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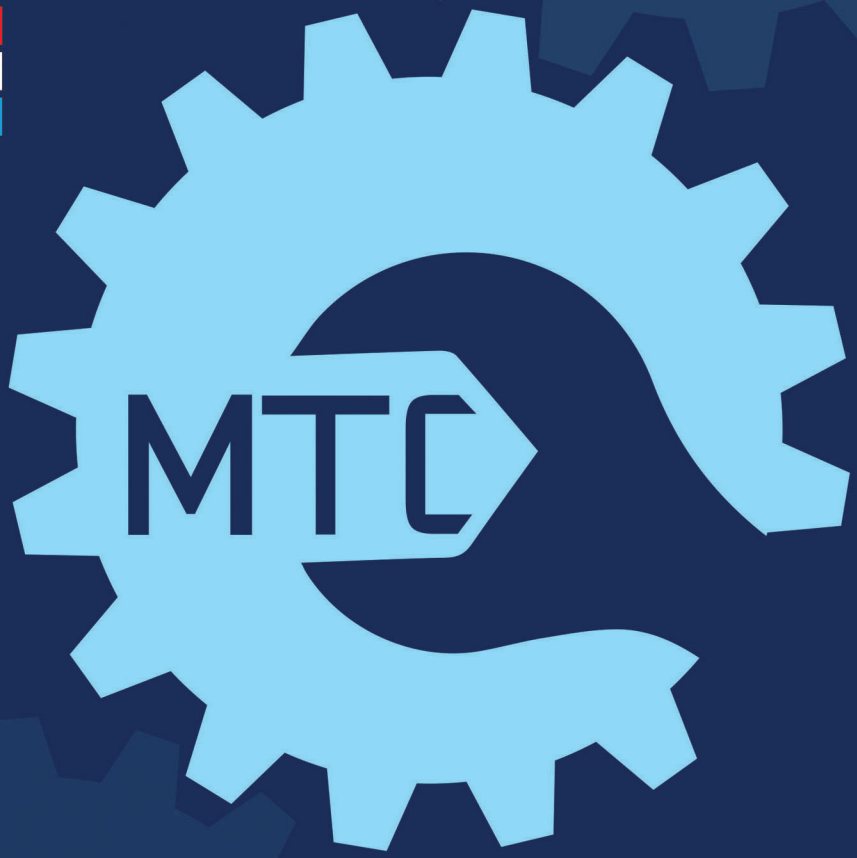

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ОРИГИНАЛЬНЫЕ НАУЧНЫЕ СТАТЬИ
ORIGINAL SCIENTIFIC PAPERS

LEACHING OF RARE EARTH ELEMENTS FROM BASTNASITE ORE (SECOND PART)

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Summary:

Dissolution of rare earth elements from bastnasite ore was studied using different leaching agents such as sulfuric acid, hydrochloric acid, acetic acid, citric acid and sodium hydroxide at 70°C, with 1mol/L, solid/liquid ratio of 0.05 between 30 and 180 min. The one-step direct leaching strategy was applied under atmospheric pressure aiming at selective leaching of rare earth elements from a matrix of iron oxides in which the rare earth elements – carbonates & flourides – are embedded.

Key words: rare earth elements, hydrometallurgy, bastnasite, acids.

Introduction

Rare earth elements are a group of metallic elements of the periodic table, often overlooked, but very significant in today's industrial landscape and modern lifestyle. Like other metals, rare earths are silvery-gray, malleable, ductile, and they conduct electricity.

ACKNOWLEDGMENTS: The research leading to these results has received funding from the European Community's Seventh Framework Programme (Call identifier FP7-NMP-2012-LARGE-6) under grant agreement n°309373. This publication reflects only the author's view, exempting the Community from any liability. Project website: www.eurare.eu. We would like to thank FEN Minerals, Norway, for sending their Rodberg sample and for their discussion in our experimental work. Especially, I would like to thank Maria Jose Gallego for the participation in the experimental work and the discussion of the results.

They appear in nature in the form of oxides and other compounds, but with one particularity – the chemical similarity between all of them is so astounding that they all occur together in their bearing minerals, substituting one another at the molecular level (Gupta & Krishnamurthy, 2005), (Castor & Hedrick, 2006, pp.769-772).

Development of new advanced materials based on oxidic powders is of high importance for different applications in modern life (Kuburović et al, 2018, pp.771-835).

Bastnasite $(La,Ce)CO_3F$ is a fluororcarbonate of the cerium group found in ore deposits, metamorphic zones and pegmatites. In average, it contains 70% rare earth oxides, most of them belonging to the light fraction and in particular lanthanum, cerium and neodymium (Stopić & Friedrich, pp.757-770). A sulfuric acid leaching process was studied for the processing of roasted ore of Dechang bastnasite in Sichuan, China, in order to obtain rare earth elements (Feng et al, 2013, pp.849-854). With a particle size of 0.074-0.100mm, 1.5mol/L sulfuric acid concentration, a liquid to solid mass ratio of 8 and a stirring speed of 500rpm, the reaction rate of the leaching process can be controlled by diffusion through the product/ash layer, as described by the shrinking-core model, and the calculated activation energy of 9.97, which is typical for a diffusion controlled process.

The main equations ruling dissolution in sulfuric acid are described as:

$$2REFCO_3 + 3H_2SO_4 \rightarrow RE_2(SO_4)_3 + 2HF + 2H_2CO_3 \quad (1)$$

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2CO_3 \quad (2)$$

$$Fe_2O_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2O \quad (3)$$

$$MnO + H_2SO_4 \rightarrow MnSO_4 + H_2O \quad (4)$$

The aim of this work is to compare the leaching efficiency of different leaching agents such as sulfuric acid, hydrochloric acid, acetic acid, citric acid and sodium hydroxide at 70°C, using 1mol/L, solid/liquid ratio of 0.05 between 30 and 180 min in order to recover rare earth elements.

Experimental work, material, parameters and procedure

The Rodberg ore sample used in these trials was analyzed and the results are given in Table 1 and Figure 1. The amount of iron of about 10.63 was smaller in comparison to the one of 73.1 % mentioned in our previous work (Stopic & Friedrich, 2018, 757-770), where the RE-content seems to be fairly lower than in the representative Rodberg samples.

Table 1 – Chemical composition of the "Rodberg bastnasite ore" sample
Таблица 1 – Химический состав образца «Родбергский бастнезит – минерал, содержащий, фторкарбонат»
Табела 1 – Хемијски састав узорка „Родберг руда које садрже флуорокарбонатни минерал"

Element	Fe	Ca	Mg	Mn	La	Ce	Nd	Sm	Y	Th
(%)	10.63	15.15	4.28	1.50	0.22	0.43	0.18	0.025	0.0124	0.057

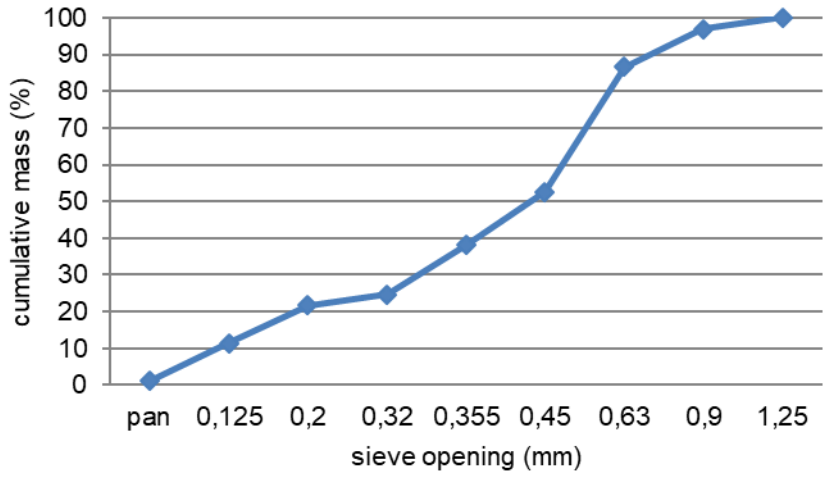


Figure 1 – Particle size distribution of the Rodberg ore
Рис. 1 – Распределение величины частиц «Родбергской руды»
Слика 1 – Расподела величине честица руде „Родберг"

Table 2 – Leaching trial design with sulfuric-, hydrochloric-, acetic and citric acid and sodium hydroxide
Таблица 2 – Разработка пробного выщелачивания с использованием серной, соляной, уксусной и лимонной кислот и гидроксида натрия
Табела 2 – План експеримената лужења сумпорном, хлороводоничном, сирћетном и лимунском киселином и натријум-хидроксидом

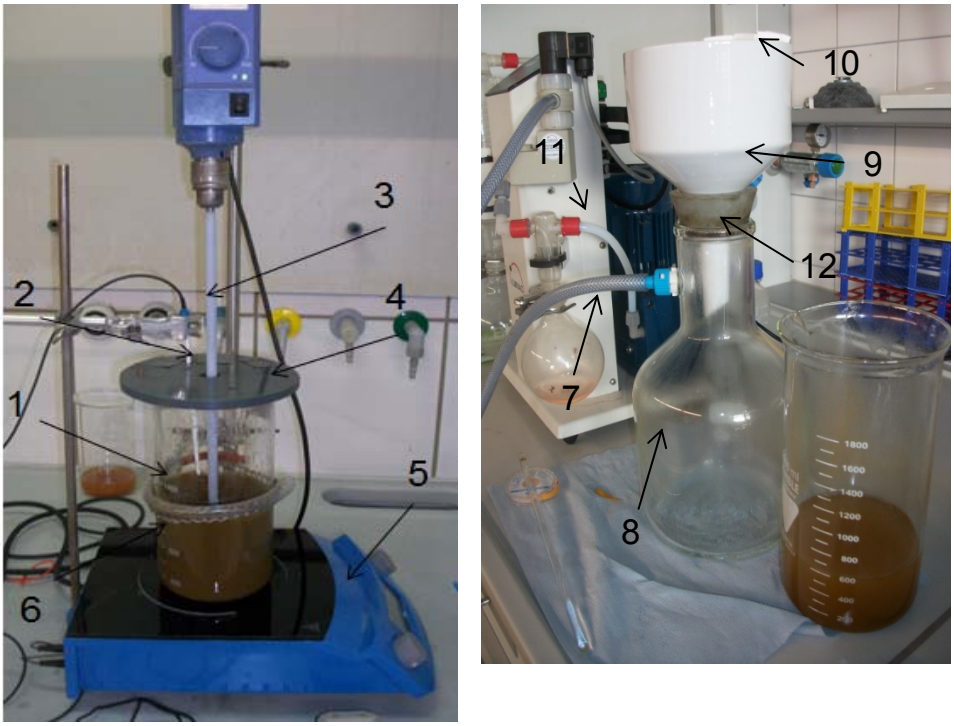
Parameter	**set value**
Concentration (mol/L)	1 (0.5)
Temperature (°C)	70
Solid-liquid ratio (g/L)	50
Time(min)	30, 60, 120, 180
Stirring rate (rpm)	300

A sample of the Rodberg ore was submitted to a series of preliminary trials where the leaching parameters were kept constant in all experiments and only the leaching agent was changed. The aim of these experiments was to obtain information about the general behavior of the Rodberg ore under acid and alkali attacks, and to choose a route for further experimentation. The desired leaching agent should not dissolve much of the iron oxide matrix and should attack the carbonate rare earth bearing minerals instead. However, this means that the non-rare earth bearing carbonates present in the ore will almost inevitably dissolve as well.

As well as the standard mineral acids, sulfuric and hydrochloric acid, and the base sodium hydroxide, two organic acids, acetic and anhydrous citric acid, were used as leaching reagents. The purpose of the organic acid trials was to investigate whether or not calcium carbonate and ankerite (a carbonate of iron, magnesium and manganese), which add up to 17% of the ore, could be selectively leached from the ore in the first leaching step. This would allow for the removal of most of the ore's impurities. The second step involving strong mineral acid leaching could then be performed to recover the rare earth elements in a solution of higher purity.

The experiments were carried out in a laboratory fume cabinet, as shown in Figure 2. A 2L beaker was placed on top of a heating induction plate and filled with one liter of the previously prepared diluted acid or reagent. A temperature measuring device was connected to the induction plate for adequate temperature control. The temperature was set at 70°C. The stirring equipment was fixed to a clamp above the beaker and

connected at a speed of 300rpm. Rod stirrers were used instead of magnetic stirrers because of the magnetic nature of the ore.



Where: 1. Beaker containing Rodberg ore + leaching agent, 2. Thermocouple, 3. Stirrer, 4. Cover, 5. Heating plate, 6. Security chain, 7. Pipe connected with a vacuum pump, 8. Glass container, 9. Ceramic filtering cone, 10. Fine filtering paper, 11. Vacuum filtering mashine, 12. Rubber adapter.

Figure 2 – Equipment for leaching and filtration
Рис. 2 – Оборудование для выщелачивания и фильтрации
Слика 2 – Апаратура за лужење и филтрацију

After reaching the desired temperature, the weighed 50g of the Rodberg ore were added, and the stop watch started. A cover was placed over the beaker to avoid excessive evaporation. The samples were taken from the leaching mixture by means of a syringe at several intervals: 30, 60, 120 and 180 min.

The taken samples were filtered using the previously weighed fine filter papers and the leachate was collected in the test tubes. Each sample gave about 40ml. The used filter papers were then placed over a

vacuum filtering machine were they were neutralized with distilled water before being introduced into a drying cabin at 105°C for three hours.

After the 3h sample was taken, the stirrer and heating plate were disconnected and the beaker content was filtered using the above mentioned filtering machine. The filtrate was collected in a bottle and the neutralizing of the solid residue and the filter was carried out before drying in the same conditions as for the rest of the samples. After the drying time had elapsed, the solid residue was weighed and the results were noted down.

Results and discussion

The summarized results are presented in Tables 3 and 4 and Figures 3 to 6.

Table 3 – Amount of the solid residue after leaching
Таблица 3 – Количество твердого остатка после выщелачивания
Табела 3 – Износ чврстог остатка након лужења

Trial No	leaching agent	net mass of solid residue (g)	mass dissolved (%)
1	sulphuric acid	33.798	32.404
2	hydrocholric acid	9.475	81.050
3	acetic acid	29.257	41.486
4	anhydrous citric acid	12.898	74.205
5	sodium hydroxide	49.635	0.730

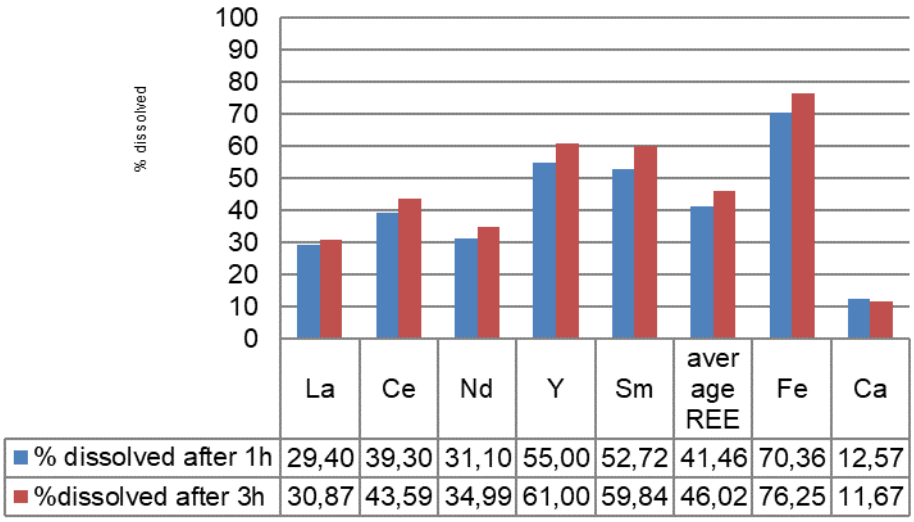


Figure 3 – Trial No1: Dissolution of rare earths and impurities during leaching with sulphuric acid
Рис. 3 – Эксперимент №1: Растворение редкоземельных элементов и примесей при выщелачивании серной кислотой
Слика 3 – Експеримент бр. 1: Растварање елемената ретких земаља и нечистоћа за време лужења сумпорном киселином

After a few hours from the leaching operation with sulfuric acid, a fine, white precipitate appeared at the bottom of test tubes and the bottle. The samples where re-filtered and the white precipitate was sent for analysis. The results are shown in Table *4*.

Table 4 – Chemical composition of the precipitate produced in H_2SO_4 leaching
Таблица 4 – Химический состав осадка, образующегося при выщелачивании H_2SO_4
Табела 4 – Хемијски састав преципитата добијеног растварањем сумпорном киселином

Element	Fe (ppm)	Ca (%)	Ce (ppm)	La (ppm)	Nd (ppm)	Pr (ppm)	Sm (ppm)	Gd (ppm)	Tb (ppm)	Y (ppm)
Amount	11/ <1 (inhomogeneous)	29,7	600	302	146	<1	<1	<1	<1	<1

As shown in Fig. 4, leaching with hydrochloric acid had higher leaching efficiency in comparison to that with sulfuric acid.

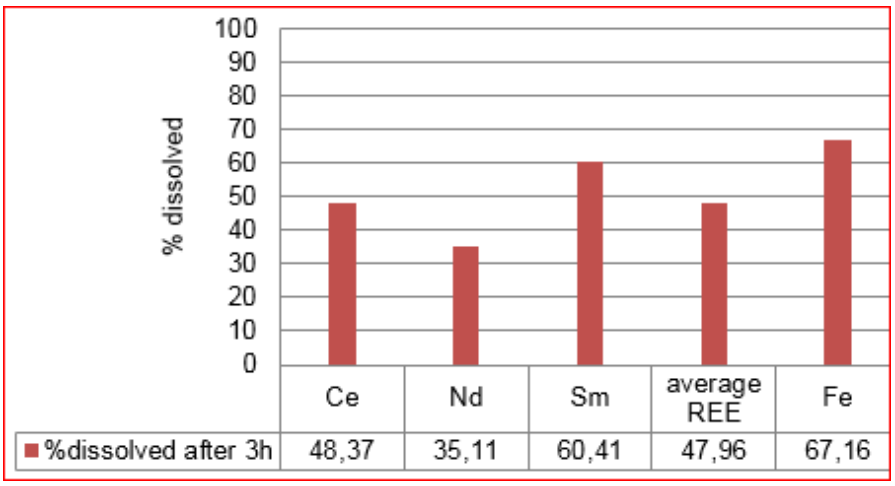


Figure 4 – Trial No 2: Dissolution of rare earths and impurities during leaching with hydrochloric acid
Рис. 4 – Эксперимент № 2: Растворение редкоземельных элементов и примесей при выщелачивании соляной кислотой
Слика 4 – Експеримент бр. 2: Растварање елемената ретких земаља и нечистоћа за време лужења хлороводоничном киселином

The chemical reactions ruling carbonate and fluoride dissolution are described as:

$$RE_2(CO_3)_3 + 6\,HCl \rightarrow 2\,RECl_3 + 3\,H_2O + 3\,CO_2 \quad (5)$$

$$REF_3 + HCl \rightarrow RECl_3 + 3\,HF \quad (6)$$

Leaching with organic acids was performed using acetic and citric acid, as shown in Figs. 5 and 6.

The results show that the extraction of rare earth elements was higher with mineral acids than with organic acids. Sulfuric acid dissolved 46%REE after 3 hours while hydrochloric acid dissolved 48%. However, the dissolution of large quantities of iron took place in parallel, 76% in the case of sulfuric acid and 67% in the case of hydrochloric acid. Hydrochloric acid also dissolved the totality of calcium present in the ore (an error in the chemical analysis or inhomogeneity of the ore gives a percentage superior to 100). Indeed, the rare earth acid carbonate minerals seem to be more resistant to acid attack than the other gangue carbonate minerals. In the sulfuric acid leachate, the dissolution values of

calcium are much lower due to the removal of the white precipitate, identified as calcium sulfate or gypsum ($CaSO_4$). The precipitate also contains small quantities of rare earth elements that have been absorbed in its crystals, namely 13.9% of cerium, 13.7% of lanthanum and 8.1% of neodymium.

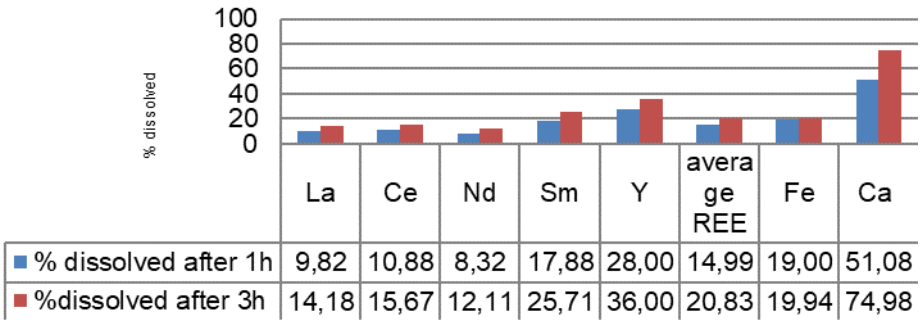


Figure 5 – Trial No 3: Dissolution of rare earths and impurities during leaching with acetic acid
Рис. 5 – Эксперимент № 3: Растворение редкоземельных элементов и примесей при выщелачивании уксусной кислотой
Слика 5 – Експеримент бр. 3: Растварање елемената ретких земаља и нечистоћа за време лужења сирћетном киселином

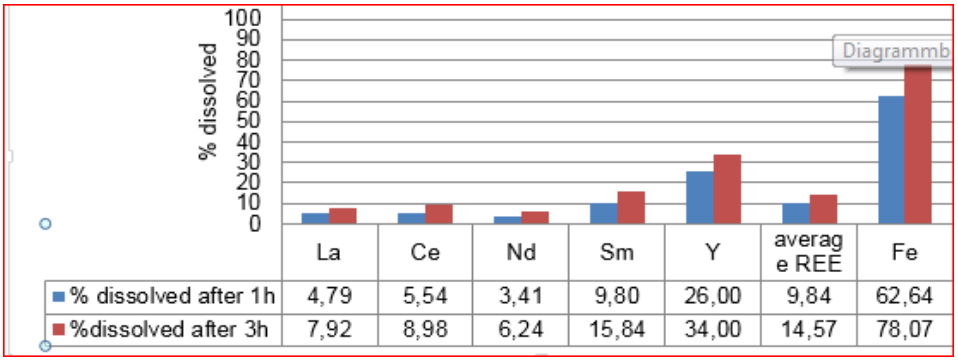
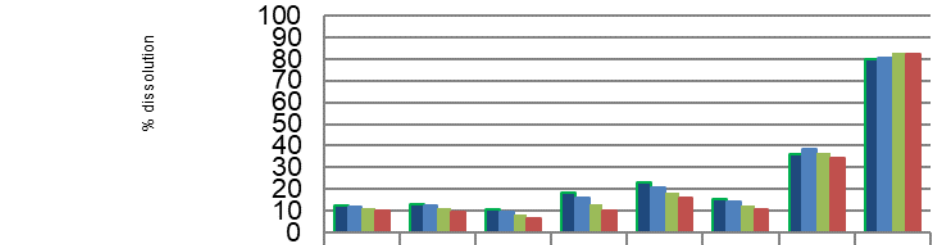


Figure 6– Trial No 4: Dissolution of rare earths and impurities during leaching with citric acid
Рис. 6 – Эксперимент № 4: Растворение редкоземельных элементов и примесей при выщелачивании лимонной кислотой
Слика 6 – Експеримент бр. 4: Растварање елемената ретких земаља и нечистоћа за време лужења лимунском киселином

The amount of solid residue left in sulfuric acid leaching is also inferior to that of hydrochloric acid (32% versus 81%), although different minerals, including iron oxide, are dissolved to a similar degree. There is a possibility that a part of gypsum is precipitating too during the leaching operation with sulfuric acid, and is collected together with the solid residue counted as undissolved material.

The organic acids failed to remove the carbonate gangue minerals without dissolving the rare earth carbonate minerals. Acetic acid leached an average of 21%REE together with 20% of iron and 75% of calcium after 3 hours. Citric acid left most rare earths untouched, but dissolved a great quantity of the gangue minerals containing iron and calcium. The likeliness of a selective leaching of gangue carbonates with organic acids was overall not encouraging.

As to the base NaOH, the total mass of ore dissolved, lower than 1%, already pointed toward little rare earth recovery.Fe dissolved in 0.03% and 0.02% after 1 and 3 hours, respectively. Calcium dissolved in 0.28% and 0.13%. All rare earths dissolved to give less than 1mg/l in the solution.



	La	Ce	Nd	Sm	Y	average REE	Fe	Ca
% dissolved after 30min	12,36	13,26	10,47	18,29	23,39	15,55	36,12	79,99
% dissolved after 1h	11,82	12,23	9,34	15,92	20,81	14,02	38,56	80,25
% dissolved after 2h	11,09	11,12	8,22	13,22	18,39	12,41	36,68	82,76
% dissolved after 3h	10,27	9,40	6,51	9,96	16,13	10,45	34,42	82,50

Figure 7 – Leaching in hydrochloric acid (0.5mol/L) - Dissolution of rare earths and impurities

Рис. 7 – Выщелачивание в соляной кислоте (0,5 моль/л). Растворение редкоземельных элементов и примесей

Слика 7 – Лужење хлороводоничном киселином (0,5 mol/L)– растварање елемената ретких земаља и нечистоћа

In an additional leaching experiment, a possibility of selective leaching was attempted with a lower concentration of hydrochloric acid of 0.5mol/L, leaving the rest of the parameters as previously determined. The results are shown in Figure 7.

A peculiarity of this hydrochloric acid trial is that all rare earths give larger values of dissolution after 30 minutes of leaching and the lapse of time reduces their quantity in the leachate. This does not happen with iron and calcium, which reach maximum dissolution levels after 1 and 2 hours, respectively. After 30 minutes, an important quantity of calcium, 80%, was leached, versus 16%REE, 10% in the case of neodymium. The amount of iron present in the leachate was 36%.

When comparing the trial No1 done with 1M HCl and this extra trial where the concentration has been halved to 0.5M, it can be concluded that the dissolution of rare earths has decreased drastically in 78.21%. Calcium remained with high dissolution rates, decreasing only in 17.50% in respect to the 1M trial, while iron was 48.75% less dissolved. This means that reducing the acid concentration was more selective toward dissolving the gangue calcium based minerals and not the rare earth bearing minerals. Reducing the concentration further, and varying other parameters, for instance leaching at lower temperatures, with higher solid to liquid ratios and longer times, could give more accurate results, and the possibility of a two-step leaching process.

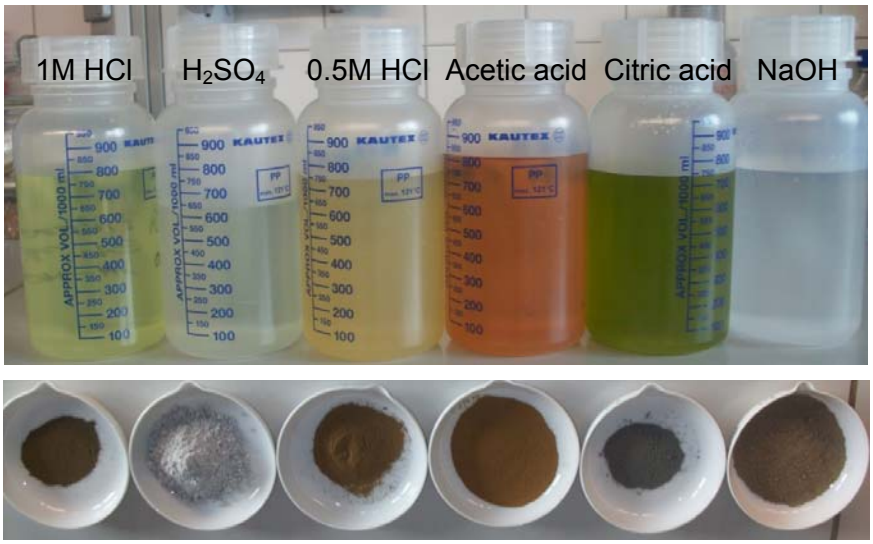


Figure 8 – Leachates and their corresponding solid residues
Рис. 8 – Полученные растворы и соответствующие твердые остатки
Слика 8 – Добијени раствори и њима одговарајући чврсти остаци

Conclusion

The dissolution of rare earth elements from bastnasite ore was performed using different leaching agents such as sulfuric acid, hydrochloric acid, acetic acid, citric acid and sodium hydroxide at 70°C, using 1mol/L, solid/liquid ratio of 0.05 with duration between 30 and 180 min. The maximal leaching efficiency was about 48% under the above mentioned conditions using hydrochloric acid and sulfuric acid in contrast to 20 % obtained using acetic and citric acid. A decrease in the concentration of hydrochloric acid from 1.0 to 0.5mol/L leads to a decrease in the leaching efficiency to 11%.

In order to increase the leaching efficiency of rare earth elements, an additional study of the increased concentration and higher pressure and temperature in an autoclave will be performed. The minimal leaching efficiency was obtained using sodium hydroxide for dissolution of rare earth elements from a bastnasite ore. Higher dissolution of iron and calcium under the above mentioned conditions is a serious problem for the leaching process selectivity.

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ВЫЩЕЛАЧИВАНИЕ РЕДКОЗЕМЕЛЬНЫХ ЭЛЕМЕНТОВ ИЗ ПОРОД, СОДЕРЖАЩИХ ФТОРКАРБОНАТЫ – ВТОРАЯ ЧАСТЬ

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ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

При исследовании процесса растворения редкоземельных рудных пород, содержащих фторкарбонат применялись различные виды выщелачивания: серной кислотой, соляной кислотой, уксусной кислотой, лимонной кислотой и гидроксидом натрия, при температуре 70° С, концентрация: 1 моль / л, соотношение твердость/жидкость: 0,05, в промежутке времени от 30 до 180 минут. Одностадийное выщелачивание проводилось с целью селективного выщелачивания редкоземельных элементов, в виде фторидов и хлоридов, находящихся в матрице оксида железа.

Ключевые слова: редкоземельные элементы, гидрометаллургия, фторкарбонат, серная кислота.

РАСТВАРАЊЕ ЕЛЕМЕНАТА РЕТКИХ ЗЕМАЉА ИЗ РУДА КОЈЕ САДРЖЕ ФЛУОРОКАРБОНАТНИ МИНЕРАЛ (ДРУГИ ДЕО)

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ОБЛАСТ: хемијске технологије
ВРСТАЧЛАНКА: оригинални научни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Растварање елемената ретких земаља из руда које садрже флуорокарбонатни минерал проучавано је коришћењем разних реагенаса за лужење, као што су сумпорна, хлороводонична, сирћетна и лимунска киселина и натријумхидроксид, концентрације 1mol/L, на 70°C у времену од 30 до 120 минута и односом чврсто/течно од 0,05. Директно лужење у једном кораку извођено је са циљем селективног лужења елемената ретких земаља у облику флуорида и хлорида, који су заробљени у матрици гвожђе оксида.

Кључне речи: елементи ретких земаља, хидрометалургија, флуорокарбонатни минерал, сумпорна киселина.

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VELOCITY OF POWDER PARTICLES IN PLASMA AT LOW PRESSURE

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ARTICLE TYPE: Original scientific paper
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Summary:

Low pressure of inert gas in the vacuum chamber significantly affects the transfer of plasma particle velocity onto powder particles, residence time of powder particles in plasma and the kinetic energy of molten particles before the collision with the substrate. In addition to low pressure of inert gas in the vacuum chamber, the size and mass density of powder particles, together with plasma arc power, have the biggest impact on the average velocity of powder particles. To measure the velocity of powder particles in the vacuum chamber at low pressure, a laser speedometer is applied.The average velocity of molten powder particles V=s/t is calculated when the length of the path of powder particles that pass between two focus distances of the laser beam is divided by the time of particle passage between the two focuses. Measurements are done for vacuum chamber pressure, the values of which are usually from 6.7 to 80 kPa. The paper describes the relationship between the average velocity of Al_2O_3 and W powder particles and the vacuum chamber pressure, granulate distribution, mass density and plasma arc power. It was found that, for powder of lower mass density, the average velocity of particles can increase for 200 m/s with a decrease in chamber pressure.The effect of pressure on W particles of larger mass density is lower but still important, because a decrease in pressure increases the average velocity of particles up to 50%. Reducing plasma arc power reduces the maximum velocity of both types of powder particles.

Keywords: VPS, plasma arc power, velocity of powder particles.

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Introduction

The velocity of powder particles is an important variable size of the VPS process which affects particle melting, coating density and cohesive / adhesion strength. When comparing powder deposition at atmospheric pressure with deposition in the environment with reduced pressure, for given arc power and arc gas flow, velocities of plasma particles and powder particles are higher at low pressure than those obtained at atmospheric pressure (Smith & Dykhuizen, 1988, pp.25-31), (Smith et al, 2011, pp.117-132), (Mrdak, 2018, pp.415-430). Pressure in the vacuum chamber is only one of the variable parameters that affect the velocity of the plasma jet and the velocity of powder particles. The average velocity of powder particles is influenced by several influential variable process values such as: powder mass flow, powder particle size, powder mass density, pressure in the vacuum chamber, plasma arc power, electrode geometry, arc gas flow rate, and plasma gas composition. In order to examine the influence of the process parameters on the velocity of powder particles in the vacuum plasma system applying a laser speedometer, it was found that there is a significant relationship between the velocity of particles and the process parameters such as powder particle size, particle mass density, pressure in the chamber, plasma arc power, and electrode geometry. The laser speedometer method is based on measuring lap times of individual powder particles passing between two highly focused laser beams along the plasma axis (Young et al, 2000, pp.788-792). After the average lap time of molten powder particles is determined, the average particle velocity is calculated based on the known distance between two focal volumes of two laser beams. Two-Focus (L2F) laser with the optical head Polytec model L2F-0-4000 and the signal processor L2F-S-100 is used for measurements (Smith, 1988, pp.77-85), (Mauer et al, 2013, pp.892–900). Within the range of the test conditions, the velocity of powder particles is relatively insensitive to changes in plasma gas velocity, gas composition, and powder flow rate. Today, a large number of powders are deposited at atmospheric pressure, but requests for high-quality coatings have led to the development of powder deposition in the vacuum chamber, which is maintained at a pressure of an inert gas, usually from 1.9 to 6.7 kPa (Muehlberger, 1974, pp.245-256), (Hamatani et al, 2002, pp.79–92). Empirical development of the vacuum deposition process parameters has been successfully carried out for a large number of materials and there are a lot published papers dealing with the fundamental nature of the process of vacuum deposition. Due to the development of nano

materials deposited in a vacuum using plasma, there is a need for further fundamental research to improve the understanding of physics and thermodynamics of this process. This simultaneously improves equipment construction, coating quality, and reproducibility of coating quality. The vacuum process is today widely used in medicine for the preparation of implants on the basis of nanoparticles of Ti, Ta, and Nb metals as well as organic reactive ceramic hydroxyapatite $Ca_{10}(PO_4)_6(OH_2)$ and bio inert inorganic ceramics: Al_2O_3, TiO_2, ZrO_2, $ZrO_2Y_2O_3$ and Cr_2O_3 which have a wide range of applications for the production of the most modern artificial hips and knees (Aebli et al, 2003, pp.356-363), (Zhang et al, 2012, pp.724-728), (Ganvir et al, 2015, pp.324–332), (Graziani et al, 2016, pp.356-363).

The aim of this study was to show and clarify the influence of the variable values of the VPS process on the average velocity value of powder particles in a vacuum. The paper describes the most important parameters in a vacuum affecting the average velocity of Al_2O_3 and W particles for different powder granulations which differ significantly in their mass densities and melting temperatures. Al_2O_3 powder has a mass density of 3.95 g/cm^3 and a melting temperature of 2072°C while W powder has a mass density of 19.3 g/cm³ and a melting temperature of 3380ºC. The difference in mass density values is large and is 15.35 g / cm³ as well as the difference in melting temperatures which is equal to 1308 ° C. Based on the above, the paper clearly shows that the pressure values of the vacuum chamber of 80 kPa, 40 kPa and 6.7 kPa significantly affect the average velocity of powder particles of different granulates and mass densities of powder particles because the pressure in the chamber affects the output velocity and the plasma jet density.

The influence of the pressure in the vacuum chamber on the velocity of powder particles depending on their granulation and mass density

The optimal VPS parameters are determined for each powder taking primarily into account the average particle size and shape, mass density, and melting temperature. At low pressure, mutual friction between ions and injected particles is necessary to occur for plasma particles to carry powder particles with them. The interaction between ions and powder particles initially accelerates powder particle velocity which increases with the distance from the anode opening. The acceleration of powder particles is directly proportional to the net force in the proper direction and inversely proportional to the mass of particles a=F/m. The mass of a

particle deposited depends on its size - volume, and its density mass on the base material. Since each powder has a different particle size range, it is necessary to compare powder particle velocities for all powder granulate ranges. Al_2O_3 powder with three granulate distributions - 20–31 μm, 44–63 μm and 53–74 μm - has shown to be the most appropriate for analyzing the influence of the particle size range on average particle velocities in plasma. Average particle velocities are measured at several points along the plasma axis in order to compare the velocity profiles for all granulate distributions. The deposition parameters of one type of powder are often used to estimate the parameters of another powder if their mass densities are approximate. Powder mass densities often differ even when other factors (such as particle size, particle morphology, and melting point) are similar. In order to clarify the influence of powder mass density on average powder particle velocities in plasma, the best is to use W with the range of granulation of 44–74 μm whose velocity values are comparable to those of average Al_2O_3 particle velocities. Tungsten and Al_2O_3 represent extremes in mass densities of materials which are often deposited. The Al_2O_3 powder density is 3.52 g/cm^3, and the density of W is 19.36 g/cm^3. The pressure in the vacuum chamber significantly affects the powder particles velocity because the pressure in the chamber affects the output velocity and the density of the plasma jet. The profiles of the average velocities for Al_2O_3 and W powders were analyzed in an Ar/He plasma jet of a power of 31 kW for the SG-100 plasma gun with the # 453 anode at the chamber pressure values of 80, 40 and 6.7 kPa. The powder particles exhibit different velocities depending on granulation, powder types and distances (Smith, 1988, pp.77-85), (Young et al, 2000, pp.788-792).

The comparisons of the average particle velocities of Al_2O_3 and W in Figures 1, 2, and 3 show that the changes in the Al_2O_3 particle granulate and in the powder mass density may lead to significant differences in the velocities of particles. At any vacuum chamber pressure, the increase of particle size results in a steady relation with a reduced acceleration / slowdown and lower maximum speeds of particles. The increase of the size and mass of particles results in the increase of the projected area. The mass increase tends to reduce the acceleration / deceleration rate and to lower the maximum speed. Conversely, increasing the surface area tends to increase the force of frontal resistance to particles, which increases the acceleration / deceleration rate as well as the maximum speed.

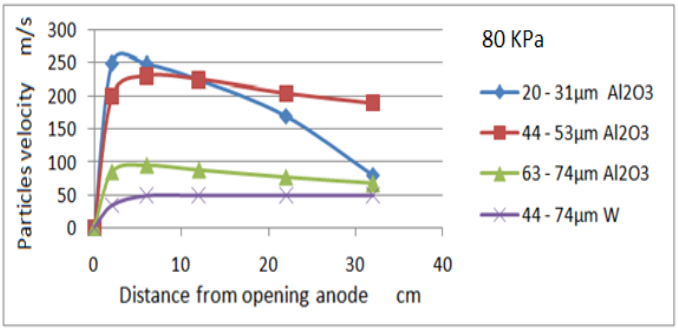

Figure 1 – Average velocities of Al_2O_3 and W particles at a pressure of 80kPa
Рис. 1 – Средняя скорость частиц Al_2O_3 и W под давлением 80KPa
Слика 1 – Средње брзине честица Al_2O_3 и W при притиску од 80 KPa

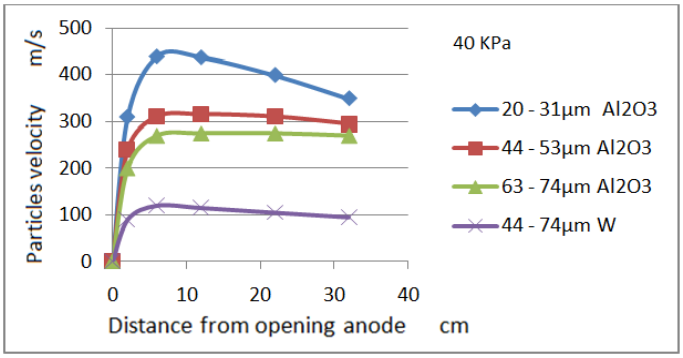

Figure 2 – Average velocities of Al_2O_3 and W particles at a pressure of 40KPa
Рис. 2 – Средняя скорость частиц Al_2O_3 и W под давлением 40KPa
Слика 2 – Средње брзине честица Al_2O_3 и W при притиску од 40 KPa

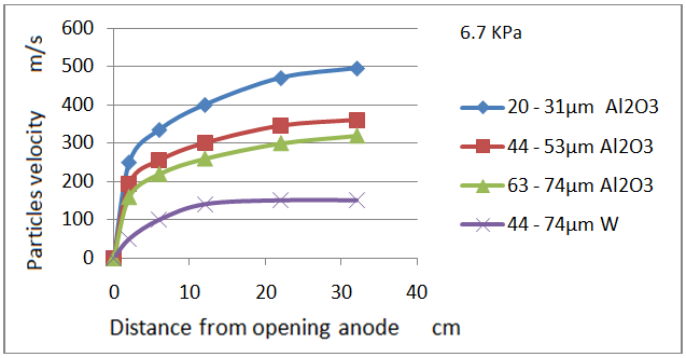

Figure 3 – Average velocities of Al_2O_3 and W particles at a pressure of 6.7 KPa
Рис. 3 – Средняя скорость частиц Al_2O_3 и W под давлением 6,7 Кра
Слика 3 – Средње брзине честица Al_2O_3 и W при притиску од 6,7 KPa

For a spherical particle or a molten droplet of the radius r, the mass increases as r^3, but the projected area increases only as r^2. Al_2O_3 particles are not spherical, but it is expected that the mass of particles increases faster than the projected area. The impacts of the increasing mass should prevail if the forces of resistance do not increase as a very fast function of the projected surface. The experimental results confirm that the increase in mass is the predominant factor for these three dimensions of Al_2O_3 powder, Figures 1, 2 and 3. The same should apply to other materials with a mass density greater than Al_2O_3 (Smith, 1988, pp.77-85), (Young et al, 2000, pp.788-792). Larger powder particles are slower and their residence time in plasma is longer although the velocity of plasma particles is higher compared to that of powder particles. The result is a better transfer of heat energy to larger particles which require more energy to be completely moltened. While this is clearly a desirable trend, experience indicates that it is still very difficult to achieve uniform melting of powder with a broad distribution of sizes. Figures 1, 2 and 3 show the results for the sizes 44–74 μm of the W powder. Based on the above description, more massive tungsten particles show lower acceleration / deceleration velocities and lower maximum velocities compared to lighter Al_2O_3 particles of the similar size. If we compare all the results at any given pressure in the vacuum chamber, there is a very obvious progressive trend towards lower, more consistent velocities while increasing the particle mass.

The influence of pressure in the vacuum chamber on the average velocity of powder particles for a constant range of granulates

The influence of changes in pressure in the vacuum chamber on the average velocity of powder particles with a constant range of granulates is shown in Figures 4, 5 and 6.

These results can be explained on the basis of changes in the velocity and density of the plasma jet related to the pressure, as well as on the basis of the density of the surrounding gas in the vacuum chamber. The exit velocity of the plasma particles from the plasma gun is approximately 1700 m/s at an operating pressure of 80 kPa, 2455 m/s, at 40 kPa, and 3300 m/s at 6.7 kPa.

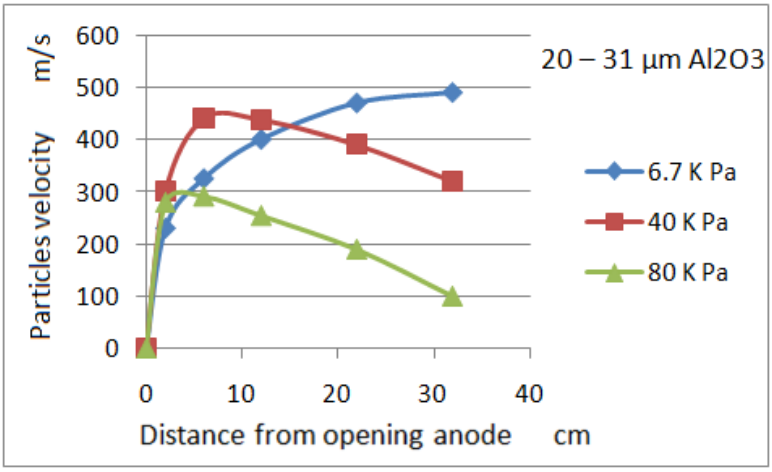

Figure 4 – Average velocities of Al_2O_3 particles with a granulation of 20-31 µm with the change of pressure
Рис. 4 – Средняя скорость частиц Al_2O_3 грануляции 20-31 µm с изменением давления
Слика 4 – Средње брзине честица Al_2O_3 гранулације 20-31 µm при промени притиска

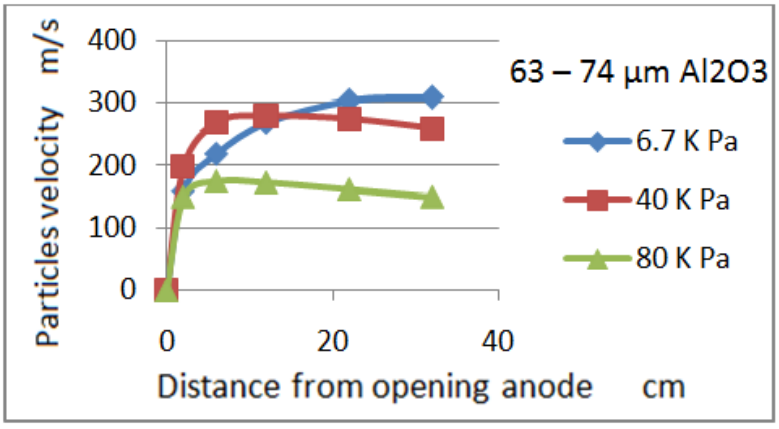

Figure 5 – Average velocities of Al_2O_3 particles with a granulation of 63-74 µm with the change of pressure
Рис. 5 – Средняя скорость частиц Al_2O_3 грануляции 63-74 µm с изменением давления
Слика 5 – Средње брзине честица Al_2O_3 гранулације 63-74 µm при промени притиска

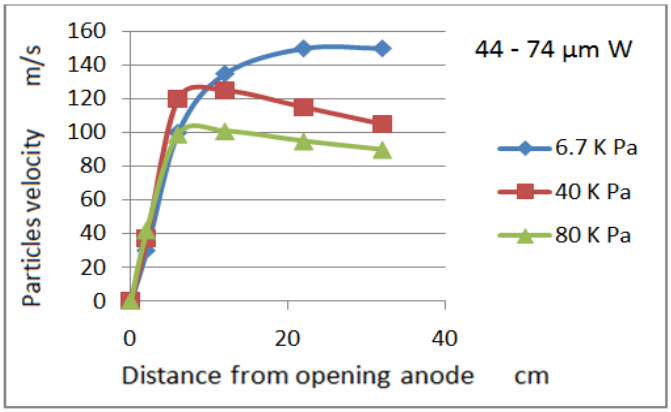

Figure 6 – Average velocities of W particles with a granulation of 44-74 µm with the change of pressure
Рис. 6 – Средняя скорость частиц W грануляции 44-74 µm с перепадом давления
Слика 6 – Средње брзине честица W гранулације 44-74 µm при промени притиска

This is in compliance with the results of the average velocities of Al_2O_3 and W powder particles shown in Figures 4, 5 and 6, which show progressively higher maximum powder particle velocity values as the pressure in the chamber decreases (Smith, 1988, pp.77-85), (Young et al, 2000, pp.788-792). Plasma density decreases with the decrease of the pressure in the chamber. Higher plasma velocity in relation to powder particles tends to increase the velocity of particles, but a plasma density decrease has the opposite effect. Based on the net combined impact of these opposing trends, the model predicts that the maximum acceleration of particles occurs at a chamber pressure of 45 kPa.

The results shown in the figures support this prediction because the particle velocity is at its highest at the first measuring point of 2.5 cm at a pressure of 40 kPa. The influence of the resistance of the surrounding gas in the vacuum chamber becomes more important with an increasing distance from the nozzle outlet. At lower chamber pressures, the resistance is lower to slow the plasma jet and depositing particles.

Therefore, as the chamber pressure decreases, the particle velocity maxima are moving away from the anode opening and the particle velocity decrease becomes more gradual. The dependence of the mass is also visible in the figures. The same trends associated with the pressure were observed for each of the three powders, but the changes in the average velocity profiles are much bigger for lighter Al_2O_3 particles.

The influence of the plasma arc power and a nozzle type on the average velocity of powder particles in the vacuum chamber

The geometry of the nozzle – anode affects the exit velocity of the plasma jet. Anode model # 453 has a divergent part at the nozzle exit designed to produce supersonic flow of plasma at atmospheric pressure. Anode model # 450 is similar to anode # 453 with the exception that anode # 450 is constructed with a simple nozzle with a flat opening for subsonic operation at atmospheric pressure. Although these anodes were originally designed to operate at atmospheric pressure, both work well at low pressure values in the chamber. Since the arc power is easy to control and observe, it is an important variable in the process of optimization of the conditions for depositing powders. The effect of the plasma arc power on the average velocity of particles was investigated by comparing the velocity profiles measured for the power values of 31 kW and 21 kW (Smith, 1988, pp.77-85), (Young et al, 2000, pp.788-792). Figure 7 shows the influence of the plasma arc power on the average velocity for fine Al_2O_3 powder particles with the particle size of 20–31μm and for coarse W powder particles with the granulation of 44–74 μm, injected through anode # 453 at a chamber pressure of 6.7 kPa.

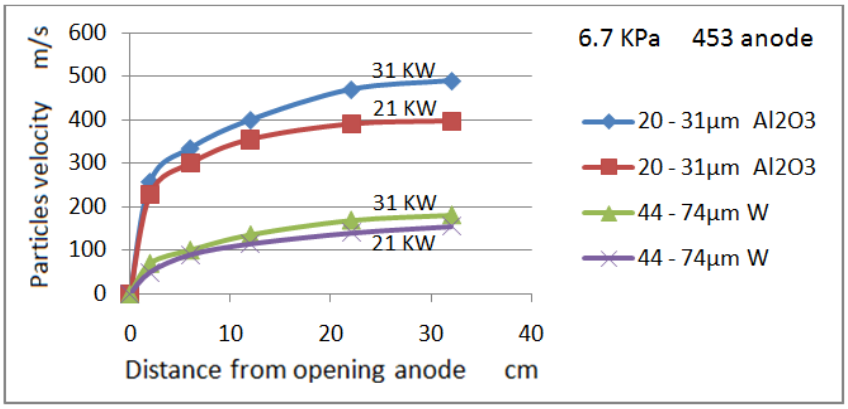

Figure 7 – Influence of the plasma arc power on the average velocities of Al_2O_3 and W particles at 6.7 KPa
Рис. 7 – Воздействие силы плазменной дуги на среднюю скорость частиц Al_2O_3 и W на 6.7 KPa
Слика 7 – Утицај снаге плазменог лука на средње брзине честица Al_2O_3 и W на 6,7 KPa

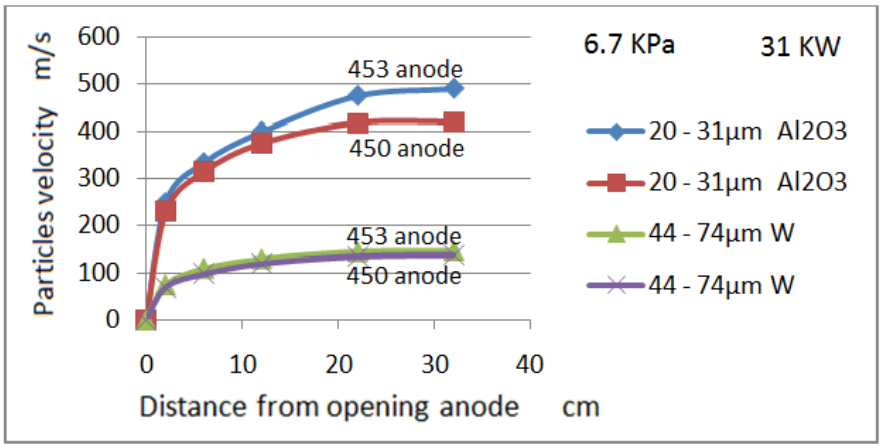

Figure 8 – Comparison of the average velocities of Al_2O_3 and W particles sprayed with 453 and 450 anodes at 6.7 KPa
Рис. 8 – Сравнение средней скорости частиц Al_2O_3 и W с анодным слоем 453 и 450 на 6.7 KPa
Слика 8 – Компарација средње брзине честица Al_2O_3 и W напрсканих са анодама 453 и 450 на 6.7 KPa

Reducing the plasma arc power from 31 to 21 kW significantly reduces the acceleration and the maximum velocity for both powder types. The actual value of the maximum velocity reduction is higher for Al_2O_3 powder and the relative change in velocity is roughly 20% for both powders. These results show that changes in the plasma arc power can significantly affect the velocity of powder particles, but it is clear that a change of the plasma arc power of only 1 or 2 kW during depositing will not have a significant impact (Smith, 1988, pp.77-85), (Young et al, 2000, pp.788-792). Figure 8 shows the comparison of the average velocity profiles for fine Al_2O_3 powder with a particle size of 20–31 µm and for coarse W powder particles with a granulation of 44–74 µm, injected through anodes # 453 and # 450 in a pressure chamber of 6.7 kPa. Changing the anode resulted in the reduction of the maximum velocity of about 10% for both powders. The results show that the anode change can also affect the velocity of powder particles.

Different flow rates and gas compositions did not show any significant effects on the velocity of particles within the range of the conditions studied. This is very interesting because these variables can have a significant effect on particle melting and the quality of the deposit. Since most plasma systems are designed to maintain a constant power supply to the plasma arc, it is emphasized that the experiments are

carried out at constant plasma arc power values. The flow of arc gas and the composition affect the relation of the current and the voltage of the plasma gun. Therefore, changes in the flow rate or in the gas composition will lead to changes in the arc power if the electric current intensity is not adjusted. If the arc power is allowed to vary as a function of the arc gas flow rate or its composition, the particle velocity will be changed as well, as shown in Figure 7(Smith, 1988, pp.77-85), (Young et al, 2000, pp.788-792).

Conclusion

The paper presents the influence of low pressure in the vacuum chamber and the plasma arc power on the average velocities of Al_2O_3 powder particles with different granulation as well as of W powder particles of extreme mass density. Based on the above, the following has been established.

For the same low pressure in the vacuum chamber, with increasing Al_2O_3 granulation, the acceleration and the velocity of powder particles progressively decrease to 200 m/s. Also, larger Al_2O_3 particles are less sensitive to the chamber pressure change from 6.7–80 MPa. Larger powder particles are slower and their residence time in plasma is longer even though the velocities of plasma particles are higher in comparison to powder particles.

W particles of larger mass density are less susceptible to a change in pressure in the vacuum chamber in relation to Al_2O_3 particles. However, even W particles show an increase in the average velocity of powder particles of 50 m/s to 150 m/s with a reduction in pressure in the chamber from 80 MPa to 6.7 MPa. At lower pressure in the chamber, there is less resistance to slow plasma jet and particle deposition. Therefore, when pressure in the chamber decreases, the maximum particle velocities move away from the anode opening and particle deceleration becomes more gradual.

With the decrease of arc power from 31 kW to 21 kW, it was noticed that acceleration was reduced as well as the maximum particle velocity for both powders. The actual value of the reduction of the maximum velocity is higher for the powder of lower mass density (Al_2O_3) and a relative change in velocity for both powders is roughly 20%. The results show that a change in the plasma arc power can significantly affect the velocity of powder particles, but it is also clear that a change of plasma arc power of only 1 or 2 kW during deposition will not have a considerable impact.

This article has shown that the change of pressure in the vacuum chamber for Al_2O_3 and W powders can lead to a change in the average velocity of powder particles with the plasma spray distance depending on particle granulation distribution and the plasma arc power.

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СКОРОСТЬ ЧАСТИЦ ПОРОШКА В ПЛАЗМЕ ПОД НИЗКИМ ДАВЛЕНИЕМ

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ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Низкое давление инертного газа в вакуумной камере оказывает значительное воздействие на передачу скорости плазменных частиц на частицы порошка, время нахождения порошка в плазме и кинетическую энергию расплавленных частиц до момента соприкосновения с защитным слоем. На среднюю скорость частиц порошка, кроме низкого давления инертного газа в вакуумной камере наибольшее воздействие оказывает величина и плотность частиц порошка, а также сила плазменной дуги. Для измерения скорости частиц порошка в вакуумной камере под низким давлением используются лазерные измерители скорости. Средняя скорость частиц расплавленного порошка V = s/t рассчитывается, следующим образом: длина пути частиц порошка, прошедших между двумя очаговыми расстояниями лазерного луча делится на время прохождения частиц между двумя фокусами. Измерение давления производится в вакуумной камере, при давлении, которое чаще всего применяется: от 6,7–80 kPa. В данной работе представлено каким образом давление в

вакуумной камере, распределение гранулята, плотность и сила плазменной дуги влияют на среднюю скорость частиц порошка Al_2O_3 и W. Исследования показали, что скорость частиц порошка с меньшей плотностью может увеличиваться на 200 м/с при снижении давления в камере. Выявлено, что эффект давления на частицы с большей плотностью W значительно меньше, хотя он тоже важен, так как при снижении давления увеличивается скорость частиц до 50%. При уменьшении силы плазменной дуги снижается удельная скорость частиц обоих видов порошков.

Ключевые слова: ВПН, сила, плазменная дуга, скорость частиц порошка.

БРЗИНЕ ЧЕСТИЦА ПРАХА У ПЛАЗМИ НА НИСКОМ ПРИТИСКУ

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ВРСТА ЧЛАНКА: оригинални научни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Низак притисак инертног гаса у вакуум-комори знатно утиче на пренос брзине честица плазме на честице праха, време боравка честица праха у плазми и кинетичку енергију истопљених честица пре судара са подлогом. На средњу брзину честица праха, поред ниског притиска инертног гаса у вакуум-комори, највећи утицај има величина и масена густина честица праха и снага плазма-лука. За мерење брзине честица праха у вакууму на ниском притиску коморе примењује се ласерски мерач брзине. Средња брзина честица истопљеног праха V = s/t прорачунава се када се дужина пута честица праха које прођу између два жижна одстојања ласерског зрака поделе са временом пролаза честица између две жиже. Мерења се обављају за притисак у вакуум-комори који је најчешће од 6,7 до 80 kPa. У раду је приказана веза између средње брзине честица праха Al_2O_3 и W у зависности од притиска у вакуум-комори, расподеле гранулата, масене густине и снаге плазма-лука. Установљено је да се за прах мање масене густине може, уз смањење притиска у комори, повећати просечна брзина честица за 200 m/s. Ефекат притиска на честице веће масене густине W је мањи, мада је битан, јер се са смањењем притиска увећава средња брзина честица до 50%. Смањење снаге плазма-лука смањује максималне брзине честица за оба праха.

Кључне речи: ВПС, снага плазма-лука, брзина честица праха.

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ANALYSIS OF TWO GROUPS OF PLANE INFANTRY TARGETS AS SETS OF GEOMETRIC PRIMITIVES

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ARTICLE LANGUAGE: English

Abstract:

A comparison of two groups of plane shooting targets (PSTs) characterizing the shooter-silhouette in different observation and rifle-firing positions was the starting point for this study. Selected infantry targets are used for shooting training in the Russian Federation and in the Swiss Confederation. The comparison results of two target groups (five PSTs in each of them) showed a significant similarity of their geometric shapes. To explain this fact, a targets design system (TDS) was developed. The TDS is based on attributing a certain number of simple geometric shapes – geometric primitives (GP). In our case, the number of GPs was equal to ten (five polygons for Russian and five polygons for Swiss targets). The TDS enabled building a human-like target silhouette. If two sides of two adjoining GPs or their parts become common for them, then such GPs can be combined into one common geometric figure whose area is equal to the sum of the two GPs. The TDS was further transformed into two isomorphic graphs. Their adjacency matrix (AM) was obtained. The AM matrices for the Russian PSTs and the Swiss PSTs were the same. To improve the estimation of the area and the coordinates of the target centroid, a matrix modification of Bourke's formulas were proposed. The geometric areas for the Russian and Swiss PSTs and the location of their centroids were refined and compared. GNU Octave, GeoGebra and Mathcad were used as mathematical software for computer calculations and for graphic visualizations.

Key words: shooting target, geometric primitive, graph, adjacency matrix, centroid of a polygon, Octave, GeoGebra, Mathcad.

Introduction

An infantry shooting target is an object at which marksmen aim and shoot during shooting practice and owing to which shooting performance effectiveness is analyzed (Khaikov, 2018), (Khaikov, 2019). Usually, paper, cardboard, wood-based panels, plastic materials or metal plates are the basic materials for manufacturing two-dimensional or plane shooting targets. It is common that military shooting training with small arms is still conducted with human-like shaped targets, which imitate rival shooters as part of enemy's manpower.

The process of transformation of a three-dimensional moving combatant's figure into a two-dimensional plane silhouette, which is used now as a target, had various national and cultural traits in different armies of the world, but a common feature of the shape extraction phenomenon was the simplification of the outer contour of a shooter and its replacement with some abstract form. In the Soviet Army, schematized (polygon-like) silhouettes of shooting targets were enacted in the shooting training course of the 1969 year (MoD USSR[1], 1969). Such PSTs were used (without or with some modifications) in the Armed Forces of the Warsaw Pact.

From a geometric point of view, targets of the Swiss Confederation (*cibles de campagne*) are close to the shapes of Soviet/Russian military PSTs[2]. In the shooting training literature, there is also evidence of the targets sizes and their areas, but the generalized rules for constructing the geometric contours of a human's silhouette have not been disclosed. There is no systematic data on the coordinates of the geometric centers (centroids) for each of PSTs.

The aim of this paper is to reveal the construction principles and to analyse the geometry of two groups of PSTs representing silhouettes of the opposing force shooters. The main objectives of the research are the development of variants of target geometric description as polygons and the estimation of the target centroids coordinates and the target area using computer mathematics. GNU Octave, the interactive geometry software GeoGebra and the computer algebra system Mathcad are used to solve these sets of tasks.

[1] MoD USSR stands for the Ministry of Defense of the USSR.

[2] maybe vice versa because the article states the geometric similarity of target's forms, but does not explore the historical priority of their appearance.

Principles of the PSTs construction

The shooting target design process for combatant silhouettes has not been explained in scientific literature. Therefore, eliminating such a gap and explaining these rules from the point of view of planimetrics is a needful and urgent objective.

The set of human-like silhouettes (Fig. 1) consists of five different Soviet/Russian[3] targets with numbers 5, 5*a*, 6, 7 and 8 (Tarchishnikov, 2011) and, respectively, five Swiss *cibles de campagne* with the notations K, H, G, F, E (Shooting target, 2018). Below we give an interpretation of the silhouettes, which will be useful for their deeper understanding.

Table 1 shows target designations in English, Russian, German, and French. The attention should be paid to the target denominations used in the Armed Forces of the GDR[4] (MoD GDR, 1984). For example, the torso target (target No. 7) was called *the shooter shooting from the kneeling position*, and the man-sized figure (target No. 8) was named *the running shooter.*

Table 1 – Four language -interpretations of the PSTs names
Таблица 1 – Интерпретации названий плоских стрелковых мишеней на 4-х языках
Табела 1 – Називи ДМГ на четири језика

Types	English	Russian	German	French
Target 5	The head target	Головная фигура	Beobachter	Silhouette tête
Target 5*a*	The head and shoulders target	Голова и плечи	Eingegrabener Schutze	Tête et épaules
Target 6	The chest / upper torso target	Грудная фигура	Ligender Schutze	Silhouette buste
Target 7	The torso target	Поясная фигура	Kniender Schutze	Silhouette à genou
Target 8	Man sized / full sized target	Ростовая фигура	Laufender Schutze	Silhouette mannequin

A set of X- and Y-projections in the Cartesians system is usually used for describing plane targets. The performed analysis of the geometry of all ten targets shows that they are polygons whose vertices are connected by straight lines. The designations of the targets and their

[3] The notation S/R will be used in the tables for Soviet/Russian shorter writing.
[4] GDR stands for the German Democratic Republic.

geometrical dimensions in centimeters are shown in Fig. 1. The *cibles de campagne* were partially analyzed in the paper (Khaikov, 2019). It would also be interesting to know that the Armed Forces of the Polish People's Republic (PPR) developed their own PSTs entitled *figury bojowe* (*pol.*) (MoD PPR, 1977).

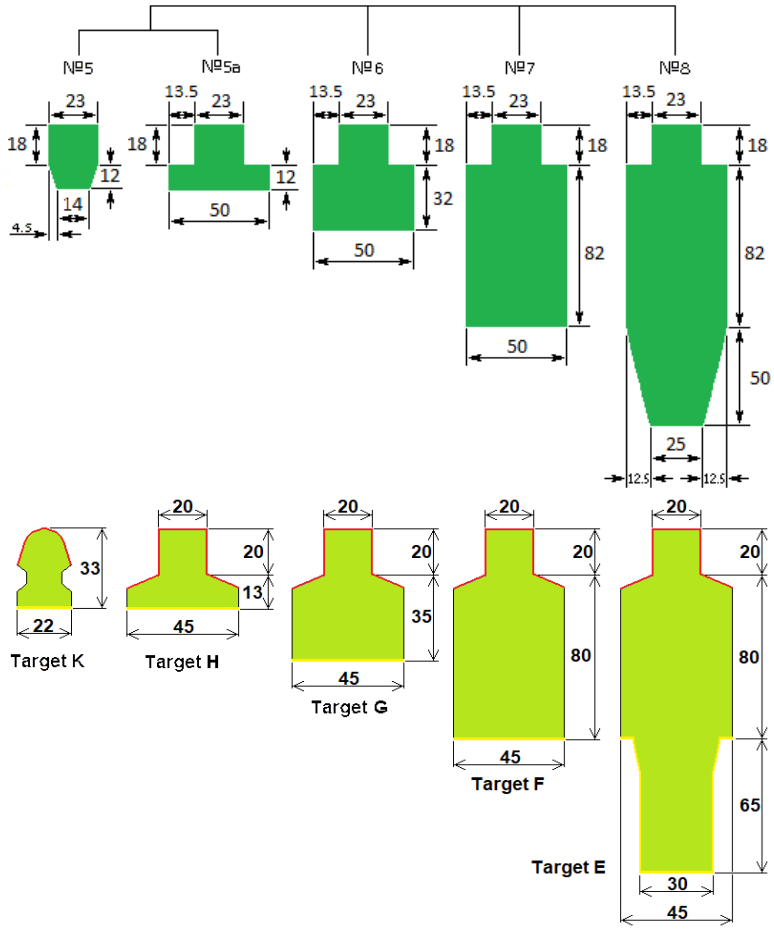


Figure 1 – Silhouettes of five Soviet/Russian PSTs (top row) and five Swiss shooting targets (cibles de campagne) (bottom row)
Рис. 1 – Пять советских / российских плоских мишеней (верхний ряд) и пять швейцарских мишеней (нижний ряд)
Слика 1 – Силуете пет совјетских/руских ДМГ (горњи ред) и пет швајцарских мета за гађање (доњи ред)

The geometric study shows that the Soviet/Russian and Swiss infantry targets are based on geometric primitives i.e. plane figures of an elementary form: triangles, rectangles and trapeziums. The silhouette design of PSTs is based on the following rules:

(1) The principle of simplifying the original complex form is the basis for the construction of infantry shooting targets. A complex silhouette is reproduced by merging into a coherent whole more simple GP;

(2) The silhouette of a PST is a plane figure, all vertices of which are interconnected by first order lines. By connecting the vertices with two-order or more order curves, it is possible to enhance the visual effect of target perception (for example, the Swiss target K);

(3) PSTs, being geometric shapes, are usually symmetric along the vertical axis OY.

PST No. 5*a* «head» is composed of a rectangle and an isosceles trapezoid, a large base of which is joined to the base of the rectangle. In all subsequent constructions, the «head» as a polygon acts as an independently functioning geometric primitive. For PST No. 5, the GP «shoulder» consists of a rectangle and a right-angled triangle. The right and left «shoulders» of PST No. 5 are symmetrical. In turn, figure No. 5 is a more difficult geometric primitive for PSTs No. 6-8. Based on this, we formulate the 4-th rule: «A more complex PST shape is built on the principle of merging a new geometric primitive with the shape that was formed on the previous step». Thus, targets No. 5*a*, 5-8 can be represented as a combination of the following five geometric primitives: «head», «shoulders (left / right)», «bottom of the chest», «bottom of the torso» and «legs». The GPs for Soviet/Russian targets are listed from left to right in Fig. 2*a*. The GPs for Swiss targets are represented in Fig. 2*b*. All dimensions in Fig. 2 are indicated in centimeters.

The figure «head»[5] (it is target No. 5, made of simpler shapes) for subsequent figures is also considered to be a geometric primitive. By merging it with the «shoulders» primitives[6], we obtain target No. 5 (or the Swiss target H). Further, by merging target No. 5 (we will consider it as the next geometric primitive) with «the bottom of the chest» primitive, we obtain target No. 6 (or the Swiss target G). Targets 7 and 8 (or the Swiss targets F and E) are made by the same rule of merging.

[5] geometric primitive «head» (Fig. 2*b*) was modified relative to the original Swiss target K.
[6] left and right shoulders.

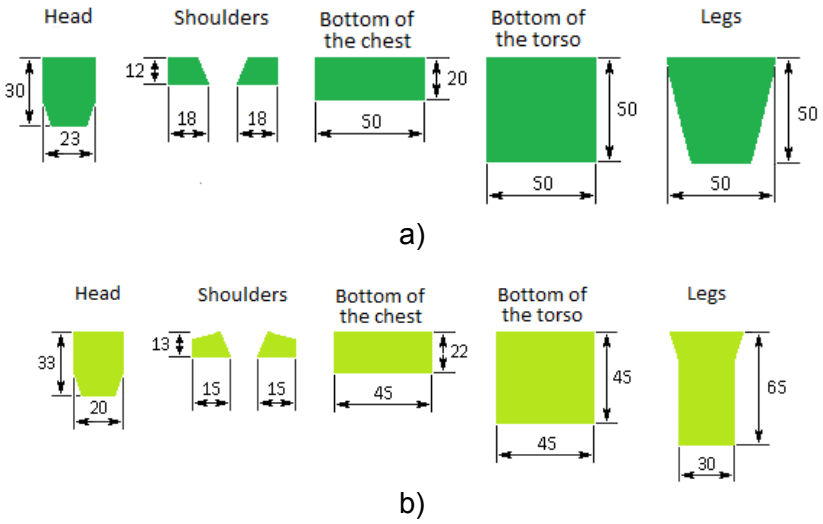


Figure 2 – Geometric primitives as constituent elements of PSTs
a) Soviet / Russian targets; b) Swiss targets;
Рис. 2 – Геометрические примитивы как составляющие
а) советских / российских мишеней; b) швейцарских мишеней;
Слика 2 – Основне геометријске фигуре као конститутивни елементи ДМГ
а) совјетских/руских мета; b) швајцарских мета

The comparative characteristics of the areas of the Soviet/Russian and the Swiss geometric primitives are illustrated in Table 2 (all dimensions – in square centimeters).

Table 2 – Comparative characteristic of the areas of GPs (square centimeters)
Таблица 2 – Сравнительная характеристика площадей ГП (кв. сантиметры)
Табела 2 – Поређење карактеристика површина ОГФ у квадратним центиметрима

Types	Head	Shoulders	Bottom of the chest	Bottom of the torso	Legs
A - areas of S/R GPs	636	2*189=378	1000	2500	1875
B - areas of Swiss GPs	614.5	2*154=308	990	2025	1988
100-(100*B/A) ratio, %	3.4	18.5	1	19	-6

From the data collected in Table 2, it can be seen that the GPs («head», «shoulders», «bottom of the chest», «bottom of the torso») of the Soviet/Russian targets are 1–19% bigger than the GPs of the Swiss

targets; however, the area of the Swiss GP «legs» are larger (6%) than the corresponding Soviet/Russian one.

The principle of sequential merging of geometric primitives and the formation of PSTs Nos. 5, 5*a*, 6–8 are shown in Fig. 3. At the top in the yellow rectangle, there are five GPs used in the merging process, and below, in a blue rectangle, there are five PSTs silhouettes formed from them.

The quantity of arrows at the bottom of the yellow rectangle (near numbers 0–4) shows the quantity of GPs which were used to build all five PSTs. The quantity of arrows at the top of the blue rectangle (near numbers 5–9) shows the quantity of the geometric primitives-components that were used to build an appropriate silhouette.

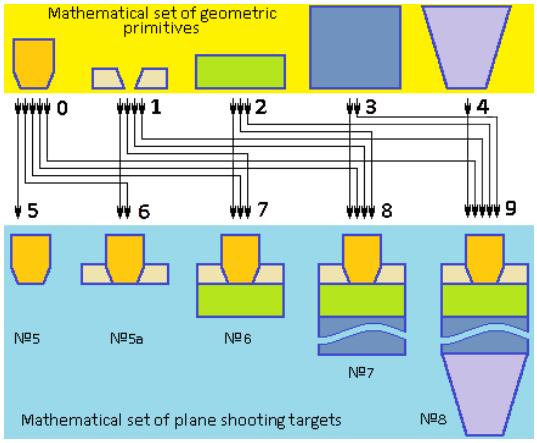
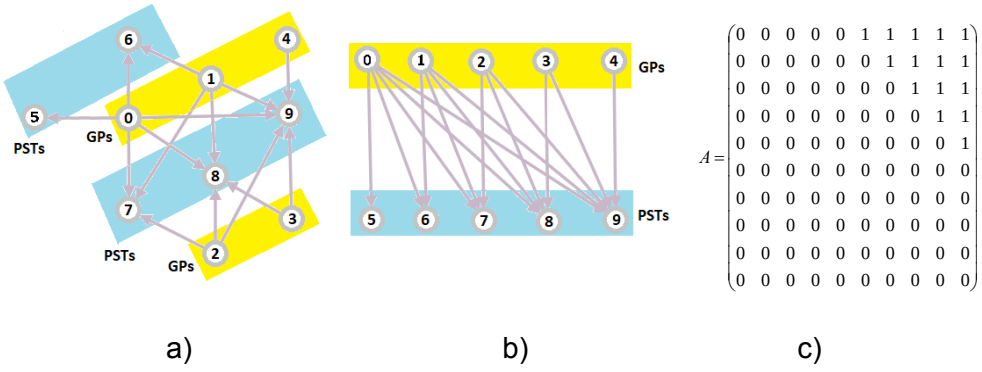


Figure 3 – The implementation of the principle of consistently combining geometric primitives into target silhouettes (the shooting targets design system)
Рис. 3 – Реализация принципа последовательного объединения геометрических примитивов в силуэты стрелковых мишеней (система порождения мишеней)
Слика 3 – Примена принципа конзистентног комбиновања основних геометријских фигура у силуете мета (систем пројектовања мета за гађање)

The construction of a PST silhouette can be compared with a mosaic puzzle. Each puzzle piece has a different shape. Mosaic elements in this task correspond to geometric primitives and the result of their conjunction (merging) will match the external contour of the target silhouette (see Fig. 3). When we attempt to place a puzzle piece in its place, it will only fit if it is placed properly in the correct location of the considered shooting target. In order to get the correct silhouette of target No. 8, not only is it necessary to use the six «mosaic elements», but also

to place them in a correct order. The structure such of Fig. 3 was named the target design system (TDS). The TDS consists of GPs (top row on a the yellow background) and PSTs (bottom row) that can be built from them. The TDS of Fig. 3 illustrates the formation of Soviet/Russian PSTs; however, this scheme can be used to explain the principle of the construction of Swiss PSTs.

If the GPs of Fig. 3 are numbered from 0 to 4, and the PSTs from 5 to 9, then the TDS can be transformed into a directed graph that has 10 (from 0 to 9) vertices (5 GPs + 5 targets) and 15 edges[7] (Fig. 4 *a, b*). Two graphs of Fig. 4 *a, b*[8] are isomorphic. Since the graph had 10 vertices thus the adjacency matrix (AM) ***A*** has a size of 10×10. Its 100 elements are presented in Fig. 4*c*:



a) b) c)

Figure 4 – Directed graphs (a, b) and graph adjacency matrix or the connection matrix (c)
Рис. 4 – Направленные графы (а, b) и их матрица смежности (с)
Слика 4 – Усмерени графови (а, b) и матрица повезаности графа (с)

The received AM (Fig. 4*c*) is a sparse matrix because it contains only 15 nonzero elements and 85 zero-elements. The matrix sparsity is 85%, and the matrix density – 15%. All nonzero-valued elements form a special upper triangular matrix with four diagonals that are parallel to the main diagonal. The AM is singular, since its determinant is 0. It should be noted that the AMs for Soviet/Russian and Swiss PSTs are the same.

The bipartite graph of Fig. 4*b* is a graph whose vertices are divided into two disjoint and independent sets of GPs / PSTs such that every edge connects a vertex in GPs to one in PSTs.

[7] The edge is a connection between two vertices.
[8] Graphs of Fig. 4*a*, 4*b* were built by using Internet-application http://graphonline.ru .

Geometric specification of PSTs

The main way of the geometric description of PST silhouettes is recreating them by the projections of the sides on the X and Y axes of the Cartesian coordinate system. But for describing the target contour, three more ways can be used:

1. Representation of the PST by the coordinates of the vertices of the polygon that describes the silhouette. The shape-forming matrix consists of two columns: the first column contains the coordinates of the abscissas, and the second - the coordinates of the ordinates.

The coordinates of the six vertices of target 5*a* (left matrix) and the modified «head» primitive (right matrix) written in the form of a Mathcad-matrix are shown below. These are rectangular matrices, each row of which contains the X and Y coordinates (cm) of the corresponding vertex of the polygon, while the seventh row repeats the first vertex coordinates and makes the contour of the target closed:

$$T1 := \begin{bmatrix} 18 & 0 \\ 32 & 0 \\ 36.5 & 12 \\ 36.5 & 30 \\ 13.5 & 30 \\ 13.5 & 12 \\ 18 & 0 \end{bmatrix} \qquad T2 := \begin{bmatrix} 16 & 0 \\ 29 & 0 \\ 32.5 & 13 \\ 32.5 & 33 \\ 12.5 & 33 \\ 12.5 & 13 \\ 16 & 0 \end{bmatrix} .$$

Using the Cartesian coordinate system, Fig. 5*a* illustrates the increase in the height of Soviet/Russian PSTs if every new GP is included in the target composition. All geometrical dimensions of Fig. 5*a* are in centimeters. The image was obtained using GNU Octave software.

2. The target silhouette can be described by a set vector magnitudes and direction angles relative to the previous one Fig. 5*b*. The geometrical dimensions of Fig. 5*b* are in millimeters. The vertices of the targets (as plane polygons) are designated as A1, A2, ... Ai. The angles between the sides (or edges) of both polygons (Fig. 5*b*) are in degrees. The dashed line in Fig. 5*b* (right fragment) shows the connection boundary of the GP «head» with the primitive «shoulders».

3. The silhouette description using analytical equations of the sides of the polygon with an indication of their boundaries (start/end points).

For method No. 2, the vector magnitudes and the direction angles can be replaced by the coordinates of the vector in the Cartesian coordinate system (XOY).

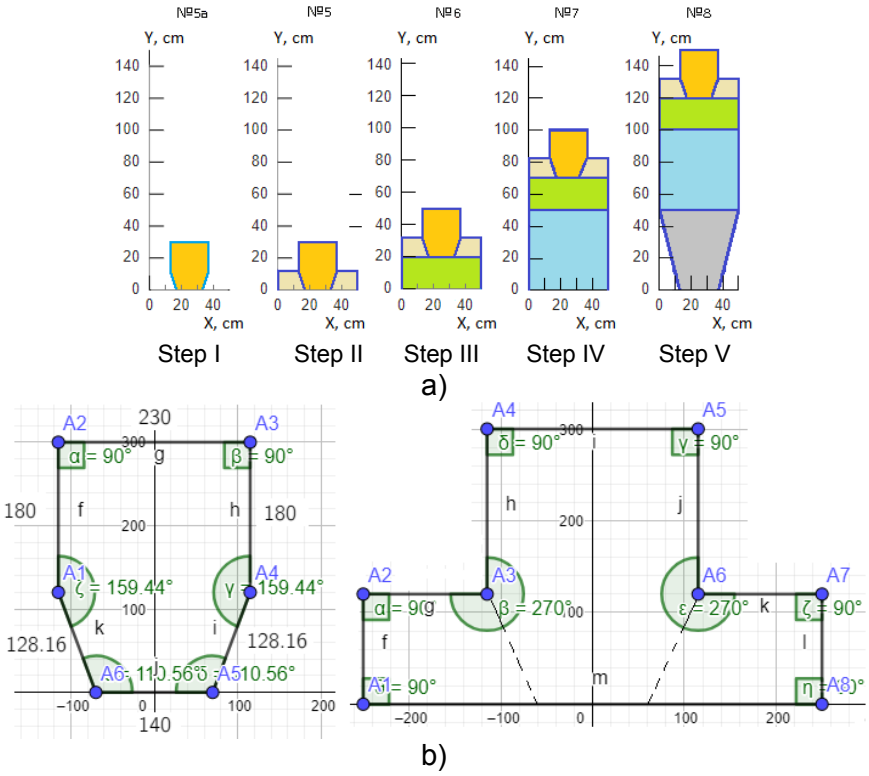


Figure 5 – Increase of the height of shooting targets relative to each other (a) and their structure (b)
Рис. 5 – Увеличение высоты стрелковых мишеней относительно друг друга (а) и структура мишеней (b)
Слика 5 – Повећање висина мета за гађање у међусобном односу (а) као и у односу на њихову структуру (b)

For a shooter, the necessary a priori information about a target is: the target size (the maximum width and the maximum height); the target area, and the coordinates (abscissa and ordinate) of the target centroid[9].

[9] The centroid of a polygon is also known as the «center of gravity» or the «center of mass».

The geometrical dimensions and the description of PSTs can be found in shooting reference books, for example (Tarchishnikov, 2011, pp.118-120), (MoD GDR, 1984), (MoD PPR, 1977).

Shoelace formula (or Gauss's area formula) is a mathematical tool for estimating the PST area like a geometric polygon. If the numbering of the vertices of the polygon is counterclockwise, then its area A can be calculated (Bourke, 1988):

$$\mathrm{A} = \frac{1}{2}\sum_{i=0}^{N-1}\left(x_i y_{i+1} - x_{i+1} y_i\right), \tag{1}$$

where *N* is the number of vertices of the polygon.

Since the determinant of a 2×2 matrix ***B*** (b_{11}=*a*; b_{12}=*b*; b_{21}=*c*; b_{22}=*d*) is

$$|B| = \det(B) = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc\,.$$

Expression (1) can be modified

$$\mathrm{A} = \frac{1}{2}\sum_{i=0}^{N-1}\begin{vmatrix} x_i & y_i \\ x_{i+1} & y_{i+1} \end{vmatrix} \tag{2}$$

but in (Wolfram MathWorld, 2018) the area's formula is given based on the sum of determinants (*det*)

$$\mathrm{A} = \frac{1}{2}\left(\begin{vmatrix} x_0 & x_1 \\ y_0 & y_1 \end{vmatrix} + \begin{vmatrix} x_1 & x_2 \\ y_1 & y_2 \end{vmatrix} + \ldots + \begin{vmatrix} x_{N-1} & x_0 \\ y_{N-1} & y_0 \end{vmatrix}\right) = \frac{1}{2}\sum_{i=0}^{N-1}\begin{vmatrix} x_i & x_{i+1} \\ y_i & y_{i+1} \end{vmatrix} \tag{3}$$

but, since

$$|B| = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = \begin{vmatrix} a & b \\ c & d \end{vmatrix}^T = \begin{vmatrix} a & c \\ b & d \end{vmatrix} = \begin{vmatrix} d & b \\ c & a \end{vmatrix} = \begin{vmatrix} d & c \\ b & a \end{vmatrix}$$

we repeat expression (2). Therefore, the transformed Bourke's formula (2) and the expression from (Wolfram MathWorld, 2018) (3) coincided.

The resulting formula (2) is more convenient, since it corresponds to the matrix of the coordinates that describe the vertices of the polygon. If the vertices of the polygon are numbered not counterclockwise, but vice versa, then this imperfection can be eliminated in two ways:

(1) vertical flip of the matrix; in the computer software Mathcad, this can be implemented using the *vertflip(M)* command;

(2) by using the absolute value of A (the modulus of a real number A).

In order to calculate the polygon's area by using formulas (1, 2), it is necessary to know the number of vertices of the polygon (N); then, for the considered targets, we will collect them in Table 3.

Table 3 – Comparative characteristics of the number of vertices for PSTs
Таблица 3 – Сравнительная характеристика количества вершин для мишеней
Табела 3 – Упоредне карактеристике броја врхова ДМГ

Types	Head target	Head and shoulders	Upper torso target	Torso target	Full sized target
Number of vertices for S/R PSTs	6	8	8	8	10
Number of vertices for Swiss PSTs	6	8	8	8	14

Table 3 shows that the result of comparing the N numbers for Soviet/ Russian and Swiss targets shows the similarity of these two groups of PSTs. The minimum number of vertices is six, and the maximum is fourteen.

Using formulas (1) and (2), we estimate the area of the Soviet/ Russian and Swiss targets. The resulting data are combined in Table 4. The areas of all Soviet/Russian targets are bigger by 3.4–12.8 percent than the corresponding areas of the Swiss targets.

Table 4 – Comparative characteristics of the PST areas
Таблица 4 – Сравнительная характеристика площадей стрелковых мишеней
Табела 4 – Упоредне карактеристике површина ДМГ

Types	Head target	Head and shoulders	Upper torso target	Torso target	Full sized target
A1 - areas of S/R PSTs, cm^2	636	1014	2014	4514	6389
A2 - areas of Swiss PSTs, cm^2	614.5	922.5	1913	3938	5925
100-(100*A2/A1) ratio, %	3.4	9.0	5.0	12.8	7.3

The ratio of areas of geometric primitives in the total area of four targets for the group of Soviet/Russian targets is shown in Fig. 6. White color indicates the area of the GP «head»; orange color corresponds to the area of primitive «shoulders»; dark blue is «bottom of the chest»; blue specifies, «bottom of the torso»; and purple means «legs». As the shape of a PST becomes more complex, the area of each part of the GP set is decreased. The target «head» is absent since only one GP is used for its formation.

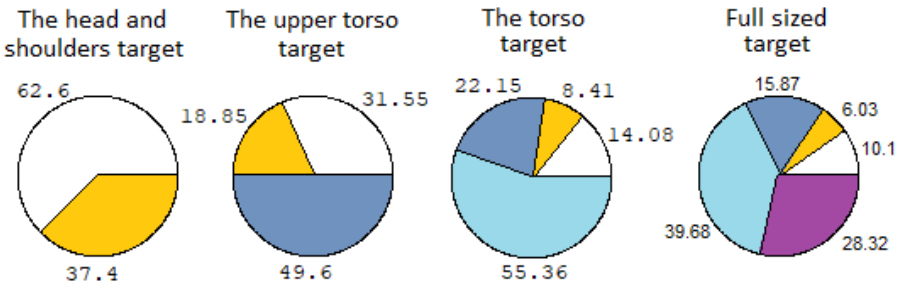


Figure 6 – The proportion of GP areas in the total area of PSTs
Рис. 6 – Доля площади геометрических примитивов в общей площади стрелковых мишеней
Слика 6 – Удео површина ОГФ у укупној површини ДМГ

Another kind of Bourke's equations (Bourke, 1988) can be used for estimating the coordinates of the polygon centroid:

$$C_x = \frac{1}{6A}\sum_{i=0}^{N-1}(x_i + x_{i+1})(x_i y_{i+1} - x_{i+1} y_i), \tag{4}$$

$$C_y = \frac{1}{6A}\sum_{i=0}^{N-1}(y_i + y_{i+1})(x_i y_{i+1} - x_{i+1} y_i), \tag{5}$$

where N is the number of vertices of the polygon.

Applying to (4, 5) an expression for the 2×2 determinant ($|A|$ or *det*(A)), we modify these formulas

$$C_x = \frac{1}{6A}\sum_{i=0}^{N-1}\left[\begin{vmatrix} x_i & -1 \\ x_{i+1} & 1 \end{vmatrix} \cdot \begin{vmatrix} x_i & y_i \\ x_{i+1} & y_{i+1} \end{vmatrix}\right], \tag{6}$$

$$C_y = \frac{1}{6A}\sum_{i=0}^{N-1}\left[\begin{vmatrix} y_i & -1 \\ y_{i+1} & 1 \end{vmatrix} \cdot \begin{vmatrix} x_i & y_i \\ x_{i+1} & y_{i+1} \end{vmatrix}\right]. \quad (7)$$

For such interpretation, the area of the polygon is the sum of the 2×2 determinants, and the abscissa and the ordinate of the centroid are their product. Thus, the formulas for the area and the coordinates of the polygon centroid now have a matrix form.

We calculate the centroid coordinates of the Soviet/Russian PSTs and compare them with the corresponding coordinates of the centroids of the Swiss targets. The results of the comparison are given in Table 5.

Table 5 – Comparative characteristic of the coordinates of PST centroids
Таблица 5 – Сравнительная характеристика координат центроидов стрелковых мишеней
Табела 5 – Упоредне карактеристике координата центроида ДМГ

Types	Head target	Head and shoulders	Upper torso target	Torso target	Full sized target
C_x of S/R PSTs, cm	25	25	25	25	25
C_y of S/R PSTs, cm	15.9	12.1	21.1	45.6	75.7
C_x of Swiss PSTs, cm	22.5	22.5	22.5	22.5	22.5
C_y of Swiss PSTs, cm	17.4	13.3	22.7	44.5	83.8
$100 \cdot C_y/H_{max}$ for S/R	53%	40.3%	42.2%	45.6%	50.4%
$100 \cdot C_y/H_{max}$ for Swiss	52.7%	40.3%	41.2%	44.5%	50.8%

The value of $100 \cdot C_y/H_{max}$ shows the location of the centroid Y-coordinate relative to the PST height. The ratio of these parameters for targets such as «head», «head and shoulders» and «full sized target» for Soviet/Russian and Swiss targets is less than one percent. For the «upper torso target» and «torso target» targets its 2.2 and 2.4 percent. The X-coordinate of the centroid lies on the axis of symmetry (22.5 cm for Swiss PSTs and 25 cm for Soviet/Russian targets).

Conclusions

Planimetrics and graph theory allowed us to formulate a general construction principle for analysing Soviet/Russian and Swiss PSTs, which is based on the use five similar in geometry GPs. To compare different groups of infantry targets, a TDS was proposed that consists of geometric primitives set; directed lines between GPs and obtained

infantry targets. The TDS can be represented as a graph or an adjacency matrix.

Investigated by us two target groups had the same directed graphs and, therefore, an equal adjacency matrix. This matrix refers to the type of sparse matrix and has the following characteristics: dimension: 10×10 (15 nonzero elements and 85 zero-elements); matrix sparsity is 85%, and matrix density – 15%.

For formulas which determining of an area and centroid coordinates of polygons we propose their matrix forms. These kinds of expressions are more convenient by combining information about polygon vertices coordinates in a matrix with n×2 dimension.

Comparison of Soviet/Russian and Swiss PSTs showed that areas of all Soviet/Russian targets are more by 3.4–12.8% than the corresponding area of Swiss targets. The exception to this rule relates to the ratio of the areas of «man sized» targets. Due to the fact that all targets have an vertical axis of symmetry, the X-coordinate of a target centroid depends on location its abscissa. The Y-coordinate of a centroid was compared with a height of the target. The maximum offset of the Y-coordinate of centroids for Soviet/Russian targets relative Swiss targets was 2.4%. Thus, the similarity of the geometry of two reviewed groups of PSTs is explained by the resemblance of a formation mechanism, the uniformity of the mathematical graph (adjacency matrix) and identified geometric primitives. The results of this study can be extended to other PSTs groups.

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АНАЛИЗ ДВУХ ГРУПП ПЛОСКИХ СТРЕЛКОВЫХ МИШЕНЕЙ КАК СОВОКУПНОСТЕЙ ГЕОМЕТРИЧЕСКИХ ПРИМИТИВОВ

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ЯЗЫК СТАТЬИ: английский

Резюме:

Сравнение двух групп стрелковых мишеней, которые характеризуют силуэт стрелка в различных его положениях при ведении наблюдения и стрельбе, стало отправной точкой для начала исследования. Выбранные для рассмотрения мишени используются в процессе стрелковой подготовки в Российской Федерации и в Швейцарской Конфедерации. Результат сравнения двух групп мишеней (по пять мишеней в каждой группе) показал межгрупповое сходство их геометрических форм. Для объяснения этого факта, была разработана система построения мишеней (СПМ). Она основана на выделении некоторого количества простых геометрических фигур во множество так называемых геометрических примитивов (ГП) с дальнейшим конструированием мишеней на их основе. В нашем случае общее количество ГП – пять в каждой рассматриваемой группе. Принцип объединения ГП состоит в том, что если две стороны двух смежных примитивов или их части являются общими для них обоих, то такие ГП объединяются в одну общую геометрическую фигуру, площадь которой равна сумме их площадей. Далее СПМ была преобразована в два изоморфных графа, которые позднее были трансформированы в матрицы смежности. Такие матрицы для российских и швейцарских мишеней оказались равными. Для

улучшения оценки площади и координат центроида стрелковой мишени как плоского многоугольника была предложена матричная модификация формул Берка (Bourke). В результате их использования были уточнены значения геометрических площадей для российских и швейцарских мишеней и значения координат их центроидов. В качестве математического программного обеспечения для реализации компьютерных расчётов и графической визуализации результатов построений были использованы GNU Octave, GeoGebra и Mathcad.

Ключевые слова: стрелковая мишень, геометрический примитив, математический граф, матрица смежности, центроид многоугольника, Octave, GeoGebra, Mathcad.

АНАЛИЗА ДВЕ ГРУПЕ ДВОДИМЕНЗИОНАЛНИХ ПЕШАДИЈСКИХ МЕТА КАО СКУПОВА ОСНОВНИХ ГЕОМЕТРИЈСКИХ ФИГУРА

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ОБЛАСТ: примењена математика (балистика, теорија гађања)
ВРСТА ЧЛАНКА: оригинални научни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Ова студија пореди две групе дводимензионалних мета за гађање (ДМГ) у облику силуете стрелца који пуца из пушке из различитих положаја. Одабране пешадијске мете за гађање користе се за увежбавање гађања у Руској Федерацији и Швајцарској Конфедерацији. Поређење резултата две групе мета (по пет у свакој групи) показује значајну сличност њихових геометријских облика. Да би се објаснила ова чињеница, развијен је систем пројектовања мета (СПМ) заснован на одређеном броју једноставних геометријских облика – основних геометријских фигура (ОГФ). У нашем случају тај број је био десет (пет полигона за руске и пет полигона за швајцарске мете). Користећи СПМ, израђене су мете у облику људских силуета. Ако две странице две суседне ОГФ, или њихови делови, постану заједнички, њиховим комбиновањем добијена ОГФ има површину једнаку укупним површинама двеју површина суседних ОГФ. Даљом трансформацијом СПМ добијају се два изоморфна графа. Њихове добијене матрице повезаности (МП) биле су исте и за руске и за швајцарске ДМГ. За побољшање естимације површина и координата центроида мета, предложена је модификација матрице Буркеовим формулама. Геометријске површине руских и швајцарских ДМГ, као и локације њихових центроида, прецизно су одређене и упоређене. Математички софтвери коришћени за

компјутерска израчунавања и визуализацију путем графова били су GNU Octave, GeoGebra и Mathcad.

Кључне речи: мета за гађање, основне геометријске фигуре, граф, матрица повезаности, центроид полигона, Octave, GeoGebra, Mathcad.

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PROBLEMS OF QUANTIFYING SAVINGS WITHIN ASSET ACQUISITION

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Abstract:

The article describes the application of standard methods of determining savings in the commodity acquisition, which do not impose an obligation to evaluate the centralized award system and the Methodology for the Quantification of Savings set by the Ministry for Regional Development of the Czech Republic. The process is related to the tyres within the Ministry of Defence acquired in the centralized and decentralized manners in the period 2014-2017. In the decentralized manner, higher variability of unit prices and higher variability of the number of suppliers are expected. In the centralized manner, the constant price level is predicted since the supplier is permanent during the whole period of the performance of the framework agreement for a period of two years. Statistical methods - the hypothesis testing method - are used to compare the unit prices in both manners. The comparison has been carried out by the two-sample t-test of the mean values of two selections in order to determine the differences in the amount of financial resources. It has been found that the unit prices of the centralized acquisition are higher than the unit prices of the decentralized acquisition; therefore, the centralized manner of acquisition is more expensive than the decentralized one.

Key words: absolute savings, centralized purchase, decentralized purchase, methods, tyres, relative savings, statistics.

Introduction

Centralized awarding of public contracts is based on the condition that the central bodies of state administration have at least two subordinate organizations in their organizational structure. This condition is satisfied by all ministries of the Czech Republic, i.e. the Ministry of

Defence of the Czech Republic as well. This implies the obligation to centralize public contracts for the acquisition of commodities according to Annex 2 of The Czech Republic Government Decree No. 24, 2016, irrespective of the expected value of the public contract (Parliament of the Czech Republic, 2016). The commodities concerned are included exhaustively: electricity, gaseous fuels, telecommunications services, office technology and equipment, computers and data processing machines, passenger cars, furniture, and office supplies. The commodities underlying public contracts are subject to a centralized manner of awarding; their estimated value exceeds 2 million CZK (Parliament of the Czech Republic, 2016). This condition is met by most of the public contracts across all public bodies. In the first group of the commodities subject to the centralized awarding of public contracts, there is an obligation to evaluate the departmental systems for the past year, the part of which is quantifying the savings. As for the second group of commodities, the public bodies are not under this duty.

Subject of research

Tyres as a commodity are a subject of the research within the Ministry of Defence. They are acquired in a centralized manner for the main types of military ground vehicles (TATRA, PANDUR, IVECO, DINGO, UAZ, LANDROVER) and in a decentralized manner for other types of military ground vehicles. It is a very wide range of tyre types and, therefore, the portfolio mentioned has been defined only for the TATRA 815 vehicle type as it creates the largest part of vehicles within the Army of the CR.

Research methods

The following standard methods (Ministry for Regional Development of the Czech Republic, 2017) have been used to quantify savings: the historic pricing method, the consumption basket method and the benchmark price method.

The historic pricing method lies in comparing the unit prices achieved when purchasing a particular commodity in two different periods. The time period must be the same, usually one calendar year. At the same time, inflation must be taken into account (preferably at the level of a given commodity). The method is suitable for the commodities that are internally poorly structured and the financial volume for the purchase of this commodity can be related to a specific unit of measure, e.g. electricity or natural gas. The advantage is the simplicity of

calculation and small demands for data logging. The disadvantage is the need to find a common unit of measure and take into account the year-on-year price indices published by the Czech Statistical Office (Czech Statistical Office, 2018). The mathematical relation is given:

- For the **relative** amount of savings: 1 - (the price for a unit of measure in the current year / the price for a unit of measure in the previous year expressed in the prices of a current year, i.e. adjusted by the year-on-year Consumer Price Index); (1)

- For the **absolute** amount of savings: the relative amount of savings* the price for a unit of measure in the previous year expressed in the prices of the current year. (2)

- The application of this method is inappropriate for the surveyed tyre.

The consumption basket method lies in comparing the prices at the level of consumption baskets. The commodity as a whole is not investigated, but the price movements over time in selected standard products or services within a given commodity are investigated. The method is commonly used in statistical practice to estimate the changes in price levels. When applying this method, it is always necessary to identify at least three standard commodities that do not change over time (i.e. they are purchased annually, such as telecommunications or office supplies). The advantage is the simplicity of calculation, small demands for data logging and the relative high accuracy of savings, especially for the purposes of comparing the individual departmental systems of the centralized award, if consumption baskets are the same for all of these systems. The disadvantage is the determination of the consumption basket itself since it depends on who determines the consumption basket and in what way. The mathematical relation is given:

- For the **relative** amount of savings: 1 - (the total price for the consumption basket achieved in the current year / the total price for the consumption basket achieved in the previous year expressed in the current year prices adjusted for the year-on-year Consumer Price Index). (3)

The total price for the consumption basket achieved in the current year will be calculated as the sum of financial volumes of purchases of individual items in the consumption basket and the financial volume of the purchase will be calculated as the product of the quantity purchased in the current year and the prices in the current year. The total price for the consumption basket achieved in the previous year will be calculated as the sum of financial volumes of purchases of individual items in the

consumption basket and the financial volume of the purchase will be calculated as the product of the quantity purchased in the current year and the prices in the previous year:

- For the **absolute** amount of savings: the relative amount of savings* the financial volume of the goods acquisition for the previous calendar year expressed in the prices of the current year. (4)

The application of this method to quantify savings for the commodity under investigation may be appropriate.

The benchmark price method lies in comparing the prices of the purchase of specific products or services (i.e. individual items within a particular commodity) with benchmark prices, which are presented as follows:

a) By the list price - the price published on the websites or in the catalogue of the supplier;

b) By the average value of the offer price within the tender;

c) By the average price published on one of the web portals comparing prices in Internet-based shops.

The above-mentioned method assumes that centralization will result in price reductions below “normally quoted market prices”. The method can be used with each commodity. The advantage is high accuracy (the comparison with market prices is more accurate than the comparison with historical prices). The disadvantage of the method is the difficult check of saving calculation, which cannot be compared across the individual departmental systems, and the high demands for data logging. The mathematical relation is given:

- For the **relative** amount of savings: 1 - (the total price for selected products achieved in the current year / the total price for selected products achieved for benchmark prices). (5)

The total price for selected products achieved in the current year will be calculated as the sum of the financial volumes of selected product purchases during the entire current calendar year (if a given product was purchased in the course of the year repeatedly, it is necessary to add up all of these purchases). The total price for selected products achieved for benchmark prices will be calculated as the sum of the financial volumes of selected product purchases and the financial volume of the purchase will be calculated as the product of the quantity purchased in the current year and the average benchmark price:

- For the absolute amount of savings: the relative amount of savings* (the financial volume of the goods purchase in the current year / (1 - the relative amount of savings). (6)

The application of the method for the commodity under investigation may be limited in 2017 for benchmark prices a) and c) since it is based on the assumption that the prices found on suppliers' websites or the average prices of Internet-based shops do not differ from those in 2017. Benchmark prices b) are not used due to unavailability of the contractual documentation. The above-mentioned methods have also been used to compare the centralized and decentralized manner of acquisition.

The statistical method for hypothesis testing - the two-sample t-test (Neubauer et al, 2016) has been used to compare the unit prices of the centralized and decentralized manner of tyre acquisition for the period 2014-2017, irrespective of the type of vehicles. The mathematical relation is given for the basic test criterion (statistics) as follows:

$$t = \frac{\bar{d}}{s_d}.\sqrt{n} \tag{7}$$

where

$\bar{d}$ - the arithmetic mean of the differences of both sets,

s_d - the standard deviation of the differences of both sets,

n - number of measured unit prices (number of set elements).

It follows from the above-mentioned data that testing the statistical hypotheses is based on the assumption of the probability of dividing the monitored random variable, i.e. null hypothesis H, against which an alternative hypothesis A is built. The validity of the null statistical hypothesis is verified based on the selection values. In this case, this is a paired test of two selections, in which the equivalence of the mean values is

$$H : \mu_1 = \mu_2 . \tag{8}$$

When the null hypothesis H is valid, the test criterion (7) has Student's t-distribution (v) with degrees of freedom

$$v = n - 1 . \tag{9}$$

According to the alternative hypothesis, the critical regions W_α are selected, where α represents the level of significance - the probability that the null hypothesis will be rejected, most often $\alpha = 0.05$:

$$> \mu_2 \Rightarrow W_\alpha\{t; t \geq t_{1-\alpha}(v)\}, \quad (10)$$

$$A: \mu_1 < \mu_2 \Rightarrow W_\alpha\{t; \leq -t_{1-\alpha}(v)\}, \quad (11)$$

$$A: \mu_1 \neq \mu_2 \Rightarrow W_\alpha\{t; |t| \geq t_{1-\frac{\alpha}{2}}(v)\}, \quad (12)$$

where $t_{1-\alpha}(v), t_{1-\frac{\alpha}{2}}(v)$ the Student's distribution quantiles are shown in the statistical tables (Neubauer et al, 2016). Based on the calculation of the test criterion t and its comparison with the critical values $t_{1-\alpha}(v), t_{1-\frac{\alpha}{2}}(v)$, a conclusion on the rejection or non-rejection of H will be set, i.e. whether the unit prices of the centralized acquisitions are higher than the unit prices of the decentralized acquisitions.

Results of research

Quantification of tyre savings in the centralized manner of acquisition

Within the quantification of savings for the T-815 tyres acquired in the centralized manner, when comparing unit prices, their mutual agreement in 2014-2015 was found since the supplies during this period were provided by a single supplier. These are agreed prices in the framework agreement, which are constant during the whole period of the performance of the agreement. The comparison of 2015-2016 was not made due to the acquisition of one commodity. A possible comparison was over the years 2015 and 2017 (2017 would be considered the current year). However, this does not correspond to the mathematical relations of the above-mentioned standard methods from the viewpoint of the sequence of the studied periods, i.e. successive years. In this case, the consumption basket method with relations (3) and (4) is used to quantify the savings. The above-mentioned facts are stated in Table 1.

Table 1 – Overview of the T-815 tyres acquired in the centralized manner in 2015 and 2017
Таблица 1 – Обзор покрышек для Т-815, приобретенных методом централизованной закупки в 2015 и 2017 гг.
Табела 1 – Преглед гума за Т-815 набављених централизованим поступком набавке 2015. и 2017. године

Period – year	2017			2015		
Type of tyres	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]
TYRE 12 R22.5 DM1 M+S	262	7,792.40	2,041,608.80	511	8,457.90	4,321,986.90
TYRE 12,00 R20 BS71 ROAD	168	9,105.25	1,529,682.00	199	10,043.00	1,998,557.00
TYRE 11.00 R20 NR 55	282	8,385.30	2,364,654.60	296	9,196.00	2,722,016.00
TYRE 445/65 R22.5 BS49	210	13,479.40	2,830,674.00	451	13,673.00	6,166,523.00
TOTAL			8,766,619.40			15,209,082.90

On the basis of unit prices, it is possible to state that the prices of the items in question in 2015 are higher than those in 2017. The next step includes the conversion of the prices in 2015 to the prices in 2017. The result is illustrated in Table 2.

On the basis of (3), the relative savings in 2017 are 0.39 (i.e. 39%) as compared to 2015 and on the basis of relation (4), the absolute savings are equal to 5,588,499.95 CZK. In spite of the increasing inflation from 2015 to 2017 by 2.2% (from 0.3% to 2.5%) (https://www.czso.cz/, nd), the unit prices in 2017 are lower as a result of new lower agreed prices of another supplier for the 2016 - 2018 period of the performance of the agreement.

Table 2 – Conversion of the prices of the T-815 tyres acquired in the centralized manner in 2015 to the prices in 2017 (the current year)
Таблица 2 – Пересчет цен на шины Т-815, приобретенных централизованно в 2015 году, в цены в 2017 году (текущий год)
Табела 2 – Конверзија цена гума за Т-815 набављених 2015. године централизованим поступком набавке у цене из 2017. године (текућа година)

Period – year	2017			2015		
Type of tyres	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]
TYRE 12 R22.5 DM1 M+S	262	7,792.40	2,041,608.80	511	7,792.40	3,981,916.40
TYRE 12.00 R20 BS71 ROAD	168	9,105.25	1,529,682.00	199	9,105.25	1,811,944.75
TYRE 11.00 R20 NR 55	282	8,385.30	2,364,654.60	296	8,385.30	2,482,048.80
TYRE 445/65 R22.5 BS49	210	13,479.40	2,830,674.00	451	13,479.40	6,079,209.40
TOTAL			8,766,619.40			14,355,119.35

In case of benchmark prices, a comparison has been used on the www.heureka.cz web portal. The list prices could not be used due to the unavailability of the said types of tyres in terms of their exact designation on the supplier's web portal. The result of the research is Table 3.

According to relations (5) and (6), relative savings of 13% and absolute savings of 1,045,468.47 CZK have been set. The current supplier delivers the tyres of the said types for the lowest prices compared to both 2015 (consumption basket) and benchmark prices; this is illustrated in Table 2 and Table 3. These prices are in relation to 2018 and their current amount may differ from the benchmark prices in 2017.

Table 3 – Determination of benchmark prices for the T-815 tyres acquired in the centralized manner
Таблица 3 – Определение ориентировочных цен на шины Т-815, приобретенных централизованно
Табела 3 – Одређивање цена бенчмаркингом за гуме за Т-815 набављене централизованим поступком набавке

Period – year	2017			Benchmark price		
Type of tyres	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]
TYRE 12 R22.5 DM1 M+S	262	7,792.40	2,041,608.80	262	9,181.00	2,405,422.00
TYRE 12.00 R20 BS71 ROAD	168	9,105.25	1,529,682.00	168	9,618.00	1,615,824.00
TYRE 11.00 R20 NR 55	282	8,385.30	2,364,654.60	282	9,423.00	2,657,286.00
TYRE 445/65 R22.5 BS49	210	13,479.40	2,830,674.00	210	15,967.00	3,353,070.00
			8,766,619.40			10,031,602.00

Quantification of tyre savings in the decentralized acquisition manner

The quantification of savings in the decentralized manner of the T-815 tyre acquisition has been aimed at 2014 and 2015 (the current year). The research in other years was not possible since only one common item was acquired both for 2015 - 2016 and for 2016 - 2017. The method selected has been the standard method of the consumption basket again. The following Table 4 provides an overview of the T-815 tyres acquired in the decentralized manner in 2015 most often in the unit price comparison in 2014:

The unit prices of the tyre types examined show higher values in 2015 than in the previous year. A total of 26 cost centres were supplied by three suppliers. In case of TYRE 15.00-21 16PR ET and TYRE 15.00-

21 MP 913, which were also acquired in the centralized manner, there was only one supplier during that period who delivered the types of tyres for the same unit price to 5 cost centres (in 4 cases TYRE 15.00-21 16PR ET, in 1 case TYRE 15.00-21 MP 913) in 2014.

Table 4 – Overview of the T-815 tyres acquired in the decentralized manner in 2014 and 2015
Таблица 4 – Обзор шин Т-815, приобретенных децентрализованно в 2014 и 2015 годах
Табела 4 – Преглед гума за Т-815 набављених децентрализованим поступком 2014. и 2015. године

Period – year	2015			2014		
Type of tyres	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]
TYRE 15.00-21 16PR ET	1,582	18,798.21	29,738,775.00	134	17,545.00	2,351,030.00
TYRE 15.00-21 MP 913	60	18,876.00	1,132,560.00	38	17,545.00	666,710.00
TYRE 295/80 R22.5 FH1 SI	2	8,615.00	17,230.00	6	6,413.00	38,478.00
TOTAL			30,888,565.00			3,056,218.00

In the following year, the supplier increased this price by 7% on the average and provided supplies to 22 cost centres (TYRE 15.00-21 16PR ET) and 1 cost centre (TYRE 15.00-21 MP 913). In this period, the item of TYRE 295/80 R22.5 FH SI was delivered by two different suppliers to 2 cost centres (one by one in 2014 and in 2015), resulting in a unit price difference.

After the necessary conversion of the prices in 2014 to the prices in 2015, Table 5 has been created.

It is evident from Tables 4 and 5 that the prices of the T-815 tyres acquired in 2015 were higher than those in 2014. The determination of savings has not been implemented since it achieves negative values, i.e. the selected commodity savings in 2015 did not occur in relation to 2014. The investigation of benchmark prices has not been carried out as the corresponding items of the tyres assessed were not found for the purposes of comparing the prices of Internet- based shops.

From a global point of view, savings were achieved within the decentralized acquisition of tyres, irrespective of the type of vehicles used only in the comparison of 2015 and 2016 as the current year in the amount of 44%.

Table 5 – Conversion of prices of the T-815 tyres acquired in a decentralized manner in 2014 to the prices in 2015 (the current year)
Таблица 5 – Пересчет цен на шины Т-815, приобретенных децентрализованно в 2014 году, в цены в 2015 году (текущий год)
Табела 5 – Конверзија цена гума за Т-815 набављених 2014. године децентрализованим поступком набавке у цене из 2015. године (текућа година)

Period – year	2015			2014		
Name	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]
TYRE 15.00-21 16PR ET	1,582	18,798.21	29,738,775.00	134	18,798.21	2,518,960.71
TYRE 15.00-21 MP 913	60	18,876.00	1,132,560.00	38	18,876.00	717,288.00
TYRE 295/80 R22.5 FH1 SI	2	8,615.00	17,230.00	6	8,615.00	51,690.00
TOTAL			30,888,565.00			3,287,938.71

Quantification of tyre savings in the comparison of decentralized and centralized manners of acquisition

When investigating the quantification of savings in the acquisition of the T-815 tyres, the comparison of two successive years is generalized. The comparison is carried out in the whole context of the period 2014-2017 assessed. The reason is the fact that only one item was left when comparing the acquisition of the tyres for the above-mentioned vehicles in the centralized and decentralized manner. Table 6 illustrates a comparison of the unit prices of both manners of acquiring the commodity concerned.

The data in Table 6 is ranked according to the quantity of the T-815 tyres acquired in the centralized manner and suggests that the centralized manner of acquiring selected items besides TYRE 15.00-21 16PR ET (the commodity in question) in the given period does not bring savings to the relation of decentralized acquisition while using relations (3) and (4).

The saving values range in negative numbers. After the conversion of unit prices in the decentralized manner of acquisition to unit prices in the centralized manner of acquisition, the absolute savings of the decentralized purchase of the items in Table 6 amounts to 37.09 million CZK, i.e. relative savings of 44%.

Table 6 – Comparison of the unit prices for the T-815 tyres in the centralized and decentralized acquisition manners over the period 2014-2017
Таблица 6 – Сравнение цен на единицу продукции: шины Т-815 при централизованных и децентрализованных закупках за период 2014–2017 гг.
Табела 6 – Поређење јединичних цена гума за Т-815 набављених централизованим и децентрализованим поступцима набавке у периоду 2014–2017. године

Name of the commodity	Centralized manner of acquisition			Decentralized manner of acquisition		
	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]	Quantity [pcs]	Price for u/m [CZK]	Total price [CZK]
TYRE 15.00-21 16PR ET	4,384	18,521.28	81,197,292.00	2,380	18,749.35	44,623,462.22
TYRE 12.00-20 154J M+S	58	9,922.00	575,476.00	12	7,747.03	92,964.36
TYRE 15.00-21 MP 913	56	21,175.00	1,185,800.00	98	18,359.90	1,799,270,00
TYRE 11.00 R20 146K LET	34	9,075.00	308,550.00	6	7,320.61	43,923.66
TYRE 12 R22.5 152L FH1	32	7,852.91	251,293.00	13	6,207.30	80,694.90
TOTAL			83,518,411.00			46,640,315.14

At this point, it should be noted that there is a difference in the costs of acquisition in the whole cycle for both manners of awarding public contracts within the Ministry of Defence when the centralized manner is more expensive in terms of the number of elements involved in the acquisition.

Comparison of unit prices of the centralized and decentralized acquisition manners

The tyres acquired both by the cost centres themselves and also at the level of the Ministry of Defence have been selected for this study. Table 7 shows the individual items acquired in the two manners in the period 2014-2017, irrespective of the type of vehicles:

Table 7 – Acquired tyre items between 2014 and 2017 in the centralized and decentralized manners
Таблица 7 – Приобретенные шины за период с 2014 по 2017 год централизованно и децентрализованно
Табела 7 – Гуме набављене у периоду од 2014. до 2017. године централизованим и децентрализованим поступком набавке

		Centralized acquisition			Decentralized acquisition		
	Name and designation	Quantity [pcs]	Unit of measure [CZK]	Total price [CZK]	Quantity [pcs]	Unit of measure [CZK]	Total price [CZK]
1	TYRE 15.00-21 16PR ET	4,384	18,521.28	81,197,292.00	6,764	18,601.53	125,820,761.00
2	TYRE 365/80 R20 152K MPT	1,596	12,574.99	20,069,689.20	1,624	12,575.48	20,422,578.44
3	TYRE 12 R22.5 DM1 M+S	882	8,260.21	7,285,507.30	888	8,254.62	7,330,101.56
4	TYRE 445/65 R22.5 BS49	683	13,623.40	9,304,779.00	861	13,168.06	11,337,700.17
5	TYRE 215/90 R15 99K	627	1,984.40	1,244,218.80	1,297	1,683.11	2,182,999.71
6	TYRE 11.00 R20 NR 55	626	8,830.80	5,528,078.60	664	8,751.16	5,810,768.48
7	TYRE 10.00-20 OI73 M+S	568	3,920.40	2,226,787.20	588	3,923.20	2,306,840.80
8	TYRE 12.00 R20 BS71 ROAD	437	9,682,49	4,231,249.00	512	9,180.55	4,700,442.22
9	TYRE 14.00 R20 160G M+S	383	17,908.00	6,858,764.00	393	18,006.52	7,076,564.00
10	TYRE 7.50 R16 C 116/114N	379	4,235.00	1,605,065.00	937	3,902.44	3,656,584.24
11	TYRE 8.25-20 10PR NT 8	312	4,505.08	1,405,584.40	4	4,719.00	18,876.00
12	TYRE 12 R22.5 FM1 VECTOR	310	8,228.00	2,550,680.00	360	8,110.36	2,919,730.00
13	TYRE 205/80 R16 104T M+S	192	1,996.50	383,328.00	363	1,927.29	699,605.06
14	TYRE 325/85 R16 137J XML	164	30,719.32	5,037,968.70	183	30,636.30	5,606,443.70
15	TYRE 12.00-20 154J M+S	58	9,922.00	575,476.00	70	9,549.15	668,440.30
16	TYRE 15.00-21 MP 913	56	21,175.00	1,185,800.00	154	19,383.57	2,985,070.00
17	TYRE 11.00 R20 146K LET	34	9,075.00	308,550.00	40	8,811.84	352,473.65

		Centralized acquisition			Decentralized acquisition		
	Name and designation	Quantity [pcs]	Unit of measure [CZK]	Total price [CZK]	Quantity [pcs]	Unit of measure [CZK]	Total price [CZK]
18	TYRE 215/70 R15 109R ZIM	32	2,947.56	94,321.92	34	2,360.08	80,242.82
19	TYRE 12 R22.5 152L FH1	32	7,852.91	251,293.00	45	7,377.51	331,987.90
		11,755	10,313.81	151,344,432.12	15,781	10,048.51	204,308,210.05

The items in Table 7 are ranked in descending order according to the frequency of the centralized acquisition manner. From the global point of view, it can be stated that the decentralized acquisition manner prevails quantitatively within the above-mentioned items. For the investigation of unit prices when comparing the decentralized and centralized acquisitions, the data were ranked in the descending order according to unit prices, as shown in Table 8.

Table 8 – Unit prices of the tyres acquired in 2014-2017 in the centralized and decentralized manners
Таблица 8 – Поштучная цена на шины, приобретенные за период 2014-2017 гг. централизованным и децентрализованным методами закупок
Табела 8 – Јединичне цене гума набављених у периоду 2014–2017. централизованим и децентрализованим поступком набавке

Item number	CENTRALIZED PURCHASE	Unit price	Item number	DECENTRALIZED PURCHASE	Unit price
1	TYRE 325/85 R16 137J XML	30,719.32	1	TYRE 325/85 R16 137J XML	30,636.30
2	TYRE 15.00-21 MP 913	21,175.00	2	TYRE 15.00-21 MP 913	19,383.57
3	TYRE 15.00-21 16PR ET	18,521.28	3	TYRE 15.00-21 16PR ET	18,601.53
4	TYRE 14.00 R20 160G M+S	17,908.00	4	TYRE 14.00 R20 160G M+S	18,006.52
5	TYRE 445/65 R22.5 BS49	13,623.40	5	TYRE 445/65 R22.5 BS49	13,168.06
6	TYRE 365/80 R20 152K MPT	12,574.99	6	TYRE 365/80 R20 152K MPT	12,575.48
7	TYRE 12.00-20 154J M+S	9,922.00	7	TYRE 12.00-20 154J M+S	9,549.15
8	TYRE 12.00 R20 BS71 ROAD	9,682.49	8	TYRE 12.00 R20 BS71 ROAD	9,180.55
9	TYRE 11.00 R20 146K LET	9,075.00	9	TYRE 11.00 R20 146K LET	8,811.84
10	TYRE 11.00 R20 NR 55	8,830.80	10	TYRE 11.00 R20 NR 55	8,751.16
11	TYRE 12 R22.5 DM1 M+S	8,260.21	11	TYRE 12 R22.5 DM1 M+S	8,254.62
12	TYRE 12 R22.5 FM1 VECTOR	8,228.00	12	TYRE 12 R22.5 FM1 VECTOR	8,110.36

Item number	CENTRALIZED PURCHASE	Unit price	Item number	DECENTRALIZED PURCHASE	Unit price
13	TYRE 12 R22.5 152L FH1	7,852.91	13	TYRE 12 R22.5 152L FH1	7,377.51
14	TYRE 8.25-20 10PR NT 8	4,505.08	14	TYRE 8.25-20 10PR NT 8	4,719.00
15	TYRE 7.50 R16 C 116/114N	4,235.00	15	TYRE 10.00-20 OI73 M+S	3,923.20
16	TYRE 10.00-20 OI73 M+S	3,920.40	16	TYRE 7.50 R16 C 116/114N	3,902.44
17	TYRE 215/70 R15 109R ZIM	2,947.56	17	TYRE 215/70 R15 109R ZIM	2,360.08
18	TYRE 205/80 R16 104T M+S	1,996.50	18	TYRE 205/80 R16 104T M+S	1,927.29
19	TYRE 215/90 R15 99K	1,984.40	19	TYRE 215/90 R15 99K	1,683.11

After arranging the unit prices in the descending order, the order of items acquired in the centralized manner corresponds to the items that were acquired in the decentralized manner, except the items under order numbers 15 and 16. To calculate the basic test criterion t, it is necessary to determine the differences of the individual unit prices of both manners of acquisition, as shown in Table 9.

Table 9 – Expression of the unit price differences of the centralized and decentralized acquisitions
Таблица 9 – Разница в цене при централизованном и децентрализованном методах закупки
Табела 9 – Разлике у јединичним ценама при централизованом и децентрализованом поступку набавке

Item number	Name of the item acquired	Unit of measure of the centralized purchase (x_i) [CZK]	Unit of measure of the decentralized purchase (y_i) [CZK]	Difference d_i (x_i-y_i) [CZK]
1	TYRE 325/85 R16 137J XML	30,719.32	30,636.30	83.01697
2	TYRE 15.00-21 MP 913	21,175.00	19,383.57	1,791.429
3	TYRE 15.00-21 16PR ET	18,521.28	18,601.53	-80.2517
4	TYRE 14.00 R20 160G M+S	17,908.00	18,006.52	-98.5242
5	TYRE 445/65 R22.5 BS49	13,623.40	13,168.06	455.3347
6	TYRE 365/80 R20 152K MPT	12,574.99	12,575.48	-0.4861
7	TYRE 12.00-20 154J M+S	9,922.00	9,549.15	372.8529
8	TYRE 12.00 R20 BS71 ROAD	9,682.49	9,180.55	501.9408
9	TYRE 11.00 R20 146K LET	9,075.00	8,811.84	263.1587
10	TYRE 11.00 R20 NR 55	8,830.80	8,751.16	79.63914
11	TYRE 12 R22.5 DM1 M+S	8,260.21	8,254.62	5.593484

Item number	Name of the item acquired	Unit of measure of the centralized purchase (x_i) [CZK]	Unit of measure of the decentralized purchase (y_i) [CZK]	Difference d_i (x_i-y_i) [CZK]
12	TYRE 12 R22.5 FM1 VECTOR	8,228.00	8,110.36	117.6389
13	TYRE 12 R22.5 152L FH1	7,852.91	7,377.51	475.3974
14	TYRE 8.25-20 10PR NT 8	4,505.08	4,719.00	-213.922
15	TYRE 7.50 R16 C 116/114N	4,235.00	3,923.20	332.5622
16	TYRE 10.00-20 OI73 M+S	3,920.40	3,902.44	-2.79864
17	TYRE 215/70 R15 109R ZIM	2,947.56	2,360.08	587.4771
18	TYRE 205/80 R16 104T M+S	1,996.50	1,927.29	69.21333
19	TYRE 215/90 R15 99K	1,984.40	1,683.11	301.2853

Using the relations of the two-sample t-test (7), the test criterion $t=2.65$ has been determined. Since the values of the Student´s distribution quantiles $t_{0.95}(18)=1.734$ and $t_{0.975}(18)=2.101$ are lower than t and correspond to relations (10) and (12), it can be stated that at the significance level of 0.05 there is a difference between the prices of the centralized and decentralized acquisitions, i.e. the prices of the centralized acquisition are higher.

Conclusions

The managing body for awarding public contracts within the Ministry of Defence is responsible for quantifying the savings and transferring the data together with the evaluation of the past year to the system administrator. On the basis of the application of the Methodology for the Quantification of Savings using the consumption basket method, it can be stated that in the selected subject of the research there were partial savings in the centralized and decentralized manners of acquisition in the given period.

When comparing the centralized and decentralized acquisitions using the above-mentioned method, it has been found that, for the selected tyre items, partial savings of 44% were achieved in the decentralized manner. This assertion is also supported by the statistical method of the two-sample t-test of the difference in unit prices of the two manners of acquisition.

Under the current law (http://www.portal-vz.cz/getmedia/abd1a02e-3ef8-44a7-9a8c-a06037a6e007/ZZVZ/, 2018), it is possible to apply its provisions on operating units that could acquire the given items in a decentralized manner at the estimated value of the public contract over 2 million CZK excluding VAT. The Ministry of Defence has given its approval

to determine the "operating unit" status. Thus, cost centres could acquire assets with lower cost loads throughout the acquisition cycle flexibly and in compliance with the 3E principles.

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ПРОБЛЕМЫ КВАНТИФИКАЦИИ ЭКОНОМИИ ПРИ ЗАКУПКАХ

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Резюме:

В статье описаны стандартные методы определения экономии при приобретении средств, которые не подразумевают обязательную оценку централизованной системы принятия решений, а также методологию квантификации экономии, предписанную Министерством регионального развития Чешской Республики. Данный процесс описан на примере централизованных и децентрализованных закупок шин, приобретенных для нужд Министерства с 2014 по 2017 год. При децентрализованных

закупках ожидается большая степень вариабельности как в отношении цены, так и в отношении количества поставщиков. При централизованных закупках предусмотрена постоянность цен, поскольку с поставщиком подписывается договор на двухлетний срок действия. Статистические методы – метод проверки гипотезы был применен для сравнения цен за единицу продукции при закупках обоих видов. Т-критерий был применен для сравнения средних значений двух групп выборок, с целью выявления разницы в количестве финансовых ресурсов. Было установлено, что цены за единицу при централизованных закупках были выше, чем цены за единицу при децентрализованных закупках. Следовательно, централизованный метод закупок обходится дороже, чем децентрализованный метод.

Ключевые слова: абсолютная экономия, централизованные закупки, децентрализованные закупки, методы, шины, относительная экономия, статистика.

ПРОБЛЕМИ КВАНТИФИКАЦИЈЕ УШТЕДЕ ПРИЛИКОМ НАБАВКЕ СРЕДСТАВА

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Сажетак:

У раду се описује примена стандардних метода одређивања уштеде при набавци средстава која не намећу обавезу евалуације централизованог система одлучивања и методологије за квантификацију уштеде коју је прописало Министарство регионалног развоја Републике Чешке. Описани процес односи се на гуме набављане централизованим и децентрализованим поступком за потребе Министарства одбране у периоду 2014–2017.године. При децентрализованом поступку очекује се виша варијабилност, како код јединичних цена, тако и код броја снабдевача. При централизованом поступку предвиђа се константни ниво цене, јер је снабдевач исти током целог договореног периода снабдевања од две године. Статистичке методе – методе тестирања хипотезе користе се за поређење јединичних цена у оба поступка. Коришћен је т-тест два узорка за поређење просечних вредности две групе узорака како би се одредила разлика у

количини финансијских извора. Утврђено је да су јединичне цене централизоване набавке више од јединичних цена децентрализоване набавке, па се може закључити да је централизовани поступак набавке скупљи од децентрализованог.

Кључне речи: апсолутна уштеда, централизована набавка, децентрализована набавка, методе, гуме, релативна уштеда, статистика.

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IMPROVING E-GOVERNMENT SERVICES FOR ADVANCED SEARCH

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Abstract:

The E-government services depend on many archived documents mostly scanned and partially described to be machine searchable in order to be found fast and to offer appropriate responses to citizens and to the government personnel as well. In order to improve the existing state, the hybrid solution based on the previous research results is presented. This paper presents an in-depth view of the Web solution that combines different technologies on both the client and the server side thus improving regular search services amd making them accessible to people with dissabilities (e.g. blindness).

Key words: text search, text similarity, speach recognition, metadata exploitation.

Introduction

Contemporary document management systems provide different ways for storing and searching the archived content. However, there are many documents used in government affairs, archived in formats that are not appropriate for searching tasks. They are often in a paper format. To make such archives digitalized, the offered software solutions include scanning of documents, saving them mostly in PDF/A (portable document format for archiving) and storing them on some shareable repository, relational or non-normalized (NoSQL) database, as a core of some CMS (content management system), or some more advanced system (Asili & Tanriover, 2014, pp.57-67).

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For making them searchable, one has to make these documents machine-readable first. Without converting scanned content into text, the describing process is inefficient. Fortunately, there are many OCR (Optical Character Recognition) solutions on the market designed for this purpose (e.g. ABBYY Fine Rider as a commercial one, or FreeOCR as a desktop solution, etc.). By using this software, the scanned content, previously readable only for humans, becomes machine-readable. This is a prerequisite for performing a text analysis and making a static footprint for each document. In contemporary CMS, this is usually the last phase in making their content searchable for further exploitation.

Sometimes this is not enough. Especially in e-government services where the users (other Web based applications and services as well as government staff and citizens) demand high reliability and accurate response. There should be additional information that describes the documents in a better and more efficient way. Adding this information needs engagement of extra resources – people who should better describe the meaning of a document than machines do. Unfortunately, the personnel responsible for it are not always competent enough. Moreover, introducing people into the process significantly slows it down. Consequently, a document will be found only if there is a hundred percent matching of the title, the key words, or some other specific property within the search criteria. If IT designers try to make such a system more flexible, another problem arises: flexibility causes too many hits (results) that are not useful for further processing.

Overcoming the described situation represents one of the basic motives for the project. It is not possible to perform advance search in order to obtain fast fact finding (and offering appropriate responses to the citizens and to the government personnel) based only on the document features presented in some standard format (e.g. Dublin Core, *http://dublincore.org/documents/dces/*). This paper presents the results, collected experiences and considerations on this matter.

Problem Description and Existing Solutions

The previously described process for preparing archived content for further search brings all types of documents to the same level of complexity. These are text documents presented in different formats (PDF, DOC, DOCX, ODT, etc.). Different formats include a lot of non-informational content intended just to keep the content structure and presentation. Practically, this part of a document does not contain information interesting for users and introduces information noise

(Watson, 2009). On the other hand, removing the format data converts a text from structured into a plain format, which can lead efforts in the wrong way.

There are already implemented technologies for separating useful document content from its formatting part. For instance, Apache Tika (Mattmann & Zitting, 2012) represents a software solution for text filtering. In other words, it extracts text and metadata from almost every standard document format. It separates these two and enables their use for further searching.

On the other hand, there are software solutions focused on grouping a huge number of distributed documents, based on their similarity. A good example for such a solution is a combination of Mohout (Owen et al, 2011) (analyzing and clustering tool) and Hadoop (Sammer, 2012) (top framework for large scale concurrent processing). Both are the Apache projects dedicated for improving advanced search capabilities. Besides open-source solutions, there are also commercial ones. Upon purchase, contractors deliver released packages as unchangeable black boxes (Asili & Tanriover, 2014, pp.57-67). Also on demand, they can customize delivering for specific purpose, which consequently results in extra costs of software products.

From the technology prospective, there are programming languages that offer support for advanced search. For instance, the Python libraries and especially the Natural Language Processing Toolkit (NLTK) (Bird et al, 2009) have built-in, high-level linguistic functions that provide powerful processing of linguistic data contained in different document formats such as XML (*xml.etree* library), MS Word (*pywin32* library), PDF (*pypdf* library), RSS feed (*feedparser* library), email (*imap* and *email* libraries). Moreover, there are libraries that represent interfaces for access to data stored in DBMS (e.g. *mysql-python* library), or large document collections (e.g. *pylucene* library). Different from other systems, the NLTK can analyze the content semantically. It offers numerous functions providing the rule-based inferring on textual content. On the other hand, there are grammars (knowledge bases stored in *fcfg* files) that hold definitions of rules. The NLTK recognizes the meaning of the content by trying to match the patterns in content's sentences with the patterns defined in the rules. Sequentially, each matching produces a true or a false result and finally, the system can find a meaning of the content analyzed. The NLTK supports the rule-based grammars formalized by the Propositional Logic as well as the First Order Logic.

The main disadvantage is that the Python libraries best fit the content written in English and there is a lot of room for contributions for

other languages. For instance, one can translate grammars and adapt them to a language other than English. For instance, there is Serbian *WordNet* – the lexical database of Serbian language (Serbian-dictionary.com/wordnet) [X], based on English *WordNet* designed by the Princeton University. Consisting of almost 2500 records named *synsets* (words in the basic form enriched with synonyms), it enables a semantical analysis and translation of the content written in Serbian. Alternatively, translating sentences into English and analyzing them afterwards, represents another solution.

Going deeper into the problem domain, there are pure mathematical solutions that can overcome the non-English content search problem and avoid complex solutions based on lexical analyses. It depends on similarity measures performed on statistically transformed text content and query strings. TFIDF (Yang & Chute, 1994) represents one of the most used statistical measures. This is a combination of term frequency (hereinafter TF) and inverse document frequency (hereinafter IDF). TF represents the number of term occurrences in the text modified in order to express term significance (Šimić, 2015). A term can be one word (any part of speech), or a collocation (phrase, or a few words frequently appearing together). IDF is another measure that expresses significance of a term regarding to the whole (usually huge) set of documents considered. This way, IDF acts as a corrective factor for each term considered. In the further processing, the advanced search system measures the documents' similarity based on TFIDF, clustering them based on their mutual similarity. Finally, the statistical model and indexes represent the documents that are clustered and ready for search. Then the system is ready for exploitation, which means it transforms the search criteria in the same way as documents in order to measure the similarity with them. The most similar documents represent the search result. The statistical transformation of the content includes the term normalization (part of speech should be put in single, neutral / infinitive form – lemmatized) and elimination of so-called *stop words* (articles, pronouns, propositions, conjunctions, and interjections). As it needs the existence of an appropriate language knowledge base, the conclusion is that there is no one pure mathematical solution which is language neutral.

Proposed Solution

Although many technologies support advanced document search, the results still depend on a search language. In other words, there

should be institutions responsible for forming textual and lexical resources at the national level. These resources should be accessible for advanced search services over the Internet.

On the other hand, if one tries to avoid language dependency by implementing pure mathematical functions and by using only quantitative values, without combining the semantical similarity in comparison with document content and search criteria, the results can be below expectations. Simplicity represents the biggest advantage of such systems.

There are several ways for obtaining the communication between software modules written in different programming languages. The oldest one is by using language native interfaces. The results can be below expectations as it can be very complex for implementation and inflexible in case of language version changes. A more flexible and easier solution is using already built modules (well known as *bridges*) that establish the black – boxed, but reliable communication channel, free of a lot of coding and cleaned from many implementation details. For instance, if one wants to couple Java and Python clients, there is a bridge named Py4J (https://www.py4j.org/) referenced from both clients as a gateway server application. Several solutions use this approach (Svyatkovsky et al, 2016) for advanced text processing. Moreover, many flexible solutions offer different ways for cross language communication. One of them is Apache ActiveMQ (http://activemq.apache.org/) that represents cross language support for information exchange between application clients written in different programming languages offering many different protocols for this purpose.

Considering the facts mentioned above, the proposed solution should be a modular one, a flexible hybrid system that can establish the connections with different resources useful for text processing and information retrieval.

Frontend (Client) application

The basic components of the system are the HTML5 based client application(s) on the frontend, RESTful based services as a façade (*Façade* design pattern) of the backend part, intermediate interfaces and modules that provide different stages of processing user inputs (speech to text transformation, text normalization), generating queries and making searching request sent to different resources. By using HTML5 based technologies (e.g. Angular and Typescript JS libraries and Bootstrap frameworks), the client applications can adapt the user interface for any kind of platform (smartphone, tablet, or laptop).

The server side delivers a client application on demand. On the client side, the Web browser hosts it and takes the responsibility for further data exchange. This way, the client application is platform independent. The *Fat* client application performs all necessary preparations on user input (query). The client application has a full multimedia support (particularly multimedia recording) and therefore, there are two possible scenarios of usage – voice and textual search. In the first case (Figure 1), the client obtains the voice search that can be especially useful for users on the move. The client application uses the Google Cloud Text – to – Speech service (hereinafter the GCTtS service, https://cloud.google.com/text-to-speech/) for this purpose. The client application uses Web Speech API for recording the voice query, sends it to the service and receives the textual query for further processing.

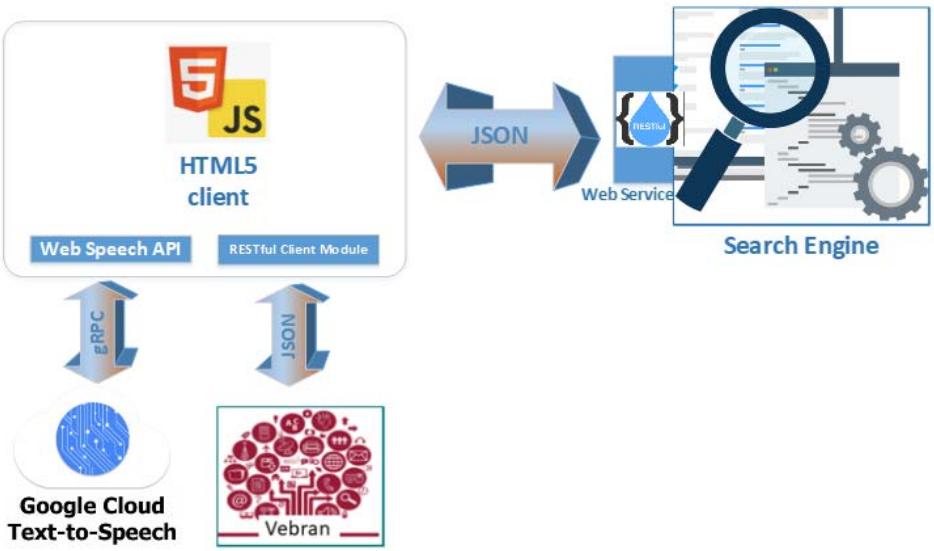

Figure 1 – Frontend – Backend communication with speech recognition
Рис. 1 – Взаимодействие пользовательской и серверной частей системы
Слика 1 – Комуникација између клијентског и серверског дела система

The GCTtS service supports almost 150 languages. Among others, there is a support for Serbian language. On the other hand, the client application has Serbian as a predefined language. As this is a parametrized value, it is changeable on demand. The client side application uses Web Speech API for establishing the communication channel to the GCTtS service, preparing it for Serbian speech recognition and for emitting the recorded voice query. On the other hand, the GCTtS

service is responsible for processing this request and for responding with the voice query transcript as a result. The gRPC (https://grpc.io/) protocol represents the flexible framework for this kind of communication. It enables sending audio files as well as establishing audio streams in the client–to–server direction. Transcriptions are the results in any case. In the same time, they represent the queries that client sends to the server side of the system.

Further, as the Serbian language has rich morphology, in both scenarios the client application continues with the preparation of a query. A particular module called 'normalizer' processes the query, preparing it for comparison with the content on the server side of the system. This 'preprocessing' includes several transformations: converting verbs into the infinitive form, nouns into the singular form, removing stop words, converting nouns into the 1st case (nominative). The client application uses the service named *Vebran* (*hlt.rgf.bg.ac.rs/VeBran*) for this purpose. This service provides all morphological forms for the term given as an input in both Cyrillic and Latin letters. As a term can be one or more words, the *Vebran* service expands the initial query with these forms. The client application uses only the basic forms of the words consisted in the initial query preparing the new one. Further, the client application sends the transformed query as a RESTful service request to the search engine on the backend side.

Backend architecture

Backend architecture supports three main functionalities of the system: extraction of useful content and metadata from original documents (accessible on the local repositories or over the network), document indexing and clustering and advanced search (Figure 2). Firstly, the system processes documents in order to clean all non-information content and to extract metadata useful for searching. Such content represents a searchable form of the original document and the system stores it in the local document storage. There is not heavy load for local storage as this is a pure textual representation.

Secondly, the system analyzes this searchable formatted content and performs its indexing. Through this process, the system creates the new data forms (files) that contain statistical information and indexes necessary for fast finding and advanced search ability.

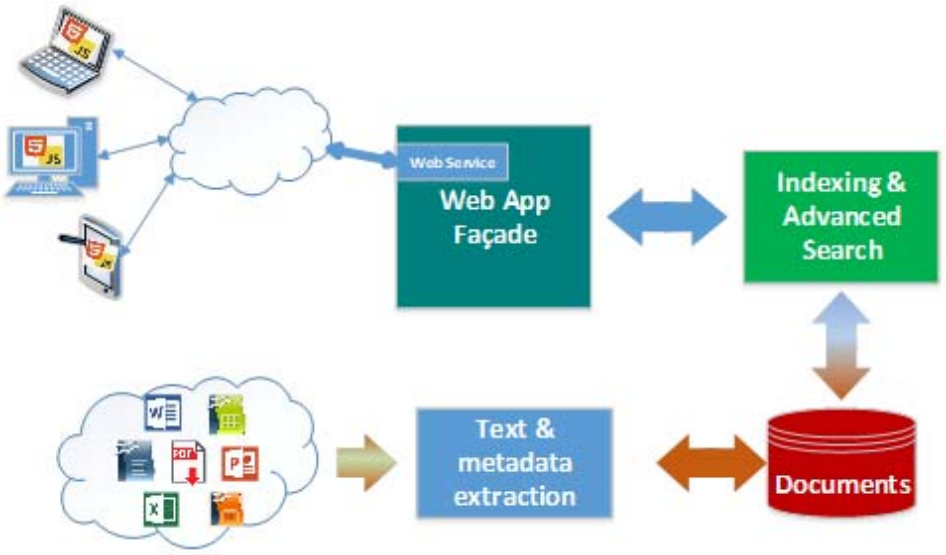

Figure 2 –Overall backend architecture
Рис. 2 – Архитектура серверной части системы
Слика 2 – Архитектура серверског дела система

The system is ready for advanced search only if it has previously performed both of the operations described above. It accepts clients' requests through the Web service forwarding them to the search engine in the middle of the system. Further, the system returns the search results in the form which consists of titles, short descriptions and links to the original documents.

Backend Preparations

As mentioned in the previous section, to be ready for exploitation, the proposed framework should have the content (documents) prepared for searching. There are several phases necessary for this purpose. The text filtering for both the information and the metadata found in different types of documents is the first one - 'Filtering' phase (Figure 3). The proposed solution uses the Apache Tika framework for this purpose. It performs the extraction of useful content from many different document formats (for instance, MS Word, Excel, PDF, various open document formats etc.). Further, the system creates a JSON formatted plain document representation from the extracted content and puts it in the appropriate document storage.

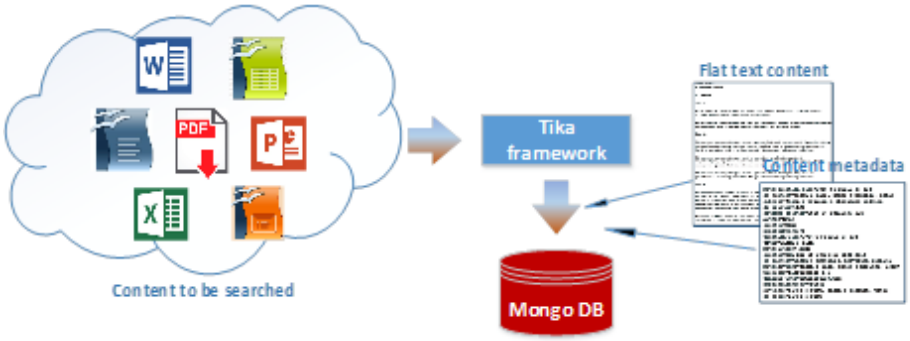

Figure 3 – Framework Backend 1st phase - 'Filtering'
Рис. 3 – Первый этап обработки документов на сервере - Очистка
Слика 3 – Прва фаза обраде докумената на серверској страни – пречишћавање

In other words, the proposed solution generates two separate flat text documents for each document. As they differ in size and structure, the solution uses the MongoDB (NoSQL document database, docs.mongodb.com) as storage for non-normalized content. It enables easy document manipulation. Moreover, it provides indexing and making descriptive queries on documents. However, it does not have a support for the Serbian language (only 15 languages are supported) and for this reason, it is not appropriate for advanced search. Therefore, the solution uses the Apache Solr (https://lucene.apache.org/solr) indexing and search platform that can use the Python libraries for this purpose. It happens in the next phase named '*Indexing*' (Figure 4).

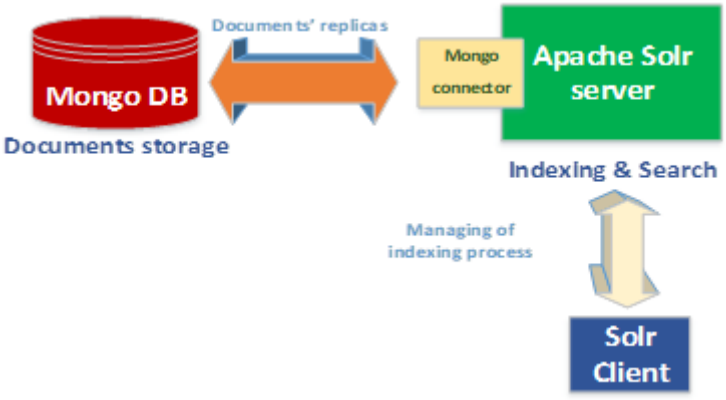

Figure 4 – Framework Backend 2nd phase - 'Indexing'
Рис. 4 – Второй этап обработки документов на сервере - Индексирование
Слика 4 – Друга фаза обраде докумената на серверској страни – индексирање

There is a separate Solr *core* – the logical instance of the interface created for indexing remote content (stored on the MongoDB). On the other hand, the MongoDB setup enables the Solr indexing server to access the documents stored in the database. The data exchange happens over the Mongo Connector (created by Mongo Labs but community maintained by YouGov, Plc). For safety reasons, the Solr performs indexing on temporary created documents' replicas delivered through the connector instead the originals stored on the Mongo DB. The Solr supports the indexing of documents written in Serbian (in both Cyrillic and Latin letters). Moreover, the framework additionally improves the indexing by using the Python library named *SolrClient*. Before indexing, it enables full specification of particular fields that represent the documents, mapping them to the appropriate stop-word, synonyms and normalization filters. This way, it optimizes the indexing process and improves the searching results. Next is the code fragment that points to the important parts of the JSON request used for remotely setting up the Solr server in order to perform the indexing of documents written in Serbian (Figure 5).

```
3 {"add-field-type":{"name":"text_rs","class":"solr.TextField","positionIncrementGap":"100",
...       ...
11        "filters":[{"class":"solr.StopFilterFactory","ignoreCase":"true","words":"stopwords_rs.txt"},
12                   {"class":"solr.SynonymFilterFactory","synonyms":"index_synonyms.txt",
13                       "ignoreCase":"true","expand":"false"},
14                   {"class":"solr.LowerCaseFilterFactory"},
15                   {"class":"solr.SerbianNormalizationFilterFactory","haircut":"bald"}]}},
16                    "add-field" : {"name":"tekst","type":"text_rs","multiValued":"true",
```

Figure 5 – JSONized request that sets up the Solr server for indexing in Serbian
Рис. 5 – Настройка сербского языка на сервере Solr
Слика 5 – Подешавање Solr сервера за српски језик

The set up statement includes the document's field to be indexed (*text_rs* in the figure above), and links it with the appropriate content analyzer. Further, the analyzer's set up consists of different types of filters. In the example above, there are four different filters included. The first one is for finding and excluding the Serbian stop words (see *Problem Description*) from the indexing process. The second filter is for recognizing synonyms in the Serbian dictionary. The third one converts letters to the lower case. The last one preforms the text normalization. After the customization through the set up request, the Solr is ready for

indexing. This process includes the text analysis in the same order as the filters are enlisted in the set up statement.

The system performs indexing on the set of documents stored in the MongoDB by importing the fields specified for indexing (the Solr uses *solr-mongo-importer* and *solr-dataimporthandler* libraries for this purpose). In other words, the MongoDB consists of whole documents while the Solr stores only the fields, their statistical properties, important for search and references to the documents of origin. This way, the system keeps the data redundancy at the minimum level.

During the exploitation, if there is a new document stored in the MongoDB (after passing the Tika extraction), the system updates the indexes (simple *add* method call) immediately as the Solr is already set up. Only if there is another field of interest in the searching process, the Solr should explicitly reset before indexing.

Exploitation (Case Study)

When the user accesses the system URL, it delivers the reach client searching application implemented in HTML5 and JS (*Bootstrap*) technologies. This way, the client application has an adaptable layout regarding the concrete display dimensions. The next illustration shows the user interface adapted for a smartphone (Figure 6). The user interface contains a text field for typing and showing the search criteria, navigation buttons, the execution button and the voice search button.

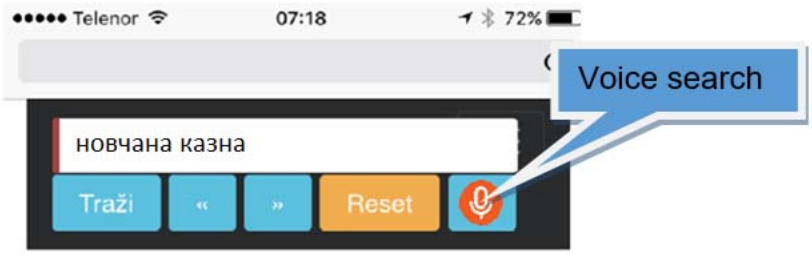

Figure 6 – Adaptable client applicaiton layout
Рис. 6 – Адаптивный пользовательский интерфейс
Слика 6 – Прилагодљив интерфејс клијентске апликације

In the shown example, the user performed voice search. He can start and stop recording by toggling the voice search button. The client application uses simple mouse-over JavaScript to generate audio descriptions of each button. It helps people with disabilities (e.g.

blindness) to find the toggle button for start / stop recording. The next illustration shows the most important code fragments for the voice search implementation (Figure 6). As mentioned before, the client application uses WebSpeech API for this purpose. The application firstly creates the instance of the *SpeechRecognition* class. This class encapsulates speech recognition functionality hiding implementation details such as voice recording by microphone, sending the recorded voice as a byte array to the Google Cloud Speech-to-Text service and receiving the transcript responded from the service.

Recording starts by calling the *start* method on the *SpeechRecognition* object (Figure 7). The application will render the talk immediately after start, simultaneously sending it to the remote service. The service also responds immediately. The client catches the results by the *onresult* event handler. The service response is structured and it is accessible over the *event* object. It consists of an array named *results*. This array, among other properties, contains the transcribed text held in the *transcript* object.

```
<textarea id="recognizedText" rows=10 cols=80></textarea>
<button id="button" onclick="toggleStartStop()"></button>
<script type="text/javascript">
  var stat;
  var speechRecognition = new SpeechRecognition();
  ....
  speechRecognition.onresult = function (event) {
    for (var i = event.resultIndex; i < event.results.length; ++i) {
      if (event.results[i].isFinal) {
        recognizedText.value += event.results[i][0].transcript;
      }
    }
  }
  ....
</script>
```

Figure 7 – Fragment of the client application code for voice search
Рис. 7 – Фрагмент пользовательского кода для голосового поиска
Слика 7 – Фрагмент клијентског кода за гласовну претрагу

As described, the client application performs the normalization of the transcript forwarding it to the *Vebran* service encapsulated in the class named *NormalizationService* (Figure 8). The implementation of this functionality is in the method named *getNormalized*. This method sends the transcript previously changed into the query form to the service over the *http get* request, and returns the service response.

```
import { Observable } from 'rxjs/Observable';
...
@Injectable()
export class NormalzationService {
  private serviceUrl = 'http://...../vebran/../';
  ...
  getNormalized(transcript: SolrQuery): Observable<string> {
    let q = transcript.getQ();
    ...
    var response = this.http.get(this.serviceUrl + q)
                .map(response => response.json() as string)
                .catch(this.handleError);
    return response;
  }
...
```

Figure 8 – Fragment of the client application code for the normalization of the search query
Рис. 8 – Фрагмент пользовательского кода для нормализации запроса
Слика 8 – Фрагмент клијентског кода за нормализацију упита

The client application makes the services mutually synchronized by defining the service call methods (in classes that encapsulate them) *Observable*. The next code presents the important parts of the *performSearch* method (Figure 9). This method uses the *Vebran* service by calling the observable *getNormalized* method. Further, it synchronously calls the Solr service and updates the user interface with the search results.

```
performSearch(transcript:SolrQuery):void{
    ....
  let getDlfs = this.NormalzationService.getNormalized(transcript)
      .map(query => this.storeResults(query),
          ...
      ).mergeMap(response => this.SolrService.getResults(query)
      ).subscribe(
          response => this.updateSolrResults(response),
          ...
      );
  ...
}
```

Figure 9 – Using the Vebran service
Рис. 9 – Использование сервиса Vebran
Слика 9 – Коришћење Vebran сервиса

The Vebran response represents the plain string of all search criteria forms (singular, plural, in all cases) separated with a semicolon: *новчана казна;новчаним казнама;новчана казно;новчаном казном;новчану казну;novčana kazna;novčanim kaznama;novčana kazno;novčanom kaznom;novčanom kaznom*. Before calling the Solr service, the client application composes the search query by using the normal forms of the each word. Consequently, it calls the *getResult* service method passing the query and waiting for the service response. Finaly, the returned result is rendered thorough the synchronized (by the *subscrybe* function) *updateSolrResults* method. The server side receives the search queries in the pure text (JSON) format.

The server side RESTful controller service acts as a façade [X] of the backend system. It propagates the request to the Solr server for searching the indexed fields. The Solr returns the result records that contain references to the documents. Further, the server application uses these references to find the documents stored in the MongoDB. Such approach provides fast finding of the parts of documents large in size and with a complex structure. Finally, the service returns the name and the part of the text that matches the criteria for each resulting document (Figure 10).

Figure 10 – Search result
Рис. 10 – Результаты поиска
Слика 10 – Приказ резултата претраге

The client application renders the JSON formatted returned result by using the CSS specification of each returned field.

For evaluation, there were 100 different searching tasks performed. The next chart (Figure 11) shows the results. There is a big difference

between server side processing and communication time. The server side processing includes the activities: accepting search request, finding the similar documents and preparing the responses. The measured processing time is less than 10e-1 second (bottom part of the chart). The communication time is measured on the client side from sending the search request to receiving the search result from the server. The communication time is more than ten times longer (upper part of the chart).

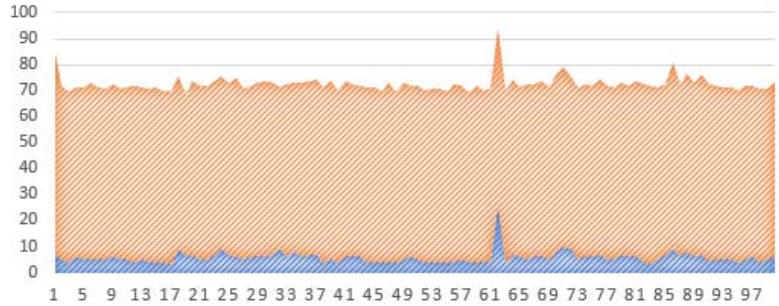

Figure 11 – Processing vs. communication time
Рис. 11 – Время обработки данных и время обмена данными
Слика 11 – Време обраде и време размене података

The other part of the evaluation includes the client side search query preparations (speech-to-text as well as lexical transformations). The measured values were similar to the client - server communication time. During experimentation, the overall responding time of the search service measured was 1.7 second in average.

Conclusion

The focus of the proposed solution is improving the Serbian e-government searching service in order to provide advanced search of huge documents corpuses in an efficient way as well as to enable this service for people with disabilities. Focusing on the Serbian language was a big challenge due to its grammar complexity and rich vocabulary of words, terms, synonyms and homonyms. We tried to overcome these difficulties on both sides – client and server applications. The client side application uses the *Vebran* service that performs an in–depth lexical analysis of the text responding with the all-possible forms of the sentence given as the search criteria. The client application uses the normalized one and sends it to the search engine on the server side.

The solution uses the *Google Cloud Speech-to-Text* service as an appropriate one to obtain searching by voice. As typing is complex for drivers or passengers and impossible for people with disabilities, this service is included in the solution. By setting it up in the proper way, this service presents a high level of accuracy and satisfactory responding time in both cases - during the evaluation and exploitation.

On the other hand, there are other languages of interest in Serbia (Albanian, Hungarian, Bulgarian, etc.). Owing to the flexibility, modularity and low coupling of components of the proposed solution, as well as to a lot of supporting libraries in the frameworks included, these requests are feasible on both the client and the server side application. The *Google Cloud Speech-to-Text* service supports 120 languages (including the above enlisted) while the Solr can provide indexing for 36 languages. Moreover, the Python libraries incorporate an advanced analysis and the processing features for more than 50 languages.

There are experimentations presented in the paper. Their results demonstrate respectable processing power of all the services used. The network speed still represents the main factor for slowing down the service response.

As document storage, the MongoDB is a flexible solution for holding non-normalized content. It fits well a great number of documents that differ in size and content structure. This way, it is appropriate for storing short content such as messages, comments and emails as well as books, laws, magazines and similar ones, much greater in size and more complex in structure. Also, a well-supported communication between the MongoDB and the Solr (*solr-mongoimporter* library) provides high performances in both indexing and searching processes.

The *Vebran* service authors suggest query expansion with the sentence returned by it service (Stanković et al, 2016, pp.112-123) in order to obtain results that better fit the initial query. On the other hand, the more terms and forms supported by the service, the better results returned. For instance, if the user changes the query above with one more word "*Дефиниција новчаних казни*" (*Definition of amercements*), it practically changes the term. If the service does not support a concrete collocation of the words in the criteria, the query will not have expected expansion and consequently, it will not produce the proper search result. Therefore, the client application uses the service firstly to find collocations (the terms that represent the ordered sequences of two words) and secondly, to find forms of the rest of the words contained in a query. Based on the previous example, it means that the word 'definition' will be treated separately from the term 'criminal acts'. This way, the

client application prepared the query for searching the documents written in Serbian.

The proposed solution is scalable. As the MongoDB and the Solr hold different information of documents, the system is flexible for distribution. There can be more than one MongoDB and Solr instances. If these instances can hold the same documents translated into different languages, the solution can provide the same searching improvements for each one. Moreover, both MongoDB and Solr have support for cloud solutions. The MongoDB offers the Atlas (https://www.mongodb.com/cloud) commercial cloud solution while the SolrCloud () solution is free of charge. Nevertheless, migration on the cloud should depend on the size of the document base as well as on the number of requests (users). If these numbers arise rapidly, the service providers should start planning in time.

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УЛУЧШЕНИЕ СЕРВИСА ЭЛЕКТРОННОГО ПРАВИТЕЛЬСТВА ДЛЯ РАСШИРЕННОГО ПОИСКА

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ЯЗЫК СТАТЬИ: английский

Резюме:

Услуги электронного правительства зависят от архивирования документов, которые в основном сканируются и частично описываются с целью обеспечения машинного поиска и быстрого нахождения соответствующих ответов как для пользователей, так и для сотрудников электронного правительства. Для улучшения существующей ситуации было разработано гибридное решение, основанное на результатах предыдущих исследований. В данной работе представлено описание Веб-сервера, комбинирующего различные технологии, направленного на улучшение стандартных услуг поиска и обеспечения их доступности для людей с ограниченными возможностями.

Ключевые слова: текстовый поиск, схожесть текстов, распознавание речи, использование метаданных.

УНАПРЕЂЕЊЕ СЕРВИСА Е-ВЛАДЕ ЗА НАПРЕДНУ ПРЕТРАГУ

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ОБЛАСТ: информатика
ВРСТА ЧЛАНКА: оригинални научни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Услуге е-управе зависе од архивских докумената који су углавном скенирани и делимично описани како би се могли машински претраживати и брзо проналазити одговарајући одговори за грађане и службенике. Да би се побољшало постојеће стање, представљено је хибридно решење засновано на претходним резултатима истраживања. Овај рад представља опис веб софтверског решења које комбинује различите технологије како на страни клијента тако и на

страни сервера, побољшавајући редовне услуге претраживања и чинећи их приступачним за особе са инвалидитетом.

Кључне речи: претрага текста, сличност текстова, препознавање говора, експлоатација метаподатака.

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СТРУЧНИ РАДОВИ
ПРОФЕССИОНАЛЬНЫЕ СТАТЬИ
PROFESSIONAL PAPERS

CONTRIBUTION TO THE ANALYTICAL CALCULATION OF THE PERFORMANCES OF A MOTOR VEHICLE EQUIPPED WITH A HYDRODYNAMIC TORQUE CONVERTER

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Abstract:

Hydrodynamic torque converters (hereinafter referred to as HDTC) are becoming increasingly widespread in motor vehicles. The internal combustion engine (ICE) and the HDTC system can be viewed as one aggregate the output characteristics of which are uniquely defined by the characteristics of the engine and the corresponding HDTC. Namely, the engine and the hydro-converter can be considered as one system, with a precisely defined output torque and output angular velocity. This creates a possibility that the drive force can be calculated as if it is a mechanical transmission, in which the output torque of the hydro-converter is the input into the planetary gears train (if any). Harmonizing the joint work of the ICE-HDTC is a complex process. An attempt has been made in this paper to make a model of the aforementioned system in order to harmonize more easily the characteristics of the combined operation of the internal combustion engine and the HDTC.

Key words: vehicles, engines, hydrodynamic, torque converter, performances.

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Introduction

The hydrodynamic torque converter (hereinafter referred to as HDTC) is a turbo machine consisting of three or more blade wheels (pump, stator and turbine) and transferring mechanical energy through the working fluid in it (Burciu, 2004), (Kelić, 1985), (Kirchner, 2007), (Laptev, 1973), (Milidrag, 1987), (Demić & Lukić, 2011). For illustration, the scheme of an HDTC on which (1) indicates a pump wheel, (2) is a turbine wheel and (3) is a stator (Laptev, 1973) is shown in Figure 1. The propulsion engine turns the pump wheel so that its blades force the fluid to perform a complex movement. The liquid turns along with the pump wheel and flows from the input to the exit from the blade channels. Due to the energy transfer to the turbine wheel, the speed of the liquid decreases. During its flow through the stator, the fluid changes direction, causing appearance of a reactive torque. In the first approximation, it can be argued that the total energy has not changed (if losses are neglected), but that only redistribution between the kinetic and potential energy of the liquid has occurred. If the redistribution of the kinetic energy is greater, the torque of the turbine is higher than the torque of the pump and vice versa, which depends on the HDTC operation mode. As the mode change is continuous, such is the change in the torque and the angular velocity of the output shaft.

In the application of the HDTC for motor vehicles, in order to achieve harmonization of the characteristics of the combined operation of the internal combustion engine (hereinafter ICE) and the HDTC, an additional mechanical single-speed gearbox is often applied, before the pump wheel. In addition, due to a low transmission ratio, the HDTC is usually combined with a planetary mechanical gearbox installed before the final drive.

The analyses carried out in (Burciu, 2004), (Laptev, 1973), (Demić & Lukić, 2011) showed that the ICE-HDTC systems can be viewed as one aggregate whose output characteristics are uniquely defined by the characteristics of the engine and the corresponding HDTC, which will be discussed below. Namely, the engine and the hydro torque-converter can be considered as one system, with an exactly defined output torque and output angular velocity. In doing so, the driving force of a vehicle can be calculated as if it is a mechanical transmission whose output torque of the HDTC is actually the input to the planetary gearset (if any). It is emphasized that the harmonization of the combined operation of the ICE and the HDTC is a complex task (Milidrag, 1987).

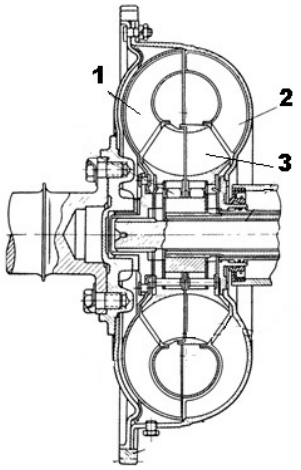

Figure 1 – Scheme of one HDTC
Рис. 1 – Схема одного ГДТКМ
Слика 1 – Шема једног ХДТОМ-а

Therefore, an attempt is made in this paper to simplify the task by using a mathematical model. Furthermore, in the following text, the behaviour of vehicles equipped with HDTCs will be observed in variable modes of motion, which required the definition of a system model that includes non-stationary and stationary operations of the ICE-HDTC system. This problem is very important for traffic in a wider sense because it enables the calculation of performances of motor vehicles.

Modelling the combined operation of the ICE-HDTC

In order to better understand the model forming process, the definition of the most important parameters of the HDTC is briefly given, (Burciu, 2004), (Demić & Lukić, 2011).

The hydraulic transmission ratio of the converter:

$$i_h = \frac{n_P}{n_T} = \frac{\omega_P}{\omega_T} \ . \tag{1}$$

The transmission ratio of the converter:

$$i = \frac{n_T}{n_P} = \frac{1}{i_h} \ , \tag{2}$$

where

$\omega_P, \omega_T, n_P, n_T$ - angular velocities and revolutions per minute (rpm) of the pump and the turbine wheel, respectively.

Slip:

$$s = \frac{n_P - n_T}{n_P} = 1 - i = 1 - \frac{1}{i_h}. \tag{3}$$

The hydrodynamic torque of the pump and the turbine wheel.

$$\begin{aligned} M_P &= \lambda_P \rho D^5 n_P^2 \\ M_T &= \lambda_T \rho D^5 n_P^2, \end{aligned} \tag{4}$$

where

λ_P, λ_T - torque coefficient of the pump and the turbine wheels, respectively,

ρ - density of the operating fluid, and

D - active diameter of the converter.

The torque Transformation Coefficient:

$$k = \left| \frac{M_T}{M_P} \right| = \frac{\lambda_T}{\lambda_P}. \tag{5}$$

The hydraulic efficiency represents the power ratio of the turbine to the pump:

$$\eta_h = \frac{P_T}{P_P} = \frac{M_T \omega_T}{M_P \omega_P} = \frac{k M_P \omega_T}{M_P \omega_P} = ki = k \frac{1}{i_h}. \tag{6}$$

For illustration purposes, Figure 2 shows the transmission diagram of a vehicle with the HDTC (Burciu, 2004), (Laptev, 1973), (Demić & Lukić, 2011).

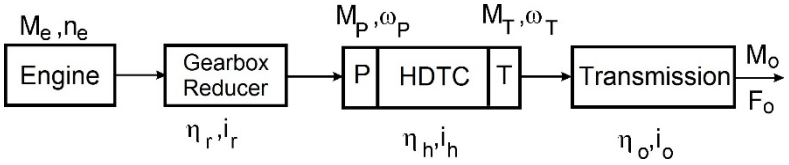

Figure 2 – Scheme of the vehicle transmission with the HDTC
Рис. 2 – Схема трансмиссии автомобиля с ГДТКМ
Слика 2 – Шема трансмисије возила са ХДТОМ

In the case of the straight-line motion, the vehicle overcomes the same resistance forces as in the case of mechanical transmission, so the differential equation of motion of the vehicle can be written (Demić & Lukić, 2011), (Genta, 2003), (Gillespie, 1992), (Janković & Todorović, 2001), (Milliken & Milliken, 1995):

$$R_j = F_o - R_f - R_v - R_u = F_o - \sum R, \tag{7}$$

where
R_j - inertial resistance (resistance of inertial forces),
R_f - rolling resistance,
R_v - aerodynamic resistance, and
R_u - gradient resistance.

Based on (7), it follows:

$$\frac{dv}{dt} = \frac{F_o - \sum R}{m\delta_u}, \tag{8}$$

where
δ_u - rotational mass coefficient which takes into account the mechanical and hydraulic elements, $\delta_u = \delta_m + \delta_h$.

Vehicle speed is given by the expression:

$$v = \frac{2\pi n_e r_d}{i_h i_m i_o}, \tag{9}$$

where
n_e - engine speed-rpm,
i_o - the final drive ratio, and
i_m - the planetary gearset ratio.

The torque on the drive wheels, according to the power and torque transmission scheme shown in Figure 2, is given by the expression:

$$M_o = M_T i_o i_m \eta_o \eta_m, \tag{10}$$

where
η_0, η_m - efficiency of the final drive and the planetary gearset, respectively.

The tractive force on the drive wheels is (Demić & Lukić, 2011):

$$F_o = \frac{M_o}{r_d} = \frac{M_T i_o i_m \eta_o \eta_m}{r_d}. \quad (11)$$

The torque on the HDTC turbine's output shaft is (Burciu, 2004), (Kelić, 1985), (Kirchner, 2007), (Laptev, 1973), (Milidrag, 1987), (Demić & Lukić, 2011):

$$M_T = kM_P . \quad (12)$$

Based on (11) and (12):

$$F_o = \frac{kM_P \eta_m \eta_o i_m i_o}{r_d} . \quad (13)$$

The system shown in Figure 2 can be seen as two subsystems, i.e. two equivalent masses rotating (I, II) (Demić & Lukić, 2011):

- one subsystem includes the masses of the rotational parts, the mass of the shaft and the part of the pump before the converter, all parts being reduced to the pump's shaft, and
- the other subsystem that includes the masses of the rotational and translational moving parts behind the hydrodynamic converter, whereby all parts are reduced to the turbine's output shaft.

Subsystems I and II are shown in Figures 3 and 4.

The first subsystem

By applying Newton's law to subsystem I (Figure 3), it is obtained:

$$J_1 \frac{d\omega_P}{dt} = M_r - M_P, \quad (14)$$

where

J_1 - equivalent moment of inertia of the first subsystem, and

M_r - torque of the gearbox reducer given by:

$$M_r = M_e i_r \eta_r , \quad (15)$$

where

M_e - engine torque,

i_r - transmission ratio of the additional mechanical gearbox, and

η_r - efficiency of the additional mechanical gearbox.

Therefore, differential equation (14) takes the form:

$$J_1 \frac{d\omega_P}{dt} = M_e i_r \eta_r - M_P . \tag{16}$$

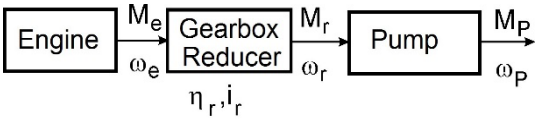

Figure 3 – Subsystem I
Рис. 3 – Подсистема I
Слика 3 – Подсистем I

The inertial moment of subsystem I can be determined as the sum of the hydraulic M_{in}^{P} and the mechanical M_{in}^{M} moments of inertia:

$$M_{in}^{I} = M_{in}^{P} + M_{in}^{M} , \tag{17}$$

where

M_{in}^{M} - moment of inertia of the mechanical part: $M_{in}^{M} = J_z \dot{\omega}_z$,

M_{in}^{P} - moment of inertia of the hydraulic part:

$M_{in}^{P} = M_{in}^{M} i_r \eta_r = J_z \dot{\omega}_z i_r \eta_r$,

i_r - transmission ratio of the reducer: $i_r = \frac{\omega_z}{\omega_P}$ and

$\dot{\omega}_z$ - angular acceleration of the flywheel: $\dot{\omega}_z = \dot{\omega}_p i_r$,

J_z - moment of inertia of the flywheel.

The moment of inertia of the hydraulic part of subsystem I is:

$$M_{in}^{P} = J_z \dot{\omega}_P i_r i_r \eta_r = J_z \dot{\omega}_P i_r^2 \eta_r . \tag{18}$$

The summary moment of inertia of subsystem I is:

$$M_{in}^{I} = \left(J_p + J_z i_r^2 \eta_r \right) \dot{\omega}_P = J_1 \dot{\omega}_P . \tag{19}$$

The equivalent moment of inertia of part I is:

$$J_1 = J_P + J_z i_r^2 \eta_r . \tag{20}$$

Second subsystem

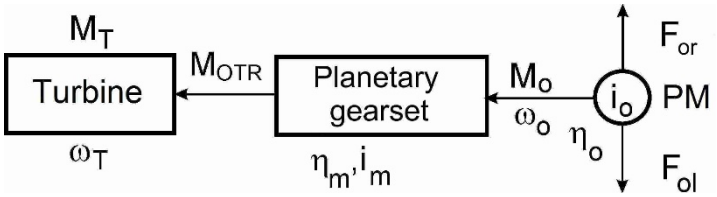

Figure 4 – Subsystem II
Рис. 4 – Подсистема II
Слика 4 – Подсистем II

Based on the distribution scheme of the torque and the tractive force of the vehicle, the resistant moment of the vehicle can be determined, Figure 4:

$$M_{OTR} = \frac{F_o r_d}{i_m i_o \eta_m \eta_o}, \tag{21}$$

where

$F_o = F_{ol} + F_{or}$ - tractive force on the drive wheels, equal to the sum of the tractive forces on the left, F_{ol} and right wheels F_{or},

By applying the Newton's law to subsystem II, shown in Figure 4, it is obtained:

$$J_2 \frac{d\omega_T}{dt} = M_T - M_{OTR}, \tag{22}$$

where

J_2 - equivalent moment of inertia of the second subsystem.

If expression (21) is taken into account:

$$J_2 \frac{d\omega_T}{dt} = M_T - \frac{F_o r_d}{i_m i_o \eta_m \eta_o}. \tag{23}$$

The moment of inertia of the wheels is:

$$M_{intockova} = \sum J_{toc} \dot{\omega}_{toc}, \tag{24}$$

where

J_{toc} and $\dot{\omega}_{toc}$ - moment of inertia and the angular acceleration of the wheels, respectively.

If it reduces to a turbine wheel, it follows:

$$M^{T}_{in\ \ tockova} = \frac{\sum J_{toc}\dot{\omega}_{toc}}{i_m i_o \eta_m \eta_o}\,, \tag{25}$$

where angular acceleration is:

$$\dot{\omega}_{toc} = \frac{\dot{\omega}_T}{i_m i_o}. \tag{26}$$

The final form of equation (25) becomes:

$$M^{T}_{intockova} = \frac{\sum J_{toc}}{i_m^2 i_o^2 \eta_m \eta_o}\dot{\omega}_T\,. \tag{27}$$

The moment of inertia of the mechanical transmission is:

$$M^{in}_{transm} = J_{transm}\dot{\omega}_{transm}\,, \tag{28}$$

where the angular acceleration of transmission is:

$$\dot{\omega}_{transm} = \frac{\dot{\omega}_T}{i_m}\,. \tag{29}$$

The moment of inertia of the transmission reduced to a turbine wheel:

$$M^{T}_{\mathrm{int}ransm} = \frac{J_{transm}}{i_m \eta_m}\dot{\omega}_{transm} = \frac{J_{transm}}{i_m \eta_m}\frac{\dot{\omega}_T}{i_m} = \frac{J_{transm}}{i_m^2 \eta_m}\dot{\omega}_T\,. \tag{30}$$

The total moment of inertia is:

$$M^{T}_{in\ u} = M^{T}_{in\ \ trans} + M^{T}_{in\ \ toc}\,, \tag{31}$$

namely:

$$M^{T}_{in\ u} = \frac{J_{transm}}{i_m^2 \eta_m}\dot{\omega}_T + \frac{\sum J_{toc}}{i_0^2 i_m^2 \eta_m \eta_0}\dot{\omega}_T + J_{turb}\dot{\omega}_T \tag{32}$$

The moment of inertia of subsystem II is, (Figure 3):

$$J_2 = J_{turb} + \frac{J_{transm}}{i_m^2 \eta_m} + \frac{\Sigma J_{toc}}{i_o^2 i_m^2 \eta_o \eta_m}. \tag{33}$$

The total resistance of the inertial forces is equal to the sum of the resistance of the inertial forces due to the accelerated movement of the vehicle and the accelerated movement of the rotating parts:

$$R_j = R_j^{transl} + R_j^{rot} . \quad (34)$$

The inertial force due to the accelerated translation movement of the vehicle is:

$$R_j^{transl} = m\frac{dv}{dt} . \quad (35)$$

The inertial force generated by the accelerated rotational movement of the vehicle parts can be presented as the sum of the inertial forces of the rotational parts of the wheels and the transmission parts:

$$R_j^{rot} = R_j^{transm} + R_j^{toc} , \quad (36)$$

that is,

$$R_j^{transm} = J_2 \frac{\eta_m \eta_o i_m i_o}{r_d} \frac{d\omega_T}{dt} , \quad (37)$$

where

- the inertial force due to the accelerated rotational movement of the transmission elements and

$$R_j^{toc} = \frac{\Sigma J_T}{r_d} \frac{d\omega_{toc}}{dt} , \quad (38)$$

- the inertial force that occurs due to the accelerated rotational movement of the wheels.

The angular velocity at the exit of the turbine wheel is:

$$\omega_T = \omega_{toc} i_o i_m = \frac{v}{r_d} i_o i_m . \quad (39)$$

The angular acceleration of the turbine wheel is:

$$\frac{d\omega_T}{dt} = \frac{i_o i_m}{r_d} \frac{dv}{dt} . \quad (40)$$

The angular acceleration of the wheel is given by the expression:

$$\frac{d\omega_{toc}}{dt} = \frac{1}{r_d} \frac{dv}{dt} . \quad (41)$$

After arranging, the final expression for the resistance of inertial forces is obtained:

$$R_j = \left(\underbrace{m + \frac{\Sigma J_{toc}}{r_d^2} + J_2 \frac{i_m^2 i_o^2 \eta_m \eta_o}{r_d^2}}_{\delta_m} \right) \frac{dv}{dt}, \tag{42}$$

or

$$R_j = m \left(1 + \frac{\Sigma J_{toc}}{m r_d^2} + J_2 \frac{i_m^2 i_o^2 \eta_m \eta_o}{m r_d^2} \right) \frac{dv}{dt}. \tag{43}$$

If (according to 42 and 43) the total resistance of the inertial forces is defined as: $R_j = m \delta_m j$, the mechanical rotational masses coefficient, δ_m, is:

$$\delta_m = 1 + \frac{\Sigma J_{toc}}{m r_d^2} + \frac{J_2}{m} \frac{i_m^2 i_o^2 \eta_m \eta_o}{r_d^2}. \tag{44}$$

The angular velocity of the pump wheel is:

$$\omega_P = i_h \omega_T = i_h i_m i_o \frac{v}{r_d}. \tag{45}$$

The angular acceleration of the pump wheel is:

$$\frac{d\omega_P}{dt} = \frac{di_h}{dt} i_m i_o \frac{v}{r_d} + i_h i_m i_o \frac{1}{r_d} \frac{dv}{dt}. \tag{46}$$

If a shift is introduced: $\frac{di_h}{dt} = \frac{di_h}{dv} \frac{dv}{dt}$, the angular acceleration of the pump wheel is:

$$\frac{d\omega_P}{dt} = \frac{i_m i_o}{r_d} \left(v \frac{di_h}{dv} + i_h \right) \frac{dv}{dt}. \tag{47}$$

The torque that is transferred from the engine to the gearbox reducer according to Figure 1 is:

$$M_r = M_e i_r \eta_r, \tag{48}$$

further:

$$J_1 \frac{i_m i_o}{r_d} \left(v \frac{di_h}{dv} + i_h \right) \frac{dv}{dt} = M_r - M_P. \tag{49}$$

Bearing in mind the traction balance of the vehicle, and after the corresponding transformations:

$$m\left[\delta_m + \frac{bC}{m} J_2 + kJ_1\left(v\frac{di_h}{dv} + i_h\right)\right]\frac{dv}{dt} = bkM_r - \Sigma R, \tag{50}$$

where

$$C = \frac{i_0 i_m}{r_d} \quad b = \frac{i_m i_0}{C}. \tag{51}$$

Based on expression (51), the equation for the rotational masses coefficient of the hydraulic part of the transmission is:

$$\delta_h = \frac{i_o i_m}{m}\left[J_2 + kJ_1\left(v\frac{di_h}{dv} + i_h\right)\right]. \tag{52}$$

The analysis of expression (52) shows that the rotational masses coefficient, in the case of the HDTC, depends on the inertial parameters of the mechanical part of the transmission, and also on the transformation of the fluid energy in the HDTC.

Now the traction balance equation can finally be written (Demić & Lukić, 2011):

$$m\left(\delta_m + \delta_h\right)\frac{dv}{dt} = \frac{\eta_m \eta_o}{i_m i_o} M_r - \Sigma R. \tag{53}$$

or

$$m\left(\delta_m + \delta_h\right)\frac{dv}{dt} = \frac{M_e k i_m i_o i_r \eta_m \eta_o \eta_r}{r_d} - \Sigma R. \tag{54}$$

A system of differential equations that describes the motion of a hydrodynamic transmission system is:

$$\begin{aligned} J_1\frac{d\omega_P}{dt} &= M_r - M_P, \\ J_2\frac{d\omega_T}{dt} &= M_T - M_{opt}^T, \\ m\left(\delta_m + \delta_h\right)\frac{dv}{dt} &= \frac{\eta_m \eta_o r_d k}{i_m i_o} M_r - \Sigma R. \end{aligned} \tag{55}$$

Dynamic simulation

In order to research the reliability of the applied mathematical model of the combined operation of the ICE-HDTC, it was considered appropriate to apply it to the example of a Florida diesel engine prototype (Wong, 2001). In this case, the engine and the HDTC were used and their experimental characteristics are shown in Figures 5-7 (indicated by B).

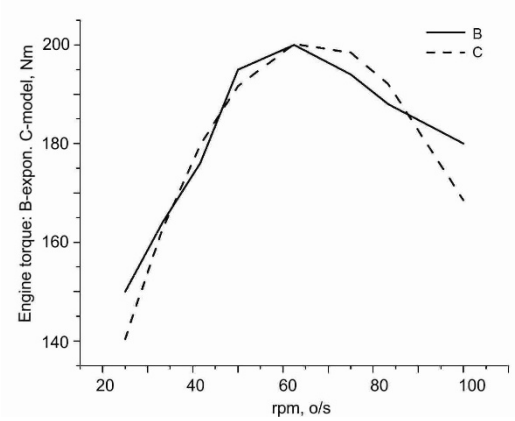

Figure 5 – Torque of the applied engine
Рис. 5 – Крутящий момент испытуемого двигателя
Слика 5 – Обртни момент посматраног мотора

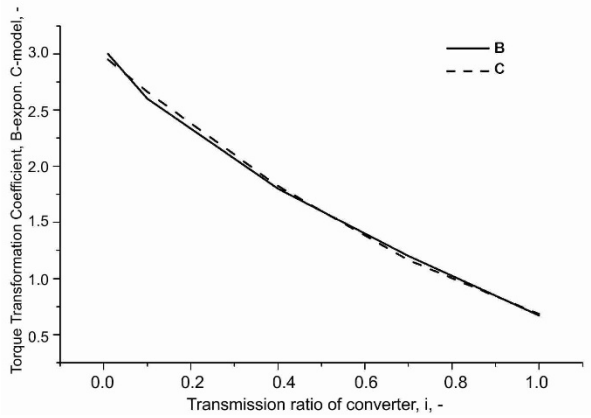

Figure 6 – Torque Transformation Coefficient
Рис. 6 – Коэффициент трансформации крутящего момента
Слика 6 – Коефицијент трансформације обртног момента

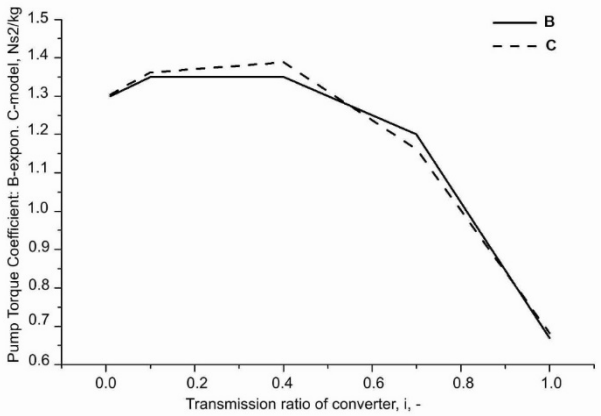

Figure 7 – Pump Torque Coefficient
Рис. 7 – Коэффициент крутящего момента насоса
Слика 7 – Коефицијент момента пумпног кола

For the purpose of easier dynamic simulation, the experimental data in Figures 5-7 were approximated by polynomials. Bearing in mind that the observed engine has regulated characteristics, its torque could not be more precisely modelled with the second-degree polynomial (Simić, 1988), so the minimum of the sum of squared errors was satisfied by using the fifth-degree polynomial. The HDTC data were approximated by the third-degree polynomial. The calculation of the unknown coefficients of polynomials was carried out using the program in Pascal, based on optimization methods.

The coefficients are shown in Tables 1-3.

Table 1 – Engine torque
Таблица 1 – Крутящий момент двигателя
Табела 1 – Обртни момент мотора

a_0	$4.337*10^{1}$
a_1	$5.064*10^{0}$
a_2	$4.351*10^{-2}$
a_3	$7.163*10^{-14}$
a_4	$6.173*10^{-7}$

Table 2 – Torque Transformation Coefficient
Таблица 2 – Коэффициент трансформации крутящего момента
Табела 2 – Коефицијент трансформације обртног момента

a_0	$1.167*10^{0}$
a_1	$1.161*10^{-1}$
a_2	$9.779*10^{-4}$

Table 3 – Coefficient of the pump torque
Таблица 3 – Коэффициент крутящего момента насоса
Табела 3 – Коефицијент момента пумпног кола

a_0	$9.720*10^{-1}$
a_1	$5.073*10^{-14}$
a_2	$3.313*10^{-5}$

The vehicle and the HDTC used in the dynamic simulation are given in Table 4 (Zastava automobili, 2008).

Table 4 – Basic data on the used vehicle and the HDTC
Таблица 4 – Основные данные об б/у автомобиле и ГДТКМ
Табела 4 – Основни подаци о коришћеном возилу и ХДТОМ-у

m	1200, kg
r_d	0.273, m
i_m	1; 1,5, -
I_0	8.5, -
i_r	0.35, -
φ	0.7, -
η_0	0.98, -
η_r	0.96, -
η_m	0.98, -
f	0.02, -
$K*A$	0.525, Ns^2/s^2
l_0	2.5, m
J_p	0.92,kgm^2
J_t	0.90, kgm^2
J_{transm}	1, kgm^2
J_{toc}	5,kgm^2
J_z	0.1, kgm^2
D	0.11, m

It is noted that the harmonization of the engine and the HDTC characteristics is achieved by changing the active diameter D of the pump wheel or the gear ratio, i_r, of the gearbox reducer, which is installed between the engine and the HDTC (Laptev, 1973), (Demić & Lukić, 2011):

$$i_r = \sqrt[3]{\frac{D^5 \lambda_P \rho \omega_e^2}{M_e \eta_r}} \tag{56}$$

where
D - active diameter of the HDTC,
M_P - torque on the pump wheel,
λ_P - torque coefficient of the pump, and
ω_P - angular velocity of the pump wheel.

In practice, the HDTC transmission ratio is chosen from the requirements for ensuring the best traction and speed characteristics of the vehicle and fuel consumption. If i_r is calculated from the conditions of the vehicle starting from a standstill, then λ_P has the value for $i_h = 0$. In addition, ω=(0.75÷0.85)*ω_p for motor vehicles with diesel engines, where ω_p is the angular velocity at the maximum engine power.

In this case study, the calculated value for i_r is 0.35, which means that instead of the reducer, it is necessary to use a speed multiplier gearbox.

Due to non-linearity, differential equations (55) were solved numerically using the Kutta-Merson method in the program realized in Pascal. The initial integration step was 0.001, s, and the integration was carried out at 500,000 points, which ensured the reliability of the results in the area 0.002-500, Hz (Bendat & Piersol, 2010). Bearing in mind that the aim of the simulation was to calculate the performance of a vehicle with an HDTC, this frequency range is acceptable.

It was considered appropriate to analyse the performance of the motor vehicle, and therefore a dynamic factor is calculated (Simić, 1988) according to the formula:

$$D_V = \frac{F_0 - R_v}{mg} = f\cos(u) + \sin(u) + \frac{\delta_m}{g} j. \tag{57}$$

where the labels from the preceding text, that is, the usual labels from (Simić, 1988), were used, so here they will not be specifically explained.

It was concluded by the analysis that only the results of a dynamic factor simulation in the case of 100% fuel injection in the engine and a

transmission ratio of the planetary gearset 1, i.e. 75% of the fuel injection in the engine and the transmission ratio of the planetary gearset 1.5, should be shown here in Figures 8 and 9 (and not the performance of the HDTC, which is treated as a black box).

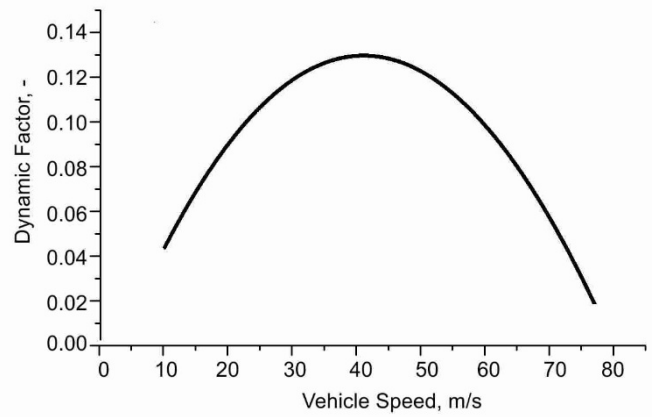

Figure 8 – Dynamic factor for 100% fuel injection in the engine and transmission ratio of the planetary gearbox equal 1
Рис. 8 – Динамический коэффициент для 100% впрыска топлива в двигатель и передаточного числа в планетарной коробке передач равен 1
Слика 8 – Динамички фактор за 100% довода горива у мотор и преносни однос у планетарном преноснику једнак 1

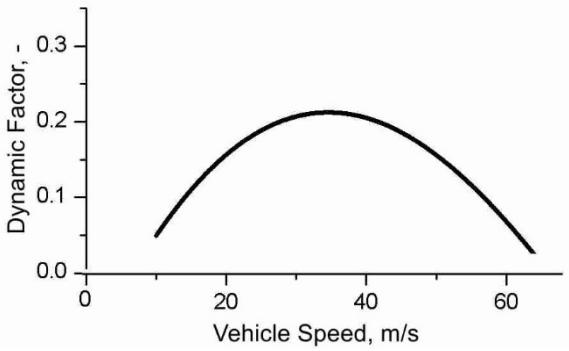

Figure 9 – Dynamic factor for 75% fuel injection into the engine and transmission ratio of the planetary gearbox equal 1.5
Рис. 9 – Динамический коэффициент для 75% впрыска топлива в двигатель и передаточного числа в планетарной коробке передач равен 1.5
Слика 9 – Динамички фактор за 75% довода горива у мотор и преносни однос у планетарном преноснику једнак 1,5

Results and analysis

Using all the calculated values of the dynamic factor, which are partially shown in Figures 8 and 9, and the procedures described in detail in the references (Demić & Lukić, 2011), (Janković & Todorović, 2001), (Simić, 1988), the maximum values of the dynamic factor and the speed at which it occurs (D_{max} and V_{Dmax}), the maximum vehicle speed (V_{max}), the maximum vehicle acceleration (j_{max}) and the maximum slope the vehicle can climb (u_{max})are calculated. The values were calculated using a program developed in Pascal, and the data are shown in Table 5.

Table 5 – Maximum values
Таблица 5 – Максимальные значения
Табела 5 – Максималне вредности

Fuel supply,%	i_m, -	D_{vmax}/V_{Dvmax}, -/m/s	v_{max}, m/s	j_{max}, m/s^2	u_{max}, %
100	1	0.129/30.97	62.47	0.413	10.9
50	1	0.088/26.54	53.34	0.257	6.8
100	1.5	0.292/25.73	54.71	0.775	27.2
75	1.5	0.212/24.59	51.76	0.547	19.2
50	1.5	0.133/22.61	46.98	0.322	11.3

Based on the data in Table 5, it can be determined that a better performance is achieved in the case of the maximum fuel supply for both transmission ratios in the planetary gearbox. With the reduction in the amount of fuel brought into the engine, the performance of the vehicle also drops. It should be noted that with the transmission ratio in the planetary gearbox equal 1, it was impossible to move the vehicle (the calculated speed of the vehicle had values below 0).

By analysing the effect of the transmission ratio in a planetary gearbox, it was found that all performance parameters are better in the case of a reduction in it, except for the maximum speed which in this case is lower. This is understandable when taking into account the facts in (Demić & Lukić, 2011), (Janković & Todorović, 2001), (Simić, 1988), which relate to the theory of the movement of motor vehicles with classical-mechanical gears.

It should be noted that some data whose values had to be approximately determined were used in this paper, such as: moments of inertia, masses of individual parts of the aggregate, etc., which inevitably leads to errors in the simulation results. Therefore, it is necessary to pay more attention in the following period to the experimental determination

of the inertial parameters of the vehicle and its aggregates as a whole, or of the constituent elements. The used model vehicle (engine)-passenger makes it easier to harmonize their combine operation.

Conclusion

The developed ICE-HDTC model makes it easy to calculate and analyse the performance of motor vehicles. In the following period, attention should be paid to the experimental determination of the necessary parameters in order to improve the reliability of the simulation results. The used model makes it easier to harmonize the combined ICE - HDTC operation in variable vehicle regimes.

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ПРИЛОЖЕНИЕ К АНАЛИТИЧЕСКОМУ РАСЧЕТУ ЭФФЕКТИВНОСТИ АВТОМОБИЛЯ С ГИДРАВЛИЧЕСКИМ ТРАНСФОРМАТОРОМ КРУТЯЩЕГО МОМЕНТА

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Резюме:

Гидродинамические трансформаторы крутящего момента (далее именуемые ГДТКМ) становятся все более распространенными в автомобильной промышленности. Система ГДТКМ и двигатель внутреннего сгорания (ДВС) рассматриваются как агрегат, выходные характеристики которого однозначно определяются характеристиками двигателя и соответствующим ГДТКМ. А именно, двигатель и гидротрансформатор можно рассматривать как единую систему с точно определенным выходным крутящим моментом и угловой скоростью на выходе. Таким образом создается возможность расчета движущей силы так, как это делается при расчете механической трансмиссии, входной сигнал в планетарную коробку передач которой (если есть) является выходным крутящим моментом гидротрансформатора. Согласование совместной работы ДВС – ГДТКМ является весьма сложным процессом. В данной статье была сделана попытка представить моделирование вышеописанной системы, с целью упрощения процесса согласования характеристик совместной работы двигателя внутреннего сгорания и ГДТКМ.

Ключевые слова: транспортные средства, двигатели, гидродинамический, гидротрансформатор, производительность.

ПРИЛОГ АНАЛИТИЧКОМ ИЗРАЧУНАВАЊУ ПЕРФОРМАНСИ МОТОРНОГ ВОЗИЛА СА УГРАЂЕНИМ ХИДРАУЛИЧКИМ ТРАНСФОРМАТОРОМ ОБРТНОГ МОМЕНТА

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ОБЛАСТ: машинство, моторна возила и мотори
ВРСТА ЧЛАНКА: стручни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Хидродинамички трансформатори обртног момента (ХДТОМ) налазе све ширу примену код моторних возила. Систем мотор са унутрашњим сагоревањем (МСУС)–ХДТОМ може се посматрати као један агрегат, чије су излазне карактеристике једнозначно дефинисане карактеристикама мотора и одговарајућег ХДТОМ-а. Наиме, мотор и хидротрансформатор могу се посматрати као један систем, са тачно дефинисаним излазним моментом и излазном угаоном брзином. То ствара могућност да се погонска сила може израчунати као да се ради о механичкој трансмисији, чији је улаз у планетарни преносник (ако постоји) излазни момент хидротрансформатора. Усаглашавање заједничког рада МСУС–ХДТОМ представља сложен процес. У овом раду настојано је да се поменути систем моделира, како би се што једноставније могле усагласити карактеристике заједничког рада мотора са унутрашњим сагоревањем и ХДТОМ-а.

Кључне речи: возила, мотори, хидродинамички, трансформатор обртног момента, перформансе.

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OPEN DATA CONCEPT, ITS APPLICATION AND EXPERIENCES

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Abstract:

Creating a richer, more equitable and just society requires that governments work in a more transparent and responsible way - to maintain regular and meaningful communication with citizens. Open data is the means to achieve this goal. Open data is digital data available to the public. It has such technical and legal characteristics that anyone, at any time and everywhere can use, re-use and redistribute it. The focus in this paper is data that is easily accessed and used and distributed for free. It is structured for usability and computer analysis. Such data is called publicly available or open data. The paper deals with the basic concepts of Open data, where it is most used, the most important experiences and benefits in its use, how it impacts human lives, which foregoing preconditions have to be met in order to significantly increase the effects of open data, how influence is created with it and the challenges that arise in its use.

Keywords: open data, concept of open data, public data, open data usage experience, open source, open source hardware, open content, open access.

Introduction

"When we have all the information online, it will be great for mankind. It is a prerequisite for solving many of the problems faced by contemporary society." - Robert Cailliau[1]

Today, in modern society, data and information itself play a very important role and importance can be compared to the importance of

[1] Robert Cailliau - born on 26 January 1947, a Belgian computer engineer and computer scientist. He helped Tim Berners-Leeu to develop the World Wide Web.

energy or perhaps even more. Unlike energy, information can be transmitted in various ways, but the most popular way is certainly over the Internet. The Internet is an unprecedented phenomenon in the entire human history with the fastest growth. There is only one purpose of the Internet - the link between people around the world and exchange of information through it. As information is becoming more accessible to people, their "hunger" for information is getting bigger and bigger. So, the idea of free, useful information was born.

In the context of the Fourth Industrial Revolution (characterized by the fusion of the physical, digital and biological worlds (Schwab, 2015), data is at the heart of business intelligence and is increasingly considered to be the key to improving business intelligence of the public sector.

In the scientific sphere and in the software and hardware industry, for more than thirty years there has been a so-called "Open" movement that differentiates submembers such as open source[2] (Open Source Initiative, 2018), open source hardware[3] (Pearce, 2016), open access[4] (Pearce, 2016), (Suber, 2014) and open content[5] (Open Content, 2018a).

The focus in this paper is data that is easily accessed and used and distributed for free. It is structured for usability and computer analysis. The synonym for open data is publicly available or open data (OD). Under the main subtitle of the article, there are the basic concepts of OD, areas of its use, the most important experiences and benefits, its impact on human lives, previous preconditions that have to be met in order to significantly increase the impacts of OD, influence it creates and which challenges arise in its use.

In order to gain a complete view of the open data problem, the following basic chapters explain the basic concepts of OD. In the third

[2] In production and development, open source as a development model promotes universal access through a free product design license or plan and universal redistribution of that design or plan, including subsequent enhancements by anyone. (Open Source Initiative, 2018)

[3] Open source hardware (OSH) consists of physical artifacts of technology designed and offered by the open design movement. Both free and open-source software (FOSS), as well as open-source hardware is created by this open-source culture movement and applies a like concept to a variety of components. (Pearce, 2016)

[4] Open access (OA) refers to online research approaches that do not include all access restrictions (e.g. access / usage payments) and no usage restrictions (such as specific copyright and license restrictions). (Suber, 2014)

[5] Open content is a neologism that David Vilei described in 1998 as a creative work that others can copy or modify. The term comes from open source software which is a related concept in the software. (Open Content, 2018b)

chapter, the term OD is explained more closely. The fourth chapter outlines the principles that must be met by OD. The following chapter presents the application - the results and experiences achieved by regions. The sixth chapter discusses the influence of OD on human lives. The very act of changing the ways of doing business and applying the OD necessarily creates certain challenges. OD has a certain influence and how it is created. All of this is the content of the seventh chapter. The penultimate chapter deals with the arguments for and against the application of OD. At the end of the paper, a conclusion is made outlining the basic contributions of this paper and plans for future work.

Open Data Concept

The general objective of OD is to foster and strengthen the cooperation leading to the adoption and implementation of common principles, standards and good practices of open data from various sectors throughout the world.

The open data is digital data, available to the public. It has such technical and legal characteristics that anyone, at any time and everywhere can use, re-use and redistribute it.

We are witnessing the great global revolutions, created under the influence of technology and digital media - with the help of data and information. This transformation has enormous potential to encourage governments, civil society organizations and the private sector to work more transparently, more accountably, more efficiently and more efficiently. It helps design, achieve, and evaluate the goals of sustainable development at a global level.

The OD concept speaks directly about the basic issues of ownership, responsibility and control. When opening data - publishing on public portals, legal and ethical issues appear as reasons for not publishing data research with the article. It is often the case that researchers do not agree to share data. Also, there is a fear that others may misuse or misread their data (Wouters, 2017).

In order to increase the efficiency of the use of OD, it is necessary to establish a legal and regulatory environment. Traditionally, there is a strong tendency in the OECD countries to use transparency and freedom of information as a legal basis for open government data (Ubaldi, 2013).

Creating a richer, more equitable and just society requires that governments work in a more transparent and responsible way - to maintain regular and meaningful communication with citizens. A global information revolution is underway to improve co-operation on key social

issues, enable public oversight of government activities, and stimulate innovation, sustainable economic development, efficient public policies and programs.

The central policies of open governments, strategies and action plans are of crucial importance for the OD policy to be activated (OECD, 2018).

Open Government Data (OGD) Policies, Programs and Open Government Initiatives have the potential to provide a range of economic, social and political benefits to governments (Ubaldi, 2013).

What goals can be achieved and where a proper use of OD can help?

The following are the goals that can be achieved by using open data correctly (International open data charter, 2018):

- OD allows governments, citizens and civil society organizations and the public sector to make decisions based on a greater amount of information. Efficient and timely access to information helps individuals and organizations to come up with new knowledge and innovative ideas that can bring social and economic benefits and improve the quality of life of people around the world.

- OD enables users to compare, combine, and use links between different data sets, tracking them through multiple programs and sectors. If it is possible to combine and compare data efficiently, it is possible to identify trends, social and economic problems and inequalities, and compare the progress made in public programs and services.

- OD can help governments, citizens and organizations to achieve better results in the field of public services in areas such as health, education, public security, environmental protection, human rights and natural disasters.

- OD can contribute to economic development and help create and strengthen new markets, businesses and jobs. These benefits are increased when a large number of civil society and private sector organizations adopt good OD practices and give up their own data.

- OD can improve the flow of information within and between governments, and make government decisions and making decision making more transparent. Greater transparency promotes responsibility and good governance, promotes public debate and helps fight corruption. OD offers opportunities for innovative political solutions based on evidence, economic benefits and social development for all citizens.

How OD goals are achieved?

Goals are achieved (International open data charter, 2018):

- OD helps create policy based on evidence. It encourages governments to use data in policy making and evidence-based decision making. It thus provides a better result of public policies, and lays the foundations for sustainable economic and social development;
- OD facilitates sectoral cooperation. It helps cooperation between governments, citizens and civil society organizations and the private sector in developing policies and providing better public services;
- OD allows tracking cash flows. It shows how well public money is spent, which encourages governments to prove they use public money in an effective way;
- OD improves the quality of management of natural resources. It increases awareness of the use of natural resources, spending on extraction revenues, and ways of carrying out transactions and managing land;
- OD enables tracking of results and effects. It helps evaluate the effects of public programs, which enables governments, civil society organizations and the private sector to respond more efficiently to the needs of local communities.
- OD promotes equal development, sustainable growth and growth through the creation and strengthening of markets, companies and workplaces;
- OD allows geo location data. It provides references for geo-spatial data and Earth observation data, which supports comparability, interoperability, and effective analysis.
- OD improves decision-making. It enables citizens to make decisions based on a greater amount of information, services and quality standards of services they should expect. When used in this way, OD is a key public good for helping citizens to establish values, discovering ideas, ideas and services that would create a better world for everyone.

We know that governments and other public sector organizations preserve a huge amount of data that may be of interest to citizens and that such data represents unused resources. If this information were to be opened, it could stimulate the construction of interconnected societies that would largely meet the needs of citizens. These societies would enable the expansion of innovation, fairness, transparency and prosperity while at the same time providing civic participation in public decision-making and government responsibility.

So let us follow the six principles that will be the basis for accessing the data and for publishing and using the data (International open data charter, 2018). These principles prescribe that data should be:

- open in principle,
- timely and comprehensive,
- affordable and usable,
- comparable and interoperable,
- for improved management and greater citizen engagement, and
- for inclusive development and innovation

What is OD?

According to one of the definitions, OD is such data that is freely available, accessible, machine-readable and available in open formats.

OD is publicly available data that can be universal and easy to access, used and distributed for free. It is structured for usability and computer analysis. The openness of data exists on the continuum, although much of the information we are discussing here may not be strictly open in the descriptive sense; it can still be delusional, used by third parties, and capable of widespread transformation (Young & Verhulst, 2016, p.5).

The openness of data is applied to all components of the research process, not just for the outcomes of the research. OD must be embedded in the research process from start to finish. Such changes will probably affect the entire research cycle and its organization from the establishment of research to its publication. In researching the system as a whole, this shift from OD can also lead to the emergence of new disciplines, raise the quality and impact of research, and open new ways of publishing (Wouters, 2017).

Principles that open data must satisfy

On 7 and 8th January 2007, in Sevastopol, California, 30 advocates of open governments met to develop a set of principles of open government data. The aim was to achieve understanding why government open data is important for democracy (DNA Doe Project, 2018).

State data shall be considered open if published in a manner consistent with the following principles:

- Complete: All public information is available and does not fall under the applicable privacy, security or privilege limits.

- Essential: Data is collected at source, with the highest degree of granularity, not in aggregate or modified forms.
- Timely: Data is available as soon as possible to maintain data value.
- Affordable: Data is available to the widest range of users for the widest range of uses.
- Machine readable / processed: Data is reasonably structured to allow automatic processing.
- Non-discriminatory: data is available to everyone without registration.
- No ownership: data is available in a form that no one has exclusive control of.
- No license: Data is not subject to any copyright, patent, trademark or business secrecy policy. A reasonable limit of privacy, security, and privilege may be allowed.

Why do institutions open data?

Public institutions collect and produce a large amount of different data, and by ensuring its availability in the form of OD (without compromising trust or privacy) it becomes accessible to a wider range of users.

Institutions not only provide higher levels of public work, but also provide citizens and businesses with new opportunities to generate new value from data - whether it is a new application, business model, visualization, mapping, research project, etc.

Through open data, the state encourages the development of creative business and knowledge economy, but also receives valuable feedback, which can be used to improve data quality, better understanding of user needs, better formulation and implementation of public policies.

Application and experience by regions

OD at the international level

Countries around the world found long ago that OD promotes economic growth, makes public administration more efficient and more economical, provides better services to citizens, ensures transparency and reduces corruption.

The European Union, among the first, recognized the importance of opening up data to the public authorities, and in 2003 adopted the

Directive on Re-Use of Public Sector Information, which was upgraded in 2013 (Lampoltshammer et al, 2017).

The first portal (OD) was set up by the United States of America in May 2009, and today there are close to 200,000 open data sets in it. The European Union established its Open Data Portal in 2015 (the portal automatically collects data sets from the Portal of the member states. The Republic of Serbia also submits certain data sets to the mentioned portal).

The European Commission estimates that data opening will create a market worth 40 billion euros annually, while the total value for the EU economy will reach 200 billion euros. That is why data at the international level has been referred to as "new oil" for a long time, and OD has been identified as one of the key factors for achieving the goals of sustainable development and the digital transformation of society. A significant level of political support for opening up data at the international level is dealt with in the Open Government Partnership Initiative (Serbia's membership since 2012), as well as in the International Open Data Charter.

Countries' Data Campaign progress can be tracked across a number of international rankings, such as the Global Open Data Index or the Open Data Barometer.

Below you will find the results of the application of OD in different countries in the world. The outcomes are presented by sectors where the methodology was applied and the effects of impacts implemented.

Brazil: Open Transparency Portal, Outcome: Government Enhancement, Sector: Public, Impact: Facing Corruption and Transparency.

Description: A tool designed to increase fiscal transparency.

Through the open state budget information, the Brazilian federal government has made improvements over the past decade. The Transparent Portal is now one of the country's primary anticorruption tools, registering the average age of visitors, with 900,000 unique visitors per month registered. Local authorities around Brazil and the other three Latin American countries have modelled similar initiatives of financial transparency.

Slovakia: Open Contracting Projects Sector: Public, Impact: Facing Corruption and Transparency,

Description: In January 2011, Slovakia introduced an unprecedented regime in the area of OD, requesting that all public procurement documents be linked (including revenues and contracts) on the Internet and condition the importance of public contracts and their publication. There were more than two million contracts published on the Internet,

and these reforms had a dramatic impact on corruption and were equally important for business climate and perception of corruption.

Indonesia: Kaval Pemilu; Sector: Politics and Elections; Impact: Facing Corruption and Transparency;

Description: A platform launched immediately after the controversial presidential elections in Indonesia in 2014. Kaval Pemilu's organizers teamed up with more than 700 volunteers to compare official voices with the original voting and digitization tables, often handwritten, making data readable and accessible.

Assembled in a mere two days, with a total budget of just $54, the platform enabled citizen participation in monitoring the election results, increased public trust in official tallies, and helped ease an important democratic transition.

Tanzania: Shule's Education Open Data Dashboard; Outcome: Empowerment of Citizens Sector: Education Impact: Social Mobilization

Description: Two recently established portals provide the public with more data on average grades and other information related to the performance of the schools in Tanzania. Educational Open Data Dashboard is a project that was established by the Tanzania Open Data Initiative; Shule was led by Arnold Minde, a developer, entrepreneur, and enthusiast of open data. Despite the challenges posed by low penetration rates in Tanzania, these locations slowly change the way citizens access information and make decisions. They encourage citizens to seek greater responsibility from their school system and public officials.

Great Britain: UK Survey; Outcome: Creating Opportunities Sector: Geographic Services; Impact: economic growth.

Description: Data from Ordnance Surveys, mapping by British agencies, essentially supports any UK industry or activity that uses a map: urban planning, real estate development, ecological science, communal services, retail and more. Ordnance Survey is essential for selection and, in spite of launching its Ordnance Survey OpenData platform in 2010, it uses a model of mixed prices, with some open data and some paid data. The expected Ordnance Survey OpenData products were delivered between 13 million pound net with a jump to 28.5 million pound increase in the GDP over the first 5 years.

The United States is one of the most advanced countries in the application of OD. Below you will find a few examples of OD and benefits received from different business areas in the country.

United States of America: OD about the government has changed the way the notion of citizenship is understood. It is a movement with its principles that has its own development in the United States, its history of

movement, applications for transparency and civic engagement, short legal history, data quality, prioritization, case studies and paradox in transparency.

United States of America: Business Atlas in New York; Sector: Business; Impact: Economic Growth

Description: Developed by the Mayor and Data Analysis Office (MODA), Business Atlas is a platform designed to mitigate market research differences between small and large enterprises in New York. The tool enables small businesses to access high-quality data on economic conditions in the given region to help them decide where to set up a new business or to expand the existing.

United States of America: NOAA: Opening of global weather data in cooperation with companies; Sector: Time; Impact: economic growth.

Description: Opening time data through NOAA has significantly reduced economic and human costs associated with weather conditions and damage through forecasts; enabled the development of a multi-billion financial industries that deliver weather forecasts based on weather conditions depending on seasonal data records; and catalyzed the growing industry in $ millions of tools and applications derived from NOAA data in real-time.

United States of America: Opening GPS data for civil use; Sector: Geographic Services; Impact: economic growth;

Description: Throughout the past 20 years, the Global Positioning System (GPS) technology has led to the expansion of commercial applications across the industry and sectors, including agriculture, construction, transportation, aviation and especially increasing use of portable devices for everyday life. Due to various system shutdowns, it is estimated that the losses amounted to $ 96 billion. In addition to creating new efficiency and reducing operating costs, the adoption of GPS technology has improved security, response time and quality of life, and plenty of other benefits.

New Zealand: *Christchurch Earthquake, GIS Clusters, Sector: Emergency Services, Influence: Data Engagement*;

Description: In February 2011, Christchurch was hit by a severe earthquake that killed 185 people and caused significant disturbances and damage to the major parts of the city that had previously been degraded by an earthquake. In response to the earthquake, volunteers and officials of the recovery agencies used open data, open source tools, trusted data with trusted information, and converted materials for the development of various products and services needed to successfully respond to emerging conditions, including a web application for

emergency information that made 70,000 visits in the first 48 hours after the earthquake, among others.

Influence of open data on human lives

OD improves the work of many governments around the world. In many cases, OD projects have impacts on multiple areas at the same time. The impact on people's lives is often indirect (and somewhat subtle). Changes are reflected in decision-making or other social, political and economic factors.

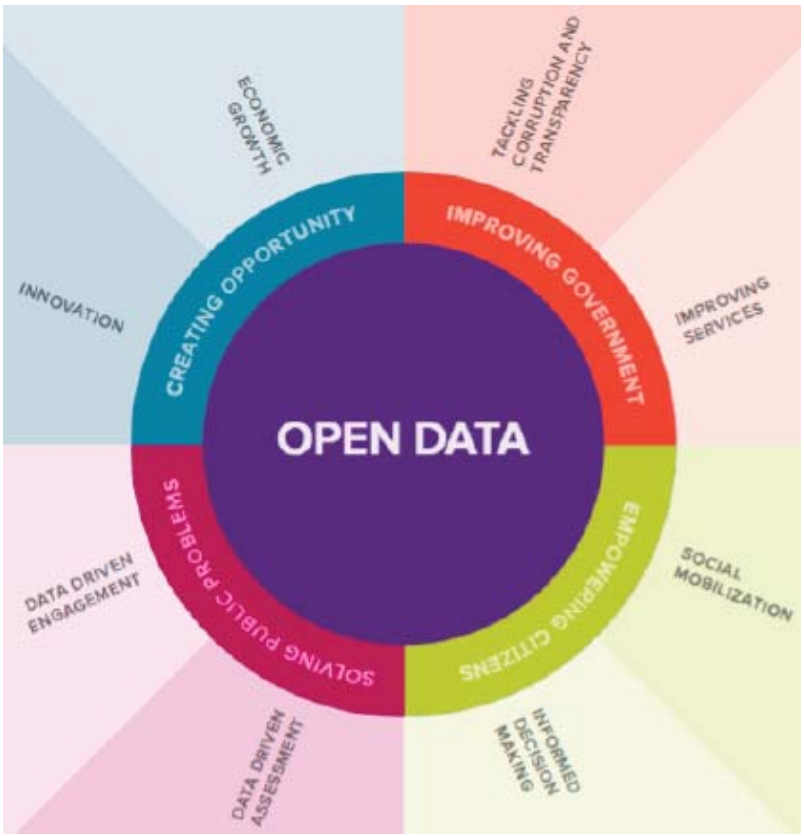

Figure 1 – The open data taxonomy[6] of impact (Young & Verhulst, 2016, p.15)
Рис. 1 – Открытые данные таксономии[6] воздействия
Слика 1 – Отворени подаци – таксономија[6] утицаја

[6] Taxonomy (in general) is practice and science about the classification of things or concepts, including the principles that are the basis of such classification. Specific taxonomies include Content.

Figure 1 lists the ways in which OD has an impact on people's lives, and they are:

- Creating a more responsible government, especially by helping to combat corruption and by introducing transparency in business, increasing accountability (especially budgeting),
- A government becomes more efficient, in particular through the strengthening of the public service and allocation of resources,
- Citizens are strengthened to take control of their lives and demand change by being enabled to make more effective decisions and by new forms of social mobilization, facilitating new ways of communication and access to information.
- OD creates new economic opportunities for citizens and organizations.
- In the end, the effect of OD is obvious in the way it helps solve major public problems, many of which seem almost irrelevant. Although most of these problems are not fully resolved, we finally see ways to improve. Through OD, citizens and policy makers can analyze social issues in new ways and engage in new forms of evaluation and data-based engagement. OD has created significant impacts during public health crises and other emergency situations.

To achieve better impacts and achieve goals, it is necessary to have (Young & Verhulst, 2016, pp.17-20):

- partnership - joint cooperation,
- public infrastructure,
- the existence of clear open data policies, including well-defined performance indicators, and
- a well-defined problem

What are the Challenges with Opening up Data? How is impact generated?

The success of each OD project also depends on the obstacles and challenges it faces. In the broader sense, four challenges have been identified, which are most often repeated in the analysed case studies (Young & Verhulst, 2016, pp.20-23):

- Readiness: It may not be surprising that countries or regions with overall low technical and human capacity or readiness often represent unacceptable environments for open data projects. Lack of technical capacity may be manifested with several variables, including low Internet penetration rate, broad digital divide or general weak technical literacy. Low technical capacities did not necessarily result in the complete "non-

squeamish" of a project. Instead, it is often a lack of potential for the project which makes it less successful than it could otherwise be.

- Responsiveness - Availability: Success is also limited when projects fail to respond to feedback and user needs. As we have seen in the previous section, the most successful projects solve a clear and well-defined need.

- Risks: The big challenge is the compromise between OD potential and the risk of privacy and security breaches. These risks are inherent in each OD project - by its nature, greater transparency exists in tensions with privacy and security.

- Allocation of resources: In the end, inadequate resource allocation is one of the most common reasons for limited success or complete failure of the project.

Some of the recommendations for the future use of OD are: the definition of key areas that OD can add value to, encouraging cooperation between sectors (especially between government, private sector and civil society), and treating data as a vital resource of public infrastructure in the 21st century.

Arguments for and against OD

Like any idea since the beginning of mankind, the concept of OD also has arguments for and against it - the debate is still ongoing. Unlike other discussions in which the arguments are categorically stated, in this discussion the arguments are changed depending on the type of information being discussed.

The main arguments in the name of OD are as follows:

- Public money is used to finance work, so it should be universally available. - The main objective of this argument is focused on Open Data in the government. The idea is that if taxpayers are paying for data collection, they also need to use free data**.**

- Facts cannot be legally protected.

- Opening up data helps to combat "data rotation" and ensures that scientific-research data is preserved over time.

- "Data belongs to the human race". Typical examples are genomes, organisms, medical sciences and environmental data after the Arusha Convention.

- Research sponsors do not get full value unless the data is available freely.

- Restrictions on reusing data create anti- communion/ poor connections.
- Data is needed for the smooth running of communal human activities and it represents an important factor in socio-economic development (health care, education, economic productivity, etc.).
- In scientific research, the rate of detection is accelerated by better data access.

The arguments against putting all available data as OD include the following:

- State funding cannot be used to duplicate or disprove private sector activities,
- Governments must be responsible for the efficient use of the taxpayer's money: If public funds are used to aggregate data and if data is made commercial (private) only for a small number of users, those users should pay the government for data charges,
- One of the serious issues with open data is "re-identification". This is a situation where someone can identify a person from a depersonalized data set,
- OD creates the possibility of inequality in the use of information. It gives everyone the opportunity for business or civic projects. Different market players have different levels of readiness to use OD. Large companies that have teams for processing such data have the ability to be even bigger, while small businesses cannot spend money for data analysis,
- Revenue generated by disclosure of data enables non-profit organizations to fund other activities,
- The government provides specific legitimacy to certain organizations to recover costs (NIST in the United States and the United Kingdom Abolition Survey),
- Privacy concerns may require that data access is limited to specific users or data subgroups,
- Collecting, "cleaning", managing and disseminating data are usually work and / or cost processes - whoever this service is provided from, they should receive fair compensation for providing these services,
- Sponsors do not get full value unless their data is used appropriately - sometimes it requires quality management, dissemination and branding that can best be achieved by charging fees to users,
- Frequently targeted end-users cannot use data without further processing (analysis, application, etc.) - if anyone has access to data, none of them can encourage the investment in processing needed to

make the useful data useful (typical examples are biologically, medical and ecological data).

Conclusion

Collaboration and data exchange between people and nations are very important for the further development of the human species. The open concept of data is an idea that accelerates development, while reducing costs and efforts. In the documentary entitled "Steve Jobs: Lost Interview" (Cringely & Sen, 2012), to the question about designers in the Apple's building (Why are there so few of them?), Jobs responds that program developers are like stones in the polishing drum. When they hit each other, they get polished and eventually the drum walls get polished. It is the same with people and ideas - when they collide with each other, they exchange ideas and eventually get extraordinary products. The OD concept is like a grinding drum, it helps ideas to reach people.

The contribution in this paper is the accentuation of public data, i.e. that which is easily accessed and used and transmitted further for free. Open data is structured for processing, utilization and computer analysis. The paper presents the basic concepts of OD, areas where it is used most and the most important experiences and benefits of its use. It has been pointed out how OD affects people's lives, and it has been emphasized that the preconditions must be met in order to significantly increase the effects of OD and how influence is created with it. Furthermore, there are some specific challenges that arise in its use.

In the research related to the material in this paper, the authors had some difficulties. Namely, there is no structured approach to open data research in government and educational institutions, but it is the privilege of large companies such as Amazon, Google, Facebook, and Microsoft, for example. Although open access to data is a growing trend, practical research is limited to journals that have free access and open licensing for academic publications, and there is scarcity in material associated with open data problems.

In the coming period, our work will be focused on the state of affairs in the field of OD in Serbia, as well as on the examples of its application in specific fields, such as medicine / public health in the world as well as in Serbia.

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КОНЦЕПЦИЯ ОТКРЫТОЙ ДАТЫ, ЕГО ПРИМЕНЕНИЕ И ОПЫТ

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РУБРИКИ: 20.19.00 Аналитико-синтетическая переработка документальных источников информации
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Создание более богатого, более справедливого и справедливого общества требует от правительств более прозрачной и ответственной работы - поддержания регулярного и значимого общения с гражданами. Открытые данные являются средством для достижения этой цели. Открытые данные - это цифровые данные, доступные для общественности. Они обладают такими техническими и юридическими характеристиками, что каждый может в любое время и в любом месте использовать их, повторно использовать и распространять их. Основное внимание в этом документе уделяется данным, которые легко доступны, используются и распространяются бесплатно. Они структурированы для удобства использования и компьютерного анализа. Такие данные называются общедоступными или открытыми данными. В статье рассматриваются основные концепции открытых данных, где они наиболее часто используются, наиболее важный опыт и преимущества их использования, как они влияют на человеческую жизнь, которым должны соответствовать вышеизложенные предварительные условия для значительного усиления воздействия открытых данных, как они создаются. влияние на них и проблемы, возникающие при их использовании.

Ключевые слова: открытые данные, концепт открытых данных, публичные данные, практика применения системы открытых данных, открытый код, открытое аппаратное обеспечение, открытое содержание, открытый доступ.

КОНЦЕПТ OPEN DATA, ЊЕГОВА ПРИМЕНА И ИСКУСТВА

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ОБЛАСТ: информатика
ВРСТА ЧЛАНКА: стручни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Стварање богатијег, равноправнијег и праведнијег друштва захтева да владе раде на транспарентнији и одговорнији начин – да одржавају редовну и значајну комуникацију са грађанима. Отворени подаци, који су дигитални и доступни јавности, јесу средство да се тај циљ достигне. Они имају такве техничке и правне карактеристике да сваки човек, у сваком тренутку и свуда, може да их користи и пре расподељује. Подаци којима се лако приступа и бесплатно се користе и дистрибуирају структурирани су за употребљивост и компјутерску анализу, а називају се јавно доступни или отворени подаци. У раду су изложени основни концепти Open Data и дати одговори на питања: где се највише користе, каква су искуства и користи при њиховој употреби, какав је њихов утицај на живот људи, који се предуслови морају испунити да би се знатно повећали утицаји отворених података, како се остварује утицај помоћу њих и који се изазови јављају при њиховом коришћењу.

Кључне речи: отворени подаци, концепт отворених података, јавни подаци, искуства у коришћењу отворених података, отворени код, хардвер отвореног кода, отворени садржај, отворени приступ.

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MODELING THEORY AND THE LEVEL OF MODEL COMPLEXITY

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Abstract:

This article deals with the level of detail and complexity of the model. The aim of the article is to find out what are the objective options for determining the optimal level of detail and complexity of the model. First, the basic concepts of the model and modeling are explained. Consequently, the concepts of complexity and level of detail are examined. One of the solutions to this problem is a fictitious model and a theory of model performance measurement.

Key words: modeling, simulation, level of detail, complexity.

Introduction

The area of models and modeling is very broad. Models are used in many fields like industry, science, humanitarian help, etc. One of many model definitions (The Open University: OpenLearn, 2019) says that it is an *abstraction* which allows the observer to concentrate on the essentials of a (complex) problem by keeping out non-essential details. It also postulates that models are built in order to help in activities such as the development of large software systems. Models are less complicated than reality since they are simplifications of reality. Only the properties of the reality relevant to the modeler's main concern are represented. For example, a road map is a model of a particular part of the earth's surface. It does not show details such as vegetation or birds' nests as they are not relevant to the map purpose. The map should only contain the aspects of the real world that serve the purpose of planning journeys.

Another author (Maria, 1997) defines a model as a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. A model should be, on the one hand, close to the real system. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. In simple words, *a good model is a judicious tradeoff between realism and simplicity*. Simulation practitioners in general recommend increasing the complexity of a model iteratively. A model intended for a simulation study is a mathematical model developed with the help of simulation software. Mathematical model classifications include deterministic (input and output variables are fixed values) or stochastic (at least one of the input or output variables is probabilistic); static (time is not taken into account) or dynamic (time-varying interactions among variables are taken into account). Typically, simulation models are stochastic and dynamic (Maria, 1997).

Processes of building models can vary as there are many types of models. Its basic concept is usually similar, used by other authors as well, for instance (Brunclík, 2017).

It consists of several steps (Dlouhý, 2007):

1. Identification of examined problem and goal setting;
2. Building of a conceptual model;
3. Data collection;
4. Building of a simulation model;
5. Verification and validation;
6. Experiments and result analyses;
7. Documentation of a model; and
8. Implementation.

These steps are illustrated in Figure 1 bellow.

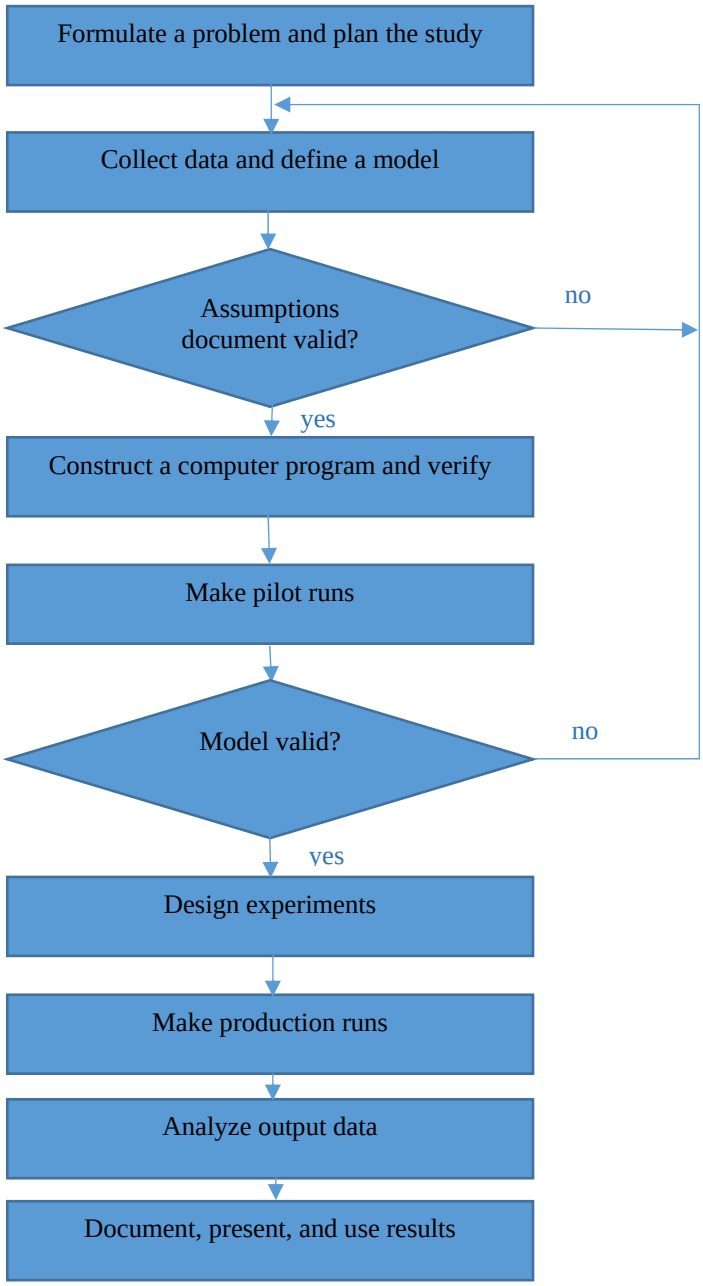

Figure 1 – Steps of modeling and a simulation of a model (Law, 2015)
Рис. 1 – Шаги в моделировании и симуляции модели (Law, 2015)
Слика 1 – Кораци у моделирању и симулацији модела (Law, 2015)

As it was indicated above, during the modeling process,a question of model complexity/simplicity arises. Not even knowing the answer, the modeler solves this question in the step of conceptual model building. The goal of this step is to choose the best conceptual model which will lead to the best result of a project.

The conceptual model can be defined as a system representation created by the compositions of concepts that help people understand or simulate the entity that the model represents. The most widespread is the understanding of the model as something that in a certain sense represents another entity that, in the context of the model, is considered something to be imitated - modeled. There must be some kind of similarity between the model and the original for which the model is created. For example, by making it possible to consider from the results of the experiment with the model, what would be the results of the corresponding experiments performed on the original (Křemen, 2007)?

Choosing the best model is often a problem of selecting an appropriate level of detail or complexity, which is considered one of the most difficult aspects of the modeling process (Brooks & Tobias, 1996). It is important to realize that the aspect of model complexity can decide about the project success. If a too high level of detail is chosen, the results are on the one hand precise and accurate. On the other hand, processing such a level of detail can be very expensive, so it takes much longer time to consider and measure so many data and finally the model also cannot be easily transformed for future use. The opposite situation would be if the model is too vague. Such a model could be easily transformed and used for a different situation. The problem is that the result of the model is too general and does not represent the specific reality to the desired extent.

Level of detail and complexity

Unfortunately, there is not one accepted definition of level of detail or complexity. However, in case we want to apply this term in the environment of the model and modeling, the level of detail could be understood as an extent of model's particularity. For instance, the extent of model elements, like the number of security scanners and guards in case of a model of the airport security check-in or the amount of cars, drivers, warehouses and customers in case of a distribution chain model.

Complexity, on the other hand, is used much more often in different kinds of the fields of science. For example, there is the mathematical

complexity describing the difficulty in computing, software complexity, behavioral complexity, logical complexity and others.

Flood & Carson (1993) see the complexity as anything that is hard to understand. Johnson (2001) says that complexity characterizes the behavior of a system or model whose components interact in multiple ways and follow local rules, meaning there is no reasonable higher instruction to define the various possible interactions.

Usually, the simple model is considered as the opposite to the complexity model.

As was mentioned above, the problem of choosing the best model or the best level of detail and complexity can also be easily imagined as the problem of selection the right one among many alternatives. Each of this alternatives has different specifics and would produce different performance in the project. Therefore, in order to select one alternative, each of them would have to be examined in terms of performance and compared.

Unfortunately, the research in this area is not sufficient. The possibilities of model performance measuring is examined in the next section.

Model performance

Brooks & Tobias (1996), in their article Choosing the Best Model: Level of Detail, Complexity, and Model Performance postulate 11 steps, needed for proper measurement of model performance, divide them in 4 areas according to their role in a specific project. The word specific is, in this case, an important one. The model would provide different performances when applied for two different projects.

Area of RESULTS

1. The scope in which the model output describes the behavior of the examined object (adequacy of detail).
2. The accuracy of model results.
3. The simplicity with which the model and the results can be understood.
4. The area of the FUTURE USE OF THE MODEL
5. The portability of the model and the ease with which it can be combined with other models.
6. The area of VERIFICATION AND VALIDATION
7. The errors appearance probability (the created model does not correspond to the conceptual one)

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8. The accuracy with which the model corresponds to the historical data
9. The strength of the theoretical basis of the model including the quality of the input data (credibility of the model).
10. The area of the REQUIRED RESOURCES
11. The time and cost to build the model (data collection, verification, validation, etc.)
12. The time and cost to run the model
13. The time and cost to analyze the model results
14. The hardware requirements to run the model (pc memory, processor, etc.)

Assessing these steps in a model project and its alternatives could help to determine the level of detail and complexity appropriate to the model.

These steps can now be closely described using the example of the previously mentioned airport security check-in procedure.

Model example

Let the fictional check-in procedure be considered for a project of building one medium-sized airport. The problem of this part of the project is to buy a specific number of scanners, to hire a specific number of guards and to decide, consequently, how big this airport area should be. The goal of the model is therefore to determine the likely number of customers going through the security scanners per day.

Step 1 can be described as a scope in which the results of a model cover the experimental frame (Zeigler, 1976). It shows the level of detail of the model results. The following step 2 can simply be described in the following words: the more the results are accurate, the more the decisions taken and the conclusions drawn are likely to be correct. In the case of the airport project, it is desired that the result, the number of customers per day, is accurate in order to determine the optimum amount of all elements. However, it is not needed to know the exact number of customers for each day per year as there are some occasions like Christmas, New Year or Easter when the number would be much higher. These specific days only need to be considered as a deviation from the standard day.

If the project solver wants to be able to demonstrate the results of the model and the model itself properly, he/she needs to keep the model as simple as possible. This is how step 3 could be described. On the one

hand, we want the model to be accurate; on the other hand, the more complicated the model is, the more likely some mistake in processing it can be made. Also, in many cases, the project owner is only the contracting authority and the model builder must subsequently present the results to them. It is not the part of their business to be able to understand specific scientific terms. Therefore, the builder should know to pay attention to this field as well.

Step 4 deals with the portability of the model. It means the possibility to transfer the model into a different system. In the case of the airport project, it means to take the model security check-in procedure and use it with different data. It might be important for a case when the project owner has two possible scenarios and is not sure about the concrete location of the airport. So, the model should be complex enough to enable the accurate results but also abstract enough to enable the portability between more system scenarios.

The scope of the level of detail used within the model may also correspond with the probability that the created model will not be the same as the conceptual model or that some input data will not be valid. The model must be trustworthy and all planned aspects in the conceptual model should be therefore included in the created model and stand on the true grounds. Also, is important that the model stays in the frame of historical data. Last but not least, the quality of the input data is also a very important factor. These points are considered in steps 5, 6 and 7. By going through these steps, we can consider the extent of complexity of the model and the level of its detail in order to ensure the accurate results.

The last area of steps 8 to 11 estimates the resources needed to build the model. These steps consider the adequacy between the time and the costs spend for the model, the results it can bring and the level of detail and complexity which is incorporated in the model.

Conclusion

This area is not fully mapped, so it is not possible to determine unequivocally the optimal level of detail or complexity with which the model, or its results, should be processed. One option is outlined in the article along with a specific example of the model. There are 11 steps that model makers could use to have an overview of the significant points that should be particularly noticeable when designing and which can, at least partially, contribute to selecting the appropriate level of detail and complexity of the model.

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ТЕОРИЯ МОДЕЛИРОВАНИЯ И СЛОЖНОСТИ МОДЕЛЕЙ

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ВИД СТАТЬИ: профессиональная статья
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Резюме:

В данной статье рассматриваются уровни детализации и сложности моделей, с целью выявления объективных

вариантов определения оптимального уровня детализации и сложности моделей. В первой части статьи описаны основные концепции моделей и моделирования, а затем были представлены результаты испытаний концепции сложности и уровня детализации. В решении настоящей проблемы могут помочь воображаемая модель и теория оценки эффективности модели.

Ключевые слова: моделирование, симуляция, уровень детализации, сложность.

ТЕОРИЈА МОДЕЛОВАЊА И НИВО СЛОЖЕНОСТИ МОДЕЛА

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ОБЛАСТ: логистика, моделовање
ВРСТА ЧЛАНКА: стручни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

У чланку се разматрају детаљи и сложеност модела, с циљем да се утврди које су објективне опције при одређивању њиховог оптималног нивоа. Објашњавају се основни концепти модела и моделовања, а затим се испитују концепти сложености и нивоа детаља. Једно од решења овог проблема представља замишљени модел, као и теорија мерења перформанси модела.

Кључне речи: моделовање, симулација, ниво детаља, сложеност.

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CHALLENGES OF THE IMPLEMENTATION OF THE CONCEPT OF FLEXIBLE USE OF AIRSPACE IN THE REPUBLIC OF SERBIA

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Abstract:

The authors analyze the implementation of the concept of flexible use of airspace in the Republic of Serbia, which deals with problems related to airspace capacity. The problem of airspace capacity and air traffic that takes place in it was not seriously considered in Europe before the Second World War, due to the simple fact that the number of flights in that period was relatively small. Achieving this goal and solving the problem is being sought in a better organization of the airspace of Europe, which directly influences the organization and strategy of the development of the airspace of all countries in Europe and the Republic of Serbia (as a signatory and a member of international organizations dealing with traffic management and airspace organization). The concept of flexible use of airspace should provide a solution to this problem. The implementation of the concept requires some legal and organizational solutions, so a wider national concept is needed for a consistent implementation of the concept. The problems encountered by the creators of the concept in Europe and Serbia and the solutions that have been made are the subject of this paper. The content of the paper is presented through several questions to give an overview of the problem of airspace capacity and an increase expected in the upcoming period. The paper also deals with the division of airspace in the world and in our country; planning, registering and

announcing flights; the concept of flexible use of airspace; and the problems of applying the concept in Serbia.

Key words: concept, airspace, Republic of Serbia, European Union, international organizations, air transport.

Introduction

With the development of airline industry and the discovery of new types of aircraft engines and the modernization of aeronautical techniques, it was possible to cover large distances in a relatively short time. People began to intensively use air transport for various purposes. The development of tourism and modern business has had a direct impact on the rapid development of air transport. Air travelers arrive for a much shorter time at their destinations than travelers using road or water transport. The long-haul flights has become common and the number of users in air traffic has been constantly increasing. With the constant increase in the volume of air traffic, there was also a need for the adoption of certain specific laws and regulations that guarantee the safety and security of all traffic participants while at the same time facilitating the smooth flow and development of traffic. The aim of the paper is to show the influence of international treaties (signed by the Republic of Serbia) on the organization of the airspace above its territory and the necessity of defining a clear strategy for the development of the airspace of the Republic of Serbia. The ATM Air Traffic Management (ATM) has the data showing that, in the sky of Europe, there are about 26,000 flights daily on average. Forecasts indicate that the volume of air transport will double by 2020 (Eurocontrol. What is the Single European Sky, 2018), which makes traffic demands significantly larger than the capacity of airspace. An additional problem in the deployment of civilian air traffic is the activation of military zones in which military flying is carried out. When activating military zones, the airspace of the area covered is closed to civilian traffic, which as a result has a major decline in capacity in a certain part of Europe's airspace, because of the need for aircraft to be vectorized[1] around the military zones. (Službeni vojni list, 14/ 2018)

The ultimate effect of activating military zones is most often the introduction of air traffic control measures whose negative impact is manifested in the form of plane rerouting or delay (delay) on the ground

[1] Radar guidance or vectorization is the use of radar data for determining the rate, speed and height of aircraft operations (or to determine the optimal route around the activated military zones in order to reduce delay in air traffic).

before taking off. Delaying the plane on the ground or its rerouting creates an additional cost to airlines. The fact that the activation of military zones creates major problems in air traffic is also evidenced by the fact that Eurocontrol[2] established a special department for civil-military cooperation dealing with the problem of flexible use of airspace by civilian and military aircraft (Eurocontrol. Civil-Military, 2018). Eurocontrol's main goal is to better utilize airspace capacity and reduce current flight delays in Europe's airspace.

Airspace sharing

Today there are many different definitions of airspace. Sovereignty in airspace from the viewpoint of territorial integrity and state security is defined by international legal acts. The Convention on International Civil Aviation held on 7 December 1944, Part I, Chapter I, Article 1 defines: "States Parties recognize that each State has complete and exclusive sovereignty over the airspace above its territory" (International Civil Aviation Organization, 2006). This implies, on the one hand, sovereignty that is not shared with others, and on the other hand, the realization that it is a comprehensive sovereignty over land and the territorial sea. The military lexicon defines airspace as follows: "The airspace is the space around the Earth filled with air. The upper limit of the airspace is not legally defined. The smallest distance in the vertical plane is taken by the one that has the air and which allows the flight of aerodynamic aircraft. The airspace of the state is defined by a space in the vertical and horizontal plane above its surface (land, lake, river, inland sea waters and territorial or coastal sea), which forms part of its state territory and on which its sovereignty extends. The state of the air is inviolable. The entry into the airspace is regulated by the state and is authorized to prohibit it. Through international obligations, states take over the obligations to allow international traffic in their airspace" (Vojnoizdavački zavod, 1981). The Rules on the Flying of Military Aircraft of the Republic of Serbia (Službeni vojni list, 14/2018) and the Law on Air Transport of the Republic of Serbia in Article 4 define "airspace as the space above the territory of RS. The use of the RS airspace is available for all aircraft operating air transport, according to international acts, this law and other regulations" (Službeni glasnik RS, 66/2015). By the NATO definition, the airspace is a space above the territory and the territorial sea of a NATO member state. The

[2] The European Organization for the Safety of Air Navigation is an international organization, founded in 1963, the primary objective of which is the development of a continuous, pan-European air traffic management system.

Law on Air Transport and the Rules on the Flying of Military Aircraft of the Republic of Serbia do not define the upper border of the airspace.

The legal nature of the airspace is determined by the airspace over the land and water areas of the state and over it the state exercises sovereign power, and over the open sea there is a free airspace that is not subject to sovereignty of states. International law and internal law are based on the fact that the state has full and exclusive sovereignty in the airspace above its land and water area.

However, the authorities of a state are legally limited in exercising their territorial sovereignty by the obligation to provide other states with the opportunity to use the airspace in a certain way and under certain conditions. Thus, for example, the right for foreign aircraft to fly over is contracted, provided that it is not offensive and only in peace, that it is done by airlines of the Contracting States, and the home state prescribes rules on the acceptance of foreign aircraft, entry and exit corridors, air flying routes, for overflights, landing and landing aerodromes and a general safety regime on the basis of which it may require the landing of a foreign aircraft. In order for the traffic to run smoothly and prevent delays, i.e. to increase the capacity of the airspace, states resort to the signing of certain international agreements, which, in cooperation with Eurocontrol, are scientifically trying to solve problems at the national levels. The precondition for defining a new way of organizing airspace and applying scientific methods for increasing airspace capacity is to control that space.

Controlled airspace

Controlled airspace "is a dimensionally defined airspace in which the control and "control of " the aircraft is performed by air traffic control, according to the visual and instrumental flight rules and in relation to the classified airspace. Controlled airspace is divided into several categories; there are classes "A", "B", "C", "D", "E", "F", and "G". The rule is that a flight must be announced and authorized by Flight Control (FC; in Serbian KL) with an adequate flight permit, from flight to landing, during the flight in the controlled airspace when flying by the instrument flight rules (IFR). During the flight, the transponder "mod C" or "mod S" must be on the plane. In this way, FC provides adequate separation of IFR-based aircraft. FC also provides separation and "guidance" of VMC-Visual Meteorological Conditions, which fly according to IFR rules. It is important to note that FC is not responsible for the separation of IFR-flying and those that fly by Visual Flight Rules under conditions without radar identification (Skybrary. Classification of Airspace, 2018). In Figure 1, we can see the airspace dividing chart.

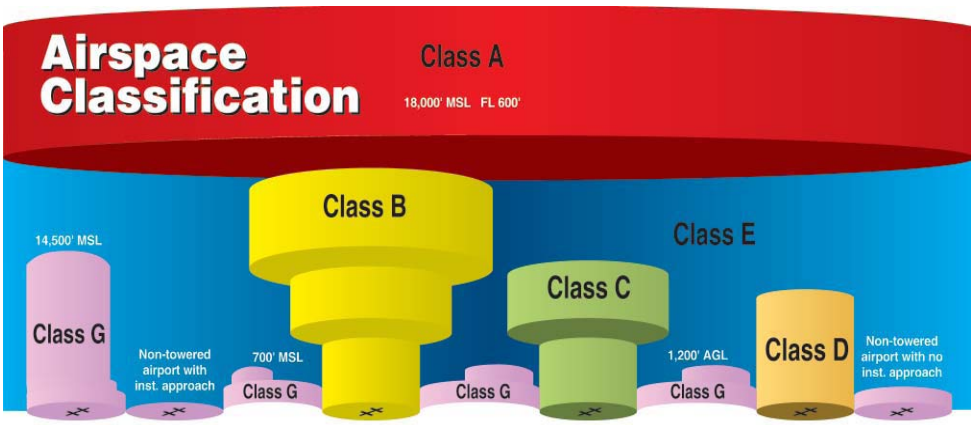

Figure 1 – Distribution of airspace by classes (Federal Aviation Administration, 2018)
Рис. 1 – Классификация воздушного пространства (Federal Aviation Administration, 2018)
Слика 1 – Подела ваздушног простора по класама (Federal Aviation Administration, 2018)

	Class A	Class B	Class C	Class D	Class E	Class G
Entry Requirements	ATC clearance	ATC clearance	Prior two-way communications	Prior two-way communications	Prior two-way communications*	Prior two-way communications*
Minimum Pilot Qualifications	Instrument Rating	Private or Student certification—local restrictions apply.	Student certificate	Student certificate	Student certificate	Student certificate
Two-Way Radio Communications	Yes	Yes	Yes	Yes	Yes, under IFR flight plan*	Yes*
Special VFR Allowed	No	Yes	Yes	Yes	Yes	N/A
VFR Visibility Minimum	N/A	3 statute miles	3 statute miles	3 statute miles	3 statute miles**	1 statute mile†
VFR Minimum Distance from Clouds	N/A	Clear of clouds	500' below, 1,000' above, 2,000' horizontal	500' below, 1,000' above, 2,000' horizontal	500' below,** 1,000' above, 2,000' horizontal	Clear of clouds†
VFR Aircraft Separation	N/A	All	IFR aircraft	Runway operations	None	None
Traffic Advisories	Yes	Yes	Yes	Workload permitting	Workload permitting	Workload permitting
Airport Application	N/A	• Radar • Instrument approaches • Weather • Control tower • High density	• Radar • Instrument approaches • Weather • Control tower	• Instrument approaches • Weather • Control tower	• Instrument approaches • Weather	• Control tower

*Exception: temporary tower or control tower present
**True only below 10,000 feet
† True only during day at or below 1,200 feet AGL (see 14 CFR part 91)

AGL—above ground level
FL—flight level
MSL—mean sea level

Figure 2 – Conditions for using particular airspace classes (Federal Aviation Administration, 2018)
Рис. 2 – Условия использования воздушного пространства в соответствии с классом (Federal Aviation Administration, 2018)
Слика 2 – Услови за коришћење одређене класе ваздушног простора (Federal Aviation Administration, 2018)

The "A" airspace class represents the limited air space from flight level FL 180 (FL-Flight Level) or 18,000 feet (≈6000 m to FL 600 or 60,000 feet (≈20000 m). All planes that fly to "A" "airspace classes must comply with the IFR flight rules, have the FC license for flight at that altitude and a height-adjustable altimeter at a standard pressure (QNE = 1013mbar / 760 mmHg), thus ensuring the required separation of planes at horizontal and vertical levels. VFR flights in the A-class airspace are not allowed. A-class airspace is used by aircraft that can fly at high altitudes and high speeds for flying between major cities. In order to enter that class, there must be an ATC Air Traffic Control, pilots must have the prescribed flight permit under such conditions, two-way radio communication is required as well as the monitoring and separation of the traffic and the advisory role of FC, while there are no requirements related to the airport (A class is limited to the altitudes from FL 180 to FL 600 and does not extend to the ground, Figure 1).

The "B" class of airspace is used around large airports and extends from ground to a height of 10,000 feet in some cases and more. At higher levels of the "B" class of airspace, the horizontal limit of FC liability may be greater than 15 nautical miles around the tower (Figure 1). Consequently, there is no universal provision of the "B" airspace class but it is formed on the basis of airport needs, and the volume of traffic at that airport and the geographical position of the airport itself. In class "B" of the airspace, flights of ultra-light aircraft are prohibited. The "B" class is remembered on the basis of the English slogan "Big City airspace", for the airspace above big airports, i.e. cities. For this class, there must be an ATC license, pilots must have the prescribed flight permit for such conditions, visual flying with a visibility of more than 3 miles is permitted, two-way radio communication is mandatory, FC has traffic monitoring and advisory role, and the airport is equipped with all the necessary tools for FC in that class (Figure 2).

The "C" airspace class - if "B" is for "Big Cities", then "C" is simply for "Cities". The spatial constraints of the "C" class are smaller than those for the "B" class (Figure 1), only flying by FC is permitted. The control tower in the "C" class is equipped with a radar for FC and can also control some smaller airplanes (which cannot belong to the D class). Ultra-light aircraft cannot fly in the "C" class without a special license issued by FC based on a phone call or a radio call. Cities that have the "C" class of the airspace are not big cities, but they have traffic with large planes and normal commercial flights. In order to enter this class, there does not have to be an ATC license, which pilots have after completed some degree of training, but students and trainee pilots can fly in that

class, two-way radio communication is mandatory, visual flight is allowed with visibility greater than 3 static miles and the prescribed distance from the clouds: horizontal 2000 fits, above the clouds is shifted to 1000 feet and below 500 fits, traffic monitoring and advisory role of FC is carried out, and the airport is equipped with all necessary means for FC in that class (Figure 2).

The "D" airspace class is used for small airports that have their own control tower. The "D" label explains the size of the airport (city) as "Diminutive" or "Dime-sized" (reduced, small). All commercial flights are permitted in this area, flight through this area must be announced and approved by the control tower (FC). Radio communication is required. Separation in this area is done by FC; such space (airport) is often used for training flights and training of young pilots. The dimensions of such a space are within the boundaries from the earth up to 2,500 feet high and about 8.6 nautical miles (10 static miles) around the tower.

The "E" class of airspace is a controlled space that is not included in "A", "B", "C", and "D" classes. The "E" class of airspace can be defined as "E" for "Elemental" or "Everywhere airspace" (adjacent, other airspace), and represents the space that starts from the surface of the earth or of some indicated height (heights based on which the airspace of the mentioned classes "A", "B", "C" and "D" is already occupied Figure 1) and the adjacent airspace (space between classes). For example: if an airplane is flying on an air path below 18,000 feet, it is in the "E" class. As the "E" class, a space between two terminal FCs at a height of 14500-18000 is defined. The class "E" of the airspace provides control of IFR-controlled airplanes to remain in a controlled airspace as well as the regulated separation of aircraft on the route.

The "F" airspace class is a space in which both the IFR and VFR rules can be applied. Separation in that area is performed by FC as long as it is practical and airplanes fly according to the IFR rules. Traffic information can be provided until the time FC finds practical in relation to other flights.

The "G" airspace class is an uncontrolled airspace in which VFR is applied. The "G" class of airspace can be defined as "G" for "ground". The upper limit of the "G" class is where the lower limit of the other classes is. This includes the entire airspace that is not defined by the above classes. No FC is provided in this area. To enter this class, there is no ATC license but only two-way radio communication, visual flight is allowed with visibility greater than 1 mile and without clouds, there is no separation performed by the tower, but by pilots themselves based on the traffic data obtained (Figure 2). This means that the only requirement

for a flight in that class is required visibility for the crew and its plane. Based on the signed international treaties, while respecting the specifics of the relief, shape and position of the country, the Republic of Serbia carried out the division of its airspace.

Airspace division in Serbia

The airspace of the Republic of Serbia is divided into controlled and uncontrolled airspace. The Decree on Airspace Classes of the Republic of Serbia introduces C, D, and G classes and the conditions for their use (Službeni glasnik RS, 106/2013). The C class airspace is applied in a controlled airspace from the lower limits of the controlled airspace to flight level (FL) 660, except in controlled zones and airport traffic zones when they are active.

The D class airspace is applied in controlled zones during the operating hours of the air traffic control units responsible for providing services in the controlled zone except in the airport traffic zones when they are active.

The G class of the airspace is applied:

- outside the controlled airspace;
- above flight level (FL) 660;
- in all airport traffic zones up to the levels published in the Integrated Aviation Information Package, when those zones are active or up to the level approved by the competent air traffic control unit;
- in zones of sports activities, up to the levels published in the Integrated Aviation Information Package, when those zones are active.

VFR flying in the C, D and G classes of airspace is permitted if the following meteorological conditions are met:

- minimum visibility in flight:
    - 8 km at and above 3,050 m (10,000 ft),
    - 5 km below 3.050 m (10.000 ft);
- minimum distance from clouds:
    - 1,500 m horizontally,
    - 300 m (1,000 ft) vertically.

In the controlled zone, the competent air traffic control unit may grant a VFR flight (so-called special VFR flight) below the minimum prescribed in paragraph 1 of this Article at speeds of less than 140 kt IAS (Indicated Air Speed) in the following meteorological conditions: 1) minimum visibility in flight: 1,500 m (800 m for helicopters); 2) bottom base of clouds: 180 m (600 ft). Since it is a controlled airspace, an application for the use of a particular airspace or the use of a particular route must be recorded and properly processed. The entry and exit from the zone must be announced and reported to the competent air traffic control, as this is the only way to satisfy the needs of the users and control the capacity of the airspace. The mode of announcement and registration of flights is defined by each state separately, with respect to international agreements related to the standardization of the form of flight plans that are located at each airport flight control.

Planning announcements and flight security announcements

Planning, announcing, reporting and securing flights of military and civil aircraft are carried out in accordance with certain regulations determined by the national aviation authority and must be in accordance with the signed international agreements (SMATSA, 2008). Such regulations regulate air traffic in a particular country. The planning regulates the modes, procedures and obligations of the air traffic control authority. Flight planning of military aircraft represents the actions and procedures of the competent authorities in the preparation and delivery of the flight plan to the competent air traffic control service. Civil Aviation Planning represents the actions and procedures of domestic and foreign air carriers and other civil aircraft owners or holders of the right to dispose of aircraft that are submitted to the Flight Control Agency in the form of flight plans or flight clearance requests. The flight announcement of the aircraft represents the actions and procedures of the flight control service on the receipt and distribution of the flight plan to participants in the provision of flying and the identification of aircraft in the airspace. Airplane flight recordings represent the actions and procedures of flight control services to provide information for the identification of aircraft to military authorities. The flight ID is an alphanumeric series of up to 7 (seven) characters, which enables all participants in the announcement process to register the aircraft identification in flight. Identification of aircraft in the airspace consists of the actions and procedures of flight control and military authorities in order to determine the belonging of

aircraft and compliance with the approved conditions for flight execution. Flight security is a set of measures and procedures undertaken in order to provide timely and complete security for the safe and efficient execution of flights. The flight registration recognizes: airport flying, out of the airport flight and overflight. Member States in international aviation organizations have pledged to clearly state their needs for occupying airspace at precisely defined time intervals by planning, announcing, reporting and securing flights.

By its membership in international aviation organizations, the Republic of Serbia has undertaken the commitments dictated by organizations such as ICAO[3] or the European Civil Aviation Conference - ECAC (Republic of Serbia is a member since 27 November 2002) and the European Organization for the Safety of Air Navigation - EUROCONTROL (Republic of Serbia is a member since 01. 07. 2005); also, by signing the Multilateral Agreement with the European Commission on the establishment of the "Common European Aviation Area" - ECAA[4] (Republic of Serbia has been a member since June 28, 2006), Serbia has undertaken the implementation of pan-European programs, goals and principles contained in the ATM Strategy 2000+ (Air Traffic Management - ATM Strategy 2000+).[5] Eurocontrol's European Sky Development Strategy is primarily designed and built because of:

- the expected increase in the requirements for the use of airspace of all groups of users (military aviation, naval and land forces, air carriers, general, agricultural and sports aviation),
- existing forecasts indicating a doubling of the volume of commercial air traffic by 2020 compared to 1995,
- inability of the existing air traffic management systems - ATM systems to satisfactorily provide growing demands. (Stanković & Petošević, 2012, pp.211-229)

The problems encountered by Eurocontrol were primarily related to the necessity of introducing numerous changes in the organization of

[3] In 2000, the Republic of Serbia renewed its membership in the ICAO International Civil Aviation Organization, which was interrupted by developments on the territory of the former SFRY in the 1990s.

[4] The legal basis for the integration of the Republic of Serbia into the European Union in the field of air transport is the "Multilateral Agreement on the Establishment of a Common European Aviation Area" (ECAA agreement) (Civil Aviation Directorate of the Republic of Serbia. Multilateralni sporazum, 2018).

[5] ATM Strategy 2000+ was adopted in January 2000, with the aim of improving air traffic management capabilities with a vision for the period up to 2020.

airspace and the organization of flights in it. Ensuring greater capacity for overflight traffic was the main obstacle in ensuring efficient use of the European airspace. The formed airspace structures at the national level are complex and diverse, so the evolution of Eurocontrol's airspace strategy for the ECAC member states aims to ensure simplification and harmonization. The planned national airspace development strategies cannot be developed in isolation, since each country is individually an integral part of the European system.

The strategic goal of organizing the airspace is to move, in proportion to the development of aircraft and increasing traffic, towards a unique organization of the airspace called Single European Sky - SES (Eurocontrol, What is the Single European Sky, 2018), which will represent one space for all ECAC members. In practice, this means that the entire airspace is not limited to national borders and provides maximum freedom for all users, with the required level of air traffic safety, without disturbing defense and security systems at the state level. In this context, a key mechanism recognized by the European Commission is the creation of a functional airspace that would be based on operational requirements for airspace management, regardless of national boundaries. The main project for achieving this goal is the implementation of the Flexible Use of Airspace (Eurocontrol. Flexible Use of Airspace, 2018) fully, without limitations. The program objectives of the airspace strategy are:

- "development of new customized airspace structures that will better respond to the requirements of the users for the provision of air traffic,
- achieving the unique application of airspace structures and classification in Europe,
- increasing the freedom of movement for all users of the airspace, and
- application of the existing improvements in the use and introduction of new ones" (Stanković & Petošević, 2012, pp.211-229).

Eurocontrol has recognized the importance of the new organization of airspace in the domain of economy and the impact on the overall quality of life of citizens using flight services. The freedom of movement of people and goods, the development of traffic and the increasing demands of the military for the ever-increasing allocation of large areas of airspace for training and training flights, inevitably leads to a new organization of airspace and flight rules related to separating and monitoring aircraft. In the space where requests for its use are increasing

every day, and the organization responsible for its distribution (use) has no possibility to increase it, the issue of the safety of all users is put in the first place. Flying safety is a fundamental issue in all organizations dealing with flying, from air carriers to the military. Eurocontrol and national aviation authorities (civil and military) are expected to meet safety requirements, while the security aspect of air traffic control and its organization should be implemented by clearly defining carriers of specific areas and identifying responsibilities. The needs of national defense and protection must be a priority. The Republic of Serbia is determined to actively cooperate in international frameworks, thus confirming its desire to build peace and stability in Europe. In achieving the goals of national security, the Republic of Serbia has been determined to apply the concept of cooperative security within the framework of European security structures, as well as within other regional security associations. By signing international treaties, the Republic of Serbia has the obligation to train and prepare civil and military structures to fulfill obligations in the area of defense and airspace management, which must meet both national and international security requirements. Both the demands of the army and the demands of the civil sector can be met by flexible airspace management which will harmonize the requirements of different user groups. The concept of flexible use of airspace is imposed as a solution to increase the capacity of the airspace. The basis of the concept lies in the tendency that the airspace is no longer defined as purely military or purely civilian, but viewed as unique and flexibly used on a daily basis (Eurocontrol. Flexible Use of Airspace, 2018). Accordingly, any segregation of the airspace for a particular purpose will be of a temporary nature.

The concept of flexible use of airspace

The concept of flexible use of airspace is designed to provide maximum flexibility in the use of airspace for the ECAC countries, where airspace is considered as one continuum to be allocated to users based on their daily needs (Eurocontrol. Flexible Use of Airspace, 2018). Each separation of airspace is temporarily based on the use of that space in real time and within a defined time frame. The airspace size is not limited to national boundaries. The difference in the use of airspace between civilian and military aircraft is high. Military aircraft as well as civilian ones transport goods and passengers from point A to point B, but also have far more demanding and complex exercises in which the use of airspace for altitude changes and flight speeds is multiple and is realized in a very

short time interval (training flights of combat aviation, air defense flights, training group flights, individual and group overflights to other airports, air patrols, humanitarian flights related to the evacuation of the population, search and rescue, fuel feed in the air, parachute jumping and freight throwing, supersonic interception, flight at low level by day and night, reconnaissance flights, radar interception and interception of aircraft without visual contact).

The challenges that arise in the implementation of the concept of flexible use of airspace are primarily reflected in the levels of planning the use of a particular space. Within the concept, the use of airspace is planned and divided into three organizational levels:

- "Level 1 is strategic; planning is done on a yearly and monthly basis. It is made on the basis of earlier plans and traffic from previous years. It is strategically planned to take over the airspace with conditional routes (CDR - Conditional Route) and the zones that were active in the last year. The plan is based on the structure of the airspace and the envisaged air traffic for that period.
- Level 2 is pre-tactical; planning is done from seven to one day in advance. Data is received up to seven days in advance and distributed to the main Eurocontrol management in Brussels. The day before the planned activities, the requirements for activating the zones are submitted. In Brussels, the incoming requests are analyzed and based on the priority, dislocation and relocation of a part of air traffic is done. With this, the airspace is dislocated from 06:00 h on the day of the start of the activities related to the occupation of the airspace until 6: 00h the following day.
- Level 3 is tactical; planning and coordination are carried out on the day of execution. These are changes that happen early in the morning, such as the cancellation of certain zones or some other changes related to already announced flight restrictions, which are important for the smooth flow of traffic. Changes that take place must be made until 9:00 am, local time, to the main air traffic control center in Brussels. After that, all the changes that are taking place, and are related to changes in the airspace, are resolved at the tactical level between civilian and military flight controllers." (Eurocontrol. Flexible Use of Airspace, 2018)

Flight controllers implement the scenario provided for in the operational plan and instruct pilots to strictly observe the planned and displayed flight plans. Under normal conditions, there is no need for a flight controller to react in order to further fill in flight plans because they have already incorporated all real changes that can be made based on the operator's options and wishes and the actual situation that the system offers based on all existing restrictions. Conditionally, if the data sent and come via the data delivering link become interesting / usable for all users, the execution phase will be further developed and real-time changes on the flight paths will be possible.

The next challenge faced by the creators of this concept was the implementation restrictions in the ECAC countries. The limitations were different and depended on many factors that were neither standard nor the same for all countries. The difficulties in implementing the concept were directly influenced by incomprehensible manuals that were supposed to simplify the introduction of the concept into operational use. Eurocontrol annually reported to the Member States on the degree of implementation of the concept (Hallgren, 2009). The main implementation difficulties were primarily related to non-standard space (geographic size and position of the country) in which the implementation of this agreement should be implemented and the FC system unified. Historical circumstances in these countries and their relationships with neighbors had direct influence, and the implementation also depended on current political circumstances that dictated the pace of the implementation of that agreement through the institutions of a particular country. Requests issued by the military for airspace needs in each country were different, with the direct impact of the military's technical equipment and the ability to monitor air traffic. The regulations related to the constraints and division of airspace in each country are different and depend on the national interest of that country and the professional staff who carried out the division of the airspace. The organization of the civil-military cooperation at the national level had a direct impact on the speed at which the coordination of the two systems that control airspace was coordinated. The most important factor that had a direct impact on the standstill in the implementation of the concept was the money that every state should set aside for the creation of institutions and the introduction of certain standards in order to better communicate with all factors controlling the European sky.

The problems that have arisen at the strategic level (Hallgren, 2009):

- The procrastination of the activities that took place nationally in the creation of new or merging already existing institutions into the functional units required by the concept (unified civil and military structure).
- The absence of agreed meetings for the regulation and adoption of acts and rules on the allocation and use of airspace between the states (border zone of the flight).
- Direct dependence on the level of civil / military co-operation achieved at the national level.
- Some countries based the whole concept on "fixed" airspace, which is a contradiction to the concept itself. The goal was to get one continuum from one created sky, which everyone would use according to their needs (both civilians and the army).
- Approach that the tools developed to improve the work of the concept itself were used to solve problems that only occurred at the tactical level.

The problems that have arisen at the pre-tactical level:

- Inability to see all the needs related to the use of air routes.
- Lack of data on the traffic flow and the needs of the army for flying.
- Lack of common air traffic information related to the technical support of a particular country (radar systems, aircraft equipment, etc.).
- Limited capabilities of the air routes themselves (based on the geographical location of a country) for changes in flight elements during the flight.
- Restrictions related to the timetable for using a particular route or zone. When it comes to commercial flying, the needs for new airways and cancellled zones above (through) which traffic can be directed come relatively late, i.e. the army is late in announcing the release of some of the zones. The request from the military authorities for the release of these zones is requested several hours in advance, which is too early for them since they do not have information from their commands whether there have been some changes.
- Co-operation and data exchange with the FC flow management is limited.
- There was a conflict of interest in the use of conditional routes - civilian aircraft require permanent and stable routes, while military aircraft require flexible routes that can be changed and adapted to their needs.
- The airspace clearance is not standardized in all ECAC countries. It arises from direct needs of civilian and military aircraft, and such displacement was not possible beyond all state borders as planned.

The problems that have arisen at the tactical level:

- There was no good classification and definition of airspace in certain ECAC countries.
- The pre-tactical plan was unrealistic for execution.
- Adequate data on the spread of the concept was not available.
- Poor civil / military cooperation and coordination.
- Traffic management at the tactical level was limited.

In addition to all the challenges encountered by the creators of this concept, the implementation perspective has not been called into question. Forecasts that are realistic about increasing air traffic in the coming years do not leave much room for airspace designers to handle it. The benefits of the concept are reflected in better organization and better planning of airspace use. Based on the data provided by the manager of Eurocontrol Anders Hallgren (Hallgren, 2009), only for 2008, using the FUA concept (coordination at pre-tactical and tactical levels using conditional routes) reduced fuel consumption by 108,000 tons. With a better airspace organization (without waiting on the ground and rerouting), companies saved 87 million euros, while reducing carbon dioxide emissions by 340,830 tons. If we know that from year to year the number of flights is constantly increasing, it is easy to predict the size of the savings achieved by the introduction of such a system. The desire to base the airspace on a single continuum that is not burdened with national borders allows further development of aviation and air traffic. It provides users with maximum freedom in planning and using airspace. The concept as such makes it clear that everyone in the air is equal and that the use of airspace is available to everyone, but only as much as it is necessary for the execution of planned tasks and flights. The accent is also placed on finding such airspace that is not too much burdened by traffic so that it can provide adequate space for training for military aviation (space along state borders). The fact is that even though all countries signed an agreement and embarked on the implementation of the concept through European Commission Regulations, (EC) No 549/2004, 550/2004, 551/2004, 552/2004 and 2150/2005 (Official Journal of the European Union, 2005) on the rules for implementation of the concept, the concept did not come to life in all countries at a satisfactory level. One of these countries is Serbia where its geographical position, historical and political circumstances (Kosovo and Metohija and Bosnia and Herzegovina), technological equipment and, finally, the most important factor, money, have slowed down the implementation of the concept to the full extent.

Implementation of the concept of flexible use of airspace in Serbia

The problems of implementing the concept of flexible use of airspace in Serbia had all of the stated characteristics (problems) of the implementation of the concept in Europe. Defining regulations at the national level, while respecting all constraints of one's own airspace and the airspace of neighboring countries (arising from the geographical position and the size of the country itself), had to be in line with the rules and regulations in the world. The process of the implementation of the concept in the Republic of Serbia (Službeni glasnik RS, 69/2011) is divided into the preparatory period and the period of introduction as in all European countries (Eurocontrol, 2003, p.3). During the preparatory period, the Republic of Serbia was supposed to:

- form the (National) Airspace Committee which will be responsible for the introduction of the concept,

- review the management of FC in the environment (ATM-Air Traffic Management environment),

- translate the concept into a national plan with the consent of the relevant civil and military authorities,

- prepare all functions, necessary procedures, including coordination and negotiation processes,

- prepare appropriate communication tools that will enable the implementation of the concept at all three levels (levels 1, 2 and 3).

During the implementation of the concept, states should activate all procedures and functions necessary for the operational execution of the procedures at three levels of FC (ACM-Airspace Control Measures). The minimum requirements to be fulfilled by the Republic of Serbia are given in Table 1.

Table 1 – Minimum requirements for the implementation of the FUA concept (Eurocontrol, 2003, p.10)
Таблица 1 – Минимальные требования для осуществления FUA концепции (Eurocontrol, 2003, p.10)
Табела 1 – Минимални захтеви за имплементацију FUA концепта (Eurocontrol, 2003, p.10)

1	Adoption of the FUA concept by the state Translation of the FUA concept into a national plan for the consent of the appropriate civilian and military authorities	REC 1 p.8
2	Information process Start the process of informing about the FUA concept as soon as possible in order to familiarize all interested parties with it before its implementation, including the publication of the AIC	REC 2 p.8
3	Establishment of the National Airspace Committee at level 1 Joint civil / military body responsible for implementing the concept and defining the strategy of ACM policy at level 1	ACM HB para 3.2 & 3.5.
4	Assessment of the current airspace and routing structure and the introduction of flexible airspace structures In the upper airspace and, where applicable, in the terminal area, establish manageable spaces in accordance with the accepted harmonized / coherent routing network	ACM HB para 3.3; 3.4; 3.7; 3.8 & 6.3.
5	Publication of the FUA structure Publication of the FUA structure in the national Air Area	ACM HB para 7.1 & 4.6.3.
6	Introducing the software or the contact point Establish an official civil / military center for airspace management to manage flexible airspace structures where they exist, and where they do not, a focal point for international coordination at level 2	ACM HB para 4.5
7	Introduction of the software into the FC system Official request from the FC Director in Brussels to install a terminal with the software followed by the training of the FC staff	ACM HB para 4.5.
8	Identification of AA Establishment of units, called Approved Agencies (AAs), authorized by the national authorities to submit requests for airspace, negotiate and use the allocated airspace by FC	ACM HB para 4.2.

9	Education about the FUA functions at level 2 FC training based on the expected traffic forecasts	ACM HB para 4.3.
10	Establish a link between all concerned parties at level 2 Ensure that appropriate means of communication are in place between all stakeholders in FC (from the strategic level to the tactical level)	ACM HB para 7.2.
11	Establishment of the FC procedures at level 2 Ensure that the coordination procedures and the negotiation process are in accordance with the FUA on-site work schedule	ACM HB para 4.7
12	Implementation of the real-time coordination procedures at level 3 Provide procedures for civil / military, controller to controller, real-time coordination, adopted by civil and military authorities and published in the Letter of Agreement-LoA.	ACM HB para 5.2.
13	Upgrading the FC (ATM) system at level 3 Upgrade the ATM tools and communication devices between civilian and military ATC providers to facilitate: -Direct controller-controller communications using a direct telephone line - automatic exchange of flight data from civilian to military controllers, including the position and intent of GAT -providing national and international data on the usability of the airspace (CBA) to the staff of respective controls using telephones and faxes -use of the airspace circulation function based on a direct means of communication (telephones)	ACM HB para 5.4.

The challenges of the implementation of the concept in Serbia were primarily related to the lack of a clear organization that manages the airspace (it has already been said that Serbia has renewed its membership in the European Organization for the Safety of Air Navigation - EUROCONTROL, 2005). In that period, there were two state organizations in Serbia that dealt with the organization of the airspace:

- at level 2, there was the Civil Aviation Directorate (established on January 1, 2004) (Civil Aviation Directorate of the Republic of Serbia. About the Civil Aviation Directorate, 2018) and
- at level 3, there was the Serbia-Montenegro Air Traffic Services Agency (SMATSA) state agency for airspace control services in the airspace of Serbia and Montenegro (established on December 29, 2003) (SMATSA. General overview, 2018).

In that period, there was no organizational unit in Serbia that would deal with the strategic management of the airspace of the Republic of Serbia. Such an organizational unit should contain unified civil and military processes within the (National) Airspace Committee. At level 2, there is the Civil Aviation Directorate (CAD), but there is no military aviation authority that solves the problems of military aircraft related to normative-regulatory and operational-control functions (what CADs were doing for civil aircraft). At level 3, there is the Flight Control of Serbia and Montenegro, but there is no organizational unit from the army that should deal with the activities in Table 1 (real-time allocation, activation and deactivation of the airspace, solving specific FC problems and traffic situations between civilian and military air traffic controllers, etc.). However, the problem that required an urgent solution was the delay in Europe's airspace which caused the activation of the TSA-01 military zone (Temporary Segregated Area), shown in Figure 3.

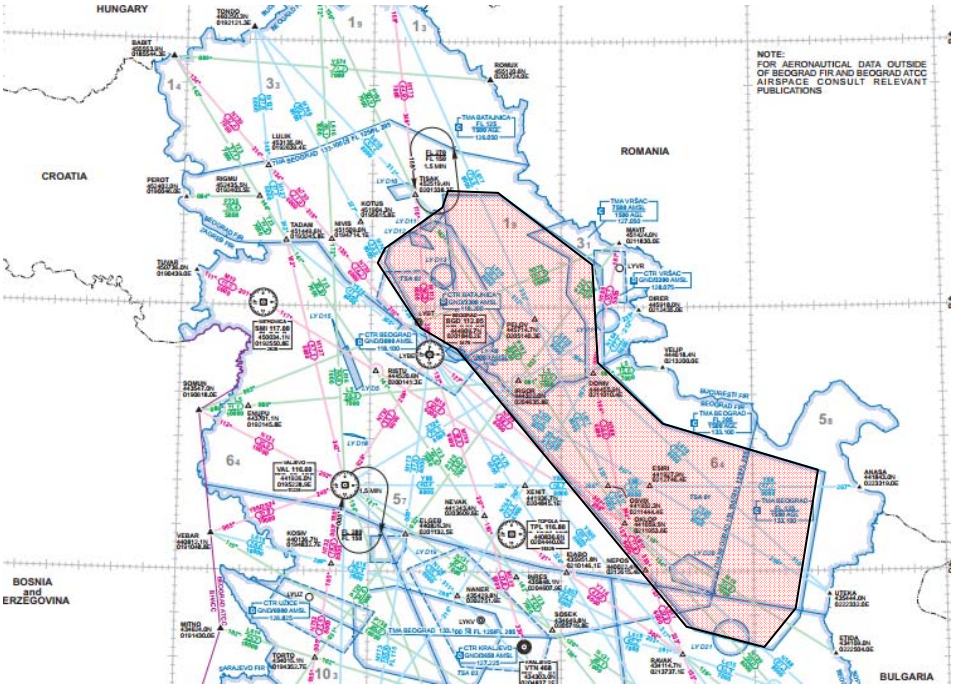

Figure 3 – Map of the air routes in the Republic of Serbia (SMATSA. Map of the lower level of the air routes in the Republic of Serbiai)
Рис. 3 – Карта воздушных трасс Республики Сербия (SMATSA. Карта низкого эшелона воздушных маршрутов Республики Сербия)
Слика 3 – Карта ваздушних путева у Републици Србији (SMATSA. Karta nižeg sloja vazdušnih puteva u R. Srbiji)

The seizure of the zone and its non-use by the Serbian Armed Forces (Air Force and Air Defense) caused delays in air traffic in the southern part of Europe. Based on the data obtained from the SMATSA Control Agency (Appendix no. 1 from 2004 to 2007), the size of the generated delays caused by the activation of the military zone can be seen. Generated delays were the reason why Eurocontrol insisted that an adequate solution be found for this problem. Table 2 shows the data for the caused delays in 2008.

Table 1 – (Pečenković, 2008)
Табела 1 – Активация зоны TSA-01 (Pečenković, 2008)
Табела 2 – Activation of the zone TSA-01 (Pečenković, 2008)

	datum	br notama	vreme rada zone		I	II	br notama C	I kasnjenje minuta	II kasnjenje minuta	ukupno kasnjenje minuta	broj aviona pod restrikcijom I	broj aviona pod restrikcijom II	ukupan broj aviona pod restrikcijom
1	15.01.08.	A0044	11:30-12:30		CNL		A0045			0			0
2	16.01.08.	A0046	11:30-12:30		?					0			0
3	17.01.08.	A0047	09:00-09:30	11:00-11:30	CNL	CNL	A0048/16.01.			0			0
4	23.01.08.	A0049	11:00-11:30		CNL		A0051	11		**11**	2		**2**
5	24.01.08.	A0052	11:00-11:30		√			9		**9**	1		**1**
6	01.02.08.	A0069	11:00-11:30	12:00-12:30	√	CNL		140	64	**204**	6	3	**9**
7	09.02.08.	A0080	11:00-13:00		CNL		A0081	37		**37**	2		**2**
8	11.02.08.	A0082	12:00-14:00		CNL		?			0			0
9	12.02.08.	A0086	09:00-10:00	11:30-12:30	√	√		0	0	0			0
10	20.02.08.	A0098	09:00-09:30	11:30-12:00	√	CNL		0	75	**75**	0	7	**7**
11	27.02.08.	A0111	10:00-11:00		√			135		**135**	5		**5**
12	07.04.08.	A0187	10:00-11:00		√			5		**5**	1		**1**
13	08.04.08.	A0189	08:00-09:00	11:00-12:00	CNL	CNL	A0193			0			0
14	08.04.08.	A0194	11:00-12:00		√			73		**73**			0
15	11.04.08.	A0205	11:00-12:00		CNL		A0208	45		**45**	3		**3**
16	12.04.08.	A0211	09:00-10:00		CNL		?	61		**61**			0
17	14.04.08.	A0217	10:00-11:00		√			150		**150**	7		**7**
18	15.04.08.	A0218	12:00-13:00		√			69		**69**	6		**6**
19	16.04.08.	A0220	11:00-12:00		CNL		A0221/15.04.			0			0
20	07.05.08.	A0255	08:00-09:00		√?			53?		0	1		**1**
21	07.05.08.	A0256	09:00-10:00		√			37		**37**	2		**2**
22	28.05.08.	A0295	09:00-10:00		√			39		**39**	1		**1**
23	04.06.08.	A0300	16:00-17:00		CNL		A0305	0		0			0
24	05.06.08.	A0303	10:00-11:00		√			0		0			0
25	06.06.08.	A0308	10:00-11:00	15:00-16:00	CNL	CNL	A0313/05.06.	0		0			0
26	03.10.08.	A0604	08:00-08:30	10:30-11:00	CNL	CNL	A0607	0		0			0
27	06.10.08.	A0613	08:00-08:30	10:30-11:00	√	CNL		26		**26**	2		**2**
28	08.10.08.	A0623	10:00-10:30		√			114		**114**	11		**11**
29	09.10.08.	A0626	09:30-10:00	11:30-12:00	√	CNL	A0631	0	25	**25**	0	1	**1**
30	13.10.08.	A0635	10:00-10:30		√			21		**21**	4		**4**
								972	**164**	**1136**	**54**	**11**	**65**

√	**18**	**47%**
CNL	**20**	**53%**
UKUPNO	**38**	

Table 2 shows the dates of the activation of the TSA-01 zone by the Serbian Armed Forces. The section *datum* (the date) gives the days when the zone was activated by the Serbian Armed Forces for the period

from January to October 2008. In the NOTAM[6] number section (*broj notama*), the NOTAM numbers by which the zone is activated are registered (based on the number of the NOTAM, the work plan in the zone, the zone activation time and the height reserved by NOTAM can be checked). The zone activation time represents the time period in which the zone is occupied; by one NOTAM, two different time periods of the zone can be activated (January 17, 2008, number A0047 from 09:00 to 09:30 and by the same NOTAM the activated zone for the period from 11:00 to 11:30; the same is the case for the days of 01.02.2008, 20.02.2008, 08.04.2008, 06.06.2008, 03.10.2008, 06.10.2008, and 09.10.2008). The columns presented in Roman numerals "I" and "II" indicate whether the flight was executed (marked with "√") or not (canceled by "cancel - CNL"), for the first zone activation period and for the second zone activation period. On February 1, 2008, February 20, 2008, October 6, 2008 and on October 9, 2008, the flights in the first zone activation period were executed while they were canceled for the second period. Such cases occur when one-day flights are performed at supersonic speeds (Ma-2,05) and high altitudes (H>20.000m) - such flights are performed after the replacement of the engine on airplanes. It is often a case that some flaws are found on the plane after the first flight, making it impossible to go to the ceiling of the flight, and that is why the second flight is canceled. The *broj notama C* section (NOTAM number C-cancel) contains the NOTAM numbers with which the annulment of the already published NOTAM that activates the TSA-01 zone is entered. A new NOTAM again allows flying over our country. The table also shows cases with a date besides the published NOTAM which means that the SA canceled the published NOTAM the day before (24 hours earlier it was found out that the plane would not be ready for the flight because of its technical conditions) that activated the TSA-01 zone. In practice, this means that the originally published NOTAM was not activated on the specified date and had no impact on the traffic flow. Such an example can be seen for the day of January 17, 2008. when the zone was activated by NOTAM A0047, but the day earlier on 16.01.2008 it was deactivated by NOTAM A0048. For the days when there is no date next to NOTAMs that deactivate activities in the TSA-01 zone, it means that the flight was canceled due to adverse weather conditions or a technical fault had been identified before or during the takeoff. In sections *I delay*

[6] NOTAM - Notice to Airmen is a notice submitted by the authority responsible to Air traffic control to warn pilots with potential risks along the flight route or at a location that could affect flight safety.

in minutes, II delay in minutes, and total delay in minutes, there is the data on the additional aircraft retention on the ground from their planned take-off times (start of the engine). The delay times are generated by the software in Brussels thus minimizing the total delay caused by the activation of the TSA-01 zone. "I minute delay" and "II minute delay" refers to the total time of the zone operation and whether the zone was activated twice in one day. "Total delay in minutes" represents the sum of the first two delay sections and shows the size of the delay in one day caused by the activation of the TSA-01 zone. The table shows that for the days when the zone was deactivated on time (24 hours earlier) there were no delays (January 17, 2008, April 16, 2008, and June 6, 2008). The sections *the number of aircraft under restriction I, the number of aircraft under restriction II, the total number of aircraft under restriction* give the values of the number of aircraft that are covered by the delay, i.e. the number of aircraft assigned to some delay time. We see that the regulation of the airspace does not have to have an impact on the air traffic above our country - for the indicated dates (on 12.02.2008, 20.02.2008, 05.06.2008, and 09.10.2008) the activation of the zone did not have any impact on the planned traffic. But on October 8, 2008, the use of the zone had an impact on 11 aircraft which were included in the restriction, resulting in a total delay of 114 minutes. In all other cases, the number of aircraft covered by the restriction was in the range from 1 to 7. The total delay of 1136 minutes or almost 19 hours refers to the given period, with the use of the zone for 30 minutes. From the summary in the additional table shown below Table 2, it can be seen that the zone was used only 18 times for 30 minutes each time, a total of 9 hours. Using a zone of only 9 hours causes a delay of 19 hours. For each hour of activation of the zone on the European sky, a delay of two and more hours is caused. In order to stop this practice of creating "delays" in the sky of Europe, it was necessary to find an adequate solution that would satisfy all stakeholders.

Serbia had to respect the signed international agreements. After the meetings of the Serbian Arned Forces (Air and Air Forces) and SMATSA, a proposal was made to establish a department for civil-military cooperation at level 3. In early 2006, under the Command of the Air and Air Forces on the premises of SMATSA, a Department for the control, protection and allocation of airspace was established. This department deals with the allocation of airspace at the tactical level (level 3). This department is in charge of contacting the Eurocontrol Network Manager in Brussels responsible for monitoring the capacity and flow of air traffic at the European level. By establishing this department and coordination

at the tactical level, Serbia has entered the ranks of countries that have effectively applied the concept of flexible use of airspace.

The obligation to establish the National Air Level Committee at level 1 (a joint civil / military body responsible for the implementation of the concept and the definition of an airspace management strategy) was met in 2013. Bearing in mind the need for changes to include the function of civil-military coordination in the management and allocation of the airspace, in accordance with the signed European Common Aviation Area Agreement, the Government of the Republic of Serbia adopted Decision no. 02-10323 / 2013 (Službeni glasnik RS, 106/2013) which established the National Aviation Committee responsible for the strategic management of airspace. It is competent to provide efficient airspace management at the strategic level, ensuring that the use of airborne structures and routes is carried out in a safe and efficient manner by respecting the requirements of all airspace users.

The Directorate of Civil Aviation (DCA) is "an organization that is responsible for issuing regulations and first instance administrative acts, issuing public documents, keeping records, auditing aircraft operators, participating in the work of international aviation organizations and institutions and their working bodies and cooperating with competent authorities of other countries in the Republic of Serbia". The DCA in the Republic of Serbia represents level 2, airspace management.

With this analysis of the formed organizational entities and units (National Aviation Committee - Level 1, Civil Aviation Directorate-Level 2 and SMATSA and Air Traffic Control, Protection and Allocation Department-Level 3), the impression is that Serbia has rounded up the process of forming a structural and a legal framework for the smooth implementation of the concept of flexible use of airspace in the sky of Serbia. The process of implementing the concept of flexible use of airspace has not yet been fully completed, and work is still under way to link all levels into one functional entity. In order to solve the problem adequately, it is necessary to establish a Military Aviation Authority in the Republic of Serbia. The first indication that Serbia is heading in the right direction is the fact that the problem of airspace capacity is getting the attention of the decision-makers in the Serbian Government. The fact that the Government of Serbia has adopted a Conclusion on determining the national airspace management policy of the Republic of Serbia is a serious fact that the problem is seriously understood. The Conclusion confirmed the attitudes towards establishing: "organized, efficient and integrated airspace planning and management, as a common resource for all categories of users, which is used in a flexible and transparent

manner, while taking into account the needs of defense and security, environmental protection and obligation arising from confirmed international agreements, membership in international aviation organizations and international standards and recommended practices" (Službeni glasnik RS, 8/2014). The upcoming activities will show whether this Conclusion was a list of wishful thinking or a list for resolving the problem of airspace organization in Serbia and the desire to implement the concept in the sky of Serbia to the full extent.

Conclusion

The needs expressed for the use of airspace are far greater than the current capacity of airspace in Europe. Growing needs have imposed a completely new approach in understanding and organizing airspace as a space where numerous activities are carried out by various users. To this end, new air quality standards have been established by the organization responsible for the airspace of Europe (Eurocontrol in Brussels) and new strategies have been developed that differently define the organization and management of the airspace in the sky of Europe. In addition to the Single Sky Europe and the ATM 2000+ strategy, a very important European airspace program is also the concept of Flexible Use of Airspace as a program that is a prerequisite for achieving all other strategies, concepts and programs. The paper presents how to implement the concept of flexible use of airspace in Europe and the Republic of Serbia. It was concluded that the concept has not yet been completed in all European countries. All the countries of Europe have common problems such as problems of non-standard airspace, historical and political circumstances, technical equipment of the army and poor civil-military cooperation, but in the first place in all European countries there is money as the main reason why the concept has not yet been applied and come to life in the sky of Europe. The concept has proven that only a scientific approach to addressing airspace capacity can help airline companies to save by reducing fuel consumption, carbon dioxide emissions, airborne delays on the ground, or rerouting. Serbia has created a legal framework for the implementation of the concept and has started with the formation of organizations that would be responsible for the concept. In Serbia, there are: National Aviation Committee - level 1; Civil Aviation Directorate - level 2; SMATSA and Airspace Control, Protection and Allocation Department - level 3. A problem that has not yet been solved is the absence of an aviation military authority that would perform normative-regulatory and operational-control functions (what the CAD does in civilian affairs).

The result of this paper is also the understanding of the impact of the signed international agreements on the development of the airspace of the Republic of Serbia through observation and deliberate clarification of the significance of the implementation of the flexible use of airspace in Serbia.

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ВЫЗОВЫ ПРИ ВНЕДРЕНИИ КОНЦЕПЦИИ ГИБКОГО ИСПОЛЬЗОВАНИЯ ВОЗДУШНОГО ПРОСТРАНСТВА В РЕСПУБЛИКЕ СЕРБИЯ

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Резюме:

В данной статье представлен анализ концепции гибкого использования воздушного пространства, делая особый акцент на вызовы при ее внедрении в Республики Сербия, учитывая все

проблемы, связанные с размером и границами воздушного пространства. Надо подчеркнуть, что проблемой размеров и границ воздушного пространства, также как и вопросами воздушных маршрутов до Второй мировой войны в Европе никто всерьез не занимался, по причине малого количества полетов в те времена. В качестве решения настоящей проблемы авторы данной статьи предлагают улучшение организации воздушного пространства Европы, что напрямую влияет на организацию и стратегию развития воздушного пространства всех европейских стран, в том числе и Республики Сербия (как члена и подписчика международных организаций, которые занимаются управлением авиамаршрутов и организацией воздушного пространства). Концепция гибкого использования воздушного пространства должна решить эти проблемы. Однако для внедрения вышеупомянутой концепции требуется пересмотреть раннее законодательские и организационные нормативы, и соответственно первоначально достичь национального консенсуса, в целях последовательного внедрения данной концепции. Проблемы, с которыми столкнулись создатели концепции в Европе и Сербии и решения, которые могут помочь решить эти проблемы представлены в настоящей работе. Структура работы была организована в виде ответов на многие ключевые вопросы по данной тематике, приведен обзор проблем, связанных с размером и границами воздушного пространства и улучшенных перспектив, которые ожидаются в ближайшее время; приведена сопоставительная классификация воздушного пространства; а также методы планировки, регистрации и объявлении о полете, описана концепция гибкого использования воздушного пространства и освещены проблемы при ее применении в Республике Сербия.

Ключевые слова: концепция, воздушное пространство, Республика Сербия, Евросоюз, международные организации, авиамаршруты.

ИЗАЗОВИ ИМПЛЕМЕНТАЦИЈЕ КОНЦЕПТА ФЛЕКСИБИЛНОГ КОРИШЋЕЊА ВАЗДУШНОГ ПРОСТОРА У РЕПУБЛИЦИ СРБИЈИ

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ОБЛАСТ: ваздушни саобраћај
ВРСТА ЧЛАНКА: стручни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

У раду је анализирана имплементација концепта флексибилног коришћења ваздушног простора у Републици Србији, који се бави проблемима који се односе на капацитет ваздушног простора. Пре Другог светског рата капацитет ваздушног простора и авио-саобраћај који се одвијао у њему није озбиљније разматран у Европи, због чињенице да је број летова у том периоду био релативно мали. Данас се тражи да се ваздушни простор Европе боље организује, што директно утиче и на организацију и стратегију развоја ваздушног простора свих земаља у Европи, па и Републике Србије (као потписника и члана међународних организација које се баве управљањем саобраћаја и организацијом ваздушног простора). Концепт флексибилног коришћења ваздушног простора треба да дâ решење за тај проблем. Његова имплементација захтева нека законска и организацијска решења, па је неопходан шири национални консензус. Проблеми са којима су се сусрели творци концепта у Европи и Србији и решења која су донета предмет су овог рада. Садржај рада изложен је кроз неколико питања: дат је осврт на проблем капацитета ваздушног простора и повећање које се очекује у наредном периоду; приказана је подела ваздушног простора у свету и код нас; описан је начин на који се врши планирање, пријава и најава летова, као и сам концепт флексибилног коришћења ваздушног простора и проблеми који се јављају при примени концепта у Србији.

Кључне речи: концепт, ваздушни простор, Република Србија, Европска унија, међународне организације, авио-саобраћај.

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ANALYSIS OF THE CAPACITY CHANGES IN THE "GARAJEVAC-ISTOK" EXCAVATION BY APPLYING THE GIS TECHNOLOGY

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Abstract:

The paper discusses the concept of construction and monitoring of capacity changes - the volume of the "Garajevac-Istok" excavation (mine), located in the cadastral municipality of Novi Bečej. Namely, in the earlier period, the physical surface of the Earth and geospace in general were shown two-dimensionally (2D), in a plane, by some of the cartographic methods (contour lines, points heights, hypsometry) or three-dimensionally (3D), by modeling of reliefs and relief cards. The cartographic principles of terrain making and visualizing on relief mapping models allow the creation of 3D views, but not enough quality and engineering precise 3D terrain models. In addition, there is a possibility of quantitative and qualitative assessment of the terrain on the mentioned models not to be accurate enough.

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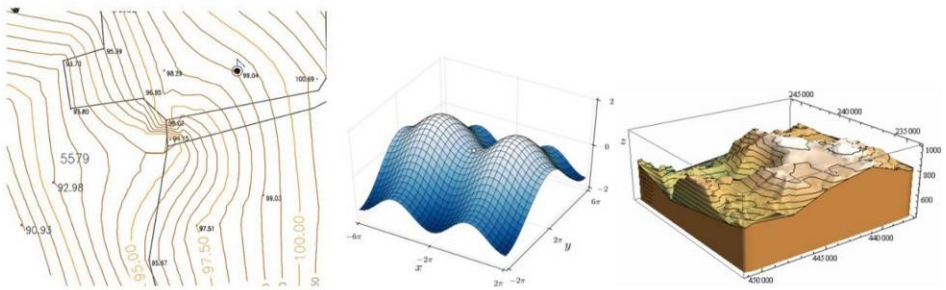
With new technologies, the 3D geospatial display mode changes, and the concept of digital terrain modeling (DTM) is being applied. The main goal of the work is to create 3D models and to give an analysis of the "Garajevac-Istok" mine for a certain period of exploitation.

Key words: maps, GIS, volume, changes of terrain, DTM, analysis.

Introduction

The elevation of the terrain (relief) in the cartographic sense can be represented by contours lines, shadows, hypsometry or their combination. Today, GIS technology, i.e. the digital terrain modeling (DTM) method, is increasingly used. Namely, DTM is the mathematical (statistical) representation of the continuous terrain surface based on a representative set of data in the form of points, lines and other characteristic details collected on the ground (Li et al, 2005). The surface of the terrain in a digital form can be presented in three ways (Figure 1):

- contour lines;
- the function of the two variables; and
- volumetric (volume) model.



a) b) c)

Figure 1 – Terrain preview: a) contours, b) functions of the two variables Z=f(x,y), c) volumetric
Рис. 1 – Отображение местности: а) контуры, b) функции двух переменных Z = f (x, y), c) объемное
Слика 1 – Приказ терена: а) изохипсама, b) функцијом двеју варијабли Z=f(x,y), c) волуметријски

The subject of this paper is the geomorphological changes in the terrain and the capacity of the "Garajevac - Istok" surface mine in the cadastral municipality of Novi Bečej in the period of 2015, and a comparison with the situation from the period of 2014 and 2013. The analysis of the changes and the comparisons is done by calculating volume and by making terrain profiles. Also,

the comparison of the condition of the terrain from 2015 is shown by the curve of the capacity (volume) in relation to the physical - topographic surface and the creation of profiles for the purpose of future use of data in the analysis and maintenance of the land using DTM.

Geospatial data is collected and processed automatically to obtain 3D field models in raster or vector formats (Cross & Moore, 2014). The visualization of field changes can be accomplished by using heights or depths, or can be described using a profile (Ceylan et al, 2011).

Calculation of the excavation and excavation capacity for each part of the capacity curve with regard to the surface is based on the prism calculation method (Omura & Benton, 2013). The procedure consists of calculating the partial volume of the excavation between the two contour lines. Namely, the partial volume is calculated from the mean surface of the contour (the upper and lower contour of the part "height-depth" being examined), multiplied by the difference in the height of these two contour lines (Chappel, 2014). The surface of the contours can be obtained using GIS or the CAD technology using a digitized map with contour lines (Arrighi & Soill, 1999). When calculating the cubature in a given region for different epochs in which the change is monitored, it is first necessary to define the position (horizontal) surface A_Δ which occurs by projecting the 3D surfaces on the horizontal plane along the vertical (Figure 2).

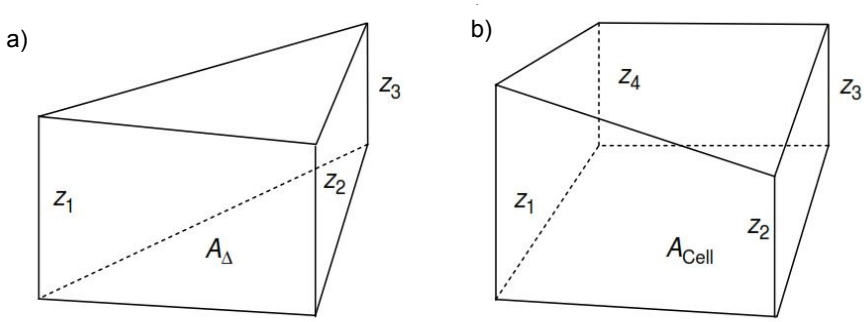


Figure 2 – Calculation of a volume based on a) TIN and b) Grid model
Рис. 2 – Расчет объема, основанный на a) TIN и b) Грид модели
Слика 2 – Рачунање кубатуре засновано на: a) TIN и b) Грид моделу

The volume V_3 of the triangulation prism from Figure 2 under a) can be determined by the formula:

$$V_3 = \frac{z_1 + z_2 + z_3}{3} \times A_\Delta$$

where the distances (height) of the DTM points to the horizontal plane. Similarly, for DTM in the form of Grid (Figure 2 under b), the volume V_4 can be determined according to the formula:

$$V_4 = \frac{z_1 + z_2 + z_3 + z_4}{4} \times A_{cell}$$

Based on these two formulas, the volume V of the excavation and the embankment, and based on the DTM engineering design can be expressed:

$$V = V_{originalDEM} - V_{newDEM}$$

In addition, the resulting values for V can be interpreted as $V > 0$ for the excavation, $V < 0$ for the embankment, and $V = 0$ when there are no changes.

Methodology and technology of work

The main task in this paper is to calculate the soil (clay) mass of cubes, in order to monitor excavation changes as a result of continuous exploitation for a certain period of time. The implementation process is based on the methods of forming a 3D terrain model for the previous period and the period after exploitation. All modeling and computation of changes and volume masses are carried out in software packages for geo-engineering works (Chappel, 2014).

In addition to the primary task in the work, the control of the display was performed as well as the verification of the calculation of the volume through the transversal profiles, the analysis of the obtained DTMs, and their visualization. The time periods included in the modeling relate to 2013, 2014, and 2015; more precisely, the 3D models are formed on the basis of data related to changes throughout the entire year (January - December).

Research area

The location covered by the work is located in the Central Banat District, the municipality of Novi Bečej, the cadastral municipality of Novi Bečej, on the eastern border of the construction zone of the city in the area "Garajevac" (Figure 3).

Figure 3 – Display of the the area covered by the work
Рис. 3 – Отображение площади, охваченной работами
Слика 3 – Приказ подручја које је обухваћено радом

The plot itself, i.e. the land, belongs to the construction company "Polet" AD, Novi Bečej, which realizes the excavation of clay for the needs of the production of construction products (tile, brick, ceramics). At the site, there was already one mine on the west side of the mine covered by this work, which had been exploited in the past, until the moment when all the land owned by the company was used. At that time, the land was purchased for the purpose of opening a new mine, which is being discussed here, in order to provide raw materials for production needs.

Data collection for the DTM formation

For DTM, relevant data on the surface of the terrain to be modelled are necessary (Šiljeg et al, 2018). For this purpose, relevant data from digital substrates - geodetic plans, which were formed in previous measurements and area analyzes, were used. The existing data in a cartographic form are in CAD formats, where the main carriers of relevant information are points whose positions are described by the *x,y,z* coordinates, contours and symbols applied to describe topographic relationships of objects (Figure 4).

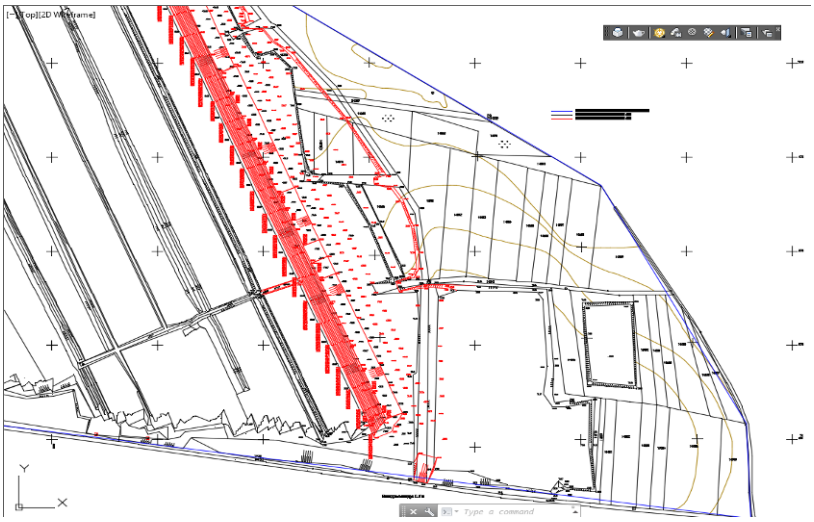


Figure 4 – Existing digital cartographic data
Рис. 4 – Существующие цифровые картографические данные
Слика 4 – Постојећи дигитални картографски подаци

It is necessary to adapt data for the needs of DTM modeling to enable the required processing (Zhang, 2005). This is generally done by raising the points and isohypses into the 3D space, since in the original state they are set horizontally with the written heights.

Since the excavation of the material - clay takes place throughout the year, more precisely from the beginning of the spring to the beginning of the winter, it is necessary to collect data for each year from the field in order to monitor the

changes in the terrain created by the excavation. The field work of data collection is mainly conducted at the end of the year, i.e. after the completion of the excavation for that year. It is practiced that at the end of the year, the current state of the excavation is measured due to favorable meteorological conditions and reduction of field work at the end of the year, when the measurement conditions are worse (Zhang, 2005).

For terrain surface capture, a terrestrial polar method of total cell measurement was used (Simon & Howel, 2007). The working group consists of four people: two geodetic experts - the more experienced one organizes the measurement process itself and keeps the record/sketch of field measurements (Figure 5), while the other one works with the instrument, and two assistants carrying prisms.

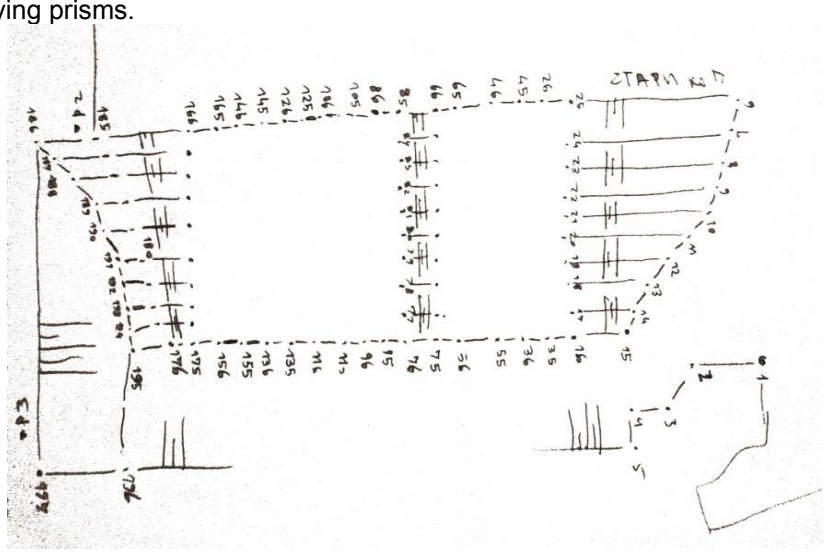


Figure 5 – Field sketch of the measurement
Рис. 5 – Эскиз полевого измерения
Слика 5 – Теренска скица снимања

The geodetic basis for the measurement is established in previous measurements, and relies on the state trigonometric and polygon network. During recording, all measurement data are automatically stored in the total station, so it was not necessary to conduct additional recording minutes other than a sketch of the recording. This also enables simple data transfer in a digital form from the instrument to the computer memory. Recording takes place according to all the rules of the profession (Environmental Systems Research Institute, 2010). The accuracy class is prescribed by the project task, which is compiled by the investor and amounts to:

- standard deviation of the horizontal position ≤ 50cm; and
- standard deviation of the vertical position ≤ 5cm.

Since it is monolithic excavation (Figure 6), the recording is performed on profiles at distances of 25m, with exceptions in places where significant changes in the terrain occur, and where the recording is swollen by points. This way of generalizing during recording ensures that the required accuracy is achieved in terms of describing the real surface of the field.

Figure 6 – The excavation site
Рис. 6 – Изображение карьера
Слика 6 – Изглед ископа

In this paper, AutoCAD was used for data preparation, creation of breaklines (structural lines), insight and definition of the model scope as well as for neglecting the existing data that have no impact on modeling. Also, the AutoCAD software package can be used to model 3D complex objects that can be arbitrarily measured, tilted, rotated, and displayed in projections, views and transverse profiles from all directions, etc. (Chappel, 2014).

AutoCAD Civil 3D is a program designed for engineering in construction and geodesy (Autodesk, 2018). It is used for designing, analyzing, producing documentation, visualizing, etc. It relies on an AutoCAD work environment and built-in functions with extensions that allow for additional design options related to the application area (Chappel, 2014). In this paper, AutoCAD Civil 3D was used to create DTM, to calculate the cubature of the soil mass, to control modeling and calculations, as well as for various analyzes and visualizations.

Formation of digital terrain models in the TIN structure

The first step in forming DTM is to prepare data in AutoCAD. After the recording is completed, the data is stored in the computer memory in a specific format (dwg, dxf, txt, etc.). Data processing starts with loading the new recorded data onto the existing map formed in the previous year (in this case, 2012). This is presented in Figure 7.

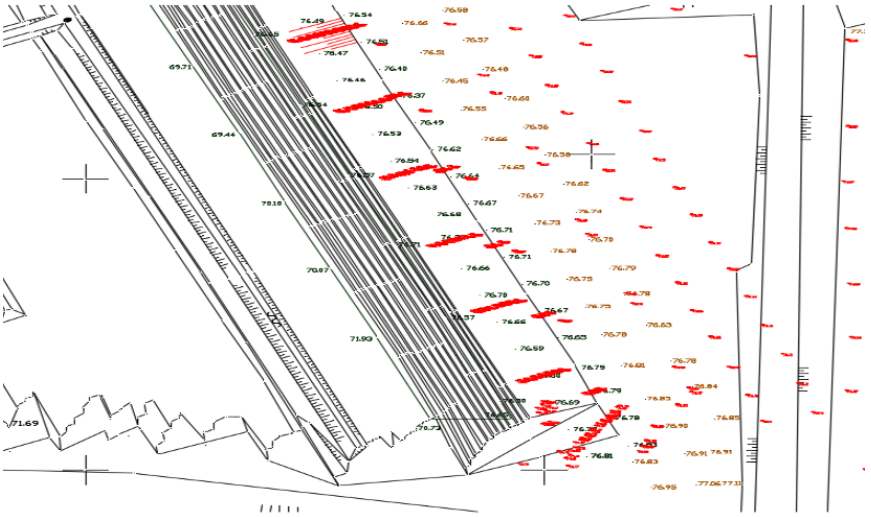


Figure 7 – Downloading the recording data onto the existing map
Рис. 7 – Загрузка замеренных данных на существующую карту
Слика 7 – Учитавање података снимања на постојећу карту

The measurement data from the current year are shown in red and in the following text, for easier explanation, they are called calculative data, while the data from the previous year in black are called zero states.

Points are loaded as 3D, i.e. they are positioned on all three coordinate axes (*x*, *y* and *z*). After that, the structural lines are defined by connecting the points with 3D polylines (Figure 8), which, based on the acquired experience, will play a major role in the quality development of DTM. The connection is done on the basis of the field sketch, in which the characteristic lines are indicated, as an essential element.

Structural lines are very important in the formation of DTM. They introduce a limitation during triangulation which says that the triangle sides connecting the points (the vortices of the triangles, knots) should not cut the structural lines (Šiljeg et al, 2018). The map thus formulated serves as a starting point for further work. In addition, data that will be further used for the DTM formation (points, lines, contours) should be selected.

In this paper, since the field data were collected in the previous years, points are generally used as basic data, complemented by structural lines. It is recommended that prior to moving to the DTM model, those data that are of greater significance should be selected and extracted for easier processing in later stages (Li et al, 2005). For this reason, data are also extracted here by such selection, where only data that are in the scope of the new state are taken from the old set of data, while others are ignored because they have no effect on the formation of DTM (Figure 9).

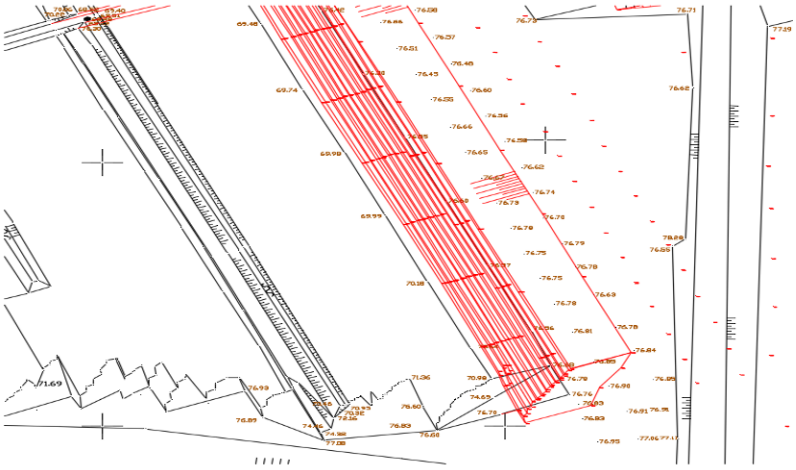


Figure 8 – Construction of the structural (course and ridge) lines
Рис. 8 – Проектирование структурных линий
Слика 8 – Конструисање структурних линија

Figure 9 – Separation of the data based on which the DMT is formed
Рис. 9 – Выделение данных на основании которых создается ЦММ
Слика 9 – Издвајање података на основу којих се формира ДМТ

This sort of data is saved as a new *.dwg* file, which is processed further on. After that, the DTM is modeled in AutoCAD Civil 3D. The previously prepared data are loaded into the program. The display is identical to that of the classic AutoCAD. In the left part of the program, there is a toolbar (ToolSpace) with

different models. The Surfaces option is selected, and the right click is applied to create new surfaces (Figure 10).

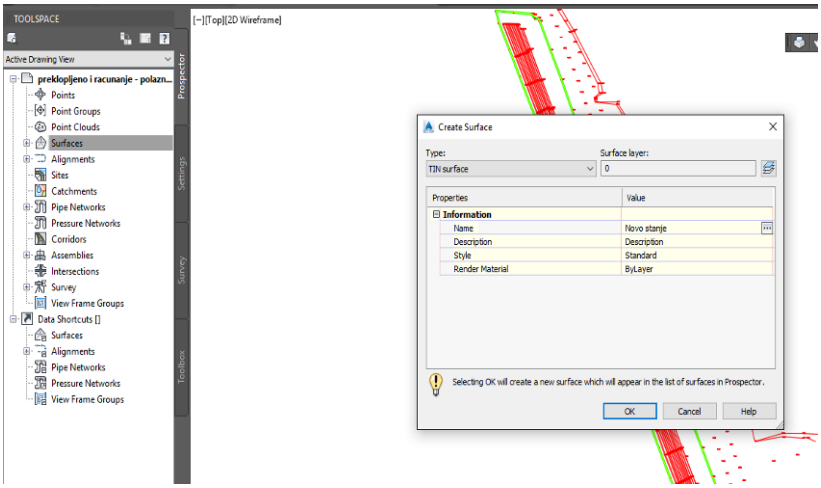


Figure 10 – Creating new surfaces in AutoCAD Civil 3D
Рис. 10 – Проектирование новой местности в AutoCAD Civil 3D
Слика 10 – Креирање нове површи у AutoCAD Civil 3D

Namely, a window with the basic surface settings appears, where the surface type, in this case the TIN structure, is selected as well as other settings such as the choice of layers, display styles, etc.. After that, the surface itself is defined by adding the data on which the modeling will be done. Given the input data type, and these are 3D points, the option of adding points is chosen (Figure 11).

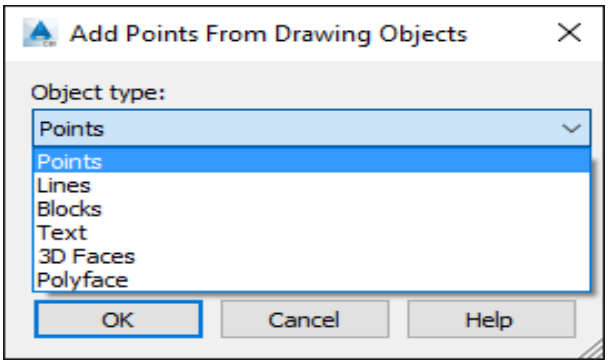


Figure 11 – Input data (3D points)
Рис. 11 – Входные данные (3Д точки)
Слика 11 – Улазни подаци (3Д тачке)

A 3D terrain model was created, i.e. DTM. In the style of the created surface, isohypses with the one-meter equidistance were selected (Figure 12). Visual inspection shows that the contour lines do not represent the given terrain well.

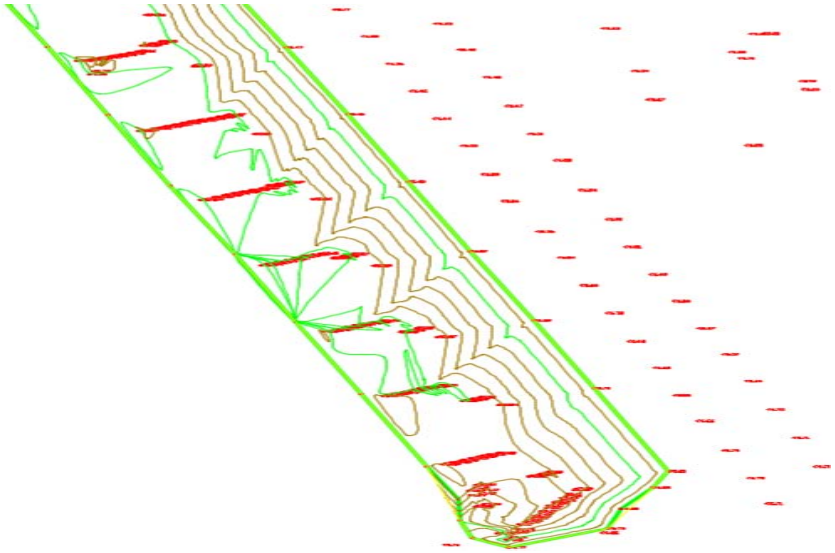


Figure 12 – Appearance of the isohypses of the created DTM
Рис. 12 – Вид изогипсы, разработанной ЦММ
Слика 12 – Изглед изохипси креираног ДМТ

In order to confirm the doubts about the created model, it is necessary to see it in some other views. A 3D view was selected in a realistic form (Figure 13). What is suggested from the display of the isohypses is confirmed by the 3D view, i.e. the obtained model is not good. The reason for this is the note described earlier, relating to the structural lines. Since the bottom of the excavation has a shape of a saw, it is expected that it will be the same on the model as well. Namely, in these places there are sudden ridges of the terrain and they must be taken into account, i.e. the structural lines already created as 3D polylines.

The input of the structural lines is done in the tool space, where the surface of the new condition is selected by right-clicking on the Breaklines option. After that, there is a selection of 3D polylines which are constructed in the previous steps, in the same way as in the selection of points. Once the selection of a set of structural lines is confirmed, the program automatically processes the 3D model that obtains a new appearance (Figure 14).

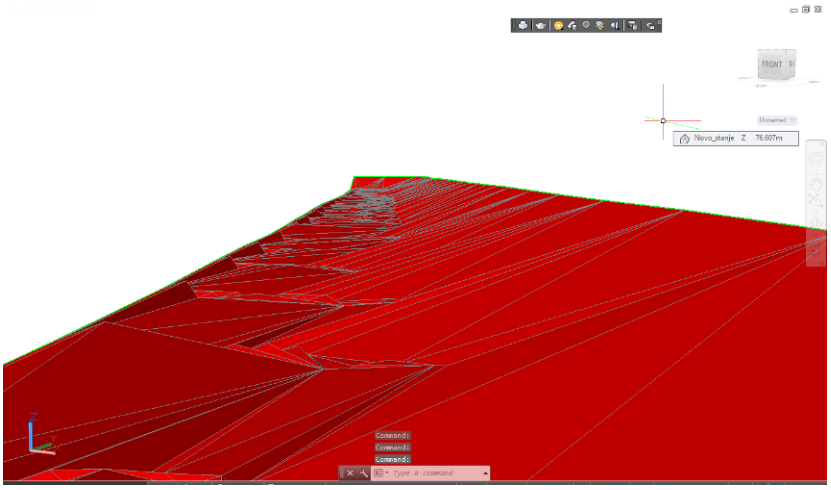


Figure 13 –3D model view in a realistic form
Рис. 13 – Изображение 3Д модели в реалистичной форме
Слика 13 – Приказ 3Д модела у реалистичној форми

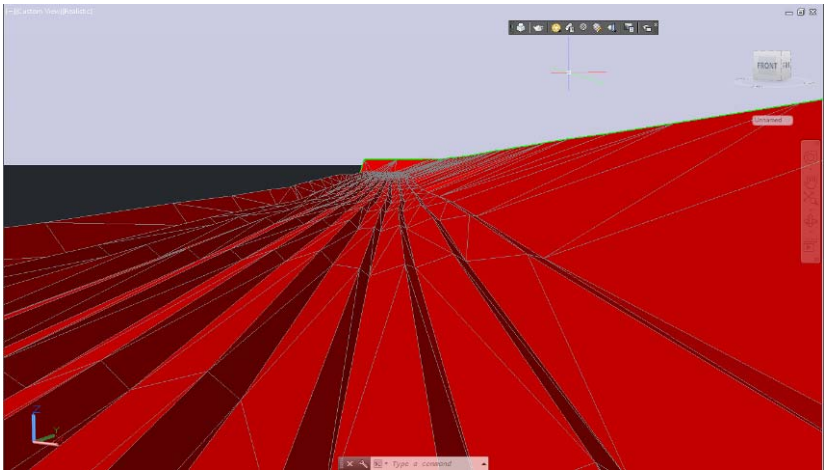


Figure 14 – Appearance of the DTM after adding the structural (course and ridge) lines
Рис. 14 – Изображение ЦММ после добавления структурных линий
Слика 14 – Изглед ДМТ након додавања структурних линија

By visual inspection of the model and the comparison with the actual surface of the terrain (Figure 15), we can conclude that the formed DTM satisfactorily represents the real physical surface.

Figure 15 – Appearance of the actual surface of the terrain
Рис. 15 – Изображение настоящей поверхности местности
Слика 15 – Изглед стварне површи терена

The DTM was created in the TIN structure for 2013, and in this paper it will present the first zero state in the calculation of the volume. After that, it is necessary to create the DTMs for 2014 and 2015, according to the same procedure as explained for the 2013 3D model (Figure 16).

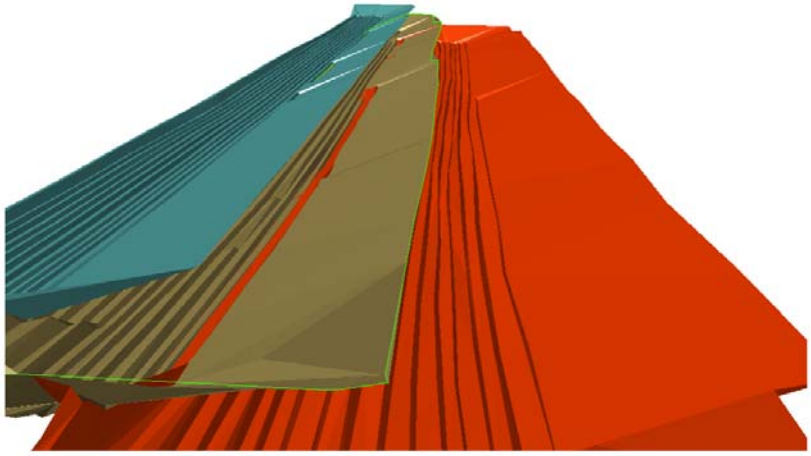


Figure 16 – DTM for years: 2013 (first on the left), 2014 (middle) and 2015 (right)
Рис. 16 – ЦММ в 2013 году (первое слева), 2014 году (в середине) и 2015 году (справа)
Слика 16 – ДМТ за године: 2013. (први с леве стране), 2014. (средњи) и 2015. (десни)

It is clear from the Figure that the models are created only for the excavation for the year they are showing, and do not include data from the following, i.e. neighboring years. More precisely, in the vertical sense, they do not overlap completely. Also, from the top view onto the models, it can be clearly seen that the excavation is shortened in the years after 2013 (Figure 17).

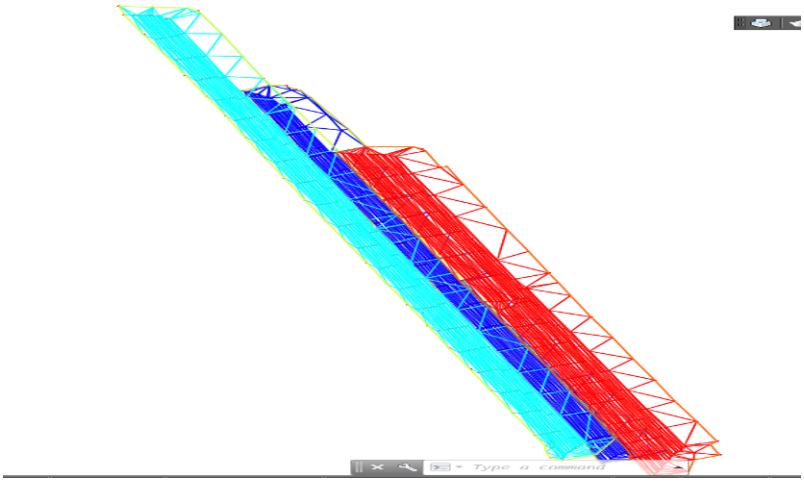


Figure 17 – 3D model view from above
Рис. 17 – Вид 3Д модели сверху
Слика 17 – Поглед на 3Д модел одозго

In order to be able to calculate the volume of the soil (clay) mass, it is necessary that the boundary of the surfaces for both epochs be identical. This implies the addition of data to the surface in order to complement the border.

The procedure is performed as with the original definition of DTM, by selecting and adding points. The filling was done on the 2013 model with the data from 2014, by selecting the points of the upper rim of the excavation. In this way, we have ensured that the zero model (2013) fully covers the calculation model from 2014 (Figure 18, left). In Figure 18, the right models are only spaced vertically in order to visualize the fitting of the two models.

The supplementary model clearly shows that in some places there is a punching of the calculating surface through the zero surface. The conclusion is that the heights referring to the calculation surface are higher than the heights in that zone on the zero surface. It is to be expected that this phenomenon is numerically interpreted in the calculation of the volume.

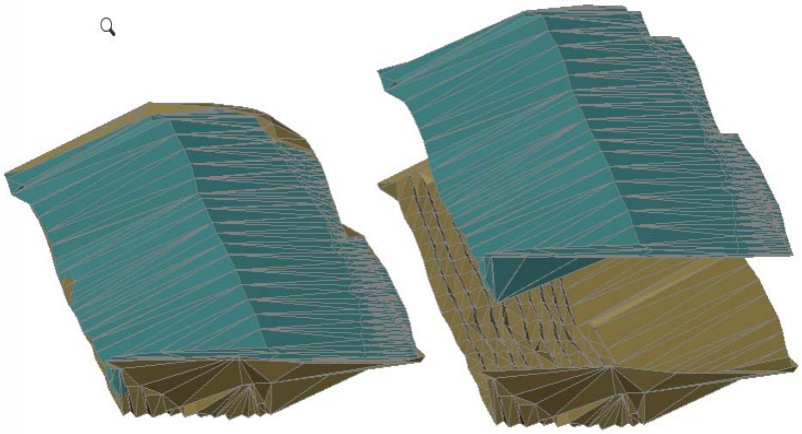


Figure 18 – 2013 model supplemented with the data from 2014
Рис. 18 – Дополненная модель из 2013 года данными из 2014 года
Слика 18 – Модел из 2013. године допуњен подацима модела из 2014. године

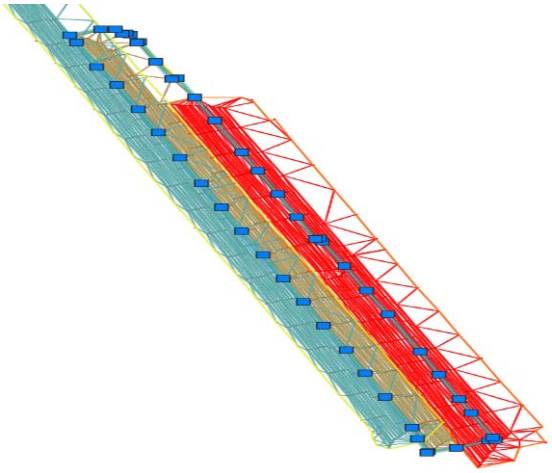


Figure 19 – Calculation boundaries for 2013 and 2014
Рис. 19 – Рубежи расчета 2013 г. и 2014 г.
Слика 19 – Граница рачунања за 2013. и 2014. годину

Also, the 2013 model is longer, so it is necessary to define the boundary of the volume calculation. This is accomplished by drawing 3D polylines connecting the peripheral excavation points from 2014 and adding the boundary in the toolbox, via the Boundaries option (Figure 19).

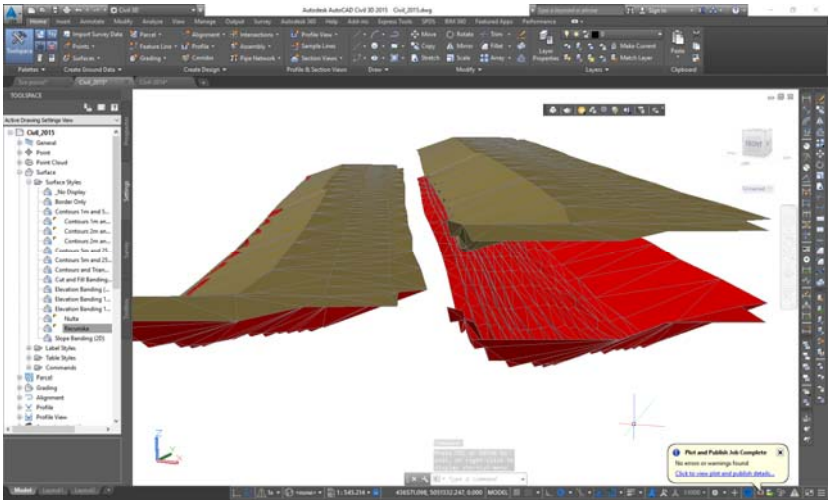


Figure 20 – Models of 2014 and 2015 for calculating the volume
Рис. 20 – Модели 2014 г и 2015 г. для расчета объема
Слика 20 – Модели из 2014. и 2015. године помоћу којих се обрачунава кубатура

In the same way, the model is expanded for the period 2014 – 2015 (Figure 20).

Calculation of the soil (clay) volume

After the established DTMs for 2013, 2014, and 2015, the calculation of the volume of excavated clay is accessed. All works are of great importance, but especially geodetic works should be carried out carefully and precisely. Namely, when the satisfactory quality of the created DTM is confirmed and accepted, then the volume is calculated in the AutoCAD Civil 3D software package. Calculation is done individually for 2014 in relation to 2013 and for 2015 in relation to 2014. This method of calculation was selected because the company that is the contracting authority monitors the changes of the "Garajvac - istok" surface mine annually.

As already mentioned, the DTMs used for 2013 are used as a zero surface, and those for 2014 as a calculating surface. Calculation of the volume is performed in AutoCAD Civil 3D. In addition, tools are used where the options for calculating the volume of the 3D model of reference surfaces are chosen and the names of the volume models are continuously adjusted, where the base surface is zero, and a comparing one is a calculation surface. A report on the amount of volume can be stored in some of the textual formats. The calculated volumes for 2013.- 2014 have the following values:

- excavation (cut): 42385m^3;
- fill (fill): 147m^3; i.e
- total volume change (net): 42238m^3.

In the same way, the volume of the excavated clay for the period 2014 - 2015 is calculated. Based on the established DTM for those years, the following volume values were obtained:

- excavation (cut): 62948m^3;
- fill (fill): 62m^3; i.e
- total volume of changes (net): 62887m^3.

Based on the calculation and based on this period, it can be concluded that the excavated volume values were expected, given that the embankment value is only 62m^3.

Calculation control over transversal profiles

In the previous chapter, the required volume meters were calculated. The confirmation of the correct calculation was made only on the basis of the conclusion that the created DTMs are correct. In order to perform additional control of the calculation and at the same time to perform the DTM verification, the analysis of the transversal profiles of the DTM should be carried out. In order not to burden the work with unnecessary repetitions of procedures, the average profiles for only one calculated volume will be shown - for 2013 - 2014.

The profiles are defined at distances of 25m, and such a choice is justified by the fact that the survey of the terrain was done by profiles at the same distance. It is estimated that such a profile layout will give good control of the calculation. First, the profiles are arranged for DTM. The direction of the profiles is normal to the direction of the excavation extension, which is largely straightforward. A total of 20 profiles were distributed (Figure 21).

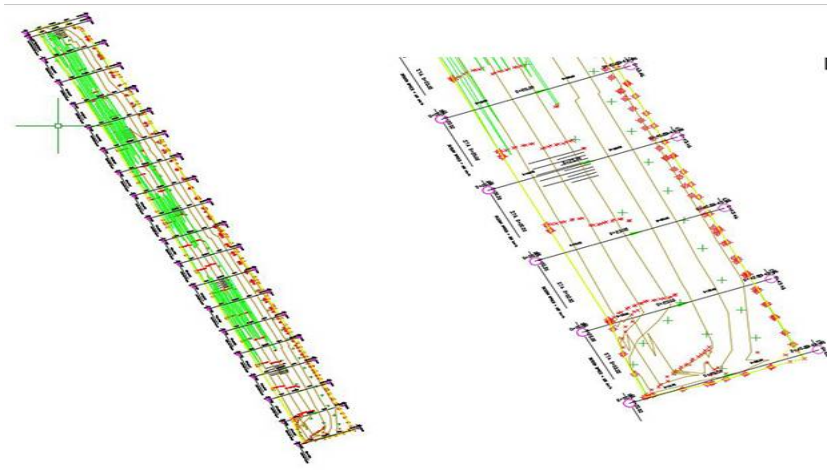


Figure 21 – Splitting the transversal profiles via DTM
Рис. 21 – Распределение поперечных профилей с помощью ЦММ
Слика 21 – Распоређивање попречних профила преко ДМТ

The arrangement of the profiles is mostly influenced by the configuration of the terrain, and given that in this case it is a monotonous excavation, the chosen profile layout provides quite satisfactory results. When defining a profile, it is necessary to draw out the intersection lines by which the 3D model (cross sections) will be cut and will be made in the direction as stated above. When all the lines are plotted, the program should be set to show that they will actually represent the profile cross section lines (Figure 22).

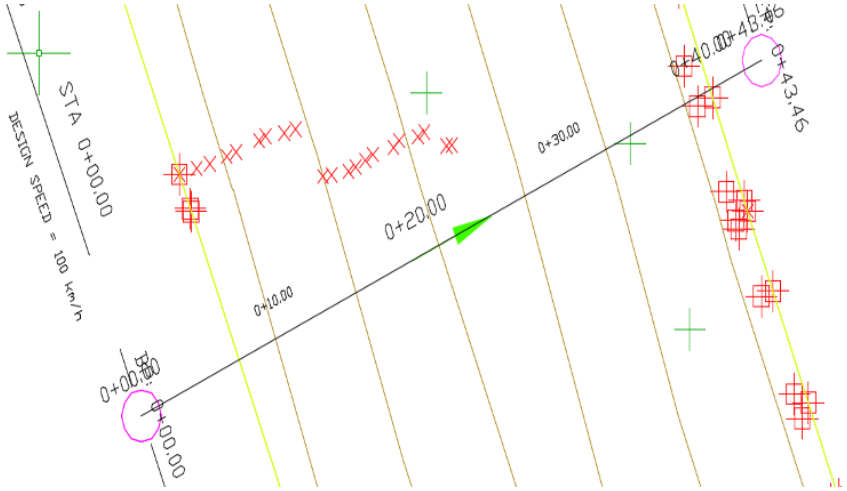


Figure 22 – Creating the cross-lines of a 3D model
Рис. 22 – Проектирование линий сечения 3Д модели
Слика 22 – Креирање линије пресека 3Д модела

When a cross section of the 3D model is created, it is also necessary to define the profile itself, i.e. which profile the concrete line of the cross section refers to. The most important settings are: select the cut line for the profile that is being created, add surfaces that will be included in the transversal profiles as well as other settings (layers, display styles). When the profile parameters are set (the profile to which it relates, the display styles, etc.), the specific profile is plotted, or it is confirmed on the drawing worksheet where the profile will be generated (Figure 23).

The generated profile layout contains information about the appearance of the zero surface (green line), the calculating surface (red line), the surface of the figure that the profiles limit, the height, etc. All other profiles are formed according to the same principle (total of twenty). Nineteen profiles are at distances of 25m, and the last one is at 4.85m because this is the space left to the end of the excavation (Figure 24 and Figure 25).

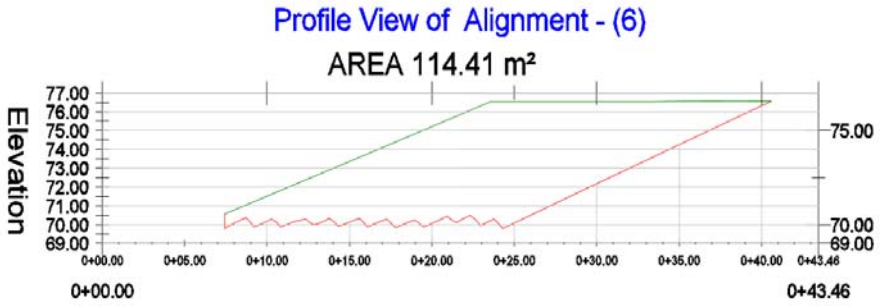


Figure 23 – Generating the profile layout
Рис. 23 – Генерирование вида профиля
Слика 23 – Генерисање изгледа профила

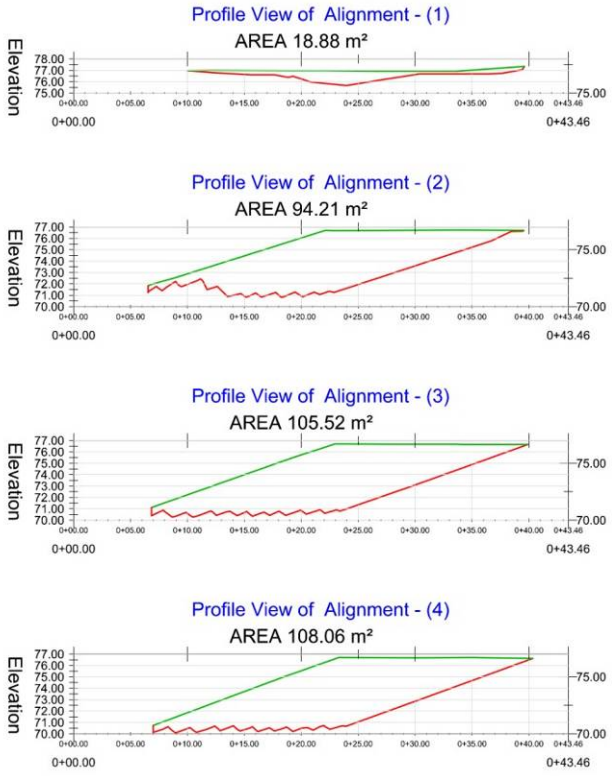


Figure 24 – Generated profiles from 1 to 4
Рис. 24 – Сгенерированные профили с 1 до 4
Слика 24 – Генерисани профили од 1 до 4

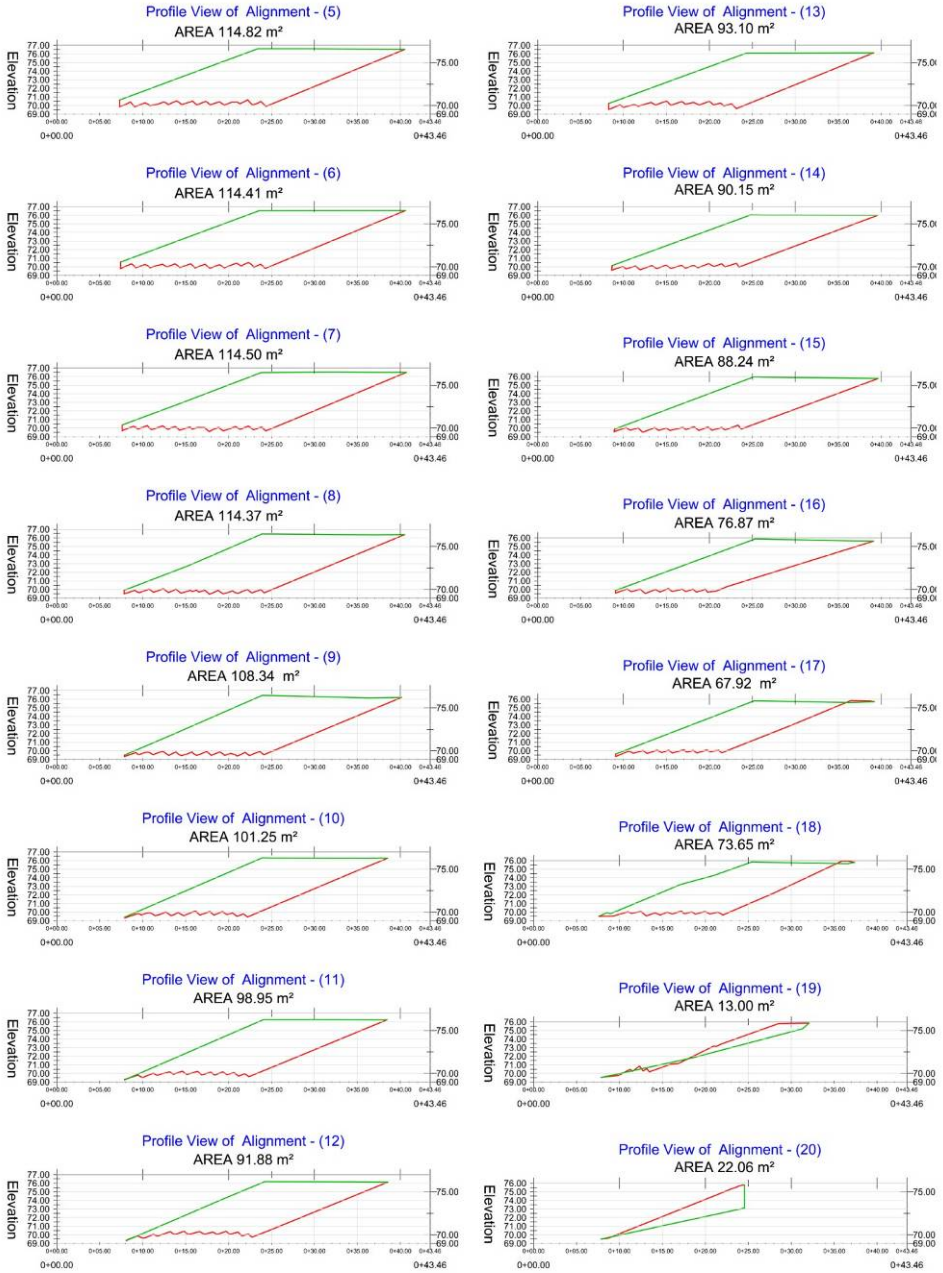


Figure 25 – Generated profiles from 5 to 20
Рис. 25 – Сгенерированные профили с 5 до 20
Слика 25 – Генерисани профили од 5 до 20

When the profiles and the surfaces of the figure limited by the lines of the zero and calculating surfaces are determined, the control calculation of the volume for the period of 2013 – 2014 can be carried out. The control of the calculation is performed in the following way: the individual volume of soil (clay) is defined, limited by the zero and calculating surfaces and two adjacent profiles. For determining such a volume, it is necessary to determine the mean value of the surface of the figures from two adjacent profiles, as the arithmetic mean of the formula:

$$P_{i,zapremine} = \frac{P_i}{P_{i+1}}$$

where is:

$P_{i,zapremine}$ - the mean value of the figure surface area between two adjacent profiles;

P_i - the area of the profile figure where there is the beginning of the individual volume;

P_{i+1} - the area of the profile figure where there is the end of the individual volume.

Then, an individual volume value is calculated between each two adjacent profiles as the product of the mean value of the figure surface area and the distance between the profiles:

$$V_i = P_{i,zapremine} * L_i$$

where is:

L_i - distance between two adjacent profiles (25m, except the last one).

The calculation results are shown in Table 1. The calculated volume value for the observed period of changes from 2013 to 2014, based on the cross sections, is 41889.52m³. Bearing in mind the previously calculated volume which amounted to 42385m³, or programmatically based on the formed 3D terrain models for 2013 and 2014, it can be considered that the obtained values of the volume are consistent to a large extent. The reason for the discrepancy between the results is that the generalization process occurs, or due to the deployment of the profile lines, when the cross-section profiles are plotted, the mentioned process leads to generalization and certain distortion of the results.

Since the matching of the results from these two counting processes amounts to 98.8%, and on the basis of previous work experience, it can be considered that the volume obtained on the basis of the formed DTM is completely acceptable, i.e. obtained by auto-counting in AutoCAD Civil 3D.

Table 1 – Calculation of the total volume of the excavation based on transversal profiles
Таблица 1 – Расчет общего объема карьера на основании поперечных профилей
Табела 1 – Рачунање укупне кубатуре ископа на основу попречних профила

Number of the profile	Square of the profile (m²)	Mean value of the square figure(m²)	Distance between the profiles (m)	Cubature between the adjacent profiles (m³)
1	18.88	56.545	25	1413.63
2	94.21			
2	94.21	99.865	25	2496.63
3	105.52			
3	105.52	106.790	25	2669.75
4	108.06			
4	108.06	111.440	25	2786.00
5	114.82			
5	114.82	114.615	25	2865.38
6	114.41			
6	114.41	114.455	25	2861.38
7	114.50			
7	114.50	114.435	25	2860.88
8	114.37			
8	114.37	111.355	25	2783.88
9	108.34			
9	108.34	104.795	25	2619.88
10	101.25			
10	101.25	100.100	25	2502.50
11	98.95			
11	98.95	95.415	25	2385.38
12	91.88			
12	91.88	92.490	25	2312.25
13	93.10			
13	93.10	91.625	25	2290.63
14	90.15			
14	90.15	89.195	25	2229.88
15	88.24			
15	88.24	82.555	25	2063.88
16	76.87			
16	76.87	72.395	25	1809.88
17	67.92			
17	67.92	70.785	25	1769.63
18	73.65			
18	73.65	43.325	25	1083.13

Number of the profile	Square of the profile (m²)	Mean value of the square figure(m²)	Distance between the profiles (m)	Cubature between the adjacent profiles (m³)
19	13.00			
19	13.00	17.530	4.85	85.02
20	22.06			
Total cubature:				**41889.52**

Namely, the method of calculating the volume on the basis of transversal profiles can be used as a counting control, as is confirmed by the results. In addition to this control purpose, generating cross-sectional profiles plays an important role in verifying the 3D model, since it provides a clear image of the vertical cross-sectional view. In this case, it is clearly seen that the bottom of the excavation is saw-shaped and that one side of the excavation climbs steadily to the top, which absolutely corresponds to the actual situation on the ground.

Different types of information are contained in the generated transversal profile, for example, the slopes of the terrain. Also, the measurement of many elements shown in the transversal profile is enabled (Figure 26).

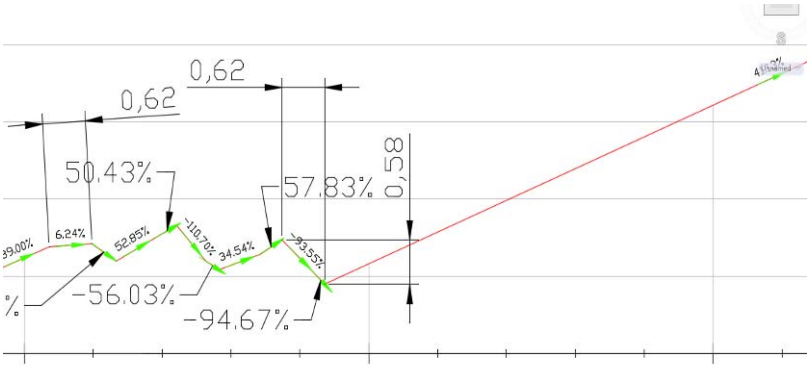


Figure 26 – Slopes of the surfaces shown on the transversal profile of the 3D surface model

Рис. 26 – Уклоны на местности, изображенные на поперечном профиле 3Д модели

Слика 26 – Нагиби површи приказани на попречном профилу 3Д модела површи

Also, the surface can be more clearly and easily seen via the cross-sectional view, so it is often used in design in construction works, traffic, hydrography, mining, etc.

3D terrain model visualisation

In the previous part, 3D modeling of the surface of the ground for different time moments (2013, 2014, and 2015) was carried out, based on which different analyzes were performed in order to solve a certain type of problems

(calculation of volume). In explaining these procedures, the formed 3D terrain models were interpreted in different ways (using contour lines, profiles, 3D solid models, etc.).

Visualization of the 3D model is one of the most important features. The way in which the information is transmitted to the user depends on the model itself. Styles, colors, data display, and viewing angles provide the field information that should be approximate to that that might be collected by observing actual surfaces on the ground. Also, visual verification is very important in controlling 3D modeling. Due to all of the above, several ways of presenting DTM will be displayed.

One of the most commonly used methods of displaying geomorphologic characteristics is contour lines. Based on the established DTM, this display mode is possible at any moment (Figure 27) and generating a model with a different equity is extremely simple and automatic (Figure 28).

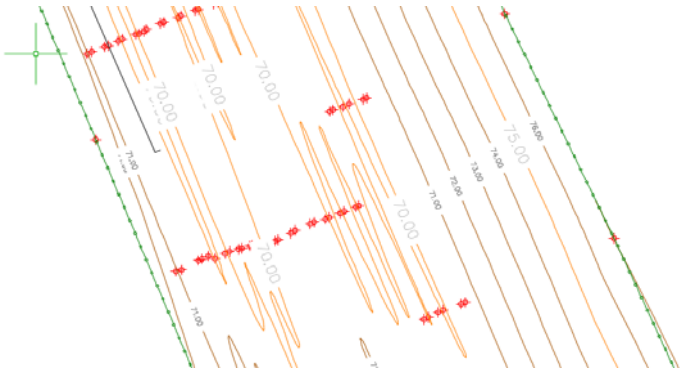


Figure 27 – Model display via contour lines - equidistance 1.0 m
Рис. 27 – Изображение модели изогипсой – равенство отстояний 1.0 м
Слика 27 – Приказ модела преко изохипси –еквидистанција 1,0 m

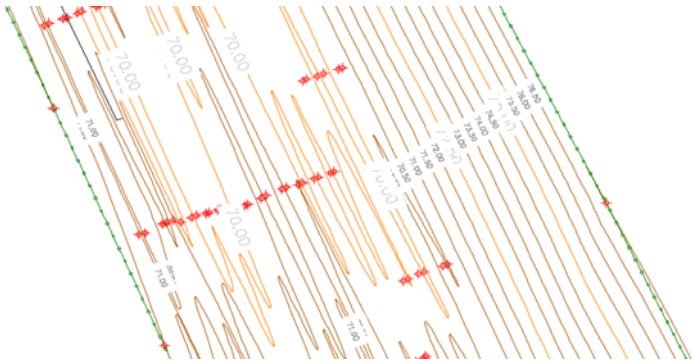


Figure 28 – Model display via contour lines - equidistance 0.5 m
Рис. 28 – Изображение модели изогипсой – равенство отстояний 0.5 м
Слика 28 – Приказ модела преко изохипси – еквидистанција 0,5 m

To see the triangles formed during triangulation, one of the good ways of displaying is a wired model (Figure 29) or a shady solid model made up of three-dimensional facets (Solid model - 3d faces) shown in Figure 30.

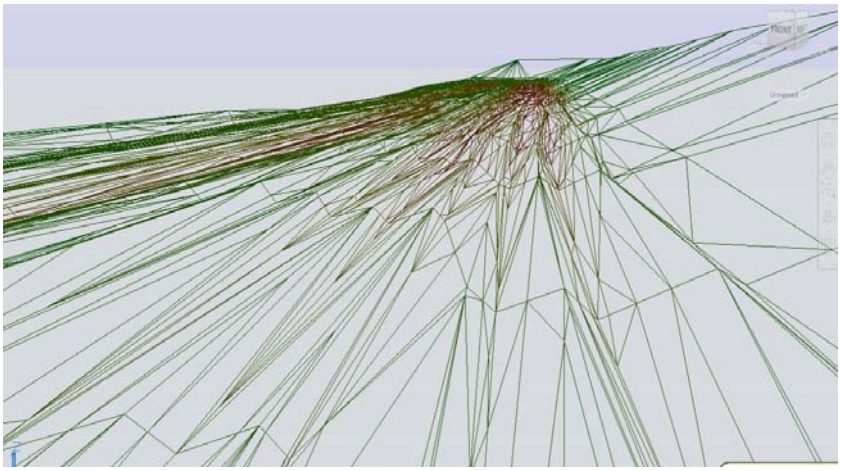


Figure 29 – Wired 3D model
Рис. 29 – Каркасная 3Д модель
Слика 29 – Жичани 3Д модел

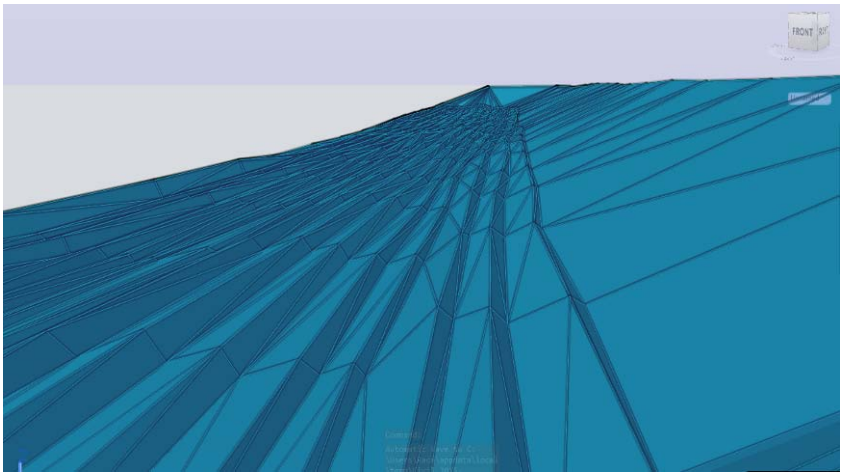


Figure 30 – Shaded model composed of triangular facets
Рис. 30 – Модель затенения, состоящая из треугольных граней
Слика 30 – Сенчени модел који се састоји од троугаоних фасета

Conclusion

The paper presents the entire process of creating and forming 3D models, from measuring and data processing to displaying and monitoring changes in the capacity of the "Garajevac - Istok " mine. The research and analysis pallete that can rely on the image of the digging profile and its three-dimensional display is far more extensive. The primary analysis is to monitor changes in the shape and capacity of the excavation during the exploitation of clay during the subsequent period (2013-2014, 2014 - 2015).

3D models were formed on the basis of the data collected on the terrain by terrestrial recording by the total station and taken from the already existing digital maps and plans. Progress in terms of improving the technique of collecting data on the field is certainly possible, first and foremost, by using modern methods of recording (laser recording, photogrammetry). However, in order for various planners, engineers and local services to use depth measurement data on a daily basis and to have the latest state available, it is useful to establish a geoinformation system. Such a system requires constant data updating and its upgrading to new data layers. In this way, a rich database will be obtained, useful primarily for a rapid development of 3D excavation models, precise profiles and various thematic maps.

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АНАЛИЗ ИЗМЕНЕНИЙ ОБЪЕМА КАРЬЕРА «ГАРАЕВАЦ - ВОСТОК», ВЫПОЛНЕННЫЙ С ПОМОЩЬЮ ГИС ТЕХНОЛОГИИ

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РУБРИКИ: 36.23.00 Прикладная геодезия. Прикладные применения аэросъемки и фотограмметрии

ВИД СТАТЬИ: профессиональная работа

ЯЗЫК СТАТЬИ: английский

Резюме:

В данной работе рассматривается проект разработки и наблюдения за изменениями объема карьера «Гараевац-Восток», находящегося на кадастровой карте муниципалитета Нови-Бечей. Надо подчеркнуть, что раньше физическая площадь и геопространство в целом, представлялись двумерно (2Д), на плоскости, с помощью оного из картографических методов (изолинии, высотные отметки, гипсометрия) или трехмерно (3Д) с помощью проектирования моделей и рельефных карт. Картографические принципы визуализации местности на рельефных картографических моделях позволяют создавать 3Д изображения, но они с инженерной точки зрения, были недостаточно качественными и точными. При этом сложно было проводить количественную и качественную оценку местности на вышеупомянутых моделях. Однако благодаря современным технологиям меняется и 3Д изображение геопространства, то есть применяется концепция разработки цифровой модели местности (ЦММ). Главная цель настоящей работы заключалась в создании 3Д модели и проведении сравнительного объема карьера «Граевац-Восток» в течение определенного эксплуатационного срока.

Ключевые слова: карты, ГИС, объем, изменения на местности, ЦММ, анализ.

АНАЛИЗА ПРОМЕНА КАПАЦИТЕТА КОПА „ГАРАЈЕВАЦ – ИСТОК" ПРИМЕНОМ ГИС ТЕХНОЛОГИЈЕ

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ОБЛАСТ: геонауке
ВРСТА ЧЛАНКА: стручни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

У раду се разматра концепт израде и праћења промена капацитета – кубатуре копа „Гарајевац– исток", који се налази на катастарској општини Нови Бечеј. Раније су се физичка површ Земље и геопростор уопште приказивали дводимензионално (2Д) у равни, неком од картографских метода (изолиније, коте, хипсоскала) или тродимензионално (3Д), израдом макета и рељефних карата. Картографски принципи израде и визуализације терена на рељефним картографским моделима омогућују стварање 3Д приказа, али не и довољно квалитетног и инжењерски прецизног 3Д модела терена. Притом је могућност квантитативне и квалитативне оцене терена на поменутим моделима отежан и није довољно тачан. Са појавом нових технологија мења се начин 3Д приказа геопростора, односно примењује се концепт израде дигиталних модела терена (ДМТ). Основни циљ рада јесте креирање 3Д модела и упоредна анализа кубатуре копа „Гарајевац–исток" за одређени период експлоатације.

Кључне речи: карте, ГИС, кубатура, промена терена, ДМТ, анализа.

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SUBMACHINE GUNS IN THE ARMED FORCES OF THE NATO COUNTRIES

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FIELD: Weapons
ARTICLE TYPE: Professional Paper
ARTICLE LANGUAGE: English

Abstract:

The paper presents a brief review of modern achievements and directions of further development of one type of small arms in the armament of foreign armed forces - namely, submachine guns in the armed forces of the countries signatories of the North Atlantic Treaty Organization (NATO). The article follows the historical genesis of the development of the use of submachine guns as specific types of small arms. Access to recent literature represented a major problem; consequently, data from the Internet was largely used. Submachine guns are one of the most effective and efficient types of infantry weapons of foreign armed forces so a more versatile look at the effects of their use is purposeful as well as the need for innovation and investing in our own resources. The article presents a synthesis of the authors' practical experience with the use of submachine guns and the relevant theoretical knowledge.

Key words: NATO countries, armed forces, submachine guns.

Introduction

Submachine guns fall into the category of small arms and are intended for action against live targets that are rapidly moving. They are especially effective for fighting at close ranges, especially in combat operations in trenches, forests, mountains, and urban settlements. The

basic features of submachine guns are simplicity of design and ease of use while the effective range is up to 200 m. (Arsić, 2002a)

Although they were one of the most massively used weapons during the Second World War, submachine guns today have relatively limited use and are used mostly by members of special units in almost all foreign armed forces (airborne units, military police units, and counter-terrorist units). Exceptions are crew members of armored and other combat vehicles and artillery weapons. Neglecting the development of submachine guns compared to other types of small arms is a result of the efforts to develop primarily a unique intermediate cartridge for (semi) automatic rifles due to the logistics needs of armed forces (AF).

Modern submachine guns are made from light metals, plastics, composites and steel. The ammunition capacity of submachine guns ranges from 20 to 100 rounds (usual capacity is from 30 to 35 rounds), and the velocity of the projectile is in the range from 300 to 900 m/sec. Most often they are equipped with: optical sights, silencers, laser target designators, thermal imaging devices, and most have a folding or retractable stock.

Submachine guns are now mostly based on the 9 mm Parabellum pistol cartridge, but in recent years designers and manufacturers of weapons have begun to produce submachine guns that use the 5.56x45 mm and 5.7x28 mm (NATO standard) or 5.45x39 mm (GOST) ammunition, with completely new design and constructor solutions as well as in a „bullpup“ configuration. (Mihajlović & Arsić, 2003)

The greatest attention to developing new models and modifications and to improving the performance of the existing models of submachine guns is paid by American, German and Russian designers of weapons, who emphasize the following advantages of submachine guns over other types of small arms:

- high density of fire,
- rare ricochet bullets,
- high efficiency and effectiveness, and
- high-speed firing.

Basic concepts and classifications of small arms

Small arms encompass all means intended for destruction and incapacitation of living creatures and moving things by an individual (the shooter). In relation to the source of energy used, these weapons can be divided into:

- cold weapons, and
- firearms.

Cold weapons use the mechanical energy of the weapon operator or tightened strings. This group of weapons include: daggers, swords, spears, bows and arrows, crossbows, or any other provisional or locally found assets that can be used as a weapon.

Firearms are weapons based on the use of energy of powder gases generated by burning gunpowder. In relation to the purpose of utilization of energy of powder gases created after firing, there are three basic types of firearms:

- non-automatic,
- semiautomatic, and
- automatic. (Generalštab VJ, 1998)

In non-automatic firearms, gunpowder gases energy is only used to provide the initial kinetic energy for a round, or muzzle velocity, while the gun is reloaded and fired manually. The weapons of this type are most often used when greater precision is required, and not high rate of fire as is the case of sniper rifles. (Generalštab VJ, 1998)

In semi-automatic weapons, besides for providing the initial kinetic energy for rounds, the energy of powder gases is used for other automatic operations: extracting and ejecting spent cartridges, cocking the firing mechanism and reloading; however, for each subsequent firing it is necessary to pull the trigger again. (Generalštab VJ, 1998)

In automatic weapons, the propellant gas energy is used to provide the initial kinetic energy to the round, to recharge weapons and fire the next shot as long as the shooter holds the trigger or until there are rounds in the magazine.

According to the purpose and the tactical and technical requirements, weapons of armed soldiers in the land forces of foreign armies can be divided into:

- pistols and revolvers,
- submachine guns,
- rifles,
- rifle-machine guns,
- machine guns,
- automatic guns, and
- automatic grenade launchers. (Arsić, 1996)

Submachine guns are individual weapons designed to destroy live force at close distances. These weapons can achieve high density of fire, because a rate of fire in practice is about 100 rounds/min. Submachine guns are particularly useful in urban areas for combat actions (c/a) where

the enemy is at close ranges and where larger weapons could not show their full power. Ammunition for submachine guns has been developed based on the pistol round with a small charge, which allowed the production of weapons of simple construction with great firepower. Some submachine guns have fire regulators which enable single fire in addition to the automatic one. Modern submachine guns, unlike the submachine guns used in the Second World War, are lighter and smaller, but still of simple construction.

The principle of operation of most modern submachine guns is based on free bolt recoil (open or closed). Unlike submachine guns of World War II in which the bolt mechanism and other elements were contained behind the barrel, in modern submachine guns bolts are of a telescopic type, that is, bolts are of smaller dimensions and mass, but with still retained other significant characteristics of the weapon. (Petrović, 2009)

The basic, or, in the opinion of most weapon constructors, the most important characteristics of small arms can be divided into four basic groups:

- combat,
- design,
- purpose (exploitation), and
- production - economy.

The combat characteristics of weapons consider a possibility of firing at the enemy with normal, i.e. non-failure operation. The combat characteristics of weapons are usually evaluated by three parameters: power of weapons, maneuvering characteristics and reliability of weapon effects. Weapon power is measured by the total amount of energy of fired rounds hitting a target in unit time. The maneuverability of these arms includes their transportability, transfer of fire and the possibility of application under different conditions. The reliability of weapon effects represents the totality of characteristics that show non-failure operation of these weapons, their service life and insensitivity to external influences and damage. (Petrović, 2009)

The design parameters include the following parameters:

- operation flowchart,
- specific constructions of assemblies and parts (type of automation, bolt type, etc.),
- dimensions of weapons in battle and marching positions,
- ease of construction.

The usage (exploitation) characteristics of weapons should provide simple and uninterrupted operation of all weapon mechanisms as well as firing safety, and also the automatic work and manoeuverability in different conditions of use.

Production-economy characteristics comprise all parameters that provide a simple and inexpensive production of weapons while preserving their quality.

The historical development of the use of submachine guns

Trench warfare way of c/a, as it was in the First World War, encouraged the construction of unique types of weapons which would later become common on battlefields around the world: hand grenades, sniper rifles, flame throwers, light mortars and submachine guns.

The submachine gun stemmed from an automatic pistol. The first submachine gun was patented by Italian designer of weapons Abiel Revel Botello on 8 April 1914. The first submachine gun had the name of Villar Perosa M15. Botello's invention did not experience success although it had a possibility of firing 1,200 rounds/min. The caliber of this submachine gun was 9 mm; it had two interconnected barrels, each with its own firing mechanism, and an effective range of fire of up to 120 m. The weight was 7,41 kg and the magazine capacity was 25 or 50 pistol rounds. The weight of the weapon was regarded as its main drawback.

Although not developed on the basis of Botello's invention, the submachine gun of Beretta constructors „Beretta Model 1918", is also considered one of the pioneering steps in the development of submachine guns as a specific type of small arms. This submachine gun model was developed as a modification of the „Menlicher Corcan" rifle. It had a wooden stock, an „acceptable" weight of 3.72 kg, a possibility of firing 900 rounds/min and an 851 mm long bayonet. The same as Botello's Villar Perosa M15, Beretta's first submachine gun never went into production.

The then Germany was also a pioneer in the development of submachine guns - its military constructors created the first practical construction of a submachine gun, originally called „Maschienpistolen", and then it received the official designation of 9 mm Bergman MP18/1. During the Battle of Verdun in 1916, Germans realized that the „bolt action rifles" had major limitations in the trench warfare. They were too long, cumbersome to carry, with low rate of fire and too powerful for that type c/a, where target distances rarely exceeded 180 m, so the rifle with

the theoretical range of over 1800 m was totally unnecessary. A short-range weapon, with a possibility of automatic fire and a large magazine capacity was more than necessary so that the development of Bergman became a landmark in the further development of these types of weapons. (Petrović, 2009)

The Bergman MP18/1, shown in Figure 1, was the invention of two German weapon construction giants, Hugo Schmeisser and Theodore Bergman. The MP18/1 or „Musk“, as it was called by German soldiers, resembled Mauser k98 (mostly by the shape of its wooden stock) and had a length of 815 mm and a weight of 5.26 kg. it was serviced by two soldiers (gunner and his assistant). It used the 9 mm Parabellum ammunition, had the option of firing 650 rounds/min and a range of effective fire of 70 m, which was ideal in trench warfare.

Between late 1916 and 1918, about 30,000 copies of this submachine gun were produced and it was often copied in other countries. The MP18/1 had several drawbacks, the main one being the use of an unreliable small drum from a Luger pistol which was soon replaced by a simpler box-magazine of the capacity of 32 rounds. The term „submachine“ originated from the use of a smaller caliber round than that of a rifle round, i.e. a specific type of a pistol round, and the fact that it was able to achieve full automatic fire. Although it proved to be a very effective weapon, the MP18/1 manufacture did not continue after the First World War because Germany empire was defeated and its arms production was banned by the Versailles Peace Treaty.

Figure 1 – Bergman MP 18/1
Рис. 1 – Бергман МП 18/1
Слика 1 – Bergman MP 18/1

The Allies were also aware of the need to modify existing weapons to fight in trenches; however, British soldiers as well as their military leadership did not have enough confidence to arm individuals with automatic weapons. Namely, it was believed that a soldier armed with

automatic weapons would fire all the rounds in a short time, after which he would remain helpless on the battlefield. But the real reason was hidden in the fact that, in times of war, a small number of countries were ready to introduce a greater volume of new technology into the war economy which was already under great strain due to the production of war materials.

The United States of America, which joined the war in 1917, shared the same view and was also reluctant to accept new technologies. The US Rifle, Model M1903 Springfield, was considered the best military rifle, and a good part of American soldiers were armed with the Colt M1911semi-automatic pistols. Nevertheless, reports from battlefields which were coming to the command of US AF began to indicate that the Colt proved to be an excellent weapon to fight in trenches, which was not the case with the Springfield rifle.

Head of the Small Arms Department in the US Army Technical Service Command from 1914 Brigadier General John T. Thompson was of the opinion that, despite economic difficulties, there had to be work on developing new weapons technology. Thanks to General Thompson, there was enormous development of small arms, and in the heart of this development lies the invention of one of the most popular submachine guns ever. With the outbreak of the war, General Thompson left the army and became Head of the Construction Department in the Remington comany. Together with his son, Lieutenant Colonel Marselius Thompson, in 1916 he founded a company for design and production of arms under the name Auto-Ordnance Corporation. (Arsić, 2002b)

General Thompson returned to the army to his old appointment in 1917, when he became responsible for supplying the Army with small arms. He was especially interested in the disadvantages of standard military rifles, bearing in mind the fact that he had already had a vision of the submachine gun project. For developing new weapons, Thompson hired several talented individuals, especially captain John N. Bliss (seaman, mathematician and physicist who had already discovered important properties of certain metals associated with adhesion that were applicable in the construction of locking mechanisms) and constructor Theodore H. Ejkof (soon to become a senior engineer in the newly opened Auto-Ordnance Company). Ejkof had extensive experience in the construction of weapons since he had worked in technical service before the war, where at one time he was engaged on a study of the existing automatic weapons being developed worldwide.

The prototype of the first Thompson submachine gun „saw the light of the day“ in September 1917 and was called „Thompson Auto

Rifle“. This submachine gun was a basic version of all models of Thompson submachine guns that would appear several years later. The prototype itself had a lot of shortcomings, notably in terms of locking the barrel, so the Thompson submachine gun was not to enter into operation in the US Armed Forces during the First World War, but during the forties of the 20th century. It is interesting that this weapon was first accepted by criminals from Chicago and New York City during the Prohibition era. Police and the Bureau of Investigation, who considered themselves poorly armed, armed their forces with Thompson submachine guns, especially with a special model M1921A shown in Figure 2. This submachine gun model got a lot of publicity in clashes of the police with gangsters, especially after its use in the massacre on St. Valentine's Day 1929. It soon attracted the attention of Hollywood producers and started to be used a lot in films. In fact, Thompson's appearance in the movies was not in proportion to its use on the streets and under the normal circumstances it would have surely faded in the late thirties because the police had already dealt successfully with gangs by that time. (http://world.guns.ru/smg-e.html)

Figure 2 – M1921 Submachine gun
Рис. 2 – Автомат M1921
Слика 2 – Аутомат M1921

The Japanese attack on Pearl Harbor in December 1941 made the US forces quickly arm themselves in order to fight in the war. The US AF then had more or less identical weapons that had been used in the First World War. Despite the fact that the concept of submachine guns was never particularly attractive in the US AF, and that the Thompson was not widely accepted for use in military units, it was available in the market. It became an obvious choice for land forces and Marine Corps, and later the Thompson, affectionately nicknamed „Tommy Gun“ became world known and accepted as the most famous Allied submachine gun of the Second World War.

The Auto-Ordnance Company soon realized the importance of that nickname and patented it. The Thompson was used by Americans,

British, French, Indians, Australians, Canadians, South Africans, New Zealanders, Soviets, Chinese, Yugoslavs, etc. It was used in combat in all types of terrains - in deserts, mountains, jungles and forests, in the fields and in the streets - and in all environments it proved to be highly effective and usable. No one called it perfect, because the fact is that it was not - but one thing is certain: no one relinquished its services. Firepower generated by 11.43 mm rounds was always welcome in all combat situations. Few of those who received a rafal from the Thompson survived to testify about its combat power. The production of the Thompson submachine gun finally stopped in 1944, after 1,387,134 produced pieces. (http://world.guns.ru/smg-e.html)

In preparation for conducting „blitzkrieg“ (a rapid war), Germany's weapons introduced a whole range of new models of small arms. One of the most interesting models is certainly the MP38 submachine gun (Figure 3) – the most famous military submachine gun of all times. It was often called Schmeisser, although constructor Hugo Schmeisser had nothing to do with its design or production (constructor was Volmer and it was produced in the „Erma-Werke“ company). It was a synonym of German firepower and the „blitzkrieg“ doctrine in general. The Germans used it in their marketing campaigns, on propaganda posters. Its enormous fame was largely accredited to the Hollywood industry in the postwar years due to which there was an impression that every second member of the Wehrmacht was armed with the Schmeisser submachine gun.

Figure 3 – MP 38 Submachine gun
Рис. 3 – Автомат МП38
Слика 3 – Аутомат МР38

This was far from the reality. Schmeissers were relatively rare in the armament of the Wehrmacht. In the period from 1939 to 1945, there were a total of 908,317 pieces produced, which is almost negligible compared to the multimillion production of K98k carbines. On the battlefield, a submachine gun was inferior to the K98k, particularly in relation to MG34, MG42 and StG44 machine guns. True, it was designed as a tank crew weapon, for paratroopers and close combats in urban areas, i.e. primarily

for special troops, and not for the overall use. Finally, during its exploitation, several dangerous defects came to light. (http://military-today.com)

In the early days of the war, the production of the MP38 showed to be quite expensive, and it was necessary to have cheaper, faster and more massive production of weapons. The technology of metal stamping began to be used in the production of small arms. The production of the MP38 with the application of new technologies started between March and July 1940. This new model, the MP40 submachine gun, was basically the same weapon, but with differences in the receiver and bolt as well as the magazine housing. Therefore, the main difference was in the production, because this model used stamped sheet metal and simple component parts which could be produced by other manufacturers throughout Germany. The use of high-quality steel was avoided to the greatest extent, and spot welding was used for binding parts. Mass production of MP40s was entrusted to the firms: „Erma“, „Haenel“, and „Steyr“. (Petrović, 2009)

The MP40 had several varieties, but the appearance was little altered. The most interesting version was the MP40 / II. The new model was produced in late 1943 and had a double housing stock which could accommodate two magazines with 32 rounds each. One was connected to the feed mechanism and when it ran out, the other was repressed in its place, i.e. inserted. This model was actually an attempt of German constructors to respond to the Soviet submachine gun, the PPs model. In practice, this did not work well because of the heavy weight and poor balance. A weapon with a wooden stock, based on the MP40, known under the name of the MP41, was Haener's trial investment, but never accepted as an official weapon.

During combat exploitation, soldiers noticed a few drawbacks of this submachine gun. First, delays occurred after the first shot was fired. Germans long studied the reasons for these deadly flaws. Several causes were found: soldiers would hold the magazine instead the foregrip, which, during recoil, led to its malfunctioning and change in the feed angle. Soldiers were instructed to lubricate the magazine, dirt would mix with lubricating oil and the friction between the magazine walls and cartridges would increase from a coefficient of 0.15 to 0.30. In addition, a zigzag arrangement led to an unfavorable pressure between the ammunition and rounds changing their positions. This flaw was never completely eliminated, although strict instructions about holding the weapon were issued, a stronger feed spring was introduced (which

decreased the ammunition capacity from 32 to 28 rounds) as well as a new regulation on cleaning and maintenance. (Petrović, 2009)

The second flaw was accidental firing when the bolt was in the forward position. Due to large recoil forces and inertia, the bolt would „fly" backwards and perform charging and firing. As a temporary solution, an instruction was issued to apply a special leather harness fixed around the barrel. The bolt handle was firmly fixed with a special loop. This temporary solution was even commended, because the harness was covering the cartridge ejection port and prevented penetration of dirt. As a permanent solution, from the mid-1942, all manufactured submachine guns had the old cocking handle replaced by a new one, the head of which would be secured in the forward position by being pushed into the notch on the magazine. Replacement was completed by mid-1943 (adapted M38s were labeled as MP38/40s), and all newly produced submachine guns were fitted with new handles. (Petrović, 2009)

The end of the Second World War saw a huge surpluses of various low-cost submachine guns left behind, and the development of small arms, mainly semi-automatic rifles in bigger calibers, went in a different direction. The development of new, fully automatic assault rifles in smaller rifle calibers, gave another dimension and much more firepower to infantry weapons than they previously used to have. In the West, the development of assault rifles began around the 7.62x51 mm NATO cartridge, and soon went on to small-caliber ammunition by introducing the American M-193 5.56x45 mm cartridge as the NATO standard. The development of a new concept of weapons and the new generation of assault rifles (initially started by German constructors during the war), especially their shorter and lighter versions at the end of the sixties of the 20th century, made the submachine gun lose its importance as a basic combat weapon because of its limitations in range, accuracy and firepower. From the military point of view of the great powers, it was thought to have lost any significance. (Vojvodić, 2009, pp.11-12)

Thus, in the late sixties and early seventies, production of submachine guns ceased almost completely because they were considered to be completely anachronistic and acceptable only as an auxiliary weapon to equip non-combat units. Limited use of submachine guns remained important only in Third World countries which mainly did not have their own production of modern assault rifles. A milestone for further development, or actually for the survival of submachine guns, lies in the formation of a new German weapons factory - Heckler & Koch. The founders, but also the leading tandem of constructors, were Edmond Heckler (1906-1960) and Theodore Koch (1905 -1976). In a very short

time, in 1956, their new model of an assault rifle, the G3, appeared for the purpose of arming the Bundeswehr. It was developed in the then dominant Western (American) 7.62x51 mm NATO and .308 Winchester caliber. Their solution, which combined an ingenious locking system solution (delayed recoil) with movable rollers, taken from the MG-42 machine gun and the then new and revolutionary technology of making weapons using pressed sheet metal and components from molded plastic, resulted in a new and very unusual assault rifle, the G3, which has become one of the leading and most respected western infantry weapons in the world. (Vojvodić, 2009, pp.11-12)

Experimenting with different variants of rifles soon resulted in some compact models designed for some more modern and weaker ammunition (5.56x45 M193 first, then Soviet 7.62x39 M43 ammunition and 5.45x39 for small arms). During 1964, a maximally reduced, facilitated and redesigned version appeared, intended for pistol ammunition, primarily for the 9 mm Para, as well as for a more archaic Soviet 7.62x25 TT. This last variant was called the MP5 (Maschinenpistolen model 5-slot model 5). In 1996, the MP5 in 9x19 Parabellum caliber was introduced in serial production at the request of the German border police who needed such weapons to equip their members.

The new MP5, Figure 4, kept the locking mechanism from the assault rifle from which it originated so the bolt was closed and locked during operation thus proving to be much more precise than all previous submachine guns. In addition, built to the highest technological standards of the time (almost unattainable today), it was the first weapon in the world with absolute possibility of replacement of all parts of all produced copies ever. Experiments of this type were carried out in our country, in the Institute of Security in Belgrade after purchasing this model; all parts of ten submachine guns were disassembled and mixed to be later assembled randomly, and SMGs continued to function flawlessly. After the terrorist attack on the Israeli Olympic delegation in Munich in 1972, the German border police (Bundesgrenzschutz) formed a first special unit in this country, called GSG-9 (Grenzschutzgrupe 9), which immediately included this already proven submachine gun in their standard arsenal. So this weapon, along with the prestige of this unit, slowly began to appear in the armaments of those who looked up to it. (Vojvodić, 2009, pp.11-12)

The H&K MP5 tactical - technical characteristics:

- caliber: 9x19 mm,
- weight: 2.28 kg,

- length: 660 mm,
- barrel length: 225 mm,
- principle of operation: semi-free bolt recoil – closed bolt
- muzzle velocity: 400 m/s,
- rate of fire: 800 rounds/min,
- magazine capacity: 15 or 30 rounds,
- effective firing range: 200 m.

Figure 4 – H&K MP 5 Submachine gun
Рис. 4 – Автомат Х&К МП5
Слика 4 – Аутомат H&K MP 5

Submachine guns in the use of the armed forces of the NATO countries

This part of the paper provides an overview of the most popular and the most widely used submachine guns in the armies of the NATO countries. Each submachine gun type (representative of its kind, that is, a particular model) has been described according to its origin, i.e. according to the manufacturer's country, AFs of the NATO countries where it is used (indicating also other security forces using them) and the summary of the basic tactical technical characteristics of each model of submachine guns. Submachine guns of some countries that are not NATO members (Sweden, Israel and Switzerland) are also presented since they are widely used in the armies of the NATO countries (and many others around the world). Due to the lack of recent literature in this field, some of the data was downloaded from the Internet.

The FN P90 submachine gun, shown in Figure 5, was designed and manufactured by the Belgian company FN Herstal. It was created in response to NATO's request for a replacement weapon using 9x19 mm ammunition. The FN P90 submachine gun was designed as a compact, yet powerful weapon for the crew of combat and other armored fighting vehicles, special units, and counter-terrorist units. It appeared in the early nineties of the 20th century. There are several innovations in the design of the FN P90 such as an integrated reflex sight, a frame, a unique top-

mounted magazine as well as a special FN 5.7x28 mm pistol ammunition.

Submachine gun feeding is done in a unique way. The magazine is placed on top of the submachine gun receiver, and ammunition is arrayed at an angle of 90 ° relative to the barrel. At the end of the magazine, there is a spiral feed ramp that rotates the ammunition coming to it under the action of the spring in the magazine in the direction of the barrel, and alignes it downwards, and, while going to the forward position, the bolt takes a cartridge and places it into the barrel chamber. Also, the receiver is made of semi translucent polymer that allows the shooter to see how much ammunition is left in the magazine. The FN P90 submachine gun operates on the principle of free recoil bolt with the closed bolt. It is suitable for being carried concealed because of its smooth edges. It was made in „bullpup“ design, which means that the magazine and all actions related to firing happen in the stock, thus making it easy to carry and maneuver easily in small and narrow spaces. (Arsić, 1996)

The tactical - technical characteristics:

- caliber: 5.7x28 mm,
- weight: 2.54 kg,
- length: 500 mm,
- barrel length: 263 mm,
- principle of operation: free bolt recoil – closed bolt
- muzzle velocity: 850 m/s,
- rate of fire: 900 rounds/min,
- magazine capacity: 50 rounds,
- effective firing range: 200 m.

Figure 5 – FN P90 Submachine gun
Рис. 5 – Автомат ФН П90
Слика 5 – Аутомат FN P90

The Specter M4 submachine gun shown in Figure 6 was developed in Italy by two famous constructors Roberto Teppa and Claudio Gritti in the mid-eighties of the 20th century. This weapon is mostly used in Italy and Switzerland mainly by law enforcement forces. The special characteristic of this submachine gun is the trigger mechanism that works on the principle of double action. The bolt handle is located on top so cocking can be done with both hands. The ammunition is fed by the magazine of the capacity of 30 and 50 rounds. It is worth noticing that the civilian version is available with 5, 10 and 15-round magazines. The main drawback of this submachine gun is a small range of effective fire. (http://www.military-today.com)

The tactical - technical characteristics:

- caliber: 9x19 mm Parabellum,
- weight: 2.90 kg,
- length: 580 mm,
- barrel length: 130 mm,
- principle of operation: free bolt recoil – closed bolt
- muzzle velocity: 400 m/s,
- rate of fire: 850 rounds/min,
- magazine capacity: 30 and 50 rounds,
- effective firing range: 50 m.

Figure 6 – Spectre M4 Submachine gun
Рис. 6 – Автомат Spectre M4
Слика 6 – Аутомат Spectre M4

The Steyr TMP submachine gun, shown in Figure 7, was designed in the famous Austrian military company Steyr-Mannlicher in the early nineties of the 20th century. Its production officially began in 1992 and terminated in 2001 primarily due to poor sales. The license for the production was transferred to a Swiss company and one of the design solutions is still produced. The Steyr TMP submachine gun enables slower, but more controlled fire. It has been found that it is very stable during automatic fire. The shooter fires a burst of 10 to 15 rounds while other submachine guns are limited to a burst of 2 to 3 rounds. Many parts

of the submachine gun are made of polymer. It is interesting that there is no stock, and that it can be fired single-handedly. It has 15 and 30- round magazines.

The tactical - technical characteristics:

- caliber: 9x19 mm,
- weight: 1.30 kg,
- length: 282 mm,
- barrel length: 130 mm,
- principle of operation: free bolt recoil – closed bolt
- muzzle velocity: 370 m/s,
- rate of fire: 800-900 rounds/min,
- magazine capacity: 15 and 30 rounds,
- effective firing range: at 50 to 100 m.

Figure 7 – Steyr TMP Submachine gun
Рис. 7 – Автомат Steyr ТМП
Слика 7 – Аутомат Steyr TMP

The original Steyr AUG submachine gun, shown in Figure 8, is a modified and improved design of the original Steyr AUG assault rifle. It is designed for close combat in police and military actions. This weapon combines relatively compact dimensions with good precision, thanks to a long barrel and a closed bolt. If necessary, the Steyr AUG can be fitted with a silencer. Some basic components are taken from the Steyr AUG assault rifle, such as the polymer stock, while the principle of operation is different. What was kept is the hammer-firing mechanism with a special progressive trigger (pulling the trigger halfway produces a single shot while pulling it until the end produces burst fire). Also, the magazine housing has a special magazine adapter. (Mihajlović & Arsić, 2003)

The tactical - technical characteristics:

- caliber: 9x19 mm Parabellum,
- weight: 3.50 kg,

- length: 665 mm,
- barrel length: 420 mm,
- principle of operation: free bolt recoil – open bolt
- muzzle velocity: 400 m/s,
- rate of fire: 670 rounds/min,
- magazine capacity: 25 rounds,
- effective firing range: 200 m.

Figure 8 – Steyr AUG Submachine gun
Рис. 8 – Автомат Steyr AUГ
Слика 8 – Аутомат Steyr AUG

The Brugger & Thomet MP9 submachine gun, Figure 9, is a modified version of the Steyr TMP. Swiss weapons designers made a total of 19 changes to the TMP. The MP9 submachine gun is currently used in Switzerland, India and Portugal. This submachine gun is smaller than the H&K MP5, which makes it ideal for special units and law inforcement forces. Its compact size has, however, led to the reduced range of effective fire. The MP9 is designed so that it has an integrated front handle, so it can be easily controlled during automatic fire. This submachine gun can be fired single-handedly. The main novelty of the MP9 compared to the TMP is a side-folding stock and a Picatinny-type scope rail which can accept a wide variety of optical sights. The MP9 submachine gun also has a mechanical sight and is compatible with silencers.

The tactical - technical characteristics:

- caliber: 9x19 mm,
- weight: 1.40 kg,
- length: 523 mm,
- barrel length: 130 mm,
- principle of operation: free bolt recoil – closed bolt
- muzzle velocity: 400 m/s,
- rate of fire: 900 rounds/min,
- magazine capacity: 15, 20, 25 and 30 rounds,

- effective firing range: from 50 to 100 m. (Mihajlović & Arsić, 2003)

Figure 9 – Brugger & Thomet MP9 Submachine gun
Рис. 9 – Автомат Brugger & Thomet MP9
Слика 9 – Аутомат Brugger & Thomet MP9

The Scorpion EVO III submachine gun, Figure 10, is the latest product of the well-known Czech Republic Zbrojovka factory (CZ-UB). Its development began in Slovakia in early 2002 as a submachine gun under the name of Laugo. When the design became famous, it was sold to CZ-UB which in 2009 produced the version Scorpion EVO III. Although this weapon was primarily designed for police forces, it can also be found in some military units. It uses a 9x19 mm Parabellum ammunition, but it is also developed to use .40 S&W ammunition in order to be sold in foreign markets (primarily the US). It has a separate hammer mechanism and the settings for single shots, 3-round bursts and continuous fire. The bolt handle is on the left side of the weapon. The receiver, the adjustable folding stock, the grip, the trigger mechanism, and the foregrip are made of polymer. Iron sights are mounted on a Picatinny-type scope rail at the top of the receiver, to which various optical sights can be mounted. Additional three Picatinny rails are installed at the level of the foregrip. The magazine is made of transparent plastic.

The tactical - technical characteristics:

- caliber: 9x19 mm, .40 S&W
- weight: 2.77 kg,
- length: 660 mm,
- barrel length: 196 mm,
- principle of operation: free bolt recoil – closed bolt
- muzzle velocity: 370 m/s,
- rate of fire: 1100 rounds/min,
- magazine capacity: 20 and 30 rounds,

- effective firing range: to 200 m. (http://world.guns.ru/smg-e.html)

Figure 10 – Scorpion EVO III Submachine gun
Рис. 10 – Автомат Scorpion EBO 3
Слика 10 – Аутомат Scorpion EVO III

The Kriss Super V submachine gun, Figure 11, was designed by TDI company. Its name comes from the name for the Indonesian sword or large knife. It works on the principle of free bolt recoil and fires from the closed bolt. Its ammunition is .45 ACP (11.43x23 mm). A version for caliber .40 S & # 38; W (10x22 mm Smith & Wesson) is also available. Due to a special system, the Kriss Super V has reduced recoil and muzzle climb. The recoil force is redirected downwards, which improves overall weapon control. The producer claims that this submachine gun has 60% less recoil and 95% less muzzle climb. It is fed from the standard Glock 21 magazine with 13 rounds, optionally 30 rounds. The magazine is located in the housing in front of the grip.This weapon has a Picatinny-type rail on top so it can be fitted with iron sights and a variety of sighting devices. This submachine gun has a folding stock and an additional rail below the barrel which is compatible with laser pointers, additional foregrips, flashlights, etc. (http://world.guns.ru/smg-e.html)

The tactical - technical characteristics:

- caliber: .45ACP, .40S&W
- weight: 2.70 kg,
- length: 620 mm,
- barrel length: 140 mm,
- principle of operation: free recoil of the bolt – closed bolt
- muzzle velocity: 400 m/s,
- rate of fire: 800-1100 rounds/min,
- magazine capacity: 13 and 30 rounds,
- effective firing range: 100 m

Figure 11 – Kriss Super V Submachine gun
Рис. 11 – Автомат Kriss Super V
Слика *11 – Аутомат* Kriss Super V

The Ruger MP9 submachine gun, shown in Figure 12, is very similar to the Israeli IMI UZI. Designed as a compact weapon for law enforcement forces, this submachine gun was first introduced in early 1995. It was tested by the special units of the British AF - SAS. However, this weapon was produced in limited series. It works on the principle of free bolt recoil and fires from a closed bolt. Some parts of the weapon are made of polymer, primarily to reduce weight. The magazine housing is located in the grip and has a capacity of 32 rounds (the UZI has the same magazines). The Ruger MP9 has a redesigned folding stock. It can be cocked using either hand since the cocking handle is located on top of the weapon. The weapon does not have a Picatinny rail, and uses only mechanical sights.

The tactical - technical characteristics:

- caliber: 9x19 mm Parabellum,
- weight: 1.83 kg,
- length: 556 mm,
- barrel length: 173 mm,
- principle of operation: free bolt recoil – closed bolt
- muzzle velocity: 370 m/s,
- rate of fire: 850-900 rounds/min,
- magazine capacity: 32 rounds,
- effective firing range: 75 m. (http://military-today.com)

Figure 12 – Ruger MP9 Submachine gun
Рис. 12 – Автомат Ruger MP9
Слика 12 – Аутомат Ruger MP9

The UZI submachine gun, Figure 13, was designed by Israeli designer, Uzziah Gal in 1949, then lieutenant of the just formed AF of the Republic of Israel. The weapon is named in his honor. It was officially adopted in 1951, but become operational in 1954 and was first given to the special units of the Israeli AF. Produced by the IMI company, the UZI was so successful that it was adopted by more than 90 countries around the world, either for the army or the police forces, but it is also a favorite weapon of terrorists around the world. Over the decades, there have been a lot of „family members“ (design versions) of this model. It was licensed and produced in Belgium (FN Uzi) and Rhodesia (Zimbabwe), while the most popular unlicensed variants were produced in China (Model 320) and Croatia (Model ERO). It works on the principle of free bolt recoil and uses an open bolt. The impact of the design of the Czechoslovak submachine gun model SaVz 23 is visible, especially in the magazine housed in the grip. The UZI is simple in design and technology, has relatively few moving parts and is primarily made of metal. The weapon was selected by the Israeli AF primarily due to its simplicity and ease of production. (http://military-today.com)

The magazine is in the grip, which makes it smaller and easier for charging. It is fed by 25, 32, 40 and 50-round magazines. The main shortcomings of the UZI submachine guns are limited range of effective fire and inaccuracy. There are three basic variants: Mini UZI, Micro UZI and UZI Pro. The UZI Pro submachine gun was officially launched in 2003 and represents an improved version of the Micro UZI. It was created based on extensive research by Israeli engineers who conducted the survey and collected the impressions, observations and reports of direct users of the Micro UZI. The UZI Pro is lighter because it uses polymer and titanium alloys. This submachine gun is fed from Glock's

magazines with a capacity of 17 and 33 rounds. (http://military-today.com)

The tactical - technical characteristics:

- caliber: 9x19 mm,
- weight: 3.50 kg,
- length: 650 mm,
- barrel length: 260 mm,
- principle of operation: free bolt recoil – open bolt
- muzzle velocity: 400 m/s,
- rate of fire: 850-900 rounds/min,
- magazine capacity: 25, 32, 40 and 50 rounds,
- effective firing range: 200 m.

Figure 13 – UZI Submachine gun
Рис. 13 – Автомат UZI
Слика 13 – *Аутомат UZI*

The CBJ MS submachine gun, Figure 14, was designed by Swedish designer of weapons Bert Johnson who founded a private company for production of weapons, CNJ Tech AB. This submachine gun, i.e. its different design solutions, was presented in the period from 2000 to 2003. This compact weapon is intended for commanders, drivers, tank and artillery crews, pilots and medical staff. The CBJ MS submachine gun works on the gas principle. It fires from a closed bolt. The weapon is actually a modified version of the Israeli UZI. It uses the 6.5x25 mm ammunition which, during experiments, showed better performance than the 5.56 and 7.62 mm NATO ammunition. The primary ammunition type of this SMG is an armour-piercing round with greater penetration performance. During trials, the CBJ MS round penetrated the standard Crisat armor at a distance of 230 m. Some weapon designers claim that the CBJ MS is superior to the Belgian FN P90 and the HK MP7. This submachine gun is ideal for close combat and self-defense while being

also effective against lightly armored vehicles. (http://world.guns.ru/smg-e.html)

The barrel of the submachine gun can be easily removed for maintenance and/or replacement. The magazine is provided in the handgrip, and has a capacity of 20 or 30 rounds. A spare magazine can be kept in the foregrip to be easily changed. There is also a drum magazine version with a capacity of 100 rounds. This submachine gun has a Picatinny rail which can hold various sights, flashights, laser target designators, and the like. The CBJ MS is now being designed in a few versions and it is obvious that this SMG represents the future, or a tendency of the further development of submachine guns.

The tactical - technical characteristics:

- caliber: 6.50x25 mm,
- weight: 2.80 kg,
- length: 565 mm,
- barrel length: 200 mm,
- principle of operation: gas operated – closed bolt
- muzzle velocity: 830 m/s,
- rate of fire: 700 rounds/min,
- magazine capacity: 20, 30 and 100 rounds,
- effective firing range: 400 m.
  (http://www.zrno.ba/zrno/naoruzanje.html)

Figure 14 – CBJ MS Submachine gun
Рис. 14 – Автомат CBJ MS
Слика 14 – Аутомат CBJ MS

The H&K UMP submachine gun, Figure 15, was developed as a lighter and cheaper successor to the MP5. Its production started in 1999. The working principle is free bolt recoil with a closed bolt. The submachine gun has an effective range of fire of up to 100 m. The H&K UMP has a folding stock that folds to the right. It uses mechanical sights

or various optical sights on a Weaver-type rail mounted on top. There are three variants of the UMP: UMP45, using .45 ACP (11.43x23 mm), then UMP40 with .40 S&W (10x22 mm Smith & Wesson), and UMP9 which uses the 9x19 mm Parabellum. In addition to a variety of ammunition, all versions have the same design, while the most striking difference is a curled magazine of the UMP9. All three versions can use any ammunition type providing the bolt, the barrel and the magazine are changed. Table 1 gives a review of the tactical and technical characteristics of the H&K UMP submachine gun. (http://military-today.com)

Figure 15 – H&K UMP Submachine gun
Рис. 15 – Автомат H&K UMP
Слика 15 – Аутомат H&K UMP

Table 1 – Tactical and techical characteristics of the UMP submachine gun
Таблица 1 – Тактические и технические характеристики автоматов UMP
Табела 1 – Тактичко-техничке карактеристике аутомата UMP

Submachine gun model	UMP45	UMP40	UMP9
Caliber	.45 ACP	.40 S&W	9x19 mm Para bellum
Principle of operation	free bolt recoil – closed bolt		
Weight in kg	2.5	2.3	
Length in mm	690		
Length barrel in mm	200		
Muzzle velocity in m/s	285		
Rate of fire in rounds/min	600	650	
Magazine capacity in number of rounds	25	30	
Effective firing range in m	100		

The H&K MP7 submachine gun, Figure 16, is intended for combat vehicle drivers and tank and artillery crews. It represents a kind of response of Heckler & Koch to the Belgian FN P90. The H&K MP7 was introduced in 2000 and is currently used in the AF of Germany, South Korea and the United Kingdom. The H&K MP7 is gas operated and uses a rotating bolt. Its internal design resembles that of the H&K G36 automatic rifle. The H&K MP7 submachine gun uses 4.6x30 mm ammunition, which is also used in H&K UCP pistols. The H&K MP7 dimensions are those of a typical submachine gun but at close ranges it has firepower of an automatic rifle.

It was confirmed that the H&K MP7 submachine gun penetrates the CRISAT armour at a distance of 200 m. It is often used in offensive operations by special units. The H&K MP7 submachine gun is well balanced and easy to handle. It can be used as a pistol, using only one hand. It also has a folding foregrip and a retractable stock. The magazine is located in the handgrip and may have a capacity of 20 or 40 rounds.

The tactical - technical characteristics:

- caliber: 4.60x30 mm,
- weight: 1.50 kg,
- length: 540 mm,
- barrel length: 180 mm,
- principle of operation: gas operated – rotating bolt
- muzzle velocity: 725 m/s,
- rate of fire: 950 rounds/min,
- magazine capacity: 20 and 40 rounds,
- effective firing range: from 150 to 200 m. (http://military-today.com)

Figure 16 – H&K MP7 Submachine gun
Рис. 16 – Автомат Х&К МР7
Слика 16 – Аутомат Н&К МР7

Conclusion

As a type of small arms, submachine guns were widely used primarily by special units of AF for quite a number of years; however, it seemed they would forever remain in storage facilities. During the seventies of the 20th century, with the widening use of assault rifles, submachine guns were, it seemed, doomed to completely disappear from the historical scene. In fact, in most cases, it was considered that the functions of submachine guns can also be successfully performed by automatic rifles and/or assault rifles. Individuals even considered replacing submachine guns with automatic pistols with burst fire such as the Beretta 93R or the H&K VP 70. (http://www.zrno.ba/zrno/naoruzanje.html)

However, from the nineties of the 20th century, when this type of weapons started experiencing real expansion, SMGs have secured a strong position in the time to come. This occurs mainly due to the experience of local wars around the world, large campaign wars (Gulf War), and the escalation of terrorism in the 21st century. Submachine guns stand out due to their characteristics, the following ones in particular :

- possibility of higher density of fire and improved performance at the target,
- low weight,
- increased accuracy and precision of fire, and
- ability to use a wide range of modern systems and sighting devices.

Greater attention to innovation and upgrade of the combat performances of modern submachine guns was especially paid by German (H&K) and Israel (IMI) weapons companies. In contrast to the above countries, the United States as the leading country of NATO has only recently devoted more attention to this type of weapons, primarily due to the view of their military leadership that these weapons are considered to be supplementary weapons in many AF and police forces in the world. Proof of this lies in the fact that the United States started developing its own types of submachine guns only twenty years ago - Colt SMG, SWD Ingram, KAC-9 (factory „Knight's Armament“), AP-9 and SCC-9 (factory „Weaver Arms Corporation“) and Ruger MP9. All of the above are very compact, light and fitted with the blowback locking mechanism and a fire selector.

Based on the foregoing, we conclude that the tendency of further development of submachine guns in the AF of the NATO countries will be focused on:

- weapon weight reduction,
- reducing the weapon dimensions retaining at the same time good combat performances,
- increase of the magazine capacity (usually to 50 rounds), and
- introduction of a new round to replace the existing 9x19 mm Parabellum, which will be able to penetrate modern means of personal protection.

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АВТОМАТИЧЕСКОЕ ОРУЖИЕ В ВООРУЖЕННЫХ СИЛАХ НАТО

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ВИД СТАТЬИ: профессиональная статья

ЯЗЫК СТАТЬИ: английский

Резюме:

В данной статье представлен краткий обзор современных достижений в области развития одного из видов стрелкового оружия, а точнее автоматов, используемых зарубежными вооруженными силами, в частности в странах участницах Североатлантического Альянса (НАТО). В статье описан исторический генезис развития и использования автоматов, с акцентом на особенности данного вида огнестрельного оружия. При написании статьи авторы столкнулись с проблемой недоступности современной печатной литературы, вследствие чего обращались к интернет ресурсам. Знания об автоматах, как самого эффективного вида стрелкового оружия, используемых вооруженными силами зарубежных стран, могут помочь более целенаправленно рассмотреть все преимущества их применения, а также понять насколько велика потребность в инновационном подходе и вложениях в собственные ресурсы и средства. Статья является результатом накопленных теоретических и практических знаний авторов в области использования автоматов.

Ключевые слова: страны НАТО, вооруженные силы, автоматы.

АУТОМАТИ У НАОРУЖАЊУ ОРУЖАНИХ СНАГА НАТО ЗЕМАЉА

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ОБЛАСТ: наоружање
ВРСТА ЧЛАНКА: стручни рад
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Чланак представља кратак преглед модерних достигнућа и правце даљег развоја једне врсте стрељачког наоружања – аутомата у оружаним снагама земаља потписницама Северноатлантског савеза (НАТО). Прати и развој употребе аутомата, као посебне врсте стрељачког наоружања. У недостатку новије литературе у раду су умногоме коришћени подаци са интернета. Познавањем аутомата, као једне од најефекасније и најефективније врсте стрељачког наоружања страних оружаних снага могу се на сврсисходнији начин сагледати њихови ефекти употребе, као и потреба за иновацијама и

улагањем у сопствене ресурсе. Чланак представља сублимат искустава из праксе и теоретских сазнања аутора у вези са употребом аутомата.

Кључне речи: НАТО земље, оружане снаге, аутомати.

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ПРИКАЗИ
ОБЗОРЫ
REVIEWS

8. МЕЂУНАРОДНИ НАУЧНО-СТРУЧНИ СКУП ИЗ ОБЛАСТИ ОДБРАМБЕНИХ ТЕХНОЛОГИЈА ОТЕХ 2018 (ПРИКАЗ ЗБОРНИКА РАДОВА)

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ОБЛАСТ: војне технологије
ВРСТА ЧЛАНКА: приказ
ЈЕЗИК ЧЛАНКА: српски

Сажетак:

У овом приказу предочене су основне информације о укупним резултатима, значају, међународном програмском одбору и областима рада 8. међународног научно-стручног скупа из области одбрамбених технологија ОТЕХ 2018 (8th International Scientific Conference on Defensive Technologies ОТЕН 2018). Наведен је број тематских области, број радова, број аутора/коаутора, број сесија скупа, као и чланова програмског одбора. На овогодишњем скупу је, у односу на претходних седам, било најмање објављених радова.

Кључне речи: међународна конференција, ОТЕХ, војне технологије, приказ.

У Војнотехничком институту (ВТИ) у Београду је, 11. и 12. октобра 2018. године, одржан 8. међународни научно-стручни скуп из области одбрамбених технологија ОТЕХ 2018 (8th International Scientific Conference on Defensive Technologies ОТЕН 2018), под покровитељством Управе за одбрамбене технологије Министарства одбране Републике Србије.

Организатор ове значајне конференције је, по седми пут, Војнотехнички институт. Напоменимо да је прва конференција

одржана 2005. године, на иницијативу Војне академије, под називом 1. научни скуп одбрамбене технологије у функцији мира – ОТЕХ 2005, а имала је карактер домаће конференције, као и друга, коју је, као и све наредне конференције, организовао ВТИ. Трећа конференција била је са међународним учешћем, а од четврте је међународна. О статистичким подацима и неким детаљима претходних конференција може се видети у (Pokorni, 2017), (Gaćeša, 2010).

ОТЕХ је међународни научно-стручни скуп истраживача из подручја одбрамбених технологија који се одржава са циљем да се свеобухватно и мултидисциплинарно сагледају актуелности у овој области (http://www.vti.mod.gov.rs/oteh/elementi/cinfo.htm).

За конференцију се могу поднети радови који садрже оригиналне теоријске или практичне резултате истраживања, као и прикази практичних решења или уређаја из домена тематских области конференције.

Сваки учесник може бити аутор или коаутор највише три рада, али само једанпут први аутор. Сви радови подлежу стручној рецензији.

Прошлогодишња конференција имала је 8 секција, као и претходне две (табела 1).

До сада је у зборницима ове конференције публиковано укупно 1243 рада, укључујући и ОТЕХ 2018 (табела 2).

За конференцију се штампа програм и издаје ЦД на којем се налазе сви радови који су прошли рецензију. Од четврте конференције, одржане 2009. године (ОТЕХ 2009), када је ОТЕХ постао међународна конференција, радови се пишу и излажу на енглеском језику, али и на српском (ако у секцији у којој се излажу радови нема учесника који не разумеју српски језик, по договору са председавајућим секције).

Програмски одбор прошлогодишње конференције чинило је 38 научних радника из 11 земаља (на претходној конференцији 43 из 12 земаља): Белорусија 1, Босна и Херцеговина 2 (1 из Федерације и 1 из Републике Српске), Бугарска 1, Чешка 2, Македонија 1, Немачка 1, Нови Зеланд 1, Румунија 1, Русија 1, Србија 28 (од којих је 10 из цивилних институција). Дакле, 12 чланова, или око 32 %, било је из иностранства (на претходној конференцији 16 или 37%), табела 2.

Отварању конференције присуствовали су високи званичници Министарства одбране и Војске Србије и страни војни изасланици акредитовани у Србији.

Pokorni, S. 8. međunarodni naučno-stručni skup iz oblasti odbrambenih tehnologija OTEH 2018 (prikaz zbornika radova), pp.460-468

Овогодишњу конференцију отворио је министар одбране Републике Србије Александар Вулин, а скупу се, у име организатора и домаћина, обратио директор ВТИ пуковник др Бојан Павковић.

Табела 1 – Преглед укупног броја радова по областима конференције
Table 1 – Overview of the number of all papers grouped by the Conference areas
Таблица 1 – Обзор работ по областям, представленным на конференции

Ред. бр.	Назив области	OTEX 2011	OTEX 2012	OTEX 2014	OTEX 2016	OTEX 2018
	Пленарна излагања	3	2	2	2	3
1	Аеродинамика и динамика лета	11	12	10	12	8
2	Ваздухоплови	22	23	26	13	10
3	Наоружање и возила	28	29	21	14	10
4	Муниција и енергетски материјали			20	15	14
5	Интегрисани сензорски и роботски системи	17	16	21	20	22
6	Телекомуникациони и информациони системи	18	18	12	12	9
7	Материјали и технологије	22	34	36	35	28
8	Квалитет, стандардизација, метрологија, одржавање и експлоатација	11	11	10	11	9
9	Геотопографске технологије	7	-	-	-	
10	Медицина у функцији одбране	3	-	-	-	
УКУПНО ОБЛАСТИ		9	7	8	8	8
УКУПНО РАДОВА		142	145	158	134	113

Министар одбране Александар Вулин је, поред осталог, истакао да је оријентација Војске Србије да се у највећој могућој мери опрема и снабдева из сопствених извора и средстава, полазећи од става да је само оно што сами произведемо, она технологија коју сами освојимо заиста наша. Због тога ће се настојати да се у наредном периоду, више него до сада, улаже у стручњаке који ће бити у стању да технологију коју купимо прилагоде и примене или створе потпуно нову (http://www.vti.mod.gov.rs/index.php?view=actuality).

Директор Војнотехничког института др Бојан Павковић је, поред осталог, поручио да се у ери интензивног развоја нових технологија и брзих промена у развоју наоружања и војне опреме јавља реална

потреба за блиском сарадњом и разменом знања између свих чинилаца који учествују у том процесу (http://www.vti.mod.gov.rs/index.php?view=actuality).

Табела 2 – Број радова, аутора, секција, сесија и чланова програмског одбора по конференцијама
Table 2 – Number of papers, authors, sections, sessions and members of the Programme Committee by Conferences
Таблица 2 – Список количества представленных работ, авторов, секций, сессий и представителей Оргкомитета конференции

	OTEX 2005	OTEX 2007	OTEX 2009	OTEX 2011	OTEX 2012	OTEX 2014	OTEX 2016	OTEX 2018
Број радова	168	181	202	142	145	158	134	113
Број аутора/коаутора	268	287	374	315	402	417	507	410
Број секција	14	10	11	9	7	8	8	8
Број сесија	19	22	20	15	15	16	16	14
Број чланова Програмског одбора	30/7	30/4	22/5	31/13	29/10	38/17	43/16	38/12
Број држава	1	1	4	17	16	14	15	12

Легенда:

* Свака конференција је имала пленарне радове (табела 1) који су овде наведени.

** Број тематских области односно секција. Број сесија је број седница на којима су излагани радови по секцијама.

*** Укупан број чланова Програмског одбора/број ван институција Војске Србије за OTEX 2005, OTEX 2007 и OTEX 2009, а за OTEX 2011, OTEX 2012, OTEX 2014, OTEX 2016 и OTEX 2018 то су укупан број чланова Програмског одбора/број чланова из иностранства (при чему чланови из цивилних институција Србије нису посебно издвајани из укупног броја).

**** У број држава убројана је и Србија, као домаћин конференције.

На већини досадашњих конференција су на отварању одржана и пригодна предавања посвећена нашим познатим научницима. Тако је 2011. године пригодно предавање било посвећено животу и научним достигнућима Николе Тесле, 2014. године 160. годишњици рођења Михајла Пупина, а 2016. године математичарки Милеви Марић. Прошлогодишња конференција била је посвећена нашем познатом научнику Милутину Миланковићу, о коме је пригодно предавање одржао професор др Лаза Лазић, а организована је и изложба о његовом животу и раду уз подршку Удружења „Милутин Миланковић”.

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Након отварања одржана су три пленарна предавања, од којих су два одржали гости из иностранства: проф. др Taek Lyul Song са универзитета у Јужној Кореји и пуковник Тумар Виктар из оружаних снага Републике Белорусије. Предавач из Србије био је проф. др Момчило Милиновић са Машинског факутета Универзитета у Београду. Детаљи се могу видети на http://www.vti.mod.gov.rs/oteh/elementi/eprogram.htm и http://www.vti.mod.gov.rs/index.php?view=actuality.

Конференција је настављена радом по секцијама и сесијама. План рада по секцијама и кратки садржаји прихваћених и рецензираних радова могу се видети на сајту OTEX 2018 (http://www.vti.mod.gov.rs/oteh/elementi/eradovi.htm), док се комплетни радови налазе на ЦД-у (OTEX, 2018ab).

У зборнику конференције OTEX 2018 има укупно 111 радова и 3 пленарна рада, које је написало 410 аутора из 12 држава (укључујући и Србију). Број држава учесница је нешто мањи него на претходне четири међународне конференције, с тим што су из три државе аутори учествовали по први пут (Финска, Јужна Кореја, Мађарска), табела 3. До сада су на конференцији OTEX учествовали аутори из укупно 30 држава, међу којима и наши људи који раде у тим државама. У табели 3 наведени су и радови и аутори са пленарних излагања.

Укупан број радова прошлогодишње конференције је најмањи до сада, било да се ради о радовима домаћих или иностраних аутора (табела 2, табела 3).

За разлику од већине других конференција, за OTEX се не плаћа котизација. Осим тога, одржава се у Београду, у којем је концентрисан научни и стручни потенцијал Србије, како војни тако и цивилни. Треба рећи и то да је наш главни град привлачна дестинација за учеснике из иностранства.

Табела 3 – Преглед броја радова и аутора (и коаутора) по иностраним државама учесницама
Table 3 – Overview of the number of papers and authors (with coauthors) by foreign participating states
Таблица 3 – Обзор количества работ и авторов (соавторов) по зарубежным странам, которые представляют участники

Ред. бр.	Држава	OTEX 2011		OTEX 2012		OTEX 2014		OTEX 2016		OTEX 2018	
		Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.
1	Алжир	3	3	3	5	5	11	7	7		
2	Аустралија	1	1								

Ред. бр.	Држава	OTEX 2011		OTEX 2012		OTEX 2014		OTEX 2016		OTEX 2018	
		Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.
3	Аустрија					1	1			1	1
4	Белорусија		9	1	3	2	4	1	4	2	3
5	БиХ	5		3	6	4	8	2	5	2	3
6	Бугарска			2	4	1	2	1	4		
7	Велика Британија	1	2	2	2	1	2	1	1		
8	Египат			2	2						
9	Ирска	1	2								
10	Италија	1	1	1	1					1	2
11	Израел							1	1		
12	Јужна Кореја									1	1
13	Канада	3	3			1	1	1	1	2	2
14	Кина			2	3						
15	Мађарска									1	2
16	Македонија					3	7	3	9	1	5
17	Нови Зеланд	1	1								
18	Пољска			2	10						
19	Русија	1	1					1	1		
20	САД							1	1		
21	Словенија	1	4	1	6	1	1	2	2		
22	Судан					8	15				
23	Турска	8	11	6	10					1	2
24	Уједињени Арапски Емирати							1	1	1	1
25	Украјина	1	1	1	2					1	1
26	Финска									1	2
27	Француска	1	1	2	2	1	1				
28	Црна Гора	1	3	2	2	2	5				
29	Чешка Република	2	3	2	3	1	4	1	1	1	3
30	Швајцарска	1	1					1	1		
УКУПНО		32	47	32	61	31	62	24	39	16	28

Може се констатовати да конференција ОТЕХ и даље успешно наставља рад. Уочава се сарадња аутора из разних институција Војске и Министарства одбране Републике Србије, како са цивилним институцијама у Србији, тако и са институцијама ван Србије, али и са студентима докторских студија из других земаља, који су на студијама у Србији, посебно у Војној академији Универзитета одбране.

Број радова, као и аутора из иностранства, на последњим конференцијама се смањује (табела 4). Број радова српских аутора је већи него што је наведено у табели 4, јер је само 7 радова где су искључиво инострани аутори, а остали радови, од њих 16, јесу радови и домаћих аутора. Такође, и број аутора из иностранства је већи него што је наведено у табели 4, јер су неки инострани аутори студенти докторских студија у Србији, било на Универзитету одбране или Београдском универзитету, па су наведени у радовима заједно са домаћим ауторима. Већина радова је колективно дело више аутора –од 1 до 7. Просечан број аутора по једном раду, када се ради о домаћим радовима, ове године је 3,96, а прошле је био 4,25, док је код иностраних радова 1,62, а прошле године такође 1,62 (табела 4).

Табела 4 – Преглед броја радова и аутора/коаутора по државама учесницама
Табле 4 – Overview of the number of papers and authors/coauthors by participating states
Таблица 4 – Обзор количества работ и авторов/соавторов по странам участников

Ред. бр.	ОТЕХ 2011		ОТЕХ 2012		ОТЕХ 2014		ОТЕХ 2016		ОТЕХ 2018	
	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.	Број рад.	Број аут.
Број иностраних радова	16		15		13		14		11	
УКУПНО инострани	32	47	32	61	31	62	24	39	16	26
УКУПНО Србија	110	268	113	341	127	356	110	468	97	384
УКУПНО ОТЕХ	142	315	145	402	158	412	134	507	113	410

Премда је и на овој конференцији, као и на већини других научних скупова, ограничено да се исти аутор може појавити са највише три рада, а само на једном раду као први аутор, овог пута само један аутор је потписивао више од три рада за разлику од претходних конференција, када је било знатно више аутора са више од три рада.

Треба додати да су, као и претходних година, на конференцији учествовали и излагали радове некадашњи припадници Војске, који данас раде у високообразовним институцијама и научним и привредним институцијама, како у иностранству, тако и у Србији.

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ВОСЬМАЯ МЕЖДУНАРОДНАЯ НАУЧНАЯ ВОЕННО-ТЕХНИЧЕСКАЯ КОНФЕРЕНЦИЯ OTEX-2018 (ОБЗОР СБОРНИКА СТАТЕЙ)

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РУБРИКИ: 78.25.00 Вооружение и военная техника,
20.01.13 Научные и технические общества, конгрессы, конференции, симпозиумы, семинары, выставки
ВИД СТАТЬИ: обзор
ЯЗЫК СТАТЬИ: сербский

Резюме:

В данной обзорной статье представлена основная информация о результатах, значении, работе международного программного комитета и областях деятельности Восьмой международной военно-технической конференции, посвященной оборонным технологиям, OTEX-2018 (*8th International Scientific Conference on Defensive Technologies OTEH 2018*), а также сравнительный анализ ее проведения с семью предыдущими. Приведены данные

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о тематических областях, количестве работ, числе авторов/соавторов, порядке проведения конференции, в том числе, ее распределении по сессиям. Представлены члены программного комитета. Нужно отметить, что в этом году количество работ предоставленных к публикации, по сравнению с конференциями проведенными ранее, было намного меньше.

Ключевые слова: международная конференция, ОТЕХ, военные технологии, обзор.

8th INTERNATIONAL SCIENTIFIC CONFERENCE ON DEFENSIVE TECHNOLOGIES OTEH-2018 (PROCEEDINGS REVIEW)

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FIELD: Military Technology
ARTICLE TYPE: Review
ARTICLE LANGUAGE: Serbian

Summary:

The article presents the basic information about the overal results, significance, international programme committee and working areas of the 8th International Scientific Conference on Defensive Technologies, OTEH 2018, in comparison with the previous seven conferencies. The number of sections, number of papers, number of authors/coauthors, number of sessions and number of members of the scientific committee are presented in the review. This year's conference has had the smalest number of papers published so far.

Key words: international conference, OTEH, military technology, review.

Датум пријема чланка / Дата получения работы / Paper received on: 07.11.2018.
Датум достављања исправки рукописа / Дата получения исправленной версии работы / Manuscript corrections submitted on: 14.02.2019.
Датум коначног прихватања чланка за објављивање / Дата окончательного согласования работы / Paper accepted for publishing on: 16.02.2019.

Анализа 15 најмодернијих основних борбених тенкова у свету[1]

Интернет сајт Army Recognition представио је 15 најмодернијих основних борбених тенкова који су у производњи или спремни за серијску производњу (подаци датирају од 27. новембра 2018). Ради се о листи која искључује лаке и средње тенкове класе од 25 до 35 тона, осим једног, аргентинског тенка TAM 2IP, који је укључен као представник Јужне Америке. Још неколико лаких и средњих тенкова требало је да се нађе на овој листи, као што је турско-индонежански средњи тенк *Kaplan-Harimau* који је изузет с обзиром на датум објављивања чланка.

Анализа интернет сајта Army Recognition: 15 најмодернијих основних борбених тенкова у свету

[1] Army Recognition 30 November 2018

Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp.469-487

Листу чине следећи тенкови: T-90MS и T-14 *Armata из* Русије, M1A2 SEP V3 за САД., VT4 (MBT-3000) и *Type 99* (ZTZ99) за Кину, *Leclerc XLR* за Француску, *Leoclerc* EMBT за Француску и Немачку, *Leopard 2A7* за Немачку, *Challenger 2 Black Night* за Велику Британију, *Altay* за Турску, *TAM 2IP* за Аргентину, *K2 Black Panther* за Јужну Кореју, *Type 10* за Јапан, *Merkava IV Barak / Merkava IV M* Windbreaker за Израел, и *Karrar* за Иран.

Иако је много земаља одустало од својих основних борбених тенкова и заменило их борбеним возилима точкашима у конфигурацији 6x6 или 8x8 или гусеничарима сличне намене, чини се да потреба за тешким или средњим тенковима и даље постоји. Неке земље преиспитују своје одлуке, и па поново разматрају набавку макар средњих тенкова.

Представићемо основне борбене тенкове, почевши од најмодернијег.

Challenger 2 "Black Night"

Challenger 2 „Black Night" (ВБ) – септембар 2018.

Технолошки демонстратор Challenger 2 „Black Night" представља модернизовану верзију британског тенка Challenger 2, основног борбеног тенка коју је представила компанија „BAE Systems", која учествује у поступку Life Extension Project (LEP). Challenger 2 је стандардни основни борбени тенк који се налази у оперативној употреби британских оружаних снага од 1994. године. Нова верзија овог тенка садржи многа унапређења у куполи и ван ње. Нова опрема у куполи верзије „Black Night" садржи независну панорамску нишанску справу командира компаније „Safran Paseo", пасивну мултиспектралну термалну нишанску справу за нишањију

компаније „Leonardo" и дневно-ноћни осматрачки уређај DNVS 4 за спровођење мисије ловац-убица уз термални осматрачки уређај за нишањџију, командира и возача, што му, поред осталог, омогућава гађање циља у покрету са високим степеном вероватноће погађања мете. Модернизовани тенк опремљен је системом за аутоматско праћење мете.

Тенк *Challenger 2* „*Black Night*" користи исту куполу као и стандардна верзија тенка која се налази на средини шасије. Основно наоружање састоји се од топа компаније BAE Systems L30A1 RO Defence 120 mm са олученом цеви. Топ испаљује стандардну муницију 120 мм, а у тенку је смештено до 50 пројектила. Помоћно наоружање састоји се од спрегнутог митраљеза 7.62 мм и митраљеза на куполи. Са обе стране куполе монтирани су електрични бацачи димних граната. Купола је на електрични погон, а њом управљају командир и нишанџија у кругу од 360 степени и елевацијом до + 20 степени и депресијом цеви до – 10 степени.

Дизајн куполе сличан је куполи стандардне верзије тенка *Challenger 2*. Тенк има посаду од четири члана. Возач се налази у средини трупа, командир седи са десне стране куполе, нишанџија напред и изнад командира, док је пунилац на левој страни. Купола је опремљена другом генерацијом чобхам оклопа ради повећања заштите од кинетичких и хемијских/експлозивних пројектила, а укључује и технологију која умањује радарски одраз. Фронтални оклоп пројектован је тако да штити од свих врста кинетичких пројектила, осим совјетског кинетичког пројектила APFSDS од 115 мм (!), који, према британским проценама, може пробити предњи оклоп на даљинама од 200 м. Интересантан податак о пробојности совјетског пројектила вероватно се односи на пројектиле *3VBM-1*, *U-5TS* или *3UBM-13* који представљају прве совјетске пројектиле типа *APFSDS* са врхом од метала и осиромашеног уранијума. Наиме, током Иранско-ирачког рата, ирачки тенкови Т-62, наоружани топом од 115 мм, успешно су пробијали америчке тенкове М-60, али и британске тенкове типа *Chieftain,* што је навело Британце да одмах почну са развијањем новог оклопног пакета *Stillbrew.*

Бочна страна оклопа заштићена је од кинетичких пројектила до калибра 76 мм на даљинама од 2000 м, 57 мм на даљинама до 2800 м и 45 мм на даљинама од 1000 м. Купола је потпуно заштићена од пројектила ракетног бацача *Carl Gustav*. Поред пасивне заштите, тенк је опремљен и активним системом заштите *Iron Fist* (*APS -Active Protection System*) израелске компаније IMI (Israel Military Industries).

Што се тиче покретљивости, *Challenger 2 „Black Night*" има исту шасију, труп и погонски део као и стандардна верзија.

Ова модернизована верзија је први пут приказана током септембра 2018. године. Уколико тестирање возила буде успешно, *Challenger 2 „Black Night*" могао би се наћи у оперативној употреби у Британским оружаним снагама до 2024. године, док би укупан број модернизованих тенкова износио до 224 у оквиру програма *Challenger 2 LEP Life Extension Project* британског министарства одбране.

Унапређени европски основни борбени тенк (Француска и Немачка) EMBT (European/Enhanced Main Battle Tank) – јун 2018.

EMBT – European/Enhanced Main Battle Tan

Унапређени европски основни борбени тенк, или EMBT, у ствари је технолошки демонстратор. Компанија „Nexter" води га као „унапређени" основни борбени тенк, док га њихов немачки партнер означава као „европски". Његова шасија представља комбинацију шасије немачког тенка *Leopard 2A7* са лаком куполом и француског тенка *Leclerc*. С обзиром на то да је француска купола лакша за 6 тона то потенцијални купци могу искористити за смештај додатне опреме. Тенк је пројектовала компанија „KNDS Group", што је заједнички подухват компанија KMW и „Nexter Defense Systems". Како тенк, у суштини, представља комбинацију немачког и француског тенка неки га у шали називају и *„Leoclerc".* Ипак, ради се само о технолошком демонстратору. Француска и Немачка су се удружиле у пројекту основног копненог борбеног система који би заменио тенкове *Leopard 2* и *Leclerc* 2035. године.

T-72K (Украјина) – 2018.

T-72K (Украјина) – 2018.

Тенк T-72K представља унапређену верзију руског T-72. Опремљен је реактивним оклопном „нож". Модули оклопа разликују се од стандардних модула ERO (експлозивно-реактивног оклопа) тако што су посебно пројектовани за елиминацију или умањење штете на суседним модулима, повећавајући снагу и заштиту оклопа за 200 до 300 процената против вишеструких удара. Модернизовани T-72K опремљен је безбедним дигиталним и сателитским навигационим системима.

Karrar (Иран) – август 2016.

Karrar (ударач) основни је борбени тенк који је у потпуности пројектовала иранска индустрија наоружања. Овај тенк је први пут приказан јавности у августу 2016. године. Током марта 2017. ирански министар одбране отворио је производну линију новог тенка *Karrar*. Војни стручњаци наводе да је овај тенк заснован на совјетском тенку T-72, али са новом куполом. Према наводима пензионисаног генерала Богатирјева, *Karrar* је, у ствари, копија руског тенка T-90MC, најновије модификације тенка T-90, али са неким решењима која се налазе на тенковима *M1 Abrams* и *Challenger 2.* Руски војни експерти претпостављају да *Karrar* ипак не може да се носи са руским тенком T-90.

Karrar (Iran) – август 2016.

Leclerc XLR (Француска) – јун 2016.

Leclerc XLR

Leclerc Scorpion или XLR представља модернизовану верзију француског тенка *Leclerc* који је пројектовала и произвела француска компанија „Nexter Systems". Модернизовани *Leclerc* имаће већу ватрену моћ и већу заштиту. Током марта 2015. године, француска војна агенција за набавку обавестила је компанију „Nexter Systems" о уговору за модернизацију тенка *Leclerc.* Ова наруџбина представља трећу операцију француског министарства одбране у оквиру програма *Scorpion* који је намењен модернизацији француских оружаних снага. Уговор у вредности од 330 милиона евра обезбеђује набавку 200 унапређених тенкова *Leclerc* и 18 модернизованих оклопних возила за извлачење на бази поменутог тенка. Циљ овог програма је одржавање тенка *Leclerc* у оперативној употреби у служби француских оружаних снага до 2040. године. Прва два прототипа биће комплетирана током 2018. године, док се за осталих 198 возила завршетак модернизације предвиђа за период од 2020. до 2028. године.

Модернизована верзија тенка *Leclerc XLR* задржаће исто наоружање као и на стандардној верзији: топ 120 мм дужине 52 калибара са глатком цеви са термалним омотачем и системом компримованог ваздуха за избацивање реактивних гасова. Купола је опремљена аутоматским пуњачем који се пуни са 22 пројектила. Нова верзија тенка моћи ће да користи два основна типа граната 120 мм, кинетичке пројектиле *APFSDS* брзине од 1790 м/с и високоексплозивне противтенковске гранате *HEAT* брзине од 1100 м/с, с тим што ће обе гранате имати полусагорљиву чауру са чврстим експлозивним пуњењем. Компанија „Nexter" такође је развила нови тип високоексплозивне гранате НЕ, ознаке НЕ М3М, која се може подесити за ефекат ваздушног распрскавања. Митраљез 12.7 мм је спрегнут са топом, док је на куполи монтирана даљински управљана станица са митраљезом 7.62 мм.

Нови тенк *Leclerc XLR* модернизован је новим оклопним пакетом на шасији и на куполи. Предњи део куполе је заштићен дебелим пасивним оклопом, док је задњи крај опремљен решеткастим оклопом ради заштите погонског дела против дејства ручних ракетних бацача. Задњи крај шасије такође је заштићен решеткастим оклопом. Бочне стране куполе заштићене су додатним активним и решеткастим оклопом. Тенк ће имати масу до 57 000 кг, дужину до 9,87м, ширину до 3,71 м и висину до 2,53 м.

Погонска група неће се мењати, тако да остаје дизел мотор *SACM V8X-1500 Hyperbar* са снагом до 1118 kW и аутоматским мењачем *SESM ESM 500* са пет брзина за вожњу напред и две брзине за вожњу уназад. Максимална брзина на путу износи 72 км/ч, ван пута до 50 км/ч, док је максимални радијус крстарећом брзином до 615 км.

Тенк *Leclerc Scorpion / XLR* биће опремљен електронским уређајима отворене архитектуре, новим тактичким радио-системом, системом заштите против АБХ дејства, опремом за ноћно осматрање и командним и информационим системом. Модернизовани *Leclerc* биће опремљен ометачем против импровизованих експлозивних направа *Barage*,

дијагностичким уређајем са инерцијалном и GPS навигацијом, новим компјутерским интерфејсом за командира и нишанџију и редизајнираним главним компјутерима. Нови систем за упозоравање од ласерског озрачивања *GALIX* имаће улогу маскирања возила од ласерског означавања и термалних камера. Оног тренутка када четири инсталирана детектора открију ласерску претњу у виду ласерског означавања, 24 лансера димних граната избацују своја вишеталасна димна пуњења у кругу од 360 степени око возила. Као и претходна верзија тенка, *Leclerc Scorpion / XLR* има систем за управљање ватром који укључује модуларну термалну осматрачку камеру, ласерски даљиномер *Thales Optronics (Taunton)* HL-58 и жиростабилизоване нишанске справе за командира и нишанџију. Поред тога, командиру је на располагању и жиростабилизована панорамска нишанско-осматрачка справа *SAGEM HL 60* којом може уочити мету на даљини до 4000 м и извршити идентификацију до 2500 м.

ТАМ 2IP(Аргентина) – 2015.

TAM 2IP

Средњи аргентински тенк *Tanque Argentino Mediano* (TAM) налази се у наоружању аргентинских оружаних снага. С обзиром на недостатак искуства, аргентинско министарство одбране поверило је пројектовање

тенка немачкој компанији „Thyssen-Henschel”. Возило су заједно развили немачки и аргентински инжењери на основу немачког борбеног возила пешадије *Marder*. Развој тенка *TAM 2IP* извршила је израелска војна индустрија и компанија „Elbit Systems”. Овај тенк, у суштини, представља модернизовану верзију тенка *TAM* са додатним оклопом, новим системом за контролу ватре и новим осматрачким уређајима. Балистички профил оклопа „applique” знатно је ефикаснији и додатно штити куполу са свих страна, као и предњи и бочне делове шасије. Године 2015. уговорена је испорука 74 лака тенка типа TAM 2IP за аргентинску војску.

M1A2 SEP V3 и V4 или M1A2C/D (САД) – октобар 2015.

M1A2 Abrams SEP V3

M1A2 Abrams SEP V3 је модернизована верзија основног борбеног тенка *M1A2 SEPV V2* која је опремљена низом унапређења у областима преживљавања, одржавања, ефикасности и мрежних могућности. Верзија тенка *M1A2 Abrams SEP V3* први пут је представљена октобра 2015. године, када је произведено девет прототипова, од којих је седам предвиђено за тестирање.

Главно наоружање тенка *M1A2 SEP V3* представља топ глатке цеви 120 мм M256. Поред њега тенк ће имати нископрофилни даљински управљани оружни систем *Low Profile (LP) CROW* који се састоји од модернизоване дневне осматрачке камере која користи технологију слике у слици ради комбиновања видних поља и нуди и за 340 процената већу слику од постојећих система осматрања. Секундарно наоружање

представља коаксијални митраљез 7.62 мм M240 са десне стране топа и митраљез истог калибра који је монтиран на левој страни куполе и чије је постоље додатно оклопљено. Са обе стране куполе налазе се бацачи димних граната. Тенк *M1A2 SEP V3* ће користити муницију M829E4, пету генерацију кинетичких противтенковских пенетратора. Нова граната употребљава пенетратор од осиромашеног уранијума који је намењен за уништавање мета заштићених напредним експлозивно-реактивним оклопом и активним системима заштите. Други пројектил је *AMP* – напредни вишенаменски пројектил са три начина рада: детонацијом по контакту, одгођеном детонацијом или ваздушним распрскавањем. Систем ваздушног распрскавања може бити ефикасан и у урбаној борби против противтенковских тимова наоружаних противтенковским вођеним ракетама. Детонације по контакту и детонације са одгођеним дејством могу се примењивати у борбама против бункера, зграда или препрека.

Дизајн тенка остао је исти, али је оклопни пакет унутар куполе и шасије нов ради постизања боље заштите против импровизованих експлозивних направа.

Ради боље мобилности тенк *M1A2 SEP V3* је опремљен гасном турбином *Honeywell AGT1500,* али са смањеном потрошњом горива захваљујући новом помоћном генератору који омогућава покретање куполе без покретања главне гасне турбине.

Тенк је опремљен и новим електронским системом за неутрализацију импровизованих експлозивних направа. Такође, има и нови систем *IFLIR*, унапређен инфрацрвеним системом за идентификацију мета. Овај систем користи инфрацрвену технологију на бази дугих и средњих таласа која је уграђена у примарну осматрачку справу нишанџије и у независну термалну справу командира са дисплејима високе резолуције која знатно поправља време откривања, идентификације и напада на мету у односу на постојеће системе друге генерације.

T-14 Armata (Русија) – мај 2015.

Тенк *T-14 Armata* пројектовала је руска одбрамбена компанија „Uralvagonzavod*”.* Развој тенка покренут је 2013, а први прототип испоручен је 2015. године. Први извештаји су претпостављали да ће нова *Armata* бити заснована на руском основном борбеном тенку T-95 који је под називом T-95 *Object 195* први пут приказан 1999. године.

Тенк *T-14 Armata* опремљен је беспосадном даљински управљаном куполом, што има за циљ развој потпуно роботизованог тенка. Овај тенк је први пут приказан током војне параде у Москви поводом Дана победе 9. маја 2015. године. Према наводима руског министарства одбране, прва тестирања тенка обављена су 2014. године. Првобитно се очекивала производња до 2300 возила, али се за сада изгледа одустало од тог плана. Први тенковски пук Таманске дивизије биће прва војна јединица која ће добити нове тенкова, што би требало да се догоди након 2020. године, када тенк прође сва обавезна тестирања.

T-14 Armata

Type 99A (ZTZ99A)

Type 99A (ZTZ99A)

Кинески тенк ZTZ99A, који носи ознаку и Type 99A, производи компанија „China Northern Industries Group Corporation". Ради се о најмодернијем основном борбеном тенку кинеске војске. Ушао је наоружање Народноослободилачке армије пред крај 2001. године као наследник тенка ZTZ99. Знатно је унапређен у погледу ватрене моћи, мобилности и заштите у односу на старије кинеске тенкове који су били углавном копије руских тенкова. *ZTZ99* је произведен 1999. године у малом броју примерака (мање од 200) због високе цене од скоро 2 милиона америчких долара. *Type 99A (99A2* или *ZTZ-99A)* представља унапређену верзију тенка *Type 99.* Први прототип овог тенка тестиран је 2007. године, а први пут је приказан септембра 2015. на војној паради у Пекингу. Ради се о трећој генерацији основног борбеног тенка.

Altay (Турска) – новембар 2012.

Altay (Турска)

Altay спада у трећу генерацију основних борбених тенкова која је развијена за турску војску. Прве прототипове новог турског тенка *Altay* пројектовала је и произвела компанија „Otokar", највећа приватна турска компанија која послује под министарством одбране, током новембра 2012 године. Турска компанија „Aselsan" била је задужена за дизајн и производњу електронских подсистема као што су систем за управљање ватром и C3I систем. Током априла 2018. године објављено је да је турска компанија BMC, произвођач оклопних и тактичких возила точкаша, добила

уговор за наставак развоја и производње домаћег основног борбеног тенка. Уговор предвиђа производњу 250 тенкова која би се могла постепено проширити укупно 1000 тенкова. Многе турске компаније укључене су у производњу тенка *Altay,* укључујући компаније као што *су* „Roketsan", „Aselsan", „Havelsan" и „Machinery and Chemical Industry Institute" (MKEK). Према расположивим подацима, тенк *Altay* биће произведен у три конфигурације са истим наоружањем. Прва серија од 40 возила, под ознаком T1, биће опремљена активним системом заштите и додатним оклопом, друга серија од 210 јединица представљаће верзију T2 која ће подразумевати многа унапређења, као што су: нови оклоп, одвојена и изолована просторија за муницију, могућност гађања муницијом са ласерским навођењем и посебним камуфлажним системом. Верзија T3 биће опремљена беспосадном куполом и аутоматским пуњачем.

VT4 / MBT-3000 (Кина) – јун 2012.

VT4 / MBT-3000

Основни борбени тенк *VT4,* или експортна верзија под називом *MBT-3000,* представља нову генерацију основних борбених тенкова коју је пројектовала и произвела кинеска компанија NORINCO. Ради се о најновијој технологији која треба да испрати изазове високо- технолошког рата. Овај тенк је први пут приказан током јуна 2012. године. Његова цена је за три милиона долара нижа од цене америчког ривала, али је опремљен аутоматским пуњачем. Током јануара 2018. године краљевска војска Тајланда спровела је тестирања тенка *VT4*, а затим купила 28 ових возила са могућношћу да набави још десет.

T-90MS (Русија) – септембар 2011.

T-90MS

Тенк *T-90MS* представља следећи корак у развоју руских основних борбених тенкова типа *T-90*. Први пут је приказан током септембра 2011. године, а ради се о потпуној модернизацији тенка *T-90* која је спроведена ради повећања оперативних способности на модерном бојишту. Маса нове верзије повећана је за 1500 кг у односу на основни модел, па је достигла 48 тона, што је и даље знатно мање у односу на немачке и америчке тенкове.

Leopard 2A7 (Немачка) – јун 2010.

Leopard 2A7 први пут је приказан јавности током 2010. године, а произвела га је немачка компанија „Krauss-Maffei Wegmann". Овај тенк опремљен је додатним композитним оклопом који представља најновију генерацију пасивног оклопа која омогућује већу заштиту у односу на различите типове противтенковске муниције. По неким наводима ради се о новим нанокерамичким материјалима и модерним легурама од челика и титанијума. Овај тенк опремљен је топом компаније„Rheinmetall"од 120 мм. То је исти топ који се користи на верзији тенка *Leopard 2A6,* али се разликује од основне верзије по већој прецизности и дужем домету. Модернизација првих 50 тенкова *Leopard 2* у нову верзију *Leopard 2A7* почела је током 2012. године. Нова верзија има модуларни оклоп, повећану покретљивост и прецизније наоружање.

Leopard 2A7

K2 Black Panther (Јужна Кореја) – октобар 2009.

K2 Black Panther

Тенк K2 Black Panther представља нову генерацију основног борбеног тенка који је пројектовала и произвела јужнокорејска компанија „Hyundai Rotem". Овај тенк први пут је приказан у Сеулу током октобра 2009. године, а предвиђено је да ће заменити старе америчке тенкове *M48 Patton*. Током 2014. године влада Јужне Кореје потписала је уговор са компанијом „Hyundai Rotem" о испоруци 100 тенкова типа K2 за потребе армије Јужне Кореје. Током децембра 2015. године потписан је нови уговор о испоруци додатног броја тенкова овог типа, али без навођења прецизних цифара. Армија Јужне Кореје има потребе за око 600 тенкова типа K2, који би заједно са тенковима типа K1 чинили језгро оклопних снага ове државе.

Главно наоружање овог тенка је топ немачке компаније „Rheinmetall" од 120 мм, али са аутоматским пуњачем који може пунити топ и док је возило у покрету. Овај топ има брзину паљбе до 10 граната у минути. Коаксијални митраљез 7.62 мм постављен је са леве стране топа, а тешки митраљез 12.7 мм на горњој десној страни куполе.

Оклоп на тенку K2 састоји се од композитног оклопа непознатог типа и активног система заштите који користи експлозивно-реактивне плоче. Систем заштите састоји се од радара који ради у милиметарском таласном режиму. На основу података са радара, тенковски компјутер може извршити триангулацију надолазећих пројектила, упозорити посаду и испалити димне гранате за прикривање оптичке, инфрацрвене и радарске слике. Исти радар користиће се и за испаљивање експлозивних блокова на надолазеће пројектиле. Милиметарски радар спрегнут са системом за управљање ватром има још једну интересантну функцију: с обзиром на хидропнеуматски систем амортизације тенка, тенковски топ може бити подигнут под углом сличним углу минобацача и испаљивати програмиране експлозивне гранате на циљеве уочене поменутим радаром до даљине 8 километара.

Тенк K2 је претходно био опремљен немачким дизел агрегатом MT 833, док нове верзије имају исти мотор који се сада производи под лиценцом у Јужној Кореји и који је упарен са аутоматским мењачем компаније „Renk".

Посебну одлику овог тенка представља јединствени систем амортизације под називом *In-arm Suspension Unit (ISU),* што омогућава да се тенк употребом погонског система искоси под високим угловима надоле и нагоре и гађа високо и ниско постављене циљеве. Захваљујући овом систему тенк може да „чучне", „седне" или да се „нагне", тако да топ може да гађа са елевацијом или депресијом до + –10 степени.

Merkava IV Barak – 2004, и Merkava IV M Windbreaker (Израел) – 2009.

Merkava IV Barak

Merkava IV Barak представља најновију верзију тенкова из породице *Merkava* који се налазе у производњи од 2004. године. За овај тенк се каже да је први који има напредни систем вештачке интелигенције и систем сензора који преузима већину послова надгледања подсистема. То је први модерни тенк који нема отвор на куполи за пуниоца због опасности од пробијања крова куполе од противтенковских вођених пројектила. Овај тенк поседује израелски систем TSAWS (Tracks, Springs, and Wheels System) гусеница који је предвиђен за употребу по базалтним стенама Либана и Голанске висоравни. Тенк *Merkava IV* има нови систем за управљање ватром *El-Op Knight Mark 4* који захвата и закључава покретне мете, па чак и хеликоптере док је тенк у покрету. Овај систем укључује стабилизацију у две равни, другу генерацију телевизијског осматрачког система и аутоматског термалног трагача, ласерски даљиномер, унапређени термални ноћни систем и динамички индикатор углова. Ласерски систем упозоравања *Amcoram LWS-2* упозорава посаду на претње од ласерски вођених противтенковских ракета након чега је могуће испаљивање димних граната. Тенк је, такође, опремљен и системом за упозоравање од електромагнетског зрачења, односно радарског осветљавања. Тенк је опремљен централизованим системом *Elbit Systems BMS* (Battle Management System) који добија податке од других возила и беспилотних летелица које се налазе у близини и приказује податке на дисплејима у

боји, а може их даље прослеђивати другим возилима и јединицама опремљеним истим системом BMS.

Merkava IV M Windbreaker

Merkava IV M Windbreaker

Merkava IV M Windbreaker је тенк типа *Merkava Mark IV* опремљен активним системом заштите *Trophy*. Серијска производња ових тенкова започела је 2009. Године, а прва бригада опремљена овим тенковима формирана је 2011. године. Ови тенкови су успешно тестирани 2014. године приликом сукоба са организацијом *Hamas*. По наводима Израелаца, ниједан тенк опремљен системом активне заштите није погођен нити оштећен ракетним ручним бацачима нити противтенковским ракетама типа 9M133 Kornet за време операције „Protective Edge" која је спроведена 2014. године. Систем упозорава тенковску посаду и о локацији са које су ракета или пројектил испаљени. Систем активне заштите такође шаље координате места испаљивања ракета и другим јединицама у окружењу преко система за управљање бојиштем *Tzayad.*

Type 10 (Јапан) – фебруар 2006.

Type 10

Јапански тенк *Type 10* је напредна верзија четврте генерације основних борбених тенкова који је произвела јапанска компанија „Mitsubishi Heavy Industries" за потребе јапанских копнених одбрамбених снага. Развој овог тенка започет је 2002. године ради замене старог тенка *Type 74* који се налази у употреби у јапанским одбрамбеним снагама од 1991. године. Прототип овог тенка завршен је 2006. године, а његов развој 2009. године. Производња је започела 2010. године, када је испоручено и првих 13 возила.

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ПОЗИВ И УПУТСТВО АУТОРИМА
ПРИГЛАШЕНИЕ И ИНСТРУКЦИЯ 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, DOI: 10.5937/VojnotehnickiGlasnik; https://doi.org/10.5937/VojnotehnickiGlasnik), 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, те остала теоријска и практична достигнућа која доприносе усавршавању свих припадника српске, регионалне и међународне академске заједнице, а посебно 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 2018. годину:

за област технолошки развој:

– на листи часописа за материјале и хемијске технологије:

категорија водећи научни часопис националног значаја **(М51)**,

– на листи часописа за машинство:

категорија научни часопис националног значаја **(М52)**,

– на листи часописа за електронику, телекомуникације и информационе технологије:

категорија научни часопис **(М53)**,

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику:

категорија научни часопис **(М53)**.

Усвојене листе домаћих часописа за 2018. годину могу се видети на сајту Војнотехничког гласника, страница *Категоризација часописа* (Министарство просвете, науке и технолошког развоја Републике Србије још увек није објавило званичну категоризацију научних часописа за 2019. годину).

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), 1,5 бод (категорија М52) и 1 бод (категорија М53).

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 (Clarivate Analytics) цитатним индексима. Детаљи о индексирању могу се видети на сајту Војнотехничког гласника, страница *Индексирање часописа*.

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Радови се предају путем онлајн система за електронско уређивање АСИСТЕНТ, 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 *АСИСТЕНТ* 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 – АСИСТЕНТ*.

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, руском и енглеском 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 резимеа са кључним речима на енглеском и руском 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 и руски 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 хијерархији 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 поред имена и презимена аутора.

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 *Војнотехничком гласнику* класификују се на научне и стручне чланке.

Научни чланак је:

– оригиналан научни рад (рад у којем се износе претходно необјављени резултати сопствених истраживања научним методом);

– 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);

– кратко или претходно саопштење (оригинални научни рад пуног формата, али мањег обима или прелиминарног карактера);

– 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 чланак је:

– стручни рад (прилог у којем се нуде искуства корисна за унапређење професионалне праксе, али која нису нужно заснована на научном методу);

– информативни прилог (уводник, коментар и сл.);

– приказ (књиге, рачунарског програма, случаја, научног догађаја, и сл.).

Језик рада

Језик рада може бити српски, руски или енглески.

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 уредништва 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 или руском језику, пожељно је да се, поред сажетка на српском и руском, 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 АСИСТЕНТ 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.

За слике и графиконе не сме се користити снимак са екрана рачунара програма за прикупљање података. У самом тексту чланка препоручује се употреба слика и графикона непосредно из програма за анализу података (као што су Excel, Matlab, Origin, SigmaPlot и други).

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 АСИСТЕНТ 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 АСИСТЕНТ у сврху контроле правилног исписа листе референци користи специјалну алатку RefFormatter: контрола обликовања референци у складу са Харвардским приручником за стил.

Пропратно писмо (само за ауторе из Републике Србије и по посебном захтеву уредника)

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.

Сви радови подлежу стручној рецензији.

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. Применение этого Акта способствует повышению качества отечественных журналов и их более полному вовлечению 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 стандартам Республики Сербия.

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, DOI: 10.5937/VojnotehnickiGlasnik; https://doi.org/10.5937/VojnotehnickiGlasnik, является мультидисциплинарным научным журналом Министерства обороны Республики Сербия, который публикует научные и профессиональные статьи, а также техническую информацию о современных системах вооружения и современных военных технологиях. Журнал следит за единой межвидовой технической поддержкой вооруженных сил, основанной на принципах системной логистики, за прикладными и инновационными научными исследованиями, в том числе, в области производства вооружения и военной техники, и за прочими теоретическими и практическими достижениями, которые способствуют профессиональному росту представителей сербского, регионального и международного академического сообщества, и особенно военнослужащих Министерства Обороны и Вооружённых сил Республики Сербия.

Министерство образования, науки и технологического развития Республики Сербия, согласно решению принятому в соотвествии со ст. 27 абзац 1, пункт 4 и на основании толкования ст. 25 абзац 1 пункт 5 Закона о научно-исследовательской деятельности («Службени гласник РС», № 110/05, утвердило категоризацию «Военно-технического вестника» за 2018 год:

Категории в области технологического развития:

– Область материалов и химической технологии:

ведущий научный журнал национального значения **(M51)**,

– Область механики:

научный журнал национального значения **(M52)**,

– Область электроники, телекоммуникаций и информационных технологий:

научный журнал **(M53).**

Категории в области основных исследований:

– Область математика, компьютерные науки, технические науки:

научный журнал **(M53)**.

С информацией относительно категоризации за 2018 год можно ознакомиться на странице сайта «Военно-технического вестника» *Категоризация Вестника* (Министерством просвещения, науки и технологического развития Республики Сербия пока не произведено официального ранжирования научных журналов за 2019 год).

Более подробную информацию можно найти на сайте Министерства образования, науки и технологического развития Республики Сербия.

С информацией о категоризации можно ознакомиться и на сайте КОБСОН (Консорциум библиотек Республики Сербия по вопросам объединения закупок).

Категоризация Вестника проведена согласно Положению о порядке и способе категоризации научно-исследовательских результатов, утверждённого Национальным комитетом по науке и технологиям (Службени гласник РС, № 38/2008).

В соответствии с вышеуказанным Положением и таблицей с показателями классификации и категоризации индивидуальных научно-исследовательских результатов, являющейся неотъемлемой частью Положения, научная статья, опубликованная в «Военно-техническом вестнике», оценивается следующим способом: 2 балла (категория М51), 1,5 балла (категория М52) и 1,5 балл (категория М53).

Журнал соответствует стандартам Сербского индекса научного цитирования (СЦИндекс/SCIndeks) – наукометрической базы данных научных журналов Республики Сербия, а также Российского индекса научного цитирования (РИНЦ). Журнал постоянно подвергается мониторингу и оценивается количественными наукометрическими показателями, отражающими его научную ценность, в т.ч. опосредованно в международных индексах цитирования (Clarivate Analytics).

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, утверждёнными Creative Commons (CC BY). С инструкцией об авторских правах можно ознакомиться на странице *Авторские права и политика самоархивирования*, перейдя по ссылке http://www.vtg.mod.gov.rs/index-ru.html.

Рукописи статей направляются в редакцию журнала с использованием online системы е-Ур: Электронное издательство – ASSISTANT, запущенной Центром поддержи развития образования и науки (ЦПРОН).

Регистрация в системе и оформление прав доступа выполняется по адресу http://www.vtg.mod.gov.rs/index-ru.html, через страницу *ASSISTANT* или *СЦИНДЕКС* (aseestant.ceon.rs/index.php/vtg).

С инструкцией по регистрации и правам доступа можно ознакомиться по адресу http://www.vtg.mod.gov.rs/index-ru.html, на странице *Инструкция по е-Ур: Электронное издательство ASSISTANT*.

Все авторы, предоставляющие свои рукописи для публикации в редакцию журнала «Военно-технический вестник» должны пройти предварительную регистрацию в реестре ORCID (Open Researcher and Contributor ID). Эта процедура осуществляется в соответствии с инструкцией, размещенной на странице сайта *Регистрация в реестре ORCID для присвоения идентификационного кода*.

«Военно-технический вестник» публикует статьи на сербском, русском или английском 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 аннотацию с ключевыми словами, введение, основную часть, выводы, список использованной литературы и резюме с ключевыми словами на английском языке (без нумерации заголовков и

подзаголовков). Объём статьи не должен превышать один авторский лист (16 страниц формата А4 с пробелом Single).

Статья должна быть набрана на компьютере с использованием специально подготовленного редакцией макета, который можно скачать на странице сайта *Правила и образец составления статьи*.

Заголовок

Заголовок должен отражать тему статьи. В интересах журнала и автора необходимо использовать слова и словосочетания, удобные для индексации и поиска. Если такие слова не содержатся в заголовке, то желательно их добавить в подзаголовок. Заголовок должен быть переведён на английский язык. Название заголовка (подзаголовка) пишется перед аннотацией на соответствующем языке.

Текущий заголовок

Текущий заголовок пишется в титуле каждой страницы статьи с целью упрощения процесса идентификации, в первую очередь копий статьей в электронном виде. Заголовок содержит в себе фамилию и инициал имени автора (в случае если авторов несколько, остальные обозначаются с «et al.» или «и др.»), название работы и журнала (год, том, выпуск, начальная и заключительная страница). Заголовок статьи и название журнала могут быть приведены в сокращенном виде.

ФИО автора

Приводятся полная фамилия и полное имя (всех) авторов. Желательно, чтобы были указаны инициалы отчеств авторов. Фамилия и имя авторов из Республики Сербия всегда пишутся в оригинальном виде (с сербскими диакритическими знаками), независимо от языка, на котором написана работа.

Наименование учреждения автора (аффилиация)

Приводится полное (официальное) наименование и местонахождение учреждения, в котором работает автор, а также наименование учреждения, в котором автор провёл исследование. В случае организаций со сложной структурой приводится их иерархическая соподчинённость (напр. Военная академия, кафедра военных электронных систем, г. Белград). По крайней мере, одна из организаций в иерархии должна иметь статус юридического лица. В случае если указано несколько авторов, и если некоторые из них работают в одном учреждении, нужно отдельными обозначениями или каким-либо другим способом указать в каком из приведённых учреждений работает каждый из авторов. Аффилиация пишется непосредственно после ФИО автора. Должность и специальность по диплому не указываются.

Контактные данные

Электронный адрес автора указываются рядом с его именем 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 журнале распределяются по следующим категориям:

Научные статьи:

– оригинальная научная статья (работа, в которой приводятся ранее неопубликованные результаты собственных исследований, полученных научным методом);

– обзорная статья (работа, содержащая оригинальный, детальный и критический обзор исследуемой проблемы или области, в который автор внёс определённый вклад, видимый на основе автоцитат);

– краткое сообщение (оригинальная научная работа полного формата, но меньшего объёма или имеющая предварительный характер);

– научная критическая статья (дискуссия-полемика на определённую научную тему, основанная исключительно на научной аргументации) и научный комментарий.

Однако, в некоторых областях знаний научная работа в журнале может иметь форму монографического исследования, а также критического обсуждения научного материала (историко-архивного, лексикографического, библиографического, обзора данных и т.п.) – до сих 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 номера.

Профессиональные статьи:

– профессиональная работа (приложения, в которых предлагаются опыты, полезные для совершенствования профессиональной практики, но которые не должны в обязательном порядке быть обоснованы на научном методе);

– информативное приложение (передовая статья, комментарий и т.п.);

– обзор (книги, компьютерной программы, случая, научного события и т.п.).

Язык работы

Работа может быть написана на сербском, русском или английском языке.

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, проставляемыми с правой стороны в круглых скобках.

Аннотация (абстракт) и резюме

Аннотация (абстракт) является кратким информативным обзором содержания статьи, обеспечивающим читателю быстроту и точность оценки её релевантности. В интересах редакции и авторов, чтобы аннотация содержала термины, часто используемые для индексирования и поиска статьей. Составными частями аннотации являются цель исследования, методы и заключение. В аннотации должно быть от 100 до 250 слов, и она должна находится между титулами (заголовок, ФИО авторов и др.) и ключевыми словами, за которыми следует текст статьи. Если работа написана на сербском или русском языке, желательно, чтобы кроме аннотации на сербском и русском, была бы предоставлена и аннотация в расширенном виде на английском языке – в качестве т.н. резюме (summary). Такое резюме должно 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 аннотация из начала статьи). Началом данного резюме может быть переведенная аннотация (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 оно было пропорционально их размеру и в то же время отражала суть.

Ключевые слова

Ключевыми словами являются термины или фразы, адекватно представляющие содержание статьи, необходимые для индексирования и поиска. Ключевые слова необходимо выбирать, опираясь при этом на какой-либо международный источник (регистр, словарь, тезаурус), наиболее используемый внутри данной научной области. Число ключевых слов не может превышать 10. В интересах редакции и авторов, чтобы частота их встречи в статье была как можно большей. Ключевые слова даются на языке, на котором написана статья (аннотация), и на английском языке. В статье они пишутся непосредственно после аннотации (в начале) и после резюме (в конце).

Программа ASSISTANT предоставляет возможность использования сервиса KWASS, автоматически фиксирующего ключевые слова из источников/словарей по выбору автора/редактора.

Дата получения статьи

Дата, когда редакция получила статью; дата, когда редакция окончательно приняла статью к публикации; а также дата, когда были предоставлены необходимые исправления рукописи, приводятся в хронологическом порядке, как правило, в конце статьи.

Выражение благодарности

Наименование и номер проекта, т.е. название программы благодаря которой статья возникла, совместно с наименованием учреждения, которое финансировало проект или программу, приводятся в отдельном примечании, как правило, внизу первой страницы статьи.

Предыдущие версии работы

В случае если статья в предыдущей версии была изложена устно (под одинаковым или похожим названием, например, в виде доклада на научной конференции), сведения об этом должны быть указаны в отдельном примечании, как правило, внизу первой страницы статьи. Работа, которая уже была опубликована в каком-либо из журналов, не может быть напечатана в «Военно-техническом вестнике» ни под похожим названием, ни в изменённом виде.

Нумерация и название таблиц и графиков

Желательно, чтобы нумерация и название таблиц и графиков были исполнены на двух языках (на языке оригинала и на английском). Таблицы подписываются таким же способом как и текст и обозначаются порядковым номером с верхней стороны. Фотографии и рисунки должны быть понятны, наглядны и удобны для репродукции. Рисунки необходимо делать в программах Word или Corel. Фотографии и рисунки надо поставить на желаемое место в тексте. Для создания изображений и графиков использование функции снимка с экрана (скриншота) не допускается. В самом тексте статьи рекомендуется применение изображений и графиков, обработанных такими компьютерными программами, как: Excel, Matlab, Origin, SigmaPlot и др.

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 применяет Гарвардскую систему (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: (Petrović, 2010, pp.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 ASSISTANT предоставляет при цитировании возможность использования сервиса CiteMatcher, фиксирующего пропущенные цитаты в работе и в списке литературы.

Примечания (сноски)

Примечания (сноски) к тексту указываются внизу страницы, к которой они относятся. Примечания могут содержать менее важные детали, дополнительные объяснения, указания об использованных источниках (напр. научном материале, справочниках), но не могут быть заменой процедуры цитирования литературы.

Литература (референции)

Цитированной литературой охватываются, как правило, такие библиографические источники как статьи, монографии и т.п. Вся используемая литература в виде референций размещается в отдельном разделе статьи.

Названия литературных источников не переводятся на язык работы.

«Военно-технический вестник» для оформления списка использованной литературы применяет Гарвардскую систему (Harvard Style Manual). В списке литературы источники указываются в алфавитном порядке фамилий 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.

При оформлении списка литературы программа ASSISTANT предоставляет возможность использования сервиса RefFormatter, осуществляющего 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.

Все рукописи статей подлежат профессиональному рецензированию.

Список рецензентов журнала «Военно-технический вестник» размещён на странице сайта *Список рецензентов*. Процесс рецензирования описан в разделе *Правила рецензирования*.

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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, DOI: 10.5937/VojnotehnickiGlasnik; https://doi.org/10.5937/VojnotehnickiGlasnik) 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 on modern weapon systems and military technologies. The journal covers inter-service technical support to the Army on the principle of logistic system support; fundamental, applied and development research; production and use of weapons and military equipment as well as other theoretical and practical achievements leading to professional development of all members of Serbian, regional and international academic communities, members of the Ministry of Defence and the Army of Serbia in particular.

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 2017

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 mechanical engineering,
category: scientific periodical of national interest **(M52)**,
– on the list of periodicals for electronics, telecommunications and IT,
category: scientific periodical **(M53)**,
in the field fundamental research:
– on the list of periodicals for mathematics, computer sciences and mechanics,
category: scientific periodical **(M53)**.

The approved lists of national periodicals for the year 2018 can be viewed on the website of the Military Technical Courier, page *Journal categorization* (The Ministry of Education, Science and Technological Development of the Republic of Serbia has not yet published the official evaluation of scientific journals for 2019).

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), 1,5 (one and a half) point (category M52) and 1 (one) point (category M53).

The journal is in the Serbian Citation Index – SCIndex (data base of national scientific journals), in the Russian Index of Science Citation/Российский индекс научного цитирования (RINC/РИНЦ) and is constantly monitored depending on the impact within the bases themselves and indirectly in the international (e.g. Clarivate Analytics) citation indexes. More detailed information can be viewed on the website of the Military Technical Courier, page *Journal indexing*.

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Manuscripts are submitted online, through the electronic editing system ASSISTANT, 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 *ASSISTANT* 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 - ASSISTANT*.

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, Russian or English, 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:

– Original scientific papers (giving the previously unpublished results of the author’s own research based on scientific methods);

– Review papers (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution demonstrated by self-citation);

– Short communications or Preliminary communications (original scientific full papers but shorter or of a preliminary character);

– Scientific commentaries or discussions (discussions on a particular scientific topic, based exclusively on scientific argumentation) and opinion pieces.

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:

– Professional papers (contributions offering experience useful for improvement of professional practice but not necessarily based on scientific methods);

– Informative contributions (editorial, commentary, etc.);

– Reviews (of a book, software, case study, scientific event, etc.)

Language

The article can be in Serbian, Russian or English.

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 and Russian, articles in Serbian and Russian 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 or Russian 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 ASSISTANT 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.

For figures and graphs, proper data plot is recommended i.e. using a data analysis program such as Excel, Matlab, Origin, SigmaPlot, etc. It is not recommended to use a screen capture of a data acquisition program as a figure or a graph.

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 ASSISTANT system uses a special tool CiteMatcher 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.

All articles are peer reviewed.

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
СООБЩЕНИЯ ДЛЯ АВТОРОВ И ЧИТАТЕЛЕЙ
INFORMATION FOR CONTRIBUTORS AND READERS

Ради доделе награде „Рецензент године” и признања „Истакнути рецензент“ ЦЕОН и СЦИндекс тим оцењују рецензенте

ЦЕОН, СЦИндекс тим и редакција *Војнотехничког гласника* започели су оцењивање рецензената ради доделе награде „Рецензент године” и признања „Истакнути рецензент“. Оцењују се само рецензенти радова који се уређују онлајн, посредством система за електронско уређивање АСИСТЕНТ у поступку који *Војнотехнички гласник* у потпуности и доследно спроводи. Сви рецензенти *Војнотехничког гласника* испуњавају овај неопходан услов.

Правилник о награђивању доступан је на сајту ЦЕОН-а (https://www.ceon.rs/images/pdf/RR_pravilnik_sr.pdf), а опште упутство о оцењивању у Уредничком сервису часописа. Награда „Рецензент године” састоји се од повеље и новчане награде. Новчана награда исплаћује се у облику ваучера за покривање трошкова за учешће на научној конференцији по избору награђеног, у максималном износу од 1.500 евра.

ЦЕОН и СЦИндекс тим позивају уредништа чији се часописи не уређују посредством СЦИндекс Асистента да уложе додатни напор у подстицању квалитета рецензирања, стандардизацијом рецензентских образаца, допунском едукацијом рецензената и њиховом селекцијом, праћењем и вредновањем.

Команды ЦЕОН и СЦИндекс начали проводить оценку работы рецензентов, с целью присуждения награды “Рецензент года” и премии “Выдающийся рецензент“

Команды ЦЕОН и СЦИндекс начали проводить оценку работы рецензентов, с целью присуждения награды “Рецензент года” и премии “Выдающийся рецензент“. Оценивание рецензентов проводится при технической поддержке системы АССИСТЕНТ, однако это касается только тех рецензентов, работы которых редактируются онлайн, с помощью системы электронного редактирования АССИСТЕНТ, все процессы которого непрерывно-последовательно проводятся журналом «Военно-технический вестник». Рецензенты журнала «Военно-технический вестник» выполняют все необходимые процедуры.

С Регламентом конкурса можно ознакомиться на сайте ЦЕОН, перейдя по ссылке: https://www.ceon.rs/images/pdf/RR_pravilnik_sr.pdf, а с Инструкцией по

оцениванию в Редакторском отделе журнала. Награда «Рецензент года» представляет собой Почетную грамоту и денежное вознаграждение. Денежная премия выдается в виде ваучера, покрывающего расходы (максимально до 1500 евро) на участие в научной конференции по выбору лауреата.

Команды ЦЕОН и СЦиндекс совместно приглашают редакции, журналы которых не редактируются посредством СЦИндекс Ассистентом, самостоятельно принять дополнительные усилия для повышения качества рецензирования, путем проведения стандартизации рецензентских образцов, дополнительной подготовки рецензентов в повышении квалификации, а также путем их отбора, наблюдения и оценки.

CEON and the SCIndex team started the evaluation of reviewers to find new laureates of the *Reviewer of the Year Award* and the *Outstanding Reviewer Recognition*

CEON, the SCIndex team and the Military Technical Courier Editorial Office are glad to announce the beginning of the reviewer evaluation process for honouring the *Reviewer of the Year Award* and the *Outstanding Reviewer Recognition.* The assessment is technically supported only for the reviewers of the articles edited online through the ASSISTANT e-editing system, consistently and fully applied by the Military Technical Courier. All Military Technical Courier reviewers meet this necessary requirement.

Awards Regulations are available on the CEON site (https://www.ceon.rs/images/pdf/RR_pravilnik_sr.pdf), while the General Instructions on Assessment are available in the Editorial Service of the Journal. The *Reviewer of the Year Award* consists of a diploma and a voucher to cover the expenses up to 1500 Euros for the participation in a scientific conference of the laureate's choice.

CEON and the SCIndex team are encouraging editorial offices of journals not edited through the SCIndex Assistant to promote reviewing quality by putting their effort into standardizing reviewer's forms, additional education of reviewers as well as their selection, monitoring and evaluation.

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