Figure 1).

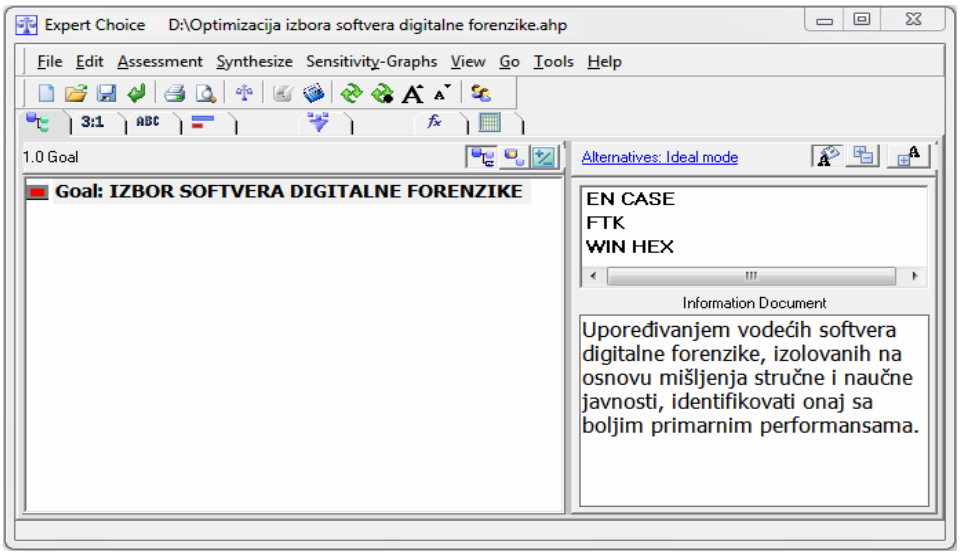

Figure 1 – Definition of alternatives and a detailed description of the objective
Рис. 1 – Определение альтернатив и подробное описание цели
Slika 1 – Definisanje alternativa i detaljno opisivanje cilja

In the stages of defining criteria and sub-criteria, the hierarchy is structured (Figure 2), and it is necessary to enter the data on criteria - "DISK IDENTIFICATION" and "DISK COPYING" and the information on sub-criteria: 1 GB flash disk, 4GB flash disk and 8 GB flash disk in the form of "disk 1", "disk 4" "disk 8" (Figure 3).

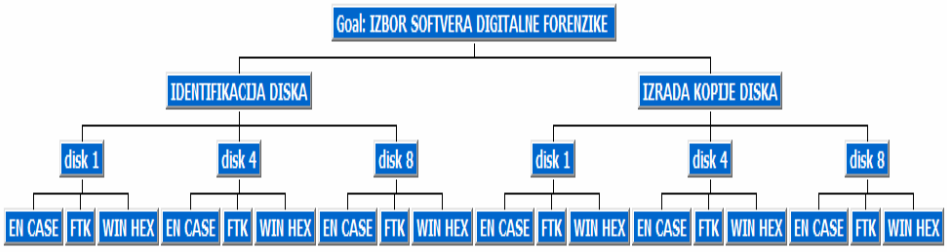

Figure 2 – Hierarchical structure of the problem of digital forensics software selection
Рис. 2 – Иерархическая структура проблемы выбора программного обеспечения цифровой форензики
Slika 2 – Hijerarhijska struktura problema izbora softvera digitalne forenzike

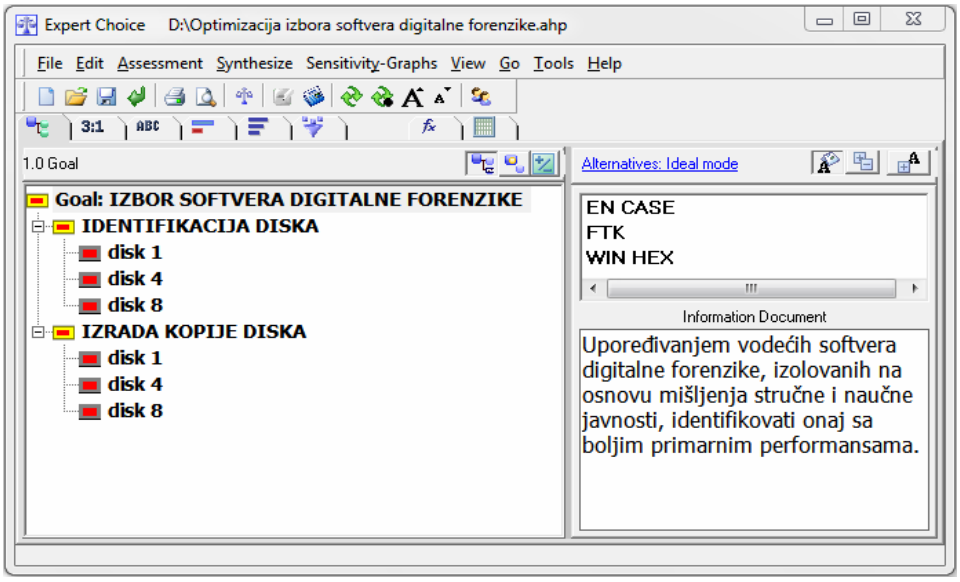

Figure 3 – Defining criteria and sub-criteria in EC 2011 program
Рис. 3 – Определение критериев и субкритериев в программе EC 2011
Slika 3 – Definisanje kriterijuma i potkriterijuma u programu EC 2011

In the phase of comparing the criteria in relation to the objective, their weight ratios are assessed in relation to the objective by comparing pairs of criteria with the help of textual descriptions of the levels of importance of one over the other[1], taking into account the index inconsistencies[2] in the assessment criteria.

Upon completion of the comparison of the criteria to the objective and the sub-criteria in relation to the criteria, EC 2011 program expresses each criteria/sub-criteria weight factor (importance) to the object, or the criterion (Figure 4). When the criteria are compared, the criterion of "DISK COPYING" (0.800) is more important than the criterion of "DISK IDENTIFICATION" (0.200). In comparison with other sub-criteria (in the case of both criteria) the most important sub-criterion is "disk 8" (0.147 / 0.588), followed by sub-criterion "disk 4" (0.041 / 0.165) and the least important is sub-criterion "disk 1" (0.012 / 0.046). The resulting weights indicate that EC 2011 followed the decision-maker's will.

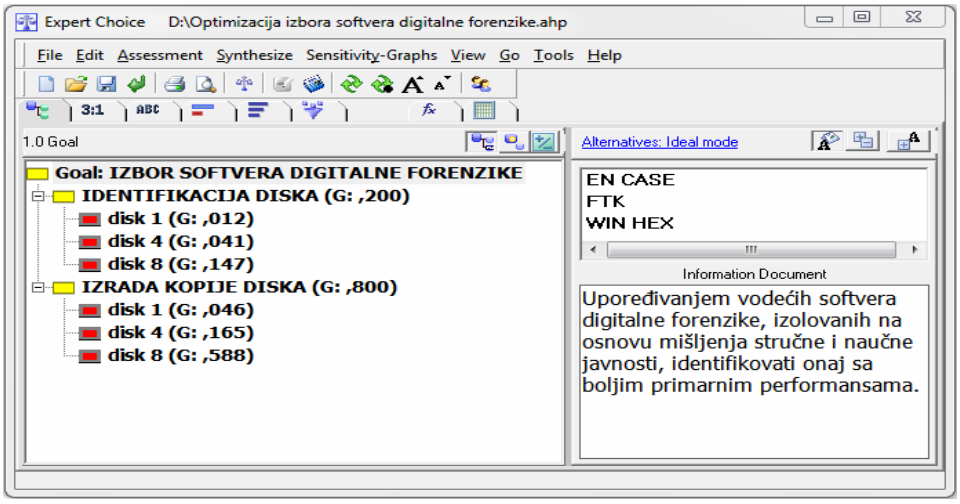

Figure 4 – Weights of criteria (sub-criteria) compared to the objective (criterion)
Рис. 4 – Вес коэффициента критериев (субкритериев) к объекту (критерий)
Slika 4 – Težinski koeficijenti kriterijuma (potkriterijuma) u odnosu na cilj (kriterijum)

[1] Equal (criteria that are being compared are of the same importance), Moderate (one criterion is moderately more important than the other), Strong (one criterion is significantly more important than the other), Very Strong (one criterion is quite significantly more important than the other) i Extreme (one criterion is extremely more important than the other).
[2] Inconsistency (lat. inconsistentia) transience, impermanence, incongruity, contradiction, diskrepancy.

Regarding the obtained results (coefficients), it is important to note that EC 2011 was guided by the expressed will of decision-makers (evaluators). It is this feature of EC 2011 that allows decision-makers to create basic optimization parameters according to their interests and needs. At the stage of comparing alternatives to the sub-criteria, unlike the previous phase of comparing the criteria and the sub-criteria, comparing alternatives is based on the quantitative indicators obtained by testing, with a free will of decision-makers completely excluded.

Given the above, before comparing alternatives, it is necessary to adjust the results obtained by testing to the text assessment scale of the EC 2011 program (Table 5). It should be noted that the 2011 EC program allows mutual comparison and evaluation of: the criteria in relation to the objective; the sub-criteria with respect to the criteria, or the alternatives with respect to the sub-criteria in different modes (options). In addition to the text mode (option "ABC") decision-makers can use a graphical mode (option "ıı"), or a numeral mode (option "3:1"). These modes of comparison correspond to preferences of decision-makers who can express themselves better either with numbers, words or visually.

Table 5 – Results obtained by testing adapted to the text scale of the EC 2011 program
Таблица 5 – Результаты, полученные путем тестирования, приспособленные пользовательской шкале программы EC 2011
Tabela 5 – Rezultati dobijeni testiranjem prilagođeni tekstualnoj skali programa EC 2011

РЕЗУЛТАТ	ЕКВИВАЛЕНТ	ТЕКСТУАЛНА СКАЛА	ЗНАЧЕЊЕ
300	→	*Extreme*	- екстремно значајно
229	→	-	- веома јако до екстремно значајно
202	→	*Very Strong*	- веома јако значајно
147	→	-	- јако до веома јако значајно
70	→	*Strong*	- јако значајно
55	→	-	- умерено до јако значајно
15	→	*Moderate*	- умерено значајно
6	→	-	- једнако до умерено значајно
0	→	*Equal*	- једнако значајно
6	→	-	- једнако до умерено значајно
15	→	*Moderate*	- умерено значајно
55	→	-	- умерено до јако значајно
70	→	*Strong*	- јако значајно
147	→	-	- јако до веома јако значајно
202	→	*Very Strong*	- веома јако значајно
229	→	-	- веома јако до екстремно значајно
300	→	*Extreme*	- екстремно значајно

The results obtained by testing are adapted to the text scale of the EC 2011 program in such a way that the smallest value obtained by testing (0 s) is equal to the minimum value of the text scale of the program (equal) and

the maximum value obtained by testing (300 s) is equal to the highest value of the text scale of the program (extreme). The values between the minimum and maximum values obtained by testing, depending on their size, are equal to the corresponding values of the text scale of the program.

The technique of evaluating alternatives with respect to the sub-criteria, with the exception of the free will of decision-makers, is identical to the previously described technique of assessing the criteria in relation to the objective, or the sub-criteria with respect to the criteria. After the assessment of the significance of alternatives with respect to all sub-criteria, by positioning to "DIGITAL FORENSICS SOFTWARE SELECTION", the EC 2011 program shows the weights (importance) with respect to the objective for each alternative (Figure 5).

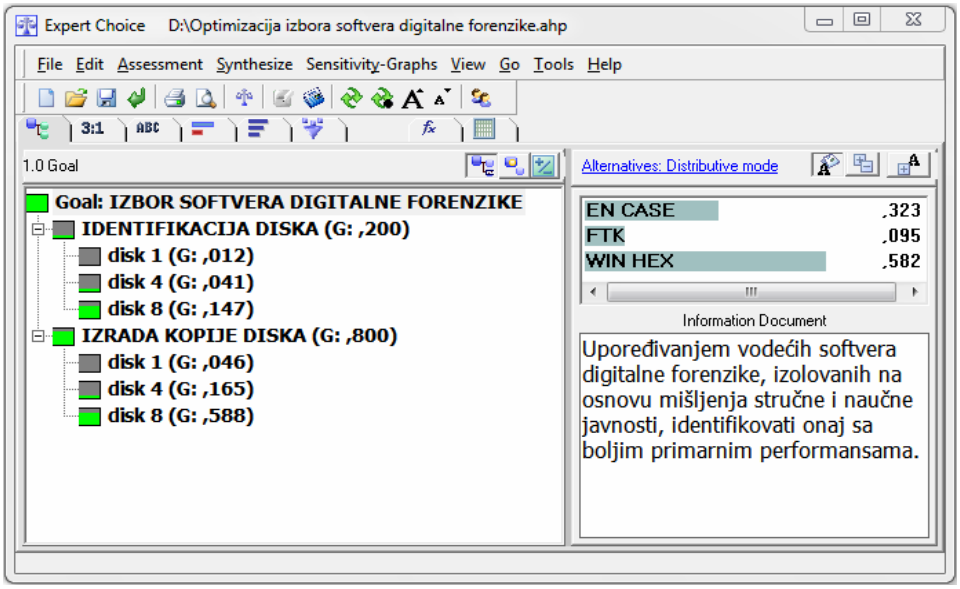

Figure 5 – Weights of alternatives in relation to the objective
Рис. 5 – Весовые коэффициенты альтернатив цели
Slika 5 – Težinski koeficijenti alternativa u odnosu na cilj

When comparing alternatives in relation to the objective, the most important is the alternative "WIN HEX" (0.582), less important is the alternative "EN CASE" (0.323) and the least important is the alternative "FTK" (0.095). In the phase of the synthesis of alternatives with respect to the objective, selecting the With Respect to Goal option in the Synthesize menu results in a graph of the expected alternative values with respect to the objective (Figure 6).

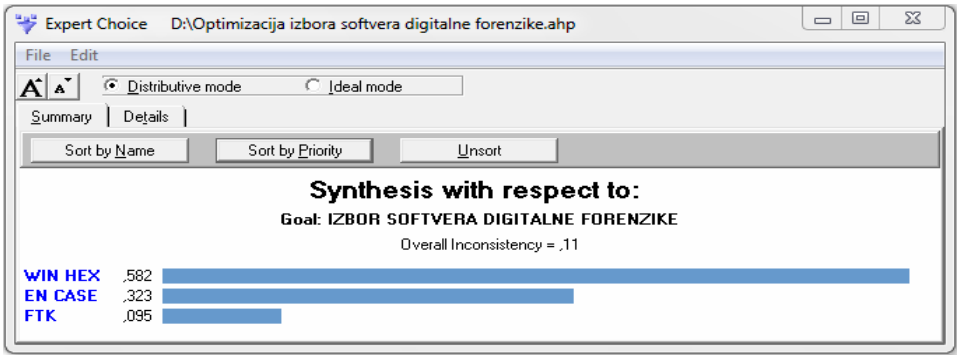

Figure 6 – Graph of the anticipated alternatives in relation to the objective
Рис. 6 – Диаграмма предполагаемых альтернатив цели
Slika 6 – Graf očekivanih alternativa u odnosu na cilj

In the final analysis, digital forensics software with the best performance is the primary software "WIN HEX" (0.582).

In the phase of the sensitivity analysis, four graphic forms of the sensitivity analysis of the obtained results can be used. These forms are accessed from the Sensitivity Graphs menu: performance analysis (Performance option), analysis of the impact of each individual criterion on the final solution (Gradient option), analysis of para-alternatives with all their criteria "forehead to forehead"(Head to Head option) and dynamic analysis (Dynamic option) as well as the possibility to simultaneously display all four graphs (Open Four Graphs option). The sensitivity analysis of the obtained results was carried out by the Dynamic option in the Sensitivity Graphs menu that can monitor changes in the priorities of other criteria and alternatives (Figure 7).

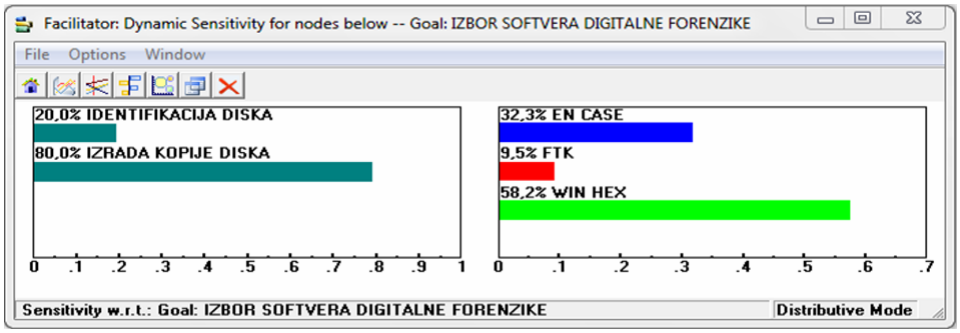

Figure 7 – Graph of the dynamic analysis
Рис. 7 – График динамического анализа
Slika 7 – Grafik dinamičke analize

During the dynamic analysis, changing the weights of multiple criteria distorts the initial bases of the criteria priorities which results in the creation of new alternative priorities. If small changes in weight for multiple criteria lead to a shift in priorities for alternatives, it is considered that the obtained solution is sensitive and, in this case, the first two ranked solutions should equally be taken into account in the selection of the final solution. Otherwise, it is considered that the solution is not sensitive and, as such, final.

In order to check sensitivity, a significant change in the priority of the "DISK IDENTIFICATION" criterion has been done from 20.0% to 80.0%, when the program automatically calculates the values of the change of the "DISK COPYING" criterion priority from 80.0% to 20.0%. It is also automatically shown how these changes affect the change in the value of the priority of alternatives. In this case, the change of the criteria priority has led only to a change in the alternative value: "WIN HEX" alternative was changed from 58.2% to 49.9%, "EN CASE" alternative from 32.3% to 43.4% and "FTK" alternative from 9. 5% to 6.7%.

Bearing in mind that changing the criteria priority did not lead to changes in the priority of alternatives, i.e. that the best solution is still the "WIN HEX" alternative (Figure 8), it is considered that the obtained solution is not sensitive to changes, and, as such, is the final selection.

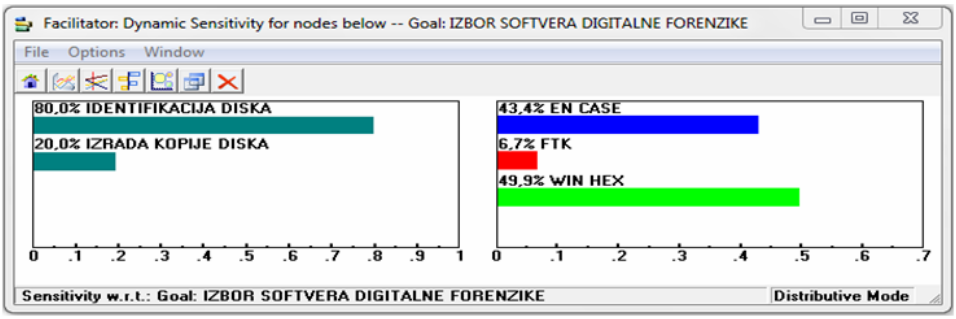

Figure 8 – Revised graph of the dynamic analysis - the "DISK IDENTIFICATION" criterion
Рис. 8 – Измененные графики динамического анализа - по критерию "ИДЕНТИФИКАЦИЯ ДИСКА"
Slika 8 – Izmenjeni grafik dinamičke analize – po kriterijumu „IDENTIFIKACIJA DISKA"

This model is applicable in the case of a large number of criteria, sub-criteria and alternatives. Randjelovic's (2011, pp. 112-113) comparative analysis of the authenticity and the verification of forensic tools EnCase, FTK Sleuth Kit with Autopsy browser shows a possibility of structuring the problem in the EC 2011 program in the case of a large number of alternatives, criteria and sub-criteria (Figure 9).

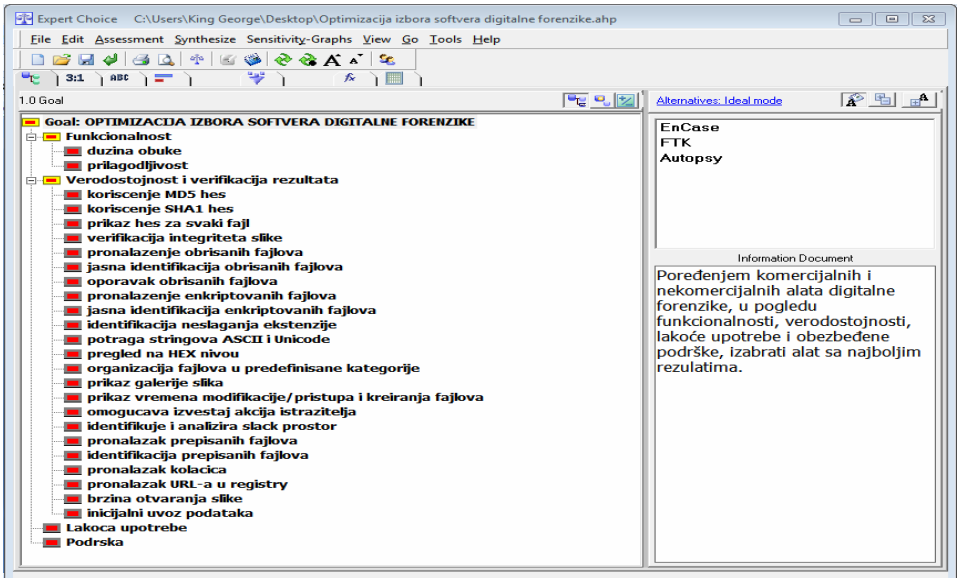

Figure 9 – Example of structuring a problem in EC 2011 with a large number of alternatives, criteria and sub-criteria
Рис. 9 – Пример структурирования проблемы в программе EC 2011 при большом количестве альтернатив, критериев и субкритериев
Slika 9 – Primer strukturiranja problema u programu EC 2011 pri većem broju alternativa, kriterijuma i potkriterijuma

Conclusion

This paper presents a model of selecting digital forensics software using most advanced scientific achievements in support of decision making based on the method of the analytic hierarchy process. One of the major problems in the application of this method is to define criteria and the evaluation of their relative weights. The authors have defined criteria and assessed the values of their relative weights based on their own experience gained in previous scientific research and practical investigation of crimes of cybercrime.

A precise procedure of this method implementation has resulted in the following order of alternatives in the model: "EN CASE" (first alternative) - 0.323 (second in the ranking), "FTK" (second alternative) - 0,095 (third in the ranking) and "HEX WIN" (third alternative) - 0.582 (first in the ranking). Particularly significant is the fact that changing the criteria priority does not lead to changes in the priority of alternatives, i.e. that the solution obtained is not sensitive to changes.

The first alternative has the highest rank (0.582), which is why it is the best or the optimal one. This alternative is also acceptable with

regard to the disk identification criterion and the disk copying criterion, i.e. this alternative enables the shortest time for the identification and copying of digital evidence. The advantage of this alternative is particularly evident with the increase of the treated disk capacity.

The second alternative in the rank has a lower value (0.323) which makes it less favorable. A change in the criteria priority does not lead to a change in alternative priority, but further increases the value of this alternative. This alternative is acceptable according to the criterion of disk identification but not according to the criterion of disk copying; namely, this alternative enables fast identification without securing digital evidence – this drawback is more pronounced with the increase of the treated disk capacity.

The third alternative in the rank has a minimum value (0.095), which is why it is the least favorable. This alternative is not acceptable either according to the criterion of disk identification or according to the criterion of disk copying, i.e. this alternative does not enable fast identification and provision of digital evidence - this disadvantage is more pronounced with increasing the capacity of the treated disk.

This conclusion applies only to the results of the tests carried out for this study. The choice is narrowed down to mainly older versions of Digital Forensics EnCase, FTK and a newer version of WinHex software and their performances in disk identifying and copying.

Some software tools, such as FTK and, in certain segments, EnCase, have options that cannot be deactivated and which are not necessary for the disk identification and copying and which further extend these processes. These background processes are the reason why for FTK software it is not possible to predict the time required to copy the disk, while the estimated copy time for EnCase is unreliable. Unlike the aforementioned software tools, WinHex provides accurate time necessary to copy a particular disk and warns the investigator if it is very long.

At the same time, the background processes carried out by FTK improve its performance in the next phases of digital forensic investigations, such as disk search and analysis. Significant advantages of FTK are the functions to filter files in order to distinguish irrelevant (system) files from the relevant (evidence) files, as well as a possibility of decryption of encrypted files. This software is considered to be the best software for searching and analysis of electronic messages (e-mails).

On the other hand, for the same phases of the investigation, EnCase and WinHex use software modules (scripts) for the automation of individual research. In addition to this, a significant advantage of these software tools is a possibility to search disks of virtually unlimited capacity.

All of these and many other advantages of particular software tools, both common and specific ones, are essential for a thorough and complete digital forensic investigation. For this reason, for the needs of particular digital forensic investigations, it is necessary to choose and use

the optimal digital forensics software for each stage of the investigation, taking into account that optimization criteria and sub-criteria should meet the needs of individual stages of the investigation.

It is important to mention that this is the case of an optimization model with a minimum number of alternatives, criteria and sub-criteria, from the viewpoint of the entire digital forensic investigation. Consideration of a large number of alternatives, criteria and sub-criteria and each individual phase of the investigation makes an analysis and an optimization more complicated but guarantees better results and, therefore, a more thorough and complete digital forensic investigation.

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ПРИМЕНЕНИЕ МНОГОКРИТЕРИАЛЬНОГО ПРИНЯТИЯ РЕШЕНИЙ ПРИ ВЫБОРЕ ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ ЦИФРОВОЙ ФОРЕНЗИКИ

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ОБЛАСТЬ: компьютерные науки, информатика
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В наше время почти не существует преступлений, раскрытие которых обошлось бы без цифровых доказательств. Так как объем носителей, хранящих цифровые данные ежедневно увеличивается, требуется больше времени на выявление и копирование (приобретение) цифровых доказательств. В этой связи, выбор соответствующих программных обеспечений цифровой форензики более чем актуален.

Выбор соответствующего программного обеспечения изначально включает сравнительный анализ двух или более программных обеспечений цифровой форензики, а также их оптимизацию. Целью сравнительного анализа программного обеспечения является определение и сравнение их реальной и сопоставимой производительности. Оптимизация производится с целью определения какое из программных обеспечений цифровой форензики обладает лучшей производительностью.

В данной статье представлен один из вариантов выбора программного обеспечения цифровой форензики, при применении последних достижений науки, касательно поддержки принятия решений на основании аналитического иерархического процесса (AHP), и компьютерной программы Expert Choice.

Ключевые слова: *судебно-программное обеспечение, цифровые экспертизы, эксперт выбор, оптимизация, цифровые доказательства, сравнительный анализ.*

PRIMENA VIŠEKRITERIJUMSKOG ODLUČIVANJA U IZBORU SOFTVERA DIGITALNE FORENZIKE

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OBLAST: računarske nauke, informatika
VRSTA ČLANKA: stručni članak
JEZIK ČLANKA: engleski

Sažetak:

U današnje vreme gotovo da nema krivičnog dela u čijem rasvetljavanju digitalni dokazi nemaju ključnu ulogu. Konstantno povećanje kapaciteta medija na kojima se skladište digitalni podaci neprestano povećava vreme neophodno za identifikaciju i kopiranje (akviziciju) digitalnih dokaza. S tim u vezi, izbor adekvatnog softvera digitalne forenzike sve više dobija na značaju.

Izbor adekvatnog softvera podrazumeva prethodnu uporednu analizu dva ili više softvera digitalne forenzike i proces optimizacije. Cilj uporedne analize ovih softvera jeste utvrđivanje i međusobno upoređivanje njihovih realnih i uporedivih performansi. Optimizacija ima za cilj da se utvrdi koji od softvera digitalne forenzike ima bolje performanse.

U ovom radu prikazana je jedna od mogućih varijanti izbora softvera digitalne forenzike, korišćenjem najsavremenijih naučnih dostignuća u podršci odlučivanju zasnovanih na metodi analitičko-hijerarhijskih procesa (AHP) i računarskom programu Expert Choice.

Ključne reči: *forenzički softver, digitalna forenzika, expert choice, optimizacija, digitalni dokaz, uporedna analiza.*

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APPLICATION OF MODERN MONITORING SYSTEMS IN MINI HYDROPOWER PLANTS

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FIELD: energy, mechanical engineering, electronics
ARTICLE TYPE: professional paper
ARTICLE LANGUAGE: English

Abstract:

The paper describes the application of modern monitoring systems in mini hydropower plants. Nowadays, special attention is paid to maintaining existing systems, as well as to the construction and installation of new mini hydropower plants. Mini hydropower plants are incorporated into power supply networks. They are very important for electricity production, as well as for the maintenance of power supply systems. New monitoring systems that allow continuous monitoring and supervision of technical correctness of mini hydropower plants have been implemented. Moreover, monitoring systems prevent damage to the system in case of major breakdowns and failures. Maintenance and overhaul are performed depending on real needs and technical conditions of hydropower plants. Modern equipment of renowned manufacturers, personal experience and knowledge of many co-workers have been used in this project realisation.

Key words: *mini hydropower plants, modern monitoring systems, technical correctness, diagnostic parameters, diagnostic methods, system vibrations, devices, equipment.*

Introduction

Modern monitoring systems in mechanical installations have a primary goal to timely react in order to prevent damage to mechanical assemblies or complete installations. Monitoring systems available on the market have broad applications: they can be used for internal combustion engines, hydroelectric power plants, thermal power plants, gas turbines, turbine systems in the process industry, reciprocating compressors, shipbuilding industry, cement factories, machine tools and for all other

systems with installed slide and roller bearings, gears and other machine elements. The end user is offered a complete solution for monitoring mechanical systems without dismantling, and only in some installations partial disassembling is necessary in order to install a monitoring system (Žegarac, 1993). Monitoring systems allow fast and reliable measurement of the size of the gap in sliding and rolling bearings, measurement of vibration parameters and powerful vibration analyses as well as the measurement of speed, measurement of temperature of lubricating oils and coolants, lubricating oil analysis, and the positioning of the upper dead point in internal combustion engines. Since they are multichannel systems, a large number of diagnostic parameters can be monitored and measured.

The Electrical Industry Montenegro (EPCG) was offered two conceptions of monitoring systems (Žegarac, 2005a), (Žegarac, 2005b):

1. ON-line monitoring systems for continuous measurement and technical condition analyses. Measuring sensors (encoders) and measuring systems are installed into mechanical installations.

2. OFF-line monitoring systems are intended for periodic evaluation and analyses of the technical condition of machinery. Some sensors are permanently built into systems, depending on measured values, while other sensors are built into monitoring system portable parts for periodic measurements.

ON-line monitoring systems were chosen as a better solution.

The concept and definition of mini hydropower plants

Literature offers many definitions of small hydropower plants (SHPs). It is very difficult to find two countries with identical classification systems. The basic parameters that should be used in the classification of SHPs include (Žegarac, 2005b):

- Installed power of hydro units,
- Aggregate type in relation to the turbine, and the method of operation,
- Rpm (revolution per minute),
- Operation in relation to the overall energy system
- Installed head, etc.

Depending on turbine power, there are micro turbines (power up to 100 KW), mini turbine power systems up to 1 MW and small or medium-sized turbines up to 10 MW. Also, regarding available power and head, there are the following SHPs types (Table 1).

Table 1 – Types of mini hydropower plants
Таблица 1 – Виды мини-ГЭС
Tabela 1 – Vrste mini-hidroelektrana

Type HPPs	Power (KW)	Head (m) small	Head (m) middle	Head (m) large
Micro HPPs	do 50	below 15	15-50	over 50
Mini HPPs	50-500	below 20	20-100	over 100
Small HPPs	500-5000	below 25		over 130

The MHPs division according to available head is accepted in most countries which define equipment in accordance with the installed head. So, for example, a number of manufacturers of electro-mechanical equipment in the United States produce standardized aggregates that include a turbine, synchronous generator with an automatic control system, inlet valves, and a control panel for a maximum head of 15 m and a power of 10 to 5000 KW.

MHPs are further divided:

a) Depending on the procedure:

- Flow with side grip from the main watercourse
- With the reservoir-dam, with daily, weekly, annual or perennial smoothing,

b) Depending on the flow regulation:

- MHPs with adjustable flow control at the turbine inlet (manual or automatic control)
- MHPs with a constant flow rate, either because of the actual nature of the load or due to destruction of excess energy,

c) Depending on the network and operation mode:

- Isolated power plants - independent operation,
- Plants connected to the network-parallel operation,
- Power plants operating under the regime of on ±, off ±
- Plants with one, two or more units,
- Plants that operate if necessary, depending on consumption,

d) Depending on the installed capacity of hydropower:

- Pocket hydro electric power plants to 20 KW,
- Small HPPs from 0.5 to 1 MW,
- Small hydro power plants from 1 to 3 MW
- Medium HPPs from 3 to 10 MW,
- Large HPPs over 10 MW,

Advantages and disadvantages of MHPs

The advantages of building MHPs in relation to the construction of other energy sources are numerous:

- Compared to large hydropower plants, there is neither flooding of wide areas (in order to provide space for water accumulation) nor disrupting of local ecological systems,
- They can provide land irrigation, water supply to surrounding villages, construction of ponds and flood protection,
- They reduce investments for electrification of remote settlements from the general electricity grid so that the electrification of these rural settlements can contribute to their development,
- They are exploited with very low material costs,
- Their operation life is very long, practically unlimited; the average life is 30 years, although there have been MHPs in operation for 80 years.

As energy sources, mini hydropower plants, compared to other similar sources, have drawbacks such as:

- High investment costs per installed KW,
- High research costs relative to total investment,
- Exploitation depends on existing resources,
- They require an integrated water supply system solution, where systems for water supply and irrigation have priority; therefore, MHPs must work with installed flow determined with respect to other consumers,
- If they operate autonomously, production of electric power depends on consumption, so the surplus remains unused.

Design and implementation of modern monitoring systems in mini hydropower plants

The requests to implement modern monitoring systems in mini hydropower plants within the Electrical Industry Montenegro (EPCG) were justified (Žegarac, Zuber, 2002, 2004, 2005).

An ON-line monitoring system was selected for the implementation(Žegarac, 2005).

The delivery and installation of the monitoring system equipment and devices were carried out by renowned international companies:

1. 01dB - Metravib, a member of the AREVA corporation, Lyon, France - equipment and software for noise and vibration,

2. Damalini AB, Sweden - laser alignment systems and laser geometric measurement systems,
3. Metrix USA, Low - cost systems for monitoring and protection of rotating systems,
4. CTC, USA - accelerometers and velocimeters with a lifetime warranty!
5. Guide InfraRed, China - thermal imaging cameras and monitoring systems,
6. VMI AB - Systems for dynamic balancing,
7. Technical Development Center (TRCpro) - Novi Sad, exclusive agent of the given companies.

The system of the permanent monitoring of temperature and vibrations in the MHP Šavnik

A modern monitoring system for two hydro units in the MHP Šavnik was designed. The hydro units are in the same room. The power of each aggregate is 100 KVA.

The monitoring system consists of:

-TRC PLC-based system,

- purpose-designed solution Areva 01dB-Metravib: MVX Oneprod in the eight-channel variant and Vio software.

The TRCpro PLC-based system for monitoring the state of turbines based on the RMS level of vibrations and temperature.

Description of the system

The system for protecting turbines from failure and damage is based on the measurement and monitoring of a large number of mechanical parameters of the plant. The measured and monitored values are the following ones:

- level of vibrations on the bearings (Vrms)
- temperature of the critical pump bearings,
- turbine speed,
- output electrical parameters of the generator.

These parameters directly or indirectly help in detecting irregularities in operation and in protecting plants from more possible errors. The protection system is designed to:

- prevent overheating of the turbine bearings and their damage,
- detect turbine rotor imbalance and prevent operation in conditions of high vibration levels.

Table 2 – Configuration of the monitoring system of a mini hydropower plant
Таблица 2 – Конфигурация системы мониторинга мини-ГЭС
Tabela 2 – Konfiguracija monitoring sistema mini-hidroelektrane

No	Pieces	Description
1.	6	CTC 200-1R, one axial sensors for measuring the vibration level on the bearings, Vrms, the range of 65 mm / sec, loop powered 4-20mA output
2.	6	PT100 sensors for measuring temperature of the bearings
3.	1	Acquisition and control system TRC VZ-D, which consists of: -CPU / PLC module - Analog input units (16 channels) - Digital input unit 8 x IN - Relay output unit 4 x OUT - HMI panel 5.7 "color touch panel - Purpose-designed firmware
4.	1	Communication GSM modem for sending an SMS alarm
5.	1	System installation, commissioning, operator training to work with systems

The Oneprod MVX protection system and Vio software for condition monitoring and turbine protection based on the RMS level of vibrations and temperature.

Description of the designed system

Figure 1 – Monitoring system OneproD – MVX
Рис. 1 – Системы мониторинга OneproD – MVX
Slika 1 – Monitoring sistem OneproD – MVX

The Oneprod-MVP is a modular monitoring system in 8, 16, 24 and 32-channel versions, shown in Fig. 1. Its superior possibility of simultaneous acquisition on all channels, combined with the programming of different operating modes and defining of alert thresholds for each operating mode make the system an extremely powerful solution for monitoring and on-line diagnostics of all complex rotating machines.

The Oneprod-MVX allows acceptance of all types of vibration sensors (accelerometers, velocity sensors, proximity probes for monitoring relative vibrations in the hydrodynamic sliding bearings) as well as the process inputs. The Oneprod-MVX includes a large number of different onboard (analysis in the measuring system itself - neither download to a PC is required nor postprocessing calculations of vibration parameters) processing procedures applicable through various techniques of monitoring and technical diagnostics of rolling and sliding bearings: summary levels (RMS, Peak, Peak to Peak), narrowband parameters (Narrow Band), broadband parameters (Broad Band), Kurtosis parameter, Defect factor of bearings, Smax, frequency spectra, time records, zoomed spectra, and envelop spectra. The recorder module enables recording long signals for a subsequent analysis of the harmonic lines (recording turbine starting and deceleration) of the installed system (shown in Fig. 2).

Figure 2 – Built-in monitoring system for the protection of mini hydropower plants
Рис. 2 – Встроенная защитная система мониторинга для мини-ГЭС
Slika 2 – Ugrađeni monitoring sistem za zaštitu mini-hidroelektrane

The configuration of the Oneprod-MVP system is performed on-site or remotely (from the control room or by using the Internet) using the included Oneprod CSM software. For realtime displays of all active channels and all defined parameters on channels, the Oneprod-MVX system uses Oneprod-XPR (Advanced vibro diagnostic) or Oneprod-VIO (Viewer) software. The communication of the Oneprod-MVX system with a control PC or PLC is carried out via RS485 or the Ethernet.

Options for extending the monitoring system

After installing the Oneprod-MVX system, the existing turbine monitoring can be expanded by including the following measurement values (Table 3):

- Measurement of output electrical parameters of the generator,
- Turbine speed,
- Additional channels for measuring vibrations and temperature,
- Measurement of water flow to the turbine of the mini hydropower plant,
- Measurement and regulation of water flow at the hydropower plant dam - a new technical solution (Žegarac, 2004)
- Extension with advanced software and remote monitoring.

Table 3 – Expandable monitoring systems
Таблица 3 – Возможности расширения системы мониторинга
Tabela 3 – Mogućnosti proširenja monitoring sistema

No.	Code	Description	Quantity
1.	MVX2301000	VIO-5, Viewer software for monitoring the results on a computer	1
2.	AC102-1A	Industrial ICP accelerometer 100 mV /g	4
3.	CB102-A2A-030-Z	Special cable AC102-1A sensor, 6 meters	4
4.	MNTSTD	1/4-28 - M6: mounting stud	4
5.	SW	Terminal boxes	2
6.	PT	PT100 sensors for measuring temperature of bearings	4
7.	RCK	Industrial cabinet for MVX	1
8.	DOC	Documentation in English and Serbian language	1
9.	PC	PC computer	1
10.	INS	System installation, commissioning, operator training to work with systems	1

A joint monitoring system for two mini hydropower plants in the MHP Šavnik is given in Fig. 3.

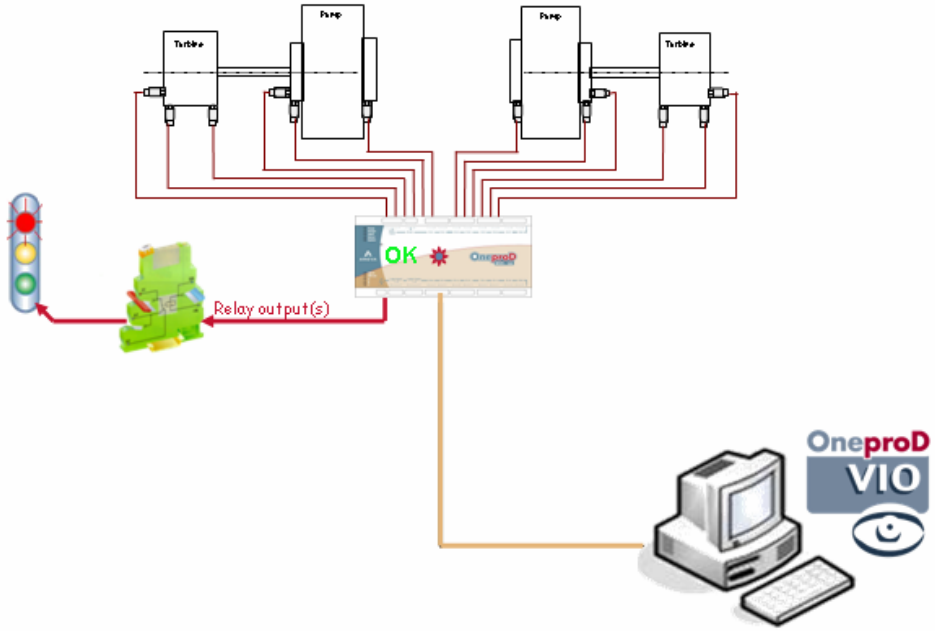

Figure 3 – The monitoring system for the mini hydropower plants in Šavnik
Рис. 3 – Система мониторинга на мини-ГЭС в Шавнике
Slika 3 – Monitoring sistem za mini-hidroelektrane u Šavniku

Measurement results and their analysis

Fig. 4 shows the scheme of the plant and the measuring points in one mini hydropower plant in the system of the EPCG Montenegro. The system consists of the mini hydroelectric generator (A), momentum (B), the multiplier (C), turbine (D) and the turbine regulator (E).

The assemblies are connected by flexible couplings and drive shafts.

Labels for the measuring directions: RH - horizontal, RV – vertical, AX – axial

The designed monitoring system includes the measurement of vibrations, temperature, operating parameters and output electric parameters of the generator. The limit values of diagnostic parameters are selected and new and classical diagnostic methods are applied (Žegarac,1989). The monitoring system allows continuous monitoring and

measurement of diagnostic values, extremely large memory of measured values as ell as wide possibilities of processing and analysing parameters.

The installation of devices and the equipment, final testing and commissioning of the operational work under the supervision of the designer were done by the TRCpro - Novi Sad.

Due to the volume of the measurement results, the paper shows only some values of the measured diagnostic parameters as well as the vibration parameters at characteristic measurement points (vibrations on the multiplier bearings).

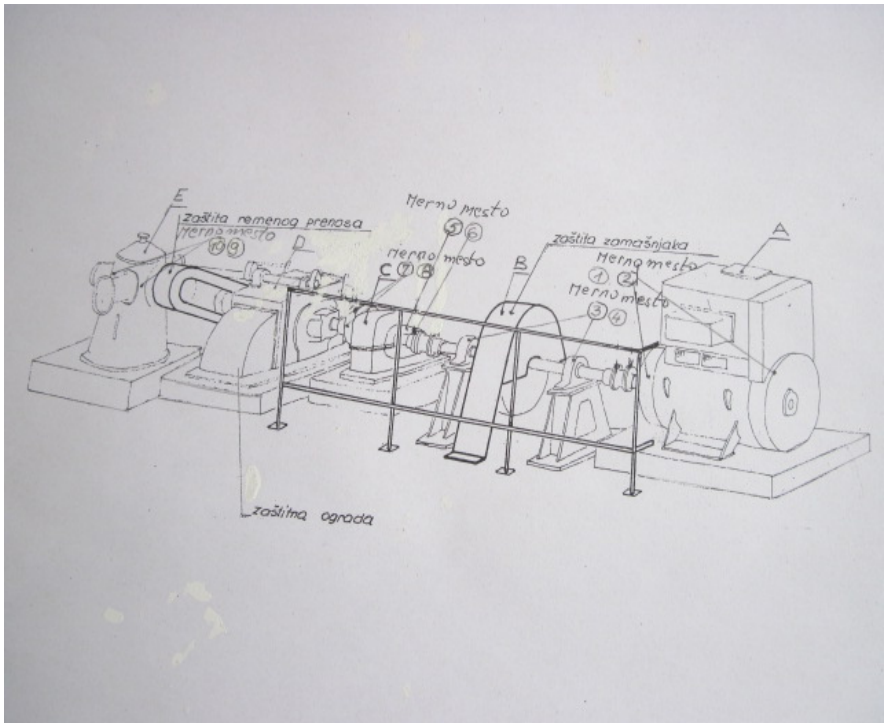

Figure 4 – Scheme of the plant and the measurement points at the mini hydropower plant
Рис. 4 – Схема установки и точки замера на мини ГЭС
Slika 4 – Šema postrojenja i mernih mesta na postorjenju mini-hidroelektrane

In the spreadsheets, high levels of vibration parameters are displayed and marked in yellow and red.

Table 4 presents the measured values of the vibration parameters of measuring point 5, the direction RV (bearing on the output shaft of the multiplier, on the side of the flywheel) while Table 5 shows the results for measuring point 7, direction RV (bearing on the multiplier drive shaft on the side next to the turbine).

Fig. 6 is a graphical display of the frequency spectrum at measuring point 5, in the directions RH, RV, AX, on the output shaft bearing, side to the flywheel, where high vibration levels can be noticed.

Table 4 – The measured values of vibration levels, measuring point 5, vertical direction-RV
Таблица 4 – Измеренные значения уровня шума, контрольная точка 5, направление RV-по вертикали
Tabela 4 – Izmerene vrednosti nivoa vibracija, merno mesto 5, smer RV – vertikalno

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			Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
5RV	5RV												
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	0	mm.s-1		0		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.001	g		.001		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.14	g		.14		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	1.07	g		1.07		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.05	g		1.05		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	5.88	DEF		5.88		High	0	0	7	10
5AX	5AX	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	2.62	g		2.62		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	7.95	mm.s-1		7.95		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.031	mm.s-1		.031		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	.0012	g		.0012		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.0023	g		.0023		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.424	g		.424		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	2.35	g		2.35		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	.965	g		.965		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	5.77	DEF		5.77		High	0	0	7	10
6RH	6RH	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	3.2	g		3.2		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	4.18	mm.s-1		4.18		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.026	mm.s-1		.026		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	.00037	g		.00037		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.0016	g		.0016		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.189	g		.189		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	2.71	g		2.71		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.92	g		1.92		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	7.79	DEF		7.79		High	0	0	7	10
6RV	6RV	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	2.19	g		2.19		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	3.72	mm.s-1		3.72		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.026	mm.s-1		.026		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	.00062	g		.00062		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.00079	g		.00079		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.111	g		.111		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	1.94	g		1.94		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	.868	g		.868		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	7.53	DEF		7.53		High	0	0	7	10
6AX	6AX	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	3.04	g		3.04		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	8.54	mm.s-1		8.54		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.097	mm.s-1		.097		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.0034	g		.0034		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.423	g		.423		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	2.78	g		2.78		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.19	g		1.19		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	6.74	DEF		6.74		High	0	0	7	10
7RH	7RH	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.4	g		1.4		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	3.82	mm.s-1		3.82		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.0084	mm.s-1		.0084		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.00055	g		.00055		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.196	g		.196		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	1.2	g		1.2		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	.483	g		.483		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	5	DEF		5		High	0	0	7	10
7RV	7RV	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.06	g		1.06		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	3.04	mm.s-1		3.04		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	0	mm.s-1		0		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.0012	g		.0012		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.129	g		.129		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	.841	g		.841		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	.495	g		.495		High	0	0	3	5

Table 5 – The measured values of vibration levels, measuring point 7, vertical direction –RV
Таблица 5 – Измеренные значения уровня шума, контрольная точка 7, направление RV-по вертикали
Tabela 5 – Izmerene vrednosti nivoa vibracija, merno mesto 7, smer RV – vertikalno

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			Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
7RV	7RV												
DEF	DEF	Hard	13/12/2006 12:15:38	4.55	DEF		4.55		High	0	0	7	10
7AX	7AX	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	2.83	g		2.83		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	8.44	mm.s-1		8.44		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.01	mm.s-1		.01		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.0023	g		.0023		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.363	g		.363		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	2.58	g		2.58		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	.728	g		.728		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	4.73	DEF		4.73		High	0	0	7	10
8RH	8RH	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.91	g		1.91		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	3.91	mm.s-1		3.91		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.016	mm.s-1		.016		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.172	g		.172		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	1.57	g		1.57		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	.807	g		.807		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	6.27	DEF		6.27		High	0	0	7	10
8RV	8RV	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.6	g		1.6		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	3.22	mm.s-1		3.22		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.025	mm.s-1		.025		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	.00031	g		.00031		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.171	g		.171		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	1.17	g		1.17		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.23	g		1.23		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	6.36	DEF		6.36		High	0	0	7	10
9RH	9RH	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.55	g		1.55		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	1.16	mm.s-1		1.16		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.0037	mm.s-1		.0037		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.066	g		.066		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	.604	g		.604		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.28	g		1.28		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	3.92	DEF		3.92		High	0	0	7	10
9RV	9RV	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.46	g		1.46		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	1.75	mm.s-1		1.75		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	.025	mm.s-1		.025		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	.0003	g		.0003		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	.00026	g		.00026		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.104	g		.104		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	.456	g		.456		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.5	g		1.5		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	4.81	DEF		4.81		High	0	0	7	10
9AX	9AX	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	.651	g		.651		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	1.81	mm.s-1		1.81		High	0	0	4.3	11.2
DEF	DEF	Hard	13/12/2006 12:15:38	3.05	DEF		3.05		High	0	0	7	10
10RH	10RH	H/S	Last Control	Value	Unit	T-1	Ref.	Avg	Alm Type	DG-	AL-	AL+	DG+
Acceleration - 2/20kHz	OL ACC	Hard	13/12/2006 12:15:38	1.26	g		1.26		High	0	0	3	5
Velocity - 10/1000Hz	OL VV	Hard	13/12/2006 12:15:38	1.12	mm.s-1		1.12		High	0	0	4.3	11.2
F0 - Mass unbalance	F0	Soft	13/12/2006 12:15:38	0	mm.s-1		0		High	0	0	4.3	11.2
H2 - Misalignment	H2	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	2.1	5.6
H3 - Misalignment	H3	Soft	13/12/2006 12:15:38	0	g		0		High	0	0	1	2.8
LF - 2/200Hz	BB LF	Soft	13/12/2006 12:15:38	.05	g		.05		High	0	0	.3	.6
MF - 200/2000Hz	BB MF	Soft	13/12/2006 12:15:38	.187	g		.187		High	0	0	1	2
HF - 2000/20000Hz	BB HF	Soft	13/12/2006 12:15:38	1.1	g		1.1		High	0	0	3	5
DEF	DEF	Hard	13/12/2006 12:15:38	4.5	DEF		4.5		High	0	0	7	10

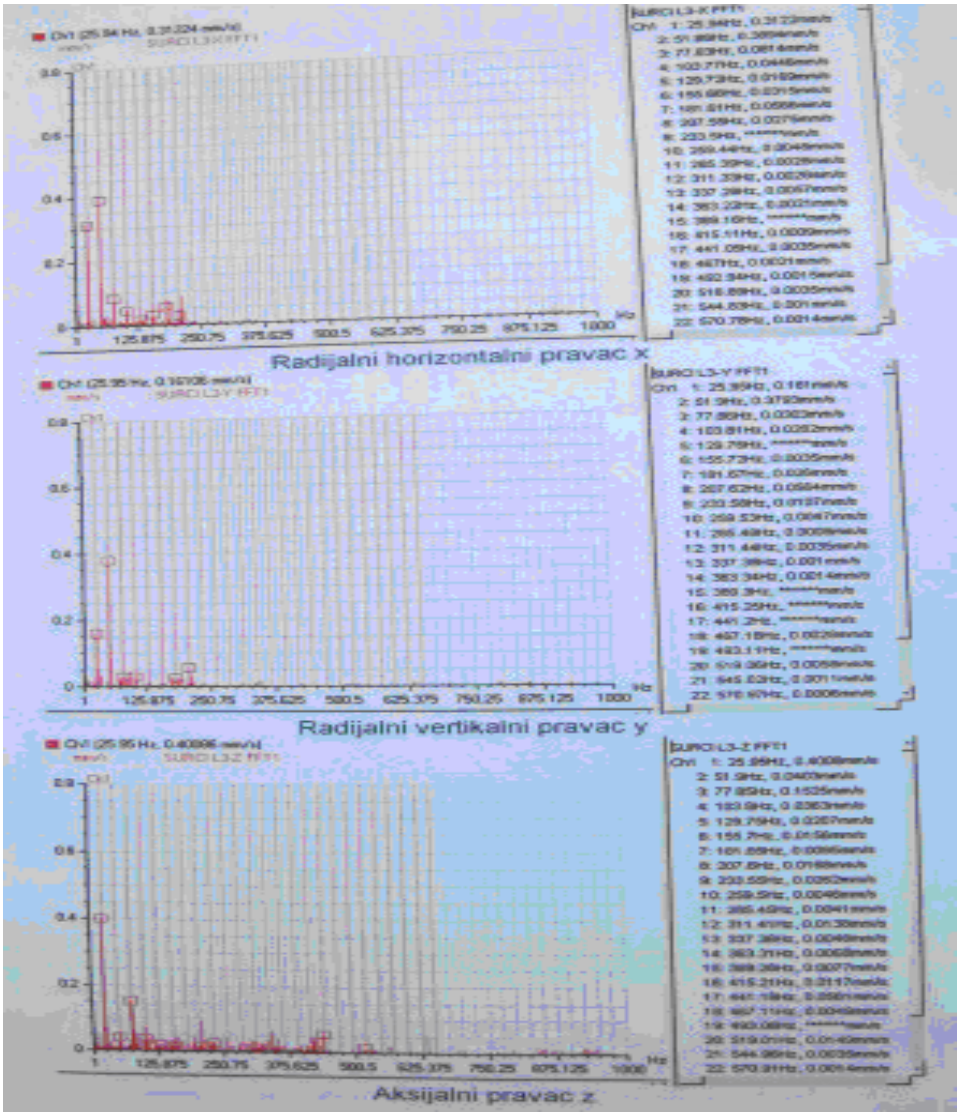

Figure 5 – Frequency spectrum of the measured vibrations and their analysis for bearing L5
Рис. 5 – Частотный спектр измеренных вибраций и их анализ на подшипнике L5
Slika 5 – Frekventni spektar izmerenih vibracija i njihova analiza za ležaj L5

Based on the measurement and the analysis of the measurement results, registered by the monitoring system, the following was determined:

The general condition of both mini hydropower plants at the location Šavnik, from the point of reference of ISO Standard 10816 and ISO Standard 2370, can be assessed as good or acceptable. On the flywheel bearings, points 3 and 4, vibrations after reaching the operating temperature of the bearings are within acceptable limits. The levels of summary acceleration in the middle-frequency domain are elevated, but due to increased vibrations on the multiplier, they are further transmitted to the flywheel bearings. For the multiplier bearings, measuring points 5 and 6 (the output shaft) and measuring points 7 and 8 (the drive shaft), vibration levels are elevated as well as summary acceleration in the medium-frequency domain. Frequency spectra of vibrations on the multiplier bearings indicate the presence of problems in the gears, most likely due to their wear. For a definite confirmation of this claim, it is necessary to provide information on the number of teeth on the gears for a more precise diagnosis.

The monitoring system indicates that there is no need for balancing rotating masses (Žegarac, Ličen, Zuber, 1999); however, due to increased levels of vibrations on the multiplier, it is necessary to plan the overhaul of the mechanical assembly.

Conclusion

Nowadays, great attention is paid to the construction of new mini hydropower plants. The paper presents the application of a modern monitoring system on the mini hydropower plants in the system of the Electrical Industry Montenegro. Regardless of the fact that these systems were installed long time ago and that they have been in use for many years, it was fully justified to carry out the modernization of these mini hydropower plants. Mini hydropower plants have an important role in the production of electricity and are networked in the electricity system. The design and construction of mini hydroelectric power plants up to 700 KW is very similar. These are hydro machines of horizontal construction and installation. In all assemblies of hydro units, there are built-in roller bearings. If power of mini hydropower plants exceeds the value of 1000 KW, the construction of such systems is in a vertical version. Embedding assemblies in such hydropower plants is performed on sliding bearings. In this case, a patented system for the diagnostics of sliding bearings is applied as well as a new technical solution for measuring and controlling the flow of water at the hydropower dam. Modern monitoring systems presented in this work are fully applicable to the systems of mini hydropower plants of higher power. On the territory of the Republic of Serbia, there is a larger number of mini hydroelectric power plants in private ownership. It is expected that, in the near future, modern

monitoring systems could be applied in them. The paper presents some examples of the application of modern monitoring systems. The function of controlling the technical correctness of such systems as well as of their overhaul is provided.The existing systems, installed in the 70s, do not have a possibility of remote control. Malfunction alert is done by light or sound signaling - ALARM system. The MHP control system is of a manual type. A great advantage of modern monitoring systems is that operators in hydropower plants can react in time and prevent damage to the system in advance if they receive signals on major defects or failure occurrence.

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ПРИМЕНЕНИЕ СОВРЕМЕННЫХ СИСТЕМ МОНИТОРИНГА НА МИНИ-ГЭС

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ОБЛАСТЬ: машиностроение, электротехника, электроника
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной работе представлены современные системы мониторинга на мини-ГЭС. В современном мире особое внимание уделяется, как сохранению существующих систем, так и строительству и сооружению новых мини-ГЭС. Мини

гидроэлектростанции входят в состав общей системы электроснабжения. Они играют важную роль в производстве электроэнергии, а также в поддержке общей системы энергопитания. В целях постоянного бесперебойного наблюдения и технического надзора за работой мини-ГЭС разработаны новые системы мониторинга. Кроме основной функции наблюдения, они также предназначены для предотвращения аварий, в случае сбоя и отказов системы. Поддержка и ремонт системы производятся по необходимости, в зависимости от технического состояния гидроэлектростанций. В осуществлении данного проекта применены современное оборудование от известных мировых производителей, а также профессиональный опыт и знания многих сотрудников.

Ключевые слова: *мини гидроэлектростанции, современные системы мониторинга, техническое соответствие, параметры диагностики, методы диагностики, вибрации системы, приборы, оборудование.*

PRIMENA SAVREMENIH MONITORING SISTEMA NA MINI-HIDROELEKTRANAMA

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OBLAST: mašinstvo, elektrotehnika, elektronika
VRSTA ČLANKA: stručni članak
JEZIK ČLANKA: engleski

Sažetak:

U radu je prikazana primena savremenih monitoring sistema na mini-hidrolektranama. U današnje vreme posebna pažnja posvećuje se održavanju postojećih sistema, izgradnji i instaliranju novih mini- hidrolektrana. One su umrežene u zajednički sistem napajanja električnom energijom i veoma su značajne za proizvodnju električne energije, kao i za održavanje celokupnog sistema energetskog napajanja. Primenjeni su novi monitoring sistemi koji omogućavaju kontinualno praćenje i nadzor tehničke ispravnosti mini-hidroelektrana. Pored toga, monitoring sistemi omogućavaju da se spreče havarije sistema u slučaju većih kvarova i otkaza. Održavanje i remonti sistema vrše se zavisno od stvarne potrebe i tehničkog stanja hidroelektrana. Korišćena je savremena oprema renomiranih svetskih proizvođača, lično iskustvo i znanje mnogih saradnika na realizaciji ovog projekta.

Ključne reči: *mini-hidroelektrane, savremeni monitoring sistemi, tehnička ispravnost, dijagnostički parametri, dijagnostičke metode, vibracije sistema, uređaji, oprema.*

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DETERMINING THE MATURITY LEVEL OF BUSINESS ORGANIZATIONS FOR ICT IMPLEMENTATION IN THE CASE OF ELECTRONIC CONTENT MANAGEMENT

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Abstract:

Starting from the fact that the use of electronic content is an imperative of our time, and from a general opinion that the application of modern information technologies can establish a solution for a reliable and simple organization and systematization of documentation, it can be stated that the organization's success depends directly on the achieved level of information management.

Timely, accurate, verifiable, readily available and consistent data are more than necessary for business activities; however, the basic problem of the use of these data is not their existence, but the place and manner in which these data are stored and organized within distributed business units. In addition, the introduction of information technologies into business processes results in more and more useful data; nevertheless, the question is the degree of their utilization.

The object of the study was to determine the degree of "maturity" of business organizations for the implementation of information and communication technologies, viewed through the prism of organizational, personnel and technological maturity of an organization for the implementation of an electronic content management system. At the same time, the use of appropriate maturity models for electronic content management aims at approaching the maturity model concept to business organizations.

Key words: *ICT, electronic content, content management system, maturity models, business organizations.*

Introduction

One of the most important factors for successful business process management is the amount of information and the method of its usage. Information and knowledge are essential for successful management at all business organization levels. This reduces uncertainty in the activities of business organizations, saves material resources and leads to rational engagement of human resources. During the implementation of business processes, information exchange between business organization units is required. Depending on the availability, accuracy and timeliness, information can affect the acceleration or deceleration of activities performed.

Linking business units through information and communication technologies enables an electronic access to relevant content as well as to coordination, integration, delivery, analysis and presentation of information. All this contributes to timely and high-quality decision making.

Information contained in electronic content has enormous significance for the business organization, regardless of its size or industry in which this organization works. There are no high-quality decisions without high-quality information. Since modern information and communication technologies are highly developed, the problem is not how to get information but how to identify useable information.

The subject of this study is to determine the degree of "maturity" of business organizations for the implementation of information and communication technologies, as seen through the prism of organizational, personnel and technological maturity of the organization for the implementation of an electronic content management system. Also, one of the objectives of applying relevant maturity models for electronic content management is introducing the concept of maturity models to business organizations.

ICT – basis for electronic content management

The development of information and communication technologies leads to the adjustment of business organizations to the market in order to be competitive, more efficient and more successful. In all markets of the modern world soaked in information and communication technologies, information plays a crucial role. The situation is similar with business organizations where timely information and its processing are crucial for the advantage on the market.

Modern management has less and less time to make decisions about the activities of business processes. There is a large amount of

data that must be processed and transmitted. Preference is given to business organizations which make decisions about their activities on the basis of timely, reliable, accurate, verifiable, consistent and easily accessible data (Milenković, 2015b, pp.7).

ICT – the concept, role and importance

Linking business units through information and communication technologies (ICT) provides an opportunity for a comprehensive approach to relevant data, to coordination, integration, delivery, analysis and presentation of information. All this contributes to making timely and high-quality decisions.

The main reason for the establishment of ICT is enabling storage and sharing of data contained in the electronic form. Virtual organizations are formed, with asynchronous, distributed and collaborative work teams who cooperate in the development of projects (collaboration), in different places (distribution) and at different times (asynchrony). As Katuu points out (Katuu, 2013), ICT have contributed to the work of many organizations to become more efficient and more successful.

The introduction of ICT leads to changes in the processes of management and decision making. ICT help managers to perform their functions more easily and efficiently. Changes in management reduce costs of horizontal communication, enabling teamwork and flexibility. Monitoring changes in the environment is critical, which means observing the real environment, competition and financial conditions that business processes and technology trends depend on (Klein and Methlie, 2009, pp. 18-22).

The importance of ICT for the business system is a common use of decision support software, unified information access, enabled electronic communication and data exchange, data management, increased productivity and reduced costs in business systems.

The development of ICT has enabled faster and better communication, improved business processes, secured storage of information, and facilitated information search from any location in the world, 24 hours a day. Thanks to ICT, quality computer connectivity of organizational units is achieved through the capacity, speed and efficiency of data collection, processing, transmission and data protection. Computer networking of organizational units contributes to the following (Milenković, 2013, pp. 4):

– the use of common data and unique understanding and knowledge of a real situation;

– increased efficiency and shortened time required for decision-making, and

– increased overall efficiency of the organization as a whole.

The concept of electronic content management

Organizations use a variety of ways to manage their electronic content, from network and local drives to specialized software such as the content management system (*Enterprise content management system*, ECMS). In an extremely negative sense, Katuu points out (Katuu, 2013) that there are cases that electronic content is not managed in any way.

According to Pelz-Sharpe (Pelz-Sharpe et al, 2010), content management systems are often used as a synonym for terms such as Electronic Document Management System (EDMS), Electronic Records Management Systems (ERMS), Integrated Document and Records Management Systems (IDRMS) and Electronic Document and Records Management systems (EDRMS).

In the context of this study, a content management system represents the most sophisticated element in managing electronic data essential to decision-making processes. The Content Management System can be defined as a set of strategies, methods and techniques used for creating, storing, processing and distributing content and documents that are a part of the life cycle of organizational processes.

The results of the introduction of electronic content management systems are increased availability and easier content control, information access control, more efficient implementation of business processes, saved material and human resources, reduced operating costs, and certainly support to decision making.

Determining the maturity degree of electronic content management systems

In order to make any decision on improving data management practices and to began implementation of new or improvement of existing solutions for data management, it is necessary to analyze a real situation of electronic content management in an organization. So-called maturity models are used for the evaluation, presentation and monitoring of the conditions and capabilities of organizations in performing their functional processes. This part of the work shows the dimensions (elements) of a maturity model of an electronic content management system in the context of its implementation within large business organizations such as a military organization.

The definition of the maturity model

Each complex business organization uses an electronic content management system (which manages documents and other electronic files). Such a system can range from storing unstructured files on local

disks or network devices, providing only the access rights to users, up to highly sophisticated software components for the management of corporate digital content in all business segments. The level of development of content management in most business organizations is between these two extremes.

In order to analyse real conditions of electronic content management in an organization, it is first necessary to assess the content by determining the type of the content, where and how this content is stored and whether and how it is managed. The answers to these questions are the key to determining the content "maturity".

Since determining the "maturity" of a business resource is a complex process which requires an analysis of multiple dependent and independent parameters, special models, so-called maturity models, have been developed. Initially, maturity models have been used for the purposes of software engineering. Later, the application of maturity models extended to other disciplines, such as: business process analysis, public administration services, financial management, human resource management, health sector, management of information technologies and project management. Maturity models are used for monitoring, evaluation and presentation of the current state of a corporation, such as, for example, a level of "maturity" of the corporate ability to perform assigned functions.

The maturity model of business organization content management is one of the models of information and data management, which developed in accordance with the principles of maturity (Matthew, 2003). This paper shows the dimensions (elements) of the maturity model of the content management system in the context of its implementation within large business organizations, with the aim of timely decision making in critical moments.

Dimensions of the maturity model of the content management system

In this paper, the emphasis has been placed on maturity models relating to electronic content management in terms of corporate environment. In order to determine properly the level of maturity of the organization in terms of its relationship to corporate content, it is necessary to define the dimensions and elements of maturity.

According to Pelz-Sharpe and Katuu (Pelz-Sharpe et al, 2010) (Katuu, 2013), the maturity of the content management system is identified through the following dimensions:

– data i.e. content storage,
– system efficiency, and
– system flexibility.

Where each of the above dimensions has some specific attributes. In assessing the dimensions required for data storage, it is necessary to identify the following attributes:

– *locations* where the content is located (Are data stored on local hard disks or on network shared resources? Are data in the context of already existing content management solutions?), and

– *formats* in which it is located (including outdated and specific formats) or in what format the content will be kept in perspective.

When considering the location, i.e. data storage capacity, it is necessary to examine the processes related to the *access* to the content. In principle, this means that it is necessary to answer to the following questions: What content is there? Is the content currently available to customers? How are shared content locations controlled? How do users share the same content?

Assessment of the dimensions for storing data from the content management system also includes considering a plan for using storage space. In organizations with low maturity, planning and development of strategies for the management of storage capacities are rarely or almost never done. In this case, solving the problem of how to maximize storage capacity is left to information technology (IT) experts. In organizations with a higher level of maturity, IT professionals have a possibility to obtain systematic reports on system usage and storage space. In this way, experts and managers can better and more easily perceive and understand the effects and trends that the content management system has on the overall operations of the organization.

Content management systems should cover the whole life cycle of content, from its creation, through distribution and final withdrawal from operational use (deletion or permanent archiving) (Milenković, 2015b, pp. 56-59). A critical characteristic in carrying out processes in the organization is their *efficiency*. Business organization systems that use manual data processing (due to which data are multiplied or there are unnecessary activities within the process) contribute to excess spending of resources, which can be either staff time spent in work processes with the content (documents), or technological resources that must be purchased to support management.

The business process *automation* is the first criterion for the efficiency of the organization. In organizations with low maturity of the content management system, content management processes are mainly performed manually and require more (redundant and non-automated) steps in all phases of the content lifecycle. In organizations with a higher maturity level of the content management system, many processes are automated, with no negative impact on their quality. Organizations with a medium level of maturity are usually in the phase

of identifying bottlenecks and failures in managing content manually. They are also in the initial stage of analyzing available technologies that can simplify these processes. The result of the automation of the content management process is easier identification and retrieval of the content in a myriad of business documents. In most organizations, transfer of content is a critical factor in achieving business goals. In organizations with low maturity of the content management system, there is no management of content transfer: electronic files are exchanged several times; neither content versions are dealt with nor the use of current versions is controlled; in addition, risk factors and distribution costs are increased. In organizations with a higher level of maturity of the system, content management processes are integrated with information technologies within the content management system. This contributes to the transfer of content to be managed in a reliable and efficient manner, within the framework of optimized business processes.

In organizations with a low maturity level, there are templates of documents but files are managed in an inconsistent way. Implementation of the content management system allows the use of the tool which easily manages the design and formats of electronic content, using standards of business organizations.

The synergy of the concept of content management with information and communication technologies represents an ideal content management system which achieves two goals: *to create once-used anywhere* and *content as you like on demand*. (Milenković, 2015b, pp. 54). The organization with a high level of maturity system reaches these goals by building tools and processes of maximum flexibility.

Creating arbitrary content (on the user's demand) in organizations with a low maturity content management system is typically a difficult and long process. It usually takes a long time to find the already existing content that users need in order to create new content (document). Still worse is the situation when the existing content cannot be found. As organizations acquire higher levels of maturity in the implementation of content management systems, their tools for content management not only keep the content in structured standardized forms bur also enable simple and efficient creation of different types of output documents with the same content used in the proper context.

According to Katuu (Katuu, 2013) using metadata can improve the creation of new content and its use through all stages of the life cycle. In organizations with low maturity content management systems, metadata represent only time of the creation and changes of documents as well as basic information about their authors. Also, using metadata is limited to

good practice and users' skills. By achieving a higher maturity level of the content management system, organizations become skilled in planning, organizing and incorporating metadata in all their content. In this way, working with corporate content becomes effective.

Applying consistent business rules combined with effective metadata provides optimal flexibility and consistency of required content (Milenković, 2015b, pp. 60). To achieve the highest level of maturity, it is necessary to:

– constantly analyse business processes,

– continuously improve business rules on creating, storing and using content, and

– carry out the integration of all these processes and rules in the context of the content management system.

One example of the electronic content management maturity model

To obtain effective content management systems of business organizations, business strategy and development of the system regarding technology must be clearly defined together with strategies of applying best practices. There are many ways to determine the maturity of the content management system, and "maturity" primarily stems from: (Milenković, 2015a, pp. 206–210):

– the use of content management systems at all levels of management in the organization,

– degree of the management of the document life cycle,

– development of organizational awareness of the importance of managing unstructured information, and

– the amount of critical data which has been successfully managed.

An electronic service for the exchange of electronically signed documents, established in the MoD and the SAF, has been used as an example of the application of the maturity model for digital content management. This service is a precursor of the Document Management System for Digital Content in the MoD and the SAF (Milenković, 2014, pp. 37-40).

Thirteen dimensions of maturity, largely affecting the content management system, have been discussed. The maturity model dimensions have been classified into three categories: personnel, information and systems, as shown in Table 1 (Milenković, 2015a, pp. 207).

Table 1 – Review of the categories and dimensions of the maturity model
Таблица 1 – Обзор категорий и размеров модели зрелости
Tabela 1 – Pregled kategorija i dimenzija modela zrelosti

Category	*Personnel*	*Information*	*Systems*
Maturity dimensions	Professional competence	Content/Metadata	Volume
	IT competence	Depth	Width
	Process dimension	Manage	Security
	Compliance of processes	Reuse	Usability
		Finding	

Each of the dimensions is described further on. For a practical application of the maturity model in a business organization and for the assessment of the achieved level of maturity in a specific business process, each of the dimensions is allocated a numerical value in an arbitrary assessment range (for example, from 1 to 5). The numeric value represents the evaluation of the achieved level of maturity (where a value of 1 represents the lowest level, and a value of 5 the highest level of maturity).

The *Personnel* category is described through four dimensions (Cameron, 2011):

– Professional competence refers to the ability of employees to understand the concept of content management systems.

– IT competence refers to the ability of employees to properly use existing and new information systems.

– Process dimension means the achieved level of the analysis of business processes in terms of content management.

– Process compliance involves a measure of the efficiency of cooperation between business process experts and IT experts, or their level of understanding and synchronization.

The *Information* category has five dimensions:

– Content / Metadata is a measure of the conducted analysis of content and its metadata in the context of business processes.

– Depth refers to the completeness of the content life cycle management.

– Management refers to the presence of rules and procedures for the management of business information.

– Reuse means the possibility to use the content for other business purposes.

– Finding means the possibility of finding the right content at the right time.

The *System* category has four dimensions:

– Volume presents a collection of organization business processes included in the content management system (for example, document management, business process management, etc.)

– Width represents the scope of business organizations vertically and horizontally, in accordance with business needs.

– Security represents an extent to which access to business content could be, in terms of security, reflected in the activities of the organization.

– Usability is an extent to which the implemented system corresponds to the actual business processes and needs.

Conclusion

This paper presents an overview of the connection of electronic content necessary for decision making and information and communication technologies. The work shows one of many studies on the management of electronic content as well as information necessary for decision making in complex organizational structures.

Starting from the fact that the use of electronic content is an imperative of our time, and from a general opinion that the application of modern information technology can establish a solution for a reliable and simple organization and systematization of documentation, it can be stated that the organization's success depends directly on the achieved level of information management, i.e. information contained in documents.

Timely, accurate, verifiable, easily accessible and consistent data are more than necessary for business activities: however, the basic problem of the use of these data is not their existence, but the place and manner in which these data are stored and organized within distributed business units. In addition, the introduction of information technologies into business processes results in more and more data: nevertheless, the question is the degree of their utilization.

The emphasis is placed on maturity models regarding electronic content management in organizations. In order to properly determine the level of maturity of an organization in terms of its relationship to corporate content or any other component of its business processes, it is necessary to define the dimensions and elements of maturity. Dimensions vary depending on the maturity of the sector the organization belongs to.

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ОПРЕДЕЛЕНИЕ ЗРЕЛОСТИ УРОВНЯ ОРГАНИЗАЦИИ ПО РЕАЛИЗАЦИИ ИНФОРМАЦИОННЫХ И КОММУНИКАЦИОННЫХ ТЕХНОЛОГИЙ В СЛУЧАЕ ЭЛЕКТРОННОГО УПРАВЛЕНИЯ ИНФОРМАЦИОННЫМ НАПОЛНЕНИЕМ

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ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Исходя из факта того, что использование электронного контента является императивом нашего времени, и общего мнения о том, что применение современных информационных технологий может создать решение для надежной и простой организации и систематизации документации, успех организации напрямую зависит от достигнутого уровня управления информацией.

Принимая во внимание, что для предпринимательской деятельности более, чем необходимы своевременные, точные, легко доступные и поддающиеся проверке данные, основная проблема использования этих данных заключается не в их существовании, а местонахождении и организационном методе их хранения в рамках бизнес-единиц. Кроме того, внедрение информационных технологий в осуществление бизнес-процессов способствует ежедневному накоплению полезной информации, в связи с чем возникает вопрос о степени их использования.

Цель данного исследования заключается в определении степени «зрелости» коммерческих организаций для внедрения

информационно-коммуникационных технологий. Данный вопрос рассматривается сквозь призму организационной, кадровой и технологической зрелости организации для внедрения электронной системы управления контентом. Применение соответствующей модели зрелости в управлении электронным контентом направлена на принятие данной модели коммерческими предприятиями.

Ключевые слова: *информационные и коммуникационные технологии, электронный контент, системы управления контентом, модели зрелости, коммерческие организации.*

UTVRĐIVANJE STEPENA ZRELOSTI ORGANIZACIJE ZA PRIMENU INFORMACIONO-KOMUNIKACIONIH TEHNOLOGIJA NA PRIMERU UPRAVLJANJA ELEKTRONSKIM SADRŽAJEM

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OBLAST: informatika
VRSTA ČLANKA: stručni članak
JEZIK ČLANKA: engleski

Saţetak:

Polazeći od činjenice da upotreba elektronskih sadržaja predstavlja imperativ današnjeg vremena, kao i od opšteg stava da se primenom savremenih informacionih tehnologija može uspostaviti rešenje za pouzdano i jednostavno organizovanje i sistematizaciju dokumentacije, uspeh organizacije direktno zavisi od dostignutog stepena upravljanja informacijama.

Imajući u vidu da su za obavljanje poslovnih aktivnosti više nego potrebni pravovremeni, tačni, proverljivi, lako dostupni i konzistentni podaci, osnovni problem upotrebe tih podataka nije njihovo postojanje, već mesto i način na koji su ti podaci smešteni i organizovani unutar distribuiranih poslovnih jedinica. Takođe, uvođenjem informacionih tehnologija u obavljanju poslovnih procesa, korisnih podataka je sve više, ali se postavlja pitanje stepena njihove iskorišćenosti.

Predmet rada jeste utvrđivanje stepena „sazrelosti" poslovnih organizacija za primenu informaciono-komunikacionih tehnologija, posmatrano kroz prizmu organizacione, kadrovske i tehnološke zrelosti organizacije za implementaciju sistema upravljanja elektronskim sadržajima. Ujedno, primena odgovarajućih modela zrelosti za upravljanje elektronskim sadržajima ima za cilj i približavanje tog koncepta poslovnim organizacijama.

Ključne reči*: informaciono-komunikacione tehnologije, elektronski sadržaj, sistemi upravljanja sadržajem, modeli zrelosti, poslovne organizacije.*

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REAL IMPROVEMENT PROCESSES IN THE ARMY BASED ON THE LEAN SIX SIGMA CONCEPT

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Abstract:

Readiness for challenge and change, doing more with less as well as focusing on quality and the customer - these are some of the most important areas of the activities of industrial producers, which military leaders in armies around the world have also developed to make their work more efficient and effective. This article provides an overview of the achievements in the United State of America (USA) military and its suppliers and associates, where the implementation of modern process management concepts has led to significant improvements and savings in various areas. The article also suggests possible applications of the existing successful business models in related areas in the Serbian Army.

Key words: *lean, suppliers, military, manager, user, field.*

Introduction

Market competition, business conditions, contemporary problems, threats and trends – they all require changes in the ways of thinking and acting of entire nations, their governments, and large organizational systems which produce complex technical systems or provide a variety of services. Military systems are, by their own nature, large users of resources and services. They mostly possess production and service capacities that are often insufficient to cover their own needs, due to changes in the execution of planned or unexpected or complex tasks, so they have to meet their own needs by joining forces with respective systems or in the open market. Approved resources are, like everywhere, a limiting factor for the execution of tasks. The system's response to emerging changes and needs in a fast, complete and high-quality way has already become an imperative, which is particularly evident when it comes to organizational systems that deal with the defense of a country, its interests, territory and resources.

Management of processes in large organizational systems in the traditional manner (decrease the cycle time, more intensive and more dynamic work, recruiting, buying more machines, analysis of profits but not losses, planning without taking into account limitations, etc.) does not give satisfactory results in the modern time. Intellectual potentials of the Army, in cooperation with industry representatives and other civilian organizations, are trying to find a solution to this problem and manage to lead a fight for quality and customers to an extent, by observing and analyzing processes, encouraging and involving all members to make changes for the benefit of both the system and their own, as well as by creating and using the methods, techniques and tools that bring improvement.

This article is based on the theoretical assumptions of modern concepts of process management in organizational systems, which have found their implementation and have given very good results in large organizational systems dealing with production of technical systems (TS) and providing maintenance services to TS such as Toyota, Ford, Boeing and others. The article presents the historical development of the Lean and Six Sigma concepts of managing organizational systems, as well as the most commonly used ones in the last decades. The principles, methods, techniques and tools of these management concepts are presented. The differences between the traditional organizational systems and the Lean Six Sigma organizational systems are given as well as significant results which can be achieved by applying the Lean and Six Sigma concepts of managing organizational systems. Most of the article deals with the display and the analysis of the startup and implementation of Lean Six Sigma transformations in foreign armies,

especially in the United States of America (USA) and the United Kingdom (UK), presenting all the potential possibilities of the application of the described conceptual approach through the implementation phases. At the end of the article, the basic management functions and processes in the Ministry of Defence (MoD) of the Republic of Serbia and the Army of Serbia are briefly analysed, with the aim of developing models to improve the situation on the basis of the Lean Six Sigma concepts, modeled on the described large systems in the USA and the UK.

Business improvement based on contemporary concepts

In order to survive in the market in contemporary business conditions, production and service systems have to focus on customers and strive to business excellence, especially in crisis conditions. A response to new circumstances imposed by market can be found in the Lean Six Sigma (LSS) concept management.

The Lean Six Sigma concept demands constant changes and continuous improvements. The emphasis is on employee involvement and teamwork, measurement and systematization of processes, reducing variations and defects and shortening the duration of the process.

The Lean Six Sigma concept has more advantages than other concepts of improvements. The concept of Six Sigma focuses more on process quality than process speed in the organizational system. The concept known as Lean is better at improving the rates of activity in the process than at improving quality.

The concept of Lean in technical and professional literature in the West first appeared in the early nineties of the twentieth century and is associated with the results of five years of extensive research which referred to the future of the automobile industry on a global level (John Krafcik, MIT student - now CEO Hyndaia). The Massachusetts Institute of Technology - MIT, USA, conducted research on the production system in the Japanese car factory Toyota, Toyota Production System (TPS), which was established under specific geographic, economic, political and cultural circumstances as an attempt to increase Toyota's competitiveness in the early 1950s and has continued to develop until today.

Books that stemmed as a result of this project represent real industry best-sellers (Figure 1) and they resulted in significant changes in the way how production is organized and viewed in the West.

The Lean management concept means to create greater values for customers or users with fewer resources invested. Lean companies know which values their customers or users require, and focus their key processes in a way to continuously add value to their customers or users.

Figure 1 – Authors of books, James P. Womack and Daniel T. Jones
Рис. 1 – Авторы книг, James P. Womack и Daniel T. Jones
Slika 1 – Autori knjiga su James P. Womack i Daniel T. Jones

The concept of Lean means "slim" and vividly describes the concept basis: to produce or provide services with fewer supplies, facilities and defective products, with less capital, labor, hault, waiting and all that does not add value to a product or service. Lean production reduces unnecessary activities and is directed to the customer order.

The Lean concept is most easily described by its five basic principles: to determine the value for a customer or user, as illustrated by the message in Figure 2, to map a way to create a new value, to make a value flow, to establish that the flow meets the requirements (PULL or withdrawal) and to constantly strive for perfection.

Lean also defines eight losses: overproduction, waste, unnecessary movements, unnecessary supplies, excess processing, hold, transport, and insufficient use of the potential of employees.

In order to eliminate losses, Lean management uses its tools such as Kaizen, 5S, Kanban, value stream mapping, JIT, TPM and others.

With its tools, Lean achieves significant results, the most important ones being:

- Total production or service time is shortened;
- Increasing work performance;
- Reducing supplies;
- Improving quality;
- Reduced time of placing a product on the market;
- Smaller space requirements;
- Smaller investments in storage;
- Faster response to market changes;
- Simplifying the planning function and reduction of business documentation.

Figure 2 – A professional soldier needs a complete, functional and reliable combat vehicle
Рис. 2 – Для профессионального солдата важнее всего укомплектованность, исправность и надежность боевой машины
Slika 2 – Profesionalnom vojniku važno je samo da je borbeno vozilo ispravno, kompletno i pouzdano

The characteristic differences between Lean organizational systems and traditional organizational systems can best be seen in the following table (Rajković, 2012).

Table 1 – Difference between traditional and Lean organizational systems
Таблица 1 – Отличия традиционной и Lean организационных систем
Tabela 1 – Razlike između tradicionalnog i Lean organizacionog sistema

TRADITIONAL ORGANIZATIONAL SYSTEM	LEAN ORGANIZATIONAL SYSTEM
complex	simple
Manages the budget	Is guided by demand
excessive supplies	Supplies based on demand
Accelerating activities that add value	Finding and maximum reduction of activities that do not add value
Mass production or provision of large scale and small assortment	Production of small series but more models or the provision of various services of a small scale
Long time from order to delivery	The minimum time from order to delivery
Quality is based on inspection and achieved by upgrade	Quality is built into the design right from the start
Functional services	Process organization

The Six Sigma (6σ) is a business concept and method for quality improvement. The application of this concept began in the company for telecommunication devices and systems Motorola, in the 1980s. Thanks primarily to the successful implementation of the Six Sigma concept, in 1988 Motorola won the "Malcolm Baldrige Quality Award", the most famous American Quality Award (Goetsch, Davis, 2006). The application of this concept in organizational systems provides tools to make their processes more successful. The ultimate goal is to achieve zero defects in manufacturing some products, services or transactions. The 6 σ quality level corresponds to the appearance which is a variation equal to a half of the default tolerance, with the allowed deviation from the mean of 1.5 σ (Figure 3) (Lazić, 2006).

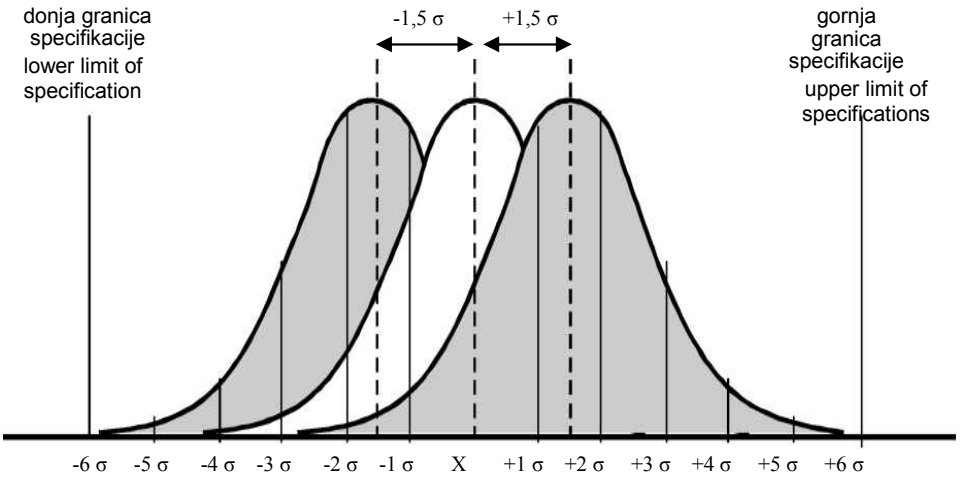

Figure 3 – Dissipation of the process and the shift of the dissipation center
Рис. 3 – Рассеивание процессов и перемещение центра рассеивания
Slika 3 – Rasipanje procesa i pomeranje centra rasipanja

Allowing deviation from the mean is very important because there is no phenomenon occurring under perfect conditions. If the tolerance limits are set to the level of +/- 6 σ and the deviation from the mean value is allowed to be +/- 1.5 σ, the level of product defects per million (DPM) will be from 3 to 4 defects. In Table 2 (Lazić, 2006), there are data for a process in which a deviation from the mean is not permitted and for a process with a permitted deviation of 1.5 σ, typical for Motorola, where Cp is the precision index.

Table 2 – The defect levels of centered and shifted processes
Таблица 2 – Концентрация деффектов процессов центрирования и перемещения центра
Tabela 2 – Nivo defektnosti centriranih i pomerenih procesa

The tolerance limits	Centered process		The process shifted for the ± 1.5 σ			Cp
	Chance	dpm	Chance	dpm	Cpk	
± σ	68.27	317.300	30.23	697.700		0.33
± 2σ	95.45	45.500	69.13	308.700	0.17	0.67
± 3σ	99.73	2.700	93.32	66.680	0.50	1
± 4σ	99.9937	63	99.379	6.210	0.83	1.33
± 5σ	99.999943	0.57	99.9767	233	1.17	1.67
± 6σ	99.9999998	0.002	99.99966	3-4	1.5	2

The application of the 6 σ concept showed a close relationship with financial results of companies. According to these results, companies, on the world scale, can be classified as world class, middle class and uncompetitive ones, as seen in Table 3 (Lazić, 2006).

Table 3 – The process capability impact on the competitiveness of companies
Таблица 3 – Влияние процессов на конкурентоспособность компании
Tabela 3 – Uticaj sposobnosti procesa na konkurentnu sposobnost kompanija

The tolerance limits	*Number of defects per million*	*The price of low quality*	*The level of competitiveness*
6 σ	3.4	< 10 % OP	World Class
5 σ	233	10-15% OP	
4 σ	6,210	15-20% OP	Middle Class
3 σ	66,680	20 - 30% OP	
2 σ	308,700	30 - 40% OP	Uncompetitive
1 σ	697,700		
Note: OP - volume of sales			

The 6 σ concept is not based so much on the number of defects per million opportunities, but rather on the process of gradually reducing the process dissipation.

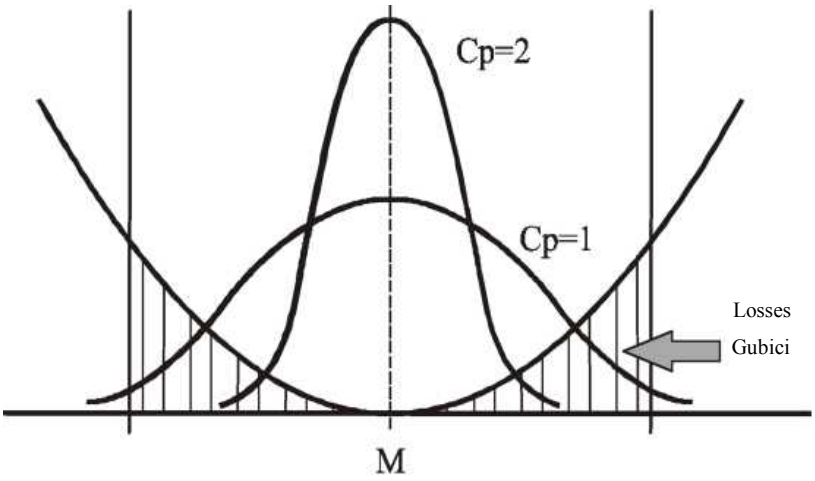

Figure 4 – Dissipation of the process and functions of losses
Рис. 4 – Рассеивание процессов и функция потерь
Slika 4 – Rasipanje procesa i funkcija gubitaka

In this way, losses are reduced and profits increased, which can be seen in Figure 4 (Lazić, 2006).

Launching the Lean Six Sigma transformations in foreign armies

Support of the highest level of command

As in private companies, at the very beginning of transformation processes, support of the army leadership and its engagement in educating and gaining support of employees is necessary for the continuity, of, above all, cultural changes.

The USA Air Force adopts the basics of the LSS concept through the entire organization. The Lean Six Sigma has expanded its functioning into three USA Air Force Logistics Centers (Robin, Tinker, Hill Air Force Bases (AFB)), where the Lean initiative brought exceptional improvements in the life cycle of processes and other key indicators (Wetekam, 2006) .

For example, various Rapid Improvement Events (RIEs) at the beginning of the 21st century in Robins AFB enabled employees to reduce the average C-5 USA military transport aircraft overhaul time from 339 days to fewer than 180 (Wetekam, 2006). It used to take more than 10% of that time or 39 days to carry out aircraft inspection or defectation before overhaul. The defectation time is today about 21 days. Although

similar improvement was achieved in all these logistics centers, a lot of work still remained for potential future improvements. For this reason, AFB directors in charge of planning and programming have a permanent task to directly involve managers in Lean transformations.

The need for cultural change

In RAFB, the beginning of LSS transformations started by seeing the need to return to the Lean management concept from 1999, when Lean was shaped and recognized as a concept for significant improvements in industrial production by the MIT (Massachusetts Institute of Technology) specialists. In RAFB, they today learn to adapt and use TPS as the basis of the Lean concept, and to discover its real power. A look at the process that takes place in this organizational system is not a new one, but the whole process is involved in the PDCA (Plan, Do, Check, Act) cycle and continuous improvement. In addition, the strength of the Toyota Production System is properly understood not only as a process of thinking, but also as a way to consider a work process in an organizational system from the point of detection and elimination of losses.

Mobilising resources in scientific work

It is crucial to reduce aircraft overhaul time in all three Army Aviation Logistics Centers in the USA which deal with the highest level of aircraft maintenance, i.e. the task of top management is to get aircraft operational as soon as possible under the conditions of limited financial resources.

Every five to seven years, C-5 military transport aircraft are repaired at the highest level of maintenance. AFB workers dismantle them into pieces, and after necessary replacements, repairs and adjustments, they assemble them again. Every overhaul takes thousands of hours from the aircraft flight time. The introduction of the LSS concept in AFB, in the period from 2000 to 2006, saved more than 100 flight days to the US Air Force, by reducing the number of days aircraft spent in the repair shops for one third. In 2006, in RAFB, they achieved that 100% of the time needed for the C-5 repair had 0% of changes in the overhaul schedule.

Analyzing numerous data related to C-5 aircraft (produced in 1960) maintenance is a complex job and scientific work. Scientific work is an area where the LSS concept has great potential. This is work that adds value to a product or service, during which significant information helps managers create a proper sense of when to use them, i.e. help them to make decisions based on real facts (Wetekam, 2006).

Value Stream Mapping (VSM) is an essential LSS concept tool, necessary to be applied at the beginning of business improvement in the organizational system as well as later because of the need for continuous improvements of any process. VSM is primarily a help in analyzing and improving the flow of materials and information necessary for the production of products or the provision of services to customers or users. The need to apply initially VSM within scientific work does not seem logical to some scholars until they see the benefits of such an approach.

Scientific work involves asking questions and answering them. It is necessary to standardize questions in the right way to accomplish a specific task in a more efficient manner. For example, when purchasing a new weapons system, a panel discussion at the highest level of management should be conducted for each individual purchase. The panel should include a standard list of questions. Examples of panel applications during the acquisition or development of new weapons systems in the US Army are numerous. Only in this way functional technology can be designed, delivered and made suitable for future improvements.

A very important segment of scientific research in RAFB is the assessment of performed work as an important part of the process of strategic planning and budgeting in a 5-year period with the purpose of relentless pursuit and elimination of losses or activities that do not add value within the Lean system transformation. This is accomplished by observing how people perform individual activities, by eliminating weeks of lost time during task clarification and by wondering where to find additional gain. The RAFB leadership has a role to "clarify" the way in the introduction of Lean.

The management responsibilites and the problem solving methods are given in Table 4.

Table 4 – Responsibilities of the management and the problem solving methods (Wetekam, 2006)
Таблица 4 – Ответственность руководства и способы решения проблем (Wetekam, 2006)
Tabela 4 – Nadležnosti rukovodstva i načini rešavanja problema (Wetekam, 2006)

RESPONSIBILITIES
Developing an effective, sustainable development action plan that will solve the problems identified in the phase of detecting the key cause and will eliminate a possibility of their return.
SOLUTIONS
- Creating a dual communication, - Developing a program of continuous self-control, - Emphasizing the need of harmonization with the directives and regulations, - Training to respect order and discipline, - Company policy must be complete, valid and consistent, - Standardization and harmonization of the control priorities on a weekly basis,

Realization of improvements in the army of the United States and the United Kingdom

Work on increasing flexibility and responsibility

As military targets are becoming more complex, fundamental changes are increasingly necessary. Missions such as, for example, destruction of an enemy's battalion clearly define the goal and the way of destruction. In these missions, unmanned reconnaissance vehicles are often used; however, they can be modified to carry missiles. The effect to be achieved is considered as well as necessary means for its realization. Lean, in this case, takes into consideration not only the elimination of losses, but also thinking about values and providing the necessary ones.

Development of the organizational system horizontally

Today, military environment requires more joint efforts and cooperation than ever before because of many activities to be carried out in complex conditions, for which multinational cooperation is often necessary.

In order to meet this demand, while working on improvements, the USA army has been adapting its organization from a vertical type of organisation to a more horizontal one, developing a network type of organisation of the LSS concept-based cooperation to become more effective. Developing a network cooperation, combined with the LSS transformation, enables creating a more effective and efficient system. Leaders must be firmly committed to change and need to talk about necessary changes from the lowest level in the organization. Subordinates need to understand the importance of the quality of their work. Acceptance of such work quickly returns through improving the quality of their work and they see improvements in their own workplaces.

Application of the Lean Six Sigma concept under the condition of limited budget of the Navy of the United States

A sense of necessity of transformation and greater readiness prevailed throughout the USA Navy, through increased involvement of personnel in the application of the LSS concept and through cultural

changes for continuous improvement. The Naval Sea Systems Command (NAVSEA), together with the Program Executive Offices (PEOs), is responsible for the project of introducing the LSS in the USA Navy. Their role is to equip the Navy ships and their weapons systems and to ensure support throughout the entire life cycle. They develop, design, procure, overhaul, maintain, modernize and finally distribute vessels, platforms and appropriate weapons systems. They have the prescribed basic procedures and contracts to act upon with the support of government agencies for maintaining core competencies. This is the basis of high responsibility. The NAVSEA has about 50,000 government people, out of which about 27,000 work in four naval shipyards, about 19,000 work in eleven combat divisions, about 1,000 in four shipyard support entities and about 2,400 people in the headquarters. Their contracts also engage thousands of people in the industry. The NAVSEA / PEOs annual volume of business is around $ 26 trillion, out of which $ 20 billion goes to industry, and the rest to government employees. The budget of shipyards and the number of ships have declined since the end of the Cold War. The current USA fleet consists of 283 ships. The growth rate is around 4 ships a year. Admiral Mike Mullen, Chief of Naval Operations in the NAVSEA, aims to expand the national fleet of naval ships to 313 in 2015 (Wetekam, 2006). This formalized challenge (a long term plan) includes and unites all the resources (government and industry) and requires a transformation that will bring greater responsibility and assets for the existing budgets. For such an undertaking, it is necessary to coordinate 50,000 people working in the NAVSEA / PEOs, plus hundreds of thousands of others in the rest of the Navy, plus the contractors. These are enormous cultural changes that the Navy has been implementing for years. The biggest change to be brought by the application of the LSS management concept is an expectation that employees become inspired for necessary changes by their daily tasks, as the leadership reprograms the approved budget and learns how to be more efficient. The goal is to reach the level when people come up with new, more advanced ideas related to the job they do, from the top to the bottom. It is necessary to find a better and easier way to do things, by eliminating losses, improving quality, reducing discrepancies and avoiding bottlenecks and constraints. In this process, the key word is recapitalization (Wetekam, 2006).

The NAVSEA / PEOs apply the LSS tools in order to create value, learning how to look at a process from its beginning to the end and to make improvements. Some tools, such as VSM, have proven to be better than other LSS tools (Figure 6).

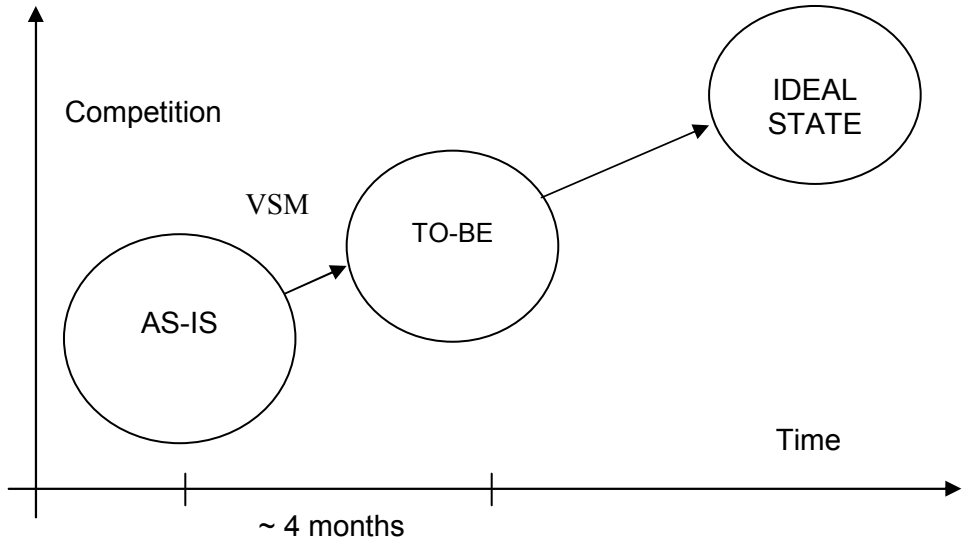

Figure 6 – Mapping the flow of creating new values
Рис. 6 – Картирование течения создания новой ценности
Slika 6 – Mapiranje toka stvaranja nove vrednosti

The NAVSEA/PEOs argue that they are successful thanks to the constant application of the LSS basic principles (Wetekam, 2006):

- providing value to the user;
- making and analyzing the road map for creating value from one end of the organizational system to the other;
- making value creating journey without delay;
- enable the user to go to meet the created value (PULL);
- strive for perfection.

The continuity of improvement until the maturity of the whole system

The next step in NAVSEA is reaching a critical mass, i.e. encouraging more employees to take part in Lean events, individual cases within the company, by managers. They try to achieve the best utilization of the equipment and readiness in each of navy area activities.

In the Norfolk naval shipyard, the Lean transformation was carried out in the activities related to drydocking, ships, engine rooms, etc. What the user requests from the facility is to see how all these improvements in the shipyard are translated into finished work - preferably with more added value - on time and within the approved budget. This can save up to 1,000,000 $.

Significant improvements have been achieved in the field of reporting. They have developed VS reporting (reporting on the activities of organizing value creation streams). Instead of reporting on 1,000 Lean events, events are grouped according to their types. The Naval Aviation Facility was the first to do that. Requirements for achieving the same level spread to other facilities and the entire NAVSEA.

Joint efforts and comparisons with other providers of similar services to the US military such as Raytheon, Lockheed Martin, Naval Air Systems Command Depots and Northrop Grumman speeded up the learning about the LSS concept implementation.

The development of the highest level of maintenance, overhaul and modernization of the facilities

In the Norfolk Naval Shipyard (NNSY), the Lean team applies the LSS concept to three completely different working models.

The first model consists of "background drives" which encompass classical machining and repair of components as well as services / protection by applying coatings. This model is more than a classic application of Lean techniques and tools. The work is executed by workforce organized into related units (cells).

The second model includes transaction-type activities whose main function (supply and delivery) is to support the vital mission of the work process. Thousands of technical drawings and work instructions, hundreds of thousands of spare parts and pieces are needed per year as support to mechanics in the right place and at the right time. Many other similar support processes also take advantage of the LSS methodology.

The third model refers to activities related to the deck and hull, which constitute the main task of the shipyard, and it significantly differs from the previous two, since hundreds of resources must move effectively on a daily basis through a very different scope of demands required for the five major ship classes. The fact that core processes and support processes result in the delivery of the right product, at the right time and the right place with the required quality makes this segment of work in the NNSY full of responsibility. It is important that all employees in the NNSY realize that their job is to support the fleet of ships and finish (deliver) complex work on schedule, with quality at the source and within the approved budget. They are helped by the LSS tools and methods to improve results in all three areas.

For the aircraft carrier Harry S. Truman (CVN-5, Figure 7), a major requirement for an overhaul in the NNSY has been recently completed.

Figure 7 – An aircraft carrier is connected to electrical cables in the port due to the removal of a magnetic field (time saving)
(http://www.maritimequest.com/warship_directory/us_navy_pages)
Рис. 7 – Авианосец привязан к причалу электрическим проводом для размагничивания (экономия времени)
(http://www.maritimequest.com/warship_directory/us_navy_pages)
Slika 7 – Nosač aviona povezan na električne kablove u pristaništu zbog uklanjanja magnetnog polja (ušteda vremena)
(http://www.maritimequest.com/warship_directory/us_navy_pages)

The project team with their co-workers (subcontractors), supported by yellow and black belt carriers in the NNSY, received that request and developed a plan for the improvement of prices, quality and safety, using the LSS tools, methods and techniques, even before the aircraft carrier came for repair. During more RIEs, they managed to complete the re-engineering process for the removal of the main shaft and the installation, which reduced the number of people involved for 1,000 per day during the assessment process (inspection and defectation). This allows the user to increase the amount of work required when selecting the NNSY for a contractor.The RIEs team in the NNSY cooperate with other naval shipyards such as Puget Sound in order to provide double application of best practice and innovations.

The inclusion of soldiers from combat units and junior officers in the Navy of the United Kingdom

Military personnel on the front line are particularly focused on and interested in improvements. When not in combat, they work on improvements every day (Wetekam, 2006). Mapping the road to the creation of value, a spaghetti diagram and other Lean tools were used to

detect losses in steps and time in different areas of a career. One of the improvements is the realization that the carrier deck can hold no more than 9 Harrier jets simultaneously in order to allow each of them to move independently. Earlier, more than 16 jets of this type were on the deck, under the assumption that this number may be even higher. The application of Lean showed that this was not the case. Standardized work has become a goal and a reality in many work areas. Everything that is an output of the aviation industry, the design of hangars or workshops for aircraft armament (shortening of the time to prepare air bombs by 80%) was evaluated for the purposes of eliminating losses. Quite simple, low-tech solutions such as painting the positions for tool shelves helped improving the flow. When lifting an aircraft in order to repair its fuselage, employees learned how to reduce the operator error by 84% and reduce the repair time by lifting the aircraft for 37% (Figure 8).

Figure 8 – The highest programmed level of the C–5 aircraft maintenance in RAFB
Рис. 8 – Высший запрограммированный уровень содержания самолета C–5 в RAFB
Slika 8 – Najviši programirani nivo održavanja vazduhoplova C–5 u RAFB

Due to the increasing number and scope of activities, the Air Management Organisation (AMO) developed a mission planning department and a sector dealing with squadron operations. The work standardization and working space optimization helped in reducing planned activities that do not bring value (by 50%) and created more flight activities that bring value. Even the dining room underwent a Lean analysis, which led to a reduction in waiting times.

Improving the highest level of maintenance of combat systems in the Red River Army Depot

The Red River Army Depot (RRAD) is a facility for the highest and most complex level of maintenance of a large part of military equipment in the USA Army. It is a part of the command for armored vehicles and weapons. The RRAD has the task of maintaining the highest level of the entire fleet of vehicles and the missile shelf-life extension.

In the RRAD, mechanics working alongside engineers, technicians and managers managed to increase productivity from five vehicles (small size vehicles) per month to 16 vehicles per month, using the LSS tools. The labor cost is reduced by half as a result of shortening the previous length (13 miles) of the total travel process (spare parts, work at different locations) for more than 70%. A Lean tool, the Spaghetti diagram, helped in recognizing the excess travel and consolidating the process into the flow process.

Another example of a successful application of the LSS concept in the RRAD is the reduction of the repair cycle time of the light multipurpose tactical truck (HEMTT, Figure 9), from an average of 120 days to 30 days.

Figure 9 – Light multipurpose tactical truck (HEMTT)
Рис. 9 – Многоцелевой транспортный автомобиль тактического назначения (HEMTT)
Slika 9 – Laki višenamenski taktički kamion (HEMTT)

Over a period of 15 months, there were several RIEs with a focus on the elimination of losses from the process in order to consolidate operations, make standard and balanced flow unities and establish visual inspection. A conversion of the accumulated process of performing operations into the form of flow had a significant impact. A better organization of the shop floor also led to the reduction of the HEMTT repair cycle time: placing necessary tools next to workers; correction; proper adjustment; scrubbing and cleaning; standardization; and a focus on safety.

Lean improvement in the accounting and financial activities in the Coast Guard of the United States

In the financial center of the USA Coast Guard as well as in many institutions of this type, there are often queues, backlogs and errors in accounting operations, as in any factory, due to millions of different payment activities per year. Since the LSS concept had been successfully applied in other military activities, the Financial center decided to start the journey of learning and applying the LSS techniques in financial accounting and transactions. All 525 employees have undergone the initial training for the LSS. In addition, first-level controllers in accounting operations had an eight-hour tour of the factory, a manufacture-related simulation and other trainings. The goal is to unite all the accounting payment processes in one, more uniform process.

Suggestions for applying the Lean Six Sigma concept in the Serbian Army and the Ministry of Defence

In the Serbian Army (VS) and the Ministry of Defence (MO) of the Republic of Serbia, there are positive examples of significant progress in the transformation of certain processes, so that the user (the whole defense system) can satisfy its requirements in an efficient manner. The intensity and extent of these changes are not in line with modern trends and requirements imposed by similar processes in other organizational systems and armies in the region.

Problems and resistance to the improvement of processes in the VS and the MO occur mostly because there is no strong and clear commitment to effective and efficient changes either with the leadership or process executors. There is not enough knowledge about the possibilities of modern concepts of process management in organizational systems, whatever they may be called, because there is no necessary exchange of information and experiences with the outside world, there is no comparison with the best in the profession (benchmarking) and trading in knowledge. This is due to saving on education and training, in line with the general tendency of treating education as cost, rather than looking to profit from that investment in a longer period of time.

Examples from the VS and MO practice, given below, have been recognized as a good basis to start improvements using the LSS concept; in all cases, it is necessary for the whole system to be committed to transformations of key processes in the VS and the MO,

based on the same concept. Introducing the concept to all employees is the next step, together with their motivation and continuous training of many years in order to obtain a quality product or service tailor-made for the defense system, within the designed limits.

Administrative tasks

Serbian army is a hierarchical complex system with many types of administrative models, procedures, forms for the same activity that takes place in different organizational units. This diversity makes it difficult for daily administration activities and operational work of the whole system, as well as for standing up for personal and business rights of individuals. There are improvements in the system development and upgrading, but bureaucratization prevails because of the resistance and different interpretations and applications of prescribed procedures. There should be a strategic commitment by the top management to make the administration system more effective and efficient through systematically breaking old habits, starting the analysis from the top downwards, finding redundant activities and patterns, defining the shortest flows of information, encouraging employees to propose changes and applying and adopting best practices on a daily basis.

Overhaul of technical systems of special purpose

The Serbian Army has overhauling institutions responsible for maintaining the highest level of its technical systems of special purpose (TSSP). Years of analyses have shown that there are various problems in their work, mostly organizational, conceptual and technological ones. That is why processes in overhauling institutions represent a great potential for improvement on the basis of the model shown in (Marić, 2010).

Maintenance of technical systems of special purpose

TSSP maintenance occupies most of their life cycle and requires significant financial means. In the TSSP maintenance theory and practice, there is a long battle for the level of optimization of TSSP maintenance costs and reliability. Maintenance management based on the model shown in (Epler, Andrejić, 2014) and (Epler, 2013, pp.121-137), can increase the effectiveness and efficiency of TSSP maintenance, without compromising maintenance quality.

Military Nutrition in the Serbian Army

In the cadet restaurant at the Military Academy, there has been an infrastructural and organizational disbalance in the capacities for the preparation and distribution of food, which makes the cadet feeding system unprofitable. The existing capacities were designed to enable the preparation and distribution of 40% more meals than the real needs are, which is, economically speaking, an unnecessary financial burden on the limited funds allocated for this purpose. In terms of meeting the economic requirements, it is possible to reduce or completely eliminate the negative effects of excess capacities by finding them other purposes or by finding alternative ways to organize nutrition at the Military Academy in a more rational way (Arsić, 2014, pp.168-186). With the support and commitment of the top management to improve business dealings in this area, the analysis given here provides a good basis for a successful transformation based on the LSS principles.

Material and financial operations

Material supply chain management in the Serbian Army is an area which has not experienced any improvement for many years, although there are daily numerous problems that the system neither answers, nor reacts to (incomplete and inefficient nomenclature of materiel, excess and inefficient documentation for disposition, the lack of a unified information system, etc.). The whole process should be fully analyzed and designed for the future in order to improve the existing situation using modern management methods, tools, techniques and IT support.

The parallel codification system of material resources (http://www.dskm.mod.gov.rs/sr/nato-kodifikacija/prednosti-kodifikacije), developed and introduced by the Directorate for Standardisation, Codification and Metrology of the Ministry of Defence of the Republic of Serbia represents a good start for the LSS quality transformation of materiel management in the Serbian Army which has thousands of various TSSP and milions of different spare parts and other materiel which has to be identified and delivered on time in required quantities.

Financial operations and the procurement process in the Serbian Army represent a regulated system with a daily circulation of a large number of various payment documents which might be consolidated and unified. Public procurement procedures are also very complex and often slow down and hinder the execution of core processes. Financial operations in the Serbian Army represent an area suitable for a transformation on the LSS principles.

Training, education and further training

In recent years, training of the Army of Serbia personnel has been unified and coordinated, which makes it high quality, more effective and more efficient. The Command for Training and the Directorate for Training and Doctrine of the SAF Headquarters (J-7) should make a VSM for the whole process of training, with the aim of detecting bottlenecks and their elimination on the basis of LSS.

Graduate and postgraduate levels of education at the University of Defence are in the process of harmonization with the global trends in the higher education system of the Republic of Serbia. Everyday processes that accompany education are often slow, complicated and do not go to meet the users, i.e. students and trainees. The whole process of higher education at the University of Defence should be visible from the enrollment to the graduation; appropriate methods, techniques and tools should be applied in order to make the system customer-focused, with higher quality and efficiency. A model presented in literature (Radošević, 2013) can help improving the education process.

Conclusion

Defects or losses are a common feature for different organizational systems providing either products or services, as well as for different processes in an organizational system. They are the ones that cause refinement, scrap, extra work of employees, increasing costs, etc. Identifying and preventing the appearance of defects or losses and their efficient and effective removal will reduce workload and costs of the process, so that available resources can be used for other investments and possible expansion of the scope of work.

Past decades of application of classical concepts and models of management of organizational systems and processes to achieve greater effectiveness and efficiency (reduction of cycle time, increasing the volume and intensity of work, hiring new people, buying more machines, analysis of gains but not losses in processes, planning without taking into account the constraints, etc.) have not brought results in organizational systems, no matter which activity they deal with.

In addition, modern business conditions, high and varied requirements of customers and users pose new and complex demands to production and service systems (companies) so that, if they want to play a part on its core business market, they must be focused on customers and strive to achieve business excellence, i.e. the quality at the source. Responses to new circumstances imposed by contemporary conditions can be found in the LSS concept of managing organizational systems.

The Lean Six Sigma concept requires continuous improvements in the organizational system, involvement of all employees in the work on improvements and changes throughout their teamwork on the measurement and systematization of processes, reduction of deviations in product quality or process duration, reduction of product defects, and everything else that can make this process of better quality and more valuable. Continuous improvement is not easy to achieve, but it is the only way to survive in the market.

The Lean Six Sigma concept has many advantages compared to other well-known concepts for improving management of organizational systems. The concept of Six Sigma focuses on quality, not on the process speed in the organizational system. The concept of Lean is better at improving speed than quality. It is therefore not surprising that the practice merged these two concepts of the management of complex and significant organizational systems that will operate on the principle of carrying out the best work in the best possible way.

Taking into account the available literature and everything said so far about the LSS concept of managing organizational systems, it can be said that the LSS management concept is the synthesis and upgrade of management in the most important elements of the organizational system, namely the concept and the organization.

The Lean Six Sigma concept of managing organizational systems represents a standardization of the proven best practices of process management through the introduction of new techniques, methods and tools. The comprehensiveness of its fundamental principles, tools, and application effects is what makes the LSS ideal for use in all types of companies i.e. organizational systems regardless of their core business and size.

The Lean Six Sigma management concept has proven its worth, as stated in the mentioned literature sources. Buyers of goods or service users get a better product or service and they become more loyal to the manufacturer or service provider. Prices are falling.The application of the LSS concept requires time, effort and money.

The Lean Six Sigma transformation in the armies around the world is sorting and cleaning equipment and optimizing inventories. This involves teaching managers, mainly by experts in this field outside the system of defense, how to see processes more clearly and comprehensively, with the aim of initiating a change in thinking and action (cultural change). First of all, it is necessary to initiate such a challenge, to invest in the training of young decision-makers, and then all the employees, because their knowledge, energy and persistence will be crucial on the long road to success and transferring the initiative to all partners and subcontractors of the army outside the military system. By applying the LSS concept of process management, troop military units would probably reach the same level of readiness with more rational and efficient

engagement of resources. Service providers in the army and their subcontractors outside the defense system would greatly increase efficiency and productivity, which would certainly contribute to their competitiveness in the domestic and international market.

There are numerous examples from the practice of the VS and the MO that can serve as a good basis to start improvements based on the proven LSS concept, which requires a commitment to system transformation, perseverance along the way, getting to know the goal, motivation of all employees, training, and long-term continuous work.

Such a systematic approach to the management of the above functions and processes in the VS and the MO, through the transparency of its results, will have a positive impact on the rest of the civil service and will make the state more successful, more effective and more efficient.

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РЕАЛЬНЫЕ ПРОЦЕССЫ СОВЕРШЕНСТВОВАНИЯ В ВООРУЖЕННЫХ СИЛАХ НА ОСНОВАНИИ LEAN SIX SIGMA КОНЦЕПТА

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ОБЛАСТЬ: логистика (организация, экономия, менеджмент в логистике)
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Резюме:

Готовность к вызовам и переменам, повышение качества продукции или обслуживания с использованием меньшего количества ресурсов, а также довольный потребитель это важнейшие постулаты в области промышленного производства. Данные правила, в целях развития и совершенствования своей сложной и ответственной деятельности и достижения большей эффективности, приняло и военное руководство во всем мире. В данной работе представлен обзор осуществленных трансформаций в вооруженных силах Соединенных Штатов Америки (США), относящихся как к военнослужащим, так и поставщикам и другим сотрудникам. В статье также описаны положительные результаты внедрения современного концепта управления процессами, такие как повышение качества и снижение расходов в разных областях деятельности. В заключениистатьи выносятся предложения по внедрению подобной модели управленческих процессов в вооруженных силах Республики Сербия.

Ключевые слова: *lean, поставщики, военный, руководитель, пользователь, область.*

REALNI PROCESI UNAPREĐENJA U VOJSCI NA OSNOVAMA KONCEPTA LEAN SIX SIGMA

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OBLAST: logistika (organizacija, ekonomija, menadžment u logistici)
VRSTA ČLANKA: stručni članak
JEZIK ČLANKA: engleski

Sažetak:

Spremnost na izazove i promene, stvaranje više dobara ili usluga sa manje resursa, usmerenje na kvalitet i na korisnika predstavljaju jedne od najvažnijih oblastii delovanja industrijskih proizvođača, a koje su vojni rukovodioci u vojskama širom sveta, po uzoru na njih, razvili sa svojim pripadnicima i snabdevačima, u težnji da celokupan, veoma složen i značajan rad učine efikasnijim i efektivnijim.

U članku se daje pregled dostignutih transformacija u vojsci Sjedinjenih Američkih Država (USA), kod njenih pripadnika, snabdevača i saradnika, gde se implementacijom savremenih koncepcija upravljanja procesima došlo do značajnih unapređenja i ušteda u raznim oblastima. Na kraju rada predložena su unapređenja u srodnim oblastima u Vojsci Srbije, primenom navedenih uspešnih modela upravljanja procesima.

Ključne reči: *lean, snabdevači, vojni, rukovodilac, korisnik, oblast.*

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CIVIL DEFENSE, LEADERSHIP AND HEURISTICS FOR THE EDUCATION OF HEADQUARTERS FOR EMERGENCY SITUATIONS

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Abstract:

This paper presents solving heuristically conceived problems in the Civil Defence by making adequate decisions in an emergency and the state of emergency with a special emphasis on the application of the heuristic model of training emergency teams-headquarters and on the role of a leader as a factor of good leadership. It is intended for command and teaching staff of the Civil Defence: local authorities (mayors of districts, cities and municipalities - commanders) and the system of protection and rescue (the Sector for Emergency Situations).The heuristic approach to problem solving should enable command staff-leaders from the local to the national level to make adequate decisions in emergency situations after the proclamation of emergency and the state of emergency in a territory part or the whole territory of the Republic of Serbia - functioning of the civil defense and the third mission of the Army of Serbia, as well as to point out the necessity of coordination between the local and national level.

Key words: *civil defense, leadership, heuristics.*

Introduction

The modern world (industrial, technological, informational, global) need leaders, trained, ready and able to: use new complex tools; quickly and efficiently acquire, build and implement a variety of knowledge; actively and responsibly participate in complex social and economic relations and processes in everyday life; and make adequate, rational and best decisions, especially in emergency situations and after the declaration of a state of emergency in the territory of the Republic of Serbia.

On the territories of local government units-LGUs (cities, municipalities) there can be an outbreak of all types of emergencies (wars, threat of natural disasters such as floods, fires of larger scales, earthquakes, landslides, etc.) as well as technical accidents i.e. emergencies (identified as 36) (Bereš et al, 2015, p.71) which should be timely detected for the purpose of taking measures to protect and evacuate people and goods.

Timely, accurate and precise information in these situations means life. Therefore, the headquarter staff for emergency situations are given special attention when it comes to their level of training, skills in handling the most modern and versatile equipment, resourcefulness in emergency situations and timely transfer of information to entities responsible for rapid intervention in the above-mentioned situations.

This work was created in the framework of the research primarily aimed at determining the relationship between learning and training emergency situation teams-headquarters after the proclamation of a state of emergency and the performance of leaders in the implementation of protection and rescue measures in these situations.

In such situations, leaders as creators of ideas and as builders of awareness about the necessity of realization of ideas have always had a crucial role in the development of the mankind. Leaders focus their abilities on technical progress, development and meeting the needs of the mankind in general and in emergency situations they focus on protecting and rescuing people, animals, material and cultural goods. These are the values that cannot be questioned, but they must not be realized at the expense of nature, environment and population, which often happened in the past. Today we are witnessing the harsh effects of such attitude of the man towards the natural world, which undoubtedly leaders are largely responsible for. Amidst ecological crises and natural and manmade disasters, when there is still no real solution to the problems in emergency situations, leaders are more often than not required to be change agents in this area. The prerequisite for changing the attitude of the man towards nature and the environment is the existence of environmental awareness and responsibility in all strata of the society in peace and emergencies alike. This work is dedicated to defining factors of environmental

awareness and responsibility and obligations of leaders to develop and apply a comprehensive policy of improving the ecological awareness and responsibility of all and at all levels in all situations.

Definition of the term

Civil Defence is a part of a unified defense system, organized for the successful functioning of government bodies, autonomous provinces, local authorities, companies and other legal entities, with the aim of protecting and rescuing citizens, providing conditions for life and work and meeting the needs of defense forces in emergency and war conditions.

Leadership in this case - the state (state leadership) as a base and system integrator of meeting the needs of the society, must take the leadership role in the development of environmental awareness, protection and rescue and responsibility to defend the country through its elected representatives (the president of the state, prime minister, etc.). To fulfill its leadership role, the state transfers its powers to local authorities (mayors of districts, cities and municipalities - commanders of emergency situation headquarters – i.e. leaders from the local to the state level) with the task of motivating the team members and the population in the endangered territory so that preventive measures and protection and rescue measures can be performed with ease and satisfaction, doubts about the future are replaced by belief, disagreements are turned into cooperative work, safety is replaced by self-confidence, and activities are implemented with the necessary quality thus providing high performances of respective organizations-local authorities units for emergencies from the local to the state level.

Heuristics - "Eureka" is defined as "I found, I discovered". The term "heuristics" means "science of the ways of finding new scientific knowledge" (Hotomski, 1995) and comes from the idea of eureka.

The integrated protection and rescue system establishes a uniform system of management, organizing citizens and logistic support in protection and rescue with an efficient system of information in peace, emergency, state of emergency and state of war (Bereš, Bereš, 2014, pp.152-164).

Leadership and Personality

In order to explain the relationship between the leadership and the personality, we analyzed the theory and some research in this field in the world and in our country:

1. Determination of leadership in terms of personality relates to the identification of personal characteristics or personality traits of leaders. Studies have shown that there are some features that are desirable for

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every leader because they increase the chances of success; on the other hand, possessing certain qualities is not sufficient for becoming a leader. "Some properties, therefore, increase the likelihood that someone will become a leader, but they are not a guarantee for it" (Petković, et al., 2002). Studying the characteristics of leaders was not in focus for a while, but with transformational and transactional leadership, that approach regained its importance. In recent years, in addition to personality traits, skills and abilities have been studied (they are often treated as one in literature). Here is some research on personality traits in leaders which may be influential in their business success.

According to Bennis (Bennis, 1991), there are a number of competencies which make a leader, but four stand out as the most significant ones. These are:

- Management of meaning, refers to the interpretation of reality to their followers,
- Management of attention, refers to drawing attention to themselves so that they could fullfill the first requirement which concerns personality traits,
- Trust management, refers to the consistency of followers because in this way they gain trust,
- Self-management, refers to the existence of a real image of themselves and their capabilities.

Benis talks about competencies, but the subtext shows that they depend on the personality traits of leaders and their skill to present themselves in the best possible way. Also, this definition is entirely related to the followers, which highlights the view that there is no leadership without followers.

Other authors consider personality traits of leaders as one of possible factors of leadership.The personal characteristics, leadership factors, (Petković, Jovanović, 2002) include:

- Personal values, a system of values and convictions of individuals, which are related to the shaping of perception, problem diagnosis, decision making and personal preferences,
- Propensity to risk refers to mastering reality,
- Skills, ability to influence others to follow them,
- Decision making, refers to speed and effectiveness or informedness and efficiency.

According to Luthans (Luthans, 2005), research distinguished the following features as the most important ones in leaders successful in business:

- Motivation to persevere in achieving the objectives,
- Motivation to lead the people,
- Integrity, which includes the desire for truth and converting words into action,

- Self-confidence that makes others have confidence in them,
- Intelligence that often consists in the ability of information processing, problem solving and discovery of solutions,
- Knowledge of the business of a particular organization,
- Emotional intelligence.

Kirkpatrick and Locke (Kirkpatrick, Locke, 1991) considered that the combination of characteristics of leaders and other factors contributes to the success of leaders in business. According to them, the most important characteristics of leaders for achieving success are as follows:

- Energy, as a desire to prove oneself, ambition, perseverance, initiative,
- Honesty and integrity, as reliability, trustworthiness, openness,
- Leadership motivation, as a desire for domination in order to achieve common goals,
- Self-confidence, as faith in their own abilities,
- Ability to perceive, as intelligence, the ability to summarize and interprete large quantities of information,
- Knowledge of the business, as knowledge of the entire industry, appropriate technical achievements, and the like.

The leaders' attributes that stood out on the basis of research are:

- Creativity, as in originality,
- Flexibility, as an ability to adapt to the needs of followers and to the demands of the situation.

2. It is interesting to see what kind of reputation today's leaders in Serbia have, how citizens see them, what they think about them and their role in the society. The study, which was conducted in December 2007 (Ajduković, 2007), generally speaking, has shown that citizens do not have a high opinion of today's leaders in Serbia. Although they agree that leadership is necessary, they do not see today's successful people as leaders in the true sense of the word. Even 60 percent of respondents to the question whether there are leaders in our country gave the answer - no. In this context, the respondents' answers to the question about the most common qualities of the Serbian leaders were not surprising (Ajduković, 2007, p.22).

The author of the study notes that "leaders typically show, unfortunately - at least the respondents think so - greed, unscrupulousness, the ability of manipulation and avidity. Only 9.2% of the respondents thought that our leaders have rightousness as a feature, and even fewer (7.1%) thought they have sincerity" (Ajduković, 2007, p.23). This study suggests that the essence of success is the possession of power, because affiliation to political parties, money or important contacts are some of the sources of power (Table 1).

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Table 1 – Which of the following characteristics usually characterize Serbian leaders? (Ajduković, 2007)
Таблица 1 – Какие наиболее распространенные черты сербских лидеров? (Ajduković, 2007)
Tabela 1 – Koje od navedenih osobina najčešće odlikuju srpske lidere? (Ajduković, 2007)

ANSWER	%	ANSWER	%
Unscrupulousness	70.3	Dynamism	20.5
Moneygrubbing	69.1	Diligence	14.3
The ability to manipulate	60.2	Objectivity	13.3
Greed	58.2	Righteousness	9.2
Forcefulness	40.3	Sincerity	7.1
Intelligence	38.5	Competitive spirit	6.6
Charisma	30.3	Some other	6.5

3. The results of the study on the characteristics of Serbian leaders or leaders in transition are given further on for possible comparisons. Since the sample is specific, a brief overview of the methods and techniques used in the study is given first.

The descriptive and empirical methods were used in this research, a so-called multiple case study. The technique used was the interview. The interview was structured, including a pre-prepared framework for asking questions. Due to the variety of respondents' jobs as well as their different social, political and life experience, the questions were not quite the same for each interviewee, but were tailored to specific situations.

Through a guided interview, data were collected on the education and the development path of the respondents. The development path refers to the work and life biography of the leader. Career information and key life events were obtained through interviews.

The performance of leaders was estimated through a set of leadership characteristics. We nvestigated the personality traits such as intelligence, work energy, vision, charisma, intuition, anxiety, depression and anger, self-esteem, desire for leadership, communication skills, creativity, ambition, persistence, consistency, informedness, and interest in politics.

The study included ten case studies, i.e. an interview was conducted with ten respondents.

For the purpose of interviewing, the questionnaire represented the basic structure and the database of questions based on which the interview was conducted. Depending on the situation, the questions were supplemented, extended, or changed. The questionnaire contains three sections: personal information and education, working biography and personality traits.

In this study, the sample consisted of ten respondents. Nine of them were male and one was female.

The research results suggest that in Serbia, males are the dominant population from which leaders come. Serbia is still perceived as patriarchal environment in which the role of women is primarily related to the family, and then to professional tasks.

All ideas about leadership are based on people, influences and targets to be achieved. It involves the use of influence to achieve particular targets.

Influence means that interactions between people are governed by the power of authority, position and knowledge.

Hence, the leadership can be understood as the ability to influence employees to strive for the achievement of a particular goal (Nikezić, 2011, pp.202-203). It is a dynamic process that involves the use of power to lead people towards a goal.

Table 2 shows a number of personal characteristics of leaders. A way to approach the key characteristics of a leader is to analyze the autocratic and democratic styles of leadership.The autocratic leader seeks to centralize authority and to make people focus on achieving objectives using legitimate power, reward and punishment. The democratic leader delegates authority to others, encourages participation and relies on expert and reference power. The first studies on these leadership characteristics were performed at the University of Iowa by K Levin (Nikezić, 2011, p.203).

Table 2 – Some personal characteristics of leaders (Nikezić, 2011, p.159)
Таблица 2 – Некоторые личностные характеристики лидеров (Nikezić, 2011, p.159)
Tabela 2 – Neke lične karakteristike lidera (Nikezić, 2011, p.159)

Physical characteristics: - activity - energy	**Personal characteristics:** - creativity - originality	**Social features:** - cooperation - prestige
Social features - background: - mobility	**Operating characteristics:** - responsibility - Orientation to the task	**Interpersonal skills:** - participation - tact
Intelligence and ability: - making conclusions - determination - knowledge - oratory skills		

In modern business conditions, leadership was studied by more than one author, starting from the contingency approach developed by Fidler, Hershey-Blanchard and the path-goal model developed by Evans and Haus. Haus also developed the model of charismatic leadership.

Three-dimensional leaders with "full-range leadership" reflect the essence of the transformational leadership profile in which capabilities to preserve the "complex structure" and make necessary changes are expressed to the maximum.

Figure 1 shows the key attributes of the transformational leadership (Nikezić, 2011, p.82).

Nowadays, international competition is on the increase as well as the importance of strategic positioning of leaders.

1. Creativity
2. Team orientation
3. Respect
4. Educating
5. Responsibility
6. Recognition

Figure 1 – Key attributes of leaders
Рис. 1 – Ключевые качества лидеров
Slika 1 – Ključni atributi lidera

In our case, 247 citizens of the Republic of Serbia (125 males and 122 females), aged 18 to 65, were interviewed through the Web research service in the period from 01.02.2014 to 07.02.2014. The survey aimed at the elimination of shortcomings in the functioning of these entities (winter service, the MIA, the Army and HQs at all levels) and the contribution of leaders from the state level to achieve better results. Comparing our results with the results of other published studies given above (without taking into account how representative the samples of these studies are), we concluded that the ability to communicate is one of the most important features of our leaders, because without the ability to communicate there is no charisma nor transfer of their vision to their followers and the others. This also applies to their ability to connect the system with communications, both vertically and horizontally, in various stages of implementing quality measures in emergency and other situations (e.g.: blizzard in Voivodina, floods in Obrenovac, etc.).

In applying the concept of quality, there are three relevant leadership roles:

1) Diagnosis, which identifies the current situation, perceives future conditions through selecting strategic actions and makes a scenario for preventive actions in emergency situations. The ability of leaders is to establish a functional link between the work oganisation of headquarters for emergency situations and the environment, to identify threats and opportunities, i.e.to anticipate and define trends in the environment which are new to headquarters as a necessity for strengthening their own position and achieving leadership through quality.

2) Adapting also means redesigning the HQs organizational structures, a higher technological level and a combination of other relevant factors, starting with the leadership capacities based on multinational and multicultural knowledge, skills, power and influence.

3) Communication involves transmission of vision, ideas and mission, attitudes and values in a clear, concise, compelling and concrete way. This leadership role is based on educational and charismatic skills to establish and maintain interpersonal relations and affection of followers, their respect and willingness to offer support. The concept of quality is based on the mutual interaction of all the functional parts of the structure that connect specialized teams-headquarters that address various aspects of quality in the stages of preparation, planning and implementation.

There are some questions:

1. What is the role and responsibility of leaders in the relation of the mankind towards nature and natural disasters?

2. Is it important for leaders to have a proper attitude towards nature and natural disasters, i.e. to have environmental awareness and responsibility?

These questions are answered through an analysis of the event of a heuristically conceived problem (Fig. 4) in the territory of responsibility and beyond, ie. the territory of the Republic of Serbia. The problem is illustrated with the photos of various events in peace and emergencies, diagrams and the analysis and comparison of our results with the results of other researchers (Fig. 2: a, b, c, d).

Figure 2a – The state support of scientific research work for the 60th anniversary of the Military Technical Courier (http://www.vtg.mod.gov.rs/60godina-fotogalerija-2.html)
Рис. 2а – Государственная поддержка научно-исследовательской работе, приуроченная 60-ти летию журнала „Военно-технический вестник“ (http://www.vtg.mod.gov.rs/60godina-fotogalerija-2.html)
Slika 2a – Podrška države naučnoistraživačkom radu povodom 60. godišnjice Vojnotehničkog glasnika (http://www.vtg.mod.gov.rs/60godina-fotogalerija-2.html)

Leadership in the Civil Defense

In this region, leaders still do not pay enough attention to this topic, as evidenced by opinion polls and recent developments of emergencies such as storm winds and snow drifts, as well as the recent floods in the Republic of Serbia.

Country and Leadership

Without the impact and contribution of leadership of the country, personal example, the development of the system of defense and the support to scientific research in this field, the efforts of other members of society may be negligible, and the results of their work can be reduced and brought down to a local character from case to case, if the state does not encourage leaders at all levels by giving its support to scientific research, by raising environmental awareness and responsibility, and by reacting in emergency situations – disasters. The examples are as follows: marking the 60th anniversary of the Military Technical Courier, snow drifts in Banat and Backa, floods in Obrenovac, etc., where the state showed what the action should be in such situations (Fig. 2: a, b, c, d).

Figure 2b – Government support in emergency situations
(snow drifts in Banat and Backa)
Рис. 2б – Государственная поддержка в чрезвычайных ситуациях
(сильная метель в Банате и Бачкой)
Slika 2b – Podrška države u vanrednim situacijama
(olujni smetovi u Banatu i Bačkoj)

Figure 2c – Government support in emergency situations (floods in Obrenovac)
Рис. 2в – Государственная поддержка в чрезвычайных ситуациях (наводнение в г. Обреновац)
Slika 2c – Podrška države u vanrednim situacijama (poplava u Obrenovcu)

Figure 2d – Support of the Government in all other situations
Рис. 2г – Государственная поддержка в других ситуациях
Slika 2d – Podrška države u svim drugim situacijama

Heuristics in emergencies and leadership

A "heuristic approach to solving problems" (Kvaščev, 1978) and heuristic modeling mean the creation of such a heuristic model that represents more originals in one same model, ie. a model that enables acquiring new knowledge and developing creativity by putting emphasis on independence and previous knowledge in specific areas (for example, frequent emergencies (Bereš, Bereš, 2014, pp.155-159).

The heuristic model determines very little action in the course of solving problems, so it leaves team members of emergency situation HQs a possibility to find one or all possible solutions, depending on their prior knowledge, level of independence and creative capabilities. This

approach to problem solving allows each individual - member of an HQ for emergency situations to reach his/her peak, no matter how talented he/she may be. The heuristic strategy means that a team member is placed in a position to find out, using prrevious experiences in new situations, new ways of creative problem solving (Bereš, 2013, pp.46-57).

Putting such a model in the function of leadership, new quality in the training is achieved. Also, a multi-media lecture with teaching topics and units is conceived as a heuristic algorithm (Figure 3), which allows listeners to select unknown matter and skip the already known, so that they achieve their maximum individuality at work.

This heuristic model as a function of leadership at all levels allows listeners a better understanding of leadership in emergency and all other situations (Figures 2 a, b and c, Figure 3 and Table 3).

Problem solving and adequate decision-making

The problem discussed is one of emergency situations (Figure 3) that can occur in Europe, Serbia or the Central Banat region, ie. blizzard with snow drifts, on the one hand, and the impact and contribution of the leadership of the country, on the other hand.

The problem is heuristically designed and described by quantitative methods to show the status or cause-effect relationships among phenomena in each of possible emergencies.

Various emergency situations in Serbia and Montenegro (1989-2006) given in the Final Report on the Risks in the Countries of South Eastern Europe – Sout Eastern Europe Disaster Risk Management Initiative - SEEDRMI, July 2007) have the following potential risks (Bereš et al., 2015, p.71, see Figure 1):

- Natural risks: - Dangerous meteorological phenomena: floods 34%, blizzards-snow drifts 4%, high temperatures - drought and forest fires 12%, strong frosts - other 4%, destructive geological phenomena: landslides, earthquakes 4% .
- Biological risks: epidemics, animal epidemics, zoonoses 8%.
- Technological risks: industrial accidents 8%, transport and storage of hazardous products, mass fires and explosions, road and rail transport, waterways, airways 26%, water pollution, potential contamination, demolition of buildings or installations, accidents caused by a cancellation of public services, objects falling from the atmosphere or the outerspace, unexploded ammunition 4% - in total 36 risks, i.e. emergencies which may happen in the European region of Banat (Bereš, 2013, pp.46-57).

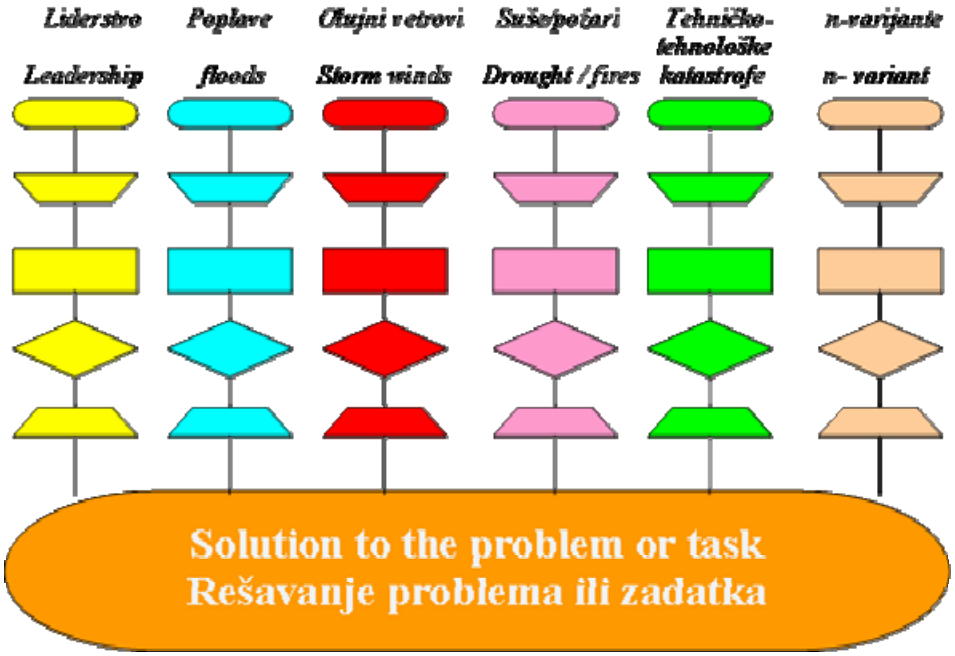

Figure 3 – Problem situation - heuristic algorithm (Amaldi, et al, 2003)
Рис. 3 – Проблемная ситуация - Эвристический алгоритм (Amaldi, et al, 2003)
Slika 3 – Problemska situacija – heuristički algoritam (Amaldi, et al, 2003)

Education-problem solving-decision making

All units engaged in the protection and rescue, receive assignments from the Headquarters for Emergency Situations in whose territory the emergency, or, if necessary, the state of emergency was declared. The actions of particular entities, from the local to the national level, were rated in an anonymous questionnaire (Table 3; actions from 1 to 6). 247 citizens of the Republic of Serbia (125 males and 122 females), aged 18 to 65, were interviewed through a Web research service in the period from 01.02.2014 to 07.02.2014. The survey was aimed at the elimination of shortcomings in the functioning of these entities (winter services, MIA, the Army and HQs at all levels) and the contribution of the state leaders to achieve better results in problem solving.

Table 3 – Public opinion on the actions of the Civil Defence entities
Таблица 3 – Мнение граждан о мероприятиях представителей Гражданской обороны
Tabela 3 – Mišljenje građana o postupanju subjekata civilne odbrane

Actions / evaluation	Positive	Negative	No opinion
Winter services	58.3	39.67	02.03
Gendarmerie	78.14	18.62	03.24
The Army of Serbia	88.67	08.09	03.24
Government of Serbia	44.65	47.20	08.15
Headquarters for Emergency Situations	44.35	47.53	8.12
Prime Minister of Serbia	60.72	31.18	18.10

Based on the problem solution, adequate decisions are made at all levels.

The survey was conducted via the Web research service, "Your attitude," and its analysis aims at answering the questions, "How do you rate the actions of: 1. winter services, 2 MIA - Department for Emergency Situations, 3. Ministry of Defense and the Army Serbia, 4. Headquarters for emergency situations at all levels, and 5. Prime Minister of the Republic of Serbia (at that time the First Vice-President), in assisting the elimination of the identified deficiencies in the functioning of these entities (winter services, the MIA, the Army and the HQs at all levels).

The survey results (Table 3) clearly show that a large percentage of the Ministry of Defense and the Army of Serbia met the expectations of the citizens of the AP of Voivodina and the Republic of Serbia. In the second place was the MIA of Serbia, and the winter services in the third. Since the headquarters for emergency situations at all levels were in the fourth place, it can be concluded that, in the opinion of citizens, they did not perform well so they are suggested to practice more through exercises.

In the experiment, the analysis of the events on the ground and heuristics helped to identify and define the problem, i.e. to determine a set of alternative solutions and a set of criteria for evaluating alternatives in order to select them and make appropriate decisions. The implementation of selected alternatives is monitored and the results achieved are evaluated in order to determine whether a solution to the problem is satisfactory from the point of view of a leader as a factor of good leadership transferred from the state level, ie. national level to the local level.

Satisfactory solutions to problems serve as an example in further education of headquarters for emergency situations and preventive

planning in the system of civil defense, especially regarding leadership (Figs. 2: a, b, c) qualities of HQ commanders at all levels through the already presented heuristically conceived problem (Figure 3).

Conclusion

The main characteristic of good leaders is that they have great power which is not based on force but on spreading clear ideas - this makes them a key factor in the functioning of the system of civil defense in emergencies and after the declaration of a state of emergency as well as in everyday life (Figs. 2 a,b,c). The aim is to educate HQ members to rationally use existing resources through team work on joint projects that combine different ideas of team members. All subjects from local levels should be engaged in order to manage emergency situations (floods, stormy winds with snow drifts, droughts, fires, technological disasters, etc.), and these models should find their place in emergencies through a demonstration of their application on concrete examples with the aim of making timely rational decisions in preventive actions and eliminating the consequences of possible disasters.

The leaders in this study obtain the support of their followers thanks to clear ideas in which many members of the society recognize their own interests with ease, and accept them with faith, understanding and enthusiasm in their implementation.

When these ideas are positive, such as the idea of improving the attitude towards the environment, (Klemenović, 2007, p.379) natural and civilization disasters, leaders realize their mission which benefits the society.

At present turbulent times of globalization and multinational and multicultural linking, the organization of headquarters for emergency situations must be continually adapted, developed and innovated. Leadership should not be viewed only from the perspective of local authorities and economic organizations, but also at the national level. A country, i.e. a wider community with a leader committed to the idea of development, contributes to its implementation at the state level. Leadership is important and is a key factor to improving the overall quality of the whole society.

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РОЛЬ ГРАЖДАНСКОЙ ОБОРОНЫ, ЛИДЕРСТВА И ЭВРИСТИКИ
В ПОДГОТОВКЕ ШТАБОВ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ

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ЯЗЫК СТАТЬИ: английский

Резюме:

В данной статье представлено решение проблем Гражданской обороны эвристическим методом, способствующим принятию соответствующих решений в чрезвычайных ситуациях и при чрезвычайном положении, с особым акцентом на применение эвристической модели в подготовке штабных команд по чрезвычайным ситуациям, а также роли лидера, как положительного фактора лидерства. Данная модель предназначена командному и преподавательскому составу кадров

Гражданской обороны: местному самоуправлению (начальникам районных управлений, председателям районных Советов, мэрам, председателям муниципальных округов и командирам), а также аварийно-спасательным службам (Сектор по чрезвычайным ситуациям). Эвристический метод решения проблем способствовует правильному выбору решений командного персонала, при наступлении чрезвычайных обстоятельств и объявлении чрезвычайного положения, как на местном, так и на национальном уровне Республики Сербия, а также функционированию систем Гражданской обороны и третьей миссии Вооруженных сил Республики Сербия, указывая на необходимость координации региональных и национальных уровней системы.

Ключевые слова: *гражданская оборона, лидерство, эвристика.*

CIVILNA ODBRANA, LIDERSTVO I HEURISTIKA U FUNKCIJI EDUKACIJE ŠTABOVA ZA VANREDNE SITUACIJE

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OBLAST: edukacija
VRSTA ČLANKA: stručni članak
JEZIK ČLANKA: engleski

Sažetak:

U članku je prezentirano rešavanje heuristički koncipiranih problema civilne odbrane, donošenjem adekvatnih odluka u vanrednim situacijama i vanrednom stanju, sa posebnim osvrtom na primeni heurističkog modela edukacije timova –štabova za vanredne situacije i uloge lidera kao faktora dobrog liderstva. Rad je namenjen komandnom i nastavnom kadru civilne odbrane: lokalnim samoupravama (načelnicima upravnih okruga, gradonačelnicima i predsednicima opština – komandantima) i sistemu zaštite i spasavanja (Sektoru za vanredne situacije). Heuristički pristup rešavanju problema treba da omogući komandnom kadru – liderima od lokalnog do nacionalnog nivoa, donošenje adekvatnih odluka u vanrednim situacijama po proglašenju vanredne situacije i vanrednog stanja na delu teritorije ili celoj teritoriji Republike Srbije.Takođe, treba da stvori uslove za funkcionisanje sistema civilne odbrane i treće misije Vojske Srbije, kao i da ukaže na neophodnost koordinacije između lokalnog i nacionalnog nivoa.

Ključne reči: *civilna odbrana, liderstvo, heuristika.*

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ПРИКАЗИ
ОБЗОРЫ
REVIEWS

APPLICATION OF NUCLEAR MAGNETIC RESONANCE IN MEDICINE AND ITS INFLUENCE ON THE QUALITY OF LIFE AND WORK ENVIRONMENT

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FIELD: Nuclear Technologies
ARTICLE TYPE: Review
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Abstract:

This work describes the application of nuclear magnetic resonance (NMR) in medicine and its influence on the work and life environment. Nuclear magnetic resonance, a powerful research tool, is based on the physical principle that cores of certain atoms (in this case hydrogen) can absorb or emit radiofrequency waves when placed in a magnetic field. This method is used for making high quality section pictures of the inside of the human body; in addition, it shows high sensitivity in revealing cancer, its position and its relation to the surrounding tissue. It is characterised by the use of non-ionizing radiation and a strong magnetic field, and, as explored by now, it does not have harmful effects on the human body.Therefore, it is completely noninvasive, comfortable and safe for patients as well for medical workers.

Key words: *nuclear magnetic resonance, NMR, cancer, non-ionizing radiation.*

Introduction

The phenomenon of nuclear magnetic resonance (NMR) was discovered in 1946 by two independent research groups from Stanford and Harward who detected the NMR signal in condensed matter (Bloch, 1946, pp.127), (Purcell, 1946, pp.37-38). For that discovery, the leading researchers, F. Bloch and E.M. Purcell, were awarded the Nobel prize for physics in 1952. Soon after that, it became a powerful research tool in different areas, from physics and chemistry, to biochemistry. It has also been sucessfully applied in medical visualization for obtaining high quality section pictures of the inside of the human body. In this fileld, it reached its peak in 2003, when the Nobel prize for medicine was awarded to P. Lauterbur and P. Mansfield for a discovery regarding soft tissue images taken by NMR.

In this paper, we will review the principle of NMR, its application in medicine, and its influence on the work and life environment.

The principle of NMR

Nuclear magnetic resonance is based on the phenomenon occurring when the cores of certain atoms, placed in a magnetic field, absorb or emit radiofrequency waves of characteristic frequency. The element of choice for this case is hydrogen, precisely the proton (Ivanović, 1971, pp.253-257). In an external magnetic field, the proton spin precesses around the direction of the magnetic field at a certain angle. Therefore, the precession frequency is equal to the resonant frequency (Georgijević, 2005, pp.753-756).

Visualization by magnetic resonance is a contemporary, almost completely noninvasive technique for screening the interior of the human body. The apparatus consists of a strong magnet which produces a static magnetic field with the induction B_0. Three additional magnets, known as gradient magnets, can adjust the value of the resulting magnetic field (in which the patient is placed) in space and time. The radiofrequency coil allows the emission of a short RF pulse towards the patient and the capture of the signal which comes from him. After the emission of the RF signal, which is of the same frequency as the one with which the protons precess around the direction of the magnetic field, the protons from the lower energy state jump to the higher one followed by the relaxation process of returning of the proton into the lower energy state with the emission of electromagnetic waves of the same frequency. Protons outside these directions will not be activated because they have different frequency from that of RF signals. By the same loop with which the RF pulse has been emitted, the emitted waves are captured and recorded by

the acquisition system. After that, some other direction is activated and the process is repeated in a number of directions. The image of the layer is then reconstructed by the same algorithms as in the case of emission tomography.

Figure 1 – NMR examination at the VMA Clinic (http://images2.kurir.rs/slika-724x489/vma-magnetna-rezonanca-pacijenti-klinicki-centar-srbije-milorad-rabrenovic-1328585176-34906.jpg)
Рис. 1 – Обследование методом ЯМР в Военно-медицинской академии (http://images2.kurir.rs/slika-724x489/vma-magnetna-rezonanca-pacijenti-klinicki-centar-srbije-milorad-rabrenovic-1328585176-34906.jpg)
Slika 1 – Pregled NMR-om na Klinici VMA (http://images2.kurir.rs/slika-724x489/vma-magnetna-rezonanca-pacijenti-klinicki-centar-srbije-milorad-rabrenovic-1328585176-34906.jpg)

The command console consists of monitors and an instrument board (Figure 1). It serves for the selection of the necessary parameters, the analysis of the obtained image and the selection of the data stored and documented. A computer is a separate unit. The obtained data can be saved on a magnetic tape or a laser disc thus being available for later interpretations and analyses. The immediate documentation of the results is performed by a multisport camera (x-ray tape) or by a polaroid camera.

Application of NMR in medicine

Application of NMR in oncology

Nuclear manetic resonance represents one of the most modern visual modalities. Its basic technical possibilities - multiplanarity, high space and tissue resolution in the combination with biological non-

invasiveness - place it in the group of the most sensitive and specific radiology methods for the most parts of the human body (Baltić, 2002).

One of its most important applications is in the early detection of breast cancer which is the leading cause of cancer death in the female population, where each ninth gets sick (Dähnert, 1996, pp.398-41). The procedure of breast screening involves the use of a special surface dressing where the patient is in the prone position. The technique of the inspection is somewhat different than for the other regions of the human body. Namely, the application of the contrast is necessary for a dynamic study where the contrast dynamics is monitored in the same, repeated time intervals. Such technique is necessary since both types of lesions, benign and malignant ones, give postcontrast signal intensity amplification. However, unlike benign, malignant lesions have characteristic signal intensity growth (Figure 2).

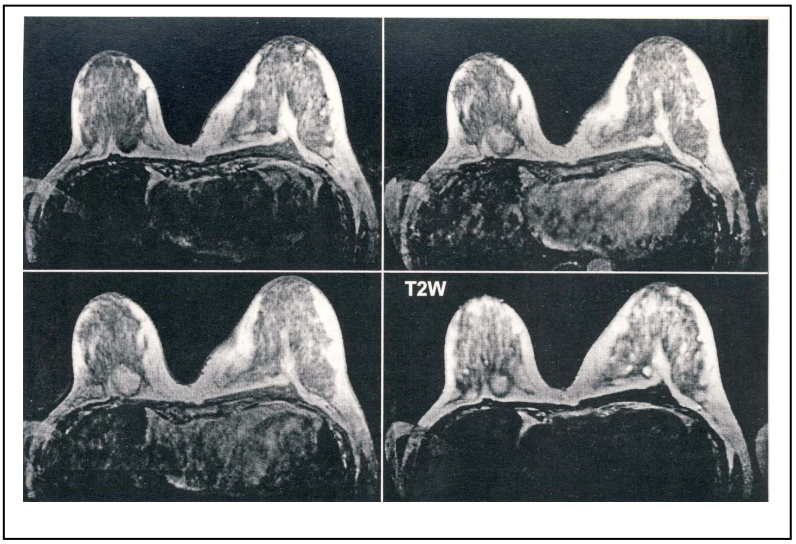

Figure 2 - Breast cancer in an NMR image.(clearly defined oval change in the right breast with typical centrifugal amplification) (Baltić, 2002)
Рис. 2 – Рак молочной железы на снимке ЯМР (на правой груди отчетливо видна овальная опухоль с типичными бугристыми уплотнениями) (Baltić, 2002)
Slika 2 – Tumor dojke na NMR snimku (jasno definisana ovalna promena u desnoj dojci sa tipičnim centrifugalnim pojačanjem) (Baltić, 2002)

The application of the NMR imaging in the diagnostics of diseases of the female genitourinary system started in the middle of the 1980s. Although the visualisation of the female genital organs can be performed by a number of radiological techniques (such as ultrasound and computer tomography), radiological diagnostics of pathological

processes in the female genital system is a very complicated problem (Rubin, 1993, pp.369-372). The advantage of NMR in comparison to other techniques is especially considerable in the diagnostics of two groups of diseases: congenital anomalies of the female reproductive system and malignant gynaecological tumours such as ovarian tumours which have high specific mortality. The major task of NMR here is the detection of the changes in the projection of the ovarian vein: physiologic cysts, primary cistoadenomas, dermoid cysts, and ovarian carcinomas. Cervical cancer is one of the leading causes of death in the female population, being in the second place of mortality just after breast cancer. Here, the role of NMR is not in the detection, but in the evaluation of the local spread of the disease.

Pancreatic cancer accounts for approximately 20% of new registered carcinomas in the world and can be surgically treated in 10-15% of cases (Kern, 1998, pp.74-78). For pancreatic cancer diagnosis, the first step is CT-imaging with the contrast and then NMR screening. In some cases, when pancreatic tumours are small and cannot be detected by CT or NMR, additional examination is performed by endoscopic ultrasound, or intraoperative ultrasound can be used for small endocrine tumours (Figure 3).

Figure 3 – Cancer of the pancreas head (Baltić, 2002)
Рис. 3 – Рак головки поджелудочной железы (Baltić, 2002)
Slika 3 – Karcinom glave pankreasa (Baltić, 2002)

Application of NMR in other areas of medicine

Soon after its introduction into clinical practice, NMR became a very important technique (Lazić, 1997, pp.360-367). It is particularly useful in the examination of the central nervous system for diagnostics and characterization of numerous lesions. Brain contusions and intracerebral hematomas are very well defined during NMR examination, which is especially important if they are located in the brain stem or back fossa, i.e. in the areas which give less diagnostic information during the standard CT-examination. Diseases from the group of dementia, which affect about 5-15% of the population over 65, with Alzheimer's disease being the most frequent, are characterized in the NMR imaging by the damage of the gray matter, deposits of iron and dilatation of the temporal horn. NMR also provides reliable evidence of changes caused by Multiple Sclerosis. The major manifestation of the disease are zones of demyelination called plaques (Figure 4).

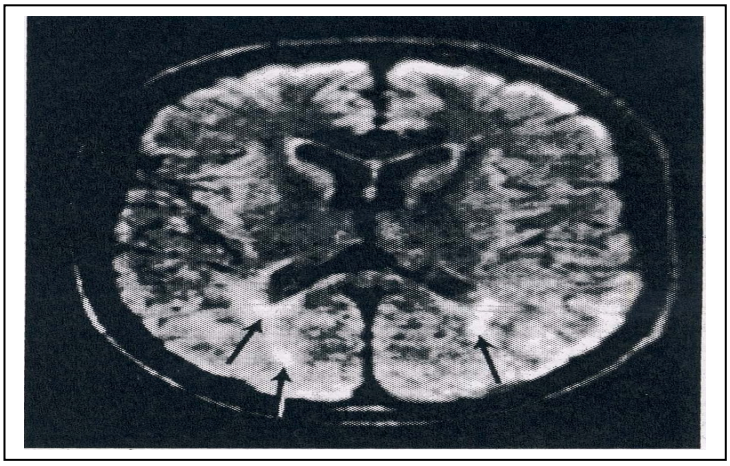

Figure 4 – NMR image of a pacient with Multiple Sclerosis (Lazić, Šobić, 1997)
Рис. 4 – Изображение ЯМР пациента, страдающего рассеянным склерозом (Lazić, Šobić, 1997)
Slika 4 –NMR snimak bolesnika sa multiplom sklerozom (Lazić, Šobić, 1997)

In the field of the diagnostics of the diseases of the torax and the cardiovascular system, the advantages of NMR are a high-resolution, wide-angle image, a possibility to choose a section plane, a high soft tissue contrast and the contrast between the blood flow in the blood vessels and the surrounding tissues. The usefulness of NMR has been verified in the examination of heart tumours, cardiomyopathy, congenital heart diseases and the diseases of the aorta and the pericardium. The ECG monitoring enables constant image quality during the whole cardiac cycle.

The application for the diagnostics of lung diseases is still limited.

Influence of nmr on the work and life environment

A formal procedure, nowadays known as environmental impact assessment, was established in the developed countries by the end of the 1960s, as a result of the increased awareness about the protection of the environment. The Law on the Environment Protection (Službeni glasnik RS, Nos 135/2004a, 36/2009a, 72/2009, and 43/2011), in our country for the first time established the obligation to analyze the impact of civil engineering structures and activities on the environment. This system of assessment was changed by passing the Law on Environmental Impact Assessment (Službeni glasnik RS, No 135/2004b and No 36/2009b), as well as by passing a number of bylaws; therefore, it has been completely adjusted to the environmental impact assessment process in the EU countries.

Strong magnetic fields and RF pulses are used in the NMR technique, so it is necessary to comply with the Act on Preventive Measures for Safe and Healthy Work during Exposure to Electromagnetic Fields (Službeni glasnik RS, No 101/2005). This Act prescribes the requirements about preventive measures employers are to meet in order to decrease or remove risks of damaging health during exposure to electromagnetic fields of frequencies from 0 Hz to 300 GHz. It also provides limit values and action values. According to this Act, employers are required to ensure that employees are in no case exposed to electromagnetic fields beyond the limit values defined by this Act.

The specific energy absorption rate (SAR), for the whole body or for particular parts - the energy absorption rate for the mass unit expressed in W/kg – is of particular importance. The specific energy absorption rate (SAR) for the whole body is a known measure for linking unfavorable thermal effects and exposure to radiofrequency waves (RF). Besides the SAR averaged for the whole body, local values of the SAR are necessary for the evaluation and limitation of the over-exposure of body parts during specific conditions of exposure. This refers particularly to the protection from acute exposure of the central nervous system, the head tissues and the torso. This Act prescribes the following limit values of the SAR for the 20-100MHz RF wave range:

- Averaged SAR for the whole body: 0.4 W/kg
- Localized SAR (head and torso): 10 W/kg
- Localized SAR (extremities): 20 W/kg.

In the case of using NMR for clinical purposes, a magnetic field with induction between 0.1 and 4.0 T is used, i.e. a magnetic field of high intensity (in order to improve the signal-to-noise ratio). For the sake of comparison, the Earth's magnetic field has induction of 50μT, which means that the 1.5 T magnetic field is 30,000 times stronger than the magnetic field of the Earth. There is a question about the

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impact of such a magnetic field on the human body. Investigations so far did not show any negative effect on the body, except a few cases of dizziness due to weaker electric current induction in some brain neuron structures. In the case of a new generation of superconducting magnets, which nowadays are in expansion, very homogeneous magnetic fields may be created due to the loss of electrical resistance. The disadvantage is very strong noise during the examination which also needs to be taken into account. Magnets themselves need to be separated from their environment, since strong magnetic fields may have negative effect on sensitive electronic equipment as well on patients with pacemakers and other prosthetic devices. The device also has to be separated from a wide range of radio-waves in order to avoid disturbance in radiofrequency waves. Therefore, the whole system is set in the Faraday cage.

When it comes to the influence of this method on the environment, nowadays when ecological awareness is increasing, it is necessary to be aware of its possible negative effects. Radiofrequency waves used in NMR devices belong to the group of non-ionizing radiations. Non-ionizing radiations are electromagnetic radiations with energy lower than 12.4 eV. This radiation does not have necessary energy to cause ionization in living creatures. Natural sources of non-ionizing radiation are rare and weak. They are: Sun, distant pulsars, other sources from the space and the Earth (lighting). Epidemiological studies and experimental research have shown that electromagnetic radiation, non-ionizing radiation as well, presents a constant threat to our health even when it is within the allowed limits (SCENIHR, 2007). The primary and the simplest negative effect of the electromagnetic field is heating. Exposure to radio-frequency radiation higher than mW/cm^2 can cause serious damage to the human tissue due the over-heating. Long exposure can cause a whole number of negative symptoms such as increased anxiety, nervousness, insomnia, headache, exhaustion and chronic fatigue, tendency to depression, problems with memory and concentration, loss of vitality, weight and activity, etc. On the other hand, some studies have shown that magnetic fields of the intensity used in NMR examination can cause visual sensations such as flickering or can stimulate nerves and muscles.

Conclusion

Magnetic resonance (MR) represents a technique used in medicine for obtaining high quality section images of the human body interior. Nuclear magnetic resonance (NMR) is a spectroscopic technique used for a long time for gathering information on the fine structure of the matter. This method is based on the behavior of the proton spin in the magnetic

field. The spin and the magnetic moment attributed to it are the fundamental characteristics of the particles such as protons and neutrons.

Magnetic resonance provides visualisation of the organs inside the human body such as the head, the neck, the thorax, the abdomen, the pelvis, muscles and joints.

The advantage of this method in comparison to other diagnostic methods is a possibility of changing the image contrast of different tissues in order to emphasize the most important elements as well as obtaining cross-sections in different planes during the same examination without changing the position of the patient. Also, this method shows high sensitivity in revealing tumours, their position and relation to the surrounding tissue. In accordance with research and taking into account that it is performed without using ionizing radiation, NMR shows no harmful effects on the human body.

This method is completely nonpainful, non-invasive, comfortable and safe both for the patient and the medical staff taking part in the examination.

When it comes to the effects of this method on the quality of the environment, longer exposure to the sources of non-ionizing radiation, where NMR devices belong, can cause damage to the tissue due to overheating and lead to a number of psychological symptoms. Also, magnetic field intensity values used during NMR examinations can cause visual sensations like blinking or they can stimulate nerves and muscles.

The effect on the global environment is negligible since the applied magnetic fields are of very low strength compared to the Earth's magnetic field and the diagnostic system itself is usually well insulated from the surrounding area.

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ПРИМЕНЕНИЕ ЯДЕРНО-МАГНИТНОГО РЕЗОНАНСА В МЕДИЦИНЕ И ЕГО ВЛИЯНИЕ НА РАБОЧУЮ И ОКРУЖАЮЩУЮ СРЕДУ

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ОБЛАСТЬ: ядерные технологии
ВИД СТАТЬИ: обзор
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной работе описано применение в медицине ядерно-магнитного резонанса (ЯМР), являющегося мощным исследовательским средством в различных сферах, а также описано его влияние на рабочую и окружающую среду. Ядерно-магнитный резонанс основан на физическом явлении поглощения веществом электромагнитного излучения, атомных ядер, находящихся в постоянном магнитном поле.

Данный метод используется для получения высококачественных изображений органов человеческого тела, а также для диагностики онкологических заболеваний и выявления опухолей. ЯМР отличается нейонизирующим излучением и сильным магнитным полем, не представляющих опасности для организма. Следовательно, применение ЯМР безболезненно, безвредно, удобно и безопасно, как для пациентов, так и для медсотрудников, проводящих процедуру.

Ключевые слова: *ядерно-магнитный резонанс, ЯМР, опухоль, нейонизирующее излучение.*

PRIMENA NUKLEARNE MAGNETNE REZONANCE U MEDICINI I NJEN UTICAJ NA KVALITET RADNE I ŽIVOTNE SREDINE

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OBLAST: nuklearne tehnologije
VRSTA ČLANKA: prikaz
JEZIK ČLANKA: engleski

Sažetak:

U ovom radu opisana je primena nuklearne magnetne rezonance (NMR) u medicini, kao moćnog istraživačkog sredstva u različitim oblastima, i njen uticaj na radnu i životnu sredinu. Nuklearna magnetna rezonanca zasniva se na fizičkom fenomenu da jezgra određenih atoma (u ovom slučaju vodonika), postavljena u magnetno polje, mogu apsorbovati i emitovati radiofrekventne talase. Ova metoda koristi se za dobijanje visokokvalitetnih slika preseka unutrašnjosti tela, a pokazuje i visoku osetljivost u otkrivanju tumora, njihovog smeštaja i odnosa prema okolini. Odlikuje se korišćenjem nejonizujućeg zračenja i jakog magnetnog polja, a prema dosadašnjim istraživanjima nema štetno dejstvo na organizam. Potpuno je bezbolna, neinvazivna, konforna i bezopasna, kako za pacijenta, tako i za zdravstveno osoblje koje učestvuje u pregledu.

Ključne reči: *nuklearna magnetna rezonanca, tumor, nejonizujuće zračenje.*

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Крстареће ракете и даље неприкосновене[1]

Многи задаци модерних ратних морнарица исти су као некада. То су стратешко присуство, контрола мора, омогућавање слободних морских комуникација, сузбијање дејства других морнарица и пројектовање моћи на копна.

Ову последњу ставку ратна морнарица је спроводила на више начина – од топовске ватре, преко употребе летелица, па до употребе навођених оружних система као што су крстареће ракете лансиране са мора (SLCM Stand off sea launched cruise missiles).

Како је јачала обална одбрана, али расла и потреба за интервенцијом по дубини копнене територије, крстареће ракете дугог домета омогућиле су малом броју ратних морнарица да гађају удаљене копнене циљеве са већег одстојања. С обзиром на модерне системе вођења оваквих ракета, до сада је само неколико ратних морнарица, међу којима су америчка и британска, којима су се од недавно прикључиле француска и руска ратна морнарица, могло да врши такозвано пројектовање силе са великим процентом прецизности.

Амерички Tomahawk

Основни систем у палети крстарећих ракета је амерички Tomahawk Land Attack Missile (TLAM). Ракета је пројектована још касних шездесетих година прошлог века као нуклеарно оружје за напад на бродове и циљеве на копну. Како је развој технологије омогућио смањење бојевих глава и повећање прецизности, систем је нашао своје место у стратешком распореду снага. Један од најјачих адута ове ракете је њен погонски систем који јој је омогућавао напад на циљеве „удаљене више од 1,000 миља". Најновија верзија ове ракете, Block IV Tactical Tomahawk (TacTom), напада циљеве на даљинама до готово 1.500 миља, што је навело многе државе да се заинтересују за набавку ове ракете, али је за сада само Велика Британија закључила уговор о набавци.

Block II TLAM појавио се први пут за време рата у Голфу 1991. године, када се Американцима први пут пружила прилика да демонстрирају операције које су развијене још пред крај хладног рата. Верзија Block III појавила се 1993. године, а њен GPS систем је знатно умањио потребе за постојањем великог броја навигационих тачака на путу према циљу. Од 1991. године верзија Block II TLAM је редовно употребљавана у борбеним операцијама.

[1] Jane's Navy International May 2016.

Лансирање ракете Tomahawk Land Attack Missile

Упркос томе, TLAM је доживео и критике. Неки су приговарали да се ради о једнократном оружју које нема велику ударну снагу нити флексибилност у односу на неке друге системе. Неки су чак износили аргументе да оружје старо 40 година није адекватно у односу на модерне, брзе тактичке операције.

Ове критике су једним делом утицале на појаву верзије Block IV која је ушла у оперативну употребу америчке морнарице 2004. године. Ово оружје је поседовало двосмерни дата-линк, што је омогућавало накнадни одабир циљева и већу тактичку флексибилност. Дата-линк је, такође, омогућавао и осматрање и прослеђивање података контролеру о насталој штети, што је већ испробано у борбеним условима.

Недавно, у оквиру буџетског плана набавке, дошло је до притиска за смањење броја ракета са 196 на 100, па се у америчком Конгресу помињала и могућност о престанку производње ракета TLAM, али се од тога одустало с обзиром на нове снаге које су се појавиле на сцени – руску и кинеску ратну морнарицу. Америчко министарство одбране закључило је да је TLAM прворазредно оружје и да ће бити потребно још следећих 30 година.

Наставиће се еволутивни развој оружја током буџетске 2017. године током којег ће тежиште бити на побољшању комуникације са ракетом током лета. Биће развијан нови, јачи дата-линк који ће омогућити операторима да боље комуницирају са ракетом у условима тешког непријатељевог ометања. Затим, биће додате нове навигационе могућности, што ће омогућити употребу ракете у условима непостојања GPS сигнала, али и редуковано време планирања мисије. Очекује се да ће ова два сегмента модернизације бити уграђена на ракету и тестирана до краја 2018. године.

Трећи елемент модернизације представља развој вишенаменског трагача са опцијама пасивног и активног тражења. Развој овог дела омогућиће ракети да повлачи нишанске податке од већег броја сензора и платформи. Ова технологија укључује модуларни, мултифункционални процесор који ће омогућити америчкој ратној морнарици интеграцију више сензора у зависности од крајњих захтева корисника. Ова фаза модернизације биће укључена у буџет за 2017. годину, док ће радови почети пред крај 2016. године.

Коначни елемент модернизације представља наставак развоја унапређене бојеве главе (Join Multiple Effects Warhead System – JMEWS). У оквиру овог елемента радиће се на унапређењу пробојности ракете, што ће проширити листу циљева на које ће се ракета наводити.

Када се говори о противбродској улози ракете, постоји потреба за убацивањем терминалног трагача који ће омогућити ракети да напада мобилне циљеве на копну и мору. Претходна верзија ракете TLAM, Tomahawk Anti Ship Missile – TASM, намењена нападима на бродове удаљене до 1,000 миља није била на висини задатка с обзиром на тадашњи ниво развоја процесора који није могао обезбедити довољно процесорске снаге за обраду комплексних података о путањи и циљу. Данашњи процесори су у стању да обраде такве количине информација да је могуће наставити рад на модернизацији.

Француски MdCN

Како су Французи били импресионирани могућностима америчке и британске ратне морнарице, одлучили су да уведу могућност дубоког удара својој ратној морнарици. Ради се о крстарећој ракети Missile de Croisiere Naval (MdCN). Ову ракету је 2006. развила компанија MBDA на основу уговора француског министарства одбране. Ракета ће бити саставни део наоружања француских вишенаменских фрегата класе FREMM које ће их лансирати из вертикалног лансирног система SYLVERA 70 и нуклеарних нападних подморница класе Suffren, које ће их лансирати из торпедних цеви.

Компанија MBDA је ракету првобитно водила под ознаком Md/CN/NCM SCALPNaval, што се односило на технолошку еволуцију ракете SCALP EG (Systeme de Croisiere Autonome a Longue Portee – Emploie General)/Storm Shadow SCALP NCM, односно конвенционалне крстареће ракете лансиране из ваздушног простора. Овај назив сада је одбачен и замењен називом NCM.

Ракета MdCN потиче од ракете SCALP EG/Storm Shadow, али је само тело ракете потпуно различито. Облик је цилиндричан (лансира се из торпедних цеви 533 мм), има три преклапајућа пераја и крилца увучена у ракету. Сам облик, као и радарско абсорбујући композитни материјал, имају задатак да умање радарску видљивост ракете.

Димензије ракете MdCN условиле су промену погонског дела. Уграђен је мањи турбоџет мотор TR50 Microturbo уместо мотора TR60-30 којим је опремљен SCALP EG/ Storm Shadow. Иако се не наводи радијус дејства нове ракете, претпоставља се да је он реда величине „неколико стотина километара”, па чак и до „хиљаду километара”.

Лансирање ракете MdCN

Као и ракета SCALP EG/Storm Shadow, MdCN располаже инерцијалном навигацијом која се рекалибрише за време крстарења путем радарског мапирања терена и корекцијама GPS система, у комбинацији са инфрацрвеним трагачем који омогућава ракети навођење са метарском прецизношћу у терминалној фази.

Прво тестирање обављено је у мају 2010. године из лансера SYLVERA 70. Други тест, подводно лансирање, обављен је у јуну 2011. године. Трећи тест извршен је у јулу 2012. године и састојао се у лансирању потпуно функционалне ракете MdCN из лансера SYLVERA 70 са инфрацрвеним начином навођења у завршној фази лета. Четврти тест следио је у октобру 2012. године и састојао се од подводног лансирања са платформе која је представљала зароњену подморницу.

Током октобра 2014. спроведен је финални тест којим су задовољени сви захтевани критеријуми, да би у мају 2015. године ракета била лансирана са фрегате класе Aquitaine FREMM.

Првобитно је планирана производња и набавка 250 ракета, али је тај број, услед штедње, смањен на 200, а затим и на 150 комада.

Руски Kalibr

Од 2008. године руска морнарица поново се појављује у улози стратешког одвраћања. Након борбених операција у Грузији и Украјини, преко успостављања рутинског присуства у Медитеранском мору, руске поморске снаге су почеле све више да се намећу присуством, искуством и ватреном моћи.

Лансирање руске ракете 3M-14T Kalibr са брода Veliki Ustyug класе Project 21631 Buyan-M

Седмог октобра 2015. године, током операција у вези са кризом у Сирији, руска ратна морнарица је први пут употребила крстареће ракете дугог домета. Четири брода која су се налазила у Каспијском мору лансирала су 26 ракета 3M-14T Kalibr на 11 циљева у Сирији. Радило се у фрегати Dagestan класе 1161K Gepard и патролним бродовима Grad Sviyazhsk, Uglich и Veliki Ustyug класе Project 21631 Buyan-M. Постојала је информација да ови бродови носе поменуте крстареће ракете, али није се знало да су икада раније лансиране, тако да је то практично представљало прву оперативну употребу крстарећих ракета Kalibr.

Русија је наставила са изненађенима тако што је извршила прво оперативно лансирање крстарећих ракета великог домета са зароњене подморнице Ростов на Дону, класе Project 636.3 „Improved Kilo". У овом случају подморница је лансирала четири крстареће ракете из својих торпедних лансера на циљеве милитаната у Сирији са своје позиције у Медитерану.

Иако је руско министарство одбране тврдило да ракета има домет 2.000 км, то није било могуће потврдити, као ни наводе о прецизности и перформансама, јер су се одмах након лансирања појавили извештаји о томе да један број ракета није стигао до својих циљева.

По угледу на своје америчке колеге које су приказивале лансирање крстарећих ракета приликом напада на Ирак током 1991. и 2003. године и руско министарство одбране је приказало компјутерски генерисане снимке ракета које пролазе одређене навигационе тачке, као и дневне и ноћне снимке лансирања са бродова и подморнице.

Поред приказивања дејства нових крстарећих ракета Kalibr, Русија је приказала и своју нову подморницу Ростов на Дону, другу из класе Project 636.3, која је након лансирања пројектила наставила пут ка својој новој луци у Црном мору.

У међувремену су се појавиле информације да ће нуклеарна нападна подморница класе „Akula" Project 971 након ремонта бити опремљена противбродском верзијом ракете Kalibr, док ће нови површински бродови класе Project 11356M Admiral Grigorovich, Project 22350 Admiral Gorshkov и патролни бродови класе Project 22160 бити наоружани верзијом ракете за напад на копну.

Поморске верзије крстарећих ракета су 3M-14 (Нато ознака SS-N-30A) за подморничку верзију и 3M-14T за верзију која се лансира са бродова. Претпоставља се да је 3M14 базирана на двостепеној ракети 3M-54-1 која је опет заснована на тростепеној верзији ракете 3M54 Kalibr. Изгледа да ове ракете воде порекло од ракете KS-122 (3M-10) са нуклеарном бојевом главом која се налазила на ракетама S-10 Granat (3K10 SS-N-21 „Sampson") лансираним са подморнице и ракета са мобилних система RK-55 Relyef (3K12, SS-X4 „Slingshot"). Руско министарство одбране је навело да су ракете Kalibr имале бојеву главу носивости до 500 кг са конвенционалним или нуклеарним пуњењем.

Пре самог напада није објављен ниједан податак о домету ракета 3M-14и 3M-14T, а рачунајући величину ракете, бојеву главу и потенцијалну количину горива, амерички званичници су претпоставили да би домет ракете могао бити до 1,485 км.

Иако су технологије, могућности и перформансе система отворене за дебате, опрема за навођење ракете Kalibr изгледа да има елементе који се налазе у постојећој породици крстарећих ракета. Састоји се од глобалног навигационог сателитског система GLONASS, инерцијалног навигационог система, активног радарског трагача и радарског система за праћење терена. У тренутку када је ракета у близини циља укључује се активни радарски трагач који је наводи на циљ.

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Piranha 5 – појачана платформа[2]

Првобитно развијена као део породице лаких оклопних возила, конфигурација 6X6 и 8X8 компаније General Dynamics European Land Systems – Mowag (GDELS-Mowag) варијанта у конфигурацији Piranha спада у ред најуспешнијих оклопних борбених возила развијених на Западу током последњих 25 година.

Сматра се да је конфигурација 8X8 идеална у смислу комбинације величине возила, масе, употребне површине, носивости и цене. До марта 2016. године продато је чак 11.500 возила Piranha у 40 различитих варијанти.

Piranha 5 базирана је на истим принципима као и претходна возила са идеалним балансом заштите, проходности и капацитета.

[2] Jane's InternationalDefence Review May 2016.

Piranha 5 опремљена куполом са топом 30 mm MK44 Bushmaster компаније Orbital ATK

Ради одговора на захтеве корисника за већом корисном површином и носивошћу, компанија је пројектовала возило Piranha 4 за којим је следило и возило Piranha 5 које потиче од напуштеног програма британске војске UK Future Rapide Effect System (FRES).

Прво возило Piranha 5 приказано је јавности током изложбе наоружања 2010. године. Од тада су извршени бројни тестови у условима топлог и хладног времена у Норвешкој, Кувајту и Уједињеним Арапским Емиратима.

Унутрашњост возила Piranha 5

Последње у низу тестирања спроведено је у Данској и резултирало је наруџбином, јер данска војска има потребу да замени своју флоту застарелих оклопних транспортера M113. Након међународног тендера селектовано је пет возила која су учествовала у серији тестова.

Задњи крај возила на којем се виде резервоари за гориво са обе стране излазних врата

Ових пет возила су: Piranha 5 у конфигурацији 8X8, ASCOD 2 компаније Santa Barbara Sistemas из Шпаније, PMMC G5 компаније Flensburger Fahrzeugbau Gesellschaft из Немачке, Armadillo компаније BAE Systems из Шведске и Vehicule Blinde de Combat d'Infantrie (VBCI) компаније Nexter Systems из Француске.

Након евалуације података са тестирања, Данска одбрамбена организација за логистику и набавку одлучила је да склопи уговор за испоруком 309 возила Piranha 5 у конфигурацији 8X8 са опцијом повећања броја на 450 комада.Дански уговор који предвиђа испоруке од 2018. до 2023. подразумева испоруку шест верзија возила Piranha 5 у конфигурацији 8X8: оклопно возило пешадије, амбулантно возило, командно возило, инжињерско возило, возило са минобацачем и возило за оправке.

Компанија ће послати возила Piranha 5 у конфигурацији 8X8 у Данску, где ће бити финализовано склапање и опремање данском комуникационом опремом. Накнадно ће бити одлучено о набавци оружног система. Piranha 5 ће се придружити постојећој данској флоти од 113 возила Piranha 3 у конфигурацији 8X8 као и возилима Eagle IV и Eagle 1 у конфигурацији 4X4 исте компаније.

Шпанске потребе

У међувремену, Шпанија је наручила четири возила Piranha 5 у конфигурацији 8X8 која ће бити испоручена током 2017. године и тестирана у сагласности са потребама шпанске армије у оквиру програма Vehiculo de Combate sobre Ruedas који предвиђа набавку између 300 и 400 возила. Уколико се успешно покажу ова возила ће заменити борбено возило пешадије BMR-600 у конфигурацији 6X6.

Шпанске пиране биће произвођене у Шпанији, а компанија GDELS-Mowag обезбедиће комплетну производну линију као што је урађено у случају производње возила у Швајцарској, Канади, САД и Великој Британији.

Шпански маринци већ располажу са 39 оклопних транспортера Piranha 3 8X8 који су им испоручивани од 2003. године. Иако је најновија верзија слична претходним верзијама, ради се о новом возилу са већом носивошћу и развојном потенцијалу.

Развојни потенцијал добија на важности с обзиром на то да је предвиђени рок службе оклопних борбених возила 30 година и да ће бити неопходно вршити хитне оперативне промене. То обично значи уградњу додатне оклопне заштите, што доводи до повећања тежине возила, а што негативно утиче на мобилност, брзину и однос снаге и масе. Маса возила обично се креће око 30.000 кг, од чега 18.000 кг одлази на базичну верзију возила. Носивост подразумева посаду, гориво, оружје и муницију, као и пакет оклопне заштите. Piranha 5 је пројектована да поднесе додатни терет од 3.000 кг.

Возач се налази на предњој левој страни, а погонски дизел агрегат на десној страни, док је остатак трупа празан. Предвиђено је и додатно место за члана посаде. Задњи део је предвиђен за смештај десантног одељења и опремљен је са четири кровна отвора који се могу закључати у вертикалну позицију. Максимални капацитет посаде је 13, укључујући возача, командира, нишанџију и десантно одељење. Купола са даљински управљаним оружним системом налази се на крају погонског одељења, али је могуће променити положај у складу са захтевима клијента.

Возило Piranha 5 покреће дизел мотор који развија 585 KS и повезан је аутоматским мењачем који има седам брзина за ход унапред и једну за ход уназад.Максимална брзина на путу је 100 км/сат. Резервоари горива од 450 литара налазе се на обе стране излазне рампе са опцијом додавања још једног дела у моторном одељењу и дају возилу радијус дејства до 550 км на путевима и ван путева. Piranha 5 поседује и систем за штедњу горива.

Прва четири и задња два точка су управљачка, што омогућава окрет у кругу од 19 до 15 м. Управљање задњим точковима се постепено смањује како се повећава брзина. Возач може одабрати управљање са свих 8 точкова у условима теренске вожње или са четири точка у условима вожње по путевима.

Возило је обично опремљено гумама 14.00R20 или 16.00R20, док је централно надувавање стандардна опрема. Могуће је уградити и систем за ход на празним гумама. Свих осам точкова опремљено је хидропнеуматском амортизацијом и интегрисаним шок абсорберима.

Возило поседује пнеуматске двоколне кочнице са шестоструким системом АБС као делом стандардне опреме. Тестирања су доказала да је проходност возила једнака или супериорна свим гусеничарима у зависности од услова на путу.

Piranha 5 има 14,5 кубних метара простора које је могуће повећати у амбулантној или командној верзији. Унутрашњост возила је редизајнирана тако да се употреби максимум простора, што је постигнуто померањем резервоара са дизел горивом ван возила.

Преживљавање

Piranha 5 нуди висок ниво заштите против балистичких, минских и импровизованих минско- експлозивних средстава.

Основни труп је произведен од заварених челичних плоча на које је могуће прикачити одговарајући модуларни оклоп који покрива бочне, као и предњу и задњу страну возила.

Седишта за ублажавање експлозивног удара окренута су једна према другима и имају појасеве са пет тачака везивања.

Возило је опремљено полицама за смештај оружја, што онемогућава додатну штету приликом експлозије мине или импровизованог експлозивног средства.

Унутрашњост возила је ојачана, а додат је и унутрашњи противминski под за заштиту од експлозија мина. Сви хидраулични и горивни водови уклоњени су из простора за посаду и смештени у двоструки под ради повећања безбедности посаде.

Постоји могућност уградње applique оклопа, као што је експлозивно реактивни оклоп (EPO) и лаки бочни оклоп намењен одбрани од кумулативних пројектила који је инсталиран на данским оклопним борбеним возилима која се налазе у Авганистану.

Компанија GDELS-Mowag приказала је возило Piranha 5 опремљено активним системом заштите Saab Land Electronic Defence Systems 150 (LEDS 150) и пресретачима Denel Dynamic Mongoose 1.

Израелски систем активне заштите Trophy успешно је демонстриран на оклопним возилима и представља додатну опцију заштите.

Возило је опремљено системом за детекцију и гашење ватре за десантно одељење, као и за простор возача.

Оружни систем

Када је Piranha 5 први пут приказана јавности, возило је било наоружано даљински управљаним оружним системом компаније Konsberg, са топом средњег калибра 30 mm MK44 са двоструким пуњењем и коаксијалним митраљезом 7.62 мм, као и даљински управљаним митраљезом M2 калибра 50.

Возило у овој конфигурацији интензивно је тестирано у Норвешкој, а испробана је конфигурација са противтенковском навођеном ракетом Javelin која омогућава напад на циљеве који се налазе на даљинама до 2.500 м.

Возило може бити наоружано куполом Lance компаније RheinmetallDefence, опремљено топом Mauser MK30 и коаксијалним митраљезом 7.62 мм којим је опремљено и возило Piranha IIIC 8X8 у поседу шпанске морнаричке пешадије.

Возило наоружано куполом Lance, опремљено топом Mauser MK30

Купола Lance има компјутеризован систем за управљање ватром и дневно-ноћну нишанску справу са уграђеним ласерским даљиномером за нишањџију и командира којем је на располагању и панорамска осматрачка справа.

Piranha 5 може бити опремљена и најновијом куполом Samson Mk II израелске компаније Rafael Advanced Defence Systems са топом 30 mm MK44 Bushmaster, компаније Orbital ATK, са двоструким пуњењем. Возило је опремљено и коаксијалним митраљезом 7.62 мм или опционо аутоматским бацачем граната 30 или 40 мм. Поред тога, могуће је додати и противтенковску вођену ракету Spike на куполу Samson Mk II.

На сајму наоружања IDEX 2015 у Уједињеним Арапским Емиратима приказана је верзија возила опремљена модуларним куполним системом Cockerill 3000 компаније CMI Defence. Ова купола може бити наоружана топовима од 25 мм, па до топа 105 мм са олученом цеви која, поред употребе стандардне топовске муниције, може лансирати и ласерски навођене пројектиле на даљинама до 5.000 м.

Компанија је направила и већи модел Piranha у конфигурацији 10x10, опремљен куполом наоружаном топом 105 мм француске компаније Nexter Systems.

Израђена је серија возила у конфигурацији 10x10, опремљена радаром за шведску обалну артиљерију, али су та возила, уместо у Шведској, завршила у британској армији и послата у Авганистан.

Прекинут је рад на конфигурацији 10x10 с обзиром на нову технологију топа 105 мм кратког повратног трзаја који је могуће уградити на возило Piranha у конфигурацији 8X8. Основна верзија возила прелази дубине од 1,5 м без претходних припрема.

Комуникациона опрема и радио-уређаји зависе од крајњег корисника, али су отворене опције за уградњу НБХ система, система за управљање битком, помоћног агрегата од 5 киловата и уређаја за сечење жица.

Демонстрациона возила била су опремљена сплит клима-уређајима, снаге 30 киловата за употребу у земљама Средњег истока.

Једно од демонстрационих возила било је опремљено и камерама у боји које покривају 360 степени око возила. Слике са камера приказују се на уређајима возача, командира и нишанџије, а постоји и дисплеј у делу предвиђеном за десантно одељење.

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Да ли је немогућа производња нових ловаца F–22?[3,4]

Амерички конгрес жели да поново покрене производњу најбољег невидљивог ловца на свету, али је за тако нешто вероватно сувише касно.

Комитет за оружане снаге тражио је од америчког ратног ваздухопловства да размотри могућност поновне производње невидљивог ловца F–22 са супersоничним крстарењем намењеном остваривању ваздушне надмоћи у одбрамбеном буџету за 2017. годину. Овај корак предузет је с обзиром на нову улогу Русије у Европи и повећане агресивности Кине у Азијскопацифичком региону.

Комитет је наложио секретару за америчко ратно ваздухопловство да спроведе процену и студију трошкова у вези с обнављањем производње ловца F–22 и да након тога извести конгресне комитете за одбрану до 1. јануара 2017. године.

Комитет је, такође, наложио ратном ваздухопловству да процени будуће потребе за остваривање ваздушне надмоћи засноване на краткорочним и средњорочним пројекцијама постојећих претњи из ваздушног простора и са копна. Конгрес такође жели да се изврши процена улоге ловца F–22 у A2/AD (anti-access/area denial environments) окружењу у моменту када флота наврши крај свог оперативног живота, затим у периоду када буде повучен ловац F-15C и у тренутку када нова генерација ловаца F-X постане оперативна.Поред тога, Конгрес је тражио процену трошкова, времена потребног за поновно покретање производне линије ловаца F–22. Законодавно тело жели и процену трошкова за набавку додатна 194 ловца којима би била испуњена квота ратног ваздухопловства предвиђена и у условима хладног рата. У том случају америчко ратно ваздухопловство располагало би са 381 летелицом. Америчко ратно ваздухопловство тренутно располаже са 186 оперативних ловаца F–22, од којих је само 123 спремно за борбу.

[3] The War is boring 22 april 2016.
[4] The Washington Post July 2009.

F–22

Конгрес је тражио и процену трошкова за производњу додатних авиона којима би било опремљено 10 борбених ескадрила. У оквиру ових процена, Конгрес је тражио податке о постојећим алатима за производњу ловца F–22, цену по јединици и укупну цену којом би била омогућена набавка већег или мањег броја летелица, као и могућностима за извоз авиона државама партнерима уколико се такав (сада забрањен) извоз омогући.

Чини се да је ситуација са производним алатима озбиљан проблем. Иако су компанија Lockheed и америчко ратно ваздухопловство учинили све што је у њиховој моћи да обезбеде правилно складиштење алата и упутстава за производњу ловца F–22, настали су проблеми када су екипе за одржавање покушале да извуку опрему неопходну за поправку оштећених ловаца.

Припадник ратног ваздухопловства, који је однедавно у пензији, а који располаже сазнањима о покушајима поправке два оштећена ловца F-22 изјавио је да су били суочени са озбиљним проблемима приликом покушаја налажења одговарајућих алата.У једном примеру сервисери ратног ваздухопловства имали су задатак да направе одређену компоненту којом би заменили оштећени део за један F-22. Отишли су до места на којем је било предвиђено да стоје одређени алати и инструкције, али су, на своје изненађење, установили да је контејнер празан.

Иста ситуација се поновила неколико пута и до данас нема сазнања о томе да ли је овај проблем решен. Закључено је да чак и када би ратно ваздухопловство хтело, не постоји физичка могућност за поновно покретање производне линије, бар не без великих инвестиција у новцу и времену.

Други проблем који је потребно размотрити јесу инструменти на ловцу F-22. Они су много старији у односу на време када је ловац постао оперативан, односно од децембра 2005. године. Иако F-22 спада у најсавременије оперативне летелице у саставу америчког ратног ваздухопловства, његова компјутерска архитектура је на нивоу из деведесетих година прошлог века. Процесори компјутера са ловца раде на 25 мегахерца (поређења ради, један просечан комерцијални процесор сада ради на брзинама од преко 4.000 мегахерца и то само за

једно језгро). За разлику од њега, F-35 употребљава мрежу од 5 мултипроцесорских плоча на којима сваки процесор ради на брзинама од 2.000 мегахерца.

У складу с тим, софтвер ловца (софтвер је рађен у програмском језику Ада за разлику од софтвера авиона F-35 који је рађен у програмском језику C++) F–22 је такође застарео и врло проблематичан за унапређивање, што представља један од разлога због којих је било врло проблематично омогућавање употребе ракета ваздух-ваздух AIM-9X и AIM-120D, а и даље је присутан проблем остваривања комуникације ловца са другим авионима. Комуникација са другим платформама је иначе један од предуслова остваривања ваздушне надмоћи ловца F–22, јер је првобитни план предвиђао да ловац прима податке од више различитих платформи, не употребљавајући своје активне системе осматрања. Такође, план је предвиђао да ловци комуницирају са другим авионима америчког ратног ваздухопловства тако што би им прослеђивали информације потребне за напад на одабране циљеве. Иначе, F-22 је једини авион америчког ратног ваздухопловства који нема у потпуности развијену ову опцију.

У случају поновне производње било би потребно заменити све инструменте летелице, не само зато што су застарели већ и због тога што се такви процесори и одговарајуће компоненте већ деценијама не производе.

Један од главних проблема представљају метална оплата, милионима вредан спољни метални слој авиона који је прекривен материјалима за апсорпцију радарских емисија, односно осетљивост овог омотача на кишу и на друге абразивне елементе, што захтева велики број радних сати одржавања. Конкретно се помиње да је потребно више од 30 сати одржавања за сваки сат лета, што подиже цену једног сата лета на 44.000 америчких долара и што представља највишу цену одржавања у односу на све авионе у америчком ратном ваздухопловству.

Године 2005. компанија Боинг открила је дефекте у титанијумским носачима који вежу крила за труп авиона, што би могло довести до „катастрофалног губитка авиона". Уместо да тада затвори производне линије, компанија Боинг је потписала споразум са ратним ваздухопловством да се проблем реши тако што ће се повећати број инспекција авиона у флоти с тим што ће ове додатне трошкове платити ратно ваздухопловство. Један од разлога јесте што је компанија Локид употребљавала велики број подизвођача, док је сам процес контроле квалитета био толико лош да су радници фабрике у Џорџији сами исправљали уочене грешке на лоше пројектованим или лоше израђеним деловима.

Године 2006. један од пилота био је заробљен неколико сати у кокпиту,јер се заглавио поклопац куполе. Сама купола не може да траје дуже од 18 месеци, јер након тога губи своју чврстину и провидност. Амерички званичници су потврдили да видљивост куполе опада много брже него што је то очекивано и да се тамне мрље и љуштење материјала појављује након само 331 сата лета уместо очекиваних 800 сати.

Процењује се да је само 55 процената флоте ловаца F-22, вредне скоро 65 милијарди долара, спремно за мисије.

Међутим, ако Конгрес одвоји довољно новца, америчко ратно ваздухопловство могло би испланирати модернизацију ловца F-22 на бази архитектуре инструмената уграђених у ловац F-35, што би омогућило Пентагону да уштеди знатна средства и да хомологизује уређаје у оба ловца, али и да коначно омогући потребну комуникацију овог ловца са другим летелицама америчког ратног ваздухопловства.

Произведено је укупно 195 ловаца F-22, што је много мање од првобитног захтева ратног ваздухопловства да им је потребно 750 ловаца.

Упркос томе што F-22 спада у најбољи икада направљени ловац, његов дизајн датира још из осамдесетих година прошлог века, односно налази се у служби већ више од деценије.

Технологија је стара, параметри у вези невидљивости, инструмената и дизајна авиона у међувремену су знатно промењени. Уколико би ратно ваздухопловство морало да инвестира неколико десетина милијарди долара у летелицу, било би важно да се увери да та технологија није превазиђена. F-22 ће до 2035. године бити више од 30 година у служби, што значи да ће тада бити потпуно застарео .

Ратно ваздухопловство вероватно никад неће поновно покренути производну линију за ловац F-22. Постојећа технологија има свој рок трајања и авион највероватније неће бити у могућности да парира летелицама као што су руски PAK-FA и кинески J-20, а у међувремену су и неке друге државе кренуле са радовима на својим ловцима намењеним остваривању ваздушне надмоћи. Америчко ратно ваздухопловство већ је почело са радовима на следећој генерацији ловца за остваривање ваздушне надмоћи; то је F-X.

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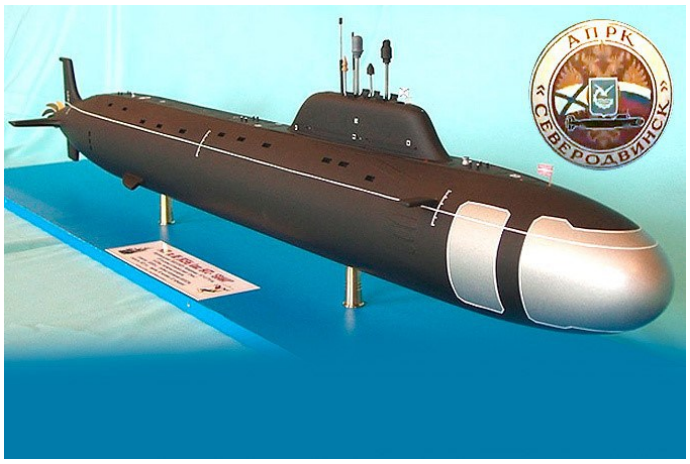
Нове руске нападне подморнице[5]

Нова руска подморница K-329 Severodvinsk, класе Project 885 Yasen, спремна је за прву борбено- тренажну мисију.

Нова руска подморница K-329 Severodvinsk

[5] The National Interest 27 March 2016.

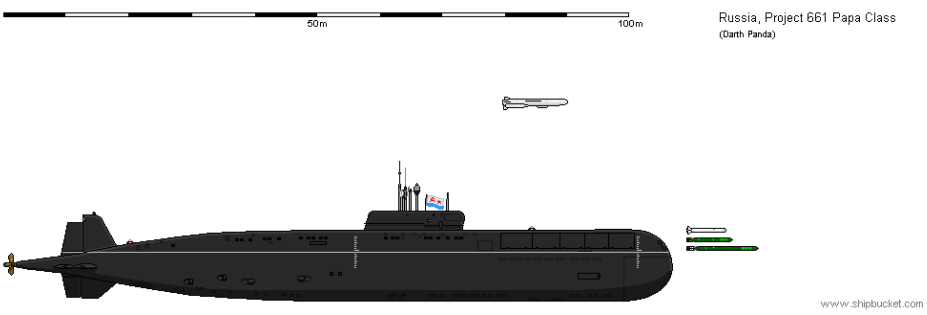
Нова подморница недавно је завршила оперативно тестирање након што је постала део флоте 2014. године. Портпарол руске северне флоте Вадим Серга изјавио је да је посада подморнице Severodvinsk извршила све припремне радње неопходне за испловљавање на планиране борбено- тренажне мисије.



Руска подморница K-329 Severodvinsk

Severodvinsk поседује многе аутоматизоване технологије које је Совјетски Савез развијао током седамдесетих и осамдесетих година са подморницама класе Project 705 Lira под америчким кодним називом Alfa. Подморнице класе Alfa, чији је труп био израђен од титанијума, биле су опремљене нуклеарним реакторима хлађеним течним металом. То су биле најбрже подморнице у то време и могле су најдубље да зароне од свих осталих подморница из тог периода. Изузетак је представљала само једна подморница, опет руска, класе Project 661 Anchar, америчког кодног назива Papa.

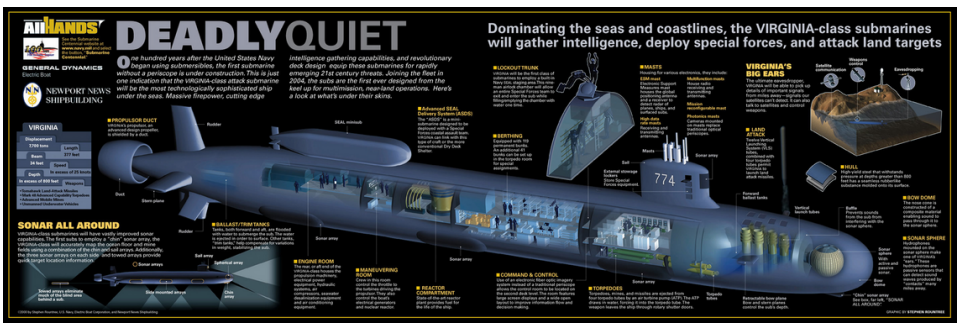
Подморница класе Project 661 Anchar



Нова подморница Severodvinsk аутоматизована је у великој мери, а посаду чине 32 официра и 58 морнара подморничара. Амерички поморски институт Combat fleets of the World процењује да би подморница могла пловити брзином од 35 до 40 чворова, а да јој је максимална „тиха" брзина око 20 чворова. Као и код других нуклеарних подморница новије генерације, реактор подморнице Severodvinsk траје колико и сама подморница. Такође, процењује се да је нова руска подморница тиша у односу на америчке подморнице класе Improved Los Angeles али не и колико подморнице класе Seawolf и Virginia.

За разлику од већине подморница совјетског дизајна, класа Yasen нема дупли труп већ има хибридни дизајн са лакшом структуром обавијеном преко унутрашњег трупа подморнице. Приметна је још једна измена, а то је сферични прамчани сонар под називом Irtysh Amfora. Због такве локације сонара торпедне цеви налазе се негде на средини подморнице, што је решење које је присутно на америчким подморницама. Severodvinsk има осам торпедних цеви од који су четири 650 мм, а друге четири 533 мм. Процењује се да би ова класа подморнице могла носити чак до 30 торпеда.

Руси су свесни да време није стало од 1993. године када су почели радови на овој подморници. Руска морнарица ће током 2016. године примити испоруку нове нападне подморнице класе Project 885M, под називом Kazan. Ово пловило биће унапређеније од Severodvinsk-a. Очекује се да ће Kazan имати унапређене сензоре и оружане системе, а биће и тиши од Severodvinsk-a.



Нова нападна подморнице класе Project 885M

Руска морнарица очекује испоруку од минимум осам нападних подморница класе Yasen. Четири подморнице су наручене, а у јулу 2013. године почели су радови на трећој подморници из ове серије под називом Novosibirsk.

Иако је подморница класе Project 885M врло импресивна, она није у потпуности једнака америчким подморницама класе Virginia у погледу акустичких и сензорских перформанси. Ова класа се може, у смислу сирових перформанси, мерити са три америчке подморнице класе Seawolf које су дизајниране још у време хладног рата за борбу против тада најмодернијих совјетских подморница класе Project 941 Akula, класе Typhoon Project 971 Schuka-B и класе Project 945 Sierra.

Подморнице класе Yasen су брзе, тешко наоружане и роне дубоко. Сједињене Државе би морале поседовати више подморница класе Seawolf за борбу против њих. Подморнице класе Virginia немају такве перформансе у погледу дубине зарањања, брзине и океанских перформанси у односу на класу Seawolf.

Русија је започела са радом на пројектовању два нова типа нуклеарних подморница које би требало да замене подморнице класе Project 949 Antey, НАТО ознаке Oscar и подморнице класе Project 945, НАТО ознаке Sierra. Ове подморнице биће за једну генерацију испред руских балистичких подморница Project 955 Borei и нападних подморница класе Project 855M Yasen које су практично развијене још за време Совјетског Савеза.

Подморница класе Project 945, НАТО ознаке Sierra

Подморница предвиђена као замена за класу Sierra означена је као „пресретач" и имала би задатак да штити руске нуклеарне балистичке подморнице, док би подморнице предвиђене за замену класе Oscar биле нуклеарне подморнице са вођеним ракетама, предвиђене за лов на америчке групе носача авиона.

Ове подморнице припадаће петој генерацији нуклеарних подморница. Обе класе имаће исти дизајн трупа. Основна разлика биће у њиховим оружаним системима, а пресретачка верзија неће носити противбродске или крстареће ракете великог домета. Ова верзија замениће подморнице класе Project 971 Schuka-B Akula, класе Project 945 Sierra и класе Project 871RTM Victor III. Друга класа која ће у свом наоружању имати противбродске и крстареће ракете великог домета предвиђена је за замену подморница класе Project 949A Oscar II.

Руси очекују почетак производње ових подморница између 2017. и 2018. године, док Американци нису толико оптимистички расположени. Амерички поморски експерти не очекују увођење ових подморница у производњу још неко време.

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Нова верзија авиона Gripen[6]

Од како је, током деведесетих година, шведско ратно ваздухопловство добило вишенаменски ловац бомбардер, он је уведен у оперативну употребу у Чешкој републици, Мађарској, Јужној Африци, Тајланду, Великој Британији, а ускоро ће се појавити и у Бразилу који је наручио 36 нових ловаца Gripen E/F. Хрватска и Словачка такође су заинтересоване, али за старију верзију GripenC/D, а и у Финској постоји интересовање за модел Gripen E. Овакав развој ситуације отвара могућност формирања интегрисане европске ваздушне песнице наоружане ловцима Gripen у оквиру система НАТО.

Грипен опремљен подвесним нишанским уређајем Litening III

[6] Jane's Defence Weekly 11 May 2016.

Овакав састав ваздушних снага у оквиру европског дела НАТО-а омогућио би потенцијалне оперативне предности у мултинационалним мисијама, али и значајну уштеду у погледу обуке пилота и одржавања. Ови авиони могли би бити употребљени за обезбеђење ваздушног простора изнад региона Балтика и Арктика, балтичких држава, Исланда и јужног дела источне Европе где би били ангажовани у блиској ваздушној подршци, прецизним ударима, тактичком извиђању, али и у разним другим операцијама.

Шведско ратно ваздухопловство тренутно располаже флотом од 73 вишенаменска једноседа JAS 39 Gripen C и D и двоседима JAS 39 D. Већина ловаца је скоро произведена, постојећа група од 120 авиона JAS 39 Gripen A и B сада је модернизована, а иначе сви авиони из те групе могу бити унапређени на конфигурацију C/D. Године 2013. Шведска је наручила 60 нових, напредних једноседа JAS 39 Gripen E који ће бити испоручивани од 2019. године са опцијом од додатних 20 летелица.

Чешка република и Мађарска имају на лизингу по 12 и 10 авиона Gripen C са по четири додатних модела D. Мађарска је у авионским несрећама изгубила један модел C и један модел D, па су Мађари на основу тога тражили замену једног авиона и поправку другог. Очекује се да ће оба ратна ваздухопловства повећати број авиона на 18.

Оштећени мађарски Gripen

Обе земље користе своје авионе у мисијама ваздушног надзора над Балтиком, док су чешки авиони типа Gripen летели и над Исландом. Оба ратна ваздухопловства развијају додатне способности за ударним нападима својих авиона Gripen.

У међувремену је Словачка одабрала Gripen C/D за наследника своје флоте мигова 29 која потиче још од Варшавског пакта. Словачка је поручила 9 до 12 авиона, а претпоставља се да ће им бити потребно још како би се из-

једначили са регионалним партнерима. Очекује се да ће авиони ући у оперативну употребу пред крај 2017. године. Током октобра 2015. године и Хрватска је започела преговоре о лизингу 8 до 10 авиона Gripen C/D са опцијом проширивања флоте. Очекује се да у будућности сва ваздухопловства пређу на нову верзију Gripen E/F, нарочито ако се идеја о формирању Европске ваздушне НАТО групе опремљене авионима Gripen испостави као успешна.

У светлу најновије затегнуте ситуације са Русијом и Финска размишља о замени своје флоте од 60 авиона F/A-18 C/D авионима Gripen E/F у оквиру програма замене ловца. Осим поменутих корисника ту је и Аустрија која размишља о економичнијој алтернативи у односу на свој ловац Eurofighter Typhoon, а и Швајцарска која наставља са спровођењем плана набавке новог ловца након што је остала без подршке јавности за набавком авиона Gripen E.

Gripen C/D

Gripen C/D ушао је у оперативну употребу 1997. године као напреднија верзија авиона Gripen A/B који се производио од 1993. до 1996. године за шведско ратно ваздухопловство.

Нови Gripen C испоручен је у марту 2015. године, па је ослобођена производна линија за Gripen E.

Суперсонични Gripen C/D покреће турбовентилаторски мотор са додатним сагоревањем Volvo RM12, а ослања се на модернизовану верзију радара PS-05/A са механичким скенирањем као свог примарног сензора. Gripen C/D може танковати гориво током лета, поседује НАТО компатибилни Link 16, комуникацију са трупама на земљи у режиму ваздушне подршке, идентификацију свој-туђи, радио и сателитске комуникационе уређаје и аплинкове, као и напредни систем за електронски рат. Такође, опремљен је дефанзивним системима, системом за нишањење преко пилотске кациге, а његова кабина је прилагођена за рад са уређајима за ноћно осматрање.

Наоружан је интерним аутоматским топом 27 мм Mauser BK 27 опремљеним радарским режимом гађања, а опремљен је са шест екстерних подвесних тачка за ракете ваздух-ваздух и оружјем за дејство у режиму ваздух-земља. Наоружан је ракетама ваздух-ваздух средњег домета AMRAAM, AIM-120, кратког домета AIM-9 Sidewinder и IRIS-T, као и ракетама за гађање циљева ван визуелног домета Meteor. У оквиру дејства у режиму ваздух-земља,Gripen C/D наоружан је навођеним ракетама Maverick, невођеним и вођеним ракетама и бомбама. Овај арсенал наоружања наводи се на циљеве преко модерног подвесног нишанског уређаја Litening III инсталираном на авионе у наоружању Чешке, Мађарске и Шведске. Шведски авиони наоружани су и ракетом ваздух-море RBS15F за гађање циљева на мору и подвесним уређајем Terma SPK 39 Modular Reconnaissance Pod II за тактичко извиђање.

Ловац бомбардер Gripen C/D добио је 2015. године најновији софтвер MS20 који му омогућује интеграцију са оружаним системима као што су ракета за гађање циљева ван визуелног домета Meteor и GBU-39 MBD Small Diameter Bomb уз низ навигационих побољшања, могућности ноћног осматрања путем подвесног уређаја SPK 39 и системом за избегавање судара на копну. Међутим, најважније побољшање извршено је у области радара PS-05/A Mk 3. Софтверски пакет MS20 омогућио је унапређење радара који је сада опре-

мљен новим процесорима и сигналом, аутоматским режимом оптимизације, што му побољшава режим откривања циљева, електронске противмере, боље перформансе у праћењу циљева и побољшање у режиму рада синтетичког радара. Такође, омогућена је нова опција претраживања на великим даљинама.

У међувремену компанија SAAB Electronic Defence ради на развоју нове варијанте радара Mk4 која ће откривати циљеве на још већим удаљеностима, поседовати могућност откривања циљева са малим радарским одразом, побољшани рад у режиму ваздух-ваздух и још два нова режима рада синтетичког радара са остваривањем резолуције циљева од 3 м и мањом, испод једног метра. Додат је нови режим трагања за малим површинским бродовима на великим даљинама.

Коначно, Gripen C/D је много поузданији авион и лак за управљање. Добро се показао у операцијама и захтевним вежбама као што су „Red Flag" и „Trident Juncture" и остаће потентан, модеран вишенаменски ловац и у следећој деценији. У следећим здруженим операцијама Gripen C/D ће се лако уклопити у раду са ловцем Gripen E/F.

Gripen E/F

Gripen E много личи на претходне моделе, али се ради о потпуно новом авиону који представља врх развоја вишенаменског ловца. Први лет овог ловца бомбардера очекује се пред крај 2016. године, а тренутно се испитује конвертовани модел D опремљен системима који ће бити уграђени на модел E. Прве компјутерске симулације показују да је Gripen E надмоћан у односу на F-35, у многим аспектима раван америчком ловцу F-22 и више него достојан супарник много већем и тежем ловцу Su-35.

Gripen E има већу површину крила, повећану носивост горива, две додатне подвесне тачке, што му повећава носивост убојних средстава на 7,2 тоне, нови размештај сјајног трапа, нову опрему за вођење електронског рата, нов систем противмера, повећане могућности за прикупљање информација, надзора, захвата циља и извиђања, као и смањени радарски одраз.

Нови Gripen E

Три основна сегмента авиона су мотор F414-GE39E компаније General Electric који је првобитно развијен за F/A18-EF Super Hornet, систем за инфрацрвено трагање и праћење Selex ES Skyward-G и радар са електронским фазирањем Selex Galileo ES-05 Raven (AESA). Овај радар опремљен је новом иновативном антеном која обезбеђује осматрачко поље од 100 степени, што омогућује ловцу да се окрене након лансирања ракета, али да настави са праћењем ракете преко дата-линка.

Радарска електронска антена спојена је потпуно дигитализованим мултиканалним улазним и излазним уређајима и процесорском линијом, што обезбеђује несметан рад у режимима ваздух-ваздух и ваздух-земља. Такође, обезбеђена је могућност сталног софтверског ажурирања, што ће му омогућити даљи развитак у складу са будућим потребама.

Систем за инфрацрвено трагање и праћење Selex ES Skyward-G је неопходан ради савладавања скупе „невидљиве" технологије која се налази у многим модерним ловцима као што су F-35 и Sukhoi T-50, тако што омогућава детекцију и праћење ваздушних и копнених циљева ван визуелног домета без активних радарских емисија које би одале присуство ловца. Систем се налази одмах испред пилотске куполе, ван централне линије са одговарајућим инст1рументима смештеним близу радара. Gripen E/F ће, такође, бити опремљен потрошним активним мамцима за ометање земаљских радара и радарски навођених ракета.

Уштеда

Компанија Aeronautics Division Saab очекује продају између 300 и 450 авиона Gripen C/D/E/F током следећих 20 година. Европска ратна ваздухопловства планирају набавку 24 до 48 авиона Gripen C/D, а очекују се додатне наруџбине из Африке и других места, што би довело до смањења производних трошкова и учинило овај авион још интересантнијим за куповину. Такође, очекује се набавка најмање 60 авиона Gripen E за Шведску и додатних 100 до 150 модела Gripen E за европске земље.

С обзиром на број авиона у употреби отварају се нове могућности у виду интегрисаног одржавања и обуке. У том случају дошло би до смањења трошкова и времена одржавања и оправке. Техничко особље би заједно ишло на обуку на једно или два места у Европи, потпуно опремљено за такав задатак, што би знатно смањило трошкове инфраструктуре и унапредило стандарде обуке и интероперабилности. Овај процес се већ спроводи за кориснике авиона у Чешкој, Мађарској и Шведској.

Заједничка обука пилота

Током година појавиле су се различите опције обуке пилота у нордијским земљама, али је појава европских НАТО Gripen снага отворила могућност обуке потпуно квалификованих и стандардизованих пилота Gripen-а. Шведска је учествовала у пројекту напредне обуке европских пилота млазних авиона који је прекинут 2012. године због различитих захтева учесника као што је Финска. Међутим, обе земље су наставиле са тражењем дугорочног решења обуке пилота грипена за шведско и финско ратно ваздухопловство.

Унутрашњост кабине ловца бомбардера Gripen C

У оквиру новог потенцијалног програма заједничке обуке пилота помиње се и база хрватског ратног ваздухопловства у Задру у којој би се обучавали пилоти Gripen C из Хрватске, Чешке, Мађарске, Словачке, Шведске, а можда и Аустрије. Пилоти ловца Gripen E обучавају се у бази F7 Satenas у Шведској.

Оперативна интеграција

Финска и Шведска су током 2013. године објавиле намеру за продубљивањем одбрамбене сарадње. Акциони план из 2014. године предвиђао је побољшану сарадњу у области обуке, ваздушног и поморског надзора и

употребу заједничке инфраструктуре. Направљен је значајан корак у повећаном степену интероперабилности између финског и шведског ратног ваздухопловства као основе за здружене операције.

Други фактор је формирање такозване групе Вишеград четири, групе централноевропских држава у оквиру које се планира формирање организације величине бригаде и додавање одговарајуће ваздушне компоненте која би учествовала у вежбама и операцијама НАТО снага за брз одговор. Група Вишеград четири има намеру да укључи и Хрватску и Словенију у своје редове, што би довело до још веће војне интеграције војних снага у оквиру НАТО-а које би покривале подручје од Арктика до Балтика и даље до Јадранског мора уколико се постигне одговарајући политички консензус.

Осим очигледних предности по питању обуке и одржавања, оваква ваздушна снага састављена од ловаца Gripen могла би бити употребљена и за одбрану држава чланица, разне операције и вежбе у оквиру НАТО-а.

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Модернизација БВП ВМР-1[7]

Украјинска индустрија приказала је нови прототип – модернизовано борбено возило пешадије БВП ВМР-1. Први прототип носи ознаку ВМР-1 UM и тренутно је фази тестирања у Украјини.

BMP-1 UM

[7] Jane's International Defence Review June 2016.

Екстензивна модификација старог руског БВП укључује замену куполе која је била наоружана топом 73 мм 2А28, коаксијалним митраљезом 7.62 мм РКТ и противтенковском вођеном ракетом КВМ 9К11 Malyutka (NATO кодни назив Sagger) која је раније била смештена изнад топа.

У оквиру модернизације, купола је замењена оружном станицом Shkval која је била развијена за возило BTR-3 у конфигурацији 8Х8. Оружна станица је наоружана стабилизованим топом 30 мм са двоструким храњењем ZTM-1 30 mm, коаксијалним митраљезом 7.62 mm КТ и бацачем граната 30 мм Ag-17 који је монтиран споља на левој страни куполе.

ZTM-1 има ефективни домет у режиму земља-земља до 2.000 м, а може ангажовати и неке врсте ваздушних мета. Максимална брзина гранате је 960 м/с. Муницијски комплет садржи 225 граната 30 мм и 2.500 метака 7.62 мм, а носи и 116 граната за бацач 30 мм, од којих је 29 спремно за употребу.

На десној страни куполе налазе се две противтенковске вођене ракете са ласерским навођењем, типа полуаутоматског командног вођења компаније Kyiev Design Bureau Bar'er. Ракета има максимални домет до 5.500 м и минимални до 100 м, а опремљена је тандем бојевом главом са високоексплозивним пуњењем и намењена за неутрализовање мета опремљених експлозивно- реактивним оклопом.

Бацачи димних патрона 81 мм налазе се испод предњег дела куполе. Посаду БВП ВМР-1 чине командир, нишанџија и возач, као и осам чланова десантног одељења.

У оригиналној верзији возила ВМР-1 десантно одељење смештено је у задњем делу возила, а војници су окренути леђима једни према другима док су на крају возила двоја врата у којима је смештено гориво. Модернизовани ВМР-1 UM има више места за десантно одељење и уместо двоја врата налази се широка излазна рампа. Десантно одељење је смештено у седиштима која ублажавају ризик од експлозија. Седишта се налазе са обе стране трупа, а војници су окренути једни ка другима.

Маса возила је 14 тона. Оригинални мотор замењен је домаћим турбодизел-мотором 3TD-2 који развија 400 КС и даје однос 28.57 КС/Т, што је значајно унапређење у односу на претходни мотор UTD-20 који је омогућавао постизање 300 КС и однос од 22.22 КС/Т.

Максимална брзина на путу је 70 КМ/С, а возило је у потпуности спремно за савладавање водених препрека путем гусеница и то максималном брзином до 7 км/ч.

Труп је произведен од заварених челичних плоча са унутрашњом заштитом. Плоче експлозивно- реактивног оклопа налазе се у одређеним деловима трупа ради повећане заштите од дејства противтенковског оружја опремљеног једноструком бојевом главом.

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Нови кинески точкаши у улози ватрене подршке[8]

Кинеска индустрија наставља са увођењем нових возила опремљеним артиљеријским системима.Компанија Poly Technologies развила је нови мобилни минобацачки систем под називом „врло покретљиви лаки минобацач 120 мм" који је интегрисан на кинеском возилу DongFeng EQ2025 Mengshi у конфигурацији 4x4 који је врло сличан америчком хамвију (HMMWV). Систем је опремљен минобацачем 120 мм W86 са муницијом сложеном хоризонтално са обе стране возила.

CSK002 у конфигурацији 4x4 базиран на возилу DongFeng EQ2025 намењен ваздушнодесантним трупама

Минобацач 120 мм W86 има цев дугу 1,54 м и углавном се превози камионима на којима је утоварена муниција, а при доласку на борбени положај потребно је откачити оруђе и припремити га за паљбу. Монтиран је на задњем крају теренског возила и механичким путем се спушта на земљу и припрема за паљбу, а на исти начин се касније, након извршене паљбе, враћа на возило.

[8] Jane's International Defence Review June 2016.

Максимални домет минобацача W86 је 7.500 м и то приликом употребе стандардне мине са бојевом главом од високоексплозивног пуњења, али је домет могуће продужити употребом ракетних мина на још 3.000 м.

Поред стандардне верзије EQ2025, развијена је ваздушнодесантна верзија CSK002, која је опремљена кровним митраљезом 12.7 мм, аутоматским бацачем граната 35 мм смештеним на десној страни возила и редом бацача димних граната смештеним на крову возила.

Платформа EQ2025 користи се за велики број борбених мисија, као што су минобацач 120 мм, мобилни минобацач 81 мм, возило за специјалне јединице, возило за противваздухопловну одбрану, амбулантно возило, као и у улози командно-контролног возила. Сва возила овог типа опремљена су централним системом надувавања гума и предњим витлом за извлачење са тешких терена.

Већ неколико година компанија NORINCO користи италијанску лаку хаубицу 105 мм компаније OTO MELARA под локалним називом AH3. У међувремену је развијена локална верзија самоходне хаубице AH3 која је заснована на теренском возилу Shaanxi Automotive SX21 00C у конфигурацији 4x4. Ново возило има ознаку 1 SP 105 mm Fire Assault Vehicle.

Артиљеријски систем 1 SP 105 mm Fire Assault Vehicle или 15P SP

Кинеска компанија Sichuan Aerospace Industries Corporation пројектовала је ово возило. Горња страна возила опремљена је ролбар конструкцијом за заштиту у случају превртања. Хаубица је смештена на задњем крају возила и гађа из правца задњег дела возила.

Главни недостатак хаубице 105 мм АН3, у вучној или самоходној варијанти је кратак домет оруђа, само 10.2 КМ, што је разлог да су многе земље одлучиле да замене оригиналну хаубицу 105 mm Model 56 оруђем са већим радијусом дејства и напреднијом и ефикаснијом муницијом.

Велика Британија заменила је своје хаубице 105 мм Model 56 топовима Royal Ordnance 105 mm L118 Light Gun који имају домет до 17.200 м и то новијом муницијом коју карактерише боља фрагментација и експлозивни ефекат.

Кинеска ослободилачка војска, од 1996. године, има у свом наоружању самоходне хаубице 122 мм Type 96. Ове самоходне хаубице сада се рекламирају на извозном тржишту под ознаком CS/SH1 122. Ови системи су монтирани на камионе и гађају преко задње осе возила, а опремљени су стабилизаторима платформе. Међутим, кабина није заштићена.

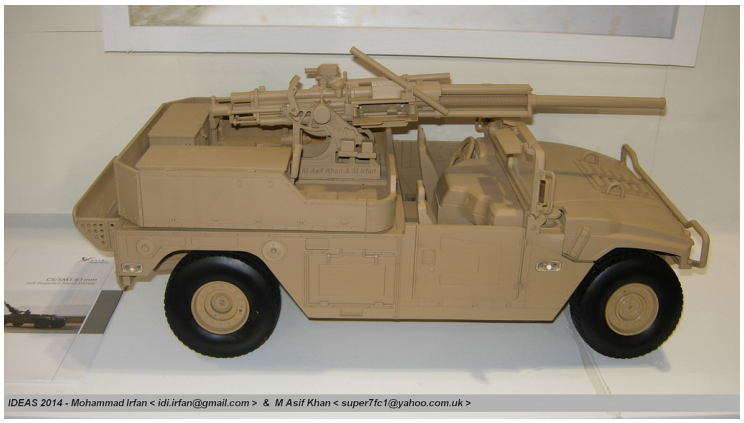
Самоходна хаубица CS/SH1 122

Током последње две године компанија Poly Technologies понудила је ново самоходно оруђе – платформу CS/SH2 НАТО калибра 105 мм која такође гађа преко задње осе возила. Ова платформа испаљује гранате 105 мм дужег домета са високоексплозивном бојевом главом домаће производње. Ова верзија оруђа опремљена је инерцијалним навигационим системом, а као и претходне верзије и она гађа преко задње осе возила.

Кинески извори наводе да верзија CS/SH2 може испаљивати обичне гранате, али и оне са ракетним пуњењем. Међутим, исти извори наводе да долази до смањења прецизности погодака пропорционално са повећањем даљине гађања.

Кина је успела да у потпуности ископира руски систем са аутоматским минобацачем Vasilyek (2B9) и да по том основу направи платформу NORINCO CS/SM1 81 мм која је инсталирана на задњем делу возила EQ2025 у конфигурацији 4x4. Минобацач је смештен на ротирајућој платформи која омогућује

брзо захватање нових циљева и носи 64 мине. Минобацач се снабдева из шаржера од четири мине које се испаљују за две секунде. Минобацачке мине овог система имају максимални домет од 6.200 м и минимални до 800 м.



Платформа NORINCOaCS/SM1 81 мм

Кинеска војна индустрија почела је да наглашава значај развоја оружаних система за извозно тржиште. Кинеска ослободилачка војска употребљава велики број вучних и самоходних артиљеријских система 122 м за разлику од артиљеријских система 105 мм који се нуде тржишту.

Компаније NORINCO и Poly Technologies су два главна извозника кинеских копнених оружаних система. Ове две компаније извозе своје производе у Африку и друге делове света који су раније сматрани интересном зоном руских и западних извозника наоружања.

Предност кинеских компанија је у већој понуди производа, цени и слободнијем тумачењу разних постојећих правилника који регулишу ову материју.

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Нова француска оклопна возила[9]

План модернизације француске војске, под називом SCORPION, предвиђа умрежавање не само копнених оружаних платформи, као што су артиљерија и пешадијски системи, већ и ваздушних платформи у облику беспилотних летелица и борбеног хеликоптера Tigre.

Кључни део програма SCORPION представља развој и увођење у оперативну употребу нове платформе: Jaguar, Engin Blinde de Reconnaissance (EBRC) и Griffon, Vehicule Blinde Multi Role (VBMR) које развијају француске компаније Nexter Systems, Renault Trucks Defence и Thales Communications&Security на основу уговора вредног 5 милијарди евра.

[9] Jane's International Defence Review June 2016.

Jaguar, Engin Blinde de Reconnaissance (EBRC) (десно) и Griffon, Vehicule Blinde Multi Role (VBMR) (лево)

Компанија Nexter Systems биће одговорна за финалну интеграцију оба возила. Компанија Renault Trucks Defence обезбедиће погонску опрему и даљински управљане оружне станице, а биће одговорна и за одржавање возила и резервне делове. Компанија Thales Communications&Security задужена је за електронски део пакета.

На основу постојећих планова, француска војска треба да добије 248 возила Jaguar EBRC који ће заменити постојећа возила AMX-10RCR у конфигурацији 6x6 са топом 105 mm и Panhard Defence Sagaie у конфигурацији 6x6 са топом 90 mm које су у функцији више од 30 година.

Маса возила Jaguar EBRC биће око 25 тона, а посаду ће сачињавати командир, возач и нишанџија. Дизел-агрегат биће смештен у задњем крају возила. Возило ће бити опремљено куполом наоружаном топом CTAI 40 mm Case Telescoped Weapon System и кровним митраљезом 7.62 мм.На крову куполе биће инсталиране противтенковске вођене ракете MBDA ради напада на већим даљинама. Осим опције директног гађања, ракете ће радити и у режиму изван визуелног домета, где ће њихове мете означавати друге копнене или ваздушне платформе.

Grifon VBMR ће заменити оклопни транспортер Vehicule de l'Avant Blinde (VAB) у конфигурацији 4x4, а очекује се производња од 1,732 возила.

Возила Grifon VBMR имаће заштићен погонски део који ће се налазити у предњем делу возила, командир и возач ће бити смештени одмах иза мотора, а десантно одељење у простору иза њих.

Маса возила Grifon VBMR биће око 24,5 тона и предвиђа укрцавање десантног одељења од осам људи поред командира и возача. Сви припадници тог одељења седеће у седиштима пројектованим за ублажавање експлозивног удара.

Француска војска тренутно располаже са око 40 различитих верзија возила VAB, тако да ће и возило Grifon VBMR бити пројектовано за различите улоге, као што су амбулантно возило, командно возило, инжињерско као и возило за поправке и извлачење.

Нови конзорцијум

Први програм новоформираног конзорцијума, који чине компаније Nexter Systems и Krauss Maffei Wegmann, могао би бити развој новог тенка који би заменио француски Leclerc и немачки Leopard 2. Ова идеја се управо разматра на нивоу влада Француске и Немачке. Претпоставља се да ће нови тенк бити наоружан топом са глатком цеви 130 мм и аутоматским пуњачем.

Највећи програм компаније Nexter Systems управо је био тенк Leclerc. Укупно је произведено 406 примерака за француску војску и 436 возила за Уједињене Арапске Емирате који су оптимизовани за операције на Блиском истоку. Возила су опремљена немачким погонским агрегатом од 1.500 КС, системом за управљање битком, клима-уређајем, различитим пакетом оклопа, помоћном погонском јединицом и унапређеним оптроничким уређајима.

Француска флота тенкова Leclerc редукована је на 220 возила, а 2015. године компанија Nexter Systems добила је уговор за модернизацију 200 тенкова Leclerc и 18 оклопних возила за извлачење, што би продужило њихову оперативну употребу до 2035. односно до 2040. године.

Компанија је завршила испоруке француској војсци са бројком од 630 возила Vehicule Blinde de Combat d'Infanterie (VBCI) у конфигурацији 8x8, од којих је 520 у конфигурацији VCI, односно борбених возила пешадије, а остатак од 110 возила је у командној конфигурацији. У току је модернизација старијих модела возила VBCI на којима се мења постојећа амортизација, што ће омогућити уградњу додатног оклопа и повећање масе возила са 29 на 32 тоне.

Током септембра 2015. године компанија Nexter Systems приказала је возило VBCI-2 у конфигурацији 8x8 предвиђено за извозно тржиште. Возило има нови дизајн трупа ради остваривања боље заштите, нови систем амортизације, јачи погонски агрегат од 600 КС и шире гуме оптимизоване су за употребу у пустињи.

Возило VBCI-2 у конфигурацији 8x8

Стандардна француска верзија француског возила VCI опремљена је куполом наоружаном топом 25 мм М811 са двоструким пуњењем и коаксијалним митраљезом 7.62 мм. Командир је смештен у трупу возила иза возача на левој страни и управља оружјем употребљавајући панорамски нишански систем на врху куполе.

VBCI-2 је опремљен куполом наоружаном топом CTAI 40 mm, а овај топ изабрали су и Британци за свој пројекат извиђачког возила Ajax. Прва серија ових топова произведена је почетком 2016. године, а ради се о највећем европском програму топа средњег калибра. Посада VBCI-2 састоји се од трочлане посаде, командира, нишанџије и возача, као и осам припадника десантног одељења. Возило може бити наоружано различитим моделима вођених противтенковских ракета.

Компанија Nexter Systems произвела је два примерка возила Tactical Infantry Transport&Utility System – тактички транспортни систем за превоз пешадије и терета (TITUS), а развијена су ради попуњавања празнине у понуди између возила VBCI 8X8 и Aravis 4X4. Компанија сматра да би ова возила могла заменити велики број оклопних транспортера М113.

Возило Aravis у конфигурацији 4x4

Возило Aravis у конфигурацији 4x4 је још једно од производа поменуте компаније, а произведено је на основу шасије компаније Mercedes Benz UNIMOG у конфигурацији 4x4 са оклопљеним трупом који нуди висок ниво балистичке заштите за седам људи које превози.

Први корисник је француска војска која је добила 15 возила која се користе за рашчишћавање путева у Авганистану. Ова возила опремљена су даљински управљаним оружним системом Konsberg Protector наоружаним митраљезом калибра .50 M2 HB. Саудијска Арабија наручила је 200 возила у основној верзији оклопног транспортера. Габон је још један корисник и располаже са 12 возила.

Компанија Renault Trucks Defence

Најбоље продавани точкаш ове компаније је VAB, а произведено је 5.000 комада. Већина је у конфигурацији 4x4, али су неки клијенти тражили конфигурацију 6x6 која има бољу теренску проходност. Компанија је модернизовала велики број француских возила VAB на конфигурацију VAB Ultima, што значи бољу оклопну заштиту и уградњу седишта за ублажавање ефекта експлозије.

Компанија је развила и VAB Mk 3 у конфигурацији 6x6 који је масе 20 тона, са модуларним оклопом, покреће га дизел-мотор снаге 340 КС и, уз аутоматски мењач, омогућава возилу постизање брзине до 105 км/ч на отвореном путу са односом снаге и масе 17 КС/Т. Возило може бити употребљавано као оклопни транспортер, командно возило, носач минобацача, као и амбулантна верзија.

VAB Mk 3 у конфигурацији 6x6

Возило VAB Mk 3 може бити опремљено оружним системима као што су TRT-25 са топом 25 мм и спрегнутим митраљезом 7.62 мм и TRT-30 са топом 30 мм и спрегнутим митраљезом 7.62 мм које производи јужноафричка компанија Land Systems.

Амфибијску верзију овог возила покрећу две турбо-млазнице које се налазе на оба краја трупа.

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Тактичке футроле за пиштоље – стандарди, намене, употреба

Тактичке футроле карактерише посебна израда, а намењене су за уметање, а затим и употребу различите тактичке опреме приликом извођења тактичких радњи у оквиру обуке, односно приликом интервенција.[10] Тако се може говорити о тактичким футролама за резервне оквире пушака, аутомата, пиштоља, тактичким футролама за ношење пиштоља, тактичким футролама за ношење ножева или сечива, средстава везе и слично. Имајући у виду да од модалитета употребе тактичке опреме може зависити и људски живот, посебно ако се говори о тактичким футролама за ношење оружја, јасно је да њиховој изради треба посветити пуну пажњу, узимајући у обзир искуства са терена, а на основу детаљних анализа.

Модели футрола

Службено лице најчешће потеже оружје само када намерава да га заиста употреби. То звучи прилично једноставно, али ситуације у пракси често нису такве. Наиме, употреба оружја некад је и последица лоше процене службеног лица, услед непознавања или неправилног тумачења околности случаја или услед изложености стресу, самим тим и умањене способности расуђивања и томе слично. Са друге стране, постоје, нажалост, и ситуације у којима употреба оружја није ефикасно реализована услед недовољне обучености службеног лица или заказивања опреме, попут самог оружја, односно футроле намењене за његово ношење.

Тактичке футроле за спуштено ношење: „5.11 Glock 17" (лево) и „BLACKHAWK, Serpa Tactical Level 2". Фото: Милош Јевтић

[10] Поред овог критеријума, у литератури се истиче и стандард усклађености ових футрола са природом тактичких радњи у смислу да конструкција футрола олакшава употребу уметнуте тактичке опреме, јер је, на пример, ергономски добро решена, у складу са биомеханичким покретом човека.

Тактичке футроле за ношење пиштоља треба да обезбеде примарно два стандарда: безбедно ношење оружја[11] и сигурно потезање оружја при употреби. Техника и брзина потезања, наравно, у великој мери зависи од увежбаности стрелца, али конструкција футроле треба да буде таква да стрелцу олакша потезање тако што не заклања рукохват оружја, али и тако што га спречава да приступи обарачу пиштоља, док га не извуче из футроле у потпуности. Додатно, поједини произвођачи опремају моделе тактичких футрола и системима који спречавају нежељено повлачење навлаке, тј. репетирање оружја.[12] Безбедно ношење оружја односи се на поуздан систем брављења оружја када се правилно убаци у футролу и блокирања оружја у том положају неким сигурносним механизмом. Са психолошког аспекта овај стандард је веома важан за носиоца оружја, јер му даје одређен ниво самопоуздања и сигурности у опрему, односно омогућава да радње и интервенције изводи пуним капацитетом, без страха да ће му лична опрема заказати.

Тактичке футроле за ношење пиштоља данас се израђују у неколико врста, према критеријуму намене. Разликују се футроле за прикривено ношење и футроле за „откривено", односно спољашње ношење. Модели за прикривено ношење су, по правилу, компактнији, посебно када је ширина футроле у питању, јер треба да буду неупадљиви приликом ношења испод одевних предмета. Данас се футроле за прикривено ношење израђују за монтирање са спољашње стране тактичког опасача или каиша, а све су популарнији и модели који су намењени за монтирање са унутрашње стране панталона, такође качењем на опасач или каиш. Супротно моделима за прикривено ношење, модели за „откривено" ношење често долазе и у конфигурацији са футролом за резервни оквир, а у пракси се монтирају са спољашње стране опасача или каиша, односно око ноге. У овом случају футрола се додатно утврђује око ноге подесивим каишевима. Такође, приметна је и пракса, актуелна међу припадницима јединица за специјалне намене, односно „контракторима", да тактичке футроле за ношење пиштоља монтирају и на тактичке или балистичке прслуке које носе приликом извршавања задатака и послова.[13] Независно од намене, тактичке футроле се израђују или као универзалне[14] или само за тачно одређене моделе за неке категорије наоружања.[15]

Данас се купцима нуде модели који се израђују од синтетичких и композитних материјала. Све траженији су модели од композитних материјала, а међу задовољним корисницима најбројнији су припадници јединица за специјалне намене. За њих реномирани произвођачи нуде посебне моделе тактичких футрола, који морају бити изузетно поуздани, а једноставни за употребу. Такође, конструкције ових модела морају бити, поред компати-

[11] И у ситуацијама када службено лице носи оружје са метком у цеви.
[12] Као што је случај са тактичким футролама за спуштено ношење пиштоља „BLACKHAWK, Serpa Tactical Level 2".
[13] Ова пракса показала се веома практичном приликом извршавања задатака и послова блиске заштите одређеног лица, посебно при обезбеђивању ескорта, када су пратиоци у возилима.
[14] У смислу категорије наоружања, на пример футроле за полуаутоматске пиштоље или футроле за револвере, односно ако су компатибилне са више серија из неке категорије наоружања, на пример за пиштоље „Glock-17", „Glock-19".
[15] На пример, футрола за спуштено ношење „Safariland Glock-17".

САВРЕМЕНО НАОРУЖАЊЕ И ВОЈНА ОПРЕМА / СОВРЕМЕННОЕ ВООРУЖЕНИЕ И ВОЕННОЕ ОБОРУДОВАНИЕ / MODERN WEAPONS AND MILITARY EQUIPMENT, pp. 1186–1224

билности са конструкцијом неког одређеног модела службеног оружја, компатибилне и са тактичком опремом која се монтира на оружје, попут тактичког светла, или ласерског обележивача циља,[16] што, нажалост, често превиђају и познати произвођачи.[17]

Српски пионир

Недавно се у Србији појавила компанија „Horned Viper", која је окупила тим стручњака, са циљем да српском и страном тржишту понуде висококвалитетне, практичне и оригиналне производе. Компанија је, за сада, специјализована за производњу футрола за ношење пиштоља различитих намена и резервних пиштољских оквира. Ови производи израђени су од квалитетног композитног материјала „kydex", који компанија увози из САД, заједно са свим осталим елементима – од шрафова до каишева. Материјали из иностранства добијају форму футрола различитих намена искључиво у Србији, а на основу вишегодишњег искуства српских стручњака који су мотивисани да љубитељима оружја, али и службеним лицима, понуде висококвалитетне, поуздане производе по приступачној цени, а уз доживотну гаранцију! По угледу на произвођаче у иностранству, а на основу богатог искуства, стручњаци своје производе и пројекте у развоју тестирају у реалним условима, на полигонима, а приликом тактичке употребе оружја. Додатно, постојеће конструкције унапређују и на основу сугестија корисника и стручних сарадника, који имају могућност да поручују производе израђене према личним захтевима. Компанија тренутно купцима нуди моделе футрола за спољно и унутрашње прикривено ношење пиштоља[18], као и футроле за тренинг, односно моделе за службену употребу. У фази усавршавања су и модел футроле за потребе такмичара у практичном стрељаштву у категорији полуаутоматских пиштоља 9 mm, као и модел футроле на платформи за ногу за тактичку употребу. Када је реч о футролама за резервне пиштољске оквире, „Horned Viper" за сада нуди футролу за један оквир за унутрашње прикривено ношење, футролу за два оквира за спољашње прикривено ношење, као и футролу за службену употребу за један оквир. У плану је и израда футрола за пушчане оквире система „Калашњиков", односно амерички „AR".

Футрола за аустријске моделе „Glock"

Серија аустријских пиштоља је веома популарна међу корисницима у Србији, а веома поузданом показала се и при службеној употреби. Моделима „17" у трећој и четвртој генерацији опремљене су елитне јединице срп-

[16] Тактичка опрема ове врсте монтира се, по правилу, на шину на доњој страни рама пиштоља, испод цеви оружја.

[17] На пример, познате тактичке футроле „BLACKHAWK, Serpa Tactical Level 2" намењене за „Glock-17", нису компатибилне за ношење овог модела са монтираном тактичком лампом у стандардној верзији ове футроле.

[18] За моделе „CZ-99", „CZ-998", „Glock-17", „Glock-19", „Glock-22", „Glock-23", „Glock-31", „Glock-32", „CZ-75 SP-01 Shadow", у калибру 9x19 mm Parabellum/Luger. Футроле ове намене за све моделе могу се употребити и за спољашње и за унутрашње прикривено ношење једноставном заменом носача футроле.

ске полиције, Специјална антитерористичка јединица – САЈ и специјалистичке чете и ронилачка јединица Жандармерије, као и Војске, Специјална бригада, односно Батаљон војне полиције специјалне намене „Кобре”.

Футрола за модел „Glock-17”. Фото: Horned Viper

Компанија нуди моделе футрола за прикривено унутрашње и спољашње ношење, ознаке „ExDATH”, као и футроле искључиво за унутрашње прикривено ношење, ознака „CCH” и „ExDCCH”. Разлика између ових модела је у дебљини материјала, па се за модел „CCH” користи „kydex” дебљине 1,5 mm (укупне масе 80 g), а за модел „ExDCCH” материјал дебљине 2,4 mm (укупне масе 95 g). Умешношћу конструктора остварена је ширина ових модела од само 8,5 cm, док је, на пример, за моделе „ExDATH” остварена ширина од 12 cm. Још једна предност конструкција футрола јесте да се могу, сходно потребама задатака и послова и/или афинитета корисника, користити и као тактичке футроле заменом носача и качењем на каиш, тактички опасач или на „MOLLE” систем.

Треба поменути да се футроле за оквир, слично као и футроле за пиштоље, заменом носача могу користити и као тактичке футроле. Све футроле за оквире карактерише поуздан подесиви систем ретензије кроз притезање/отпуштање шрафа за ретензију, чиме корисник одређује силу потребну за извлачење оквира. Поменути систем се током тестирања и употребе футрола показао изузетно једноставним и веома поузданим. Фиксираности оквира приликом ношења у футроли доприносе и карактеристике специфичног материјала „kydex”.

Карактеристике материјала „kydex”

Плоче „kydex” представљају изузетно издржљив пластични материјал који се добија из посебне термопластичне мешавине велике механичке снаге. О поузданости овог материјала говори и његова широка примена у изради савремене медицинске опреме, као и у авио-индустрији и модерном грађевинарству. Материјал је веома отпоран на механичке ударце, гребање и жлебљење, те гарантује дуготрајност производа који се употребљавају у складу са наменом и препорукама произвођача. Изузетне димензионалне стабилности, материјал „kydex” је веома отпоран на атмосферске утицаје и незапаљив је. Поред тога, веома је једноставан за чишћење, а нуди и преко 3500 могућих боја производа, укључујући и металик боју, а занимљиво је и да омогућава 8 типова рељефа и дизајнирање апликација на површини.

Футрола за модел „CZ-75 P-07 Duty”. Фото: Horned Viper

Употреба материјала „kydex” у изради висококвалитетних футрола за ношење оружја и оквира оправдава се чврстоћом материјала, самим тим и форме футроле, малом масом и израженијом модуларношћу. Поред тога, „kydex” футролу је лако прикрити испод одеће, а веома је важно да је трење између материјала и оружја приликом стављања у футролу и извлачења знатно умањено, што се позитивно одражава на дуготрајност и футроле и оружја. Такође, ове футроле не производе звук приликом кретања .

Закључак

Употреба квалитетног материјала „kydex” у изради тактичких футрола тренутно је новитет у свету, а искуства из употребе за сада су углавном позитивна. Од сада ће купци из Србије и региона имати могућност да прате светске трендове, првенствено захваљујући залагању тима српске компаније „Horned Viper”.

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ПОЗИВ И УПУТСТВО АУТОРИМА
ПРИГЛАШЕНИЕ И ИНСТРУКЦИИ ДЛЯ АВТОРОВ РАБОТ
CALL FOR PAPERS AND INSTRUCTIONS FOR AUTHORS

ПОЗИВ И УПУТСТВО АУТОРИМА О НАЧИНУ ПРИПРЕМЕ ЧЛАНКА

Упутство ауторима о начину припреме чланка за објављивање у *Војнотехничком гласнику* урађено је на основу Акта о уређивању научних часописа, Министарства за науку и технолошки развој Републике Србије, евиденциони број 110-00-17/2009-01, од 09. 07. 2009. године. Примена овог Акта првенствено служи унапређењу квалитета домаћих часописа и њиховог потпунијег укључивања у међународни систем размене научних информација. Засновано је на међународним стандардима ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999 и ISO 5122, односно одговарајућим домаћим стандардима.

Војнотехнички гласник / Vojnotehnički glasnik / Military Technical Courier (втг.мо.упр.срб, www.vtg.mod.gov.rs, ISSN 0042-8469 – штампано издање, e-ISSN 2217-4753 – online, UDC 623+355/359) јесте мултидисциплинарни научни часопис Министарства одбране Републике Србије, који објављује научне и стручне чланке, као и техничке информације о савременим системима наоружања и савременим војним технологијама. Часопис прати јединствену интервидовску техничку подршку Војске на принципу логистичке системске подршке, области основних, примењених и развојних истраживања, као и производњу и употребу средстава наоружања и војне опреме, и остала теоријска и практична достигнућа која доприносе усавршавању припадника Министарства одбране и Војске Србије.

Министарство просвете, науке и технолошког развоја Републике Србије, сагласно одлуци из члана 27. став 1. тачка 4), а по прибављеном мишљењу из члана 25. став 1. тачка 5) Закона о научноистраживачкој делатности („Службени гласник РС“, бр. 110/05, 50/06-испр. и 18/10), утврдило је категоризацију Војнотехничког гласника, за 2013. годину:

за област технолошки развој:

– на листи часописа за материјале и хемијске технологије:

категорија водећи научни часопис националног значаја **(М51)**,

– на листи часописа за електронику, телекомуникације и информационе технологије:

категорија научни часопис националног значаја **(М52)**,

– на листи часописа за машинство:

категорија научни часопис националног значаја **(М52)**,

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику:

категорија научни часопис националног значаја **(М52)**.

Усвојене листе домаћих часописа за 2013. годину могу се видети на сајту Војнотехничког гласника, страница Категоризација часописа.

Детаљније информације могу се пронаћи и на сајту Министарства просвете, науке и технолошког развоја Републике Србије.

Подаци о категоризацији могу се пратити и на сајту КОБСОН-а (Конзорцијум библиотека Србије за обједињену набавку).

Категоризација часописа извршена је према Правилнику о поступку и начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача, који је прописао Национални савет за научни и технолошки развој (Службени гласник РС, број 38/2008).

У складу са овим правилником и табелом о врсти и квантификацији индивидуалних научноистраживачких резултата (у саставу Правилника), објављени рад у Војнотехничком гласнику вреднује се са 2 бода (категорија М51) и 1,5 бод (категорија М52).

Часопис се прати у контексту Српског цитатног индекса – СЦиндекс (база података домаћих научних часописа) и Руског индекса научног цитирања (РИНЦ). Подвргнут је сталном вредновању (мониторингу) у зависности од утицајности (импакта) у самим базама и, посредно, у међународним (Thompson Reuters) цитатним индексима. Детаљи о индексирању могу се видети на сајту Војнотехничког гласника, страница Индексирање часописа.

Војнотехнички гласник омогућава и примењује Creative Commons (CC BY) одредбе о ауторским правима. Детаљи о ауторским правима могу се видети на сајту часописа, страница **Ауторска права**.

Радови се предају путем онлајн система за електронско уређивање ASEESTANT, који је развио Центар за евалуацију у образовању и науци (ЦЕОН).

Приступ и регистрација за сервис врше се на сајту www.vtg.mod.gov.rs, преко странице ASEESTANT или СЦИНДЕКС, односно директно на линку aseestant.ceon.rs/index.php/vtg.

Детаљно упутство о регистрацији и пријави за сервис налази се на сајту www.vtg.mod.gov.rs, страница Упутство за е-Ур: Електронско уређивање – ASEESTANT.

Потребно је да се сви аутори који подносе рукопис за објављивање у Војнотехничком гласнику региструју у регистар ORCID (Open Researcher and Contributor ID), према упутству на страници сајта Регистрација за добијање ORCID идентификационе шифре.

Војнотехнички гласник објављује чланке на српском, енглеском, руском, немачком или француском језику (arial, српска ћирилица или српска латиница, величина слова 11 pt, проред Single).

Поступак припреме, писања и уређивања чланка треба да буде у сагласности са **Изјавом о етичком поступању** (http://www.vtg.mod.gov.rs/izjava-o-etickom-postupanju.html).

Чланак треба да садржи сажетак са кључним речима, увод, разраду, закључак, литературу и резиме са кључним речима на енглеском језику (без нумерације наслова и поднаслова). Обим чланка треба да буде око једног ауторског табака (16 страница формата А4 са проредом Single), а највише 24 странице.

Чланак треба да буде написан на обрасцу за писање чланка, који се у електронској форми може преузети са сајта на страници Образац за писање чланка.

Наслов

Наслов треба да одражава тему чланка. У интересу је часописа и аутора да се користе речи прикладне за индексирање и претраживање. Ако таквих речи нема у наслову, пожељно је да се придода и поднаслов. Наслов треба да буде преведен и на енглески језик.

Ови наслови исписују се испред сажетка на одговарајућем језику.

Текући наслов

Текући наслов се исписује са стране сваке странице чланка ради лакше идентификације, посебно копија чланака у електронском облику. Садржи презиме и иницијал имена аутора (ако аутора има више, преостали се означавају са „et al.“ или „и др.“), наслове рада и часописа и колацију (година, волумен, свеска, почетна и завршна страница). Наслови часописа и чланка могу се дати у скраћеном облику.

Име аутора

Наводи се пуно име и презиме (свих) аутора. Веома је пожељно да се наведу и средња слова аутора. Имена и презимена домаћих аутора увек се исписују у оригиналном облику (са српским дијакритичким знаковима), независно од језика на којем је написан рад.

Назив установе аутора (афилијација)

Наводи се пун (званични) назив и седиште установе у којој је аутор запослен, а евентуално и назив установе у којој је аутор обавио истраживање. У сложеним организацијама наводи се укупна хијерархија (нпр. Универзитет одбране у Београду, Војна академија, Катедра природно-математичких наука). Бар једна организација у хијерар-

хији мора бити правно лице. Ако аутора има више, а неки потичу из исте установе, мора се, посебним ознакама или на други начин, назначити из које од наведених установа потиче сваки од наведених аутора. Афилијација се исписује непосредно након имена аутора. Функција и звање аутора се не наводе.

Контакт подаци

Адреса или е-адреса свих аутора даје се на првој страници чланка.

Категорија (тип) чланка

Категоризација чланака обавеза је уредништва и од посебне је важности. Категорију чланка могу предлагати рецензенти и чланови уредништва, односно уредници рубрика, али одговорност за категоризацију сноси искључиво главни уредник.

Чланци у часописима се разврставају у следеће категорије:

Научни чланци:

1. оригиналан научни рад (рад у којем се износе претходно необјављивани резултати сопствених истраживања научним методом);

2. прегледни рад (рад који садржи оригиналан, детаљан и критички приказ истраживачког проблема или подручја у којем је аутор остварио одређени допринос, видљив на основу аутоцитата);

3. кратко или претходно саопштење (оригинални научни рад пуног формата, али мањег обима или прелиминарног карактера);

4. научна критика, односно полемика (расправа на одређену научну тему, заснована искључиво на научној аргументацији) и осврти.

Изузетно, у неким областима, научни рад у часопису може имати облик монографске студије, као и критичког издања научне грађе (историјско-архивске, лексикографске, библиографске, прегледа података и сл.) – дотад непознате или недовољно приступачне за научна истраживања.

Радови класификовани као научни морају имати бар две позитивне рецензије.

Ако се у часопису објављују и прилози ваннаучног карактера, научни чланци треба да буду груписани и јасно издвојени у првом делу свеске.

Стручни чланци:

1. стручни рад (прилог у којем се нуде искуства корисна за унапређење професионалне праксе, али која нису нужно заснована на научном методу);

2. информативни прилог (уводник, коментар и сл.);

3. приказ (књиге, рачунарског програма, случаја, научног догађаја, и сл.).

Језик рада

Језик рада може бити српски, енглески или други језик који се користи у међународној комуникацији у одређеној научној области (руски, немачки или француски).

Текст мора бити језички и стилски дотеран, систематизован, без скраћеница (осим стандардних). Све физичке величине морају бити изражене у Међународном систему мерних јединица – SI. Редослед образаца (формула) означава се редним бројевима, са десне стране у округлим заградама.

Сажетак (апстракт) и резиме

Сажетак (апстракт) јесте кратак информативан приказ садржаја чланка који читаоцу омогућава да брзо и тачно оцени његову релевантност. У интересу је уредништава и аутора да сажетак садржи термине који се често користе за индексирање и претрагу чланака. Саставни делови сажетка су циљ истраживања, методи, резултати и закључак. Сажетак треба да има од 100 до 250 речи и треба да се налази између заглавља (наслов, имена аутора и др.) и кључних речи, након којих следи текст чланка. Ако је рад написан на српском (руском, немачком или француском) језику пожељно је да се, поред сажетка на српском (руском, немачком или француском), даје и сажетак у проширеном облику на енглеском језику – као тзв. резиме (summary). Овакав резиме треба да буде на крају чланка,

након одељка Литература. Важно је да резиме буде у структурираном облику, а његова дужина може бити до 1/10 дужине чланка (опширнији је од сажетка са почетка чланка). Почетак овог резимеа може бити преведени сажетак (са почетка чланка), а затим треба да следе преведени главни наслови, поднаслови и основе закључка чланка (литература се не преводи). Потребно је да се у структурираном резимеу преведе и део текста испод наслова и поднаслова, водећи рачуна да он буде пропорционалан њиховој величини, а да одражава суштину. Након резимеа на енглеском језику (проширеног сажетка) додаје се његов превод на српском, да би редакција извршила проверу и лектуру.

Кључне речи

Кључне речи су термини или фразе које адекватно представљају садржај чланка за потребе индексирања и претраживања. Треба их додељивати ослањајући се на неки међународни извор (попис, речник или тезаурус) који је најшире прихваћен или унутар дате научне области. За нпр. науку уопште, то је листа кључних речи Web of Science. Број кључних речи не може бити већи од 10, а у интересу је уредништва и аутора да учесталост њихове употребе буде што већа. Кључне речи дају се на језику на којем је написан чланак (сажетак) и на енглеском језику. У чланку се пишу непосредно након сажетка, односно након резимеа.

Систем ASEESTANT у ту сврху користи специјалну алатку KWASS: аутоматско екстраховање кључних речи из дисциплинарних тезауруса/речника по избору и рутине за њихов одабир, тј. прихватање односно одбацивање од стране аутора и/или уредника.

Датум прихватања чланка

Датум када је уредништво примило чланак, датум када је уредништво коначно прихватило чланак за објављивање, као и датуми када су у међувремену достављене евентуалне исправке рукописа наводе се хронолошким редоследом, на сталном месту, по правилу на крају чланка.

Захвалница

Назив и број пројекта, односно назив програма у оквиру којег је чланак настао, као и назив институције која је финансирала пројекат или програм, наводи се у посебној напомени на сталном месту, по правилу при дну прве стране чланка.

Претходне верзије рада

Ако је чланак у претходној верзији био изложен на скупу у виду усменог саопштења (под истим или сличним насловом), податак о томе треба да буде наведен у посебној напомени, по правилу при дну прве стране чланка. Рад који је већ објављен у неком часопису не може се објавити у Војнотехничком гласнику (прештампати), ни под сличним насловом и измењеном облику.

Табеларни и графички прикази

Пожељно је да наслови свих приказа, а по могућству и текстуални садржај, буду дати двојезично, на језику рада и на енглеском језику.

Табеле се пишу на исти начин као и текст, а означавају се редним бројевима са горње стране. Фотографије и цртежи треба да буду јасни, прегледни и погодни за репродукцију. Цртеже треба радити у програму word или corel. Фотографије и цртеже треба поставити на жељено место у тексту.

Навођење (цитирање) у тексту

Начин позивања на изворе у оквиру чланка мора бити једнообразан.

Војнотехнички гласник за референцирање (цитирање и навођење литературе) примењује Харвардски систем референци, односно Харвардски приручник за стил (Harvard Referencing System, Harvard Style Manual). У самом тексту, у обичним заградама, на месту на којем се врши позивање, односно цитирање литературе набројане на крају чланка, обавезно у обичној загради написати презиме цитираног аутора, годину издања публикације из које цитирате и, евентуално, број страница. Нпр. (Petrović, 2012, pp.10–12).

Детаљно упутство о начину цитирања, са примерима, дато је на страници сајта Упутство за Харвардски приручник за стил. Потребно је да се позивање на литературу у тексту уради у складу са поменутим упутством.

Систем ASEESTANT у сврху контроле навођења (цитирања) у тексту користи специјалну алатку CiteMatcher: откривање изостављених цитата у тексту рада и у попису референци.

Напомене (фусноте)

Напомене се дају при дну стране на којој се налази текст на који се односе. Могу садржати мање важне детаље, допунска објашњења, назнаке о коришћеним изворима (на пример, научној грађи, приручницима), али не могу бити замена за цитирану литературу.

Листа референци (литература)

Цитирана литература обухвата, по правилу, библиографске изворе (чланке, монографије и сл.) и даје се искључиво у засебном одељку чланка, у виду листе референци. Референце се не преводе на језик рада и набрајају се у посебном одељку на крају чланка.

Војнотехнички гласник, као начин исписа литературе, примењује Харвардски систем референци, односно Харвардски приручник за стил (Harvard Referencing System, Harvard Style Manual).

Литература се обавезно пише на латиничном писму и набраја по абецедном редоследу, наводећи најпре презимена аутора, без нумерације.

Детаљно упутство о начину пописа референци, са примерима, дато је на страници сајта Упутство за Харвардски приручник за стил. Потребно је да се попис литературе на крају чланка уради у складу са поменутим упутством.

Нестандардно, непотпуно или недоследно навођење литературе у системима вредновања часописа сматра се довољним разлогом за оспоравање научног статуса часописа.

Систем ASEESTANT у сврху контроле правилног исписа листе референци користи специјалну алатку RefFormatter: контрола обликовања референци у складу са Харвардским приручником за стил.

Пропратно писмо

Поред чланка доставља се пропратно писмо у којем треба истаћи о којој врсти чланка се ради, који су графички прилози (фотографије и цртежи) оригинални, а који позајмљени.

У пропратном писму наводе се и подаци аутора: име, средње слово, презиме, чин, звање, е-маил, адреса послодавца (ВП), кућна адреса, телефон на радном месту и кућни (мобилни) телефон, рачун и назив банке, СО места становања, број личне карте и ЈМБ грађана.

Ако је више аутора чланка, у пропратном писму се наводи појединачни процентуални удео ради обрачуна хонорара.

Сви радови подлежу стручној рецензији, а објављени радови и стручне рецензије хоноришу се према важећим прописима.

Списак рецензената Војнотехничког гласника може се видети на страници сајта **Списак рецензената**. Процес рецензирања објашњен је на страници сајта **Рецензентски поступак**.

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ПРИГЛАШЕНИЕ И ИНСТРУКЦИЯ ДЛЯ АВТОРОВ О ПОРЯДКЕ ПОДГОТОВКИ СТАТЬИ

Инструкция для авторов о порядке подготовки статьи к опубликованию в журнале «Военно-технический вестник» разработана в соответствии с Актом о редактировании научных журналов Министерства науки и технологического развития Республики Сербия, № 110-00-17/2009-01 от 09.07.2009 г. Применением этого Акта, в первую очередь, обеспечивается совершенствование качества отечественных журналов и их более полного включения в международную систему обмена научной информацией. Инструкция соответствует международным стандартам ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999, ISO 5122 и соответствующим отечественным стандартам.

Военно-технический вестник (**Vojnotehnički glasnik / Military Technical Courier**), втг.мо.упр.срб, www.vtg.mod.gov.rs/index-ru.html, ISSN 0042-8469 – печатное издание, e-ISSN 2217-4753 – online, UDK 623+355/359, является мультидисциплинарным научным журналом Министерства обороны Республики Сербия, публикующий научные статьи и статьи специалистов, в том числе технические информации относительно современных систем вооружения и современных военных технологиях. Журнал отслеживает за единственной интервидовой технической поддержкой вооруженных сил на принципах логистической поддержки, в области основных применяемых научных исследований, а также в области производства вооружений и военного оборудования и остальных теоретических и практических достижений, содействующих повышению квалификаций персонала Министерства Обороны и Вооруженных сил Республики Сербия.

Министерство образования, науки и технологического развития Республики Сербия, согласно решению по ст. 27 абзац 1, пункт 4 и по полученному толкованию ст. 25 абзац 1 пункт 5 Закона о научно-исследовательской деятельности („Службени гласник РС", № 110/05, утверждило категоризацию Военно-технического вестника за 2013 год:

Категории в области технологического развития:

– Область материалов и химической технологии:

ведущий научный журнал национального значения **(М51)**,

– Область электроники, телекоммуникаций и информационных технологий: научный журнал национального значения **(М52)**,

– Область механики:

научный журнал национального значения **(М52)**.

Категории в области основных исследований:

– Область математика, компьютерные науки, технические науки:

научный журнал национального значения **(М52)**.

Информацию относительно категоризации за 2013 год можно посмотреть на странице сайта Военно-технического вестника Категоризация вестника.

Более подробную информацию можно прочитать на сайте Министерства образования, науки и технологического развития Республики Сербия.

Информацию о категоризации можно посмотреть и на сайте КОБСОН-а (Консорциум библиотек Республики Сербия по вопросам объединения закупок).

Категоризация вестника проведена согласно Положению о порядке и способе категоризации научно-исследовательских результатов, утвержденному Национальным комитетом по науке и технологиям (Службени гласник РС, № 38/2008).

В соответствии с вышеуказанным Положением и табличкой с показателями классификации и категоризации индивидуальных научно-исследовательских результатов (являющейся неотъемлемой частью Положения), работа, опубликованная в Военно-техническом вестнике, оценивается следующим способом: 2 балла (категория М51) и 1,5 баллов (категория М52).

Журнал соответствует стандартам Сербского цитатного индекса – SCindeks (база данных отечественных научных журналов), а также Российского индекса научного цитирования (РИНЦ). Журнал постоянно оценивается (мониторинг) в зависимости от численного показателя важности научного журнала в самих базах, в т.ч. опосредованно в международных цитатных индексах (Thompson Reuters).

С информацией об индексировании можно ознакомиться на странице сайта журнала «Индексирование вестника».

«Военно-технический вестник» обеспечивает читателям возможность открытого доступа, в соответствии с положениями об авторских правах, утвержденными Creative Commons (CC BY). С инструкцией об авторских правах можно ознакомиться на странице **Авторские права**, перейдя по ссылке http://www.vtg.mod.gov.rs/index-ru.html.

Работы представляются путем online системой e-Ур: Электронное издательство ASEESTANT, запущенное Центром поддерживающим развитие образования и науки (ЦЕОН).

Права доступа и регистрация в системе оформляются по адресу http://www.vtg.mod.gov.rs/index-ru.html, через страницу «ASEESTANT» или «СЦИНДЕКС» (aseestant.ceon.rs/index.php/vtg).

С инструкцией по регистрации и праву доступа можно ознакомиться по адресу http://www.vtg.mod.gov.rs/index-ru.html, на странице «Инструкция по e-Ур: Электронное издательство ASEESTANT».

Все авторы, предоставляющие свои рукописи на публикацию в редакцию журнала «Военно-технический вестник» должны пройти регистрацию в реестре ORCID (Open Researcher and Contributor ID), в соответствии с инструкцией на странице сайта Регистрация в реестре ORCID для присвоения идентификационного кода.

Военно-технический вестник выпускает статьи на сербском, русском, английском, немецком или французском языках (Arial, шрифт 11 pt, пробел Single).

Процесс подготовки, написания и редактирования статьи должен осуществляться в соответствии с принципами **Этического кодекса** (http://www.vtg.mod.gov.rs/etichyeskiy-kodyeks.html).

Статья должна содержать сюжет с ключевыми словами, введение, разработку, выводы, список использованной литературы и резюме с ключевыми словами на английском языке (без нумерации заголовков и подзаголовков). Объем статьи не должен превышать один авторский лист (16 страниц формата А4 с пробелом Single).

Статья должна быть написана на образце написания статьи, который можно скачать на странице сайта «Правила и образец составления статьи».

Заголовок

Заголовок должен отражать тему статьи. Интересы журнала и автора состоят в использовании слов, удобных для индексации и поиска. Если такие слова не содержаны в заголовке, то желательно добавить и подзаголовок. Заголовок должен быть переведен на английский язык. Эти заголовки пишутся перед сюжетами на соответствующем языке.

Текущий заголовок

Текущий заголовок пишется в титуле каждой страницы статьи с целью упрощения идентификации, в первой очереди копий статьей в электронном виде. Содержит в себе фамилию и инициал имени автора (в случае если авторов несколько, остальные обозначаются с «et al.» или «и др.»), заголовки работы и журнала (год, объем, тетрадь, начальная и заключительная страница). Заголовки журнала и статьи могут приводиться в сокращенном виде.

ФИО автора

Приводятся полная фамилия и полное имя (всех) авторов. Очень желательно, чтобы были приведены и средние буквы авторов. Фамилия и имя отечественных авторов всегда пишутся в оригинальном виде (с сербскими диакритическими знаками), независимо от языка, на котором работа написана.

Наименование учреждения автора (аффилиация)

Приводится полное (официальное) наименование и местонахождение учреждения, в котором работает автор, а также наименование учреждения, в котором автор провел исследование. В случае сложных организаций приводится общая иерархия (напр. Университет обороны в г. Белграде, Военная академия, Кафедра военных электронных систем). По крайней мере, одна из этих организаций в иерархии должна иметь статус юридического лица. В случае если авторов несколько, и если некоторые

работают в одном учреждении, нужно отдельными обозначениями или каким-нибудь другим способом указать в каком из приведенных учреждений работает каждый из - приведенных авторов. Аффилиация пишется непосредственно после ФИО автора. Должность и квалификация по образованию не указываются.

Контактные данные

Почтовый адрес и/или электронный адрес авторов указываются на первой страницы статьи.

Категория (тип) статьи

Категоризация статьей является обязанностью редакции и имеет особое значение. Категорию статьи могут предлагать рецензенты и члены редакции, т.е. редакторы рубрик, но ответственность за категоризацию несет исключительно главный редактор. Статьи в журналах распределяются по следующим категориям:

Научные статьи:

1. оригинальная научная работа (работа, в которой приводятся раньше неопубликованные результаты собственных исследований научным методом);
2. наглядная работа (работа, содержащая оригинальный, детальный и критический обзор исследовательской проблемы или области, в который автор внес определенный вклад, видимый на основе автоцитат);
3. краткая или предварительная информация (оригинальная научная работа полного формата, но меньшего объема или имеющая предварительный характер);
4. научная критика, т.е. полемика (дискуссия на определенную научную тему, обоснованная исключительно на научной аргументации) и беглые обзоры.

Однако, в некоторых областях научная работа в журнале может иметь форму монографической студии, а также критического издания научного материала (историко-архивного, лексикографического, библиографического, обзора данных и т.п.) – до тех пор неизвестного или недостаточно доступного для научных исследований. Работы, классифицированные в качестве научных, должны иметь, по меньшей мере, две положительные рецензии.

В случае если в журнале объявляются и приложения, не имеющие научный характер, научные статьи должны быть сгруппированы и четко выделены в первой части тетради.

Профессиональные статьи:

1. профессиональная работа (приложения, в которых предлагаются опыты, полезные для совершенствования профессиональной практики, но которые не должны в обязательном порядке быть обоснованы на научном методе);
2. информативное приложение (передовая статья, комментарий и т.п.);
3. рецензия (книги, компьютерной программы, случая, научного события и т.п.).

Язык работы

Работа может быть написана на сербском, английском или другом языке, используемом в международной коммуникации в определенной научной области (русский, немецкий или французский).

Текст должен быть в лингвистическом и стилистическом смысле упорядочен, систематизирован, без сокращений (за исключением стандартных). Все физические величины должны соответствовать Международной системе единиц измерения – СИ. Очередность формул обозначается порядковыми номерами, с правой стороны в круглых скобках.

Сюжет (абстракт) и резюме

Сюжет (абстракт) является кратким информативным обзором содержания статьи, обеспечивающим читателю быстро и точно оценить его релевантность. В интересах редакции и авторов, чтобы сюжет содержал термины, часто используемые для индексирования и поиска статьей. Составными частями сюжета являются цель исследования, методы и заключение. В сюжете должно быть от 100 до 250 слов, и должен находится между титулами (заголовок, ФИО авторов и др.) и ключевыми словами, за которыми сле-

дует текст статьи. Если работа написана на сербском (русском, немецком или французском) языке, желательно, чтобы кроме сюжета на сербском (русском, немецком или французском) был предоставлен и сюжет в расширенном виде на английском языке – в качестве т.н. резюме (summary). Такой резюме должен находиться в конце статьи, после раздела Литература. Важно, чтобы резюме было в структурированном виде, и его длина может составлять до 1/10 длины статьи (оно более обширно, чем сюжет из начала статьи). Началом данного резюме может быть переведенный сюжет (из начала статьи), а затем должны следовать переведенные главные заголовки, подзаголовки и основы заключения статьи (литература не переводится). В структурированном резюме нужно перевести часть текста под заголовком и заголовком, принимая во внимание, чтобы она была пропорциональна их размеру и в то же время отражала суть.

Ключевые слова

Ключевыми словами являются термины или фразы, адекватно представляющие содержание статьи, необходимое для индексирования и поиска. Их надо присуждать, опираясь при этом на какой-то международный источник (регистр, словарь, тезаурус), наиболее приемлемый внутри данной научной области. Число ключевых слов не может превышать 10, а в интересах редакции и авторов, чтобы их частота была как можно больше. Ключевые слова даются на языке, на котором написана статья (сюжет), и на английском языке. В статье они пишутся непосредственно после сюжета, т.е. после резюме.

Программа ASSESTANT предоставляет возможность использования сервиса KWASS: автоматическое фиксирование ключевых слов из источников/словарей по выбору, т.е., которые автор/редактор воспринимает или нет.

Дата получения статьи

Дата, когда редакция получила статью, дата, когда редакция окончательно приняла статью для опубликования, а также даты, когда за истекший период были предоставлены эвентуальные исправления рукописи, приводятся в хронологическом порядке, на постоянном месте, как правило, в конце статьи.

Выражение благодарности

Наименование и номер проекта, т.е. название программы, в которой статья возникла, как и наименование учреждения, которое финансировало проект или программу, приводятся в отдельном примечании на постоянном месте, как правило, внизу первой страницы статьи.

Предыдущие версии работы

В случае если статья в предыдущей версии была изложена в устном обращении (-под одинаковым или похожим названием), сведение об этом должно быть указано в отдельном примечании, как правило, внизу первой страницы статьи. Работа, которая уже опубликована в некотором из журналов, не может быть опубликована в Военно-техническом вестника (перепечатана), ни под похожим названием, ни измененном виде.

Табличное и графическое представление

Желательно, чтобы названия всех представлений (по возможности и текстуальное содержание) были представлены на двух языках (на языке работы и на английском). Таблицы пишутся таким же способом как и текст и обозначаются порядковыми номерами с верхней стороны. Фотографии и рисунки должны быть понятны, наглядны и удобные для репродукции. Рисунки надо делать в программах Word или corel. Фотографии и рисунки надо поставить на желаемое место в тексте.

Ссылки (цитирование) в тексте

Оформление ссылок на источники в рамках статьи должно быть однообразным.

Военно-технический вестник для оформления ссылок, цитат и списка использованной литературы пользуется гарвардской системой (Harvard Referencing System, Harvard Style Manual). В тексте в скобках приводится фамилия цитируемого автора (или

фамилия первого автора, если авторов несколько), год издания и по необходимости номер страницы. Например: (Петрович, 2010., пп. 10-20). Рекомендации о способе цитирования размещены на странице сайта «Инструкция по использованию Гарвардского стиля». При оформлении ссылок, цитат и списка использованной литературы необходимо придерживаться установленных норм.

Программа ASEESTANT предоставляет при цитировании возможность использования сервиса CiteMatcher: фиксирование пропущенных цитат в работе и списке литературы.

Примечания (сноски)

Примечания указываются внизу страницы, на которой находится текст, к которым они относятся. Могут содержать менее важные детали, дополнительные объяснения, указания об использованных источниках (напр. научном материале, справочниках), но не могут быть заменой для цитированной литературы.

Лист референций (литература)

Цитированной литературой охвачены, как правило, библиографические источники (статьи, монографии и т.п.) и она представляется исключительно в отдельном разделе статьи, в виде листа референций. Референции не переводятся на язык работы.

Военно-технический вестник для оформления списка использованной литературы применяет гарвардскую систему (Harvard Style Manual). В списке литературы источники даются в алфавитном порядке авторов или редакторов. Рекомендации о способе цитирования размещены на странице сайта «Инструкция по использованию Гарвардского стиля». При оформлении списка использованной литературы необходимо придерживаться установленных норм.

Программа ASEESTANT при оформлении списка литературы предоставляет возможность использования сервиса RefFormatter: контроль оформления списка литературы в соответствии со стандартами Гарвардского стиля.

Нестандартное, неполное и непоследовательное приведение литературы в системах оценки журнала считается достаточной причиной для оспаривания научного статуса журнала.

Сопроводительное письмо

Кроме статьи предоставляется сопроводительное письмо, в котором нужно указать о каком виде статьи речь идет, которые из графических представлений (фотографии и рисунки) оригинальные, а которые взяты взаймы.

В сопроводительном письме приводятся и сведения об авторе: имя, средняя буква, фамилия, чин, звание, e-mail, адрес работодателя (воинская почта), домашний адрес, служебный телефон и личный (мобильный) телефон, счет и наименование банка, муниципалитет места проживания и единый идентификационный номер гражданина.

В случае если авторов статьи несколько, в сопроводительном письме указывается доля участия каждого из них отдельно в процентах, в целях расчета гонорара.

Все работы подлежат спец. рецензированию, в то время как опубликованные работы и спец. рецензии оплачиваются согласно действующему законодательству.

Список рецензентов Военно-технического вестника можно посмотреть на странице сайта **Список рецензентов**. Процесс рецензирования описан на странице сайта **Правила рецензирования**.

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CALL FOR PAPERS AND ARTICLE FORMATTING INSTRUCTIONS

The instructions to authors about the article preparation for publication in the *Military Technical Courier* are based on the Act on scientific journal editing of the Ministry of Science and Technological Development of the Republic of Serbia, No 110-00-17/2009-01 of 9th July 2009. This Act aims at improving the quality of national journals and raising the level of their compliance with the international system of scientific information exchange. It is based on international standards ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999 and ISO 5122 and their national equivalents.

The Military Technical Courier / Vojnotehnički glasnik (www.vtg.mod.gov.rs/index-e.html, втг.мо.упр.срб, ISSN 0042-8469 – print issue, e-ISSN 2217-4753 – online, UDC 623+355/359) is a multidisciplinary scientific journal of the Ministry of Defence of the Republic of Serbia. It publishes scientific and professional papers as well as technical data about contemporary weapon systems and modern military technologies. Offering a logistic system support, the *Courier* is a part of a unique technical support to the Army services in the field of fundamental, applied and development research. It also deals with production and use of weapons and military equipment as well as with theoretical and practical achievements leading to professional development of the personnel of the Ministry of Defence and the Army of the Republic of Serbia.

Pursuant to the decision given in Article 27, paragraph 1, point 4, and in accordance with the acquired opinion given in Article 25, paragraph 1, point 5 of the Act on Scientific and Research Activities (Official Gazette of the Republic of Serbia, No 110/05, 50/06-cor and 18/10), the Ministry of Education, Science and Technological Development of the Republic of Serbia classified the Military TechnIcal Courier for the year 2013

in the field technological development:

– on the list of periodicals for materials and chemical technology,
category: leading scientific periodical of national interest **(M51)**,
– on the list of periodicals for electronics, telecommunications and IT,
category: scientific periodical of national interest **(M52)**,
– on the list of periodicals for mechanical engineering,
category: scientific periodical of national interest **(M52)**,

in the field fundamental research:

– on the list of periodicals for mathematics, computer sciences and mechanics,
category: scientific periodical of national interest **(M52)**.

The approved lists of national periodicals for the year 2013 can be viewed on the website of the Military Technical Courier, page Journal categorization.

More detailed information can be found on the website of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

The information on the categorization can be also found on the website of KOBSON (Consortium of Libraries of Serbia for Unified Acquisition).

The periodical is categorized in compliance with the Regulations on the procedure and method of evaluation and quantitative formulation of scientific and research results of researchers, stipulated by the National Council for Scientific and Technological Development (*Official Gazette of RS*, No 38/2008). More detailed information can be found on the website of the Ministry of Education, Science and Technological Development.

In accordance with the Regulations and the table about types and quantification of individual scientific and research results (as a part of the Regulations), a paper published in the *Military Technical Courier* scores 2 (two) points (category M51) and 1,5 (one and a half) point (category M52).

The journal is in the Serbian Citation Index – SC index (data base of national scientific journals), in the Russian Science Citation Index (RSCI) and is constantly

monitored depending on the impact within the bases themselves and indirectly in the international (e.g. Thompson Reuters) citation indexes. More detailed information can be viewed on the website of the Military Technical Courier, page Journal indexing.

Military Technical Courier enables open access and applies the Creative Commons Attribution (CC BY) licence provisions on copyright. The copyright details can be found on the **Copyright notice** page of the journal's website.

Manuscripts are submitted online, through the electronic editing system ASEESTANT, developed by the Center for Evaluation in Education and Science – CEON.

The access and the registration are through the Military Technical Courier site http://www.vtg.mod.gov.rs/index-e.html, on the page ASEESTANT or the page SCINDEKS or directly through the link (aseestant.ceon.rs/index.php/vtg).

The detailed instructions about the registration for the service are on the website http://www.vtg.mod.gov.rs/index-e.html, on the page Instructions for e-Ur: Electronic Editing - ASEESTANT.

All authors submitting a manuscript for publishing in the Military Technical Courier should register for an ORCID ID following the instructions on the web page Registration for an ORCID identifier.

The Military Technical Courier publishes articles in Serbian, English, Russian, German or French, using Arial and a font size of 11pt with Single Spacing.

The procedures of article preparation, writing and editing should be in accordance with the **Publication ethics statement**. (http://www.vtg.mod.gov.rs/publication-ethics-statement.html).

The article should contain the abstract with keywords, introduction, body, conclusion, references and the summary in English language (without heading and subheading enumeration). The article length should not exceed 24 pages of A4 paper format.

The article should be formatted following the instructions in the Article Form which can be downloaded from website page Article form.

Title

The title should be informative. It is in both Journal's and author's best interest to use terms suitable for indexing and word search. If there are no such terms in the title, the author is strongly advised to add a subtitle. The title should be given in English as well.

The titles precede the abstract and the summary in an appropriate language.

Letterhead title

The letterhead title is given at a top of each page for easier identification of article copies in an electronic form in particular. It contains the author's surname and first name initial (for multiple authors add "et al"), article title, journal title and collation (year, volume, issue, first and last page). The journal and article titles can be given in a shortened form.

Author's name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form (with diacritic signs if in Serbian).

Author's affiliation

The full official name and seat of the author's affiliation is given, possibly with the name of the institution where the research was carried out. For organizations with complex structures, give the whole hierarchy (for example, University of Defence in Belgrade, Military Academy, Department for Military Electronic Systems). At least one organization in the hierarchy must be a legal entity. When some of multiple authors have the same affiliation, it must be clearly stated, by special signs or in other way, which department exactly they are affiliated with. The affiliation follows the author's name. The function and title are not given.

Contact details

The postal addresses or the e-mail addresses of the authors are given in the first page.

Type of articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification.

Journal articles are classified as follows:

Scientific articles:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on scientific methods);

2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);

3. Short or preliminary communication (original scientific paper of full format but of a smaller extent or of a preliminary character);

4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on scientific argumentation) and commentaries.

Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Papers classified as scientific must have at least two positive reviews.

If the journal contains non-scientific contributions as well, the section with scientific papers should be clearly denoted in the first part of the Journal.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);

2. Informative contribution (editorial, commentary, etc.);

3. Review (of a book, software, case study, scientific event, etc.)

Language

The article can be in Serbian, English or other language used in international communication in a particular scientific field (Russian, German or French).

The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and summary

An abstract is a concise informative presentation of the article content for fast and accurate evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250- word abstract should be placed between the

title and the keywords with the body text to follow. Besides an abstract in Serbian (Russian, German or French), articles in Serbian (Russian, German or French) are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract). It can start with the translated Serbian (Russian, German or French) abstract from the beginning of the article with translated main headings, subheadings and major conclusions to follow (Reference list is not translated). The structured summary should also contain the proportional informative parts of the text below the headings and subheadings.

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is, the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

For this purpose, the ASEESTANT system uses a special tool KWASS for the automatic extraction of key words from disciplinary thesauruses/dictionaries by choice and the routine for their selection, i.e. acceptance or rejection by author and/or editor.

Article acceptance date

The date of the reception of the article, the dates of submitted corrections in the manuscript (optional) and the date when the Editorial Board accepted the article for publication are all given in a chronological order at the end of the article.

Acknowledgements

The name and the number of the project or programme within which the article was realised is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programme.

Article preliminary version

If an article preliminary version has appeared previously at a meeting in a form of an oral presentation (under the same or similar title), this should be stated in a separate note at the bottom of the first page. An article published previously cannot be published in the *Military Technical Courier* even under a similar title or in a changed form.

Tables and illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by Arabic numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the text

Citation in the text must be uniform. The Military Technical Courier applies the Harvard Referencing System given in the Harvard Style Manual. When citing sources within your paper, i.e. for in-text references of the works listed at the end of the paper, place the year of publication of the work in parentheses and optionally the number of the

page(s) after the author's name, e.g. (Petrovic, 2012, pp.10-12). A detailed guide on citing, with examples, can be found on Military Technical Courier website on the page Instructions for Harvard Style Manual. In-text citations should follow its guidelines.

For checking in-text citations, the ASESESTANT system uses a special tool CiteWatcher to find out quotes left out within papers and in reference lists.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.

Reference list (Literature)

The cited literature encompasses bibliographic sources such as articles and monographs and is given in a separate section in a form of a reference list.

References are not translated to the language of the article.

In compiling the reference list and bibliography, the Military Technical Courier applies the Harvard System – Harvard Style Manual. All bibliography items should be listed alphabetically by author's name, without numeration. A detailed guide for listing references, with examples, can be found on Military Technical Courier website on the page Instructions for Harvard Style Manual. Reference lists at the end of papers should follow its guidelines.

In journal evaluation systems, non-standard, insufficient or inconsequent citation is considered to be a sufficient cause for denying the scientific status to a journal.

The covering letter

The article should be accompanied with a cover letter with the information about the author(s): surname, middle initial, first name, citizen personal number, rank, title, e-mail address, affiliation address, home address including municipality, phone number in the office and at home (or a mobile phone number), bank account and the name of the bank.

If there are more authors, their share in the article should be given in percents for honorarium calculation purposes.

The cover letter should state the type of the article and tell which illustrations are original and which are not.

All articles are peer reviewed. All authors and reviewers are paid an honorarium on publication of the article.

The list of referees of the Military Technical Courier can be viewed at website page **List of referees**. The article review process is described on the **Peer Review Process** page of the website.

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ОБАВЕШТЕЊА САРАДНИЦИМА И ЧИТАОЦИМА
INFORMATIONS FOR CONTRIBUTORS AND READERS
СООБЩЕНИЯ ДЛЯ ПАРТНЕРОВ И ЧИТАТЕЛЕЙ

DOAJ доделио *Војнотехничком гласнику* ознаку „Seal" (Печат)

Директориј DOAJ је, 20. јула 2016. године, доделио *Војнотехничком гласнику* ознаку „Seal" (Печат).

„Seal" је ознака коју DOAJ додељује већ претходно индексираним часописима у његовој основној бази (у складу са стандардним критеријумима), а који се додатно придржавају изузетно високих нивоа издавачких стандарда и најбоље издавачке праксе (Best Practice), што представља признање тим напорима. Да би добио ознаку „Seal", часопис мора да има највећи степен отворености и да у потпуности испуњава следећих седам услова:

• коришћење DOI бројева као сталних идентификатора,

• прослеђење DOAJ-у чланака са одвојеним метаподацима,

• полагање садржаја часописа са дугорочном дигиталном заштитом или програмом архивирања,

• уградња у чланке машински читљиве информације о CC лиценци,

• омогућавање неограничене поновне употребе и преобликовања садржаја, у складу са CC BY, CC BY-SA или CC BY-NC лиценцама,

• верификовање политике архивирања садржаја код релевантих међународних регистара (база података) које дефинишу политику архивирања часописа, нпр. база SHERPA/RoMEO,

• омогућавање аутору да задржи ауторска права, без ограничења.

Војнотехнички гласник је тиме постао први часопис из Републике Србије којем је DOAJ доделио ову престижну ознаку.

Више детаља може се видети на сајту DOAJ-а.

DOAJ присвоил журналу «Военно-технический вестник» знак качества "Seal (Печать)"

Директорий DOAJ 20. июля 2016 года присвоил журналу «Военно-технический вестник» знак качества "Seal (Печать)".

DOAJ Seal – это знак, который в качестве признания достижений публикации, DOAJ присваевает предварительно индексированным в его основной базе журналам (в соответствии со стандартными критериями), соответствующим высокому уровню редакционных стандартов и отличившихся наилучшей практикой (Best Practice).

Для получения знака качества Seal, публикации должны строго соблюдать все требования для обеспечения максимальной открытости своего контента, заключающихся в следующих семи пунктах:

• наличие номера DOI, в качестве цифрового идентификатора объекта,

• машиночитаемые метаданные, указанные в статье;

долгосрочное электронное архивирование содержания журналов, защищенное соответствующим программным обеспечением

• использование машиночитаемых данных о лицензии Creative Commons;

• неограниченное использование и переоформление контента, в соответствии с лицензиями CC BY, CC BY-SA или CC BY-NC

• наличие информации о политике журнала в релевантных международных базах данных, таких как, например: Sherpa/RoMEO;

• сохранение авторских прав за автором без каких-либо ограничений.

Журнал «Военно-технический вестник» является первой публикацией из Республики Сербия, удостоенный данного престижного признания DOAJ Seal.

Для более подробного ознакомления, посетите сайт базы данных DOAJ.

DOAJ Seal awarded to the Military Technical Courier

The Directory of Open Access Journals (DOAJ) awarded the Seal label to the Military Technical Courier on 20th July 2016.

The DOAJ Seal is a mark of certification for open access journals, awarded by DOAJ (in accordance with standard criteria) to journals already in its base that achieve an additionally high level of openness, adhere to Best Practice and high publishing standards. To receive the Seal, the journal must comply with the following 7 conditions:

• uses DOIs as permanent identifiers;

• provides DOAJ with article metadata;

• deposits content with a long term digital preservation or archiving program;

• embeds machine-readable CC licensing information in articles;

• allows generous reuse and mixing of content, in accordance with a CC BY, CC BY-SA or CC BY-NC license;

• has a deposit policy registered with a deposit policy registry e.g. SHERPA/RoMEO;

• allows the author to hold the copyright without restrictions.

Military Technical Courier has thus become the first journal in the Republic of Serbia with this prestigious designation.

More details can be seen on the DOAJ website.

База података SHERPA/RoMEO верификовала политику архивирања *Војнотехничког гласника* одредницом "Green RoMEO color"

Издавачка политика отвореног приступа научним садржајима и политика архивирања *Војнотехничког гласника* верификована је у бази података SHERPA/RoMEO од 20. јула 2016. године. *Војнотехнички гласник* је класификован као Зелени модел отвореног приступа RoMEO (Green RoMEO color) који омогућава архивирање рукописа поднетих за објављивање (pre-print) и рукописа прихваћених за објављивање (post-print) или објављених радова (publisher's version) / верзија у PDF формату (http://www.sherpa.ac.uk/romeo/search.php?issn=0042-8469).

RoMEO је база података за претраживање политика издавача које се односе на самоархивирање чланака из часописа на мрежи као и у репозиторијумима отвореног приступа научним садржајима.

RoMEO је део сервиса SHERPA (Securing a Hybrid Environment for Research Preservation and Access/Rights Metadata for Open Archiving), са седиштем у Нотингему, УК.

RoMEO обухвата часописе с рецензираним радовима као и серијске публикације.

RoMEO сервис користи једноставан систем обележавања бојама приликом класификације политика издавача:

Зелена – омогућено је архивирање рукописа поднетих за објављивање и рукописа прихваћених за објављивање или објављених радова/верзија у PDF формату,

Плава – омогућено је архивирање рукописа прихваћених за објављивање (тј. финалних рукописа након рецензије) или објављених радова/верзија у PDF формату,

Жута – омогућено је архивирање рукописа поднетих за објављивање (тј. пре рецензирања),

Бела – архивирање се формално не подржава.

Више детаља може се видети на сајту базе података SHERPA/RoMEO.

Международной базой данных SHERPA RoMEO подтверждена политика архивации журнала «Военно-технический вестник» и присвоена «зеленая» цветовая категория (Green RoMEO color)

Редакционная политика открытого доступа к научным публикациям и политика архивирования журнала «Военно-технический вестник» подтверждена базой данных SHERPA/RoMEO 20 июля 2016 года. Журналу «Военно-технический вестник» присвоена «Зеленая» цветовая категория открытого доступа RoMEO (Green RoMEO color), позволяющая архивацию рукописей до публикации (pre-print) и рукописей, принятых к публикации (post-print) или опубликованных работ (publisher's version)/ версия в формате PDF (http://www.sherpa.ac.uk/romeo/search.php?issn=0042-8469).

RoMEO – база данных, в которой собрана информация об этике публикации и редакционной политике издания, в связи с самоархивированием статей в сети и в репозитории открытого доступа.

RoMEO – является частью Sherpa службы (Securing a Hybrid Environment for Research Preservation and Access/Rights Metadata for Open Archiving), основанной в Ноттингемском университете, Великобритания.

Перечень RoMEO содержит рецензируемые научные журналы и периодические издания.

RoMEO применяет простую систему цветовой категоризации редакционной политики:

Зеленая – подтверждена архивация рукописей до публикации и рукописей, принятых к публикации или опубликованных работ/версия в формате PDF,

Голубая − подтверждена архивация рукописей, принятых к публикации (т.е. рукописей, прошедших рецензию) или опубликованных работ/версия в формате PDF,

Желтая − подтверждена архивация рукописей, принятых к публикации (т.е. до публикации),

Белая − архивация не поддерживается.

Для более подробного ознакомления, посетите сайт базы данных SHERPA/RoMEO.

SHERPA/RoMEO Database has coded the archiving policy of the *Military Technical Courier* according to the category: “Green RoMEO color”

The open access publishing policy and the archiving policy of the *Military Technical Courier* have been verified in the SHERPA/RoMEO database since 20 July 2016. The *Military Technical Courier* is in the category Green RoMEO color (can archive pre-print and post-print or publisher's version/PDF) (http://www.sherpa.ac.uk/romeo/search.php?issn=0042-8469).

RoMEO is a searchable database of publisher's policies regarding the self-archiving of journal articles on the web and in Open Access repositories.

RoMEO is a part of SHERPA Services (Securing a Hybrid Environment for Research Preservation and Access/Rights Metadata for Open Archiving) based at the University of Nottingham.

RoMEO covers peer-reviewed journals and serials.

The RoMEO service uses a simple colour-code to classify policies:

Green - Can archive pre-print and post-print or publisher's version/PDF,

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