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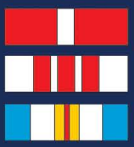

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С А Д Р Ж А Ј

С О Д Е Р Ж А Н И Е

C O N T E N T S

STRONG ENHANCEMENT OF DOUBLE AUGER DECAY FOLLOWING PLASMON EXCITATION IN C_{60}

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FIELD: molecular physics, synchrotron radiation, photoelectron spectroscopy, fullerenes, dipole resonance, Auger decay, Plasmon, collective oscillation, localized excitation, delocalized relaxation

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Abstract:

One of the important characteristics of the C_{60} molecule is the collective response of its valence electron cloud to the electromagnetic radiation. This collective behavior gives rise to the occurrence of the giant dipole resonance (so called surface plasmon) in the absorption spectrum centered around 20 eV, which has also been analyzed theoretically by various authors. Concerning photoelectron emission, plasmonic excitation is characterized by a particular intensity behavior near the threshold. We present here a new series of the K-shell photoelectron spectra with particular emphasis on the qualitative analysis of all ionization with excitation and double ionization processes. Our measurements of the C_{60} plasmon excitation follow the so-called Thomas-Derrah law and are in good agreement with the corresponding behavior of satellite excitations in atoms such as neon.

Key words: molecular physics, photoelectron spectroscopy, plasmon excitation.

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Introduction

Since the discovery of C_{60} molecule (Kroto et al, 1985, pp.162-163), (Krätschmer et al, 1990, pp.354-358) many studies have been performed to investigate its fundamental properties. These properties are mainly driven by its unique molecular structure like a spherical shell (Electronic Properties of Fullerenes, 1993), (Korica et al, 2005, pp.132031-132035). C_{60} is known to have a plasmon excitation where 240 valence electrons contribute to a delocalized electron cloud that can oscillate relative to the carbon ion core forming the C_{60} molecular cage. This oscillation produces a giant resonance in the C_{60} photoabsorption (Hertel et al, 1992, pp.784-787) and electron-energy-loss spectra (Leiro et al, 2003, pp.205-213) at the excitation energy of about 20eV. It has also been observed in the photofragmentation experiments as an enhanced relative fragmentation of C_{60}^{+} ion at the same photon energy (Karvonen et al, 1997, pp.3466-3472). It has been interpreted by different theoretical models as a dipole collective giant resonance (Amusia & Connerade, 2000, pp.41-70), (Bertsch et al, 1991, pp.2690-2693), (Ekardt, 1984, pp.1925-1928), due to autoionization, which arises from collecting the strength of the individual one-electron transitions into a single collective excitation.

Experimental set-up

The measurements were performed at the HASYLAB undulator beam line BW3 in Hamburg using monochromatized synchrotron radiation whose wavelength can be scanned with a resolution set to an appropriate value. The photon beam crosses an effusive beam of C_{60} molecules, provided by an oven heated to 500 °C. Outgoing electrons are detected in time-of-flight (TOF) electron spectrometers at two different angles with respect to the electric vector of the ionizing radiation (Fig. 1). Appropriate voltages can be applied to the TOF-analysers to keep a constant resolution of the electron spectra for different photon energies.

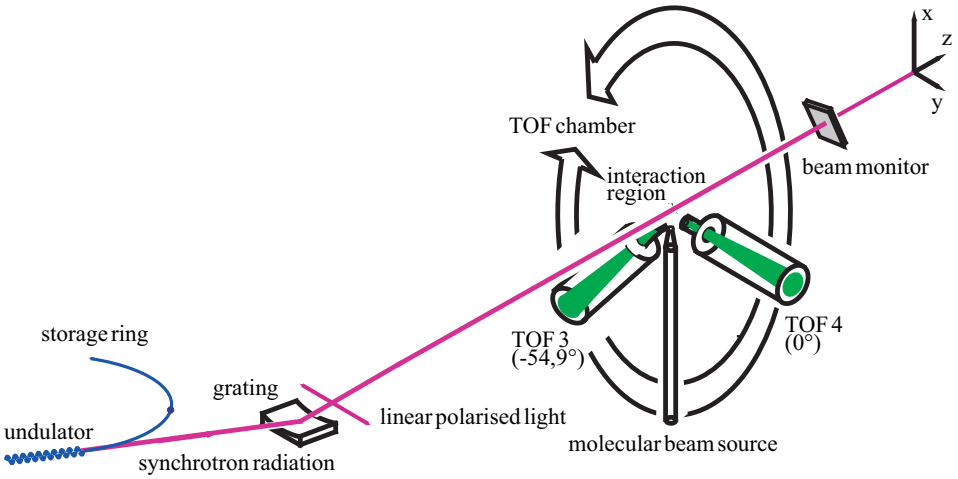

Figure 1 – The experimental set-up
Рис. 1 – Экспериментальная аппаратура
Слика 1 – Експериментална апаратура

Results and Discussion

Plasmon excitation in C_{60} molecule

Figure 2 shows an example of the K-shell photoelectron spectrum of C_{60}, recorded at 390 eV photon energy, covering the whole range of kinetic energies down to zero kinetic energy. The spectrum is converted to the binding energy and the background has been subtracted.

The spectrum consists, besides the single narrow C(1s) main line (Lichtenberger et al, 1991, pp.203-208), of a variety of satellite lines and higher lying plasmon excitation (Weaver et al, 1991, pp.1741-1744), (Benning et al, 1992, pp.6899-6913), (Terminello et al, 1991, pp.491-496). The low binding energy side of the C1s (from 1.9 eV to 9.3 eV) is characterized by different dipole and monopole shake-up satellites, except the one at the 6.0 eV which relates to the π plasmon. The energy region between 10 eV and 20 eV does not have discrete dipole transitions for free molecules and collective resonances are the dominating effects here (plasmon like excitations). The broad peak at the high binding energy side is also caused by several plasmon excitations.

Such plasmons are supposed to originate from a collective motion of σ- and/or π-electrons in the electric hull of the C_{60} molecules following the ionization of a K-shell electron.

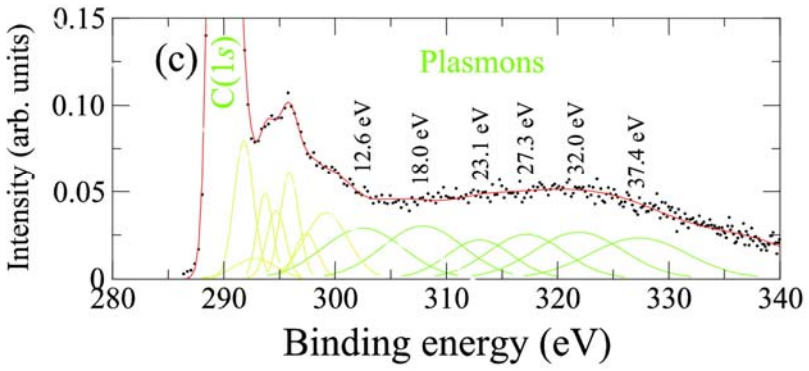

Figure 2 – A recorded spectrum of the 54.7°- analyser for a photon energy of 390eV
Рис. 2 – Анализатор спектра на 54.7°для энергии фотона 390eV
Слика 2 – Спектар анализатора на 54,7° за енергију фотона од 390 eV

We have also studied the dynamical behaviour of plasmon excitation by recording the photoelectron spectra as a photon energy function. This is illustrated in Figure 3 for several different photon energies.

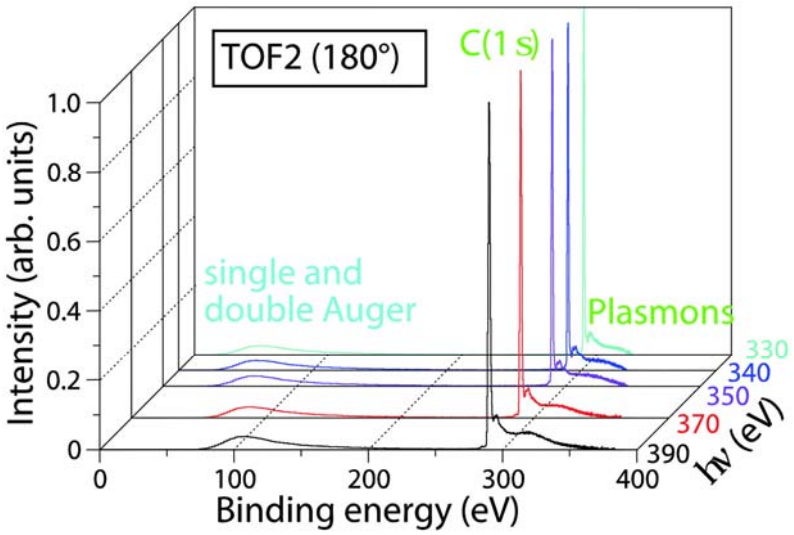

Figure 3 – Spectra as a function of the binding energy of the 180°-analyser for different photon energies
Рис. 3 – Спектр в функции связной энергии анализатора на 180° для различных уровней энергии фотона
Слика 3 – Спектар у функцији од енергије везе за анализатор на 180° за различите енергије фотона

Our results are in good agreement with the model of T. D. Thomas (Thomas, 1984, pp.417-420), a time-dependent model which describes the transition between adiabatic and sudden behaviour. It takes into account the interaction between the outgoing electron and the remaining electrons which leads to shake-up satellite electrons because the photoejected electron may emerge with less energy than in the adiabatic picture. In addition, multiple electron ejection is possible, in which case a continuous shake-off spectrum is observed since the discrete energy can be arbitrarily divided between the emitted electrons. In the frame of this model, the intensity ratio of the "shake-up" process and the C(1s) line is given by the expression:

$$\mu = \mu_\infty \exp\left\{-\left(r\left[\begin{smallmatrix}0\\A\end{smallmatrix}\right]\Delta E[eV]\right)^2 / (15.32 E_{ex}[eV])\right\}, \qquad (1)$$

where:
μ – intensity ratio of the "shake-up" process and the C(1s) main line,
μ_∞ – asymptotic value of μ (taken from Leiro et al, 2003, pp.205-213),
r – the distance until the electrons are separated from the molecule,
$r \approx 0.4Å$, note: $r << r(C_{60})$,
ΔE – the excitation energy of the "shake-up" process,
E_{ex} – the kinetic energy of the outgoing electrons.

Figure 4 shows a comparison of the experimental results with the results of the model of T. D. Thomas (Thomas, 1984, pp.417-420). With increasing energy, the plasmon intensity reaches its sudden limit faster than expected pointing to the localized excitation processes rather than to a delocalized relaxation in response to core-hole creation. The sudden limit intensity is as large as 30% of the total K-shell ionization events. Our measurements are in good agreement with the corresponding behavior of the satellite excitations in atoms such as He, Ne and Ar (Holland et al, 1979, pp.2465-2484) where electron correlation effects are supposed to enhance various cross sections.

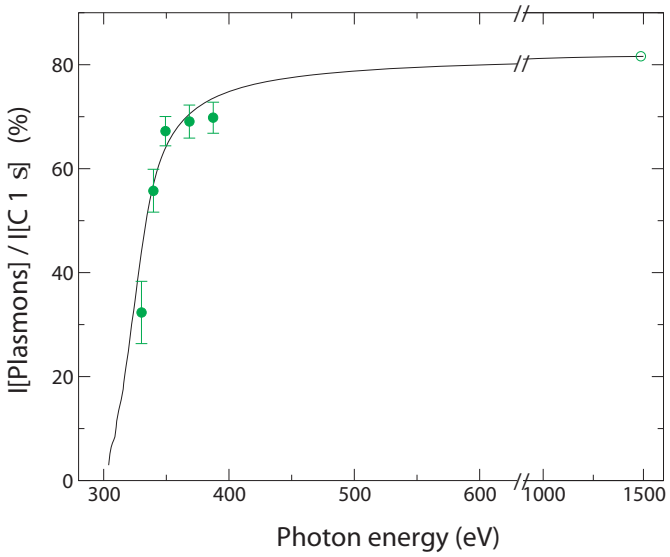

Figure 4 – Experimental and calculated values of the ratio of the intensity of all plasmon peaks and the intensity of the C(1s) main line as a function of excitation energy.
Рис. 4 – Экспериментальные и расчетные значения отношений интенсивности всех плазмонных пиков и интенсивности C(1s) главной линии в функции энергии возбуждения.
Слика 4 – Експериментална и израчуната вредност односа интензитета свих пикова плазмона и интензитета C(1s) главне линије у функцији енергије ексцитације

Double Auger decay of the excited C60

The strength of the shake-off processes contributes also significantly to total K-shell ionization rate. The relative fraction of this shake-off rate has been, however, unknown so far, although the complete photoelectron spectra exhibit a large fraction of continuously distributed photoelectron intensity which could either result from shake-off photoelectron emission or double Auger decay (Fig.5). The quality of the former K-shell photoelectron measurements was insufficient to disentangle these two contributions experimentally (Aksela et al*,* 1995, pp.2112-2115), (LeBrun et al*,* 1994, pp.3965-3968), (Brühwiler et al*,* 1993, pp.3721-3724), (Krummacher et al*,* 1993, pp.8424-8429).

The contribution of different excitation events can by separated with the *ansatz* (Fig.5):

$$Total\ Auger = Auger_{single} + Auger_{double}$$
$$= C(1s) + Satellites + Plasmons + e_{shakeoff}$$

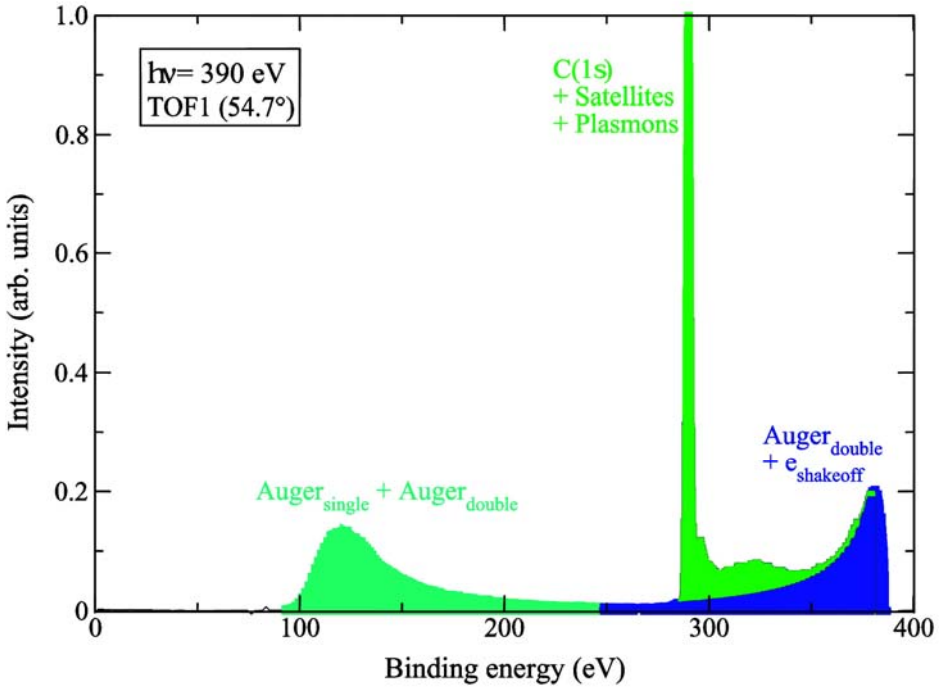

Figure 5 – Photoelectron spectrum recorded with a photon energy of 390eV. Different types of contributions are marked with colours. The intensity of the single and double Auger process can be deduced from the coloured areas.
Рис. 5 – Фотоэлектронный спектр, записанный для энергии фотона 390eV. Различные виды влияния обозначены разными цветами. Интенсивность Оже-процессов можно определить по обозначенным частям.
Слика 5 – Фотоелектронски спектар снимљен за енергију фотона 390eV. Различите врсте доприноса означене су различитим бојама. Интензитети Ожеових процеса могу се одредити из обојених области.

Performing a spectral analysis, which takes all primary and secondary ionization events into account, yields a double Auger rate as high as 60% of the total Auger yield. This is an extremely high value, raising the question of its origin. Assuming that the main line and the related shake-off emission result predominantly in single Auger decay, the K-shell photoionization associated with satellite and plasmon excitations remain the only plausible source for such a high double Auger rate.

The only reason for this highly unusual behaviour may be the fact that satellite and plasmon excitations both populate LUMO states which

are strongly delocalized and may be completely in the continuum for the double charged C_{60}^{2+} ion resulting from the K-shell ionization and the subsequent core-hole refilling process (Maxwell et al*,* 1994, pp.10717-10725), (Wästberg et al*,* 1994, pp.13031-13034). The excited electron cannot survive in this unstable situation and will consequently leave the C_{60} ion along with the Auger electron in a form of an Auger shake-off transition. These arguments, however, have to be validated by more sophisticated calculations.

Conclusion

We have studied the C_{60} molecule photoionization above the C(1s) threshold, in the photon energy range hv=(330-390)eV. A careful analysis of the spectra yielded two surprising and unexpected results:

(i) With energy increase, the plasmon intensity reaches its sudden limit faster than expected pointing to localized excitation processes rather than to a delocalized relaxation in response to core-hole creation. The sudden limit intensity is as large as 30% of the total K-shell ionization events.

(ii) Performing a spectral analysis taking all primary and secondary ionization events into account yields a double Auger rate as high as 60% of the total Auger yield.

The double Auger processes are probably linked to the plasmon excitation in the C_{60} molecules.

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УСИЛЕНИЕ ДВОЙНОГО ОЖЕ-РАСПАДА, СОПРОВОЖДАЮЩЕГО ВОЗБУЖДЕНИЕ ПЛАЗМОНОВ В C_{60}

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ОБЛАСТЬ: молекулярная физика, синхротронное излучение,
Фотоэлектронная спектроскопия, фуллерены,
дипольный резонанс, Оже-распад, плазмон,
коллективные колебания, локализованное возбуждение,
делокализованная релаксация
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Одной из самых значительных свойств молекулы C_{60} является коллективная реакция ее валентных электронов на электромагнитные излучения. Вследствие коллективной реакции в спектре поглащения возникает огромный дипольный резонанс (так называемый поверхностный плазмон), приблизительно на 20 eV, который был неоднократно представлен различными авторами в их теоретических исследованиях. В случае фотоэлектронной эмиссии, наблюдаются характерное поведение плазмонов при возбуждении на пороге ионизации. В работе представлена новая серия фотоэлектронных спектров K-оболочки, а также подробный квалитативный анализ всех ионизаций с возбуждениями в процессе двойной ионизации. На основании проведенного анализа и измерений плазмонного возбуждения C_{60} при применении так называемого закона Томас-Дерраха можно утверждать, что они полностью совпадают с соответствующим поведением сателлитного возбуждения атомов в неонах.

Ключевые слова: молекулярная физика, фотоэлектронная спектроскопия, возбуждение плазмонов.

ЈАКО ПОЈАЧАЊЕ ДВОСТРУКОГ ОЖЕОВОГ РАСПАДА КОЈИ ПРАТИ ПЛАЗМОНСКУ ЕКСЦИТАЦИЈУ У C_{60}

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ОБЛАСТ: физика молекула, синхротронско зрачење, фотоелектронска спектроскопија, фулерени, диполна резонанца, Ожеов распад, Плазмон, колективна осцилација, локализована ексцитација, делокализована релаксација
ВРСТА ЧЛАНКА: оригинални научни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Једна од значајних карактеристика C_{60} молекула је колективни одговор његових валентних електрона на електромагнетно зрачење. Ово колективно понашање доводи до појаве огромне диполне резонанце (тзв. површински плазмон) у апсорпционом спектру на око 20 eV, који су различити аутори и теоријски анализирали. Када је у питању фотоелектронска емисија, плазмонску ексцитацију карактерише посебно понашање на прагу јонизације. Приказана је нова серија фотоелектронских спектара К-љуске са тежиштем на квалитативној анализи свих јонизација са ексцитацијама и процесима двоструке јонизације. Мерења плазмонске ексцитације C_{60} прате тзв. Томас-Дирахов закон и у великој су сагласности са одговарајућим понашањем сателитских ексцитација у атомима као што је неон.

Кључне речи: физика молекула, фотоелектронска спектроскопија, плазмонска ексцитација.

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COMPUTER SIMULATION OF THE 7.62mm TT PISTOL EXTERNAL BALLISTICS USING TWO DIFFERENT AIR RESISTANCE LAWS

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Abstract:

A description of a pistol (rifle) cartridge often involves two ballistic coefficients that characterize its ballistic qualities with respect to various air resistance laws (ARLs). How close are the obtained ballistic trajectories with varied ARL specifications and what are the differences between them? How to evaluate ballistics if the ARLs are to be expressed in various mathematical forms? In this paper, the evaluation of external ballistics trajectories is given for two ARLs (the law brought in 1943 and the Siacci law). All the obtained results relate to the TT pistol with 7.62 × 25mm Tokarev cartridge.The paper also presents the answer to the question: how to calculate the ballistic trajectory if the ARL is expressed as a rational function, piecewise function or spline. For the 1943 ARL, a graphical interpretation of the function $Cd\ (i, v)$ *in the form of a surface is shown. This paper shows that, due to the selection of ballistic coefficients, it is possible to obtain sufficiently similar form of ballistic trajectories. A method of graphical comparison of external ballistic parameters is presented as well as the mathematical tools for quantitative analysis of a shape of ballistic curves.The difference between the two trajectories is proposed to be estimated using a relative error in regard to a selected ballistic parameter. Computer simulation considered for the 1943 and Siacci ARLs for the 7.62×25mm Tokarev cartridge indicates that the profiles of the function of instantaneous projectile velocity vs time of flight (TOF) had the greatest non-coincidence in relation to other ballistic parameters (e.g. horizontal range, height of the trajectory, etc.) The obtained maximum of the relative error was 0.8%. Its magnitude localizes at the point of impact.*

Key words: computer simulation, external ballistics, TT pistol, air resistance law, drag function, the 1943 year law, bullet trajectory, spline, Mathcad.

There are no dangerous weapons;
there are only dangerous men.
Robert A. Heinlein

Introduction

For one projectil type (bullet) that has equal initial conditions (x_0, y_0, θ_0, v_0), but its motion is characterized by two different ARLs, it is possible to calculate so-called «twins-trajectories». These are two trajectories with a practically identical form, but due to differences in ARLs descriptions, they have different values of the ballistic coefficients *C*. Errors related to inequality of such trajectories are usually not reported and it's completely unclear which of the external ballistic parameters x, y, θ, v for each of «twins-trajectories» has the greatest inconsistency.

In Europe and in the countries of North and South America, external ballistics of small arms projectiles is generally based on the use of well-known *G1/G7* air drag models; however, ARLs like the 1943 year law and the Siacci law are often used in the Commonwealth of Independent States or in countries - former members of the Warsaw Pact (or in countries that had in the past a military-technical cooperation with that defense treaty). One of the objectives of this article is to show how to carry out a ballistic simulation by using the 1943 and Siacci ARLs with various forms of their mathematical expressions. The second task is to present equality or inequality of the ballistic curves obtained as a result of the estimation process. For reducing the computer simulation (calculation) time, we will use the Mathcad 15 computer algebra system.

From the point of view of external ballistics, it is interesting to estimate the ballistics of one of well-known pistols, for instance, of the 7.62mm Tokarev-TT[1] pistol using two previously mentioned ARLs. It is known that pistols based on the TT construction were produced in many countries and the 7.62×25 cartridge is widespread.

In the scientific article (Bogdanovich, 2012, p.42) one can find «…one of the best pistols based on the 7.62mm TT design was certainly the M57. This gun was constructed in Yugoslavia, at the «Zastava» plant and produced by Serbian «Zastava Arms» for export to various countries, including Europe and America». The arms plant «Crvena Zastava» (Kragujevac) began to produce the pistol-predecessor of the M57, namely the M54, in 1954 and at the same time the ammunition factory «Prvi Partizan» (Užice) launched a serial production of the

[1] 7.62mm Tokarev self-loading pistol model TT 1930 (TT-30) / TT 1933 (TT-33). The abbreviation «TT» means Tula-Tokarev.

7.62×25mm Tokarev cartridges. In addition, it should be said that the TT pistol and its upgrades were manufactured in PRC (Type 51 & Type 54), in Hungary (M48, Tokagypt 58 with cartridge 9x19mm Para), in Romania (TTC), in DPR Korea (Type 68) and in other countries.

Ballistic and technical data. Table 1 shows the necessary technical specifications of TT-33, M54, and M57 pistols, important for evaluating their ballistics.

Table 1 – Technical specifications of TT-33, M54, and M57 pistols
Таблица 1 – Технические характеристики пистолетов ТТ-33, М54, М57
Табела 1 – Техничке карактеристике пиштоља ТТ-33, М54 и М57

№/№	Specifications	Units	Model of pistols	
			TT-33, M54	M57
1	Chambering	mm	7.62x25 TT	7.62x25 TT
2	Fire modes	-	Semi-Auto, Single Action	Semi-Auto, Single Action
3	Bullet weight	g	5.49-5.52	5.49-5.52
4	Bullet length	mm	14[2]	-
5	Bore length	mm	116	116
6	Rifling length	mm	100	-
7	Number of grooves	-	4 RH	4 RH
8	Number of lands	-	4	4
9	Twist rate	mm per turn	240	240
		inch per turn	9.45	9.45
		clb[3] per turn	31.496	31.496
		° ' "	5°41'45"	5°41'45"
10	Initial velocity	mps	420	440
11	Bullet muzzle energy	Joule	485.54	532.88
12	Bullet spin rate	rps	1750	1750-1896
13	Effective firing range	m	50	50
14	Bullet flight range	m	800-1000	1640
15	Sight radius	mm	156	158
16	Max mean pressure	kg/cm^2	2234	-
17	Practical rate of fire	rpm	30	-
18	Precision (range: 50 m)	m	0.25	-

Sources: (Bogdanovich, 2012, p.49) and author's estimations

[2] for ordinary bullet P-type (cyrillic: пуля «П» - простая)
[3] clb – bullet caliber

Based on (http://popgun.ru,nd), the curves of pressure and bullet velocity vs rifling length (time) for the 7.62mm bullet of the TT-33 pistol in a logarithmic scale were built (Figure 1). The main advantage of the logarithmic scale is that it allows «to stretch the graph» in the direction to the origin (to the point «0 mm» by using the argument bore length and to the point «0 seconds» by using the argument time). The fragment *a* of Figure 1 shows the change of the projectile velocity in the barrel; the fragment *b* indicates the internal ballistic curve of the mean pressure in the barrel.

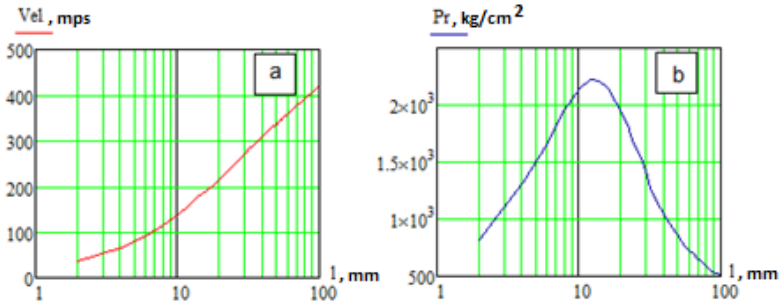

Figure 1 – Internal ballistic curves of the TT pistol (argument - bore length)
Рис. 1 – Внутрибаллистические кривые пистолета ТТ (аргумент – длина ствола пистолета)
Слика 1 – Унутрашње балистичке криве пиштоља ТТ (аргумент – дужина цеви)

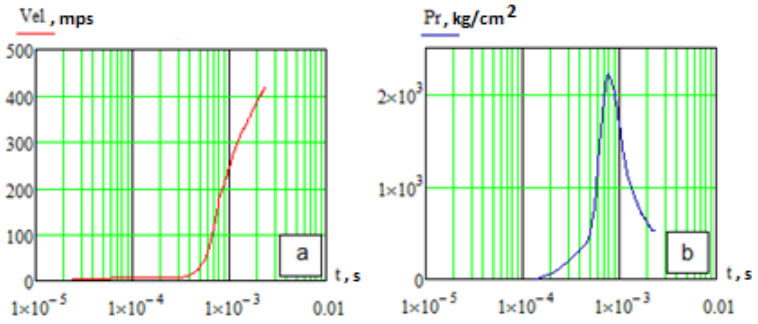

Figure 2 – Internal ballistic curves of the TT pistol (argument time): a – the projectile velocity in the barrel; b – internal ballistic curve of the mean pressure in the barrel.
Рис. 2 – Внутрибаллистические кривые пистолета ТТ (аргумент – время): а – скорость снаряда в стволе; b – внутрибаллистическая кривая среднего давления в стволе.
Слика 2 – Унутрашње балистичке криве питоља ТТ (аргумент – време): а) брзина пројектила унутар цеви, б) унутрашња балистичка крива средње вредности притиска унутар цеви.

The dependences of the bullet velocity and the mean pressure as a function of time are also obtained (Figure 2). The graphs show that the bullet initial velocity is 420 mps, and the mean pressure maximum is 2234 kg/cm^2. The duration of the intraballistic cycle for the TT-33 pistol is approximately 2.5 milliseconds.

The mathematical model. Longitudinal motion of a pistol bullet in the Earth's atmosphere can be described by the system of ODEs with an independent argument TOF (*t*) (Regodić, 2006). This type of mathematical expression belongs to the Point-mass Trajectory Model type:

$$\begin{cases} \dfrac{dv}{dt} = -g\sin(\theta) - \dfrac{\rho v^2}{2m} AC_d \\ \dfrac{d\theta}{dt} = -\dfrac{g\cos(\theta)}{v} \\ \dfrac{dx}{dt} = v\cos(\theta) \\ \dfrac{dy}{dt} = v\sin(\theta) \end{cases} \quad (1)$$

where v – the instantaneous bullet velocity, m/s; t – the time of flight, s; g – the acceleration of gravity at the point of departure, m/s2; θ – the angle of the velocity vector relative to the base of a trajectory, radian; ρ – the air density, kg/m3; m – the mass of projectile, kg; A – the cross section of the projectile, m2; C_d – a drag function, dimensionless; x – the abscissa (horizontal range) of the trajectory, m; y – the ordinate of the trajectory, m.

The density of the air ρ as a function of the projectile flying altitude y:

$$\rho=\rho_0 \cdot H(y),$$

where ρ_0 is the density of the air at the ground-level; $H(y)$ is the function which indicates a relative variation of the air density with respect to the altitude y.

Using the standard ARLs C_{dst} and the coefficient i, it is possible to transform the first ODE of system (1):

$$\frac{dv}{dt} = -g\sin(\theta) - \frac{\rho v^2}{2m} AiC_{d\,st}$$

where i – coefficient taking into account a shape of (launched) bullet (so-called form coefficient[4]), dimensionless; C_{dst} – the standard air drag function, dimensionless.

Coefficients *i* and ARL models. According to collected sources, the i coefficients for the 7.62mm pistol bullet and 9mm bullets are shown in Table 2.

Table 2 – Values of the coefficient i for pistol bullets
Таблица 2 – Значение коэффициента i для пистолетных пуль
Табела 2 – Вредности коефицијента i за зрна пиштоља

Type of cartridge and bullet	Initial velocity v_0, mps	Bullet weight, g	ARL		Source
			1943	Siacci	
7.62×25mm Tokarev	420	5.505	1.35	0.75	(Kirillov, 1963, p.68)
9x18mm Makarov[5]	315	6.1	-	0.98	(Vodorezov, 2017, p.166)
9x19mm Luger (FMJ)	376	7.4	1.526	0.77	(https:// forum.guns.ru, nd)
9x19mm Luger (HP)	308	9.4	1.509	0.755	(https:// forum.guns.ru, nd)

A comparison of the values of the coefficients i for 7.62×25mm Tokarev indicates that its value for the ARL of Siacci is 1.8 times lower than i for the ARL of the 1943 year.

The 1943 law drag model is often used to describe ballistics of pistol bullets, for example, for 9mm Para cartridge (Jankových, 2012, p.29) or for 9mm Luger (https://guns.ru, nd).

The coefficient i can be calculated by the following formula (Faraponov et al, 2017, p.35)

$$i = \frac{m}{1000d^2} C$$

[4] In the book of Semikolenov, Bondarenko & Krasner «Principles of small unit weapons firing» (Semikolenov et al, 1971) on the p.67 i is named as "the coefficient for the projectile shape".

[5] The files for software Exterior Ballistics 2.5 (http://ballistics.eu/index.html, nd) contain data for the cartridge 9x18 Makarov with FMJ bullet (6.22 g.) and V_0=346 mps: BC=0.1; drag model G1.

where i – the form coefficient, dimensionless; m – the mass of the projectile/bullet, kg; d – the caliber of the projectile/bullet, m; C – the ballistic coefficient of the projectile, m^2/kg.

«Although the coefficient i is usually regarded as a constant value, as it can be seen from the expression

$$i = C_d\left(\frac{v}{a}\right)\left(C_{d_{st}}\left(\frac{v}{a}\right)\right)^{-1},$$

it, strictly speaking, depends on the instantaneous projectile velocity.

Therefore, using a projectile (bullet) of the same shape in different ranges of velocity, we can get some discrepancies in the numerical values of the coefficient i. For the same reason, the value of the coefficient i for the same projectile and for the same initial velocity depends on the angle of departure (AOD). This is explained by the fact that changing of AOD gives a change in the velocity range along the trajectory» (Shapiro, 1946, p.58).

For example, the relationship between the 1943 year ARL and the Siacci ARL in the range of up to 5 *M* is shown in Figure 3 (Khaikov, 2017, p.83). The coefficient i as a function of the Mach number (M) is complicated, i.e. it is not monotonous. The graph of the $i(M)$ function has two local minimums and one local maximum (see the right graphics window). However, $i(M)$ can be characterized by some average value, which is equal to half of the area under the $i(M)$ function graph.

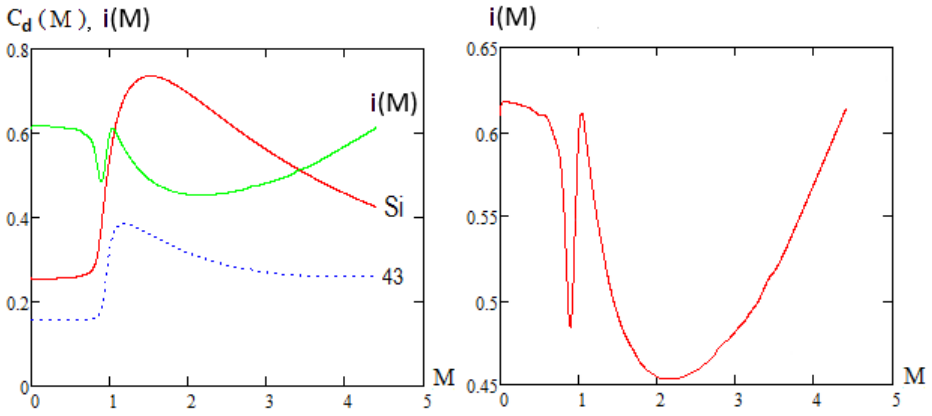

Figure 3 – Relationship between the two ARLs
Рис. 3 – Отношение двух законов сопротивления воздуха
Слика 3 – Однос између два закона отпора ваздуха

If $i(M)$ and the coefficient i are considered as a constant, then the function $C_d(i,v)$ can be represented as a surface (Figure 4). For $i=1$, we have a standard function $C_{d_{st}}\left(\frac{v}{a}\right)$, which is a section of the surface (orange line). For $i\neq 1$, the individual function C_d, such as a purple line ($i>1$).

Using the value of the coefficient i, the caliber of the bullet, its mass, it is possible to calculate the ballistic coefficient C (Germershausen, 1982, p.159)

$$C = 1000 \cdot i \cdot d^2 \cdot q^{-1}$$

In this case, we obtain the function $C_d(C, v)$.

However, there is an alternative formula for calculating the ballistic coefficient (BC) $C = m \cdot \left(d^2 \cdot i\right)^{-1}$. In order to avoid misunderstanding, it is necessary to indicate a type of a calculation formula for ballistic coefficient determination.

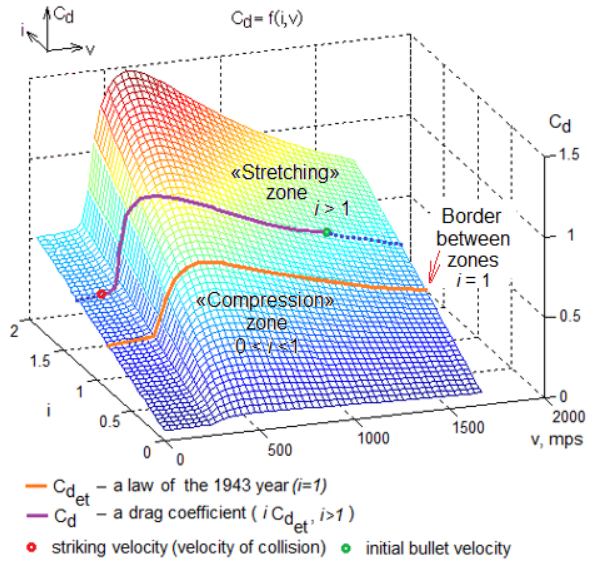

Figure 4 – The function $C_d(i,v)$ in the form of a surface
Рис. 4 – Функция $C_d(i,v)$ в форме поверхности
Слика 4 – Функција $C_d(i,v)$ у облику површине

So, if $i(v) = const$, then the surface (Figure 4) shows all possible individual drag-functions which depend on i. When the coefficient i is multiplied by $C_{d_{st}}\left(\frac{v}{a}\right)$, a linear transformation of the function takes place: for $i > 1$, the graph is stretched from the abscissa axis i times; for $0 < i < 1$ this is the compression of the graph to the x-axis by $1/i$ times.

Therefore, the standard function $C_{d_{st}}\left(\frac{v}{a}\right)$ is the boundary between the «compression» and «stretching» zones of the $C_d(i,v)$ surface. Since any ballistic trajectory has the initial and striking velocity of the projectile, due to the surfaces $C_d(i,v)$ or $C_d(C,v)$ we can show the range of the coefficient C_d that is necessary for flight path calculations.

Different forms of ARL expressions. ARLs or function can be described as: a classical analytical function; a piecewise function and a spline function. The spline function can be regarded as a special kind of the piecewise function.

Analytical forms for the ARL of the 1943 year. In view of the fact that the summit of the bullet trajectory in air for pistol external ballistics is not a large value, the speed of sound can be considered as a constant value. That is in the formula

$$M=v/a,$$

where v – instantaneous bullet velocity; a – local speed of sound (constant).

The ARL of the 1943 year is a table-valued function that can be found in (Konovalov & Nikolayev, 1979, p.191) and approximated using a rational function:

$$C_{d\,43_{RF}}\left(\frac{v}{a}\right) = P\left(\frac{v}{a}\right)\left(Q\left(\frac{v}{a}\right)\right)^{-1}.$$

The conducted investigation of possible approximation forms for the ARL of the 1943 year led to the following rational function (Khaikov, 2017, p.85) $\left(0.1 \le v/a \le 4\right)$:

$$C_{d43_{RF}}\left(\frac{v}{a}\right)=\frac{1.378212-7.1379605\left(\frac{v}{a}\right)+15.498681\left(\frac{v}{a}\right)^2}{8.7777403-45.498974\left(\frac{v}{a}\right)+99.290858\left(\frac{v}{a}\right)^2}\cdot\cdot$$
$$\cdot\cdot\frac{-17.778376\left(\frac{v}{a}\right)^3+10.605229\left(\frac{v}{a}\right)^4-1.7807148\left(\frac{v}{a}\right)^5}{-17.778376\left(\frac{v}{a}\right)^3+74.91108\left(\frac{v}{a}\right)^4-21.331814\left(\frac{v}{a}\right)^5}\cdot\cdot$$
$$\cdot\cdot\frac{-1.6876336\left(\frac{v}{a}\right)^6+1.164362\left(\frac{v}{a}\right)^7-0.2873904\left(\frac{v}{a}\right)^8}{-3.0222138\left(\frac{v}{a}\right)^6+4.0786158\left(\frac{v}{a}\right)^7-1.0962723\left(\frac{v}{a}\right)^8}\cdot\cdot \quad (2)$$
$$\cdot\cdot\frac{+0.025985844\left(\frac{v}{a}\right)^9}{+0.1012291\left(\frac{v}{a}\right)^9}$$

Another form of mathematical expression for the ARL of the 1943 year is a sum of rational and exponential functions (R&EF) (Kozlitin & Omelyanov, 2016, p.29):

$$C_{d43_{R\&EF}}\left(\frac{v}{a}\right)=\frac{P\left(\frac{v}{a}\right)}{Q\left(\frac{v}{a}\right)}+\frac{b_0}{1+\exp\left(b_1\left(\frac{v}{a}\right)+b_2\right)}+d_0 \quad (3)$$

It should be noted that the rational function (i.e. first summand) uses only even powers (from 0 to 12, namely 0, 2, 4,..10, 12). R&EF is expressed by the following formula $\left(0.1\le v/a\le 4.0\right)$ with eighteen empirical coefficients

$$C_{d43_{R\&EF}}\left(\frac{v}{a}\right)=\frac{-1.9382+4.2980\left(\frac{v}{a}\right)^{2}+0.3207\left(\frac{v}{a}\right)^{4}}{296.9213-853.9492\left(\frac{v}{a}\right)^{2}+985.5873\left(\frac{v}{a}\right)^{4}}\cdot\cdot$$
$$\cdot\cdot\frac{-9.4610\left(\frac{v}{a}\right)^{6}+8.9342\left(\frac{v}{a}\right)^{8}-0.9476\left(\frac{v}{a}\right)^{10}}{-580.8643\left(\frac{v}{a}\right)^{6}+178.6690\left(\frac{v}{a}\right)^{8}-15.4071\left(\frac{v}{a}\right)^{10}}\cdot\cdot \quad (4)$$
$$\cdot\cdot\frac{+0.0525\left(\frac{v}{a}\right)^{12}}{+1.0000\left(\frac{v}{a}\right)^{12}}+\frac{0.0531}{1+\exp\left(-90.5063\left(\frac{v}{a}\right)+85.5194\right)}+0.1639$$

The research carried out in (Khaikov, 2017, p.88) showed that the matrixes **P**, **Q**, **B** and **D** in formula (3) may have different coefficients. For example, the matrices $\mathbf{P_1}$, $\mathbf{Q_1}$, $\mathbf{B_1}$ and $\mathbf{D_1}$ with alternative coefficients are presented below:

$$\mathbf{P_1}=\begin{pmatrix}10.189924313\\-32.2497749054\\42.0499139169\\-28.8388279297\\9.989953385\\-0.6976279168\\0.0403773785\end{pmatrix}\quad\mathbf{Q_1}=\begin{pmatrix}-0.9050248435\\2.8653174742\\-3.7411757325\\2.5742663163\\-0.8961295841\\0.0627439736\\-0.0036275618\end{pmatrix}$$

$$\mathbf{B_1}=\begin{pmatrix}0.06274397\\16.399062\\57.358636\end{pmatrix}\quad\mathbf{D_1}=\begin{pmatrix}11.416713\end{pmatrix}$$

The ARL of the 1943 year can be expressed as a piecewise function (5) (Khaikov, 2017, p.80) consisting of 9 unequal intervals. This function is a modification of the formula from (Konovalov& Nikolayev, 1979, p.84) in which one more interval is added

$$C_{d43_{PWF}}\left(\frac{v}{a}\right)=\begin{pmatrix} 0.157 & 0.1<\left(\frac{v}{a}\right)\le 0.73 \\ 0.033\left(\frac{v}{a}\right)+0.133 & 0.73<\left(\frac{v}{a}\right)<0.82 \\ 3.9\left(\frac{v}{a}\right)^2-6.4194\left(\frac{v}{a}\right)+2.8025831 & 0.82\le\left(\frac{v}{a}\right)\le 0.91 \\ 1.5\left(\frac{v}{a}\right)-1.176 & 0.91\le\left(\frac{v}{a}\right)\le 1.00 \\ -1.6\left(\frac{v}{a}\right)^2+3.7632\left(\frac{v}{a}\right)-1.8287616 & 1.00<\left(\frac{v}{a}\right)\le 1.18 \\ 0.384\sin\left(1.85\left(\frac{v}{a}\right)^{-1}\right) & 1.18<\left(\frac{v}{a}\right)<1.62 \\ 0.29\left(\frac{v}{a}\right)^{-1}+0.172 & 1.62\le\left(\frac{v}{a}\right)<3.06 \\ -0.011\left(\frac{v}{a}\right)+0.301 & 3.06\le\left(\frac{v}{a}\right)\le 3.53 \\ 0.259 & 3.53\le\left(\frac{v}{a}\right)\le 4.0 \end{pmatrix} \quad (5)$$

The «*PWF*» subscript denotes a piecewisefunction.

Analytical forms for ARL of Siacci. The *F*-curve for the Siacci law is written (Mori, 2013, p.41)

$$F_{si}(v)=0.2002v-48.05\sqrt{(0.1648v-47.95)^2+9.6}+\frac{0.0442v(v-300)}{371+\left(\frac{v}{200}\right)^{10}} \quad (6)$$

Due to division by $4.74 \cdot 10^{-4} v^2$ we can transform the *F*-curve into the C_d - type function (Shapiro, 1946, p.37)

$$C_{d_{si}}(v) = \frac{F_{si}(v)}{4.74 \cdot 10^{-4} v^2} \tag{7}$$

The ARL of Siacci as a table-valued function can be found in (Konovalov & Nikolayev, 1979, p.191).

The technology of using spline functions is demonstrated in the appendix to this articleas well as in (Khaikov, 2018).

Different forms of the mathematical notations for ARLs of the 1943 year and Siacci law are combined in Table 3.

Table 3 – Forms of the mathematical notations for the ARLs of the 1943 year and Siacci law
Таблица 3 – Формы математических обозначений законов сопротивления воздуха 1943 года и Сиаччи
Табела 3 – Форме математичких појмова за законе отпора ваздуха из 1943. године и Siacci-јевог закона

ARL	Analytic functions		Table-valued function
	Classical analytic form	Piecewise form	
1943	Formulas 2 - 4	Formula 5	* [6]
Siacci	Formulas 6, 7	-	*

Mathcad programming code. The commented Mathcad-code is presented below. The characteristics for a pistol bullet are determined: caliber (0.00762*m* = 7.62*mm*), weight (0.0055*kg*) and a value of the *i* coefficient (*i_43*) (according to the the chosen law):

$d := 0.00762$ $q := 0.0055$ $i\_43 := 1.35$

[6] * - source corresponds (Konovalov et al, 1979, p.191).

An angle of departure (in radians) is calculated as a set of angular degrees, minutes and seconds:

$$Gradus:=0 \qquad Min:=10 \qquad Sec:=0$$

$$\theta_0 := \frac{\pi}{180}\left(Gradus + \frac{Min}{60} + \frac{Sec}{3600}\right) = 2.909 \cdot 10^{-3}$$

At the point of departure, the value of the acceleration coefficient of gravity is determined as 9.18 m/s^2. Further, it is necessary to determine the time interval of integration: its boundaries and the total number of integration points:

$$t_{beg}:=0 \qquad t_{end}:=1.1 \qquad n_{points}:=1000$$

The initial conditions (for formula (1)) are determined as a matrix-column *y*, which will contain their known numerical values:

$$y := \begin{pmatrix} y_0 = v(0) \\ y_1 = \theta(0) \\ y_2 = x(0) \\ y_3 = y(0) \end{pmatrix}.$$

In view of the fact that the initial velocity of the 7.62mm TT bullet is 420 m/s, the matrix-column *y* will look like:

$$y := \begin{pmatrix} 420 \\ 2.051 \times 10^{-3} \\ 0 \\ 0 \end{pmatrix}.$$

The matrix $D(t, y)$ has the form

$$D(t,y):=\begin{bmatrix} -g\cdot\sin(y_1)-\dfrac{\rho\cdot(y_0)^2}{2\cdot m}\cdot A\cdot i\_43\cdot Cd\left(\dfrac{y_0}{a}\right) \\ \dfrac{-g\cdot(\cos(y_1))^2}{y_0} \\ y_0\cdot\cos(y_1) \\ y_0\cdot\sin(y_1) \end{bmatrix} \quad (8)$$

The matrix-column $D(t,y)$ (8) is the right-hand part of the system of ODEs (1). It includes the following variables: the instantaneous projectile velocity $v - y_0$, the angle of inclination of the tangent $\theta - y_1$, the abscissa of the trajectory $x - y_2$; the ordinate of the trajectory $y - y_3$. In connection with the fact that C_d in formulas (2), (3) or other presenta long and cumbersome expression, it is given in (8) only as a «short» notation.

If a calculation in the Mathcad system is implemented, then C_d must be replaced by the complete mathematical expression. In this formula, the sign of v (velocity) is replaced by y_0. i_43 – the form coefficient of the 1943 year law in the Mathcad program.

For example, the matrix-column $D(t, y)$ will have the form (for C_d only three initial terms are given; the powers of $\dfrac{y_0}{a}$ are from 0 to 2). A Mathcad script for $D(t,y)$ is given below:

$$D(t,y):=\begin{bmatrix} -g\cdot\sin(y_1)-\dfrac{\rho\cdot(y_0)^2}{2\cdot m}\cdot A\cdot i\_43\dfrac{1.378212-7.1379605\left(\dfrac{y_0}{a}\right)^2+\ldots}{8.7777403-45.498974\left(\dfrac{y_0}{a}\right)+99.290858\left(\dfrac{y_0}{a}\right)^2+\ldots} \\ \dfrac{-g\cdot(\cos(y_1))^2}{y_0} \\ y_0\cdot\cos(y_1) \\ y_0\cdot\sin(y_1) \end{bmatrix}$$

The complete Mathcad script of $C_{d43_{RF}}\left(\frac{y_0}{a}\right)$ and $C_{d43_{R\&EF}}\left(\frac{y_0}{a}\right)$ expressions is given in formulas (2) and (4). In order to use the piecewise function (5) for the calculation in Mathcad, we transform it to the form:

$$D(t,y):=\begin{bmatrix} -g\cdot\sin(y_1)-\frac{\rho\cdot(y_0)^2}{2\cdot m}\cdot A\cdot i\_43\begin{vmatrix} 0.157\,if\left(0.1\le\frac{y_0}{a}\le 0.73\right) \\ \left(0.033\frac{y_0}{a}+0.133\right)if\left(0.73\le\frac{y_0}{a}\le 0.082\right) \\ \left[3.9\left(\frac{y_0}{a}\right)^2-6.4194\frac{y_0}{a}+2.8025831\right]if\left(0.082<\frac{y_0}{a}\le 0.91\right) \\ \left(1.5\frac{y_0}{a}-1.176\right)if\left(0.91<\frac{y_0}{a}\le 1.0\right) \\ \left[-1.6\left(\frac{y_0}{a}\right)^2+3.7632\frac{y_0}{a}-1.8287616\right]if\left(1.0<\frac{y_0}{a}\le 1.18\right) \\ \left(0.384\sin\left(\frac{1.85}{\frac{y_0}{a}}\right)\right)if\left(1.18<\frac{y_0}{a}\le 1.62\right) \\ \left(0.29\frac{1}{\frac{y_0}{a}}+0.172\right)if\left(1.62<\frac{y_0}{a}\le 3.06\right) \\ \left(-0.011\frac{y_0}{a}+0.301\right)if\left(3.06<\frac{y_0}{a}\le 3.53\right) \\ 0.259\,if\left(3.53<\frac{y_0}{a}\le 5.0\right) \end{vmatrix} \\ \frac{-g\cdot(\cos(y_1))^2}{y_0} \\ y_0\cdot\cos(y_1) \\ y_0\cdot\sin(y_1) \end{bmatrix}$$

Below we give an example of the matrix $D(t,y)$ for the description of the ARL and the system of ODEs (1) by using the cubic spline. The import of the table-valued function of ARL is carried out from an external file. Its can be the text «.txt» file or the Microsoft Excel «.xls» file[7].

$$D(t,y):=\begin{bmatrix} -g\cdot\sin(y_1)-\dfrac{\rho\cdot(y_0)^2}{2\cdot m}\cdot A\cdot i\_43\cdot interp(cspline(vel,C_d),vel,C_d,y_0) \\ \dfrac{-g\cdot(\cos(y_1))^2}{y_0} \\ y_0\cdot\cos(y_1) \\ y_0\cdot\sin(y_1) \end{bmatrix}$$

Alternatively, the data for the ARL may not be imported from the file, but be part of the *D(t, y)* matrix. In this case, data are written in the form of row-matrices (separated for velocities and separately for C_d data). Next, as in the previous example, we use cubic spline interpolation.

$$D(t,y):=\begin{bmatrix} -g\cdot\sin(y_1)-\dfrac{\rho\cdot(y_0)^2}{2\cdot m}\cdot A\cdot i\_43\cdot \begin{bmatrix} vel\leftarrow\begin{pmatrix}0 & 200 & 400 & \bullet & \bullet\end{pmatrix}^T \\ C_d\leftarrow\begin{pmatrix}7.105e-15 & 4.921 & 51.533 & \bullet & \bullet\end{pmatrix}^T \\ interp(cspline(vel,C_d),vel,C_d,y_0)\end{bmatrix} \\ \dfrac{-g\cdot(\cos(y_1))^2}{y_0} \\ y_0\cdot\cos(y_1) \\ y_0\cdot\sin(y_1) \end{bmatrix}$$

Four black circles in two lines (*vel* and C_d) symbolize the remaining elements of the matrix-lines *vel* (tabulated instantaneous velocity) and C_d (drag coefficient). The sign of T denotes the matrix transposition.

The following Mathcad command-line is showed using the solver-function *rkfixed* for the numerical solution of (1) (Kir'yanov, 2012, p.259):

$$Num\_Result := rkfixed(y,\ t_{beg},\ t_{end},\ n_{point},\ D)\ .$$

[7] Variables *vel*, *Cd* should be described as global variables. They are introduced to the matrix *D(t, y)* using the «READFILE» Mathcad function.

The solver-function *rkfixed* is implemented in the non-stiff fourth order Runge-Kutta numerical method with a fixed step. More information about the integration of ODEs in Mathcad can be found in (Khaikov, 2018, p.298).

Calculations. Calculations were performed for the ARL of the 1943 year for 4 C_d-types (RF, R&EF, piecewise, spline-function) and 2 types of the Ciacci ARL (analytical and spline-function). The variable *Num_Result* is the matrix that contains the results of the numerical solution of (1). In this case, the matrix has the dimension of 5 × 1001 elements and contains 5005 numbers. Five columns of the Num_Result matrix are: independent argument TOF (t); and elements of the matrix y (or D) namely v, θ, x, y. 1001 rows are the sum of 1 (initial condition) and n points. The first row of the matrix *Num_Result* includes $t(0)$, $v(0)$, $\theta(0)$, $x(0)$, $y(0)$. The first column of the matrix *Num_Result* contains 1001 discrete TOF values: from $t_{beg} = t(0)$ to t_{end} . The 5-by-1001 matrix from the second to fifth columns (in each of them) has 1001 values of the quantities v, θ, x, y respectively. This means that we have 1001 values of instantaneous velocity, 1001values of θ, 1001 values of x and so on.

It was shown previously that for obtaining two trajectories with the same horizontal range but characterized by different ARLs, it is necessary to make selection of ballistic coefficients. This procedure allows obtaining sufficiently close forms of both ballistic trajectories. However, due to the fact that the bullet movement for each flight path is determined by the intrinsic ARL, then the bullet retardation process will not coincide with «twins-trajectories». For a comparison of dependencies between the elements of ODEs (1), the method developed in (Khaikov, 2018, p.281-303) will be used below. The solution of system (1) is represented as a five-dimensional space. Each element of this 5D-space is a function between the variables (x, y, θ, v) and the argument (t), obtained as a result of numerical solution (1). The angle θ is calculated in angular minutes (or minute of angle (MOA). Since the solution of system (1) depends on the ballistic coefficient, it becomes possible to compare the same-named dependencies (x_1, y_1, θ_1, v_1, t_1), (x_2, y_2, θ_2, v_2, t_2) obtained for different values of the coefficients c_1 and c_2. The entire set of relations between the variables and the independent argument of (1) is presented in Table 4.The order of the values (x, y, θ, v, t) location in the *5-by-1001* matrix *Num_Result* and in Table 4 is different.

Table 4 – Structure of the relations for ODEs parameters (1) for two ARLs
Таблица 4 – Структура соотношений параметров системы дифференциальных уравнений (1) при различных законах сопротивления
Табела 4 – Структура односа параметара ОДЈ (1) за два закона отпора ваздуха

		X_1, X_2	Y_1, Y_2	θ_1, θ_2	V_1, V_2	T_1, T_2
		1	2	3	4	5
X_1, X_2	1	X_1 vs X_1 X_2 vs X_2	X_1 vs Y_1 X_2 vs Y_2	X_1 vs θ_1 X_2 vs θ_2	X_1 vs V_1 X_2 vs V_2	X_1 vs T_1 X_2 vs T_2
Y_1, Y_2	2	Y_1 vs X_1 Y_2 vs X_2	Y_1 vs Y_1 Y_2 vs Y_2	Y_1 vs θ_1 Y_2 vs θ_2	Y_1 vs V_1 Y_2 vs V_2	Y_1 vs T_1 Y_2 vs T_2
θ_1, θ_2	3	θ_1 vs X_1 θ_2 vs X_2	θ_1 vs Y_1 θ_2 vs Y_2	θ_1 vs θ_1 θ_2 vs θ_2	θ_1 vs V_1 θ_2 vs V_2	θ_1 vs T_1 θ_2 vs T_2
V_1, V_2	4	V_1 vs X_1 V_2 vs X_2	V_1vs Y_1 V_2vs Y_2	V_1 vs θ_1 V_2 vs θ_2	V_1 vs V_1 V_2 vs V_2	V_1 vs T_1 V_2 vs T_2
T_1, T_2	5	T_1 vs X_1 T_2 vs X_2	T_1 vs Y_1 T_2 vs Y_2	T_1 vs θ_1 T_2 vs θ_2	T_1 vs V_1 T_2 vs V_2	T_1 vs T_1 T_2 vs T_2

- relationship between the variables of ODEs (1);
- relationship between variables (1) and argument (t);
- diagonal cells.

The graphs lying inside the green backgroundare the functions between the variables of ODE (1) (x, y, θ, v). The graphs located inside the blue background associate the variables with the argument TOF (t). The diagonal cells-graphs placed on a light yellow background of the graphics window show the functions depending on themselves, for example, «y is a function of y» and so on. A small red square on each of 25 graphs shows the starting point. If we plot a horizontal and vertical line through the starting points of any graph (see Figure 5), they will connect the starting points of the graphs along the vertical row and the horizontal line.

Results analysis. Determining the magnitude of the relative error (MRE) for pistol ballistics using two different ARLsis an important element of assessment. To do this, we find the MRE of the horizontal range, the height of the trajectory, the angle of inclination of the velocity vector and the instantaneous velocity as functions of TOF. The relative error is expressed in percent.

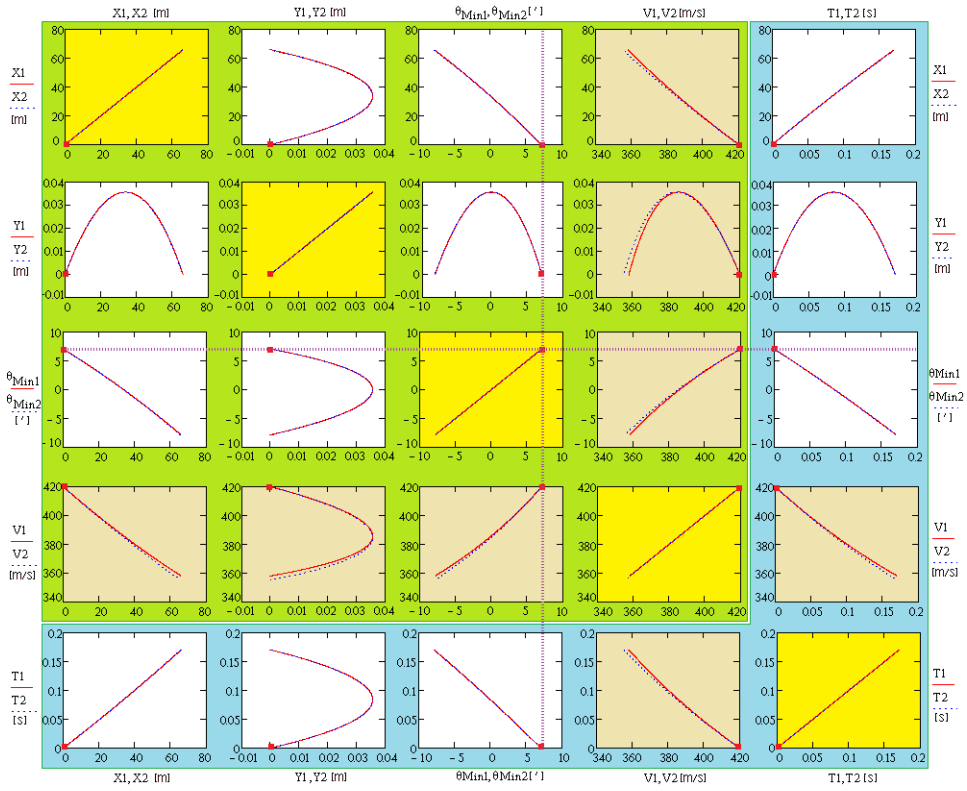

Figure 5 – Relationship between the ballistic parameters[8] ODEs (1) for ARL of Siacci (blue dotted line) and 1943 year (red solid line) (in accordance with Table 4)
Рис. 5 – Соотношение между баллистическими параметрами системы (1) при законах сопротивления воздуха Сиаччи (синяя пунктирная линия) и 1943 года (красная сплошная линия) (согласно табл. 4)
Слика 5 – Однос између балистичких параметара ОДЈ (1) за Siacci-јев закон отпора ваздуха (плава испрекидана линија) и закона из 1943. године (пуна црвена линија) (према табели 4)

Evaluation of the MRE for the horizontal range is

$$\delta_x(t) = 100\,\frac{\left|x(t)_{43} - x(t)_{Si}\right|}{x(t)_{43}}.$$

[8] each of 25 windows of Figure 5 contains 2 graphics, characterizing the ballistic parameters in relation to the 1943 ARL and the Siacci ARL.

The MRE for the height of the trajectory is

$$\delta_y(t) = 100\frac{|y(t)_{43} - y(t)_{Si}|}{y(t)_{43}}.$$

The evaluation of the MRE for the instantaneous velocity of the projectile is

$$\delta_v(t) = 100\frac{|v(t)_{43} - v(t)_{Si}|}{v(t)_{43}}.$$

The MRE for the angle of velocity vector relative to the base of a trajectory

$$\delta_\theta(t) = 100\frac{|\theta(t)_{43} - \theta(t)_{Si}|}{\theta(t)_{43}}.$$

The subscript «43» denotes that the calculations characterize the 1943 ARL and «Si» stands for Siacci.

The results of the calculations are shown in Figure 6. The MRE is found for a TOF interval of 0-1.1 s. The time of 1.1 seconds corresponds to the time of impact.

Figure 6a gives the function MRE of the horizontal range vs TOF $\delta_x(t)$ and the instantaneous velocity vs TOF $\delta_v(t)$. The results of the calculations and comparisons show that $\delta_x(t)$ and $\delta_v(t)$ are TOF-increasing functions. The maximum MRE for $\delta_x(t)$ is 0.3% for TOF 1.1 seconds. A function characterizing the MRE for the instantaneous velocity $\delta_v(t)$has a similar character (Figure 6a). The maximum value of this function is 0.8% (for the same TOF point).

The result of dividing the function $\delta_v(t)$ by the function $\delta_x(t)$ is shown in Figure 6b. Thus, the MRE for the instantaneous velocity is approximately 2.8-3 times larger than the MRE for the horizontal range.

In contrast to the functions mentioned above, the functions $\delta_\theta(t)$, $\delta_y(t)$ do not have an increasing character; moreover, they have discontinuities (Figures 6c, 6d). The discontinuity for the function $\delta_\theta(t)$ corresponds to the vertex of the trajectory. At this point, the angle θ is

zero (division by zero). The discontinuity for the function $\delta_y(t)$ corresponds to the point of impact. At this point, the height of the trajectory y is zero too and we have division by zero.

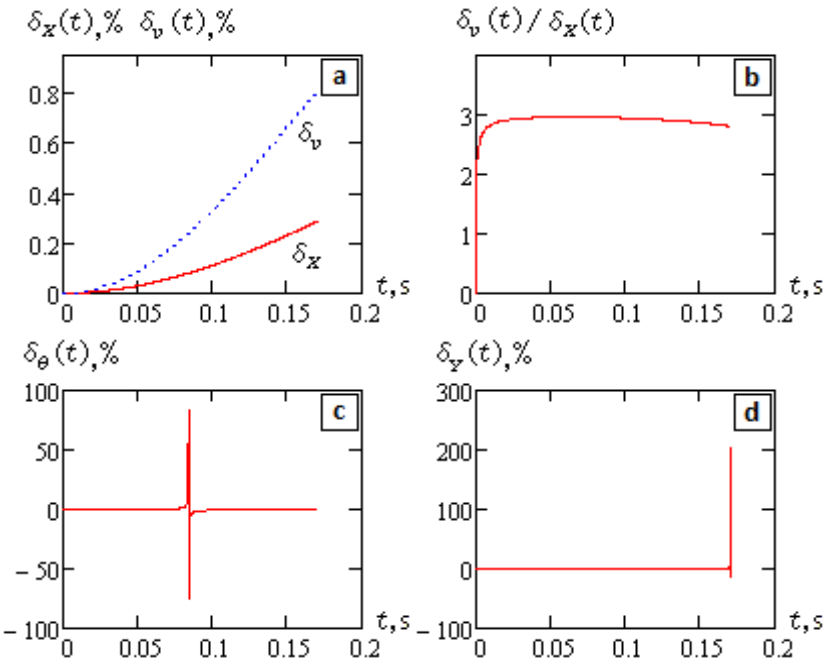

Figure 6 – Results of the error analysis: $\delta_x(t)$, $\delta_v(t)$, $\delta_\theta(t)$, $\delta_y(t)$

Рис. 6 – Результаты анализа погрешностей: функции $\delta_x(t)$, $\delta_v(t)$, $\delta_\theta(t)$, $\delta_y(t)$

Слика 6 – Резултати анализе грешака $\delta_x(t)$, $\delta_v(t)$, $\delta_\theta(t)$, $\delta_y(t)$

In contrast to the functions mentioned above, the functions $\delta_\theta(t)$ and $\delta_y(t)$ do not have an increasing character as functions $\delta_x(t)$ and $\delta_v(t)$; moreover, they have discontinuities. The discontinuity for the function $\theta(t)$ corresponds to the vertex of the trajectory (t = 0.084 s). At this point, the $\theta(t)$ = 0 (division by zero). The discontinuity for the function $\delta_y(t)$ corresponds to the point of collision (t = 1.1 s). At this point, the height of the trajectory is zero (division by zero).

Summary and conclusions

The evaluations and external ballistics trajectories of the TT pistol with 7.62×25mm Tokarev cartridge are given for two ARLs (the 1943 year and Siacci). The characteristic of the internal-ballistic period for the TT is shown. The calculation feature is to use various forms of the ARL mathematical notation: the classical analytical formulas, the piecewise formula and the function-tables form.

For the ARL of the 1943 year, a graphical interpretation of $C_d(i,v)$ function in the form of a surface and its main elements is visualized. Depending on the value of the form coefficient i, it is demonstrated how the standard drag-function $C_d(v)$ is transformed.

A method of graphical comparison of the ballistic trajectory parameters is represented. This comparison takes place in a 5×5 matrix.

It is shown that due to the selection of the ballistic coefficients, it is possible to obtain sufficiently close «twins-trajectories». However, in connection with the fact that the movement of the bullet in each of them is determined by different ARLs, then the slowing down of the bullet on each of them will have its own independent nature and therefore will not coincide with the «twins-trajectories».

The computer simulation considered for the ARLs of the 1943 year and Siacci for the 7.62×25 Tokarev cartridge indicates that the profiles of the function of instantaneous projectile velocity vs time of flight had the greatest non-coincidence in relation to other ballistic parameters (e.g. horizontal range, height of the trajectory, etc.) The obtained maximum of the relative error was 0.8%. Its magnitude localizes at the point of impact. The simulation results showed that the MRE for the instantaneous velocity is approximately 2.8-3 times larger than the MRE for the horizontal range.

Appendix

Analytical form of the cubic spline function that expresses the air resistance law of the 1943 year in the Mach number range from 0.1 to 4.0

The spline function $C_{d43_{CS}}(M)$ is given on the interval divided into 39 segments (parts). A cubic spline is a function that: on each segment there is a cubic polynomial and it has continuous first and second derivatives on the whole interval 0.1-4.0 *M*.Table 5 serves to describe a cubic spline $C_{d43_{CS}}(M)$ which is defined on 39 segments. All 39 parts of the spline function have the same length equal to 0.1 M.

$$C_{d43_{CS}}(M)=\begin{pmatrix} f_0(M) & LSB_0 \le M \le RSB_0 \\ .. & .. \\ f_i(M) & LSB_i \le M \le RSB_i \\ .. & .. \\ f_{38}(M) & LSB_{38} \le M \le RSB_{38} \end{pmatrix},$$

where $f_i(M)$ – the cubic polynomial assegments(parts) with the number i; LSB_i; RSB_i – the left and right segment borders; M – the Mach number as an argument of $C_{d43_{CS}}(M)$.

Each of the 39 cubic polynomials $f_i(M)$ has 4 coefficients. The total number of coefficients for $C_{d43_{CS}}$ is 156. The numbers in columns four through seven (Table 5) describe a polynomial in the form:

$$f_i(M)=a_{3i}M^3+a_{2i}M^2+a_{1i}M+a_{0i},$$

where a_3, a_2, a_1, a_0 – the calculated coefficients.

The spline function consisting of 39 segments and described by the coefficients from Table 5 is shown in Figure 7. All of the 39 cubic polynomials drawn in the same range of Mach numbers, i.e. in a range of 0.1- 4 M, give a large number of «branches». Figure 7 and Table 5 were obtained using software (Arndt Brünner, 2018).

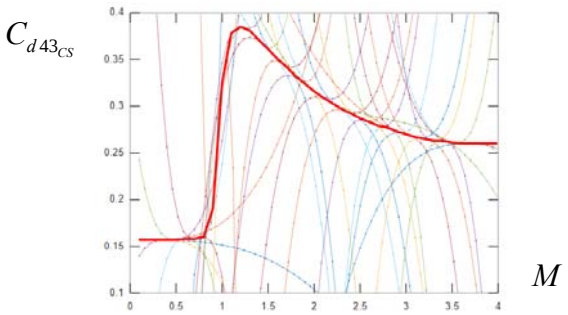

Figure 7 – Graphical construction of the Air Resistance Law of the 1943 year using 39 cubic polynomials in the MN range from 0.1 to 4 M
Рис. 7 – Графическое конструирование закона сопротивления воздуха 1943 года с помощью 39 кубических полиномов, диапазон 0.1-4 М
Слика 7 – Закон отпора ваздуха из 1943. године, графички приказан помоћу 39 кубних полинома у опсегу од 0,1 до 4 маха

Table 5 – Interval borders and coefficients of the cubic polynomials that describe the ARL of the 1943 year
Таблица 5 – Границы интервалов и коэффициенты, описывающие закон сопротивления воздуха 1943 года
Табела 5 – Границе и коефицијенти интервала кубних полинома који описују закон отпора ваздуха из 1943. године

Number	Borders		Coefficients of the cubic polynomials with the argument *M*			
	Left	Right	M^3	M^2	M^1	M^0
1	2	3	4	5	6	7
1	0.1	0.2	-0.00779	0.002337	-0.000156	0.157
2	0.2	0.3	0.038952	-0.025708	0.005453	0.156626
3	0.3	0.4	-0.148018	0.142565	-0.045029	0.161674
4	0.4	0.5	0.553119	-0.6988	0.291517	0.116801
5	0.5	0.6	-1.064459	1.727567	-0.921666	0.318999
6	0.6	0.7	1.704716	-3.256948	2.069043	-0.279143
7	0.7	0.8	-2.754406	6.10721	-4.485868	1.250336
8	0.8	0.9	35.312909	-85.254348	68.603379	-18.24013
9	0.9	1.0	-61.497231	176.13303	-166.645262	52.334463
10	1.0	1.1	23.676014	-79.386704	88.874473	-32.838782
11	1.1	1.2	2.793175	-10.473335	13.069766	-5.043723
12	1.2	1.3	0.151287	-0.962537	1.656809	-0.478541
13	1.3	1.4	1.601679	-6.619067	9.010297	-3.665052
14	1.4	1.5	-0.558002	2.451591	-3.688623	2.261111
15	1.5	1.6	0.630327	-2.89589	4.332598	-1.7495

Number	Borders		Coefficients of the cubic polynomials with the argument *M*			
	Left	Right	M^3	M^2	M^1	M^0
16	1.6	1.7	-0.963308	4.753562	-7.906526	4.778033
17	1.7	1.8	1.222906	-6.396132	11.047955	-5.96284
18	1.8	1.9	-0.928316	5.22047	-9.861929	6.583091
19	1.9	2.0	0.49036	-2.865984	5.502333	-3.147608
20	2.0	2.1	-0.033122	0.274906	-0.779447	1.040245
21	2.1	2.2	-0.357871	2.320827	-5.075881	4.047749
22	2.2	2.3	0.464608	-3.107534	6.866514	-4.710007
23	2.3	2.4	-0.500559	3.552115	-8.450678	7.033173
24	2.4	2.5	0.537628	-3.922831	9.489192	-7.318723
25	2.5	2.6	-0.649953	4.984029	-12.777958	11.237235
26	2.6	2.7	1.062185	-8.370651	21.94421	-18.85531
27	2.7	2.8	-1.598787	13.183226	-36.251257	33.52061
28	2.8	2.9	1.332964	-11.443485	32.703532	-30.837193
29	2.9	3.0	-0.733069	6.530999	-19.42247	19.551276
30	3.0	3.1	0.59931	-5.460413	16.551765	-16.42296
31	3.1	3.2	-0.664173	6.289986	-19.874472	21.217485
32	3.2	3.3	1.057383	-10.236952	33.011728	-35.194462
33	3.3	3.4	-1.565357	15.728176	-52.673194	59.058953
34	3.4	3.5	1.204047	-12.519753	43.369764	-49.789733
35	3.5	3.6	-0.250832	2.756477	-10.097038	12.588203
36	3.6	3.7	-0.200721	2.215277	-8.148718	10.250219
37	3.7	3.8	0.053714	-0.608947	2.300908	-2.637653
38	3.8	3.9	-0.014135	0.164534	-0.63832	1.085369
39	3.9	4.0	0.002827	-0.033925	0.13567	0.079182

The Internet online service (Arndt Brünner, 2018) can be used for cubic spline calculation and spline function visualization.

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КОМПЬЮТЕРНОЕ МОДЕЛИРОВАНИЕ ВНЕШНЕЙ БАЛЛИСТИКИ ПИСТОЛЕТА С ИСПОЛЬЗОВАНИЕМ ДВУХ РАЗЛИЧНЫХ ЗАКОНОВ СОПРОТИВЛЕНИЯ ВОЗДУХА (рассмотрение на примере пистолета 7.62 мм ТТ)

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Резюме:

Для пистолетов М54, М57 (7.62×25 Токарев патрон) собраны баллистические параметры характеризующие их баллистику. В статье дан расчёт внешнебаллистических траекторий для двух законов сопротивления воздуха: 1943 года и Сиаччи, при этом использованы разные виды их математической записи (классические аналитические формулы, формулы кусочного вида, а также функции-таблицы). Для решения баллистической системы дифференциальных уравнений при табличном задании функции сопротивления воздуха используются сплайны. Для закона 1943 года показана графическая интерпретация функции $C_d(i,v)$ в виде поверхности и её основные элементы. Показано, что такую поверхность можно построить для любого закона сопротивления воздуха. Показан способ графического сравнения баллистических траекторных параметров. Все вычисления выполнены в среде Mathcad 15, в статье приведён программный код расчёта. Показано, что за счёт подбора баллистических коэффициентов можно получить достаточно близкие по форме траектории. Однако в связи с тем, что движение пули по каждой из них определяется разными законами сопротивления воздуха, то замедление пули на каждой из них будет иметь свою собственную независимую форму и поэтому может не совпадать с «траекторией-двойником».

Ключевые слова: внешняя баллистика, пистолет М54, пистолет М57, патрон 7.62×25 ТТ, закон сопротивления воздуха, траектория пули, сплайн, Mathcad.

КОМПЈУТЕРСКА СИМУЛАЦИЈА СПОЉНЕ БАЛИСТИКЕ ПИШТОЉА ПРИМЕНОМ ДВА РАЗЛИЧИТА ЗАКОНА ОТПОРА ВАЗДУХА (на примеру пиштоља 7.62 мм ТТ)

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Сажетак:

За балистику метка пиштоља (пушке) карактеристична су два балистичка коефицијента која се односе на различите законе отпора ваздуха. Колико су сличне балистичке путање добијене помоћу различитих закона и какве су разлике између њих? У овом раду процењује се спољна балистичка путања на основу два закона оптора ваздуха (закон из 1943. године и Siacci-јев закон). Сви добијени резултати односе се на пиштољ ТТ са метком „токарев" калибра 7.62×25 мм. У раду је, такође, приказан начин израчунавања балистичке путање ако је закон отпора ваздуха изражен као рационална функција, прекидна функција или spline. Закон оптора ваздуха из 1943. године приказан је као графичка интерпретација функције $Cd\ (i,v)$ у облику површине. Показано је да је могуће добити довољно сличан облик балистичких путања захваљујући избору балистичких коефицијената. Представљен је метод графичког поређења спољних балистичких параметара, као и математички алати за квантитативну анализу облика балистичких кривих. Предложено је да се разлика између две путање одреди помоћу релативне грешке у односу на изабрани балистички параметар. Компјутерска симулација два поменута закона отпора ваздуха за зрно „токарев" калибра 7.62×25 мм показује да су профили функције односа тренутне брзине пројектила и времена лета имали највеће неподударање у односу на остале балистичке параметре (нпр. хоризонтални домет, висину путање, итд.). Највећа добијена вредност релативне грешке била је 0,8%, локализована у тачки удара.

Кључне речи: компјутерска симулација, спољна балистика, поштољ ТТ, закон отпора ваздуха, функција чеоног отпора, закон из 1943. године, путања зрна, spline, Mathcad

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BEST PRACTICE AS ACTUAL AND RELATIVE BENCHMARK TO INEFFICIENT UNITS: MULTISET DEA ANALYSIS

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Summary:

The direction in research of the efficiency of decision-making units in this paper is an efficient→multi-inefficient→multi-efficient unit. So, the general purpose of this paper is twofold: (1) identification of «hidden» inefficient units within a multi-set, among efficient units of the basic set, and (2) achieving the efficiency in such identified inefficient units. This indicates (warns of!) a negative efficient→inefficient process, so as to provide a timely response and thereby prevent multi-inefficiency. The specific goal is to assess the efficiency of the Serbian railway passenger stations, first within the basic set of the Passenger Transport Section Belgrade, then in the multi-set of the Passenger Transport Sections, and finally in the superset, the Passenger Transport Sector. This is achieved by means of the multi-set DEA (Data Envelopment Analysis) method, which is a system for: (i) relative efficiency assessment, in the first iteration, through the basic set analysis, and (ii) decrease in efficiency of potentially inefficient units, in subsequent iterations, through the multi-set analysis. The result is that the efficient stations Požarevac and Pančevo Bridge are at the initial level, and the (newly) efficient Požarevac, Novi Sad and Inđija at the final level. The best practice station remains the Požarevac Station, which is multi-efficient, and therefore the role model to inefficient stations. The conclusion is drawn that the solution resulting from the multi-set DEA analysis is more realistic, and less relative, because it applies to a wider analysed set of decision-making units, i.e., a larger coverage when considering the issue. This is important for fitting into the new era of growing globalization, and therefore our recommendation is the integral multi-set, as opposed to the individual single set approach.

Key words: Efficiency, Data Envelopment Analysis, Multi-Set Analysis, Railway Stations.

Introduction

A number of same-type organisational units within a single organisation jointly accomplish the objective of the organisation, thereby contributing to a higher or lesser extent. In order for the organisation to be successful, it is necessary for all of its units to be successful. Success is a multidimensional concept, with efficiency being one of its dimensions.

Efficiency is a feature of someone or somebody (people, institutions, organisations, companies, processes and other) to produce maximum output (products, services) using minimum input (resources, activities). Expressed in the simplest mathematical terms, it is the ratio of an output and an input. From a more complex mathematical point of view, it is a ratio between the weighted sum of multiple outputs and weighted sum of multiple inputs. For this purpose, the *Data Envelopment Analysis,* (DEA) was created in 1978 by *Charnes, Cooper* and *Rhodes* as a method of calculating the efficiency of the so-called *Decision Making Units,* abbreviated DMU), (Charnes et al, 1978).

The idea of this paper is to decrease the relativity and to increase the reality of the best practice through the iterative procedure "efficient→inefficient" (efficient unit in the basic set, inefficient in the multiset). Thus, success is a relative and changeable category and requires caution and constant reconsideration. With the view to the future, the goal of this paper is an early discovery of potentially inefficient so-called "hidden" units, and their respective timely redirecting.

Among numerous examples of best practices of similar companies, both local and foreign, the most suitable example is a so-called personal example, and that is the example of the same analysed set of measuring units. This is because all the units of the same company as means of their teamwork, under the same conditions, contribute to the accomplishment of a single goal. Logical conclusion is the requirement for all the units to proportionally contribute to this objective, whereby inefficient units imitate the efficient ones. And when those efficient units, acting as models for the inefficient ones, are "among us" or "ours", we believe that the efficiency can really be achieved.

On the one hand, the Sensitivity analysis of a single same set of decision making units, but applying different input/output data and opposite DEA models, results in the same efficiency (Vuković, 2016). On the other hand, the stated Multiset DEA analysis of the same data of decision-making units in a number of different, ever bigger sets, results in smaller or equal efficiency, so some efficient units become inefficient. By

application of the post DEA sensitivity analysis, newly efficient units become efficient in a wider set, a so-called multiset. Thus the research direction is efficient→multiinefficient→multiefficient units. From this point of view, the goal is two steps ahead: recognition of potentially inefficient units and achieving efficiency in a wider set. Multiset efficiency is more weighted than the monoset, as is it obatined by further decrease of input and/or increase of output, thereby improving the operation of units, which defines the contribution of our paper.

The following chapters include the overview of references, the short descriptions of the DEA method and the Multiset DEA analysis, as well as a numerical example, while the conclusion has been provided based on the stated information.

Overview of references

Having reviewed the newly published worldwide and local literature, we herewith provide the following observations:

1. Efficiency is monoset-oriented, where each decision-making unit is analysed in the same set. Examples of such sets include: 208 clinical commissions in England (Takundwa et al, 2017), 42 bus routes in Brisbane, Australia (Tran et al, 2017), and 55 universities in the state of Mexico (Sagarra et al, 2017). While in these works each unit is analysed in the same set, we here observe a unit in a wider scale, as an element of every bigger set. It is thus possible to compare the efficiency results obtained through multisets and to provide a more realistic assessment of efficiency.

2. The problem of the multiset prediction is not well known in the literature. According to certain authors, the problem is solved by consecutive decision-making, where a new multiset function of loss is proposed as a parameter of predictive policy (Welleck et al, 2017). According to others, the multiset approach is used to predict the average daily temperature, as shown by the Taipei example in Taiwan (Vamitha & Rajaram, 2015). In our paper, the Multiset DEA analysis of units is used for predicting inefficient results, which meant increasing the set of decision-making units by adding a new set. In this way, potentially inefficient units are more accurately predicted, which is helpful in solving the problems of multiset prediction.

3. The multiset theory differentiates between conventional and fuzzy logic. Conventional logic defines whether an element belongs to a set by "yes or no", whereas fuzzy logic does so by "more or less" (Pamučar et al, 2016). The Multiset DEA analysis is a connection between the

multiset theory and the DEA method. The stated analysis defines the simultaneous belonging of elements to a larger number of sets by "yes", with multiset efficient units. In addition, it also uses "yes", with multiset inefficient units. Realistically, a multiset is a family of a set of efficient and a set of inefficient units. Units "more or less" belong to a multiset, where units closer by efficiency belong to a multiset "more", and with the deviation "less".

4. Efficiency is dealt with without burdening the external society, but individually instead, within the scope of internal potential. The example of this case are premises used by institutions, command departments and units of the Serbian Army, where the application of thermal isolation is proposed to solve the problem of energy efficiency (Živković & Banjac, 2016). By applying the stated idea of using internal potential, we are solving a complex problem of efficiency of railway stations, with an additional idea of using its diverse potential, not just material but also organisational, and thereby achieving certain savings.

5. Organisational efficiency is impossible without the evaluation of the work of employees, which requires management so that it could be managed (maximised) in this way (Lukovac et al, 2014). Measurement of work at different levels by a multiset approach is a higher stage of comparison.

Core principles of DEA (Data Envelopment Analysis)

DEA is a method of mathematical programming for the calculation of efficiency and it is used, from a wider perspective, in economy, and more precisely, in different kinds of economics, depending on the type of decision making units. This is supported by numerous and diverse examples from the world and local literature, covering different types of Economics:

– Health Economics, where the effectiveness of health organizations is being decided upon (an example of this type of units is the public health system and the medical protection system of the OECD countries (Ozcan & Khushalani, 2017);

– Traffic Economics, where the effectiveness of transport organizations is being decided upon (examples are the Brazilian intermodal terminals), (Peixoto et al, 2017);

– Sports Economics, where the decision on the efficiency of sports organizations is being decided upon (for example, the football team of Serbia), (Petrović Đorđević, 2015);

– Tourism Economics, involving decision making on the efficiency of tourism organizations (e.g. ecotourism parks), (Lin et al, 2017);

– Business Economics, where the effectiveness of business organizations is being decided upon (for example, Taiwanese insurance companies), (Chen & Zhu, 2017);

– Economics of Education, where the decision making on the effectiveness of educational organizations is being decided upon (examples are Chinese educational organizations, from pre-school to higher education), (Si & Qiao, 2017);

The algorithm of the selection process with the DEA method application includes five steps, as presented in Figure 1.

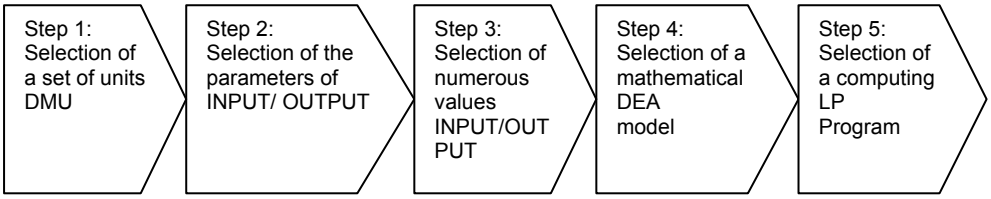

Figure1 – DEA method application algorithm
Рисунок 1 – Алгоритм применения АОД метода
Слика 1 – Алгоритам примене ДЕА методе

According to Figure 1, each example of a particular DEA method is characterised by the concrete: decision making units (DMU), input-output parameters (INPT/OUPT), numerous values of input and output, mathematical DEA model (Charnes et al, 1978), (Banker et al, 1984), (Yang et al, 2000), and a computer program (MS Excel Solver, LINDO, LINGO and other) for solving linear programming (LP) tasks, whose result is the efficiency value for each decision making unit.

By the application of the DEA method, decision making units are divided into two groups: efficient (Eff=1) and inefficient (0<Eff<1), while according to their numerical values they have a number of comparison stages, so it is possible to establish a ranking (complete or incomplete) of decision making units. Efficient units obtained based on the actual data are realistically best practice units, but they are also a substandard of efficiency as they are valid only for a concrete example (case study). Opposite to this is a generally applied standard which does not exist in this case, as there is no absolute efficiency.

Multiset DEA analysis

The Multiset DEA analysis is based on the fact that sets are not of exact size, but can be changed depending on the number of elements. Hence, the limit i.e. the final size of a set remains unknown. And it is exactly the issue of the limit of the set, being the analysis framework, which is significant for the efficiency value. The above analysis contains the principle that all the units outside the basic set break the ranking of the units of the basic set, by the value of efficiency, by analysing them in sets, which are at different (organizational, hierarchical) levels. A complete set is not known, so it is unknown which is the highest possible efficiency i.e. only experiential efficiency is known.

Similar to Savić's idea (Savić, 2017) that the algorithm should be applied several times, whereby a single input or output is added in each iteration, the idea of our paper is to add more decision-making units to each iteration, i.e. a new set of DMUs which represent a single organizational unit. However, while in the previously stated reference "turning" points among the iterations referred to the inputs/outputs (qualitative characteristics of the DMU), the "turning" points here are the sets of DMUs (quantitative characteristics). Changing qualitative features or changes of content are a feature of a systemic approach, while the change in quantitative characteristics or changes in the size of a set of features, discussed herewith, is a multi-set approach.

The multiset DEA analysis estimates the efficiency of the decision-making unit, where a unit is an element in each iteration of a new wider set. The first DEA model which we will use, from which many modified models are devised, is the CCR model (Charnes et al, 1978) whose multiset mathematical formulation consists of sets of decision making units in which the goal function is maximized with the set limits, Table 1.

According to Table 1, the Multiset DEA analysis is an iterative process of maximizing the function of the objective h_0 (efficiency) under the given restrictions, in ever increasing set till the final total sum set of all p basic sets (BSp).

The idea of the Multiset analysis is contrary to the idea of the post DEA Sensitivity Analysis. The Sensitivity analysis yields targeted activities (target values of inputs and outputs), which by the realization of an inefficient unit become effective. Contrary to this, the Multiset analysis is a kind of prediction that produces non-targeted (undesirable) inefficient units, by making some efficient units inefficient in the multiset, Figure 2.

Table 1 – Multi-Set DEA Analysis Mathematical Model
Таблица 1 – Математическая модель Мульти-множественного АОД анализа
Табела 1 – Математички модел мултискуповне ДЕА анализе

Multi-set model	DEA model	Meaning of symbols
DMUj∈{OS1}V{OS2}V… {OSp} {OS1}U{OS2}U … U{OSp}={NS} OS1={DMU1, DMU2, …, DMUa} OS2={DMUa+1,…, DMUb} ... OSp={DMUd+1, … , DMUg}	$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$ $\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1$ $j = 1, \dots n$ $u_r \ge 0, r = 1, \dots, s$ $v_i \ge 0, i = 1, \dots, m$	h_0 –efficiency of DMU for which is calculated y_{rj} – output of j DMU x_{ij} – input of j DMU n – number of DMU m – number of input s – number of ourput u_r – weighted coefficient of r output v_i – weighted coefficient of i input p – no. of OS $a,b,c...,d,...,g$ – no. of elements of BS

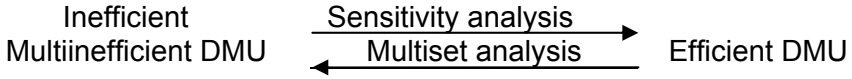

Figure 2 – Two-way process of efficiency change
Рисунок 2 – Двунаправленный процесс изменения эффективности
Слика 2 – Двосмерни процес промене ефикасности

According to Ljubisav Rakić: "The position of science in the century which has begun is to change the methodology. Instead of studying why something happened, we should move in the direction of predicting and studying of what could happen." (Rakić, 2017)

The essence of the Sensitivity analysis is as follows: (1) improving the efficiency of decision making units, and (2) aiming at proportionally equal contribution of all units of a set to the common goal of the company. The essence of opposite, multiset approach is viewing the units in a wider context.

The philosophy of the multiset approach may be explained by a modern theory included in the quotation of Stuart Diamond: "Each ceiling is a new floor", expressed in such a way to say that we could always get more (but not everything), which is also the name of his book (Diamond, 2015, p.36). Applied to the topic of our paper, provided efficiency is the

ability to maximise the results with the least possible investment - it means that by widening the analysed set by inclusion of new units we can get the efficiency of higher weight (the efficiency of the units of the basic set decreases or remains the same with multiset efficient units).

Within the context of the multiset DEA analysis of efficiency, this means that the current efficiency is disturbed by inclusion of new units and may always be overcome by new units included in the set of the analysed units, and thus new efficient units are being formed.

If, according to Marjanović (Vešović et al, 2007), the basic goals of the company are survival, facilitation of survival (efficiency of operation) and progress, then within the context of the multiset approach:

1. The current state of the set indicates: the survival (the organisation is operating with both efficient and inefficient units).

2. Targeted state of the set obtained by the Sensitivity analysis marks: Facilitating survival (as a result of targeted activities, all inefficient units become efficient).

3. Higher targeted state of the set obtained by Multiset DEA analysis marks: Progress (as the result of increase in the size of the set, the criterion for reaching efficiency has become more demanding, as the former efficient units with the same values of input-output parameters become inefficient). Therefore, the efficiency in a larger set is more weighted than the efficiency in smaller set.

Real evaluation of the efficiency for the previous period is performed by solving the preferred DEA model, or Ex-post evaluation of efficiency (backwards evaluation) for each of the analysed units of decision making. The sensitivity analysis provides the desired estimation for the future period or Ex-ante evaluation of efficiency (forward evaluation), only for inefficient units of decision making (efficient decision making units already have the desired efficiency for the unit).

Case study: Railway stations of IŽS Company

The Multiset DEA analysis is a universal system for the evaluation of efficiency of entities and their arrangement according to a given efficiency, within diverse numeric examples. However, with each individual application, it is necessary for entities to be of the same kind, as it is widely known and logical that comparison makes sense only in such circumstances. A realistic example of such entities are Serbian railway passenger stations, which are subject of our research with the aim of illustrating the stated analysis. But, why railway, why railway stations and why at this moment?

Railway is a type of transport for passengers and goods, used for civil purposes, for transporting people and equipment, and also for military purposes. Theoretically, its advantages are numerous and important in terms of transport power, traffic safety, spatial acquisition, consumption of energy, emissions of harmful substances, noise and other, which make it competitive. Railway stations are important infrastructure facilities in the transport process; apart from this, they are numerous, and financially valuable. They are also important to us as a place of departures and arrivals, loadings and unloadings. In the new era of business, according to the principle of a liberal, supranational market, it is compulsory for companies to be efficient and trending for continuous improvement. Hence, it is necessary to continuously monitor and comply with complex and expensive interoperability flows. To this purpose, a case study: Serbian Railway Passenger Stations.

On the one hand (theoretically), Serbian railway passenger stations are decision making units (DMU) within the DEA method, and on the other hand (practically), railway stations (RS) are infrastructural facilities within the *Infrastruktura železnica* Srbije Company (IŽS), Table 2. Six-set DEA analysis following the enlargement of a single-set example (Vuković, 2016).

Table 2 – Example in practice of the Serbian railways
Таблица 2 – Пример из практики сербских железных дорог
Табела 2 – Пример из праксе српских железница

DEA method			IŽS company		
DMU as element of DEA			RS as element of IŽS		
Superset	Set	Subset	Railway station	Section	Sector
LS 73 DMU	BS1 16 DMU	DMU1	Belgrade	1.Passanger Transport Section Belgrade (including OU Pančevo and OU Požarevac)	Passenger Transport Sector
		DMU2	Mladenovac		
		DMU3	Rakovica		
		DMU4	Zemun		
		DMU5	Batajnica		
		DMU6	Novi Belgrade		
		DMU7	Pančevo Bridge		
		DMU8	Resnik		
		DMU9	Pančevo Main		
		DMU10	Vršac		
		DMU11	Pančevo Town		

DEA method			IŽS company		
DMU as element of DEA			RS as element of IŽS		
Superset	Set	Subset	Railway station	Section	Sector
		DMU12	Požarevac		
		DMU13	Smederevo		
		DMU14	Mala Krsna		
		DMU15	Vranovo		
		DMU16	Radinac		
	BS2 12 DMU	DMU17	Lapovo	2. Passanger Transport Section Lapovo (including OU Kraljevo)	
		DMU18	Jagodina		
		DMU19	Stalać		
		DMU20	Paraćin		
		DMU21	Velika Plana		
		DMU22	Ćuprija		
		DMU23	Ćićevac		
		DMU24	Palanka		
		DMU25	Kraljevo		
		DMU26	Kragujevac		
		DMU27	Raška		
		DMU28	Čačak		
	BS3 12 DMU	DMU29	Niš	3. Passenger Transport Section Niš (with OU Zaječar)	
		DMU30	Leskovac		
		DMU31	Pirot		
		DMU32	Dimitrovgrad		
		DMU33	Vranje		
		DMU34	Palilulska Rampa		
		DMU35	Crveni Krst		
		DMU36	Aleksinac		
		DMU37	Zaječar		
		DMU38	Knjaževac		
		DMU39	Negotin		
		DMU40	Bor		
	BS4 18 DMU	DMU41	Novi Sad	4. Passenger Transport Section Novi Sad (including OU Ruma and OU Zrenjanin)	
		DMU42	Beška		
		DMU43	Čortanovci		
		DMU44	Sremski Karlovci		
		DMU45	Vrbas		
		DMU46	Odžaci		
		DMU47	Zmajevo		
		DMU48	Petrovaradin		

DEA method			IŽS company		
DMU as element of DEA			RS as element of IŽS		
Superset	Set	Subset	Railway station	Section	Sector
		DMU49	Ruma		
		DMU50	Šabac		
		DMU51	Šid		
		DMU52	Inđija		
		DMU53	Stara Pazova		
		DMU54	Nova Pazova		
		DMU55	Sremska Mitrovica		
		DMU56	Zrenjanin		
		DMU57	Zrenjanin Factory		
		DMU58	Kikinda		
	BS5 8 DMU	DMU59	Subotica	5. Passenger Transport Section Subotica	
		DMU60	Sombor		
		DMU61	Sonta		
		DMU62	Prigrevica		
		DMU63	Senta		
		DMU64	Bogojevo		
		DMU65	Žednik		
		DMU66	Horgoš		
	BS6 7 DMU	DMU67	Užice	6. Passenger Transport Section Užice	
		DMU68	Požega		
		DMU69	Priboj		
		DMU70	Valjevo		
		DMU71	Prijepolje		
		DMU72	Lazarevac		
		DMU73	Lajkovac		

Based on Table 2, there are 73 railroad stations within the network of Serbian Railways. They are organized in two levels: (1) Passenger Transport Sector, at a higher organizational level; and (2) Passenger Transport Section, at a lower organizational level. The sector includes six sections, four of which have organizational units (OU), as a lower organizational level. The seats of the Sections (Belgrade, Lapovo, Niš, Novi Sad and Subotica) are important railway hubs, where more lines are obtained, with more intensive traffic volumes, and are commercially significant places. By the very nature of their operation, the mutual cooperation of the Sections is very important because they are connected: (1) physically, by railroad tracks; (2) organizationally, by

traffic connections (both railways and connections are usually administered by two or more Sections). Hence, it is important that they are all efficient, in order to maintain the continuity of the technological process of work. Namely, the inefficiency of one of them jeopardizes the efficiency of any other.

If we select the following input/output parameters as follows:

– The man: "basic factor of each production, including the production of transport or post office service. It simultaneously appears as its organiser, manager and executor." (Vešović et al, 2007. p.186),

– Produced service: "Standard measure of the volume of the whole economy is the gross domestic product (GDP), which represents the value of all gods and services produced in an economy within a year." (Stiglitz, 2008, p.38),

– Wok performance: the purpose, and therefore the point of performing the works, is to gain profit,

then the following parameters are selected in our case according to the given logic: (i) number of cashiers (entry 1), (ii) number of dispatched trains (entry 2), (iii) number of dispatched passengers (exit). The sources of the concrete data for our case include:

– Job classification within the company in 2010: number of cashiers, (Železnice Srbije, 2010);

– Timetable 2013/2014: number of trains, (Železnice Srbije, 2013);

– Statistics of Serbian Railways 2013: number of passengers, (Železnice Srbije, 2014).

The option A of the multi-set DEA analysis analyses units in each basic set individually (left side of Table 3) and units in the total sum superset (right side of Table 3). The application of the CCR DEA model from Table 1 results in the values of efficiency of decision making units evaluated by *MS Excel Solver* to six decimal numbers, Table 3.

According to Table 3, the application of the Section analysis resulted in the total of 12 efficient units, which are the best practice units, whereas the Sector analysis resulted in only three efficient units: Požarevac, Novi Sad and Indjija. The remaining nine, DMU7,18,24,25,30,37,59,66 and 67, so called ‘’hidden’’ inefficient units, have been discovered by the analysis of the superset of Sectors, where they become inefficient.

This indicates the sensitivity of the DEA method to a change in a set size. A quotation of Andersen and Petersen states (Andersen & Petersen, 1993, p.1261): *A weakness of DEA is that a considerable number of observations typically is characterized as efficient, unless the sum of the number of inputs and outputs is small relative to the number of observations*.

Table 3 – Decision-making unit efficiency in the basic sets and in a superset
Таблица 3 – Эффективность единиц принятия решений в основном множестве и надмножестве
Табела 3 – Ефикасност јединица одлучивања у основним скуповима и надскупу

VARIANT A							
No of BS.	DMU no.	Efficiency (0–1]	Quantity of efficient units	SS	DMU no.	Efficiency (0–1]	Quantity of efficient units
Basic set 1	DMU1	0.879175	2	Superset	DMU1	0.798903	3
	DMU2	0.192230			DMU2	0.170841	
	DMU3	0.206022			DMU3	0.175874	
	DMU4	0.164341			DMU4	0.140289	
	DMU5	0.361602			DMU5	0.308687	
	DMU6	0.181727			DMU6	0.155137	
	DMU7	**1.000000**			DMU7	0.961284	
	DMU8	0.093544			DMU8	0.079853	
	DMU9	0.359357			DMU9	0.341007	
	DMU10	0.862869			DMU10	0.765826	
	DMU11	0.323213			DMU11	0.298594	
	DMU12	**1.000000**			DMU12	**1.000000**	
	DMU13	0.603945			DMU13	0.533680	
	DMU14	0.302814			DMU14	0.258497	
	DMU15	0.100037			DMU15	0.087856	
	DMU16	0.139338			DMU16	0.122371	
Basic set 2	DMU17	0.113290	3		DMU17	0.039702	
	DMU18	**1.000000**			DMU18	0.350449	
	DMU19	0.248430			DMU19	0.075714	
	DMU20	0.757351			DMU20	0.164219	
	DMU21	0.589529			DMU21	0.148776	
	DMU22	0.312563			DMU22	0.100666	
	DMU23	0.267623			DMU23	0.083624	
	DMU24	**1.000000**			DMU24	0.345956	
	DMU25	**1.000000**			DMU25	0.256134	
	DMU26	0.633900			DMU26	0.137451	
	DMU27	0.466613			DMU27	0.123317	
	DMU28	0.913229			DMU28	0.304692	
Basic set 3	DMU29	0.982846	2		DMU29	0.674760	
	DMU30	**1.000000**			DMU30	0.660572	
	DMU31	0.306841			DMU31	0.204181	
	DMU32	0.259709			DMU32	0.172817	

VARIANT A							
No of BS.	DMU no.	Efficiency (0–1]	Quantity of efficient units	SS	DMU no.	Efficiency (0–1]	Quantity of efficient units
Basic set 3	DMU33	0.439482			DMU33	0.148063	
	DMU34	0.249361			DMU34	0.165932	
	DMU35	0.555812			DMU35	0.187271	
	DMU36	0.647396			DMU36	0.367192	
	DMU37	**1.000000**			DMU37	0.877614	
	DMU38	0.490002			DMU38	0.320747	
	DMU39	0.472408			DMU39	0.303723	
	DMU40	0.767057			DMU40	0.468147	
Basic set 4	DMU41	**1.000000**	2		DMU41	**1.000000**	
	DMU42	0.488504			DMU42	0.488504	
	DMU43	0.266385			DMU43	0.266385	
	DMU44	0.148627			DMU44	0.148627	
	DMU45	0.544243			DMU45	0.544243	
	DMU46	0.126275			DMU46	0.126275	
	DMU47	0.307956			DMU47	0.307956	
	DMU48	0.133064			DMU48	0.133064	
	DMU49	0.215982			DMU49	0.215982	
	DMU50	0.327164			DMU50	0.327164	
	DMU51	0.340419			DMU51	0.340419	
	DMU52	**1.000000**			DMU52	**1.000000**	
	DMU53	0.732659			DMU53	0.732659	
	DMU54	0.522205			DMU54	0.522205	
	DMU55	0.422567			DMU55	0.422567	
	DMU56	0.387019			DMU56	0.387019	
	DMU57	0.022979			DMU57	0.022979	
	DMU58	0.041560			DMU58	0.041560	
Basic set 5	DMU59	**1.000000**	2		DMU59	0.477291	
	DMU60	0.721202			DMU60	0.321932	
	DMU61	0.558896			DMU61	0.178442	
	DMU62	0.584930			DMU62	0.186759	
	DMU63	0.166865			DMU63	0.074945	
	DMU64	0.063039			DMU64	0.020127	
	DMU65	0.873175			DMU65	0.278792	
	DMU66	**1.000000**			DMU66	0.443437	

VARIANT A							
No of BS.	DMU no.	Efficiency (0–1]	Quantity of efficient units	SS	DMU no.	Efficiency (0–1]	Quantity of efficient units
Basic set 6	DMU67	**1.000000**	1		DMU67	0.774963	
	DMU68	0.602181			DMU68	0.296396	
	DMU69	0.691438			DMU69	0.470662	
	DMU70	0.955143			DMU70	0.508139	
	DMU71	0.661295			DMU71	0.419728	
	DMU72	0.521605			DMU72	0.191992	
	DMU73	0.135552			DMU73	0.049899	
Totally efficient units			12	Totally efficient units			3

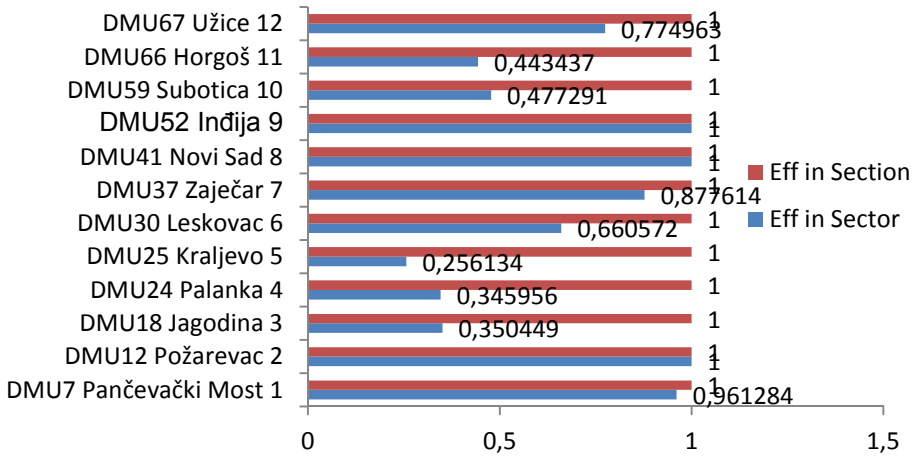

Figure 3 – Best practice units in the Section (12 units) and the Sector (3 units)
Рисунок 3 – Единицы передовой практики в Секции (12 единиц) и Секторе (3 единицы)
Слика 3 – Јединице најбоље праксе у секцији (12 јединица) и сектору (3 јединице)

The ratio between the Sector efficiency (Eff≤1) and the Section efficiency (Eff=1), for 12 efficient units in the Section, may be seen from the graph presented in Figure 3. The highest span is of DMU25 which is on the verge of efficiency (0.256134/1), with the achieved 25.6% of the goal. The lowest span is with the DMU7, which is firmly efficient (0.961284/1), with the achieved 96.1% of the target.

For the variant B of the multiset DEA analysis, through the iterative procedure, the number of DMUs gradually increases by adding the units of the following basic unit to Basic set 1, up to the superset size, Table 4.

Table 4 – Efficiency of decision-making units in BS1 and aggregate sets
Таблица 4 – Эффективность единиц принятия решения в ОМ1 и суммарных множествах
Табела 4 – Ефикасност јединица одлучивања у ОС1 и збирним скуповима

VARIANT B						
DMU no.	Efficiency					
	1st iteration (16DMU)	2nd iteration (28DMU)	3rd iteration (40DMU)	4th iteration (58DMU)	5th iteration (66DMU)	6th iteration (73DMU)
DMU1	0.879175	0.879175	0.879175	0.798903	0.798903	0.798903
DMU2	0.192229	0.192229	0.192229	0.170841	0.170841	0.170841
DMU3	0.206021	0.206021	0.206021	0.175874	0.175874	0.175874
DMU4	0.164340	0.164340	0.164340	0.140289	0.140289	0.140289
DMU5	0.361602	0.361602	0.361602	0.308687	0.308687	0.308687
DMU6	0.181726	0.181726	0.181726	0.155137	0.155137	0.155137
DMU7	**1.000000**	**1.000000**	**1.000000**	0.961284	0.961284	0.961284
DMU8	0.093543	0.093543	0.093543	0.079853	0.079853	0.079853
DMU9	0.359357	0.359357	0.359357	0.341007	0.341007	0.341007
DMU10	0.862869	0.862869	0.862869	0.765826	0.765826	0.765826
DMU11	0.323213	0.323213	0.323213	0.298594	0.298594	0.298594
DMU12	**1.000000**	**1.000000**	**1.000000**	**1.000000**	**1.000000**	**1.000000**
DMU13	0.603944	0.603944	0.603944	0.533680	0.533680	0.533680
DMU14	0.302814	0.302814	0.302814	0.258497	0.258497	0.258497
DMU15	0.100036	0.100036	0.100036	0.087856	0.087856	0.087856
DMU16	0.139337	0.139337	0.139337	0.122371	0.122371	0.122371
DMU17		0.044929	0.044929	0.039702	0.039702	0.039702
DMU18		0.396589	0.396589	0.350449	0.350449	0.350449
DMU19		0.088672	0.088672	0.075714	0.075714	0.075714
DMU20		0.177537	0.177537	0.164219	0.164219	0.164219
DMU21		0.157789	0.157789	0.148776	0.148776	0.148776
DMU22		0.111534	0.111534	0.100666	0.100666	0.100666
DMU23		0.092086	0.092086	0.083624	0.083624	0.083624
DMU24		0.389268	0.389268	0.345956	0.345956	0.345956
DMU25		0.287488	0.287488	0.256134	0.256134	0.256134
DMU26		0.148598	0.148598	0.137451	0.137451	0.137451
DMU27		0.143906	0.143906	0.123317	0.123317	0.123317
DMU28		0.349139	0.349139	0.304692	0.304692	0.304692

VARIANT B						
DMU no.	Efficiency					
	1st iteration (16DMU)	2nd iteration (28DMU)	3rd iteration (40DMU)	4th iteration (58DMU)	5th iteration (66DMU)	6th iteration (73DMU)
DMU29			0.809804	0,674760	0,674760	0,674760
DMU30			0.762116	0,660572	0,660572	0,660572
DMU31			0.237283	0,204181	0,204181	0,204181
DMU32			0.200835	0,172817	0,172817	0,172817
DMU33			0.173450	0,148063	0,148063	0,148063
DMU34			0.192833	0,165932	0,165932	0,165932
DMU35			0.219377	0,187271	0,187271	0,187271
DMU36			0.408825	0,367192	0,367192	0,367192
DMU37			0.922098	0,877614	0,877614	0,877614
DMU38			0.369195	0,320747	0,320747	0,320747
DMU39			0.348028	0.303723	0.303723	0.303723
DMU40			0.529783	0.468147	0.468147	0.468147
DMU41				**1.000000**	**1.000000**	**1.000000**
DMU42				0.488504	0.488504	0.488504
DMU43				0.266385	0.266385	0.266385
DMU44				0.148627	0.148627	0.148627
DMU45				0.544243	0.544243	0.544243
DMU46				0.126275	0.126275	0.126275
DMU47				0.307956	0.307956	0.307956
DMU48				0.133064	0.133064	0.133064
DMU49				0.215982	0.215982	0.215982
DMU50				0.327164	0.327164	0.327164
DMU51				0.340419	0.340419	0.340419
DMU52				**1.000000**	**1.000000**	**1.000000**
DMU53				0.732659	0.732659	0.732659
DMU54				0.522205	0.522205	0.522205
DMU55				0.422567	0.422567	0.422567
DMU56				0.387019	0.387019	0.387019
DMU57				0.022979	0.022979	0.022979
DMU58				0.041560	0.041560	0.041560
DMU59					0.477291	0.477291
DMU60					0.321932	0.321932
DMU61					0.178442	0.178442
DMU62					0.186759	0.186759
DMU63					0.074945	0.074945
DMU64					0.020127	0.020127

VARIANT B						
DMU no.	Efficiency					
	1st iteration (16DMU)	2nd iteration (28DMU)	3rd iteration (40DMU)	4th iteration (58DMU)	5th iteration (66DMU)	6th iteration (73DMU)
DMU65					0.278792	0.278792
DMU66					0.443437	0.443437
DMU67						0.774963
DMU68						0.296396
DMU69						0.470662
DMU70						0.508139
DMU71						0.419728
DMU72						0.191992
DMU73						0.049899

According to Table 4, in the 1st, 2nd and 3rd iteration the units DMU7 and 12 are efficient. The fourth iteration is ‘’decisive”, as in further 4th, 5th and 6th iterations, the efficient units include DMU12, 41 and 52.

The comparative results of the research of the Variants A and B of the Multiset DEA analysis indicate the units which should be further improved (highlighted), and the unit which remains efficient (bold), Table 5. This further indicates the relativity of efficiency, as practices are best, some in supersets, some however in basic sets.

Considering the efficient units from the monoset viewpoint, set BS1 should be partially improved, i.e. just one efficient unit (DMU7), sets BS2, BS3, BS5 and BS6 should completely improve their efficient units, while set BS4 "strong" is a set with both multiefficient units.

Unit DMU7 is multiinefficient due to the fact that it has been discovered as potentially inefficient within the multiset of fourth iteration and further to the superset. Based on this, target activities resulting from the Sensitivity analysis are proposed based on deceasing the input and/or increasing the output. Opposite to this, DMU12 unit is a multiset efficient unit, as it still remains as efficient as in the first set after the increase of the analysed set.

As the Passenger Transport Sector does not include the decision making units by which the analysed set would be enlarged, it is possible to add hypothetical units with hypothetical data in future observations and thus establish the complete ranking. In such future iterations, with new hypothetical units, it is necessary to further decrease the investment and/or increase the result for achieving efficiency.

Table 5 – Result of the Multiset DEA analysis (Variant A, Variant B)
Таблица 5 – Результат мульти-множественного АОД анализа (Вариант А, Вариант Б)
Табела 5 – Резултат мултискуповне ДЕА анализе (варијанта А, варијанта Б)

Variant A		Variant B			
Basic set	Efficient	Basic set and aggregate basic sets	Efficient	Multi-efficient	Multi inefficient
BS1	DMU7 **DMU12**	BS1	DMU7 **DMU12**	**DMU12**	DMU7
BS2	DMU18 DMU24 DMU25	BS1+BS2	DMU7 **DMU12**	**DMU12**	DMU7
BS3	DMU30 DMU37	BS1+BS2+BS3	DMU7 **DMU12**	**DMU12**	DMU7
BS4	**DMU41 DMU52**	BS1+BS2+BS3+BS4	**DMU12 DMU41 DMU52**	**DMU12**	–
BS5	DMU59 DMU66	BS1+BS2+BS3+BS4+BS5	**DMU12 DMU41 DMU52**	**DMU12**	–
BS6	DMU67	BS1+BS2+BS3+BS4+BS5+BS6	**DMU12 DMU41 DMU52**	**DMU12**	–

In conclusion, based on the numerical example, the following three definitions are provided:

– Definition 1: When a DMU is analysed in relation to other units in a bigger set, the DMU efficiency numerical value is smaller or equal to the efficiency obtained when a DMU is analysed in relation to other units in a smaller set. The estimation by the Multiset DEA analysis in a wider set is more restrictive than the evaluation by the monoset approach: $Eff^{multiset} \leq Eff^{set}$.

– Definition 2: When a DMU is analysed in relation to other units in an aggregate set, the number of efficient units is smaller than the total number of efficient units when units are analysed in relation to other units within the basic set:

$$N_{EffDMU}{}^{multiset} \leq \Sigma N_{EffDMU}{}^{set}.$$

– Definition 3: Multiset efficient unit is efficient in both a basic set and a superset: $Eff_{MSEff} = 1(BS, SS)$.

Additional clarification of efficiency, apart from the numerical value of efficiency, also includes the number of decision making units of the analysed set. It is a kind of weighted efficiency according to which efficient units are different and therefore comparable.

Conclusion

After reading the papers of the first and subsequent authors on the subject of the DEA method, it can be learnt that efficiency is a relative feature, as it varies depending on the data analysed. Additionally, the fact that this change may not only be positive (from inefficient to efficient unit), but also a negative one (from efficient to inefficient) has been ignored. Hence, the result of efficiency is only an estimate, and not an evaluation, that is, a final approximate value of efficiency.

With such more profound knowledge in mind, the objective of this paper is to acknowledge potentially inefficient units in order to avoid the previously stated negative process (efficient – inefficient), and sustain efficiency in such a way. In this regard, the Multiset DEA analysis has been proposed, which has also been explained from the theoretical point of view and practically illustrated, while in the end the research results were presented.

Theoretically, the Multiset DEA analysis is a mathematical way of calculating the efficiency of business operations of entities from different areas. The efficiency evaluations obtained by the Multiset analysis are re-evaluated, whereby new estimations of efficiency are equal or smaller than the previous ones, which implies very important information on potentially inefficient units.

Practically, the Multiset DEA analysis is illustrated at an actual example of Serbian railway passenger stations, which are an important part of both the railway segment and the environment. As a part of the changing environment, military sector is a more or less significant customer of transport services. We would like to mention in our paper the best practice units, Pančevački Most (DMU7) and Požarevac (DMU12) stations, within the Passenger Transport Section Belgrade, as well as Požarevac, Novi Sad and Indjija within the Passenger Transport Sector. The stated stations are: (i) an actually achievable model for inefficient units, (ii) a "live" proof of potential efficiency, and (iii) a confirmation of the application of the DEA method. The Požarevac station is a multiset

efficient station, as it is efficient in the Sector, while DMU7 is potentially inefficient as it becomes inefficient in the Sector.

Based on the results, with certain units we expect a negative process (efficient→multineffecinet). Now that we know what awaits us, our future research will definitively be the Sensitivity analysis. This is the logical order (or a post DEA analysis) as it provides concrete target values of input-output parameters (smaller inputs and/or higher outputs), which is necessary to realise in practice so that multiinefficient units can become multiefficient. Targeted activities are different in each iteration and every time, and in any larger set. There is no doubt that with them in the future, efficient units of the basic set become stable, and they remain as efficient in the end as in the beginning. Therefore, the actual efficiency indicator is not only a pure numerical value, but also the number of units included in the analysis, which makes efficiency additionally defined. The extension of the case would include new inputs and outputs as characteristics of other subsystems, i.e. an analysis of the so-called DAT approach using sets and systems.

Additionally, future research refers to providing measures which encourage activities, and then measures possible to apply in concrete conditions. Now we will make a general proposal for better conversion input/output:

– New rational technology for the operation of stations (rational number of station personnel, rational redistribution of work, modernisation of operations, etc.);

– New rational organisation of railway transport (rational number of shares i.e. fewer trains, more departures, fewer "empty" lines, shorter stays and turning and line stations, which is to be achieved by a quality made timetables, etc.);

– Improved quality of transport service (timely departures, regular trains, comfort, providing information to passengers, travel without changing trains, accessibility of stations, diverse fee-related benefits etc.).

According to the presented system and the analogy to the case shown, the efficiency of entities from other activities may also be calculated, with completely different types of data (apart from the applied traffic-transport and demographic, economic and other statistical data). In the spirit of this magazine, we will mention organisational units, institutions and individuals of the Serbian Army, which is, similarly to the railway, a significant and complex, and above all, extremely important organisational system.

Through constant innovation lasting for a number of decades, the DEA model of mathematical programming has become a subject of significant and important number of works which present the modified models and contemporary examples. In terms of such tendency, the presented subject of DEA is not a completely closed issue, but it instead eagerly waits for new ideas and new examples, all with a wider comprehension of the notion of efficiency.

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ПЕРЕДОВАЯ ПРАКТИКА В КАЧЕСТВЕ РЕАЛИСТИЧНОГО И ОТНОСИТЕЛЬНОГО ПРИМЕРА ДЛЯ ПОДРАЖАНИЯ ДЛЯ НЕЭФФЕКТИВНЫХ ЕДИНИЦ: МУЛЬТИ-МНОЖЕСТВЕННЫЙ АОД АНАЛИЗ

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Резюме:

Исследования эффективности единиц принятия решения в настоящей работе проводились в следующем направлении: эффективная→мульти-неэффективная→мульти-эффективная единица. Следовательно, цель настоящей работы – предусмотреть несколько шагов заранее, таких как: (1) идентификация "скрытых" неэффективных единиц в мульти-множестве, среди эффективных единиц в основном множестве, (2) осуществление эффективности в случаях идентифицированных неэффективных единиц. Таким образом указывается (предупреждается!) на отрицательный процесс эффективная→неэффективная, и создается возможность для своевременного реагирования, в том числе и для предупреждения мульти-неэффективности. Конкретной целью настоящей работы является оценка эффективности сербских вокзалов и железнодорожных пассажирских станций, прежде всего в основном

множестве Секции пассажирского транспорта Белград, а затем в мульти-множестве Секции пассажирского транспорта, и в конце в надмножестве – Секторе пассажирского транспорта. Это осуществляется с помощью применения мульти-множественного АОД метода (Анализ охвата данных), который представляет собой систему: (и) оценки относительной эффективности, в первой итерации, путем анализа основного множества, (ии) снижения эффективности потенциально неэффективных единиц, в последующих итерациях, путем анализа мульти-множества. В результате – эффективные станции Пожаревац и Панчевачки мост находятся на начальном уровне, а (ново)эффективные Пожаревац, Нови Сад и Инджия, на последнем уровне. Станция Пожаревац на практике остается лучшей станцией, и по своей мульти-эффективности является примером для подражания неэффективным единицам. Можно сделать вывод, что решение мульти-множественного АОД анализа в большей степени реалистично и в меньшей степени относительно, поскольку применимо к более широкому анализируемому множеству единиц принятия решения, то есть к большему охвату рассмотрения проблемы. Данные показатели являются весьма значимыми, особенно, если учитывать тенденции возрастающей глобализации, в данной связи мы рекомендуем интегральный мульти-множественный подход, в отличии от индивидуального единично-множественного подхода.

Ключевые слова: эффективность, анализ среды функционирования, мульти-множественный анализ, железнодорожные станции.

НАЈБОЉА ПРАКСА КАО РЕАЛАН И РЕЛАТИВАН УЗОР НЕЕФИКАСНИМ ЈЕДИНИЦАМА: МУЛТИСКУПОВНА ДЕА АНАЛИЗА

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ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Правац истраживања ефикасности јединица одлучивања у овом раду јесте ефикасна→мултинеефикасна→мултиефикасна јединица, а општи циљ су два корака напред: (1) откривање „скривених" неефикасних јединица у мултискупу, међу ефикасним јединицама у основном скупу и (2) постизање ефикасности код

Vuković, D., Best practice as actual and relative benchmark to inefficient units: multiset DEA analysis, pp.525-550

откривених неефикасних јединица. Тиме се указује (упозорава!) на негативан процес ефикасна→неефикасна, како би се правовремено реаговало и тиме предупредила мултинеефикасност. Конкретни циљ јесте да се процени ефикасност железничких путничких станица у Србији, најпре у основном скупу Секције за превоз путника Београд, затим у мултискупу Секција за превоз путника и, на крају, у надскупу Сектор за превоз путника. То се постиже мултискуповном методом ДЕА (Data Envelopment Analysis), што је систем за: (и) процењивање релативне ефикасности, у првој итерацији, анализом основног скупа, (ии) смањење ефикасности потенцијално неефикасних јединица, у наредним итерацијама, анализом мултискупа. Резултат је да су ефикасне станице Пожаревац и Панчевачки мост на почетном нивоу, а (ново)ефикасне Пожаревац, Нови Сад и Инђија на крајњем нивоу. Најбоља пракса је у станици Пожаревац, која је мултиефикасна и представља узор неефикасним јединицама. Закључује се да је решење мултискуповне ДЕА анализе више реално, а мање релативно, јер важи за шири анализирани скуп јединица одлучивања, тј. већи обухват сагледавања проблема. То је значајно за уклапање у ново доба растуће глобализације, те је наша препорука целовит мултискуповни приступ насупрот појединачном моноскуповном приступу.

Кључне речи: ефикасност, Data Envelopment Analysis, мултискуповна анализа, железничке станице.

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CHARACTERIZATION OF THE VACUUM PLASMA SPRAYED VPS-Ti/TiC COMPOSITE COATING

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Summary:

The paper analyzes the VPS - Ti / TiC composite coating. The powder was deposited at low pressure with an F4 plasma gun produced by Plasma Technik AG because of the influence of the environment on powder oxidation. The main goal of the work was to prevent low-pressure decomposition of TiC cubic carbide into TiO_2 and $NiTiO_3$ oxides that reduce: adhesion, cohesive strength, TiC hardness, and abrasion resistance to wear. The mechanical properties and the structure of the Ti / TiC coating were analyzed in accordance with the Pratt & Whitney standard. The microhardness values of the coating layers were in the range of 750-837 $HV_{0.3}$, and the substrate/coating bond strength was 84 MPa. The coating microstructure was examined by the light microscopy technique. The distribution of TiC in the Ti base is uniform and the deposited layers are obtained without segregation effects. The coating structure consists of titanium layers with β - Ti and α - Ti modifications and TiC cubic layers. In the microstructure, there are unmelted TiC particles present in a smaller share as well as micropores that did not affect the coating strength. The tests showed that the VPS - Ti / TiC composite coating has good mechanical properties and a good microstructure, which fully enables its application on substrates of biomedical implants.

Keywords: microstructure, coatings.

Introduction

Materials used for biomedical implants must meet a number of requirements which are often mutually exclusive. Different parts of the

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elements require different material properties. These factors often make the production of medical implants harder when using one type of material. Many implant elements, such as knee replacements, only include relative movement between the components while functioning. In such conditions, polyethylene applied on supporting metal surfaces is currently widely used. However, although polyethylene as a whole is biologically inert in the body, microscopic polyethylene particles formed by wear may be poisonous if present in large quantities and they can lead to osteolysis (Pancanti et al, 2003, pp.777-785), (Atala et al, 2010), (Amstutz & Le Duff, 2012, pp.275-282), (Hamilton et al, 2013, pp.96-100). This has led to an increasing interest in the fabrication of supporting surfaces of metal-on-metal implants, especially in applications involving a large contact surface (Liu et al, 2005, pp.319-328), (Haruna et al, 2017, pp.95-101), (Goldsmith et al, 2000, pp.39-47), (Xia et al, 2017, pp.1205-1217). The metal-on-metal approach requires that the supporting surfaces be extremely hard and resistant to wear. Manufacturing a whole implant out of a hard material is not acceptable, because such hard materials would be too brittle to use. The best approach is the application of appropriate hard surface layers on the supporting surfaces of the implant. This approach allows the production of implants with biocompatible materials with the desired properties, and the surface requirements are met with biocompatible hard surface layers. Although the application of surface coatings is certainly an advantage, which is a great benefit in the process of implant making, there are, however, some issues relating to the coating materials that must satisfy some of the requirements, such as: coating material must be biocompatible, coatings must not be brittle or prone to other damage, coatings should have adequate hardness and wear resistance, and coating material should be metallurgically compatible with the carrier material of the implant. Most coating materials, such as carbides, borides, nitrides, and oxides (Al_2O_3, ZrO_2, CaO, etc.), easily meet hardness and abrasion resistance requirements, but they are brittle and often not metallurgically compatible with metal substrates of implants. It is difficult to apply hard monophase non-metallic materials on metal substrates due to residual stresses at the interface and inside the coating; this causes brittleness, cracking of coating particles, peeling and separating coating parts from the metal substrate of the implant. For example, depositing a coating of pure TiC on the Ti alloy substrate is undesirable because the coating cracks (Liu & DuPont, 2003, pp.1337-1342). This has led to the use of composite coatings consisting of a tough metal substrate and hard non-metallic materials evenly dispersed

in the metal substrate. In this way, a coating with the desired characteristics can be produced. A soft metal substrate provides toughness to the coating as well as the metallurgical compatibility / bonding with the substrate, while hard non-metallic material reinforces the coating and provides adequate hardness and resistance to wear. Another important issue is a coating application method. In this respect, a coating application method or process should enable the production of homogeneous and thick composite coatings. The coating must be able to achieve metallurgical bonding to the base material in order to achieve adequate adhesion and to allow a minimum heat input so as not to damage the microstructure and the mechanical properties of the base material. Today, Ti / TiC composite coatings are extremely suitable for application on parts of metal-on-metal implants exposed to excessive wear. These types of coatings can be especially used on commercial titanium alloys for the production of high performance implants. The method of protecting implant parts consists of the deposition of a mechanical mixture of commercial Ti and TiC powders of Ar inert gas at low pressure by the plasma spray process in a vacuum. Depending on the working conditions of the coating, the VPS process allows the deposition of composite coatings in different quantitative relationships between carbide and metal. At low pressure of the inert gas, the reaction of metal and carbide with the air is completely eliminated. The advantage of the process is the application of the transferred arc which cleans and preheats the substrate surface prior to depositing the powder thus increasing the adhesion and cohesive strength (Mrdak, 2017, pp.30-44). The properties of coating layers are directly connected to powder technology and powder deposition parameters. TiC is dark gray, with a low density of 4.93 g/cm³ and a high melting temperature of 3140 °C. TiC particles have shown great potential as a phase that reinforces the composite material due to its high hardness level, high modulus, low density and high thermal stability. TiC-based cermets have excellent resistance to wear, high temperature, chemical corrosion, oxidation, as well as a low coefficient of friction and density (Cai et al, 2013, pp.1681−1688). TiC coatings have superior resistance when exposed to abrasion. The Ti / TiC composite base can be another metal or alloy depending on different needs and applications. Due to its excellent corrosion resistance, high strength to weight ratio and biocompatibility, titanium is used as the carrier material for the fabrication of metal parts of implants in a large number of applications (Okazaki et al, 2001, pp.599-607). Ti has a polymorphism property, since it crystallizes from the liquid state to 1665 °C in a β-spatially centered cubic lattice, and when cooled

further to 882 °C it goes into an α-hexagonal tightly packed grid. Titanium is a metal with a low density of 4.5 g/cm^3, which in combination with good mechanical properties, such as high strength and hardness, gives high specific strength. The Ti/TiC coating consists of a mixture of coarse non-molten, partially molten and completely molten TiC particles uniformly distributed in the titanium base with β-Ti and α-Ti modifications. With the increase of the TiC content in the coating, the coating hardness and resistance to wear increases. Besides by the TiC content, the coating microhardness is also affected by the content, size and distribution of micropores in the deposited layers. The coating friction coefficient depends on the content of carbides in the coating. When the content of TiC particles increases, the coefficient of friction of composite coatings decreases. The friction coefficient decreases with the increase of the content of TiC particles in the coating.

The main objective of the paper is to deposit layers of coating with primary cubic titanium carbide (TiC) in a vacuum at low pressure of inert gas, which gives excellent resistance to wear, high temperature, oxidation and corrosion. Studies have shown that the VPS - Ti/TiC coating has good mechanical properties and a microstructure in which there are no oxides of TiO_2 and $NiTiO_3$. The coating layers have adhesion and cohesion strength values which are in agreement with the coating microstructure in which the primary cubic carbide TiC dominates, thus making such a coating capable of modifying the surface of biomedical implants.

Materials and experimental details

A VPS-Ti/TiC composite coating was made from a mixture consisting of a commercially pure Ti powder of 60 wt% and TiC of 40 wt%. The morphology of powder particles was examined on a scanning electron microscope (SEM). Powder particles are of irregular shape with sharp edges, obtained by a grinding technique with a powder range ranging from 45 μm to 150 μm. Figure 1 shows a SEM micrograph of Ti powder particles, and Figure 2 shows a SEM micrograph of TiC powder particles. The substrates on which the layers were deposited were made of steel Č.4171 (X15Cr13 EN10027).

In order to test the microhardness of the Ti-TiC composite coating layers, 70x20x1.5mm samples were made, while the samples for testing the bond strength had the dimensions of Ø25x50mm. The microhardness of the layers was assessed by the $HV_{0.3}$ method and the bond strength by tensile testing.

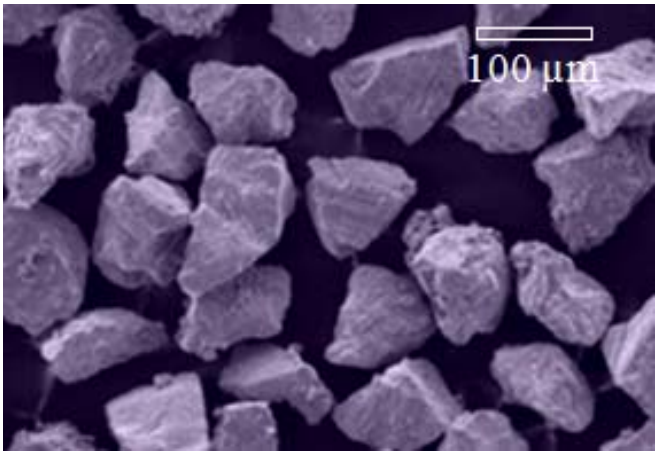

Figure 1 – (SEM) Shape of Ti powder particles
Рис. 1 – (SEM) Форма частиц порошка Ti
Слика 1 – (СЕМ) Облик честица праха Ti

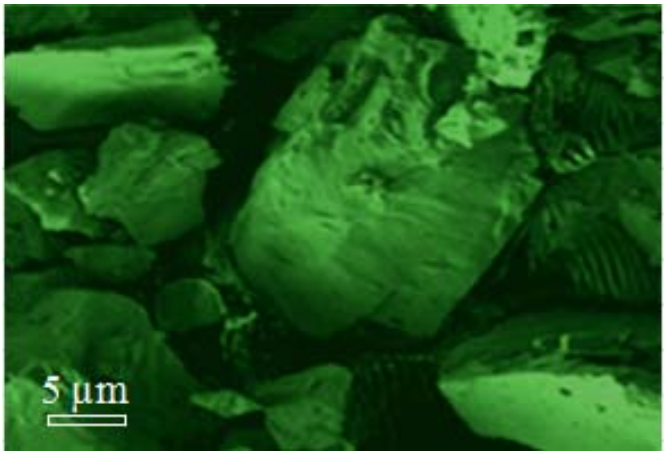

Figure 2 – (SEM) Shape of TiC powder particles
Рис. 2 – (SEM) Форма частиц порошка TiC
Слика 2 – (СЕМ) Облик честица праха TiC

In order to assess the coating homogeneity, the layer microhardness was measured in the direction along the lamellae, in the middle and at the ends of the samples. Five readings were carried out at three measuring points, and the microhardness range from the minimum to maximum value was displayed. The coating/substrate interface strength was tested by tensile testing with a tensile speed of 1mm/1min. Five test

specimens were used and the average values were presented in the report. The microstructure of the deposited layers was examined on a light microscope. The share of micropores in the coating was analysed by processing 5 micrographs at a magnification of 200x, and the report shows the average pore content in the coating. The coating mechanical and microstructural characteristics were examined in accordance with the standard (Pratt & Whitney, 2002).

Prior to the deposition of the mechanical mixture of Ti and TiC powders, the surfaces of the substrate were roughened with white corundum particles of 0.7 - 1.5 mm. The powder was deposited on the Plasma Technik AG system with a F4 plasma gun. The microprocessor unit of the VPS Plasma Technik AG has a program for depositing a powder mixture. All process parameters were included in the program, such as: chamber vacuuming, plasma gas flow, cleaning the substrate with a transferred arc, powder mixture flow, coating deposition rate, substrate cooling and vacuum chamber ventilation. The substrate surface was cleaned with a transferred arc using Ar / He gases. The powder mixture was deposited with a mixture of Ar/H_2 plasma gases. The coating was deposited with a thickness of 90-100 μm.

The plasma spray parameters of the Ti-TiC powder deposition on the samples are shown in Table1.

Tabela 1 – VPS parameters of the deposition of the Ti-TiC powder mixture
Таблица 1 – VPS параметры нанесения смеси порошков Ti-TiC
Табела 1 – VPS параметри депозиције мешавине праха Ti-TiC

Parameters	Values	
	Cleaning arc	Spraying
Plasma current, I (A)	500	745
Plasma Voltage, V (V)	65	74
Primary plasma gas flow rate, Ar (l/min)	50	40
Secondary plasma gas flow rate $He^{(1)}$,$H_2^{(2)}$, (l/min)	10 (1)	8.5 (2)
Carrier gas flow rate (l/min)	--	4
Powder feed rate, (g/min)	--	15
Stand-off distance, (mm)	290	270
Chamber pressure (mbar)	40	80
Nozzle diameter, (mm)	8	8
Speed of the gun, (mm /s)	250	250

Results and discussion

Along the lamellar microstructure of the Ti / TiC coating, the microhardness values range from 750 $HV_{0.3}$ to 837 $HV_{0.3.}$ The measured values indicate that the coating microstructure contains an undeveloped primary carbide phase TiC due to the powder deposition in an inert atmosphere of Ar at low pressure, which is confirmed by the analysis of the microstructure of the coating layer on a microscope (OM). Such a microhardness range of the deposited layers of the Ti / TiC composite coating is caused by the influence of softer Ti layers, a hard TiC carbide phase, and the presence of micropores. The tensile strength of the bond between the metal substrate and the Ti / TiC composite coating is 84 MPa. High tensile bond strength values are generally characteristic of deposited coatings in a vacuum. The roughening of the metal substrate surface and the subsequent cleaning of the substrate surface with a transferred arc at low pressure resulted in a better adherence of molten powder particles to the substrate, which led to a high adhesion value. The values of microhardness and tensile bond strength are always in correlation with the microstructure of layers.

Figures 3 and 4 are the micrographs of the structure of the deposited layers of VPS - Ti / TiC composite coatings. The qualitative analysis has shown that there are no defects in a form of discontinuity of the deposited layers, microcracks, macrocracks and separation of the coating layers from the substrate at the interface. In some places, at the substrate/coating interface, there are dark areas formed by TiC carbide particle exctraction during the sample preparation. This effect is known as pull out and, in the micrograph, it is clearly visible that these dark areas retain the morphology of an original TiC carbide particle with its angular and sharp edges.

The boundary at the substrate/coating interface is extremely clean, indicating that the substrate surface was perfectly cleaned with a transferred arc. Dark micropores of irregular shape are present in the coating layers at the lamellar borders of Ti and TiC carbides. The average value of the share of micropores was 2.7%. A smaller part of the coating contains unmelted TiC particles that are irregular in shape and darker in the micrograph. The Ti/TiC composite coating microstructure shows that the Ti and TiC layers are uniformly deposited without segregation, which is crucial for the coating good resistance to wear.

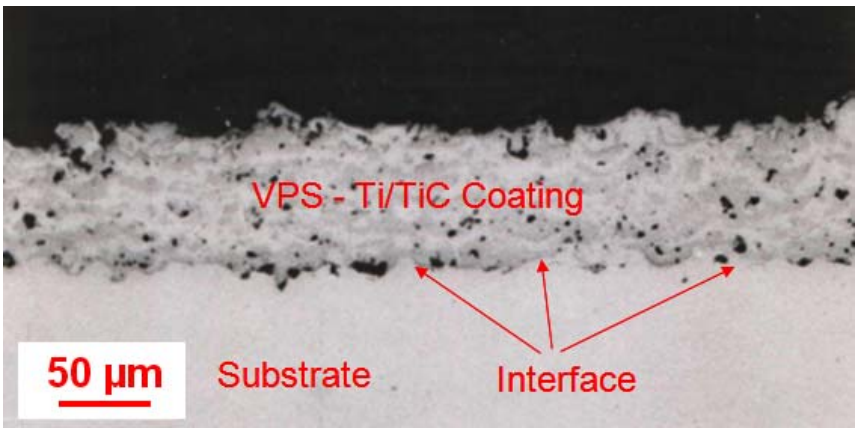

Figure 3 – (OM) Microstructure of the Ti-TiC coating in a deposited state
Рис. 3 – (ОМ) Микроструктура нанесенного покрытия Ti-TiC
Слика 3 – (ОМ) Микроструктура Ti-TiC превлаке у депонованом стању

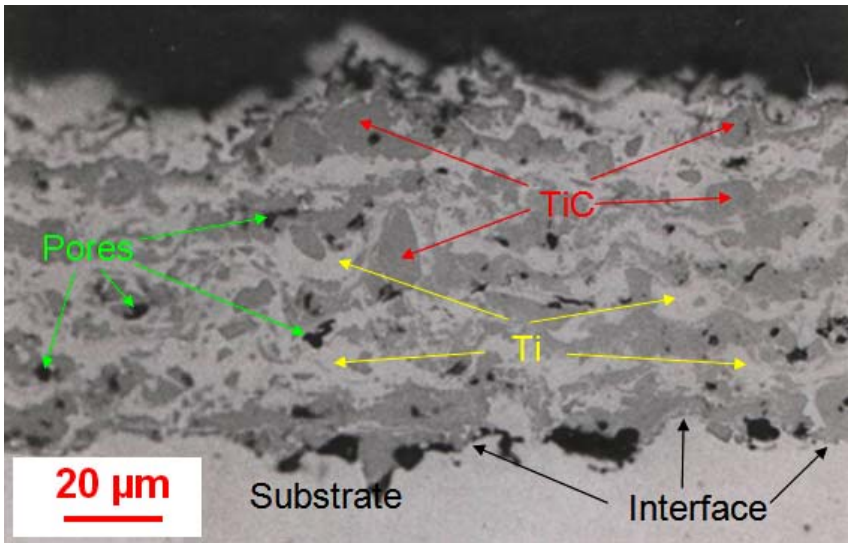

Figure 4 – (OM) Microstructure of the Ti-TiC coating in a deposited state
Рис. 4 – (ОМ) Микроструктура нанесенного покрытия Ti-TiC
Слика 4 – (ОМ) Микроструктура Ti-TiC превлаке у депонованом стању

Through the coating layers, no precipitates are observed, and longitudinal oxide lamellae are not observed at the interlamellar boundaries either. This confirms that the vacuum plasma spray process

allows the deposition of coating layers without the content of TiO_2 and $NiTiO_3$ oxides which reduce the coating mechanical properties, thus showing a great advantage over other thermal spray processes. The microstructure of the Ti / TiC cermet coating is lamellar with good interlamellar bonding of longitudinal Ti lamellae which form the basis of the coating composed of β-Ti and α-Ti modifications and longitudinal lamellae of TiC cubic carbide. Good interlamellar bonding in the deposit increases microhardness values and fracture toughness, as confirmed by mechanical tests of the coating. The inner layers of the coating are free of microcracks. The tests have shown that the VPS - Ti / TiC composite coating has such mechanical and structural properties which allow it to be used in exploitation on parts of implants exposed to wear and corrosion of liquids of living tissues.

Conclusion

In this work, the vacuum plasma spray process was used for depositing Ti/TiC composite coating layers. The mechanical characteristics and the microstructure of the coating in the deposited state were analyzed, based on which the following conclusions were drawn.

The vacuum plasma sprayed Ti/TiC composite coating had the microhardness values of 750 $HV_{0.3}$ to 837 $HV_{0.3}$. The adhesion strength between the composite coating and the substrate had a high value of 84 MPa. Cleaning the substrate surface with a transferred arc led to a better adhesion of molten particles, which reflected in the resulting adhesion value. The microhardness and adhesion strength of the Ti/TiC composite coating bond were in correlation with the microstructure of the deposited layers.

The coating microstructure is lamellar with uniformly distributed lamellae of the basic Ti coating composed of β and α modifications and longitudinal lamellae of Ti cubic carbide. At the interlamellar surfaces, there is a share of micropores of 2.7%. Through the coating layers, the segregation of the TiC carbide phase in the Ti base is not observed, which enables uniform wear of the coating in exploitation.

The vacuum plasma sprayed Ti/TiC composite coating has good mechanical and structural characteristics, and the goal was to produce a coating of increased resistance to wear and corrosion for its application in biomedicine to modify the surface of parts of biomedical implants.

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ХАРАКТЕРИСТИКИ КОМПОЗИТНОГО ПОКРЫТИЯ VPS-Ti/TiC, НАНЕСЕННОГО ВОЗДУШНО-ПЛАЗМЕННЫМ НАПЫЛЕНИЕМ

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ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной статье представлены характеристики композитного покрытия VPS – Ti/TiC. В цели предотвращения воздействия окружающей среды на оксидацию покрытия, порошок был нанесен под низким давлением с помощью плазматрона «F4» от производителя «Plasma Technik AG». Цель настоящего исследования заключалась в предотвращении разложения кубического карбида TiC на оксиды TiO2 и NiTiO3, которые снижают: адгезию, прочность сцепления, твердость TiC и износостойкость покрытия. В статье приведен анализ механических характеристик и структуры покрытия Ti/TiC в соответствии с требованиями стандарта Pratt & Whitney. Микротвердость слоев покрытия была в пределах 750 - 837 HV0.3, а твердость сцепления покрытия с основой составляла 84 MPa. Микроструктура покрытия испытана с помощью световой микроскопии. Распределение TiC в основе Ti было равномерным, а в нанесенных слоях покрытия не было эффектов сегрегации. Структура покрытия состоит из слоев титана с β - Ti і α – Ti модификациями и слоев кубического TiC. В микроструктуре покрытия выявлено небольшое количество нерасплавленных частиц TiC, а также микропоры, которые не влияют на твердость покрытия. Испытания показали, что композитное покрытие VPS – Ti/TiC обладает благоприятными механическими свойствами и микроструктурой, благодаря которым данный вид покрытия можно применять в изготовлении медицинских имплантов.

Ключевые слова: микроструктура, покрытия.

КАРАКТЕРИСТИКЕ КОМПОЗИТНЕ ПРЕВЛАКЕ VPS – Ti/TiC НАНЕТЕ ВАКУУМ ПЛАЗМА СПРЕЈОМ

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ОБЛАСТ: хемијске технологије
ВРСТА ЧЛАНКА: оригинални научни чланак
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Сажетак:

У раду су представљене карактеристике композитне превлаке VPS – Ti/TiC. Прах је депонован на ниском притиску плазма пиштољем F4, фирме Plasma Technik AG, због утицаја околине на оксидацију праха. Циљ је био да се на ниском притиску спречи разградња кубног карбида TiC у оксиде TiO_2 и $NiTiO_3$ који умањују: адхезију, кохезиону чврстоћу, тврдоћу TiC и отпорност превлаке на хабање. Анализиране су механичке карактеристике и структура Ti/TiC превлаке у складу са стандардом Pratt & Whitney. Микротврдоће слојева превлаке биле су у распону од 750 до 837 $HV_{0.3}$, а чврстоћа споја између превлаке и подлоге имала је вредност 84 MPa. Микроструктура превлаке испитана је техником светлосне микроскопије. Дистрибуција TiC у основи Ti је равномерна, а депоновани слојеви добијени су без ефеката сегрегације. Структура превлаке састоји се од слојева титана са β – Ti и α – Ti модификацијама и слојева кубног TiC. У микроструктури су у мањем делу присутне неистопљене честице TiC и микропоре које нису утицале на чврстоћу превлаке. Испитивања су показала да композитна превлака VPS – Ti/TiC има добре механичке особине и микроструктуру, које у потпуности омогућавају њену примену на субстратима биомедицинских имплантата.

Кључне речи: микроструктура, превлаке.

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ON SOME KNOWN FIXED POINT RESULTS IN THE COMPLEX DOMAIN: SURVEY

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Abstract:

In this survey paper, we consider some known results from the fixed point theory with complex domain. The year 1926 is very significant for this subject. This is the beginning of the research and application of the fixed point theory in complex analysis. The Denjoy-Wolf theorem, together with the Banach contraction principle, is one of the main tools in the mathematical analysis.

Keywords: fixed point, Jordan curve, analytic function, complex Banach space.

Introduction and preliminaries

Let f be an analytic map of the unit disk $D = \{z \in C : |z| < 1\}$ into

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itself. Now, we want to consider the fixed point of f and especially a lemma implies that f has at most one fixed point in D and some maps have no fixed point. If $f:\overline{D}\to\overline{D}$ is a continuous map, then f must have a fixed point in $\overline{D}$. From now on, we make the assumption that f is an analytic function on the open disk D.

Definition 1.1 *Suppose that f is an analytic map of the unit disk D into itself. We say that $a\in D$ is a fixed point of f if $f(a)=a$. Also, $a\in\partial D$ is a fixed point of f if $\lim_{r\to 1^-} f(ra)=a$.*

The Julia-Caratheodory theorem implies that if $a\in\partial D$ is a fixed point of f, then $\lim_{r\to 1^-} f(ra)$ exists (we call it $f'(a)$) and $0<f'(a)\le\infty$.

Theorem 1.2 (*The Denjoy-Wolf theorem from 1926.*) *If f is an analytic map of D into itself, but not the identity map, there is a unique fixed point a of f in $\overline{D}$ such that $|f'(a)|\le 1$.*

The point a in the above theorem is called the Denjoy-Wolff point of f.

The Schwarz-Pick Lemma implies that f has at most one fixed point in D and if f has a fixed point in D, it must be the Denjoy-Wolf point.

Example 1.3 1) *The mapping $f(z)=\dfrac{z+\frac{1}{2}}{1+\frac{z}{2}}$ is an automorphism of D with the fixed points 1 and -1, but the Denjoy-Wolff point is $a=1$ because $f'(1)=\dfrac{1}{3}$ $\left(f'(-1)=3\right)$.*

2) The mapping $f:D\to D$ given by $f(z)=\dfrac{z}{2-z^2}$ has three fixed points: 0, 1, and -1. The Denjoy-Wolff point is $a=0$ since $f'(0)=\dfrac{1}{2}$ and $f'(\pm 1)=3$.

3) The mapping $f(z)=\dfrac{2z^3+1}{2+z^3}$ is an inner function fixing 1 and -1, with the Denjoy-Wolff point $a=1$ because $f'(1)=1$ (note that $f'(-1)=9$).

4) The inner function $f(z)=\exp\left(\dfrac{z+1}{z-1}\right)$ has a fixed point in D which is the Denjoy-Wolff point $(a\approx .21365)$, and infinitely many fixed points on ∂D.

Definition 1.4 *Let $f:\overline{D}\to\overline{D}$ be an analytic map. The set*

$$F=\left\{z\in\overline{D}:\lim_{r\to 1^-}f(rz)=z\right\}$$

is called the fixed point set of f.

Theorem 1.5 *If f is an analytic function that maps the unit disk into itself, then there exists $E\subset F$ which has linear measure zero.*

Example 1.6 *Let K be a compact set of measure zero in ∂D. There is a function f analytic in D and continuous on $\overline{D}$ such that $f(D)\subset D$ and the fixed point set of f is $\{0\}\cup K$.*

Theorem 1.7 *Let f be a univalent analytic function that maps the unit disk into itself. Then the set F has capacity zero.*

Example 1.8 For a given compact set K in ∂D of capacity zero and a point $a\in\partial D\setminus K$, there exists an analytic and univalent function in D (say f) such that $f(D)\subset D$ and $F=\{a\}\cup K$.

In the next theorem, it is required that the Denjoy-Wolff point $a=b_0$ be normalized, i.e., $b_0=0$ or $b_0=1$.

Theorem 1.9 Let f be an analytic function with $f(D)\subset D$ and suppose that $b_0,b_1,\ldots,b_n$ are fixed points of f.

• If $b_0 = 0$, then

$$\sum_{j=1}^{n} \frac{1}{f'(b_j)-1} \le \operatorname{Re} \frac{1+f'(0)}{1-f'(0)}.$$

• If $b_0 = 1$ and $f'(1) = 1$, then

$$\sum_{j=1}^{n} \frac{1}{f'(b_j)-1} \le \frac{f'(1)}{1-f'(1)}.$$

• If $b_0 = 1$ and $0 < f'(1) < 1$, then

$$\sum_{j=1}^{n} \frac{|1-b_j|^2}{f'}(b_j)-1 \le 2\operatorname{Re}\left(\frac{1}{f(0)}-1\right).$$

Moreover, the equality holds if and only if f is the Blaschke product of order $n+1$ in case $1)$ or of order n in cases $2)$ and $3)$.

If f has infinitely many fixed points, then the appropriate inequality holds for any choice of finitely many fixed points. In particular, only countably many fixed points of f can have a finite angular derivative.

If $b_0, b_1, b_2, \ldots$ are countably many fixed points for which $f'(b_j) < \infty$, then the corresponding infinite sum converges and the appropriate inequality holds.

With the assumption that an analytic function f is univalent and that the Denjoy-Wolff point is $b_0 = 0$ or $b_0 = 1$, we have the next assertion.

Theorem 1.10 *Let f be a univalent analytic function with $f(D) \subset D$ and suppose $b_0, b_1, \ldots, b_n$ are fixed points of f.*

• If $b_0 = 0$, then

$$\sum_{j=1}^{n} \left(\log f'(b_j)\right)^{-1} \le 2\operatorname{Re} B^{-1}$$

where $B = \lim_{r\to 1^-} \log\left(\frac{f(rb_1)}{f'(0)rb_1}\right)$ and $\lim_{z\to 0} \log\left(\frac{f(z)}{z}\right) = \log f'(0)$.

• If $b_0 = 0$ and $0 < f'(1) < 1$, then $\sum_{j=1}^{n} (\log f'(b_j))^{-1} \le -(\log f'(1))^{-1}$.

Moreover, the equality holds if and only if f is embeddable in a semigroup and $f(D) = D$ with n analytic arcs removed in case $1)$ or $n-1$ in case $2)$.

• If $b_0 = 1$ and $f'(1) = 1$, then $\sum_{j=1}^{n} c_j^2 (\log f'(b_j))^{-1} \le 2\log \frac{1-|f(0)|^2}{|f'(0)|}$,

where

$$c_j = \lim_{r\to 1^-} \mathrm{Im}\left(\log\left(\frac{1}{b_j}\cdot\frac{f(rb_j)-f(0)}{1-f(0)f(rb_j)}\cdot\frac{1-f(0)\overline{f(r)}}{f(r)-f(0)}\right)\right).$$

Remark 1.11 In (Anderson & Vasil'ev, 2008, pp.101–110), the authors proved for $b_0 = 0$, case $1)$, the inequality

$$\prod_{j=1}^{n} f'(b_j)^{2\alpha_j^2} \ge \frac{1}{|f'(0)|},$$

where $\alpha_j \ge 0$ and $\sum_{j=1}^{n} \alpha_j = 1$. The equality holds only for the unique solution of a given complex differential equation with a given initial condition.

Considering $b_0 = 0$, case $3)$ and the assumption that f is embeddable in a continuous semigroup, in (Contreras et al, 2006, pp.125-142) was proved that

$$\sum_{j=1}^{n} \frac{1-\mathrm{Re}\, b_j}{\log f'(b_j)} \le \mathrm{Re}\frac{1}{G(0)} = \mathrm{Re}\,\sigma'(0),$$

where G is the infinitesimal generator of the semi-group and σ is the map from the linear fractional model.

In case $3)$, an equality condition is not included and maybe this inequality is not the best possible. Also, a sharp inequality to describe the general case has not yet been obtained.

Main results

It is known that a continuous mapping of a simply connected, closed, bounded set of the Euclidean plane into itself has at least one fixed point.

Let F be an analytic function in some domain S of the complex plane. Standard results in real numerical analysis show that the equation $z = F(z)$ has at least one solution, called a fixed point of F. If S is bounded and simply connected, F is continuous on the closure $\overline{S}$ of S, and $F(\overline{S}) \subset \overline{S}$. If the mapping F is a contraction, then there is a unique fixed point, and the iteration sequence defined by $z_{n+1} = F(z_n)$, $n = 0,1,2,\ldots$ converges to the fixed point for every choice of $z_0 \in \overline{S}$. If S is convex, then a necessary and sufficient condition for the mapping to be a contraction is that the derivative F' of F satisfies $|F'(z)| \le k$, $z \in S$, where $k < 1$.

The purpose of the next theorem is to show that the conclusion is not affected if we replace the assumption that F is a contraction by the condition that F is an analytic function.

Theorem 2.1 *(Henrici, 1969)*

We first prove a reduced form of the theorem. Let S denote the interior of a Jordan curve Γ, let F be analytic in S and continuous on $S \cup \Gamma$, and let $F(S \cup \Gamma) \subset S$. Then F has exactly one fixed point, and the iteration sequence defined by $z_{n+1} = F(z_n)$, $n = 0,1,2,\ldots$ converges to the fixed point for arbitrary $z_0 \in S \cup \Gamma$.

Note that the function $F(z) = \frac{1}{2} z^{100}$ in $|z| \le 1$ satisfies the hypothesis and $|F'(z)|$ is arbitrary large.

Proof. First let S be the unit disk. By the hypothesis, we have

$$r := \max_{|z|\le 1} |F(z)| < 1. \tag{1}$$

To prove the existence of a zero of $z = F(z)$, we apply the Rouche theorem (Ahlfors, 1953) with z in the role of the 'big' function and $F(z)$ in the role of the 'small' function. Then, using (1), we can conclude that $z - F(z)$ and z have the same number of zeros inside $|z| = 1$, namely exactly one.

With s denote the unique fixed point and let

$$t(z) = \frac{z - s}{1 - z\bar{s}}.$$

This is a linear transformation which maps $|z| \le 1$ onto itself and sends s into 0. Hence, the function $G = t \circ F \circ t^{-1}$ has the fixed point 0 and it is continuous mapping of $|z| \le 1$ onto a closed subset of $|z| < 1$. Hence,

$$k := \sup_{|z|\le 1} |G(z)| < 1.$$

We can certainly assume that $k > 0$, since otherwise, G and F are constant and the proof is straightforward. The function $k^{-1}G$ vanishes at 0 and is bounded by 1, hence by the Schwarz lemma (Ahlfors, 1953) we have $k^{-1}|G(z)| \le |z|$ and consequently,

$$|G(z)| \le k|z| \tag{2}$$

for all z such that $|z| \le 1$.

Let $w_n = t(z_n)$. Since

$$w_{n+1} = t(z_{n+1}) = f(F(z_n)) = t(F(t^{-1}(w_n))) = G(w_n),$$

we conclude from (2) that $|w_{n+1}| \le k|w_n|$, hence that $|w_n| \le k^n |w_0|$, and finally that $w_n \to 0$.

From the above, it follows that the iteration sequence converges to the fixed point, i.e., $z_n = t^{-1}(w_n) \to t^{-1}(0) = s$.

We now turn to the case where S is an arbitrary Jordan domain. By the Osgood-Caratheodory theorem (Caratheodory, 1960), there exists a function q that maps S conformally onto $|z| < 1$ and $S \cup \Gamma$ continuously

and one-to-one onto $|z| \le 1$. It is easily seen that the function $H = g \circ F \circ g^{-1}$ satisfies the hypotheses of the theorem for the unit disk. Furthermore, if the points z_n are defined by $z_{n+1} = F(z_n)$, $n = 0,1,2,\ldots$ and $w_n = g(z_n)$, then $w_{n+1} = H(w_n)$. Consequently, the validity of the theorem for the unit disk implies the validity for the general case.

We add some problems related to the previous theorem.

- It can be shown that $k \le \dfrac{2r}{1+r^2}$.
- If S is the unit disk, than $|z_n - s| \le (1+r)k^n$, $n = 0,1,2,\ldots$
- Let $F'(s) = F''(s) = \cdots = F^{(m-1)}(s) = 0$, $F^{(m)}(s) \ne 0$, for some integer $m > 1$. If S is the unit disk, show that

$$|z_n - s| \le (1+r)k^1 + k^2 + \cdots + m^{n-1}, \quad n \in \mathbb{N}.$$

- A research problem is whether similar results can be established for systems of analytic equations.

A set S is said to lie strictly inside a subset D of a Banach space if there is some $\varepsilon > 0$ such that $B_\varepsilon(x) \subseteq \mathrm{D}$ whenever $x \in S$. The following theorem may be viewed as a holomorphic version of the Banach's contraction mapping theorem.

Theorem 2.2 (Earle & Hamilton, 1970, pp.61–65)
Let D *be a nonempty domain in a complex Banach space* X *and* $h : \mathrm{D} \to \mathrm{D}$ *a bounded holomorphic function. If* $h(\mathrm{D})$ *lies strictly inside* D, *then* h *has a unique fixed point in* D.

Proof. Let us construct a metric ρ, called the CFR-pseudometric, with the contraction h. Define $\alpha(x,v) = \sup\{|g'(x)v| : g : \mathrm{D} \to \Delta \text{holomorphic}\}$ for $x \in \mathrm{D}$ and $v \in X$ and set

$$L(\gamma) = \int_0^1 \alpha(\gamma(t), \gamma'(t))t$$

for γ in the set Γ of all curves in D with piecewise continuous derivative. Clearly α specifies a seminorm at each point of D. We view $L(\gamma)$ as the length of the curve γ measured with respect to α. Define

$$\rho(x,y) = \inf\{L(\gamma): \gamma \in \Gamma, \gamma(0) = x, \gamma(1) = y\}$$

for $x, y \in \mathsf{D}$. It is easy to verify that ρ is a pseudometric on D.

Let $x \in \mathsf{D}$ and $v \in X$. By the chain rule, we have

$$(g \circ h)'(x)v = g'(h(x))h'(x)v$$

for any holomorphic function $g : \mathsf{D} \to \Delta$. Hence,

$$\alpha(h(x), h'(x)v) \le \alpha(x,v). \tag{3}$$

By integrating this and applying the chain rule, we obtain $L(h \circ \gamma) \le L(\gamma)$ for all $\gamma \in \Gamma$ and thus the Schwarz-Pick inequality $\rho(h(x), h(y)) \le \rho(x,y)$ holds for all $x, y \in \mathsf{D}$.

Now, by hypothesis, there exists an $\varepsilon > 0$ such that $B_\varepsilon(x) \subseteq \mathsf{D}$ whenever $x \in \mathsf{D}$. We may assume that D is bounded by replacing D by the subset

$$\cup\{B_\varepsilon(h(x)): x \in \mathsf{D}\}.$$

Fix t with $0 < t < \frac{\varepsilon}{\delta}$, where δ denotes the diameter of $h(\mathsf{D})$. Given $x \in \mathsf{D}$, define

$$h_1(y) = h(y) + t[h(y) - h(x)]$$

and note that $h_1 : \mathsf{D} \to \mathsf{D}$ is holomorphic. Given $x \in \mathsf{D}$ and $v \in X$, it follows from $h_1'(x)v = (1+t)h'(x)v$ and (3) with h replaced by h_1 that

$$\alpha(h(x), h'(x)v) \le \frac{1}{1+t}\alpha(x,v).$$

Integrating this as before, we obtain

$$\rho(h(x), h(y)) \le \frac{1}{1+t}\rho(x,y)$$

for all $x, y \in \mathsf{D}$.

Now pick a point $x_0 \in \mathsf{D}$ and let $\{x_n\}$ be the sequence of iterates given by $x_n = h^n(x_0)$. Then $\{x_n\}$ is a ρ-Cauchy sequence by the proof of the contraction mapping theorem.

Since X is complete in the norm metric, it suffices to show that there exists a constant $m > 0$ such that

$$\rho(x, y) \geq m\|x - y\| \tag{4}$$

for all $x, y \in \mathrm{D}$. Since D is bounded, we may take $m = \frac{1}{d}$, where d is the diameter of D. Given $x \in \mathrm{D}$ and $v \in X$, define $\rho(y) = ml(y - x)$, where $l \in X^*$ with $\|l\| = 1$. Then $g : \mathrm{D} \to \Delta$ is holomorphic and $Dg(x)v = ml(v)$. Hence $\alpha(x, v) \geq m\|v\|$ by the Hahn-Banach theorem. Integrating as before, we obtain (4).

The previous result, so called the Earle-Hamilton theorem, is still applied in cases where the holomorphic function does not necessarily map its domain strictly inside itself. The following fixed point theorem is a consequence of two applications of the Earle-Hamilton theorem.

Theorem 2.3 (Khatskevich et al, 1995, pp.305–316, S. Reic et al, 1996, pp.1–44)

Let D *be a nonempty bounded convex domain in a Banach space and* $h : \mathrm{D} \to \mathrm{D}$ *a holomorphic function having a uniformly continuous extension to* $\overline{\mathrm{D}}$. *If there exists an* $\varepsilon > 0$ *such that* $\|h(x) - x\| \geq \varepsilon$ *whenever* $x \in \partial\mathrm{D}$, *then* h *has a unique fixed point in* D.

The hypothesis that $\|h(x) - x\| \geq \varepsilon$ for all $x \in \partial\mathrm{D}$ is satisfied when D contains the origin and $\sup_{x \in \partial\mathrm{D}} \frac{\|h(x)\|}{\|x\|} < 1$. Considerably stronger results have been obtained for the case where D is the open unit ball of a Hilbert space.

Theorem 2.4 *(*Goebel et al, 1980, pp.1011–1021)

Let D be the open unit ball of a Hilbert space and $h : B \to B$ a holomorphic function. If there is a point x_0 in B such that the sequence $\{h^n(x_0)\}$ of iterates lies strictly inside B, then h has a fixed point in B. If $x \in \partial\mathrm{D}$, then h has a unique fixed point in D.

It is more complicated to obtain fixed points for nonexpansive mappings which are not contractive. One important result is that a nonexpansive self-mapping of a closed bounded convex set in a uniformly convex Banach space has a fixed point. In (Goebel et al, 1980, pp.1011–1021), it was shown that the CRF-metric ρ in the open unit ball B of a Hilbert space is uniformly convex and the fixed point theorem for holomorphic self-mappings of B was obtained.

Theorem 2.5 Let B be the open unit ball of a Hilbert space and $h: B \to B$ an arbitrary function satisfying the Schwarz-Pick inequality:

$$\rho(h(x), h(y)) \leq \rho(x, y)$$

for all $x, y \in B$. If h has a continuous extension to $\overline{B}$, then h has a fixed point in $\overline{B}$.

Corollary 2.6 If $h: B \to B$ is a holomorphic function that has a continuous extension to $\overline{B}$, then h has a fixed point in $\overline{B}$.

For a treatment of the Cartesian products of the Hilbert balls, we refer the reader to (Kuczumow et al, 2001, pp.437–515).

Szhwarz lemma and its application in the fixed point theory

In this section, we will restrict our attention to the paper (Xu et al, 2016, 2016:84) where the sharp estimates of a boundary fixed point is obtained using the Schwarz lemma. This lemma provides a very powerful tool for studying several research fields in complex analysis. For example, almost all results in the geometric function theory rely heavily on the Schwarz lemma (Ahlfors, 1953), (Anderson & Vasil'ev, 2008, pp.101–110), (Beardon, 1990, pp.41–150), (Beardon, 1997, pp.1257–1266), (Budzynska et al, 2012, pp. 504–512), (Budzynska et al, 2013a, 621–648), (Budzynska et al, 2013b, pp.747–756), (Burckel, 1981, pp.396–407), (Caratheodory, 1960), (Contreras et al, 2006, pp.125-142), (Cowen, 2010), (Cowen, 1981, pp.69–95), (Cowen & Pommerenke, 1982, pp.271–289), (Denjoy, 1926, pp. 255–257), (Earle & Hamilton, 1970, pp.61–65), (Goebel et al, 1980, pp.1011–1021), (Goebel, 1982, pp.1327–1334), (Harris, 2003, pp.261–274), (Hayden & Suffridge, 1971, pp.419–422), (Hayden & Suffridge, 1976, pp.95–105), (Henrici, 1969), (Julia, 1918, pp.47–295), (Khatskevich et al, 1995, pp.305–316),

(Kuczumow, 1984, pp.417-419), (Kuczumow et al, 2001, pp.437–515), (Lemmens et al, 2016), (Mateljević, 1998, pp.1-4), (Reich & Shoikhet, 1996, pp.1-44), (Rudin, 1978, pp.25–28), (Suffridge, 1974, pp.309-314), (Wolff, 1926), (Xu et al, 2016, 2016:84). On the other hand, the Schwarz lemma at the boundary is also useful in complex analysis, and various interesting results have been obtained (Ahlfors, 1953), (Anderson & Vasil'ev, 2008, pp.101–110), (Beardon, 1990, pp.41–150), (Beardon, 1997, pp.1257–1266), (Budzynska et al, 2012, pp. 504–512), (Budzynska et al, 2013a, pp.621–648), (Budzynska et al, 2013b, pp.747–756), (Burckel, 1981, pp.396–407), (Caratheodory, 1960), (Contreras et al, 2006, pp.125-142), (Cowen, 2010), (Cowen, 1981, pp.69–95), (Cowen & Pommerenke, 1982, pp.271–289), (Denjoy, 1926, pp.255–257).

We will summarize without proofs the relevant material on (Xu et al, 2016, 2016:84). First we set up the notation and the terminology.

Let D denote the unit disk in C. With the notion $H(D,D)$, we have the class of holomorphic self-mappings of D. Here, N stands for the set of all positive integers. The boundary point $\xi \in \partial D$ is called a fixed point of $f \in H(D,D)$ if

$$f(\xi) = \lim_{r \to 1^-} f(r\xi) = \xi.$$

The classification of the boundary fixed points is given at the begging of this survey. This classification can be done via the value of the angular derivative

$$f'(\xi) = \angle\lim_{z \to \xi} \frac{f(z) - \xi}{z - \xi},$$

which belongs to $(0,\infty)$ due to the Julia-Caratheodory theorem (see Julia, 1918, pp.47–295). This theorem also asserts that the finite angular derivative at the boundary fixed point ξ exists if and only if the holomorphic function $f'(z)$ has the finite angular limit $\angle\lim_{z \to \xi} f(z)$. For a boundary fixed point ξ of f, if $f'(\xi) \in (0,\infty)$, then ξ is called a regular fixed point. The regular fixed point is attractive if $f'(\xi) \in (0,1)$, neutral if $f'(\xi) = 1$, or repulsive if $f'(\xi) \in (1,\infty)$.

By the Julia-Caratheodory theorem (Julia, 1918, pp.47–295) and the Wolf lemma (Wolff, 1926), if $f \in H(D,D)$ with no interior fixed point, then there exists a unique regular boundary fixed point ξ such that

$f'(\xi) \in (0,1]$ and if $f \in H(D,D)$ with an interior fixed point, then $f'(\xi) > 1$ for any boundary fixed point $\xi \in \partial D$.

The following known results are very significant.

Theorem 3.1 Assume that $f \in H(D,D)$ has a regular boundary fixed point 1 and $f(0) = 0$. Then

$$f'(1) \geq \frac{2}{1+|f'(0)|}.$$

Moreover, the equality holds if and only if f is of the form

$$f(z) = -z\frac{a-z}{1-az}, \quad z \in D,$$

for some constant $a \in (-1,0]$.

The next theorem is the improvement of the previous ones. It was announced 60 years later and showed how to dispense with the assumption $f(0) = 0$.

Theorem 3.2 If $f \in H(D,D)$ with $\xi = 1$ as its regular boundary fixed point, then

$$f'(1) \geq \frac{2(1-|f(0)|)^2}{1-|f(0)|^2+|f'(0)|}.$$

Finally, the previous result has been improved and the better estimate has been obtained.

Theorem 3.3 If $f \in H(D,D)$ with $\xi = 1$ as its regular boundary fixed point, then

$$f'(1) \geq \frac{2}{\mathrm{Re}\left(\frac{1-f^2(0)+f'(0)}{(1-f(0))^2}\right)}.$$

For a fuller treatment and a deeper discussion of fixed point results in complex domain, we refer the reader to (Xu et al, 2016, 2016:84) and the references given there.

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О НЕКОТОРЫХ ИЗВЕСТНЫХ РЕЗУЛЬТАТАХ О НЕПОДВИЖНОЙ ТОЧКЕ В КОМПЛЕКСНОМ ДОМЕНЕ: ИССЛЕДОВАНИЕ

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ОБЛАСТЬ: математика
ВИД СТАТЬИ: обзорная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной обзорной статье представлены некоторые известные результаты теорий о неподвижной точке над комплексным доменом. Надо подчеркнуть, что 1962 год является ключевым для данной области. Ведь именно тогда начали проводиться исследования по применению теорий о неподвижной точке в рамках комплексного анализа. Теорема единственности для рядов Вольфа-Данжуа наряду с Банаховым принципом сжатия, становятся главным методом (результатом) математического анализа.

Ключевые слова: неподвижная точка, кривая Жордана, аналитические функции, полное Банахово пространство.

НЕКИ ПОЗНАТИ РЕЗУЛТАТИ ИЗ НЕПОКРЕТНЕ ТАЧКЕ У КОМПЛЕКСНОМ ДОМЕНУ: ИСТРАЖИВАЊЕ

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ОБЛАСТ: математика
ВРСТА ЧЛАНКА: прегледни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

У овом прегледном раду разматрани су неки познати резултати из теорије непокретне тачке над комплексним доменом. Истраживање и примена теорије непокретне тачке у комплексној анализи започети су 1926, године. Теорема Denjoy-Wolf, заједно са Банаховим принципом контракције, једно је од главних оруђа (резултата) математичке анализе.

Кључне речи: непокретна тачка, Жорданове криве, аналитичке функције, комплексан Банахов простор.

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REVIEW OF KDD CUP '99, NSL-KDD AND KYOTO 2006+ DATASETS

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Abstract:

This paper presents a review of three datasets, namely KDD Cup '99, NSL-KDD and Kyoto 2006+ datasets, which are widely used in researching intrusion detection in computer networks. The KDD Cup '99 dataset consists of five million records, each containing 41 features which can classify malicious attacks into four classes: Probe, DoS, U2R and R2L. The KDD Cup '99 dataset cannot reflect real traffic data since it was generated by simulation over a virtual computer network. In the NSL-KDD dataset, redundant and duplicate records form the KDD Cup '99 dataset are removed from training and test sets, respectively. The Kyoto 2006+ dataset is built on real three year-network traffic data which are labeled as normal (no attack), attack (known attack) and unknown attack. The Kyoto 2006+ dataset contains 14 statistical features derived from the KDD Cup '99 dataset and 10 additional features.

Key words: KDD Cup '99, NSL-KDD, Kyoto 2006+, computer network, intrusion detection.

Introduction

Intrusion can be understood as an attempt to violate information protection, data integrity and resource accessibility (Protić, 2016, pp.483-495). The most popular way to protect a computer network from various malicious activities is to detect intrusion by using an intrusion detection system (IDS). The IDS consists of software applications and/or hardware devices that constantly monitor computer network for suspicious activities, and trigger intrusion alarms if unknown or malicious activities are detected. There are typically two kinds of IDSs. A host-based IDS detects and identifies any system changes by analyzing system or server

log files and comparing them against database of common signatures for known attacks. A network-based IDS monitors network traffic and checks for irregular behavior by inspecting the content and header information of all packets to protect the system from network-based threats.

There are two well-known systems for monitoring, analyzing and detecting network security violation. Misuse-based systems rely on pattern recognition and maintain the base of indicators (signatures) extracted from previous attacks. Anomaly-based systems build statistical models of normal network traffic and observe abnormalities in order to detect what is anomalous.

For several decades, a lot of researchers have suggested to use three most known datasets, namely KDD Cup '99, NSL-KDD and Kyoto 2006+ datasets, to design anomaly-based IDSs and develop various tools for computer network security protection. The KDD Cup '99 dataset is a collection of data transferred from virtual environment to be used for the Third Data Mining and Knowledge Discovery Competition on computer network intrusion detection. The task for the learning contest was to learn a predictive model (i.e. classifier) capable of distinguishing between legitimate and illegitimate connections in a computer network (SIGKDD - KDD Cup, 2018). The KDD Cup '99 dataset is the subset of 1998 DARPA dataset that was collected by simulation of the operation of a typical US Air Force Local Area Network (LAN) with multiple attacks classified into four categories: probe, denial of service, user to root and remote to local. KDD Cup '99 dataset records contain 41 features which fall into four categories: basic, traffic, content and host related ones (Aggarwal & Sharma, 2015, pp.842-851).

Since the KDD Cup '99 dataset is a simulation of network traffic, there is a huge number of redundant records in the training set and duplicate records in the test set which prevent classifying the other records which are not redundant. To solve these issues, a new NSL-KDD dataset was proposed (Tavallaee et al, 2009). The NSL-KDD dataset consists of selected features from the KDD Cup '99 dataset but does not include redundant records in the training set and there are no duplicates in the test set. Also, the number of records in the training and test sets is reasonable.

However, both KDD Cup '99 dataset and NSL-KDD dataset do not reflect real data flow in computer network since they are generated by simulation over the virtual network. The Kyoto 2006+ dataset is built on real three year-traffic data from November 2006 to August 2009. This dataset is captured using honeypots, darknet sensors, e-mail server and web crawler (Singh et al, 2015, pp.8609-8624). Each record consists of

14 statistical features derived from KDD Cup ‘99 data set as well as 10 additional features which can be used for the analysis and evaluation of the IDS network. This paper presents a review and a comparative analysis of KDD Cup ’99, NSL-KDD and Kyoto 2006+ datasets.

Datasets

KDD Cup ’99 dataset

The most known and widely used dataset for experiments on anomaly detection in computer networks is the KDD Cup ‘99 dataset. The KDD Cup ‘99 dataset is a collection of data transfer from virtual environment to be used for the Competition of the Third Knowledge Discovery and Data Mining Tools (KDD CUP ‘99 dataset, 1999). It is the subset of 1998 DARPA dataset that was collected by simulation of the operation of a typical US Air Force LAN with multiple attacks and acquired nine weeks of TCP dump data. The dataset was collected and distributed at the Massachusetts Institute of Technology (MIT) Lincoln Laboratory.

The KDD Cup ’99 intrusion detection benchmark consists of three components: the whole KDD Cup ’99 dataset contains examples of attacks and normal connections, 10% KDD dataset the purpose of which is to train classifiers, and KDD test dataset designed for testing (Gifty Jeya et al, 2012, pp.28-32.). The whole KDD Cup ‘99 dataset contains 4,898,431 single connection records, each of which consists of 41 features labeled as normal or attacks (See Table 1).

Table 1 – Features in the KDD Cup ‘99 dataset
Таблица 1 – Атрибуты в KDD Cup ’99 базе данных
Табела 1 – Атрибути у KDD Cup ‘99 бази података

Index	Feature name	Description
1	duration	Length of connection
2	protocol type	Type of protocol (TCP, UDP...)
3	service	Destination service (ftp, telnet...)
4	flag	Status of connection
5	source bytes	No. of B from source to destination
6	destination bytes	No. of B from destination to source
7	land	If the source and destination address are the same land=1/if not, then 0
8	wrong fragments	No. of wrong fragments
9	urgent	No. of urgent packets
10	hot	No. of hot indicators
11	failed logins	No. of unsuccessful attempts at login

Index	Feature name	Description
12	logged in	If logged in=1/if login failed 0
13	# compromised	No. of compromised states
14	root shell	If a command interpreter with a root account is running root shell=1/if not, then 0
15	su attempted	If an su command was attempted su attempted=1/if not, then 0 (temporary login to the system with other user credentials)
16	# root	No. of root accesses
17	# file creations	No. of operations that create new files
18	# shells	No. of active command interpreters
19	# access files	No. of file creation operations
20	# outbound cmds	No. of outbound commands in an ftp session
21	is hot login	is host login=1 if the login is on the host login list/if not, then 0
22	is guest login	If a guest is logged into the system, is guest login=1/if not, then 0
23	count	No. of connections to the same host as the current connection at a given interval
24	srv count	No. of connections to the same service as the current connection at a given interval
25	serror rate	% of connections with SYN errors
26	srv error rate	% of connections with SYN errors
27	rerror rate	% of connections with REJ errors
28	srv rerror rate	% of connections with REJ errors
29	same srv rate	% of connections to the same service
30	diff srv rate	% of connections to different services
31	srv diff host rate	% of connections to different hosts
32	dst host count	No. of connections to the same destination
33	dst host srv count	No. of connections to the same destination that use the same service
34	dst host same src rate	% of connections to the same destination that use the same service
35	dst host srv rate	% of connections to different hosts on the same system
36	dst host same srv port rate	% of connections to a system with the same source port
37	dst host srv diff host rate	% of connections to the same service coming from different hosts
38	dst host serror rate	% of connections to a host with an S0 error
39	dst host srv serror rate	% of connections to a host and specified service with an S0 error
40	dst host serror rate	% of connections to a host with an RST error
41	dst host srv serror rate	% of connections to a host and specified service with an RST error

The features describing the connections can be classified into four categories:

Basic features are obtained from the packet header, without examining the contents of the packet (duration, protocol type, service, flag and the number of bytes sent from the source to the destination and vice versa).

Content features are determined by analyzing the content of the TCP packet (number of unsuccessful attempts to login to the system).

Time features determine duration of the connection from a source IP address to target IP addresses. The connection is a sequence of data packets starting and ending at some predefined times.

Traffic features are based on a window that has an interval of a given number of connections (not time intervals). This is suitable for describing attacks that last longer than the interval of the stipulated time features.

All attacks in the KDD Cup '99 dataset are classified as one of the four categories given in Table 2 (Al-Dhafian et al, 2015, pp.82-88).

Table 2 – Categories of attacks
Таблица 2 – Категория атак
Табела 2 – Категорије напада

Category of Attack	**Attack name**
Probe	ipsweep, nmap, portsweep, satan
DoS (Denial of Service)	back, land, neptune, pod, smurf, teardrop
U2R (User to Root)	buffer_overflow, loadmodule, perl, rootkit
R2L (Remote to Local)	ftp_write, guesspasswd, imap, multihop, phf, spy, warezlient, warezmaster

Probe: the attacker collects information about the system or computer network to find (known) vulnerabilities, by scanning a machine or a networking device in order to determine weaknesses or vulnerabilities that may later be exploited in order to compromise the system.

DoS: the attacker does not allow legitimate users access to computing resources or overloads them so that requests cannot be processed in real time. The result of this attack is the unavailability of resources, i.e. resources are too busy or too full to serve legitimate networking requests and hence denying users access to a machine.

U2R: the attacker explores vulnerabilities in order to acquire administrator privileges (root access to the system). Attacker starts off on

the system with the normal user account and looks for vulnerabilities in order to gain super user privileges (Paliwal & Gupta, 2012, pp.57-62).

R2L: the attacker does not have a user account on the victim machine, hence tries to obtain access to the remote system without having the account (Gifty Jeya et al, 2012, pp.28-32.).

Instances in the whole dataset, 10% training set (containing 10% of the total number of instances), and the test set which contains 311,029 instances, according to the categories and datasets, as well as the percentage of the total share of a given category within a particular dataset are shown in Table 3.

Table 3 – Number of instances in the KDD Cup '99 whole dataset, 10% training set and the test set
Таблица 3 – Количество случаев в KDD Cup '99 полной базе данных, 10% в течение обучения и тестирования
Табела 3 – Број инстанци у KDD Cup '99 целој бази података, 10% у тренинг скупу и тест-скупу

	Whole dataset		10% training set		Test set	
Attack category	Number of instances	(%)	Number of instances	(%)	Number of instances	(%)
Normal	492,708	19.86%	97,278	19.69%	60,593	19.48%
Probe	41,102	0.84%)	4,107	0.83%	4,166	1.34%
DoS	3,883,370	79.30%	391,458	79.24%	229,853	73.94%
U2R	52	0.00%	52	0.01%	70	0.02%
R2L	1,126	0.02%	1,126	0.23%	16,347	5.26%

There are various criticisms of the KDD Cup '99 dataset. The primary criticism is that the KDD Cup '99 dataset is not an authentic simulation of real network traffic. In addition, authors outline the following issues (Kolez et al, 2003), (Maček & Milosavljević, 2013), (Bukola & Adetunmbi, 2016):

- complexity of the calculations,
- complexity of the training and test sets,
- impact of duplicate to machine learning (ML) algorithms,
- number of instances of attack is too high in relation to the number of instances of normal traffic,
- relationship between individual categories of attack is not realistic,
- R2L instances of individual attacks are similar to normal traffic instances, which is a consequence of transforming data from the DARPA dataset to the KDD Cup '99 dataset,
- low accuracy of detecting the distribution of attacks, etc.

For these reasons, one can create alternative sets for training and testing in the following way:

– make a smaller subset of the training set,
– use only the training set,
– compose a union of parts of the training and test sets for training and for testing,
– filter instances in order to achieve proportionality of attacks, etc.

The way in which alternative sets are composed depends on the evaluation of the IDS model.

NSL-KDD dataset

The KDD Cup '99 dataset contains a number of redundant records (78%) and duplicate records (75%) which prevent classifying the other records (Revathi & Malathi, 2013). To fix these issues, a new NSL-KDD dataset was proposed (Tavallaee et al, 2009). The NSL-KDD dataset consists of a reasonable number of selected features from the KDD Cup '99 dataset which do not include redundant records in the training set nor duplicates in the test set (Kavitha & Usha, 2014, pp.77-84). Considering the design of the dataset, there are three important reasons for using it in the experiments:

– elimination of redundant records in the training set helps classifiers to be unbiased toward more frequent records;
– with duplicate records excluded from the test set, a classifier performance will not be biased by the techniques which have better decision rates on the frequent records;
– training and test sets contain a reasonable number of instances which is affordable for the experiments on the entire set without the need to randomly choose a small portion.

The training dataset is made up of 21 different attacks out of 37 present in the test dataset. The known attacks are those present in the training set, while the additional 16 attacks are available only in the test set (see Table 4). The attack types are grouped into Probe, DoS, U2R and R2L categories (Nkiama et al, 2016).

The normal traffic in the training set contains 67,343 instances which brings a total of 126,620 instances. The normal traffic in the test set contains 9,711 instances which brings total of 22,850 instances in the test set.

Table 4 – Total number of attack instances in the training and test sets
Таблица 4 – Общее количество случаев атак в течение обучения и тестирования
Табела 4 – Укупан број инстанци напада у тренинг и тест-скуповима

Attack Classes	Total number of instances in the training set	Total number of instances in the test set
DoS	45,927	7,460
	back (956), land (18), neptune (41,214), pod (201), smurf (2,646), teardrop (892)	back (359), land (7), neptune (4,657), pod (41), smurf (665), teardrop (12)
		Additional attacks
		apache2 (737), udpstorm (2), processtable (685), worm (2), mailbomb (39)
Probe	11,656	2,421
	satan (3,633), ipsweep (3,599), nmap (1,493), portsweep (2,931)	satan (753), ipsweep (141), nmap (73), portsweep (157)
		Additional attacks
		mscan (996), saint (319)
R2L	1,642	3,191
	guess_passwd (53), ftp_write (6), imap (658), phf (4), multihop (7), warezmaster (20), warezclient (890), spy (2)	guess_passwd (1,231), ftp_write (3), imap (307), phf (2), multihop (18), warezmaster (944)
		Additional attacks
		xsnoop (4), xlock (9), snmpguess (331), snmpgetattack (178), httptunnel (133), sendmail (14), named (17)
U2R	52	67
	buffer_overflow (30), loadmodule (9), rootkit (10), perl (3)	buffer_overflow (20), loadmodule (2), rootkit (13), perl (2)
		Additional attacks
		xterm (13), sqlattack (2), ps (5)
Total	59,277	13,139

Kyoto 2006+ dataset

The Kyoto 2006+ dataset was built on the three years of real traffic data from November 2006 to August 2009. A new version of the dataset contains additional data collected from November 2006 to December

2015. It consists of 14 statistical features derived from the KDD Cup '99 dataset as well as 10 additional features which can be used for the analysis and evaluation of the IDS network. The Kyoto 2006+ dataset is captured using honeypots, darknet sensors, email server and web crawler (Singh et al, 2015, pp.8609-8624). Song et al (2011, pp.29-36) provided a detailed analysis of honeypots (i.e. computer network security mechanisms which detect attempts of unauthorized use of information) and darknets data collected on many real and virtual machines as honeypots. They have deployed various types of honeypots, darknet and other systems on the five networks inside and outside of the Kyoto University, and collected all traffic data to and from honeypots (Table 5). During the observation period, there were 50,033,015 normal sessions, 43,043,225 attack sessions and 425,719 sessions related to unknown attacks.

Table 5 – Deployed honeypots, darknet and other systems
Таблица 5 – Установленные honeypots, darknet и другие системы
Табела 5 – Инсталирани honeypots, darknet и други системи

Deployed systems	
Honeypots	Solaris 8 for Intel
	Windows XP (no patch, SP2, fully patched)
	Nepenthes
	Others
Darknet	Darknet sensors (for detection of software, configuration, or authorization that use non-standard communication protocols and ports)
Other systems	Mail server (to collect various types of mails)
	Web crawler (developed by the NTT Information Sharing Platform Laboratories)
	Windows XP (to evaluate malware activities)

Based on 41 original features of the KDD Cup '99 dataset, the authors extracted the statistical features from the honeypot data, ignoring other features that contain redundant data (see Table 6).

The authors excluded substantially redundant and insignificant features as well as contents features (number of file creation operation, number of operation on access control files), because they are not suitable for network-based IDSs and it is time consuming to extract them without the domain knowledge. In addition to the above 14 statistical features, the authors also extracted additional 10 features (Table 7), which enabled them to investigate what kinds of attacks happened on computer networks.

Table 6 – Statistical features in the Kyoto 2006+ dataset derived from the KDD Cup '99 dataset
Таблица 6 – Статистические характеристики в Kyoto 2006+ базе данных, полученных из KDD Cup '99 базы данных
Табела 6 – Статистички атрибути у Kyoto 2006+ бази података који су преузети из KDD Cup '99 базе података

Index	Feature name	Description
1	Duration	The length of the connection (seconds).
2	Service	The connection's server type (http, telnet).
3	Source bytes	The number of data bytes sent by the source IP address.
4	Destination bytes	The number of data bytes sent by the destination IP address.
5	Count	The number of connections whose source IP address and destination IP address are the same to those of the current connection in the past two seconds.
6	Same_srv_rate	% of connections to the same service in the Count feature.
7	Serror_rate	% of connections that have 'SYN' errors in Count feature.
8	Srv_serror_rate	% of connections that have 'SYN' errors in Srv_count (% of connections whose service type is the same to that of the current connections in the past two seconds) feature.
9	Dst_host_count	Among the past 100 connections whose destination IP address is the same to that of the current connection, the number of connections whose source IP address is also the same to that of the current connection.
10	Dst_host_srv_count	Among the past 100 connections whose destination IP address is the same to that of the current connection, the number of connections whose service type is also the same to that of the current connection.
11	Dst_host_same_src_port_rate	% of connections whose source port is the same to that of the current connection in Dst_host_count feature.
12	Dst_host_serror_rate	% of connections that have 'SYN' errors in Dst_host_count feature.
13	Dst_host_srv_serror_rate	% of connections that have 'SYN' errors in Dst_host_srv_count feature.
14	Flag	The state of the connection at the time of connection was written.

Table 7 – Additional features in Kyoto 2006+ dataset
Таблица 7 – Дополнительные атрибуты в Kyoto 2006+ базе данных
Табела 7 – Додатни атрибути у Kyoto 2006+ бази података

Index	Feature name	Description
1	IDS_detection	Reflects if IDS triggered an alert for the connection; '0' means any alerts were not triggered and an arabic numeral means the different kind of alerts. Parenthesis indicates the number of the same alert.
2	Malware_detection	Indicates if malware, also known as malicious software, was observed at the connection; '0' means no malware was observed, and string indicates the corresponding malware observed at the connection. Parenthesis indicates the number of the same malware.
3	Ashula_detection.	Means if shellcodes and exploit codes were used in the connection; '0' means no shellcode nor exploit code were observed, and an arabic numeral means the different kinds of the shellcodes or exploit codes. Parenthesis indicates the number of the same shellcode or exploit code
4	Label	Indicates whether the session was attack or not; '1' means normal. '-1' means known attack was observed in the session, and '-2' means unknown attack was observed in the session.
5	Source_IP_Address	Means source IP address used in the session. The original IP address on IPv4 was sanitized to one of the Unique Local IPv6 Unicast Addresses. Also, the same private IP addresses are only valid in the same month; if two private IP addresses are the same within the same month, it means their IP addresses on IPv4 were also the same, otherwise are different.
6	Source_Port_Number	Indicates the source port number used in the session.
7	Destination_IP_Address	It was also sanitized.
8	Destination_Port_Number	Indicates the destination port number used in the session.
9	Start_Time	Indicates when the session was started.
10	Duration	Indicates how long the session was being established.

Datasets comparison

Al-Dhafian et al (2015, pp.82-88) presented a comparison between five datasets: DARPA, KDD Cup '99, CAIDA, NSL-KDD and Kyoto 2006+ datasets. Table 8 shows the results for all datasets except for CAIDA, which is a collection of several different types of data resulting from both

active and passive measurements of the Internet, and is not analyzed here.

Table 8 – Comparison of the standard datasets in IDSs
Таблица 8 – Сравнение стандартных баз данных в системах обнаружения атак
Табела 8 – Поређење стандардних база података у системима за детекцију упада

Dataset (year)	Features	Pros	Cons
DARPA (1998)	–	– First standard for evaluating IDS. – Consists of broad range of attacks.	– Models used to generate traffic were too simple. – Synthesized data does not simulate the background traffic in real networks.
KDD Cup '99 (1999)	41 features (32 numeric and 9 categorical)	– Used for evaluating anomaly detection systems. – Attack types in training set are distinctive from the testing set.	– Includes redundant and duplicate records. – Does not reflect the modern environment.
NSL-KDD (2009)	41 features (32 numeric and 9 categorical)	– Does not include redundant and duplicate records. – The selected records are inversely proportional to the percentage of records in the KDD Cup '99 dataset. – The number of records is reasonable.	– Not perfect for representing the existing real networks.
Kyoto 2006+ (2009)	24 features (14 statistical derived from KDD Cup '99 and 10 additional)	– Ignored features that contain redundant. – Represents the existing real networks.	– Does not mention information on particular attack types.

The DARPA dataset is considered as a popular dataset used in IDSs to measure detection rate and false alarm rate for network traffic which consists of four types of attacks (Probe, DoS, U2R and R2L). However, it faces a lot of criticism primarily because of using very simple

models to create background network traffic. As a result, synthesized data does not look like to be similar to the records of background traffic in real networks.

The KDD Cup ’99 dataset is a preprocessed version of the DARPA dataset, which classified records into 41 features. The dataset consists of a huge number of records in both training and tests sets but includes redundant and duplicate records and does not represent real network traffic. However, in the development of new intrusion detection systems and tools for data protection, the KDD Cup ’99 dataset is widely used to conduct the experiments on large amounts of data, or whenever the repeatability is a must.

The NSL-KDD dataset contains selected features from the KDD Cup ‘99 dataset. It is designed to fix problems related to redundant records in the training set and duplicated records in the test set, as well as to reduce quantity of data to a reasonable size.

The Kyoto 2006+ dataset is a comprehensive representation built on real network traffic data through ignoring features that contain redundant records. The dataset is captured using honeypots, darknet sensors, email server, web crawler and other computer network security mechanisms which detect attempts of unauthorized use of information. Researchers from the Kyoto University have deployed various types of honeypots, darknet sensors and other systems on five networks inside and outside the Kyoto University, and collected all traffic data to and from honeypots.

Conclusion

KDD Cup is an annual conference for Data Mining and Knowledge Discovery, intended for competition in the field of machine learning and data mining. In 1999, competitors had to solve the problem of protection against attacks on computer networks. For the purpose of competition, the KDD Cup ’99 dataset had been created. The KDD Cup ’99 benchmark consists of the whole dataset, 10% training set and the test set. Each record is made up of 41 features which describe the network traffic of a simulated computer network. The dataset, among other things, contains data on the following attacks: Probe, DoS, U2R and R2L.

The KDD Cup ’99 dataset is widely used as a reference for researching IDSs and for the development of new tools for protection against various attacks on computer networks. However, there are shortcomings which can affect the research such as complexity, the effect of duplicates and redundant records, unbalanced number of

attacks relative to each other and disproportion between the number of attacks and normal traffic. One way to avoid these problems is to use the NSL-KDD dataset which does not contain redundant records in the training set and duplicates in the test set. However, researchers have to be aware that both KDD Cup '99 and NSL-KDD datasets are a simulation of a virtual computer network and, consequently, experiments can give contradictory results (especially if the number of features describing the attack is small). The Kyoto 2006+ dataset represents selected features of real network traffic which is captured using honeypots, darknet sensors, email server and web crawler deployed on five networks inside and outside the Kyoto University. It does not contain information on particular attacks and ignore features that contain redundant records.

Since rapid development of computer networks and information systems has led to a large number of sophisticated attacks, researchers from all around the world develop new IDSs to protect computer networks from hackers by using known datasets and their pre- and post-processed versions. KDD Cup '99, NSL-KDD and Kyoto 2006+ datasets are widely used in the experiments to develop various tools for protection against malicious attacks. Which of the bases is used depends on the purpose of a particular IDS and security goals in specific problem solving.

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ОБЗОР KDD CUP ‘99, NSL-KDD И KYOTO 2006+ БАЗ ДАННЫХ

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Резюме:

В данной работе представлен обзор трех баз данных: KDD Cup ‘99, NSL-KDD и Kyoto 2006+ база данных, которые широко используются в исследованиях обнаружения взлома компьютерных сетей. KDD Cup ‘99 база данных состоит из пяти миллионов записей, каждая из них содержит 41 атрибут, который может классифицировать атаки по следующим четырем видам: Probe, DoS, U2R и R2L. KDD Cup ‘99 база данных не в состоянии отражать реальные данные, так как она генерирована моделированием на виртуальной компьютерной сети. Из NSL-KDD базы удалены избыточные записи, а дублированные записи удалены из баз обучения и тестирования KDD Cup ’99. Kyoto 2006+ база образована на основании данных трехлетнего реального сетевого трафика, которые обозначены, как: нормальный (не атака), атака (известная атака) и неизвестная атака. Kyoto 2006+ база содержит 14 статистических атрибутов, выбранных из KDD Cup ‘99 базы и дополнительных 10 атрибутов.

Ключевые слова: обнаружение атак, компьютерная сеть, KDD Cup ‘99, NSL-KDD, Kyoto 2006+.

ПРЕГЛЕД KDD CUP ‘99, NSL-KDD И KYOTO 2006+ БАЗА ПОДАТАКА

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Protić, D., Review of KDD Cup ‘99, NSL-KDD and Kyoto 2006+ dataset, pp.580-596

Сажетак:

У раду је приказан преглед три базе података: KDD Cup '99, NSL-KDD и Kyoto 2006+, које се често користе у истраживању детекције упада у рачунарске мреже. KDD Cup '99 база података састоји се од пет милиона записа, од којих сваки садржи 41 атрибут, који могу да класификују нападе у четири класе: Probe, DoS, U2R и R2L. KDD Cup '99 база података не може да рефлектује реалне податке, јер је генерисана симулацијом на виртуелној рачунарској мрежи. Из NSL-KDD базе уклоњени су редундантни записи и дупликати из KDD Cup '99 тренинг и тест-базе, респективно. Kyoto 2006+ база формирана је на основу података трогодишњег реалног мрежног саобраћаја, који су означени као: нормалан (није напад), напад (познат напад) и непознат напад. Kyoto 2006+ база садржи 14 статистичких атрибута издвојених из KDD Cup '99 базе и додатних 10 атрибута.

Кључне речи: детекција упада, рачунарска мрежа, KDD Cup '99, NSL-KDD, Kyoto 2006+.

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SERIOUS GAMES IN MILITARY APPLICATIONS

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Summary:

Serious games as one of the most important trends in e-learning are presented in this paper. An intensive use of information and communication technologies has led to major changes in traditional military education. One of these changes is the use of serious games for simulating the real military environment. This review paper presents several definitions and classifications of serious games, the difference between serious and entertainment games, and considers their military applications in training and simulation systems as well as in education.

Key words: serious games, video games, military education, simulation.

Introduction

There have been an increasing number of serious games in the last ten years that are related to a wide range of different areas: health, military, education, communication, etc (Djaouti et al, 2011).

The first formal definition of the concept of serious games was launched by Abt in his book (1987), which presents simulations and games for the promotion of education, both inside and outside the classroom. He provided the examples either a "mainframe computer" or games based on the "pen and paper" concept, when the video game industry had not yet started. Jansiewicz (1973) published a book describing the game he invented to learn the basics of American politics.

Years later, the concept of a "serious game" was redefined in the work written by Sawyer (2009). Several definitions of serious games have been proposed in the last decade by various authors and organizations:

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Zyda (2005) defined the serious game as "A cerebral challenge, played with a computer according to specific rules, which uses entertainment as an added value for training in institutional or private environments in the fields of education, health, civil security, as well as for communication strategy purposes".

Chen and Michael (2005) defined serious games as "games that have no fun or enjoyment as their primary goal". The term "seriousness" of these games refers to content that can be well used in education as a teaching material by a lecturer.

Alvarez & Michaud (2008) specified serious games as "Computer application, the aim of which is to combine at the same time serious aspects such as, but not limited to, teaching, learning, communication, or information, with ludic springs coming from the video game". Such an association, which takes place through the implementation of a "pedagogical scenario", is therefore aimed at moving away from entertainment.

Serious games can also be used to learn media literacy, showing that video games are not just "neutral" and can include "serious" content (Matteas, 2008). Sawyer & Reyeski helped the industry to form "*Serious Games Initiative*" and organized conferences such as "*Serious Games Summit*" and "*Games for Health*" (Games for Health Conference, 2008). A wider definition of "serious games" includes any software that connects non-entertainment purpose (serious) to the structure of the video game. Designers of serious games use interest in video games to capture the attention of users for various purposes that go beyond pure entertainment.

Center for resources and information on multimedia for higher education has the following definition: "A real training tool, communication, simulation, the serious game is a sort of useful declination of the video game at the service of the professionals. Serious games are applications developed from advanced video game technologies, using the same design and know how approaches as the classic game (3D real time, simulation of objects, individuals, environments...) but which go beyond the sole dimension of entertainment".

From these various definitions, we can conclude that the serious game is a game that combines a serious intention with playful springs of video games. So we take a video game and we associate a utility function with it. The serious game must have three utility functions: disseminate a message, provide training and allow data collection.

After the introduction, the second part considers some applications of serious games. The difference between serious and entertainment games is presented in the next section. The paper continues with the description of the simulation training in military systems. The core components of serious games are also presented because of their importance. Some examples of an application of serious games in the military edutainment are shown in the last section. Finally, at the end of the paper, concluding remarks are mentioned.

Classification of serious games

Serious games mean different names, e.g. "immersive learning simulation", "digital game-based learning", "gaming simulations", and "games that you have to play". Serious games are related to games designed to improve learning, whereas application fields include military training, health care, different levels of education, and many other social purposes. Serious games are not primarily designed for fun purpose. They have an organized game situation and have the meaning and purpose to play. The purpose of serious games in military applications is to prepare for real life situations. These games are played with the purpose of being able to cope with extreme and dangerous situations which players could face. Marczewski (2013) described military serious games as a simulator system, games that are safe for practice and perform as a virtual presentation of a real life situation.

The term serious game (SG) originates from (Abt, 1987) and is applied for games that are not developed exclusively for entertainment, but primarily for the creation of an educational value. SGs are counted among current e-learning trends and gain more and more acceptance and influence (Doujak, 2015). The development of SGs is different from entertainment games. SGs are usually individual products for a limited target audience, or organizations, such as military. This leads to high costs, although the market is showing increasing interest in economical and customized applications (Doujak, 2015). Alvarez & Michaud (2008) classified serious games in five categories, as presented in Figure 1. Possible military applications include edutainment games and training and simulation games.

Figure 1 – Classification of serious games (Alvarez & Michaud, 2008)
Рис. 1 – Классификация серьезных игр (Alvarez & Michaud, 2008)
Слика 1 – Подела озбиљних игара (Alvarez & Michaud, 2008)

Pringle (2007) investigated the use of game technology in military applications. He suggested that serious games could be useful in military training. The military training would have benefits if games combine different technologies. Roman & Brown (2008) concluded that there are few well-defined standards for the measurement efficiency of SGs. Only several military organizations have launched the necessary studies until now to include serious games in military applications.

The most remarkable example of the military application of serious games is *America's Army*. This serios game is designed for the recruitment process and education of youth about the military lifestyle (*America's Army*, 2010). That game pointed out an excitement in the military life.

Serious games and entertainment games

There is a big difference between those games with "moving purpose" and the games designed by the serious games industry. The first group includes video games that were not originally designed to serve for serious purposes, but exclusively for entertainment. However, when instructors use fun games for teaching that have a "serious scenario", the purpose of video games moves to serious ones. This "serious" dimension is not directly embedded in the game, but the

instructor uses it in a way that his students can play the game for educational purposes. So, we can consider that it is a matter of both "serious" and "game". The instructors are then obligated to adhere to a pre-prepared scenario and adapt it to their "serious" goals, while designers have full control over the contents of their games. The relationship between serious game, video game and serious gaming is illustrated in Figure 2.

There are serious games designed as software modifications for entertainment video games on the halfway between "moving purpose" and games designed from the very beginning to serve as serious games. For example, the game *Escape from Woomera* (Valentine & Jensen, 2016) is a software modification of the *Half-Life* video game. The *Half-Life* game, originally related to the fight against an alien invasion, has been transformed into "serious" information on the difficult living conditions at Australian refugee centers.

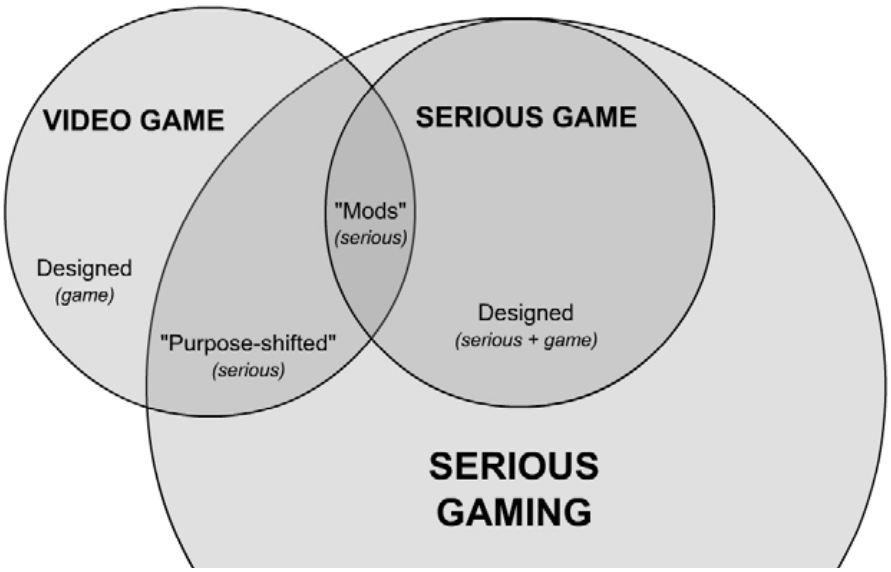

Figure 2 – Relationship between serious game, video game and serious gaming (Djaouti et al, 2011)
Рис. 2 – Взаимосвязь между серьезными играми, видеоиграми и серьезной игрой (Djaouti et al, 2011)
Слика 2 – Однос између озбиљне игре, видео-игре и озбиљног играња (Djaouti et al, 2011)

The appropriate software must be designed for both dimensions: "serious" and "game" in order the "serious game" to be considered as

relevant. Video games today have a very constructive role in educating people of all ages in educational institutions, workplaces and homes, around the world. Video games can also be significant in learning technical skills (Žižović & Plećić, 2017).

Games can play an important role at universities, as a way to increase students' efficiency to learn education materials faster and in a much better way. Universities can use video game for training in technical fields such as aerospace, electrical and computer engineering. While the participants play the game, they use their skills to learn the game and do it better every time they play. During the game, students learn the technical aspects of objects, which can be used in the real world (El Azizi & Arbai, 2017). Games have changed completely the way of life of the youngest generation. Online games such as *Monopoly* and *Sudoku* have not only increased their analytical skills, but also their ability to cope with various situations such as panic, stress, and relationships with peers.

The ability to manage multiple tasks and resources is one of the goals that help video game participants. Learning the rules and strategy of the game also helps the participants of the games. Video games encourage students to play together in the team. A fun way of games helps participants to keep pace with technology changes, thereby increasing their confidence. Video games can help to gain self-confidence by helping them to understand different emotions. Some people think that games make students be withdrawn and asocial, but there are studies pointing to the opposite. Most students like to play video games in pairs or in small groups. That play stimulates competition and strengthens the strategy.

Video games are not just tools for entertainment and relaxation, they create an atmosphere of learning and experience. Students and adults develop the key skills needed for the world through navigation an animated computer screen. To increase initiatives for serious games, various media must be able to work efficiently with current web 2.0 technology (Jaume-i-Capo & Samčović, 2015). In principle, software and hardware must be able to handle such games.

Simulation training and games in military systems

When employed for military applications, serious games are used to train soldiers using virtual environments that reproduce real-world scenarios. The main scope is to prepare soldiers for the situations and

obstacles that may appear in the real world, to make them able to take decisions faster and safer.

War games are analytic games that simulate aspects of warfare at the tactical, operational, and strategic levels. They are used to examine war fighting concepts, train and educate commanders and analysts, explore scenarios, and assess how force planning and posture choices affect campaign outcomes. War games combine game, experiment and performance. They simulate a military operation involving two or more opposing forces, using rules, data, and procedures designed to depict an actual or assumed real life situation.

Military simulations are simulations in which theories of warfare can be tested and refined without the need for actual hostilities. The main difference between military simulations and war games is generally taken the last to be referring to the civilian hobby, thus the preference for the term simulation. Military simulations are seen as a useful way to develop tactical, strategic and doctrinal solutions, but critics argue that the conclusions drawn from such models are inherently flawed, due to the approximate nature of the models used.

From a military perspective, serious game playing has a number of advantages, such as improved hand-eye coordination, improved ability to multitask, ability to work in a team using minimal communication, and willingness to take aggressive action (Chen & Michael, 2005). Many previous military simulations and war games have concerned combat, but more recent efforts also concern skills such as foreign languages and cultural training. Future application areas for the military field include massively multiplayer online games and virtual reality trainers.

We will present in this section some information about the type of modern military operations. During the Cold War, military operations were focused on big battle operations on a particular battlefield where all participants were expected to be fighters (Smith 2008a). In the modern time, the focus was usually on small unit operations in urban areas where military units are called to operate in humanitarian operations, to search, to defense objects, or to combat operations. Hence, virtual environments must represent different objects and interactions, as well as high amount of detail in the field of operations (Smith, 2008a). The virtual environments should also be capable of allowing person-to person communication that would make possible the knowledge that can be useful in military missions. This requires research in group models and personal relationships from social, cultural, and geographical points of view. Virtual environments that are able to accurately represent such

diversity could effectively be an important challenge and a significant point in military applications (Smith, 2008a).

Having in mind the above described characteristics of modern military operations, dynamic modeling of military systems and missions points on the activities are described in (Smith, 2007). The relationships among these activities are presented in Figure 3.

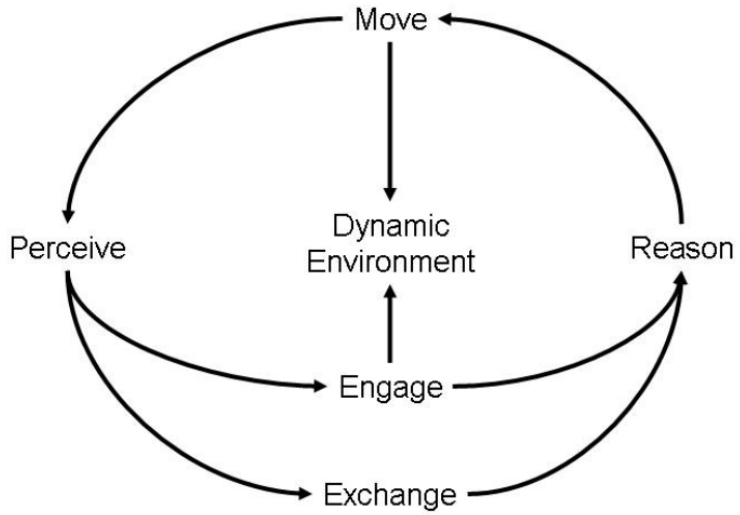

Figure 3 – Relationship model for a simple battlefield simulation (Smith, 2007)
Рис. 3 – Простое моделирование поля боя (Smith, 2007)
Слика 3 – Модел за једноставну симулацију бојног поља (Smith, 2007)

Move: Dynamic representation of a move includes a change in the position of the object over time.

Perceive: Military objects trigger the environment in order to communicate with other objects. The first step in this interaction is to perceive or discover the existence, position and identification of another object.

Exchange: Models are needed to allow objects to exchange materials and information with each other, after move and detection. Battlefield operations usually lead to the exhaustion of materials such as fuel, ammunition, food, medical devices, vehicles and people. Logistics model can be used to represent the army abilities to continuously deliver these materials to units and facilities during the military operation.

Engage: The engagement model typically involves exchange of weapons or firearms from the shooter to the target. This exchange

reduces capability of the shooter by expanding ammunition in one of many shapes (e.g. bullets, missiles, bombs, rockets, artillery).

Reason: Reasoning models rely usually on techniques developed in the field of artificial intelligence. Techniques such as expert systems, rule-based systems, neural networks, fuzzy logic, finite state machines, case-based reasoning, final analysis, and others organize information and form decisions that are similar to those of living beings.

Dynamic environment: There has been an evolution of a simulated environment from static structures to dynamic characteristics and their interactions with military facilities.

Components of game technologies

Commercial video games include technologies that have value for industries outside the environment, including military simulations. The technical cores of the game technology which military industry can use are the following (Smith, 2008b):

• 3D *engine* - presenting the simulated world by creation of the attractive and accurate visualizations that are used to stimulate players;

• *Graphical user interface* (GUI) - easy access and control the game system, it is the menu system and interactive patterns that allow a gamer to immediately begin using a game without ever reading a manual;

• *Artificial intelligence* (AI) - provides the brains that are necessary to create in-game components that are smart enough to challenge human players. This also creates an adaptive experience that can adjust the game as it runs to insure that the player works through a specific problem of interest;

• *Physical models* – create the world which includes movement, communication, detection, engagement interactions, and sensors that are accurate portrayals of the real world;

• *Global networking* - connecting on demand among players; it allows the virtual environment to be extended to multiple players around the globe. Game companies have created the most flexible and efficient methods for transferring data over a worldwide network;

• *Persistent worlds* - larger context for a small unit mission. It is also a 3D portal for tactics and intelligence data. They maintain a virtual world that can grow, change and remain active over many days, weeks, or years regardless of whether an individual player remains engaged with that world.

The above mentioned six core technologies for serious games are illustrated in Figure 4.

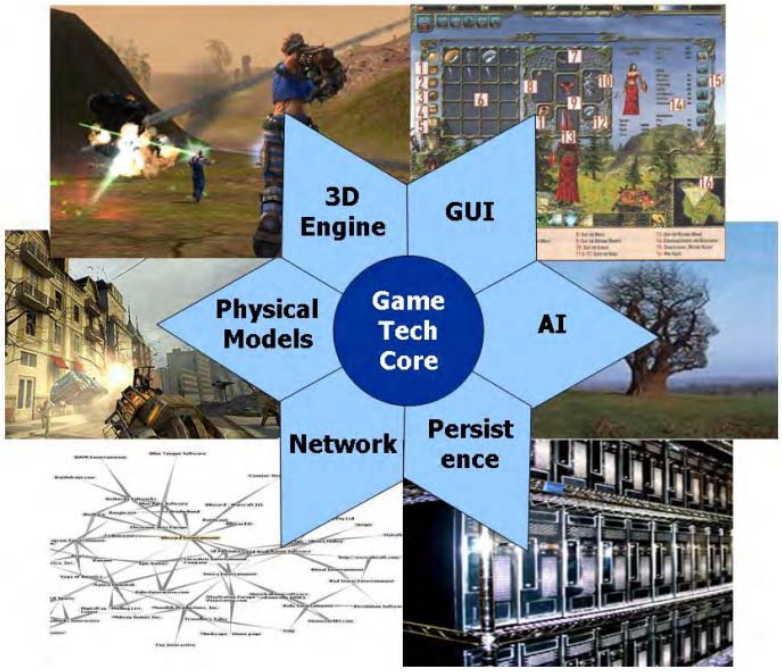

Figure 4 – Key technologies for serious games (Smith, 2008b)
Рис. 4 – Ключевые технологии для серьезных игр (Smith, 2008b)
Слика 4 – Кључне технологије код озбиљних игара (Smith, 2008b)

There is still not much overlapping between military simulations and game technology as Figure 5 shows. Military simulations focus on providing information, terrain data, networking, interoperability standards, facilities, etc. Game technology, on the other hand, focuses on 3D development, artificial intelligence, physical models, multiplayer games, etc.

A possible framework based on military simulations, game technology and the use of modern technology in military training, will be described. The framework will provide the following aspects of military practice (Yildirim, 2010):

- Training of military staff for specific cases. The case is a scenario that includes location (unknown objects, maps), people (how they look, how they dress), time (how many hours there are, effects of the time on the environment, how the operations can be carried out differently in different hours);
- Creating a list of cases and designing interactions and dependencies between cases;

- Creating a list of tactics within a context for each possibility;
- Monitoring the environment in real time by military equipment and transmission information obtained in the game. Moreover, the location specifications, people, weather, etc. can be monitored;
- The soldiers are dressed to blend in the environment around them, e.g. they wear camouflage clothes such as white uniforms in the snow conditions;
- Basic activities of military simulation systems, like movement, perception, exchange, engagement, dynamic environment, which is presented in Figure 6;
- The main components of game technologies: 3D engine, graphical user interface, artificial intelligence, physical models, networking;
- Enabling the possibility of running tactics and strategies of military operations;
- Social aspects of the operation environment;
- Developing an easy-to-understand user access.

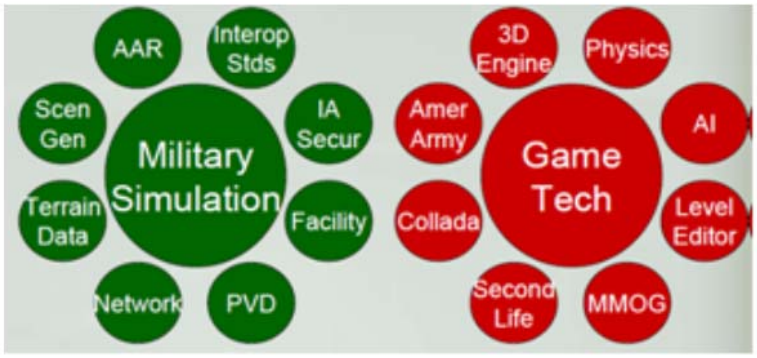

Figure 5 – Military simulation vs. game technology (Smith, 2008b)
Рис. 5 – Взаимосвязь между военным моделированием и технологией игр (Smith, 2008b)
Слика 5 – Веза између војне симулације и технологије игара (Smith, 2008b)

The described framework indicates a serious game for military training. That framework combines military simulation systems, key aspects of game technology, as well as social and cultural aspects of military operations, which is shown in Figure 5. CBR means case based reasoning.

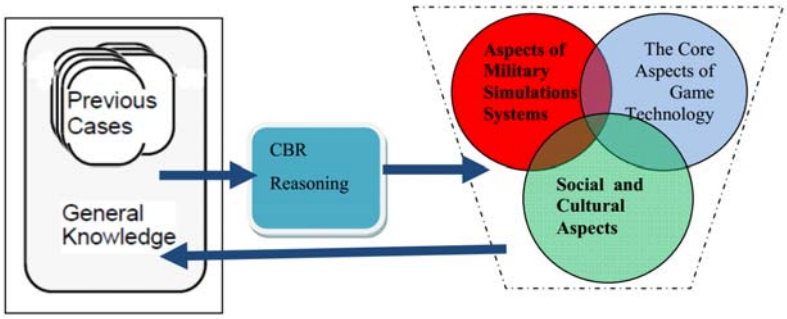

Figure 6 – Acivities in military simulation systems (Yildirim, 2010)
Рис. 6 – Активности в рамках военного моделирования (Yildirim, 2010)
Слика 6 – Активности у оквиру система војне симулације (Yildirim, 2010)

Edutainment games in military systems

Serious games are oriented to teaching and training, simulating everyday situations, or some specific activities. Serious games can consist of professional development for people who perform specific tasks of their personal activities, people's awareness about a particular topic, or everyday situations, such as vehicle configuration. Through this kind of game, simulations should be attractive and playful, while offering activities that favor the assimilation of practices and psychomotor abilities. Therefore, serious games mean digital applications that exceed the entertainment and we can say that their main goal is learning and practicing specific situations, such as, for example, military applications.

Serious games are suitable for military training by simulation of critical situations, including risk, decision making, or to develop specific activities. Other application of serious games involves military teaching where some real situations can be simulated. The knowledge of a player is essential to the evolution of a serious game. One of the objectives of serious games is to develop the stimulation of the cognitive functions, the motivation and knowledge acquisition of the players.

The first fighting video simulation was designed by *Mak Industries*, (Cruz-Cunha, 2012). This simulator was realized on the request of the US *Marine Corps* in 1997. In 1998 US Army, together with the industry, entered into a contract to continue the development of the video game *Spearhead*, to be used in the US *Army Center* and *School for Training Purposes*. At the beginning, these video games were designed only for military use.

The US Army presented in 2003 a new video game for the recruitment, which got the name *America's Army* (2010). This game had

a great success. That game was considered to be the first serious game with military application. The details provided the closest sense of being a part of a fight. This game had the influence on its users by bridging virtual experience with real or simulated (air and paintball games) fight experience. One example of the simulation of military activities is shown in Figure 7.

Figure 7 – Acivities in military simulation systems (America's Army, 2010)
Рис. 7 – Активности в рамках военного моделирования (America's Army, 2010)
Слика 7 – Активности у оквиру система војне симулације (America's Army, 2010)

SanTrain is an example of a serious game designed in the field of military first aid (Dobrovsky et al, 2017). It provides a game-based learning approach and a platform for training tactical combat casualty care. It means a specialized first aid on a battlefield and includes simple life saving steps and priorities for the first minute after injuries. The objectives of this serious game are to prioritize and treat injuries that could endanger life, to prevent further injuries and to complete a military mission. The basic principles come from the US special operations forces experience in real fighting scenarios. It has been shown that, through prioritized treatment at the battlefield, lives of soldiers with life-endangering injuries can be saved. This training can be practiced in the armed forces not only by medical personnel, but also by regular soldiers. The screen-shot of the SG *SanTrain* is presented in Figure 8.

Figure 8 – Screen-shot of the SanTrain game (Dobrovsky et al, 2017)
Рис. 8 – Изображение из игры SanTrain (Dobrovsky et al, 2017)
Слика 8 – Приказ у оквиру игре SanTrain (Dobrovsky et al, 2017)

Another example of a serious game designed for training military medical stuff and nonmedical soldiers with training on providing lifesaving care is *TC3Sim* (Hussain & Coleman, 2014). The game tasks are considered with tactical combat casualty care, including care under fire, which is illustrated in Figure 9 showing a screen-shot of this game. The training system, as well as the used scenarios, have been publicly available in an effort to promote further study on this project.

Figure 9 – Screen-shot of the TC3Sim game (Hussein and Coleman, 2015)
Рис. 9 – Изображение из игры TC3Sim (Hussein and Coleman, 2015)
Слика 9 – Приказ у оквиру игре TC3Sim (Hussein and Coleman, 2015)

Conclusion

Serious games are now being gradually involved into numerous applications such as military applications. Serious games in military have impact on education, training and learning of military staff. The concept of military games can improve the user's motivation. Several studies have demonstrated that serious games help to motivate users in the training. The realism required in military simulations can be achieved by game technologies. More recent studies show the benefits of using computer vision as an input mechanism. It can be concluded that serious games come from video games, but with a “serious scenario”. On the other hand, the psychological and social aspects of serious games should be investigated and taken into account.

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СЕРЬЕЗНЫЕ ИГРЫ В ВОЕННОЙ ПОДГОТОВКЕ

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ВИД СТАТЬИ: обзорная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Серьезные игры на сегодняшний день представляют самый популярный тренд в системе электронного образования. Масштабное использование информационных и коммуникационных технологий привело к крупным переменам в традиционном военном образовании. Одна из таких перемен отражается в

использовании серьезных игр при моделировании реальных боевых действий. В данной обзорной статье представлены несколько определений, классификаций серьезных игр и объясняется разница между серьезными играми и играми для развлечения. Кроме того, в работе рассматриваются военные приложения, пригодные в учениях, системе моделирования и в военной подготовке.

Ключевые слова: серьезные игры, видео игры, военная подготовка, моделирование.

ОЗБИЉНЕ ИГРЕ У ВОЈНОЈ ПРИМЕНИ

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ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Озбиљне игре представљају један од најзначајнијих трендова у електронском образовању. Интензивно коришћење информационих и комуникационих технологија довело је до крупних промена у традиционалном војном образовању. Једна од тих промена односи се на коришћење озбиљних игара при симулацији реалног војног окружења. Овај прегледни рад пружа неколико дефиниција, поделу озбиљних игара, као и разлику између озбиљних игара и игара намењених забави. Осим тога, у раду се разматрају војне апликације код обуке, система за симулацију и у образовању.

Кључне речи: озбиљне игре, видео-игре, војно образовање, симулација.

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СТРУЧНИ ЧЛАНЦИ
ПРОФЕССИОНАЛЬНЫЕ СТАТЬИ
PROFESSIONAL PAPERS

TESTING THE PERFORMANCE OF NoSQL DATABASES VIA THE DATABASE BENCHMARK TOOL

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FIELD: Informatics, Databases
ARTICLE TYPE: Professional Paper
ARTICLE LANGUAGE: English

Summary:

NoSQL is often used as a successful alternative to relational databases, especially when it is necessary to provide adequate system dimensioning, usage of a variety of data types and high efficiency at a low cost for maintaining consistency. The work is conceived in a manner that covers the general concept of a database, i.e. the concept of relational and non-relational databases, which are substantiated by all important aspects and in an appropriate context. After analyzing the types of NoSQL databases, emphasis is placed on explaining their advantages and disadvantages, as well as on an overview of the NoSQL and SQL database comparison. The final part of the paper presents the results of testing the performance of NoSQL databases, obtained though the Database Benchmark tool. The aim of the paper is to highlight all the details of NoSQL databases in order to establish the justification of their application in practice.

Key words: Databases, Relational databases, NoSQL databases, Performance testing.

Introduction

Nowadays, data and information are accumulated at a rapid pace from a variety of sources, and it is not easy to understand what they

mean. To cope with the growing amounts of digital data of varied nature, organizations must use sophisticated techniques for information management. Viewed from this angle, databases are essential in all areas of operation of one organization. Relational databases support most of business systems of today's organizations and for a good reason. Functionality and reliability of such databases have been proven in many systems through many years. They have been supported by a number of tools, documented in detail, and there are a large number of people qualified for the implementation and maintenance of these systems. However, both analytical and operational organizations now increasingly take into account different solutions for their business problems, which results in relational databases not always being appropriate for storing and processing data. That is why NoSQL (Not only SQL) databases have been created.

NoSQL databases apply different mechanisms for data storing and establishing relationships across data from relational databases. If data does not need to be stored in tables or there are relations that cannot be presented by classic SQL relationships, and data has to be accessed fast, then NoSQL databases are applied.

The term database

A database is a collection of interconnected logical related data stored in computer external memory, simultaneously available to users and application programs. It is organized in such a way that a set of computer programs - system for managing databases (Database Management System DBMS) - allows all users to access all data.

A database management system is a set of programs which provide the user with tools to add, delete, access and analyze the data stored in one location. Data can be accessed using queries or reporting tools (which are an integral part of the DBMS) or using application programs written specifically for the purpose of accessing the information. The DBMS also provides mechanisms for the preservation of data integrity, for the management of security and for user's access to information database in case of a crash.

This system minimizes the following issues:

- data redundancy - when the same data is stored in more than one place;
- isolation of data - when an application cannot access the data that is associated with other applications;

- data inconsistency - when different copies of the same data do not match.

On the other hand, the system maximizes:

- data security;
- data integrity - data must meet certain criteria, e.g. there must not be any letters in the field reserved for a personal identification number;
- data independence - application software and data are independent from each other (i.e. applications and data are not related to each other, which means that different applications can access the same data).

Defining a database requires not only a specification of types and data structures that need to be memorised into the base, but also the limitations of the data. In this regard, Data Definition Language - DDL is used for the execution of these activities. Data definitions are located in the system directory and are called metadata.

Add, delete, modify and search data represent the activities of manipulating databases by the help of Data Manipulation Language DML. A DML part that searches a database is called a query language. Figure 1 represents a simplified database system (http://sakshieducation.com).

Searching data in the database is probably the most frequently executed process. Structured Query Language (SQL) is the most popular language for data search. It allows the execution of complex search using relatively simple phrases or keywords. Typical keywords are SELECT (to determine the desired attribute), FROM (to determine the tables that will be used) and WHERE (to determine the conditions which will apply to search). For example: SELECT the name of the student, FROM a database of students, WHERE the average score > 9.00.

Another way to find data in the database is by using search examples (Query By Example - QBE). In the QBE search system, users fill out a template (also called a form) to define an example or a description of the desired information. Users can quickly and easily construct a questionnaire using the techniques of drag-and-drop in the DBMS. Such a search is easier than typing SQL commands.

There are many different models, such as the database Entity-Relationship model (ER model), hierarchical models, network models, relational models and object model. The most popular model is undoubtedly the Entity-Relationship model (ER model).

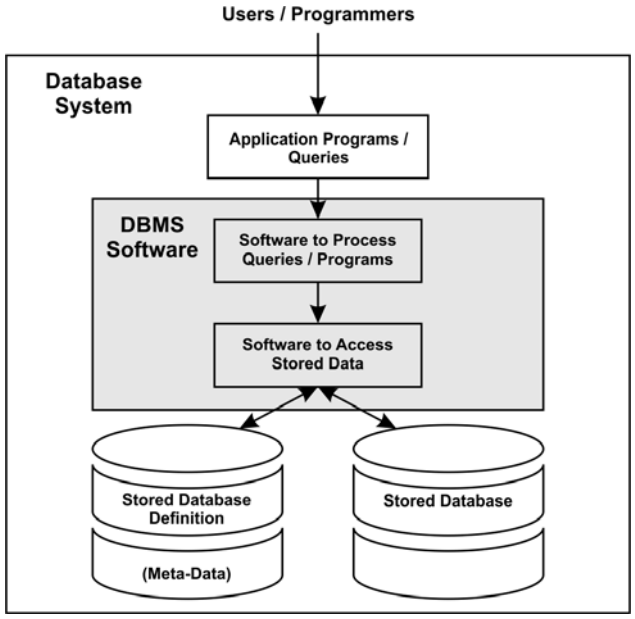

Figure 1 – Simplified database system
Рисунок 1 – Упрощенная система баз данных
Слика 1 – Поједностављен систем базе података

Relational databases

Relational databases contain and manage relational structured data, and have a system for manipulating them. The data is stored in a two-dimensional table consisting of rows and columns. The interaction with the relational database management system, in most cases, is implemented by using SQL query language. Types of data that could be stored are determined by the system while information is organized using a clearly determined scheme, typically based on the Entity Relationship (ER) model. The relational database model and SQL as a standard query language are widely accepted and were considered for long to be the only alternative to storing and organizing data which can be accessed by more than one user in a consistent manner.

Since there is a data structure, it is necessary to follow it, including the classification of data into the table by rows and columns (Figure 2). The intersection of a column and a row has only one value, and each variable has a data type, each of which has a limited domain of allowed values. Primary keys are placed in order to be able to identify each row in the table, while the foreign keys are used to interconnect multiple tables.

Because of this structure type, relational databases are vertically scalable, which means that they work best on a single node, that is, on a single computer. If expansion is necessary due to a growing amount of data, the best option is to increase the resource of that node.

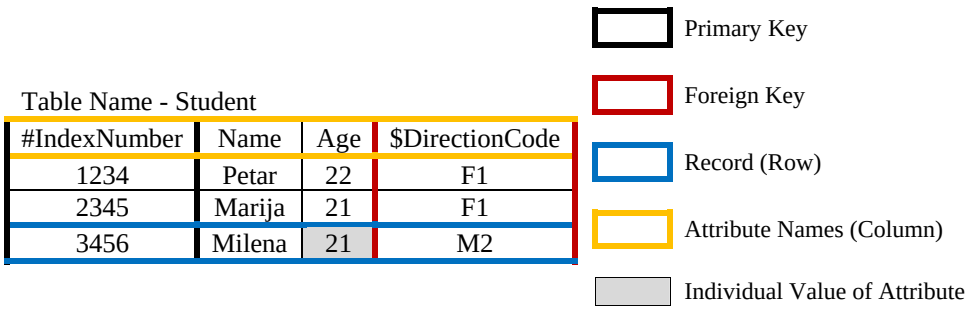

Figure 2 – Table (basic terms and components)
Рисунок 2 – Таблица (основные термины и компоненты)
Слика 2 – Табела (основни појмови и саставни елементи)

Non-relational database

As their name suggests, non-relational databases are not based on the relational model, or at least do not stick to it firmly, and include data without schemes. They are widely distributed systems that enable rapid organization and analysis of large quantities of various types of data. They are simple and horizontally scalable, meaning you can easily add a new node (computer) which does not affect the operation of the system (Strauch, 2011). Unlike relational databases, where the ACID (Atomicity, Consistency, Isolation, Durability) properties are applied, non-relational databases are based on the BASE (small plates, Soft state, are/is possible consistency) properties. The BASE properties certainly do not mean that NoSQL databases are unreliable and inconsistent, but eventual consistency means that the system will become consistent once all data is propagated into all nodes in the cluster.

ACID and BASE models

The ACID and BASE are models of control over transactions in order to ensure consistency. The difference between them depends on a layer in which they are: the ACID model is in the base layer, while the BASE model is in the application layer. Also, unlike the ACID model which is oriented to consistency, systems that use the BASE model focus on accessibility.

Relational databases support the ACID properties of transactions:

1. Atomicity - transactions must be done fully or not at all, which means that systems that provide atomicity must be prepared for all possible problems (hardware and software problems, network failures, disk problems or full system crashes);
2. Consistency - data must be entirely consistent;
3. Isolation - operations are mutually isolated (no part of the transaction is aware of the others);
4. Durability - after all transaction elements are complete, the transaction becomes permanent.

NoSQL databases follow the BASE properties:

1. Basic Availability - the system is allowed to be temporarily inconsistent in order to carry out transactions;
2. Soft state - some inaccuracies are allowed for a short time and the data can be changed while being used, in order to reduce the consumption of resources;
3. Eventual consistency - after all operations are performed, the system will become consistent.

The CAP theorem

The ACID and BASE concepts should not be seen as mutually exclusive options, but as a spectrum. The BASE concept is often mentioned along with another important concept, the CAP (Consistency, Availability, and Partition Tolerance) theorem. This proposition can clarify why it is sometimes necessary to sacrifice consistent work for other properties. For NoSQL databases, according to the CAP theorem, only two of the next three properties can be guaranteed at the same time (Kumar, nd):

1. Consistency - all nodes have identical copies of the data available for the transaction;
2. Availability - every request for information will be processed successfully or there will be a message that the request cannot be processed;
3. Partition Tolerance - the system will continue to operate in the case of breaking the link between the nodes, which would create partitions in which nodes can communicate with each other only within their own partition.

NoSQL - „Not Only SQL“

The term NoSQL ("Not only SQL") is the term that describes the entire class of databases which do not have the characteristics of

traditional relational databases and for which standard query SQL language is not generally used. NoSQL databases are considered to be the next generation databases and may be defined as non-relational, distributed databases, open source, and horizontally scalable. They are characterized by a less strict static data structure, simple support to replication and simple application programming interface (API). They are often related to large data sets that need to be quickly and efficiently accessed and changed on the Web.

Basic characteristics of NoSQL databases

The basic characteristics of NoSQL databases are:

1. Distributed computing (Scalability, Reliability, Resource Sharing, Performance) - NoSQL databases are distributed, provide horizontal scalability, and handle large amounts of data e.g. several of terabytes or petabytes with small time delay. A parallel increase in the number of users and amount of data requests relevant data from the Web and mobile applications, as well as from accompanying databases, which can be achieved by using the following two methods:
   a. Scale up - this involves adding resources to a single node by setting an additional processor or by increasing storage memory.
      - Vertical scalability with relational databases: to support a large number of simultaneous users and/or store more data, there is a need for big servers with more processors that will handle that workload, more memory and more storage space for all tables. Installing and maintaining large servers is a complex task that requires large investments (costs).
   b. Scale out - refers to adding new nodes to the system (for example, adding new computers to the distributed software application).
      - Horizontal scalability with NoSQL databases: with this method, the resource is added to a cluster of servers for data storage and supporting operations with databases. The cluster is expanded by adding additional servers to spread database processing to a larger cluster. As servers are vulnerable to failure, NoSQL databases are designed to withstand and recover from constant failures, which makes them very resistant. NoSQL databases enable a simpler, straight-line approach to scaling databases. They are best at dealing with sudden jumps in activities of new users. In order to cope with sudden jumps in volume, a new database server needs to be added to expand the cluster.

2. More flexible data model - NoSQL databases appear in one of the following models:
   - key-value databases,
   - document-oriented databases,
   - wide column databases,
   - graph databases.
3. Asynchronous insertions and updates / low transactional - Complete transactional guarantees and simultaneous execution of transactions in all nodes in a distributed environment are not provided by NoSQL databases. Instead, they guarantee the availability of data at the distributed level (through an internal synchronization). This is why NoSQL is a perfect model for applications such as social networking, where simultaneous transactions are not a limitation.
4. Follow BASE/CAP instead of ACID - Instead on ACID, NoSQL databases work more or less on the BASE principle. All NoSQL databases rely more or less on the ACID properties (CAP theorem). For example, when there are no updates for a while (this can mean a few seconds), all updates can propagate through the system at the very end, which depends on the loads, the size of the cluster and the network traffic, and it will make all nodes consistent.
5. Query language - These databases do not support SQL, unlike relational databases.
6. NoJoins - NoSQL databases do not use the concept of linking.
7. Low cost – They use clusters of low-cost, already available equipment (servers) instead of own servers for managing large amounts of data and transactions.
8. Easy implementation – They provide flexibility and simpler schemes, unlike the Relational Database Management System (RDBMS).

Types of NoSQL databases

There are four basic types of databases that are classified under the category of NoSQL (Sadalage, 2014):

1. key-value databases,
2. document-oriented databases,
3. wide column databases,
4. graph databases.

Key-value databases

Key-value databases can be compared to a table in a relational model that has two columns, the key and the value. The data is stored in

distributed hash maps, where the key is most often a string, while the value can be one of the types supported by all programming languages, such as strings, numbers, arrays, or objects. These databases store a variety of data, but do not perform any additional data search by multiple criteria.

- Advantages:
  - working with large amounts of data,
  - very fast,
  - usually support automatic replication and horizontal partition of collections.
- Disadvantages: (Graovac, 2016):
  - a high level of redundancy,
  - complex structures are implemented by a large number of collections
  - if the data is "densely" linked, the efficiency drops dramatically,
  - they have no mechanisms for the preservation of the integrity - often do not provide even transaction atomicity,
  - search condition is exclusively a fixed key value or a range of key values.

The most popular key-value databases are: DynamoDB (Amazon), Riak, Redis, Voldemort, and Oracle NoSQL.

Document-oriented databases

With document-oriented databases, data is organized as a collection of documents with possibly different structures, which supports simple adding and dropping of attributes. These bases store XML, JSON, BSON formats of documents (tagged format) or, for example, PDF format documents (unstructured format). Data is not normalized.

- Advantages:
  - very simple and efficient operation,
  - usually support at least semi-automatic replication and horizontal collection partition - often just a replication of the main-subordinate type.
- Disadvantages:
  - relatively limited domain of application,
  - many implementations do not allow ad hoc querying and changing data,
  - some implementations do not stand high frequency data changes.

Some of the most popular document-oriented databases are: CouchDB, MongoDB, RavenDB, Couchbase, Azure DocumentDB.

Wide column databases

In wide column databases, data is grouped in columns, which gives a better performance when there is a need for queries that should restore only certain attributes, and not full entities. They operate with the terms *column* and *super column*. The columns have a name, a value, and a timestamp, which indicates that there is no need to define a scheme.

- Advantages:
  - support very large amounts of data,
  - they are very fast, except in some cases of values with very complex structures
  - most support automatic replication and horizontal collection partition.
- Disadvantages:
  - a high level of redundancy,
  - complex structures are implemented by a large number of collections,
  - if the data is "densely" linked, the efficiency drops dramatically,
  - they have no mechanisms for the preservation of integrity - often do not provide even transaction atomicity,
  - search condition is exclusively a fixed key value or a range of key values.

Some of the most popular wide column databases are: Cassandra (Facebook, now part of the Apache Software), Hadoop / Hbase, Accumulo, Hypertable, Amazon SimpleDB.

Graph databases

In graph-oriented databases, data is represented in the form of graphs, with entities being represented by nodes, and their relations by the edges of the graph. Each link and node carry certain information on the basis of which quick inquiries can be made. Searching data by links shows great performance advantages.

- Advantages:
  - in contrast to other non-relational databases, they are very effective when it comes to common operations with graphs,
  - some support transactions and the ACID mode of conditions,
  - usually only the replication of the main-subordinate type.
- Disadvantages:
  - relatively restrected application domain,
  - not suitable out of their domain.

Some of the most popular databases oriented towards graphs are: Neo4J, AllegroGraph, OrientDB, ArangoDB, Infinite Graph.

The general criteria for the selection of NoSQL databases

General criteria that need to be taken into consideration before making a decision about which NoSQL database to use are as follows:

1. Storage type - one of important criteria that should be considered when choosing an NoSQL database.
   - For example, get, put and delete functions are best supported by key-value systems.
   - Aggregation becomes much simpler when using column-oriented systems. They use tables, but without joining.
   - Data mapping becomes easier with object-oriented software using NoSQL databases based on documents, such as XML or JSON.
   - A tabular format is changing, and data is saved in the graphical format.
2. Control of parallel execution - specifies how two users may simultaneously modify the same information. It often happens that one of the users loses access, so he/she cannot change or perform actions, while an active user ends editing (Kumar, nd).
   - Lock - prevents more than one active user from changing an entity such as a document, a line or an object.
   - Multiversion concurrency control (MVCC) - provides a readable overview of the base, but leads to conflicting versions of an entity, if more than one user perform changes at the same time. MVCC enables seemingly smooth processing of transactions by creating multiple versions of a site. This means that the consistency of transactions is retained, although different users at any given moment are shown various displays. All changes to the database will be displayed to all users depending on which view they are viewing.
   - In some systems there is a lack of atomicity due to which all users who modify the database do not have the same base overview.
   - ACID should be chosen if reliable transactions are needed.
3. Replication - enables continuous synchronization of backups.
   - Synchronous mode - this approach (although expensive due to dependence on another server to respond) always provides consistency.
   - Asynchronous mode - with this approach, the database update is done without waiting for a response from another database. There is a small scale of inconsistencies that can last a few milliseconds.

4. Language for implementation - assists in determining how fast the database processing can be performed. NoSQL databases written in low-level programming languages are most often the fastest. On the other hand, those written in higher-level programming languages are easier to modify.

Examples of applying the four basic types of NoSQL databases

The next part of the paper provides some examples of applying the four basic types of NoSQL databases, as well as some of the specific criteria for determining which type meets specific requirements.

Examples of application of key-value databases

The databases of type key-value are suitable for applications that have frequent short readings and typing with simple data models. The values stored in this database type can be a simple scalar value such as an integer or a boolean, but they can also be structured data such as lists and JSON structures. Generally, have the option of a simple query that allows identifying a value over its key. Some key-value databases support search functions and are therefore more flexible.

The database of the key-value type is used in a large number of applications, such as (Sullivan, nd):

- caching data from relational databases to boost performance,
- monitoring temporary attributes in a Web application, such as a shopping cart,
- storing configurations and user information for mobile applications,
- storing large objects, such as images and audio files.

Examples of the application of document-oriented databases

Databases oriented towards documents are designed to be flexible. If an application requires the ability to put different attributes together with large amounts of data, then this database is the right solution. For example, in order to present products in a relational database, the model maker can use a table for common features and additional tables for each product subtype in order to store the attributes that occur only in product subtypes. Databases oriented towards documents are the best choice for these situations.

Databases oriented towards documents are used for embedded documents which are good for denormalization. Instead of storing data in different tables, data which is often searched together is placed in the same document. In addition, these databases improve the ability of key-

value databases by indexing and by the ability to filter documents based on attributes in the document itself.

Databases oriented towards documents are perhaps the most popular NoSQL databases because of their flexibility, performance, and ease of use. They can be applied in the following situations:

- back-end support for sites with large numbers of hits and data,
- management of data with variable attributes, such as products,
- tracking changeable metadata types,
- applications that use the JSON data structure,
- applications that take advantage of denormalization by embedding structures into the existing structures.

Databases oriented towards documents are also available as cloud service (Microsoft Azure Document and Cloudant's database).

Examples of the application of wide column databases

Wide column databases are designed for large amounts of data, for reading and registration performances and they are extremely affordable. Google's Bigtable was designed for its needs, while Facebook developed Cassandra to enable the Inbox search service to its customers. These database management systems function on the principle of a cluster of multiple servers.

Wide column databases can be used in the following cases:

- applications that require a competence of permanent entries in the database,
- applications that are geographically distributed across multiple data centers,
- applications that tolerate some short-term inconsistencies in responses,
- applications with dynamic fields,
- applications with potentially vast amounts of data, for example, thousands of terabytes.

Examples of the application of graph databases

Databases oriented towards graphs are suitable for application in problems that can be solved using graphical structures for data saving and storage. One way to evaluate the utility of databases oriented towards graphs is to check if each element contains a direct pointer to the next element (if one element is connected with other elements).

For example, two orders in electronic trade probably are not linked to each other. They may have been sent by the same customer but that is a common atribute, not a link. Similarly, the configuration and progress in a game of one gamer probably has nothing to do with the configuration of another game of some other gamer. In these cases, the most commonly used are key-value databases, document oriented or relational databases.

On the other hand, examples such as railway tracks that connect cities, proteins that are intertwined with other proteins and workers who collaborate with other workers are cases where there is some kind of connection or a direct relationship between the two instances of the entities. These are the types of problems where database oriented towards graphs can be used.

Other examples include:

- online management and IT infrastructure management,
- identity and access management,
- business process management,
- recommending products and services,
- social networks.

The above examples clearly show that, when it is necessary to make a model of explicit and fast connections between the entities, databases oriented towards graphs should be used.

NoSQL advantages and disadvantages

Table 1 presents the pros and cons of NoSQL databases.

Table 1 – NoSQL advantages and disadvantages
Таблица 1 – NoSQL преимущества и недостатки
Табела 1 – NoSQL предности и мане

Advantages of NoSQL	Disadvantages of NoSQL
High scalability	Too many options (over 150), so it is hard to make a decision
Flexibility of the scheme	Limits query (for now)
Distributed computing (scalability, reliability, resource sharing, speed)	Eventual consistency is not intuitive to programs such as banking applications
There are no complicated connections	Lack of Joins, Group by, Order by features
Lower costs	ACID transactions
Open Source - all NoSQL options with the exception of Amazon S3 (Amazon Dynamo) are open source solutions	Limited support - open source

Comparison between NoSQL and SQL

Table 2 presents the difference between NoSQL and SQL (https://azure.microsoft.com).

Table 2 – Comparison between NoSQL and SQL
Таблица 2 – Сравнение между NoSQL и SQL
Tabela 2 – Poređenje između NoSQL i SQL

	NoSQL	SQL
Model	Non Relational	Relational
	Storing data in JSON documents, key-value pairs, column-oriented warehouses or graphs	Storing data in tables
Data	Flexibility due to the fact that all records do not have to store the same characteristics	Excellent for solutions where each record has the same characteristics
	Quickly add new features	Adding a new feature requires modifying the scheme
	Links are graded by denormalizing data and presenting all data for one entity in a single record	Links are built in normalized models by joining tables
	Suitable for semi-structured, complex or nested data	Suitable for structured data
Scheme	Dynamic or flexible schemes	Clearly defined schemes
	Database does not accept the scheme, and it is specified by the application. This results in agility and highly interactive development	Scheme must be maintained and be synchronized between applications and databases
Transactions	ACID transaction support varies depending on the solutions	Supports ACID transactions
Consistency and availability	Supports eventual consistency to strong consistency, depending on the solutions	Strong consistency
	Consistency, availability, and performances may vary depending on the application requirements (CAP theorem)	Consistency has priority over availability and performance
Performances	Performances can be maximised on account of consistency (if necessary)	Insertion and update performances depend on the speed of record creation, with strong consistency Performances can be maximized by scaling available resources
	All information about an entity are generally in a single record, so an update can be performed in a single operation	Information about the entity can be in many tables and rows, so it requires joining to perform updates or queries
Scalability	Scalability is mainly horizontal and data is distributed on multiple servers	Scalability is mainly vertical with more server resources

Testing the performances of NoSQL databases

Database performance testing is one of the areas with few open source tools. This may be due to the fact that most relational databases are commercial tools that come with the existing infrastructure provided by the seller. However, the current rise in NoSQL databases may still change this situation in the future.

One of the most popular, and by many the most popular open source tool for testing database performance is Yahoo! Cloud Service Benchmark (YCSB). This tool enables testing of different systems and their comparison; for example, on the same hardware configuration, multiple systems can be installed over which an identical load scenario will be run, so that eventually their characteristics can be compared. It consists of a YCSB client, a load generator, and a set of basic load scenarios (Cooper et al, 2017). The YCSB client is a Java program for generating data that will be added to the database and generate operations, which are the workload scenario. The Load Scheduler manages multiple threads of the client. Each thread executes a sequential series of operations by calling the database interface layer to load it (load phase) and to execute the load scenario (transaction phase). Threads also regulate the rate at which requirements are regulated, so it is possible to directly control the offered load on the database. Threads measure both latency and the achieved bandwidth of their operations and pass the measurements to the statistical module. Finally, the statistical module collects the measurements and reports on the average values.

Performance testing using the YCSB tool requires first a correct installation and configuration of the database management system. The configuration refers to the creation of known "template tables" (depending on the data model, as well as on the load scenario), within which the tool itself will generate data. The next step involves selecting a correct database interface layer generated by the Java class that will perform reading, writing, updating, deleting, and searching. Then a load scenario is selected from the basic set or an arbitrary one is created, to be followed by the selection of the appropriate execution parameters (number of client threads, targeted bandwidth, etc.). The last step is to load the desired amount of data into the database, and start the simulation.

Analyzing a large number of scientific and professional papers whose content is focused on testing the performance of NoSQL databases has led to two important conclusions:

- YCSB tool was used for performance testing;
- the emphasis is on testing the performance of some of the most popular NoSQL databases, such as: MongoDB, Redis, CassandraDB, Couchbase, Hbase.

Given the above facts, this part of the paper will present the results of NoSQL databases performance tests obtained using Database Benchmark. This is still one of the few tools for this purpose that has built-in support for some of the most popular NoSQL databases. The computer configuration presented in Table 3 test was used to test five less popular (but not of a lesser value) NoSQL databases: HamsterDB, LevelDB, STSdb 4.0 (database type key-value), RavenDB (document oriented database) and BrightstarDB (graphs oriented database).

Database Benchmark is one of the most powerful open-source tools for testing the performance of bases with large amounts of data. The application has two main test scenarios:

- inserting large amounts of randomly generated records with sequential or random keys and
- reading of the inserted records according to their keys.

Testing performance of NoSQL databases via the Database Benchmark tool

The limited-resource computer system whose specifications are presented in Table 3 was used for testing the performance of five NoSQL databases: HamsterDB, LevelDB, STSdb 4.0, RavenDB and BrightstarDB. Database Benchmark, a tool that was used to perform the measurement itself, was selected to keep the NoSQL databases running in different ways at approximately the same level, so that the obtained measurement results could be relatively realistically compared. The following parameters were measured:

- speed insertion of all records generated with random keys, and
- speed reading of all inserted records according to their keys.

Table 3 – Computer configuration (Acer Aspire 5750G)
Таблица 3 – Конфигурация компьютера (Acer Aspire 5750G)
Табела 3 – Рачунарска конфигурација (Acer Aspire 5750G)

	Acer Aspire 5750G
Processor	Intel® Core™ i3-2310M CPU @ 2.10 GHz
Random access memory	6GB DDR3 @ 1333 MHz
Storage	640GB SATA 5400rpm
Operating system	Microsoft Windows 10 Pro - 64 bit

Testing the performance of databases via the Database Benchmark tool includes the following steps:

- select the databases to be tested,
- select the number of data streams to be inserted (tasks),
- select the number of records to be generated for each stream of data (records),
- Select the type of generated keys for all streams (keys). Keys can be sequential or random.

Speed of insertion of all records generated with random keys

Speed of insertion of all records generated with random keys was measured in three different circumstances:

1. Number of data streams = 1; The number of records for each data stream = 50,000; Key type = random;
2. Number of data streams = 2; The number of records for each data stream = 50,000; Key type = random;
3. Number of data streams = 5; The number of records for each data stream = 50,000; Key type = random.

The obtained measurement results are presented in Figures 3 to 6.

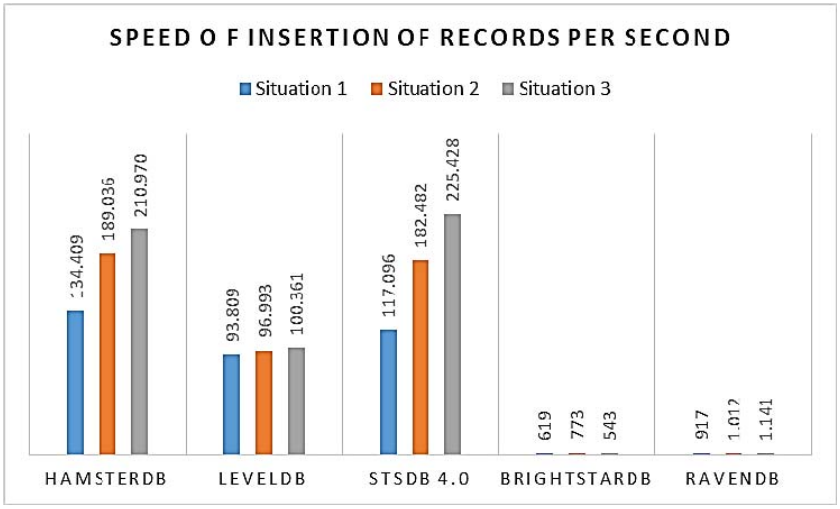

Figure 3 – Speed of insertion of records per second
Рисунок 3 – Скорость вставки записей в секунду
Слика 3 – Брзина уметања записа по секунди

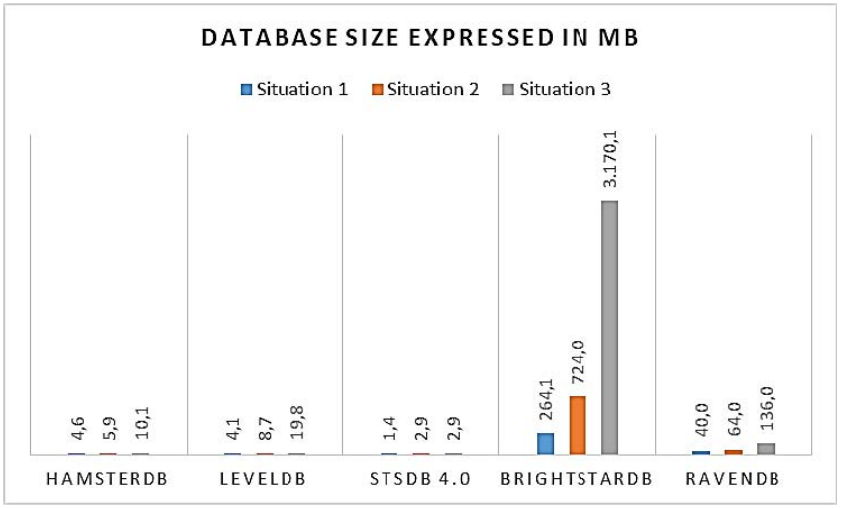

Figure 4 – Database size expressed in MB
Рисунок 4 – Размер базы данных, выраженный в MB
Слика 4 – Величина база података изражена у MB

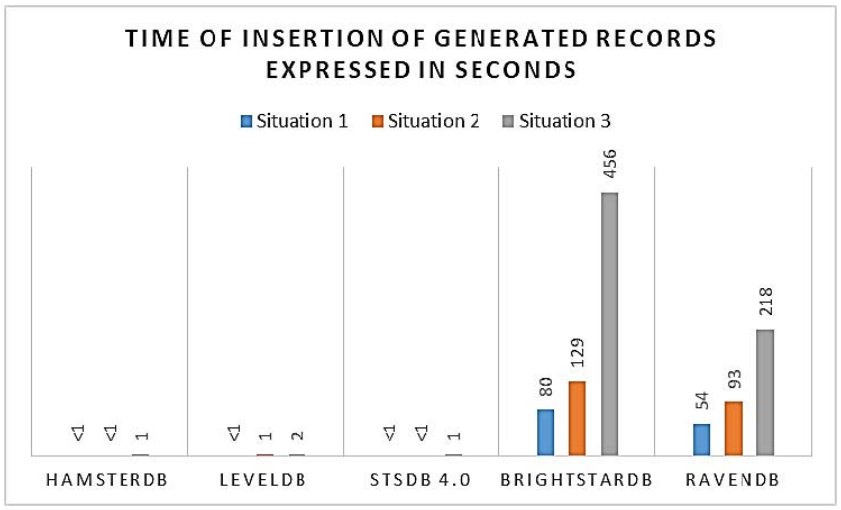

Figure 5 – Time of insertion of generated records expressed in seconds
Рисунок 5 – Время вставки сгенерированных записей, выраженное в секундах
Слика 5 – Време уметања генерисаних записа изражено у секундама

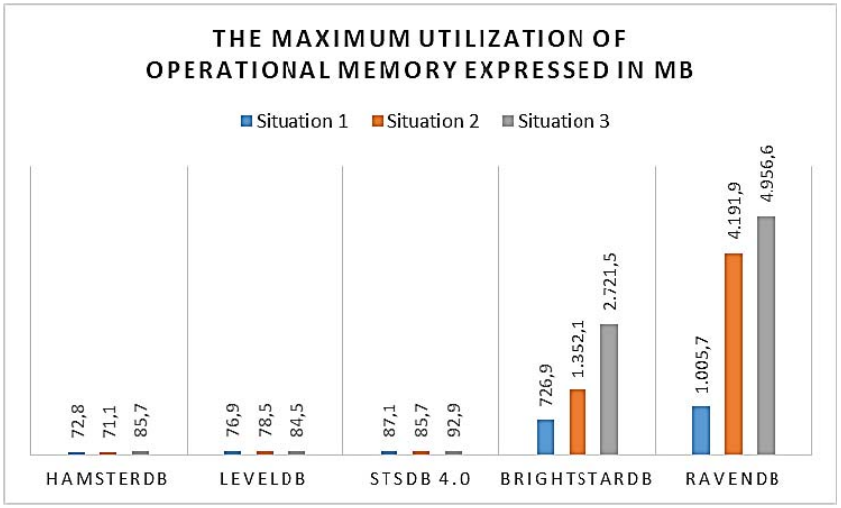

Figure 6 – Maximum utilization of operational memory expressed in MB
Рисунок 6 – Максимальное использование оперативной памяти, выраженное в MB
Слика 6 – Максимум искоришћења оперативне меморије изражен у MB

Speed of reading of all inserted records according to their keys

Speed of reading of all inserted records by their keys was measured in three different circumstances:

1. Number of data streams = 1; The number of records for each data stream = 50,000; Key type = random;
2. Number of data streams = 2; The number of records for each data stream = 50,000; Key type = random;
3. Number of data streams = 5; The number of records for each data stream = 50,000; Key type = random.

The obtained measurement results are presented in Figures 7 to 10.

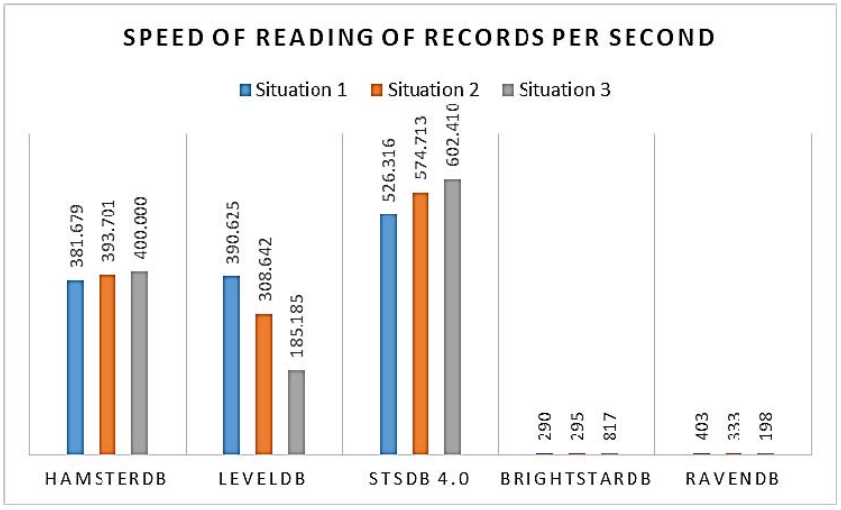

Figure 7 – Speed of reading of records per second
Рисунок 7 – Скорость чтения записей в секунду
Слика 7 – Брзина читања записа по секунди

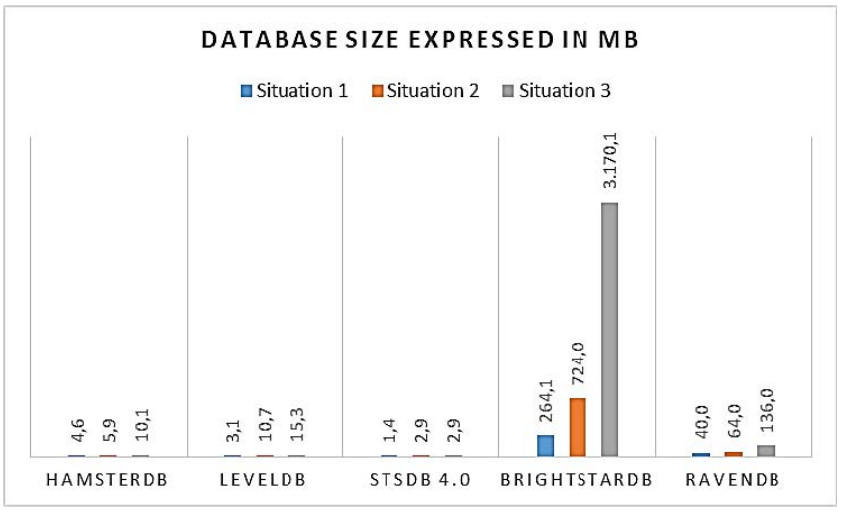

Figure 8 – Database size expressed in MB
Рисунок 8 – Размер базы данных, выраженный в MB
Слика 8 – Величина база података изражена у MB

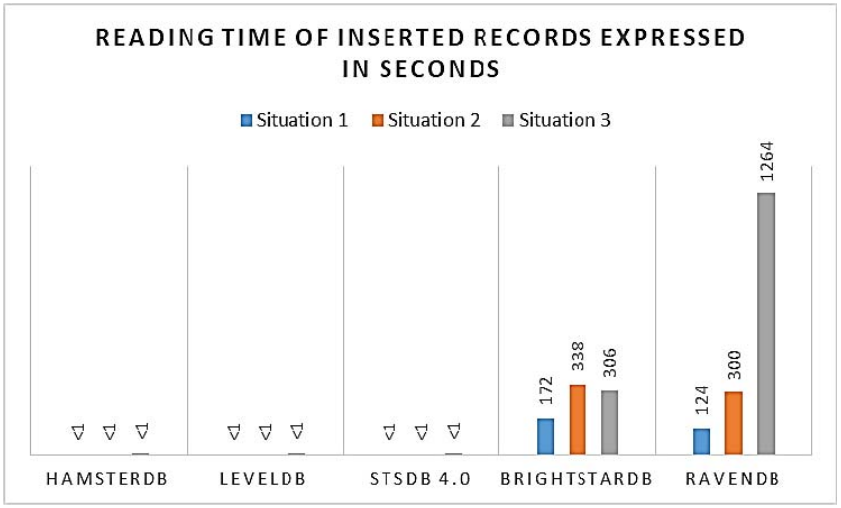

Figure 9 – Reading time of inserted records expressed in seconds
Рисунок 9 – Время чтения вставленных записей, выраженное в секундах
Слика 9 – Време читања уметнутих записа изражено у секундама

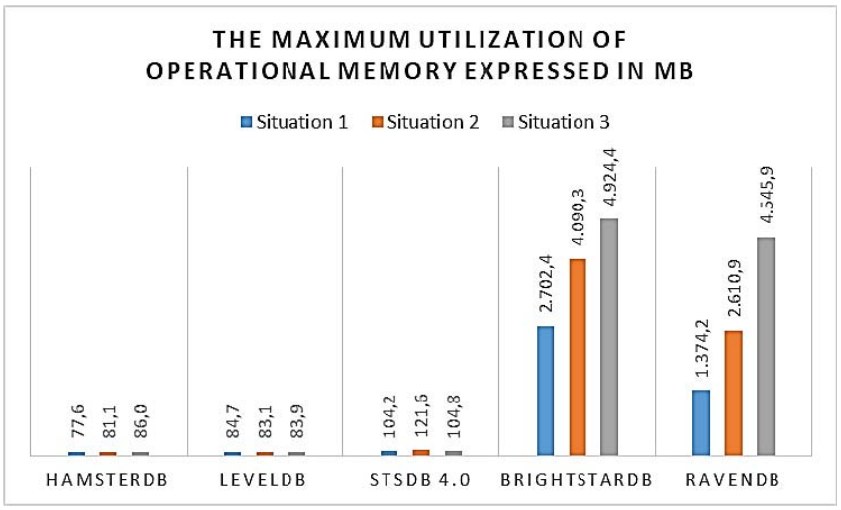

Figure 10 – Maximum utilization of operational memory expressed in MB
Рисунок 10 – Максимальное использование оперативной памяти, выраженное в MB
Слика 10 – Максимум искоришћења оперативне меморије изражен у MB

Analysis of the obtained measurement results

The analysis of the speed of inserting all records generated with random keys in situations where the number of data streams is 1, 2 or 5, the number of records for each data stream is 50,000, and the key is random can be presented as follows:

- in all three situations, HamsterDB has the highest speed of insertion of records per second, while the worst results are with BrightstarDB,
- in all three measurements, STSdb has the smallest value, while BrightstarDB has the largest value,
- the time it takes to insert all records generated with random keys in all three situations is almost similar when it comes to HamsterDB, LevelDB and STSdb, while the lowest time is achieved by BrightstarDB,
- the maximum utilization of the operating memory varies depending on the particular database, but the best result in two of the three cases was shown by HamsterDB, while the Raven showed the worst.

The analysis of the speed of reading all the inserted records according to their keys in situations where the number of data streams is 1, 2 or 5, the number of records for each data stream is 50,000, and the key type is random can be presented as follows:

- STSdb has the highest reading speed of inserted records per second in all three cases of measurement, while the smallest read speed in two of three cases has been shown by BrightstarDB,
- in all three cases, the STSdb measurement has the smallest value, while BrightstarDB has the largest value,
- the time it takes to read all of the inserted records according to their keys in all three situations is almost similar when it comes to HamsterDB, LevelDB and STSdb, while much worse time is achieved by BrightstarDB and RavenDB,
- with the maximum use of operational memory, the best result in two of the three cases was shown by LevelDB, while BrightstarDB proved to be the worst.

Conclusion

Information technologies and information systems support organizations in data management, from collecting, organizing, storing, accessing, to analyzing and interpreting data. For enormous amounts of

available data that are growing every day, relational databases are not always the best solution for managing and storing them. In this sense, big companies like Google, Facebook and Amazon have played a significant role in reviving NoSQL technology.

In order to select the best database, it is necessary to see the advantages and disadvantages of both relational and NoSQL databases. Thus, for example, if structured data are used where the consistency of data in transaction systems is very important, the right solution is a relational database. If, on the other hand, it is necessary to process unstructured data where speed and availability are important but consistency is not to such an extent, the advantage is with NoSQL databases. NoSQL databases are much cheaper than the known relational databases and do not require expensive licenses and hardware. However, this should in no way be taken as an excuse for selecting any of NoSQL databases before considering their intended purpose.

NoSQL databases have their drawbacks, but as relatively new technology, they have space for improvement. Although it can only be guessed what will happen in the future with their development, it is certain that the NoSQL market will grow significantly.

Considering the performance analysis of some less popular NoSQL databases, a concrete conclusion can be drawn that HamsterDB has the best performance, while the worst is BrightstarDB. This conclusion was expected before the start of the actual performance measurement.

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ТЕСТИРОВАНИЕ ВОЗМОЖНОСТЕЙ БАЗЫ ДАННЫХ NoSQL С ПОМОЩЬЮ DATABASE BENCHMARK ИНСТРУМЕНТА

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ОБЛАСТЬ: информатика, базы данных
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

База данных NoSQL часто используется в качестве удачной альтернативы реляционным базам данных, особенно в тех случаях, когда необходимо обеспечить соответствующие размеры системы, применение данных различных типов и высокую эффективность по низкой стоимости хранения и поддержки консистентности данных. В данной работе представлено общее определение базы данных, описаны различные виды баз данных как реляционных, так и нереляционных, выявлены их преимущества и недостатки в соответствующем контексте. Выявленные преимущества и недостатки баз данных NoSQL и SQL проанализированы, и результаты сравнительного анализа представлены в таблице. В заключительной части статьи представлены результаты тестирования возможностей базы данных NoSQL, полученные с помощью инструмента Database Benchmark. Цель данной работы заключается в выявлении всех характеристик базы данных NoSQL, ради лучшего понимания обоснованности их использования на практике.

Ключевые слова: базы данных, реляционные базы данных, NoSQL базы данных, тестирование возможностей.

ТЕСТИРАЊЕ ПЕРФОРМАНСИ NoSQL БАЗА ПОДАТАКА ПОМОЋУ DATABASE BENCHMARK АЛАТА

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ОБЛАСТ: информатика, базе података
ВРСТА ЧЛАНКА: стручни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

NoSQL база података често је успешна алтернатива релационим базама података, посебно када је потребно обезбедити адекватно димензионирање система, коришћење разноврсних типова података и високу ефикасност уз ниске трошкове одржавања конзистентности. У раду је наведен општи појам базе података, односно појам релационих и нерелационих база података, које су објашњене са свих значајнијих аспеката и у одговарајућем контексту. Након анализирања врста NoSQL база података, тежиште је на образлагању њихових предности и недостатака и упоредном прегледу анализе поређења NoSQL и SQL база података. У последњем делу рада представљени су резултати тестирања перформанси NoSQL база података добијених применом Database Benchmark алата. Циљ рада јесте истицање свих појединости NoSQL база података ради утврђивања оправданости њихове примене у пракси.

Кључне речи: базе података, релационе базе података, NoSQL базе података, тестирање перформанси.

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REALIZATION OF A TCP SYN FLOOD ATTACK USING KALI LINUX

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Summary:

Denial-of-Service (DoS) is a type of attack that attempts to prevent legitimate users from accessing network services. This is accomplished by overloading network services or by excessive connectivity, causing a drop in a connection or a service. DoS tools are designed to send large numbers of requests to the targeted server (usually web, FTP, e-mail server), in order to overwhelm server resources and make it unusable. There are various ways in which attackers achieve this. One of the usual ways is simply overwhelming the server by sending too many requests. This will disable the normal functioning of the server (and the web pages will open more slowly), and in some cases it can lead to a situation that the server ceases to operate. This paper shows some effects of TCP Syn Flood Attacks (using Kali Linux) through the change of processor utilization and the unavailability of the target computer (executing ping command).

Key words: DoS attack, Kali Linux, ping, processor utilization.

Introduction

The Transmission Control Protocol (TCP), unlike the User Datagram Protocol (UDP), is based on a connection, which means that the sending packet must establish a complete connection with its recipient or its intended recipient before sending any packets. This protocol relies on a three-way handshake mechanism (SYN, SYN-ACK, ACK) where each request forms a semi-open connection (SYN), a response request (SYN-ACK), and a confirmation to the response (ACK). Any attack attempting

to abuse the TCP/IP protocol would usually do this by sending the TCP packet in the wrong order, causing the target server to run out of resources. One of the examples of this type of attacks is TCP SYN Flood (Lawrence, 2012).

In the TCP handshake mechanism, there must be an arrangement between each side in order for the connection to be established. If a TCP client does not exist or it is a client with a fake IP address, such an arrangement is not possible. In a TCP SYN or SYN flood attack, attackers set the situation for the server to believe that they require a legitimate connection through a number of TCP requests that come from a fake IP address. In a situation when the client's IP address is fake or the client is unable to respond, the certificate (ACK packet) is never sent back from the server. The server is forced to maintain an open connection and buffer for each request for the original connection, attempting to resend the SYN-ACK packet request before the request expires. Having in mind the fact that server resources are limited and SYN flood often includes a huge number of connection requests, the server is unable to process existing requests before new requests arrive and this results in service termination.

Figure 1 shows the TCP SYN Flood attack pattern with corresponding messages sent between the server and a legitimate user, as well as the server and an attacker. As can be seen in the Figure, the connection confirmation does not arrive to the attacker as it does in the case with the legitimate user (Radware, 2013).

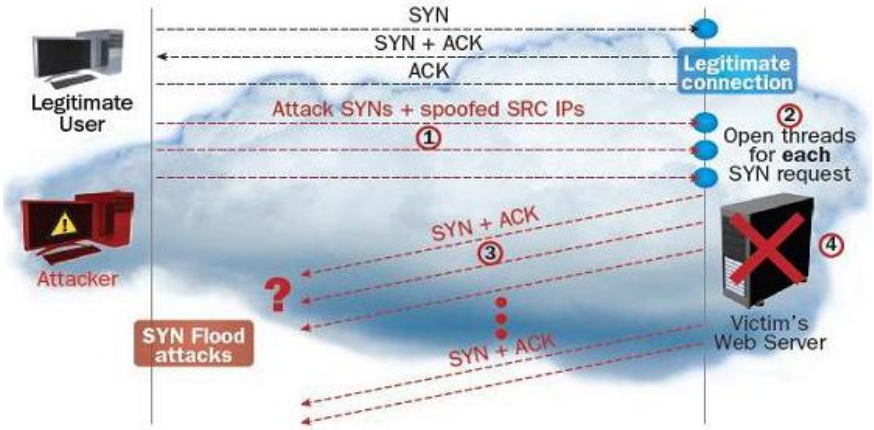

Figure 1 – TCP SYN Flood (Radware, 2013)
Рис. 1 – TCP SYN Flood (Radware, 2013)
Слика 1 – TCP SYN Flood (Radware, 2013)

Practical realization of TCP Syn Flood Attacks

To display the effects of TCP Syn Flood Attacks, we will use two computers that are connected to the same network. Kali Linux was installed on the attacking computer, as a virtual machine on Windows 10 using WMware Workstation 12 Player. The Windows 10 operating system is installed on the computer that will be attacked (Allen et al, 2014).

A computer that launches the attacks (the attacking computer). Kali Linux based on the Debian distribution is installed on this computer (Hertzog et al, 2017). It contains the hping3 tool, which is a free generator and package analyzer for the TCP/IP protocol. Hping3 is produced by Salvatore Sanfilippo. A newer version of hping3 is a script version which uses Tcl language (a simple language for creating a program) (Beggs, 2014), (Ansari, 2015).

Figure 2 shows the basic network virtual machine data obtained by typing the ifconfig command in the terminal on Kali Linux. The Figure shows that there is IP address information, subnet masks and other network card information.

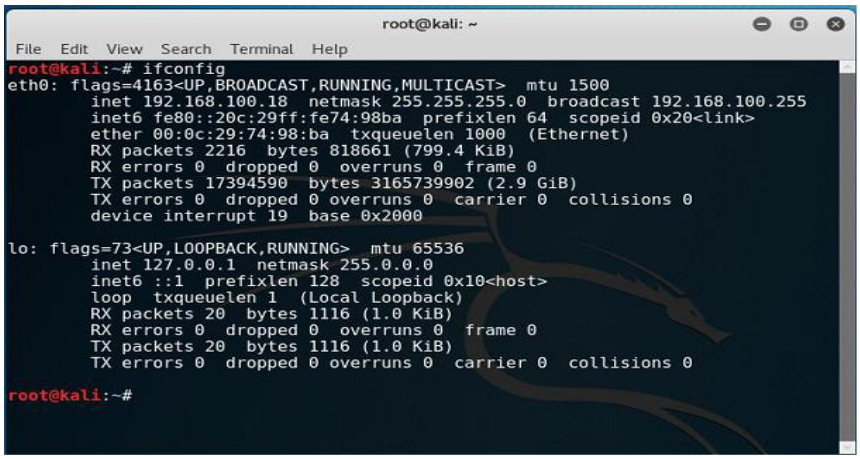

Figure 2 – Basic network virtual machine data
Рис. 2 – Базовые данные на виртуальной машине
Слика 2 – Основни подаци на виртуелној машини

The attack is implemented through the terminal by typing the command hping3 with certain parameters (Figure 3):

- The name of the used tool (hping3)
- Number of packets to send (-c 1000)
- Size of each packet that will be sent (-d 128)

- The type of packages to be sent (-s represents the SYN packets)
- TCP Window Size (-w 64)
- The attacking port (-p 8000)
- Type of Attack (- - flood). Flood mode – sending packet as fast as possible.
- Using random source IP addresses (- rand-source)
- Address of the attacked computer (destination IP address)

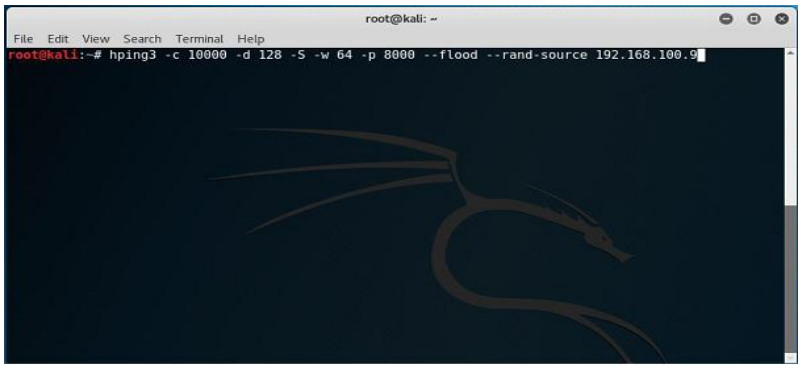

Figure 3 – Entering parameters on the attacking computer
Рис. 3 – Ввод параметров в компьютер, с которого производится атака
Слика 3 – Уношење параметара у рачунар којим се напада

Before the attack begins, we are checking the availability of the computer we are planning to attack in the Command Prompt on Windows 10, using the ping command.

Figure 4 shows that there is no problem in the connection and that the ping on the targeted computer was executed.

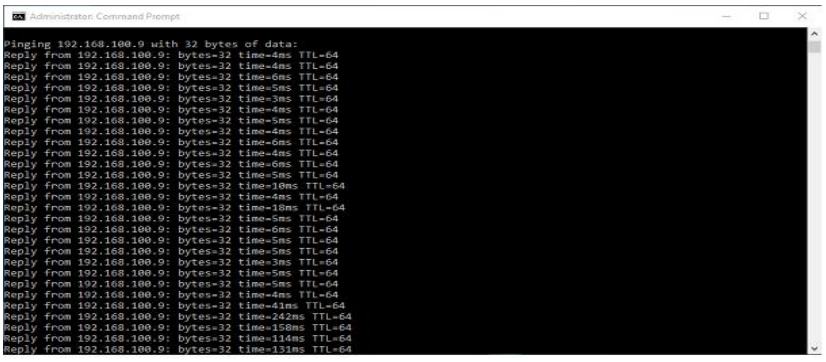

Figure 4 – Checking the availability of the targeted computer using the ping command
Рис. 4 – Проверка доступности целевого компьютера с помощью команды ping
Слика 4 – Провера доступности циљаног рачунара употребом ping команде

To increase the intensity of the attack, the command can be started from multiple terminals as shown in Figure 5.

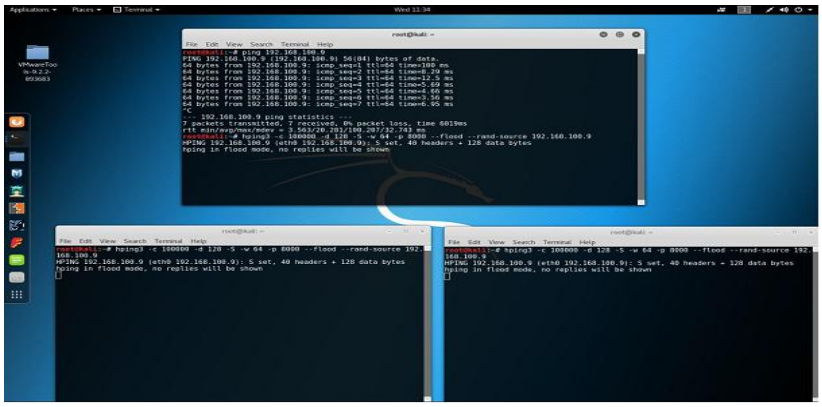

Figure 5 – Starting attacks from multiple terminals
Рис. 5 – Начало атак, нацеленных на несколько терминалов
Слика 5 – Покретања напада на више терминала

After executing the command (realization of the attack) we again use the ping command to check the availability of the attacked computer. Figure 6 shows that the computer partially responds to this command (not always available).

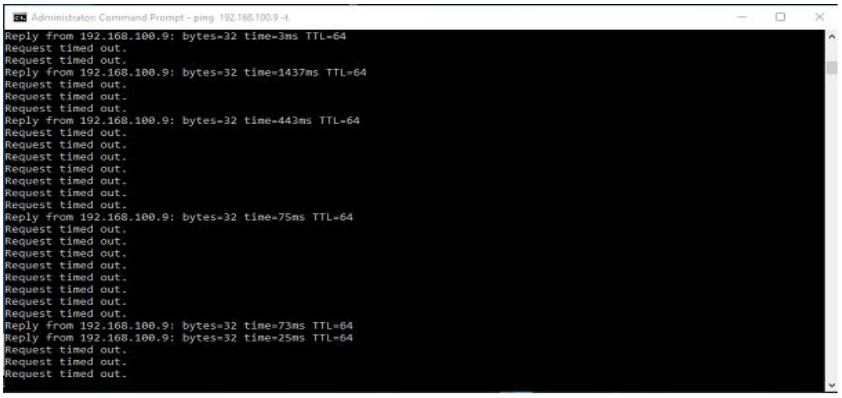

Figure 6 – Checking the availability of the targeted computer after the attack using the ping command
Рис. 6 – Проверка доступности целевого компьютера после атаки, с помощью команды ping
Слика 6 – Провера доступности циљаног рачунара, након напада, употребом ping команде

A computer that will be attacked. We are watching events on this computer before and after the attack against it. Figure 7 shows the basic information about this computer using the ipconfig command in Windows Power Shall. In the Figure, we can see the IP address information, subnet masks, and other features of the network card.

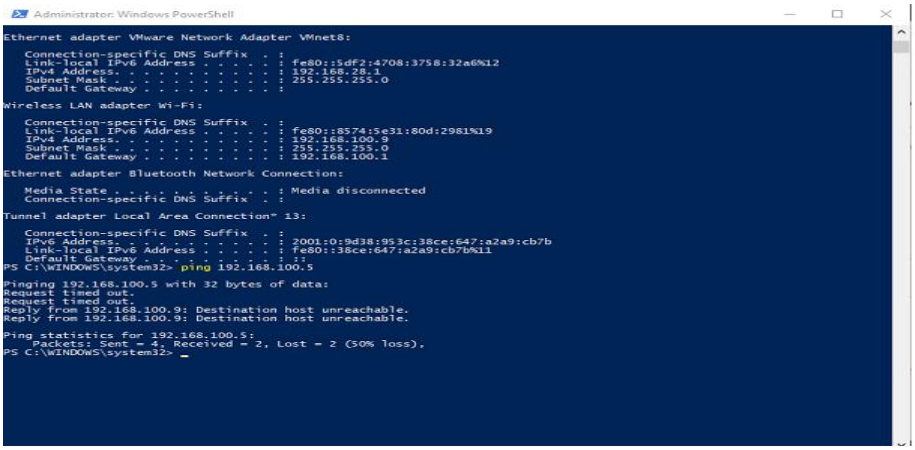

Figure 7 – Data on the attacked computer
Рис. 7 – Данные на взломанном компьютере
Слика 7 – Подаци на нападнутом рачунару

After executing the command on Kali Linux, the performance of the attacked computer has changed, as shown in Figure 8. By comparing images, it can be noted that processor utilization has increased. In addition to the performance changes, the attack made the computer unable to respond to connection requests, as shown by the ping command Request timed out. Due to the attacks, the computer could not connect and communicate with another computer on the network.

The interruption of the attack on the terminals is accomplished by pressing the Ctrl + C key. In addition to the performance changing, after stopping the attack, the ping command begins to work normally (it shows that the computer is available). This is shown in Figure 9.

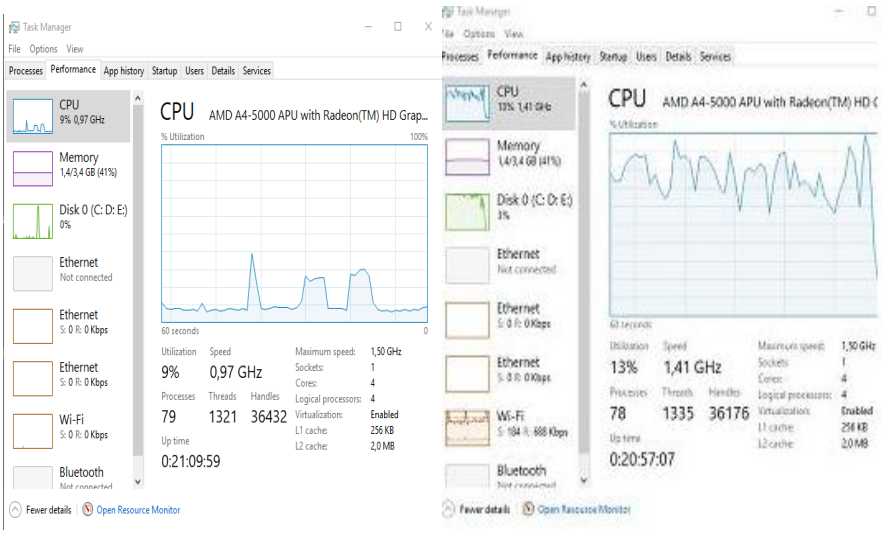

Figure 8 – CPU utilization before and during the attack
Рис. 8 – Загруженность процессора до и после атаки
Слика 8 – Искоришћеност процесора пре и током напада

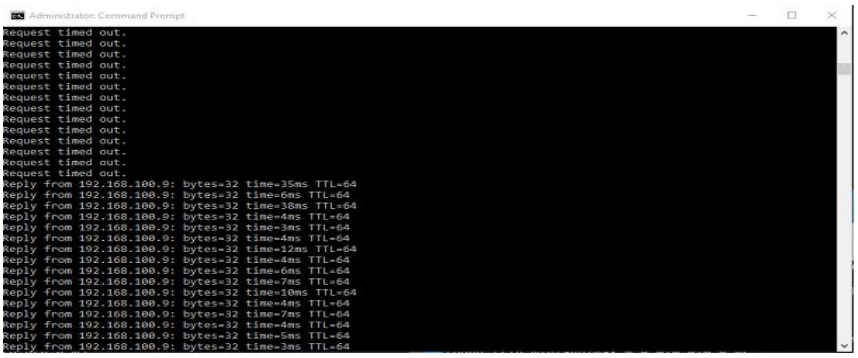

Figure 9 – Appearance of the screen when the attack is completed and the ping command is given
Рис. 9 – Экран после завершения атаки и после команды ping
Слика 9 – Изглед екрана када је напад завршен и задата ping команда

Conclusion

Every system that is connected to the Internet and equipped with TCP-based network services is a potential victim of an attack. The earliest form of DoS attack was SYN flood, which originated in 1996 and exploits weaknesses in the TCP. Other attacks exploit weaknesses in

operating systems and applications, leading to the inaccessibility of network services or even cesation of server operation.

Classic DoS attacks are one-on-one attacks in which a powerful host generates traffic that "overwhelms" the target host's connection, which hinders authorized clients from accessing network services. Distributed Denial of Service (DDoS) is a type of DoS attack that is used by multiple users. DDoS attacks have gone a step further, which is multiplying, resulting in the fact that servers or parts of the network can be totally unusable for clients.

There are several ways to execute DoS attacks such as TCP SYN Flood attack which can be done with different tools, such as Kali Linux.

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РЕАЛИЗАЦИЯ TCP SYN FLOOD АТАК С ИСПОЛЬЗОВАНИЕМ KALI LINUX

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ЯЗЫК СТАТЬИ: английский

Резюме:

Хакерская атака «отказ в обслуживании» (Denial-of-Service - DoS) – это вид взлома вычислительной системы с целью довести её до отказа, то есть создание таких условий, при которых добросовестные пользователи системы не могут получить доступ к предоставляемым системным ресурсам (серверам), либо этот доступ становится значительно затруднённым. DoS инструменты отсылают большое количество запросов целевому серверу (как правило web, FTP, электронная почта), перезагружая его ресурсы, что в итоге приводит к отказу в обслуживании. Хакерами разработано несколько методов для достижения своей цели. Один из них – это чрезмерная перезагрузка сервера огромным количеством запросов. Данные действия мешают нормальной работе сервера (вследствие чего web-страницы намного медленнее открываются), а в некоторых случаях это может привести к полному отказу в обслуживании. В данной статье были представлены отдельные эффекты TCP Syn Flood Attacks (с использованием Kali Linux), отражаемые в изменениях загруженности процессора и недоступности целевого компьютера (для ping команды).

Ключевые слова: DoS атака, Kali Linux, ping, загруженность процессора.

РЕАЛИЗАЦИЈА TCP SYN FLOOD НАПАДА УПОТРЕБОМ КАЛИ ЛИНУКСА

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ОБЛАСТ: рачунарске науке
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ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Напад одбијања услуга (Denial-of-Service – DoS) врста је напада којим се спречава да овлашћени корисници приступе одговарајућим мрежним услугама. То се постиже преоптерећењем мрежних услуга или прекобројним конекцијама, што доводи до прекида (отежане) конекције или услуге. DoS алати шаљу велики број захтева циљаном серверу (обично web, FTP, e-mail сервер) ради преоптерећења његових ресурса, чинећи га на тај начин неупотребљивим. Један од честих начина на које нападачи то

постижу јесте преоптерећење сервера слањем великог броја захтева. Таква активност онемогућиће нормално функционисање сервера (и web странице ће се отварати много спорије), па ће у неким случајевима престати и да функционише. У чланку су приказани одређени ефекти TCP Syn Flood Attacks (употребом Kali Linux-а) кроз промену искоришћености процесора и недоступности циљаног рачунара (извршавањем ping команде).

Кључне речи: DoS напад, Kali Linux, ping, искоришћеност процесора.

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ASSESSMENT OF PROTECTIVE CLOTHING CONFORMITY WITH THE REQUIREMENTS OF PROTECTIVE CLOTHING STANDARDS

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Abstract:

Assessing the compliance of protective clothing is carried out in accordance with the prescribed methods, standards, procedures and criteria in competent laboratories. This paper presents the process of assessing the conformity of the characteristics of special clothing for the protection of the body of the insulating type in accordance with the general requirements of the protective clothing standard (SRPS EN 340: 2007 Protective Clothing, General Requirements). The results presented in the paper indicate that the concept of conformity assessment does not simply involve checking the basic characteristics of a product (purpose, functionality, etc.), but also checking characteristics that are at first glance "of lesser significance" and can influence the safe use of protective clothing.

Keywords: protective clothing, assessment of the compliance, general requirements.

Introduction

In order to improve the efficiency of product production and trade as well as to ensure the required product quality, the quality management concept based on the application of standards for quality control of products is applied worldwide. The concept of product quality testing is based on the process of assessing the conformity of the declared

characteristics of the product with the standard requirements. Product quality control is carried out through conformity assessment during the processes of: development, improvement, serial production, purchasing products from domestic or foreign markets, and others. Compliance evaluation is a complex process consisting of testing, controlling and certification (Brkljač, 2009). The focus in this paper is to demonstrate the process of assessing the conformity of the characteristics of special body protective clothing of the impermeable type with the requirements of the protective clothing standard (Institut za standardizaciju Srbije, 2007b) as well as to propose measures in order to improve the mentioned process of conformity assessment.

Special impermeable protective clothing

Impermeable protective clothing is used in case of the application of weapons of mass destruction (WMD), when carrying out the decontamination procedure, scrutinizing the contaminated terrain (area), operating on the contaminated ground (ConG) and in the contaminated atmosphere (ConA), when overcoming ConG as well as when carrying out activities that require a high level of protection of users from highly toxic chemicals (HTC), nuclear, radiological, chemical and biological (CBRN) contaminants.

CBRN protective clothing produced from impermeable materials is characterized by good protective properties against the HTC effects, but is physiologically unsuitable because it does not allow for air permeability. The use of such clothing causes heat load in the user, especially during intensive physical effort and in ambient conditions with temperatures over 25 ° C. Due to heat accumulation and heat load, the wearing time of protective garments is limited depending on environmental conditions (Karkalić, 2006).

Modern trends in the development of CBRN body protectors set high protection requirements. The latest generation CBRN protective clothing is made of neoprene, hepalone, viton or multilayer laminates. On the inside of these materials is, most often, a layer of butyl. Figures 1 to 4 show the construction of the latest generation of the impermeable materials manufactured by the German company MSA-Auer (Karkalić & Popović, 2004).

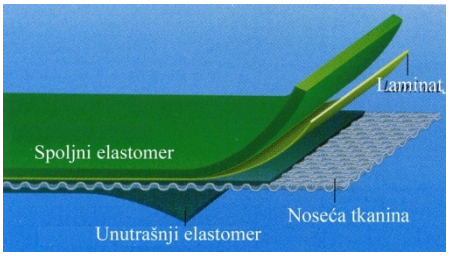

Figure 1 – Composite material Vautex Elite
Рис. 1 – Композиционный материал Vautex Elite
Слика 1 – Композитни материјал Vautex Elite

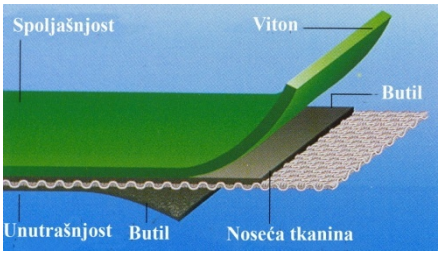

Figure 2 – Composite material Vautex SL
Рис. 2 – Композиционный материал Vautex SL
Слика 2 – Композитни материјал Vautex SL

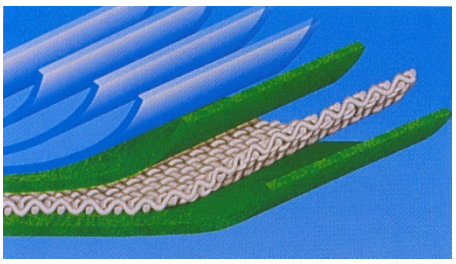

Figure 3 – Composite material Chempion Super
Рис. 3 – Композиционный материал Chempion Super
Слика 3 – Композитни материјал Chempion Super

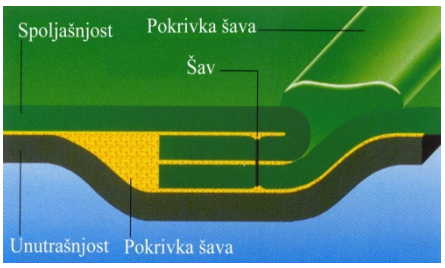

Figure 4 – Seam construction in Vautex
Рис. 4 – Конструкция шва на Vautex
Слика 4 – Конструкција шава код Vautex-а

For the needs of the NBC specialized units during the 1980s, an M3 two-piece protective suit was developed and later modernised and replaced with a one-piece M5 model (Figure 5).

The M5 suit (KZ-M5) is intended to protect the user's body from CBRN contaminants, the thermal radiation pulse of a nuclear explosion (TINE) and a flammable napalm mixture flame. The corporation "Trayal" from Krusevac (hereinafter referred to as manufacturer) is the KZ-M5 manufacturer.

Figure 5 – M5 protective suit in use in the SAF CBRN units
Рис. 5 – Защитный костюм М5, используемый войсками РХБЗ ВСРС
Слика 5 – Заштитни комбинезон М5 на употреби у јединицама АБХ службе ВС

According to the product quality regulation (Vojnotehnički institut, 1985), the manufacturer defined the following characteristics of the KZ-M5:

- camouflage properties in the visible and infrared spectrum;
- the protection against highly toxic chemicals (HTC) at a temperature of 36 ± 1 ° C is at least 150 min, and after five-fold contamination and decontamination it is at least 105 min;
- in case of the thermal radiation pulse of a nuclear explosion (TINE), with the energy of 67 J / cm2 for the duration of 3.51 s, the suit does not burn, and after the cessation of the TINE effect, there is no glowing phenomenon;
- in contact with napalm mixture drops, the material of the protective suit resists to their penetration for at least 10 s, and upon the cessation of napalm mixture effects it has a self-extinguishing property;
- it retains protective, physical and exploitation properties at temperatures from -30 ° C to + 50 ° C;

- it is easily taken off and put on;
- it allows execution of tasks in real conditions of use;
- suit material is safe to use;
- the geometric characteristics of the suit are defined in the manufacturer technical documentation;
- the basic maintenance is possible within the competence of the suit user;
- the weight of the suit does not exceed 3 kg
- It is made in three sizes.

The M5 protective suit consists of a jacket, trousers and a hood connected in one piece of clothing. The suit opens/closes on the front right side of the body by a patented zipper which is impermeable to liquids, gases and vapors. The KZ-M5 design allows it to be tightened around the waist as well as to achieve permeation by adjusting sleeves and trousers legs. The M5 suit is made of synthetic rubberized fabric covered with rubber mixtures of butyl and hypalone on both sides.

In order to create safe working conditions and eliminate heat stress, according to the valid rules of CBRN equipment use and depending on ambient temperature, the time standards for the use of this CBRN protective suit are defined (Table 1).

Table 1 – Time standards for wearing the protective suit depending on the ambient temperature (Vojnotehnički institut, 2016)
Таблица 1 – Пределеньно допустимое время ношения защитного костюма в зависимости от температуры окружающей среды (Vojnotehnički institut, 2016)
Табела 1 – Временске норме ношења заштитног комбинезона у зависности од амбијенталне температуре (Vojnotehnički institut, 2016)

Outdoor temperature	Allowed operating time in the protective position
+30 °C and more	15 to 20 min
+25 °C to +30 °C	to 30 min
+20 °C to +25 °C	40 to 50 min
+15 °C to 20 °C	1.5 to 2 h
under + 15 °C	3 to 4 h

The exposure time at 30 ° C is limited to 15 to 20 minutes, which is often insufficient for the realization of missions and tasks in the

contaminated environment. This can be a serious problem, given that in some cases, due to potentially high levels of danger or specific types of contamination, the impermeable protective suit cannot be replaced by a filtering suit which is characterized by a better physiological suitability.

The protective clothing standards

Standard SRPS EN 340: 2007 Protective Clothing prescribes the general requirements regarding the performance of protective clothing related to: ergonomics, harmlessness, size determination, durability, aging, compatibility and marking. The specified performances are prescribed as follows:

- ergonomics (anthropometric characteristics of protective clothing, biomechanical interaction between protective clothing and the human body, thermal interaction between protective clothing and the human body, interactions between protective clothing and all human senses as well as skin),
- harmlessness (protective clothing must not adversely affect the health of the user; the protective clothing material must be chemically suitable; the material must not release substances that are toxic or harmful; the material must not be degraded to release substances that are carcinogenic, mutagenic or causing allergic reactions in users; the material should be selected to reduce the environmental impact of the production and destruction of protective clothing),
- the determination of the size (protective clothing must have a size designation based on body dimensions; the measurement procedure and the size designation must comply with the applicable standards (Institut za standardizaciju Srbije, 2007c), (Institut za standardizaciju Srbije, 2007d), (Institut za standardizaciju Srbije, 2015) or relevant Serbian standards that are identical with international standards; proportions and protective clothing measures should reflect the needs of the user together with the clothing worn under protective clothing),
- construction (it must enable: correct fitting of protective clothing on the user; protective clothing remaining in place during the intended period of use; adjusting protective clothing to the morphology of the user; arm and knee bending at ease; it must ensure: that there are no uncovered parts of the body considering expected movements; that the garment can be removed easily; and that the overlapping of the jacket and the trousers is adequate),

- comfort (protective clothing must not: have rough, sharp or hard surfaces that injure the user, be so tight that it prevents the flow of blood, be so loose or heavy to interfere with movements),
- aging (harmful effects of its color, changes in size due to cleaning, changes in marking legibility after cleaning),
- compatibility with other personal protection equipment,
- marking (general marking: text in the official languages of the destination country, labeling on the product or labels ffixed to the product to be visible and legible permanently for the intended number of cleaning procedures, special designations: name, product type designation, size designation, European standard number, pictograms and performance levels, maintenance labels, notes if it is disposable clothing), and
- information provided by the manufacturer along with protective clothing (how it is donned and removed, proper use to reduce the risk of injury, usage restrictions (e.g. temperature range), cleaning instructions (temperature, drying process, PH value, mechanical cleaning), instructions regarding repair, instructions on how to identify product aging, details of defects in use (reduction of the field of vision, heat shock risk).

Conformity evaluation

Conformity evaluation[1] is an indication that the specific requirements relating to the product[2], process, system, person are met.

Assessing the compliance of body protection equipment is a set of three functions that satisfy the need or requirement to show that the specified requirements are met. According to SRPS ISO / IEC 17000: 2007 Standard (Institut za standardizaciju Srbije, 2007a), the following three basic functions are recognized:

- selection,
- determination, and
- review and decision-making.

[1] Standard SRPS ISO / IEC 17000: 2007 Evaluation of compliance - vocabulary and general principles (Institut za standardizaciju Srbije, 2007a).

[2] The product includes the assets and components of the weaponry and military equipment, the quality of which is defined by the regulation on product quality, standard, specification of characteristics and similar technical documents (Internal document of the quality management system, Technical Center of Reference, 2015).

The selection function includes planning, programming and preparatory activities for the collection or production of all information and inputs necessary for the transition to the next function or the determination function.

The determination function covers the activities being undertaken in order to obtain complete information as to whether the conformity of an assessed product or its sample meets specified requirements, which includes examination, control, etc.

The function of the review is to verify the suitability, adequacy and effectiveness of the selection and determination activities, as well as the results of these activities, in order to prove the fulfillment of the specified requirements for the conformity of the assessed product. The review is the final phase of checking, before deciding whether it is reliably demonstrated that the product conformity assessment meets the specified requirements, which results in the confirmation of compliance and a statement that the fulfillment of specified requirements exists. If the fulfillment of the specified requirements has not been shown, it indicates that it is not compliant.

Conformity assessment of the protective clothing standards requirements

After the activities have been carried out in accordance with the selection function, the analysis is carried out within the framework of the determination function. Testing is carried out through laboratory tests and tests in real conditions of use.

Examination of the personal protective equipment in real conditions is carried out by the SAF center in cooperation with the end user (unit, organizational unit from the SAF) and the medical institution (MMA, etc.). As part of this activity, the personal protective equipment testing is carried out in accordance with the requirements of the applicable standard for protective clothing - SRPS EN 340 Protective Clothing, General Requirements.

Testing in real opearational conditions is realized in different meteorological conditions, with and without load (combat equipment) and generally implies the following activities:

- Proper donning, removing and packing protective clothing,
- checking the functionality and compatibility of protective clothing with other personal protective equipment and other personal equipment,

- checking the convenience of wear and endurance in the execution of specific tasks and the implementation of different procedures; and
- possibility of care and maintenance of protective clothing (basic and periodic care, washing, drying, ironing).

The number of persons engaged in the study is defined during the testing planning process and in accordance with the purpose of the product itself, the development phase of the product (prototype, zero series, etc.), the amount of samples, etc.

In order to make more complete and more objective assessment of the characteristics of protective clothing, physically fit and psycho-physically prepared individuals of different sexes and body types and build are selected. Before the start of the examination, a medical examination of the examinees is carried out.

Also, before the start of the test, the following procedures are done: checking of the size, design characteristics and comfort of the protective clothing. Checking is performed with respondents through donning and removing, performing basic actions and procedures (squatting, raising arms up, etc.), checking body mass, etc.

The aggravating factors in the selection of respondents are:

- a minimum of 100 participants are required for complete statistical data processing and evaluation of the protective clothing from the aspect of ergonomics, comfort, and compatibility. The number of respondents is most often determined by the number of samples of protective garments;
- group packaging of protective garments contain three sizes (small, medium, large) packed in a ratio of 1: 3: 1. Body height is the basic factor in the distribution of samples for testing purposes. For this reason, there is a possibility for respondents to get unsuitable samples in terms of other design factors (shoulder width, sleeve length, waist circumference, etc.);
- the current regulations for the use of protective clothing do not specify a specific type of clothes worn under the KZ-M5; and
- ensuring the engagement of the same group of respondents during the examination process, especially when the tests last over a period of 10 working days. A change in the engagement of respondents may affect the validity and objectivity of the product assessment.

The duration of testing in real operating conditions depends on several factors (the request of the tester, the product purpose, the phase of product development, the season, etc.) and is determined by the test plan. During the examination, the test center, in cooperation with the medical institution, monitors the course of the examination and records the information on the protective clothing that is examined. All information is registered in various forms of records (recording in specially prepared notepads and records, taking photos of the observed changes, recording the stream of activities with a video camera). After completing the examination process, respondents fill out the questionnaire. The questions from the questionnaire are formed in accordance with the requirements for checking the characteristics specified in the standard for protective clothing SRPS EN 340 and in accordance with the information recorded in the mentioned records.

Results presentation

During 2015, KZ-M5 samples were tested in the SAF Testing centre. As part of the testing in real operational use, the conformity assessment was carried out according to the requirements of Standard SRPS EN 340 Protective Clothing, General Requirements. In the final examination of KZ-M5 samples, 23 respondents from the SAF CBRN Service unit participated: 22 professional soldiers and one non-commissioned officer. Out of that number, 3 respondents were female, accounting for 13% of the total number of respondents which is the average representation of women in units of the Serbian Armed Forces. The average age of the respondents was 32 years. The average time spent serving in the SAF was about 7 years. The respondents were psycho-physically prepared for the participation in the testing. During the distribution of KZ-M5 suits to the respondents, it was noticed that the respondents of a medium build were the most present. It was not possible to adequately provide for the respondents of small and large body height. Figure 6 shows the respondent who got the KZ-M5 with the size markings "V" (large) based on his body height. It is evident that there is no appropriate fitting of protective clothing on the user and that there are uncovered parts of the body due to expected movements.

Figure 6 – Reduced arm mobility at the elbow (Tehnički opitni centar, 2015)
Рис. 6 – Ограниченная подвижность рук в области локтевого сустава (Tehnički opitni centar, 2015)
Слика 6 – Смањена покретљивост руку у пределу лакта (Tehnički opitni centar, 2015)

After obtaining the garments based on the size criterion, the respondents were informed on the operational use, the planned activities, as well as the procedures regarding safety and health protection measures.

Data collection was carried out in accordance with the guidelines given in (Institut za standardizaciju Srbije, 2007b) and based on the observations recorded during the test process. During the use of the KZ-M5, respondents made their observations on the change in the material of the product, the way and the possibilities of use in the performance of the assigned tasks, basic maintenance options and other observations (wearing time, effects on increased sweating, etc.). All changes to the material of the protective clothing observed during the examination were recorded in the photo and video format.

Filling out the questionnaires was completed at the end of the examination. The respondents expressed their opinion through the questionnaire on:

- the possibility of carrying out the basic actions with the equipment (walking, sitting, getting up, suit donning and removing, etc.),

- physiological suitability in field conditions (mobility of the body when wearing KZ-M5, increased sweating during physical activity, etc.),
- allergic reactions to the materials,
- possibility of executing specific tasks within the planned activities (training),
- characteristics according to SRPS EN 340 (construction, comfort, aging, marking and instructions for use and maintenance delivered with the product), and
- compatibility of this product with other equipment for personal CBRN protection.

The material safety testing was carried out by monitoring the occurrence of allergic reactions and presenting the observations of the subjects. When assessing harmlessness, there is also a possibility of proving the presence of substances in the KZ-M5 materials that can cause allergic reactions to the user. In this case, a special group of respondents is engaged and the examination is conducted according to the program and the consent of the medical institution for conducting such type of examination. In addition, the manufacturer of the product is obliged to document the safety of the use of the product (the harmlessness of the protective clothing material to the user's health and the environment).

The results of the test have confirmed the prescribed time standards for wearing the KZ-M5 depending on the air temperature (Table 1). Part of the results from the processed questionnaires in accordance with the requirements of SRPS EN 340 is shown in Table 2.

Table 2 – Results after analysing the questionnaires in accordance with the requirements of EN 340 Protective Clothing, General Requirements
Таблица 2 – Результаты опросников, обработанных в соответствии с требованиями SRPS EN 340 Защитная одежда, Общие требования
Табела 2 – Резултати након обраде анкетних листова у складу са захтевима SRPS EN 340 – Заштитна одећа, Општи захтеви

Question from the questionnaire	Respondents' answers in%	
	YES	NO
Is the KZ-M5 comfortable?	83	17
Is it possible to take off / put on the KZ-M5 without difficulty?	96	4
Can you sit with the KZ-M5 without difficulty?	70	30

Question from the questionnaire	Respondents' answers in%	
	YES	NO
Can you stand with the KZ-M5 without difficulty?	96	4
Can you raise both arms above the head without difficulty wearing the KZ-M5?	78	22
Can you walk and climb ladders, stairs, etc. without difficulty, wearing the KZ-M5?	57	17 (26 percent of respondents did not carry out this action)
Is the KZ-M5 compatible with the protective mask M2 and M3 and with protective gloves M5?	100	-
Wearing the KZ-M5, can you carry out specific tasks with CBRN service assets and equipment?	83	17
Can you bend down wearing the KZ-M5 and take a small object (e.g. a pencil) without difficulties?	74	26
Do you have difficulties entering / exiting the vehicle (special purpose vehicles, transport vehicles, etc.)?	17	83
Is the tightness between protective gloves and the KZ-M5 jeopardized?	39	61
Is the tightness between protective boots and the KZ-M5 jeopardized?	22	78
Is the tear of the KZ-M5 material noticeable as well as the splitting of materials along the seams?	61	39

Based on the results from the completed questionnaires, the following was concluded:

- conformity assessment of the protective clothing has been carried out in accordance with the characteristics of SRPS EN 340 (ergonomics, construction, comfort, aging, marking and application of the instructions for use and maintenance) and the defined test plan;
- the engaged SAF unit has made it possible to objectively evaluate the product from the aspect of its application in real operating conditions;
- correction in the KZ-M5 is required in order to improve the design and comfort of the KZ-M5;
- special attention must be paid to the quality requirements for compatibility and selection of size numbers. In addition to the basic three sizes, it is necessary to create a larger range of KZ-M5 sizes for users of both sexes, and

- the use of the KZ-M5 in real conditions indicates the need to consider and create a special type of garments worn under the KZ-M5.

Conclusion

Assessing the compliance of the protective clothing in accordance with the requirements of the standard requires a complex approach. The example in this paper only confirms that the application of standards in the process of conformity assessment is an indispensable and necessary activity. In the complete process of protective clothing development, the participation of the end user is necessary.

Complex and comprehensive research of the body cooling system conducted within the research project of the Ministry of Defense of the RS (Jovanović, 2013) indicates that the use of cooling systems can reduce the user's sweating intensity, which contributes to preventing dehydration and improving the physical performance of soldiers when wearing CBRN protective equipment.

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ОЦЕНКА СООТВЕТСТВИЯ ЗАЩИТНЫХ КОСТЮМОВ ТРЕБОВАНИЯМ СТАНДАРТОВ ДЛЯ ЗАЩИТНОЙ ОДЕЖДЫ

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Резюме

Оценка соответствия защитных костюмов требованиям стандартов для защитной одежды проводится согласно предписанным методам, стандартам, нормам и критериям в соответствующих лабораториях. В настоящей работе представлен процесс оценивания соответствия свойств специальной защитной одежды изолирующего типа общим требованиям стандарта для защитной одежды (SRPS EN 340:2007 Защитная одежда, Общие требования). Результаты, представленные в данной работе, свидетельствуют о том, что понятие «оценивание соответствия» включает не только проверку основных свойств защитной одежды (назначение, функциональность и пр.), но и проверку свойств, которые на первый взгляд могут показаться не столь значительными, но которые в тесной связи с безопасностью использования средств ВВТ.

Ключевые слова: защитная одежда, оценка соответствия, общие требования.

ОЦЕЊИВАЊЕ УСАГЛАШЕНОСТИ СРЕДСТАВА ЗА ЗАШТИТУ ТЕЛА У СКЛАДУ СА ЗАХТЕВИМА СТАНДАРДА ЗА ЗАШТИТНУ ОДЕЋУ

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ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Оцењивање усаглашености средства за заштиту тела изводи се по прописаним методама, стандардима, поступцима и критеријумима у компетентним лабораторијама. У раду је приказан процес оцењивања усаглашености карактеристика специјалних средстава за заштиту тела изолирајућег типа у складу са општим захтевима стандарда за заштитну одећу (SRPS EN 340:2007 – Заштитна одећа, Општи захтеви). Резултати приказани у раду указују на то да се под појмом оцењивања усаглашености не подразумева само провера основних карактеристика средства НВО (намена, функционалност и др.) већ и провера карактеристика које су на први поглед „мањег значаја", а могу утицати на безбедну примену средства НВО.

Кључне речи: заштитна одећа, оцењивање усаглашености, општи захтеви.

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PREVENTIVE MEASURES FOR SAFE AND HEALTHY WORK WITH IMPROVISED EXPOLSIVE DEVICES IN MULTINATIONAL OPERATIONS

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Abstract:

Since the re-admission of the Republic of Serbia to the United Nations (UN), members of the Ministry of Defence (MoD) and the Serbian Armed Forces (SAF) have been engaged in multinational operations (MnOps). All countries which send their members to MnOps timely undertake measures so that individuals intended to participate in MnOps learn about the dangers of explosive devices, and prepare themselves for safe life and work in MnOps. One of the measures taken is to produce a brochure or a manual to help members of MnOps learn about the dangers of explosives in the particular territory and about general procedures in the event of encountering such danger.The main problem is the lack of literature as the essence of the training process and the preparation of individuals referred to MnOps. The paper combines the currently available literature with the experience of MoD and SAF members as well as foreign armed forces members previously engaged in MnOps regarding the preventive measures for safe and healthy work with explosives i.e. with a special kind of explosives - improvised explosive devices.

Key words: multinational operations, safety, procedures, prevention, measures, literature, explosives.

Introduction

The use of explosive devices during armed conflicts, and in particular their uncontrolled use, has left a large number of areas with

unexploded ordnance.The presence of explosives in some territory makes it difficult to live and work in it and pose a constant and imminent risk to health and safety of both local residents and members of MnOps. This danger is particularly present in countries with on-going or recently finished armed conflicts. Also, it is not negligible in countries where armed conflicts ended some time ago (for example: Croatia, Bosnia and Herzegovina, Angola). In such social situations, parts of the territories with explosive remnants of armed conflicts are not marked, and accordingly, both the local population and MnOp members are not familiar with their location. This fact is a direct cause of the occurrence of mine accidents (due to movement through dangerous territories). Besides the lack of information about the territories with unexploded ordnance, other causes of mine accidents are the lack of training of both the local population and MnOp members to identify dangerous territories, the lack of preventive security measures and procedures, as well as curiosity and lack of attention.

The work provides basic information about the dangers of explosive devices, definitions, classifications and examples of explosive devices, as well as instructions for identifying specific types of explosive devices – Improvised Explosive Devices and preventative measures for safe and healthy work with them. Preventive measures for safe and healthy work with improvised explosive devices, as well as procedures that are given in this paper, are of a general nature and some of the measures and procedures may not be used in all conditions and in all territories, and sometimes it will be necessary to adjust them in accordance with the specific situation in a particular territory.

Compliance with the Standing Operating Procedures (SOP) and the Rules of Engagement (ROE) for a specific MnOp, preventive measures for safe and healthy work presented in this paper, as well as the assessment of the situation in a particular territory help MnOp members reduce the risk of mine accidents caused by improvised explosive devices and thus save lives. Also, the data, instructions, measures and procedures presented in this paper can be used for the education of the local population and for joint actions in order to reduce the risk of mine threats.

Classification of explosive devices

Explosive devices can be classified on the basis of different characteristics (depending on their purpose, design, launcher

tube/caliber, etc.). The most common groups of explosives found in the territories with MnOps are as follows:

a) ***Munition;***
   1) Projectiles;
   2) Mortar shells;
   3) Rockets;
   4) Guided missiles;
   5) Rifle grenades;
   6) Hand grenades.

b) ***Mines*****;**

c) ***Submunition;***

d) ***Improvised Explosive Devices***. (NATO, 2010)

Munition – in everyday use, ,,munition" can be military and/or live ammunition and equipment. Ordnance - ammunition is a means filled with explosive, rocket fuel, pyrotechnic mixture, initial mixture or nuclear, biological or chemical material for use in military operations and for destruction (Australian Government, 2003). In territories where MnOps realize their tasks, the greatest risk of injury caused by ordnance represents a subtype of ordnance - unexploded ordnance - ammunition.

Projectiles - the term projectiles encompasses infantry, artillery and tank ammunition from the caliber of 20 mm in diameter and 2 inch (50.8 mm = 2 x 25.4 mm) to 4 foot (4 x 304.8 mm = 1219.2 mm) in length. They are fired from weapons or artillery and can have very different charges (chemical, smoke, illuminating, etc). Artillery projectiles can have a fuze at the bottom or at the top of the projectile. To stabilize the flight, projectiles can be equipped with a driving band or stabilizing fins. (Uprava inžinjerije, 1999)

Mortar shells – mortar shells can have a caliber of 45 mm to 280 mm in diameter. They are fired from mortars and may have different charges (chemical, smoke, illuminating, etc.). Mortar shells can also have a fuze at the bottom or at the top of the shell and can be stabilized by a driving band or stabilizing fins.

Rockets – rockets could be defined as self-propelled missiles. (International Mine Action Standards, 2003) They cannot be controlled during the flight. Their dimensions are from 37 mm to 380 mm in diameter, and from 1 foot to 9 feet (9 x 304.8 mm = 2743.2 mm) in length. Rockets generally have the following parts: warhead, motor and fuze. (Uprava inžinjerije, 1999)

Guided missiles - guided missiles are a special type of missiles and they represent an enhanced version of the rocket. Besides the design

solution, the main difference is a possibility of missile guidance. (International Mine Action Standards, 2003)

Rifle grenades – the paper explains one type of hand grenades, rifle grenades, so that the distinction between hand grenades and bombs is more visible. It is important to point out that the term rifle grenade which is used in the MnOp does not indicate the same type of explosive devices which exist in the Serbian Armed Forces. This term in MnOps denotes rifle grenades which are very similar to mortar shells and can be fired from specially designed launchers. They may have different charging (chemical, smoke, illuminating, etc.).

Hand grenades – hand grenades are intended for fight at close distances. They are classified based on their design solutions into the following types: offensive, defensive, antitank, smoke and illuminating (Australian Government, 2003). Hand grenades can be launched from certain types of weapons.

Mines - mines are the kind of explosive devices placed on/or in the ground, or on any other surface to be activated by the presence or contact with a person or a vehicle. Because of its characteristics, a mine is said to be „a perfect soldier, it never sleeps, never asks for payment or for food, never misses, does not ask about the task and does not care about the victims. On duty, it does not need replacement for fifty years or more. It is very difficult to find and inexpensive to purchase." (NATO, 2010)

A similar interpretation of mine has a project manager for mine demolition in the US Army, General A. Gardner: ,,Mines are obviously a cheap means of less powerful armies, especially of those who have to weigh their strength with large and well-trained armed forces such as the US Army. Put yourself in the position of US soldiers who are often exposed to randomly scattered mines that contain little or no metal, which are covered by direct or indirect fire at the time of darkness and so on. I think you begin to understand the difficulties of creating technology that can alert soldiers or units to start bypassing or other activity.“ (Radić, 2001)

Submunition - cluster munition is an explosive device separated from a larger ordnance type in order to accomplish its task (this refers to mines or some other explosive devices which are part of cluster bombs, artillery shells or rocket charges). (Radić, 2007)

Basic information about improvised explosive devices

In the last 20 years, there has not been a day without a terrorist attack and every attack, unfortunately, ends up with casualties; consequently, terrorism as a complex form of political violence has become ,,a social plague of the 21st century". For the execution of terrorist attacks and/or operations, terrorists use not only weapons, but also all kinds of explosive devices, and most often improvised explosive devices (IEDs).

Improvised Explosive Devices represent explosive devices made from nonmilitary explosives/components, intended for destruction and/or disabling of the living force, movable or fixed objects. There are various criteria for the classification of IEDs: based on their emplacement, mobility, quantity of explosives in them and similar. (UN mine action gateway, nd)

The classification used in MnOps when reporting about a found improvised explosive device is as follows:

- **Improvised Explosive Devices (IEDs)** – that are activated from a distance – by radio devices or electrical conductors.
- **Victim Improvised Explosive Devices (VIEDs)** – for suicide attacks.
- **Time Improvised Explosive Devices (TIEDs)** – with a delayed effect. (NATO, 2010)

Regarding the criterion “emplacement”, IEDs are classified as:

- **Improvised Explosive Devices (IEDs)** – placed in the ground and in buildings.
- **Person Borne Improvised Explosive Devices (PBIEDs)** – placed on persons.
- **Vehicle Borne Improvised Explosive Devices (VBIEDs**) – placed in vehicles. (NATO, 2010)

The most frequently used types of IEDs in MnOps are those based on the above criterion, so the rest of the paper will concentrate primarily on these IEDs.

Following the criterion „ mobility“, we classify IEDs as:

- **Fixed** - placed on roads, bridges, underneath vehicles, in buildings and in other places;
- **Mobile** - placed in vehicles or on persons; thrown (most frequently from overpasses) or fired from various improvised launchers. (Landmine monitor, 2010)

Improvised Explosive Devices can be activated from a certain distance (orchestrated, i.e. controlled) and/or on site. IED activation from a distance is performed from a position where terrorists could observe the area, video the incident and open fire if needed. Activation is generally carried out by fuze and/or electrical means. However, during the last 20 years, radio activated devices have been increasingly used.

IED activation at the scene in many cases is a suicide attack, but IEDs at the site may be activated by a person who has accidentally come in contact with them in one of the following ways: by changing the pressure (by pressure, movement, release), changing the temperature of the immediate environment, radio frequency, light or in some other way. Also, IEDs can be activated at the site in case they are equipped with a time fuze.

Handy materials for making fuzes used to activate IEDs are car alarms, electrical wrist watches, alarm clocks - electrical and mechanical mechanisms and similar assets.

Besides IEDs, the most commonly used types of explosive devices by terrorists are ,,booby traps". Booby traps are explosive devices or some seemingly harmless objects intended to injure and/or kill during their handling or performing activities that are normally harmless. The main difference between IEDs and booby traps is that booby traps are made of military explosives. (Kovačević & Popović, 2016, pp. 387-393) General measures for safe and healthy work with booby traps are the same as with IEDs.

The measures and procedures for safe and healthy work with Improvised Explosive Devices

The signs (indicators) that indicate the possibility that at some point there are IEDs are similar to the indicators for antitank and/or anti-personnel mines. The indicators might include the following:

- a tug - blasting fire wire or miner's cable;
- detonating fuse;
- explosive device (sometimes covered with bags, sacks and alike);
- dead animals;
- traces of works (freshly dug earth) on the ground;
- piles of gravel beside the road or other material;
- absence of people from streets or the presence of only one person;
- call for a prayer at night;
- objects that hang from trees or poles;

- shot, alternative switching the lights on and off or some other signal that MnOp members are coming;
- absence of children from the place where they usually play;
- keeping children at home during the school day;
- children approaching a checkpoint with bags on their backs.

Preventive measures for safe and healthy work with IEDs undertaken to prepare MnOp members for the protection against the effects of IEDs are as follows:

- before each patrol, it is necessary to inform all the patrol members about the following facts:
  - ✓ the patrol risk of terrorist attack, i.e. that patrolling is not "going for a walk";
  - ✓ already known IED emplacement locations in the area of responsibility during the previous period;
  - ✓ previous experience in implementing and/or possible ways of setting up and activating IEDs;
  - ✓ possible indicators in the field indicating the existence of an IED;
  - ✓ procedures undertaken by patrol members in the event of detecting indicators or an IED or in case of an accident caused by an IED.
- Raising awareness of patrol leaders and other members that any indication must be taken seriously and checked; they must be constantly aware of their surroundings. In these situations it is necessary to trust one's instincts.
- People around them should be observed for signs of nervousness and whether they are going away from patrols. Unfamiliar faces should be looked for since most terrorists will not carry out an attack among their acquaintances.
- During the implementation of the training, it is necessary to regularly test the procedures in case of encountering an IED or in case of an accident caused by an IED.
- Inform patrol members that, during the task execution, it is strictly forbidden to remove parts of personal protective equipment (helmets, body armor, ballistic panels, etc.); many lives were saved thanks to this equipment.
- Keep a prescribed distance from each other following the terrain. In case the patrol stops, do not approach each other. In particular, patrol members should be cautious when moving in

dangerous areas, over bridges, narrow roads and through traffic jams.

- It is necessary for patrol members to develop awareness that any stopping or slowing patrol's movement by local population, or due to obstacles in the way are a possible sign of an IED.
- It should always be kept in mind that terrorists constantly create new types of IEDs or improve the existing ones.

The preventive measures for safe and healthy work when encountering an IED are as follows:

- if you observe an IED, use binoculars and/or other similar means.
- If there is any indication to suspect a possibility of an IED, be sure to call explosive ordnance devices team (EOD team).
- In case you notice the existence of a detonating cord, do not touch it but immediately call the EOD team.
- In case of finding a blasting cable and/or fire wire, do not follow them because of a possibility of additional or secondary IEDs. Where a blasting cable leads to is tested only with the help of robots.
- During task implementation, never concentrate only on the found IED; the first step is to go back to a safe distance, secure the perimeter and inspect the terrain for additional or secondary IEDs, first in a radius of 5 m and then within a radius of 25 m around the vehicle. After that, report to superiors and wait for further instructions.
- In case of threat to personal safety, it is allowed to skip certain actions, use personal weapons and remove the threat to life.
- When submitting a report to the superior, the data on the IED is delivered exclusively in the form of the so-called ,,9-line Explosive Hazard Spot Report". (Australian Government, 2003)

Preventive security measures against terrorist attacks, particularly in suicide attacks, which have so far proved as the most appropriate solutions, are as follows:

- maintaining distance;
- controlling the area within a radius of 100 m;
- avoiding concentration of vehicles and persons;
- use of force.

Locations for positioning IEDs can be very different. The analysis of accidents has shown that in most cases IEDs are placed in territories that can be observed, recorded, and fired upon, as most terrorist attacks

using IEDs are mainly characterized by IED activation from a distance. Some examples of placing IEDs are given in Figures 1 to 4.

Figure 1 shows an IED in a form of an artillery shell that can be activated by pressure and/or move or release when a motor vehicle (m/v) passes near by.

Figure 1 – Positioning an IED behind a road metal barrier
Рис. 1 – Установка СВУ с задней стороны металлических дорожных отбойников
Слика 1 – IED постављен иза металних граничника пута

Near one of the busiest roads in Kabul, an IED was found in one of the sacks used for food delivery in one of local military bases. It was obvious that the terrorist's initial plan had been thwarted so the IED was intentionally left in the vicinity of a frequent road - Figure 2.

Figure 2 – An IED in a sack
Рис. 2 – Установка СВУ в мешке из мешковины
Слика 2 – IED постављен у џак од саргије

Figure 3 shows an Improvised Explosive Device positioned in a niche in a wall, hidden behind a poster. Positioning an IED as illustrated allows for directed action, i.e. for an effect in a specific direction and in a particular time with modern means of activation.

Figure 3 – Positioning an IED in the wall, masked by a poster
Рис. 3 – Установка СВУ в стене, замаскированная плакатом
Слика 3 – IED постављен у зиду, маскиран постером

Figure 4 shows an IED found in the waste of cardboard boxes at an improvised landfill site close to the central market in Kandahar.

Figure 4 – Positioning an IED in cardboard waste
Рис. 4 – Установка СВУ в картонных отходах
Слика 4 – IED постављен у картонски отпад

The measures and procedures for safe and healthy working with Person Borne Improvised Explosive Devices

One of the most terrifying forms of terrorist attacks and/or actions has been the use of PBIEDs. This kind of attack represents a major threat to both MnOp members and local population. Such attacks are characterized by a large number of victims, but in most cases, the victims are civilians because they are performed most often in places where there are a lot of people (squares, shopping centers, intersections, cinemas, theaters, metro, train and bus stations, buses, etc.), which has a terrifying effect on the sense of security of the local population.

,,Cruel ingenuity" of terrorist organizations is best reflected in the involvement of suicide bombers (according to the classification of terrorism by prof. PhD Dragan Simeunović, suicide terrorism is only one of the types of terrorism, according to the methods of implementation of actions), who intentionally take on the role of a ,,smart bomb". They select when and where to activate the explosive which they have on them and thus cause the greatest damage not hesitating to sacrify their own lives to a greater cause. In the literature on terrorism, the terms PBIED and suicide bombers are often used as synonyms which is not true because it is actually a question of a means of carrying out terrorist actions and a special type of perpetrators.

Preventive measures for safe and healthy work with PBIEDs undertaken to prepare MnOp members to protect themselves against PBIED effects encompass informing MnOp members of the indicators of the PBIED existence:

- Since the effect of such attacks causes a great fear in the local population, an MnOp member should look out for the signs of locals around him behaving anxiously or moving away from him, or running from the scene because this is a sign that something is wrong and that there is a possibility of some kind of a threat to present people.

The analysis of suicide attacks has established a profile of people who are direct perpetrators of attacks (although this is not constantly the rule, most suicide bombers have the following characteristics):

- age from 18 to 24;
- male/female persons (up to September 1995, they were only men; since September 1995, the Lebanese terrorist organization Hezbollah has been ,,using" women ,,martyrs"-suicide killers; today it is unfortunately standard practice);
- unmarried, without family;

- short hair cut, shaved, and the use of strong perfumes (smell conceals explosives);
- nervous and sweating a lot, or too slow and calm;
- thoughtful and silent, or uttering a prayer in a low voice;
- there is a sign of desperation in their eyes. (Australian Government, nd)

The indicators that a certain person may be a suicide bomber are as follows:

- loose clothing that can cover PBIEDs under it;
- slow and unnatural gait;
- hands in the pockets;
- protrusions on the clothes;
- sewn clothing or covering garment;
- backpacks that are full, cannot be closed and/or with visible wires;
- handbags that have traces of work on them and/or with visible wires.

The preventive measures for safe and healthy work undertaken by MnOp members in case of encountering a potential suicide bomber are the following:

- Stop, alert the other patrol members and evacuate the area if possible.
- Take shelter, point a gun at the suspect and in a strong and loud voice warn a suspect to stop (in the given situation, there is a high likelihood that the suspect will activate a PBIED).
- In the event that the suspect obeys the order, the procedure is as follows:
  - ✓ Order the suspect to show his hands with fingers spread. In the given situation, there is a possibility that another person triggers the PBIED on the suspect.
  - ✓ Order the suspect to put his things onto the ground, to the side and to move away to a safety distance.
  - ✓ Lift up the upper part of clothes in order to check whether there are explosives beneath it.
  - ✓ Order the suspect to lie down on the ground, spread his arms and legs, palms turned upwards and face turned to one side.
  - ✓ Do not approach, call the EOD team. It is necessary to stand at a safety distance from the suspect if possible (about 300 m).
  - ✓ report to the superior. (NATO, 2010)
- In case the suspect does not follow the orders, the procedure is as follows:

- ✓ take a safety distance from the suspect and do not allow the suspect to move, do not to approach and call the EOD team.
- ✓ report to the superior.
- ✓ use firearms only in case the suspect moves or endangers the safety of the people present.

The measures and procedures for safe and healthy work with Vehicle Borne Improvised Explosive Devices

Vehicle Borne Improvised Explosive Devices allow terrorists effects with a higher amount of explosives.Terrorists can activate VBIEDs while they are parked and/or when they are in motion. In most cases, when a m/v is parked, VBIED activation is carried out from a certain distance, and when a m/v is in motion, activation represents a suicide attack. Targets of attacks are most commonly motorcads with MnOp members. Some terrorists are exclusively engaged to enter premises of MnOp members with VBIEDs. The preventive measures for safe and healthy work with VBIEDs undertaken to prepare MnOp members for the protection against VBIEDs are as follows:

- Before movement, it is necessary to warn the superiors and drivers (in the case of a motorcad) about possible VBIEDs during movement, and remind them of the procedure known as ,,**3D"** (**distance** - maintain the distance between the vehicles; **direction** - to move in the ordered direction, and **description** - recognize and be able to describe).
- Do not stop during the motion, unless it was previously determined by the action plan, and especially do not stop because of artificial barriers in the way, as it is possible that an IED is positioned nearby. In the case of artificial obstacles in the way, the commander of a m/v and the driver should immediately speed up and quickly leave the risk area to a safe tactical distance. The safety distance depends on the task, the opponents, the terrain and weather conditions, support, time available and other.
- If the commander of a m/v and the driver timely detect a possible IED on the road, they can leave the road and pass the IED at a safe distance.
- In case the task is to keep a safety distance from an IED, it is necessary to secure the area and inspect the terrain for additional or secondary IEDs, first in a radius of 5 m and then within a radius of 25 m around the vehicle.
- Report to superiors about the situation.

- Also, it is necessary to inspect the terrain and spot the signs of enemy's operations i.e. whether there are any lookouts near the IED or a person with a camera and the like, because an IED can serve for demonstration purposes, i.e. can be part of an organised attack.
- Further follow the instructions of superiors and not use communications means within a radius of 300 m from the IED. (NATO, 2010)

The type of suicide attacks with an m/v loaded with explosive on MnOp members is also called **SVIED - Suicide Vehicle Improvised Explosive Devices**. When a potential SVIED is spotted to approach too closely and/or at high speed, the procedures and actions of members of MnOps are as follows:

- signalize the m/v to slow down, with the traffic regulations, flares, green lasers, lights or in any other visible way.
- In case the m/v continues to approach posing a direct threat, it is necessary to warn the m/w by pointing the weapon at it, thus showing the readiness to use it, and then shoot into the air.
- In the event that the m/v does not stop at the warning signs and further endangers the safety, shoot first to the m/v engine block and then to the driver's seat until the m/v stops.
- In the event that the m/v stops, it is necessary to take a safety distance from the m/v if possible (a safety distance from the stopped m/v depends on the type and dimensions of the m/v, see a general overview given in Table 1). (UN mine action gateway,nd)
- Report to superiors and ask for further instructions for the operation.
- Secure the area and inspect the terrain in order to spot signs of enemy's operation, i.e. whether there are lookouts nearby or whether there are people with cameras, etc.

Figures 5 to 6 show places on different types of m/v where VBIEDs can be installed. Figure 5 shows a possibility of installing a VBIED in a passenger car. (Army technology, nd)

Figure 6 shows possible places of VBIED installation in a van. (Army technology, nd)

Table 1 – Review of a safety distance from a vehicle with a VBIED
Таблица 1 – Обзор безопасного расстояния от автомобилей с автомобильной бомбой
Табела 1 – Преглед безбедног одстојања од возила са *VBIED*

REVIEW **a safety distance from** VBIEDs	Maximum capacity of explosives in kg	Distance of lethal air blast in m	Minimum distance for evacuation in m	Fragmentation effect of the glass in m	Minimum distance for the evacuation of people in buildings in m
 Small car	227	30	457	381	98
 Big car	455	38	534	534	122
 Van	1818	61	838	838	195
 Small truck	4545	91	1143	1143	263
 Cistern	13636	137	1982	1982	375
 Motor vehicle with trailer	27273	183	2134	2134	475

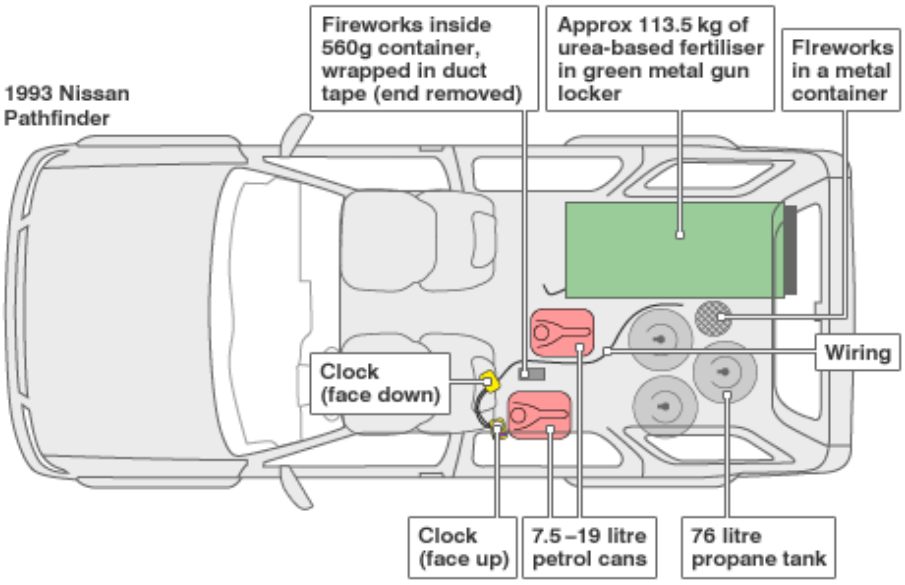

Figure 5 – Positioning a VBIED in a passenger car
Рис. 5 – Установка автомобильной бомбы в легковом автомобиле
Слика 5 – VBIED постављен у путнички аутомобил

Figure 6 – Positioning a VBIED in a van
Рис. 6 – Установка автомобильной бомбы в фургоне
Слика 6 – VBIED постављен у комби

Conclusion

In the last few years, the risk of injury at work is often a subject of much debate and discussion, particularly since the implementation of the provisions of the Law on Safety and Health at Work. Risk, as a result of a combination of the probability and hazardous events, may be reduced or eliminated solely by timely and diligent application of preventive measures, and by using the appropriate equipment which every individual (irrespective of work categories) has to apply permanently. Quality training, as a process, with all its elements, is the basic measure of prevention from accidents provoked by explosives. The basis of any kind of training consists of instructors, disposable and non-disposable goods as well as literature. (Kovačević, 2015, p.167)

These elements of the training have a cause-effect relation, and it is practically impossible to perform any kind of training without them. However, the generic link of all three elements of training is documentation, i.e. regulations and instructions that define the implementation sequence of all training elements. On the other hand, in order to achieve the quality of essential training documents, it is necessary to implement the lessons learned from practice, in particular in dealing with IEDs (and other types of explosive devices), acquired by members of the SAF and the MoD, as well as foreign armed forces, in MnOps. In other words, it is necessary to apply consultations on training as well as subsequent analyses in order to influence the process of drafting and adoption of documents that would regulate this complex area.

Working with IEDs but also with other types of explosive devices is very hard and complex physical and mental work that requires, above all, a very good theoretical knowledge of the characteristics of specific IEDs, physical exertion as well as practical training for their clearance. The creation and use of new textbooks, regulations, lessons, scripts and manuals that develop didactic and methodical approach to work with IEDs during the preparation of persons for the engagement in MnOps greatly reduce the risks of injury, and to a large extent raise awareness about possible dangers and consequences that can arise from unskilled work with IEDs. This work represents a modest contribution of the authors to enrich the existing literature in this area.

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ПРОФИЛАКТИЧЕСКИЕ МЕРЫ ПО БЕЗОПАСНОЙ ДЛЯ ЖИЗНИ И ЗДОРОВЬЯ РАБОТЕ С САМОДЕЛЬНЫМИ ВЗРЫВНЫМИ УСТРОЙСТВАМИ В РАМКАХ МНОГОНАЦИОНАЛЬНЫХ ОПЕРАЦИЙ

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ОБЛАСТЬ: безопасность и охрана труда, инженерство
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

После повторного приема Республики Сербия в Организацию Объединенных Наций (ООН) сотрудников Министерства обороны

(МО) и Вооруженных сил Сербии (ВСС) привлекают к участию в многонациональных операциях (МнОп). Все страны мира, прежде чем отправить своих сотрудников в МнОп, предпринимают все возможные меры, по их подготовке в предотвращении опасности от взрывных устройств, а также по подготовке безопасного проживания и работы во время МнОп. Одной из таких мер является публикация проспектов и инструкций по безопасности, с которыми члены МнОп должны ознакомиться, в цели предотвращения угрозы для их жизней и здоровья, во время работы со взрывчатыми веществами на территории МнОп. Главная проблема в том, что не существует соответствующая литература, применяемая в учебном процессе и подготовке лиц, задействованных в МнОп. В статье представлен обзор, имеющейся в настоящее время литературы и опыта МО и ВСС и иностранных вооруженных сил, участвовавших в МнОп, а также рекомендации профилактических мер по безопасной для жизни и здоровья работы с взрывчатыми веществами и самодельными взрывными устройствами.

Ключевые слова: многонациональные операции, оборона, процедуры, профилактика, меры, литература, взрывные устройства.

ПРЕВЕНТИВНЕ МЕРЕ ЗА БЕЗБЕДАН И ЗДРАВ РАД СА ИМПРОВИЗОВАНИМ ЕКСПЛОЗИВНИМ НАПРАВАМА У МУЛТИНАЦИОНАЛНИМ ОПЕРАЦИЈАМА

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ОБЛАСТ: безбедност и здравље на раду, инжињерија
ВРСТА ЧЛАНКА: стручни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Након поновног пријема Републике Србије у Уједињене нације (УН) припадници Министарства одбране (МО) и Војске Србије (ВС) ангажују се у мултинационалним операцијама (МнОп). Све државе света чији се припадници упућују у МнОп правовремено предузимају мере да се они упознају са опасностима од експлозивних средстава и припремају их за безбедан живот и рад. Једна од мера које се предузимају јесте и израда брошура или приручника којима се припадници МнОп-а упознају са опасностима од експлозивних средстава и општим поступцима у случају наиласка на њих. Наиме, основни проблем представља недостатак литературе као

основе процеса обуке, односно припреме лица која се упућују у МнОп. Чланак представља преглед тренутно расположиве литературе и искустава припадника МО и ВС и страних оружаних снага који су били ангажовани у МнОп-у, а у вези са превентивним мерама за безбедан и здрав рад са експлозивним средствима, односно једном посебном врстом ових средстава – импровизованим ескплозивним направама.

Кључне речи: мултинационалне операције, заштита, процедуре, превенција, мере, литература, експлозиви.

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ПРИКАЗИ
ОБЗОРЫ
REVIEWS

20. МЕЂУНАРОДНА КОНФЕРЕНЦИЈА ICDQM-2017 (ПРИКАЗ ЗБОРНИКА РАДОВА)

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ОБЛАСТ: менаџмент, квалитет, поузданост, рачунарске науке, информационе технологије
ВРСТА ЧЛАНКА: приказ
ЈЕЗИК ЧЛАНКА: српски

Сажетак:

У овом приказу наводе се основне информације о укупним резултатима, значају, међународном програмском одбору и областима рада 20. међународне конференције „Управљање квалитетом и поузданошћу ICDQM-2017" (радови су на српском језику) и 8. међународне конференције „Управљање и инжењерство животног циклуса" (радови су на енглеском и руском језику), која је одржана под истим називом ICDQM-2017. Представљени су број и структура радова обе конференције, у секцијама: војно инжењерство, инжењерство квалитета, инжењерство поузданости, индустријско инжењерство, системско инжењерство, енергетска ефикасност и економична производња, а приказани само пленарни радови припадника Војске и Министарства одбране Републике Србије.

Кључне речи: квалитет, поузданост, војно инжењерство, конференција, приказ.

У Пријевору код Чачка, у Истраживачком DQM центру одржана је, од 14. до 15. септембра 2017. године, 20. DQM међународна конференција „Управљање квалитетом и поузданошћу ICDQM-2017" (20th International Conference Dependability and Quality Management

ICQDM-2017) и, истовремено, 8. међународна конференција „Управљање и инжењерство животног циклуса" (8th DQM International Conference Life Cycle Engineering and Management).

Организатор конференције је, као и до сада, DQM истраживачки центар (Истраживачки центар за управљање квалитетом и поузданошћу) из Пријевора код Чачка, којим руководи академик Академије за проблеме квалитета Руске Федерације, проф. др Љубиша Папић.

Конференција обухвата области: инжењерство квалитета, инжењерство поузданости, индустријско инжењерство, системско инжењерство, војно инжењерство, енергетску ефикасност и економичну производњу. До сада је у зборницима ове конференције публиковано 2423 рада.

Области ICDQM конференције веома су интересантне и значајне и за припаднике Војске Србије и Министарства одбране Републике Србије (МО), па на конференцији постоји и посебна област војно инжењерство (уведено као секција 2009. године), због значаја радова и континуитета учешћа припадника Војске и Министарства одбране.

Програмски одбор 20. DQM конференције има 26 чланова из 10 земаља (БиХ 1, Велика Британија 3, Канада 2, Норвешка 2, Русија 4, САД 1, Србија 13, од којих су 3 из Војне академије, затим Шпанија 1, Чиле 1 и Украјина 2) (ICDQM, 2017a). Програмски одбор 8th DQM конференције има 35 чланова из 13 земаља (Аустрија 1, БиХ 1, Велика Британија 1, Израел 4, Индија 6, Јордан 1. Русија 9, САД 1, Србија 4, од којих су 2 из Војне академије, затим Шведска 2, Шпанија 1, Холандија 1 и Хрватска 3) (ICDQM, 2017b).

И ове године је Комисија програмског одбора, од радова саопштених на прошлој конференцији, прогласила два најбоља рада, један из области академских истраживања, а један из области примењених истраживања у привреди:

1. „Треба ли преобликовати Леан филозофију" чији је аутор *Заим Смајић* из Високе техничке школе струковних студија из Новог Београда;

2. „Заштита радника у процесу палетизације помоћу роботског палетизера на примеру упакованог шећера" чији су аутори *Стево Миладиновић* и *Душан Галвански* из Фабрике шећера „Црвенка" из Црвенке.

На конференцији је отворена „Изложба посвећена 3. ракетном дивизиону 250. ракетне бригаде противваздухопловне одбране Војске Србије", чији је аутор пуковник Славиша Голубовић. Такође, у

Pokorni, S., 20. međunarodna konferencija ICDQM-2017 (prikaz zbornika radova), pp.686-694

оквиру промоције нових књига приказана је монографија „Пад ноћног сокола" истог аутора.

За конференцију су штампана два зборника радова, а постоје и на компакт дисковима. У зборницима има укупно 133 рада (прошле године 148), аутора из 8 земаља (прошле године 7): Алжира, Босне и Херцеговине, Хрватске, Немачке, Русије, Србије, Шведске и Шпаније (ICDQM, 2017a), (ICDQM, 2017b), (Pokorni, 2017).

Званични језици конференције били су енглески, руски и српски.

У зборнику радова „20. DQM међународна конференција Управљање квалитетом и поузданошћу ICDQM-2017" (на српском језику) објављено је 78 радова (прошле године 99), и то 7 пленарних саопштења, 13 радова у секцији инжењерство квалитета (Quality Engineering), 10 у секцији инжењерство поузданости (Reliability Engineering), 18 у секцији индустријско инжењерство (Concurent Engineering), 12 у секцији системско инжењерство (Systems Engineering), 16 у секцији војно инжењерство (прошле године 30), 2 у секцији енергетска ефикасност, и 1 у секцији економична производња (Lean Production).

У зборнику радова „8th DQM International Conference Life Cycle Engineering and Management" (41 рад на енглеском и 14 на руском језику) објављено је 55 радова (прошле године 49), аутора из 12 земаља (Аустрија, Босна и Херцеговина, Црна Гора, Еквадор, Колумбија, Индија, Русија, Словачка, Србија, Шпанија, Чешка Република и Чиле), од чега 20 пленарних саопштења, 6 у секцији Quality Engineering, 3 у Reliability Engineering, 6 у Industrial Engineering, 4 у Systems Engineering и 14 у Military Engineering.

Припадници Војске, односно Министарства одбране Србије, имају укупно 51 рад (32 на српском, 18 на енглеском и 1 на руском језику), а прошле године 64. У табели 1 приказан је број радова припадника Војске Србије и МО и укупан број радова на конференцији, у последњих 9 година, од када постоји секција војно инжењерство (Pokorni, 2017). И ове године је број радова припадника Војске и МО у секцији војно инжењерство већи него у осталим секцијама (30 у односу на 21, табела 1), а уочљиво је да има више радова на енглеском језику у односу на прошлу годину.

Припадници Војске и МО имали су 3 рада на страном (енглеском) језику у пленарној секцији, а у осталим секцијама 16 радова на страним језицима (15 на енглеском и 1 на руском језику), (табела 2).

Табела 1 – Преглед броја радова припадника ВС и МО и укупног броја радова на ICDQM
Table 1 – Overview of the papers of the Serbian Army and MoD members and the overall number of papers at the ICDQM
Таблица 1 – Обзор количества работ представителей ВС и МО и общего количества работ, представленных на конференции ICDQM

	Година								
	2017.	2016.	2015.	2014.	2013.	2012.	2011.	2010.	2009.
Секција војно инжењерство	30	36	28	22	9	6	6	18	12
Остале секције	21	28	19	20	21	10	8	10	2
Укупно ВС и МО	51	64	47	42	30	16	14	28	14
Укупно ICDQM	133	148	160	160	180	155	141	162	148

Због великог броја радова припадника Војске и Министарства одбране Републике Србије, чије би представљање учинило овај приказ преобимним, наводимо укратко садржај само њихових пленарних радова, редоследом како су наведени у зборницима радова (објављених пре одржавања конференције).

На нивоу пленарних предавања публиковано је 6 радова припадника МО, 3 на српском и 3 на енглеском језику.

Радови на српском језику:

Славиша Голубовић, Београд

Експлоатациона поузданост ракетног система противваздухопловне одбране С-125М (НЕВА) у ратним условима

У раду је описано обарање америчког тактичког бомбардера стелт технологије F-117A, које је извео 3. ракетни дивизион ПВО 250. ракетне бригаде ПВО, ракетним системом противваздухопловне одбране С-125М (нева), 27. марта 1999. године. Описују се и просторни, временски и технички услови у којима је изведено гађање, и услови који су утицали на поузданост рада ракетног система нева (старост система, технологија, обученост посаде итд.).

Pokorni, S., 20. međunarodna konferencija ICDQM-2017 (prikaz zbornika radova), pp.686-694

Табела 2 – Преглед броја радова припадника ВС и МО по секцијама (2017/2016)
Table 2 – Overview of the papers of the Serbian Army and MoD members in the conference topics (2017/2016)
Таблица 2 – Обзор количества работ представителей ВС и МО в разделах (2017/2016)

СЕКЦИЈА	Радови на језику			Укупно
	српски	енглески	руски	
Пленарна саопштења	3/2	3/0	0/0	6/2
Инжењерство квалитета	4/6	0/1	0/0	4/7
Инжењерство поузданости	4/4	2/4	0/0	6/8
Индустријско инжењерство	4/6	0/0	0/0	4/6
Системско инжењерство	1/1	0/0	0/0	1/1
Енергетска ефикасност	0/2	0/0	0/0	0/2
Економична производња	0/1	0/0	0/0	0/1
Допунска саопштења	0/1	0/0	0/0	0/1
Војно инжењерство	16/30	13/5	1/1	30/36
УКУПНО	32/53	18/10	1/1	51/64

Марко Андрејић, Марјан Миленков, Универзитет одбране, Војна академија, Београд

Прилог унапређењу промишљања о променама у логистици одбране

У резимеу овог рада аутори констатују да је систем логистичке подршке одбране, посебно Војске, у последњих двадесетак година доживео више промена, планских и превентивних, али и изнуђених услед неопходности реаговања на промене у окружењу; да су променама изложене (још увек трају) теорија и пракса логистике, организациона култура и клима, концепција, организација, терминологија (категоријално појмовни апарат), технологија, логистичка политика, систем, елементи, функције и процеси у логистици; да је спроведна нагла смена генерација у логистичким системима и релаксирање од искусног кадра носиоца примене логистичке технологије; да потребан трансфер знања и искустава није направљен, што је довело до успоравања промена и отпора променама и различитог реаговања на промене; да је ради рационализације бројних захтева неопходно актере промена благовремено информисати, упознати са идејама водиљама и укључити у процес промена. У раду се, комбинованим приступом, усмереним, с једне стране, на изношење теоријских одредница

важних за логистику одбране, а, с друге стране, уопштеним приказом динамике промена ствара подлога за разумевање текућих и завршених процеса промена и унапређење промишљања о даљим променама, путем континуиране иновације.

Владимир Радивојевић, Министартсво одбране Републике Србије, Војска Србије, Ниш

Неки аспекти нарушавања конкуренције у поступцима јавних набавки у Србији

У резимеу овог рада аутор констатује да ефикасан систем јавних набавки почива на слободном тржишном надметању понуђача. Учесници рестриктивних споразума у поступцима јавних набавки настоје да кроз различите облике сарадње и договарања повећају цену или умање квалитет предмета јавног уговора, чиме нарушавају слободну конкуренцију и елиминишу погодности које из ње проистичу. Циљ рада јесте да се сагледају најчешћи облици нарушавања конкуренције у јавним набавкама и њихов утицај на слободно тржишно надметање, као и да се истраже досадашњи резултати у откривању и санкционисању рестриктивних споразума у јавним набавкама у Србији. Истраживачки налази указују на скромне резултате које је Србија остварила у овој области и наглашавају потребу за идентификацијом кључних фактора ограничавања конкуренције у поступцима јавних набавки.

Радови на енглеском језику су следећи:

Хајрадин Радончић, Универзитет одбране, Војна академија, Београд

Confessional structure of population from 1921 until 2011 and its impact on national identification of Serbia

Рад се бави променама у конфесионалној структури становништва Србије (на основу пописних података) у периоду 1921–2011. година и њиховим утицајима на националну идентификацију у Србији.

Pokorni, S., 20. međunarodna konferencija ICDQM-2017 (prikaz zbornika radova), pp.686-694

Дејан Васовић, Горан Јанацковић, Универзитет у Нишу, Факултет заштите на раду, Ниш
Стеван Мушицки, Универзитет одбране, Војна академија, Београд

Review of the genesis of various environmental management systems based on the systems approach

Рад се бави карактеризацијом и генезом организација значајних за управљање заштитом животне средине, пре свега оних заснованих на системским стандардима. У раду се, такође, говори о значају стандардизације и принципима, циљевима и посебностима развоја и имплементације стандарда на различитим нивоима – глобалном, ЕУ и националном нивоу. Тежиште аутора је на питањима ауторитета различитих субјеката и анализи ставова заинтересованих страна.

Небојша Николић, Министарство одбране, Институт за стратегијска истраживања, Београд

Hybrid warfare impact on command and control process

Рад се бави појмом хибридног ратовања и његовим утицајем на процес командовања и управљања са намером да идентификује могуће недостатке у ланцу командовања и управљања.

На крају, може се констатовати да ова конференција има мањи укупан број радова него претходна, што се односи и на припаднике Војске и Министарства одбране Републике Србије (табела 1), премда је њихово учешће у укупном броју веома значајно – 38%.

Наставља се тренд сарадње аутора из разних институција Војске и МО Србије међусобно и са институцијама ван Војске. Већина радова је колективно дело више аутора. Међутим, неколико истих аутора јавља се на више од 3 рада (на већини научних скупова је ограничено да се исти аутор може појавити на највише 2 рада, а на некима 3).

Као и претходних година, на конференцији су учествовали некадашњи припадници Војске, који сада раде у високообразовним институцијама у цивилству.

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Pokorni, S. 2017. 19. međunarodna konferencija ICDQM 2016 (prikaz zbornika radova). *Vojnotehnički glasnik / Military Technical Courier*, 65(2), pp.550-557 (in Serbian).

20-АЯ МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ ICDQM-2017
(ОБЗОР СБОРНИКА СТАТЕЙ)

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ОБЛАСТЬ: менеджмент, качество, надежность, компьютерные науки, информационные технологии
ВИД СТАТЬИ: обзор
ЯЗЫК СТАТЬИ: сербский

Резюме:

Данный обзор включает основную информацию о результатах работы и значимости 20-ой Международной конференции "Управление качеством и надежностью" – ICDQM-2017 (доклады на сербском языке) и 8-ой Международной конференции «Управление и инженерия этапами жизненного цикла» (доклады на английском и руском языках), которая была проведена под одноименным названием «ICDQM-2017». В обзоре приведены: номер и структура докладов, зачитанных на конференции, распределеных по секциям: военная инженерия, инженерия качества, инженерия надежности, промышленная инженерия, системная инженерия, энергоэффективность и бережливое производство, но в данном обзоре рассматриваются исключительно пленарные статьи, авторами которых являются военнослужащие, представители Министерства Обороны Республики Сербия. На данной конференции по сравнению с предыдущей приняло участие меньшее количество представителей Министерства обороны Республики Сербии, но с другой стороны, работ, написанных на английском языке, было больше.

Ключевые слова: качество, надежность, военно-инженерное дело, конференция, обзор.

Pokorni, S., 20. međunarodna konferencija ICDQM-2017 (prikaz zbornika radova), pp.686-694

20TH INTERNATIONAL CONFERENCE ON DEPENDABILITY AND QUALITY MANAGEMENT ICDQM-2017 (PROCEEDINGS REVIEW)

Slavko J. Pokorni
Information Technology School, Belgrade, Republic of Serbia

FIELD: Management, Quality, Reliability, Computer Sciences, Information 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 20th DQM International Conference on Dependability and Quality Management ICDQM 2017 (papers printed in Serbian) and 8th DQM International Conference on Life Cycle Engineering and Management (papers printed in English and Russian), which was held under the same acronym ICDQM-2017. The number and structure of papers of both conferences are given in Sections: Military Engineering, Quality Engineering, Reliability Engineering, Industrial Engineering, Systems Engineering, Energy Efficiency and Lean Production, as well as a review of the plenary papers presented by the participants from the Armed Forces and the Ministry of Defense of the Republic of Serbia. This year's Conference has fewer papers from participants from the Armed Forces and the Ministry of Defense of the Republic of Serbia compared to the previous conference, but with more papers writen in English language.

Key words: quality, reliability, military engineering, conference, review.

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Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp.695-716

Кинески тенк Type 99: да ли је бољи од америчког M1 Abrams или руског T-90?[1]

Кинески тенк Type 99

Кина поседује осам до девет *хиљада* тенкова, укључујући и оне који су у резерви, а налазе се по складиштима.

Већина кинеских тенкова су старији типови као што су Type 59 и 69 који су више-мање копије руских тенкова из педесетих година, као што је T-54. Такви тенкови понекад се могу наћи и у двориштима дечијих вртића.

Међутим, нови кинески тенк Type 99 већ је изазвао поштовање међународних посматрача, иако није извезен нити је коришћен у борбеним условима. Разлог је једноставан: његове перформансе су сличне или једнаке многим западним тенковима, али Type 99 има и неколико својих карактеристика.

Нови Type 99 има два важна противника – амерички M1A2 Abrams и руски T-90A. Постављају се и питања: да ли Кина уопште има потребу за

[1] The National Interest, January 23, 2018

тенковима и која је вероватноћа сукоба између америчког тенка M1 Abrams и кинеског Type 99 имајући у виду Пацифички океан?

Питања су релевантна ако се узме у обзир поређење са руским Т-90. Москва тренутно одржава добре односе са Пекингом са којим дели и дугу границу, али се две силе нису увек слагале и замало су и заратиле крајем шездесетих година.

Оно што је још важније јесте да Русија продаје своје наоружање Индији и Вијетнаму као што су борбени системи – крстарећа ракета Brahmos, али и преко 1.000 тенкова Т-90 распоређених дуж хималајске границе.

Кина је водила рат са Индијом 1962. године дуж поменуте границе и још један са Вијетнамом 1979. године који је имао за циљ кажњавање Вијетнама због подршке режиму црвених кмера у Камбоџи.

Данас Кинеска војска види непријатеља у Индији, потенцијалној суперсили, те је потпуно милитаризовала заједничку границу и саградила мрежу путева којим би пролазила тешка војна возила између високих планина. Кина је савезник са Пакистаном који је неколико пута водио ратове са Индијом, а честе су и размене војних технологија између две земље.

На крају, није искључена ни могућност потенцијалног грађанског рата или слома режима у Северној Кореји, па није искључена ни могућност сукоба са снагама Северне Кореје.

Такмичари су следећи…

Амерички тенк Abrams је класичан амерички пројекат који је десетковао ирачке оклопне снаге током Голфског рата 1991. године без иједног губитка код ирачких оклопних снага. Накнадна дејства америчких тенкова у урбаним и полуурбаним срединама показала су да Abrams ипак није нерањив, нарочито на дејства импровизованих експлозивних направа или противоклопних вођених и невођених ракета, а нарочито са задње и по бочним странама. У Јемену је у току својеврсно испитивање рањивости саудијских тенкова Abrams, уз обилато коришћење противоклопних средстава, што је довело до нарушавања изграђеног имиџа америчког тенка и до велике нервозе Американаца који су у једном тренутку размишљали и о обустави испорука нових тенкова Саудијској Арабији. Додуше, ова несрећна статистика резултат је не баш врхунске обучености саудијских копнених трупа.

Тенк Т-90 је први руски тенк који се појавио након краја хладног рата. Иако није у потпуности изједначен са америчким тенком Abrams, он је приказао значајна унапређења у погледу прецизности и заштите нарочито са моделима који су опремљени најновијом генерацијом експлозивно-реактивног оклопа. Иако је Русија у међувремену приказала нови, револуционарни тенк Т-14, за сада нема довољно финансијских

средстава за његову масивнију серијску производњу. Русија је произвела само 550 тенкова Т-90А за које се може рећи да спадају у ред модернијих тенкова, а затим кренула у обиман програм модернизације своје флоте тенкова Т-72 на ниво Т-72 Б3 који је врло сличан нивоу опреме тенка Т-90А.

Русија је развила још модернију варијанту – тенк Т-90АМ који још није ушао у производњу, али је његова извозна варијанта, под ознаком Т-90МС, продата Индији и то 354 примерака. Индија има преко 1.200 тенкова Т-90 од којих је већи део распоређен на кинеско-индијској граници.

Кинески тенк Type-99 комбинује труп који подсећа на продужени Т-72 са куполом у стилу западних тенкова која је вероватно инспирисана немачким тенком Leopard 2. Овај тенк је први пут приказан на паради 1999 године под ознаком Type 98, а затим је тенк добио садашњу ознаку Type-99 и уведен у наоружање 2001 године. Са својом масом од 57 тона он се налази између америчког Abramsa од 70 тона и руског Т-90 од 48 тона. Тенк је у међувремену унапређен новим технологијама и сада носи ознаку Type 99A2. Кина има скоро 500 тенкова овог типа у оперативној употреби, распоређених у шеснаест оклопних батаљона. Овај тенк се не налази на списку извозних артикала, али одређене технологије су употребљене у тенку VT4 који се извози.

Ватрена моћ

Тенкови Type 99 и Т-90 ослањају се на топове 125 мм са аутоматским пуњачима који се не разликују много од првобитних совјетских пројеката. Ови топови нису могли да пробију чеони оклоп америчких и британских тенкова Abrams и Challenger, али нови поткалибарни пројектили од волфрама то ипак омогућују, додуше на краћим раздаљинама.

Нови кинески тенк Type 99A2 појављује се са новим дужим топом, што у теорији омогућава постизање веће брзине пројектила и побољшава пробојност и прецизност.

Постоје индиције да је Кина намеравала да инсталира нови већи топ од 140 мм на свој тенк Type 99, али се то до данас ипак није обистинило Та опција није искључена у некој блиској будућности с обзиром на то да због развоја у области заштите тенкова многе државе раде на пројектима унапређења тенковских топова са калибра 120 и 125 мм на калибре 130 и 140 мм. Тренутно не постоје потребе за тим, а велике су и залихе тенковске муниције постојећих калибара.

Кина је развила своју сопствену муницију од осиромашеног уранијума за своје топове од 125 мм за коју се тврди да може да пробије чеони оклоп америчког Abramsa на даљинама до 1,4 километра.

Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp.695-716

Посаду америчког тенка Abrams чине четири члана, што омогућава повећану каденцу паљбе, а четврти члан посаде може заменити евентуално повређеног члана посаде. Због тога је купола тенка већа и тежа.

Тенкови Type 99 и T-90 могу испаљивати противоклопне вођене ракете из тенковског топа за разлику од америчког тенка Abrams. Type 99 користи ракету AT-11 Refleks којом је могуће нападати копнене и нисколетеће циљеве на већим даљинама, али у последњих педесет година ова опција није коришћена.

Када су у питању осматрачки и нишански сензори, Русија је начинила одређени напредак на пољу тенковских нишанских справа и термалних осматрачких уређаја, иако на Западу и даље сматрају да су њихови уређаји ове врсте много супериорнији. Руски тенк T-90A није опремљен најмодернијом руском опремом (само одређен број тенкова опремљен је француским термалним осматрачко-нишанским справама Catherine, док извозни модел T-90MS има унапређени нишански систем Kalina.

Кина је позната по својој изврсној електроници, а Type 99A2 је, наводно, опремљен новим инфрацрвеним системом за праћење непријатељских тенкова и верује се да је овај систем бољи од система исте намене на руском T-90A.

Заштита

Тенк Type 99 опремљен је композитним и експлозивно-реактивним оклопом. Нова верзија, Type 99A2, опремљена је вишеслојним системом за који се претпоставља да је сличан руском оклопу Relikt који користи радар за детонирање експлозивних плоча пре удара противничког пројектила. Овакав оклоп намењен је у одбрани против тандем-кумулативних противоклопних ракета.

T-90A користи експлозивно-реактивни оклоп старије генерације Kontakt-5, а нови тенкови T-90MS који су у употреби у индијским оружаним снагама опремљени су новијим системом Relikt. Ови оклопи су нарочито ефектни против противоклопних вођених ракета, али у мањем обиму и против кинетичких пројектила.

Type 99 опремљен је уређајем за откривање ласерског озрачења који упозорава командира тенка да је возило означено ласерским обележивачем, што би у теорији омогућило возачу накнадно маневрисање и евентуално избегавање противничког пројектила. Многи тенкисти у Сирији и Јемену би здушно поздравили овакво упозорење с обзиром на то да су, судећи по снимцима са интернета, многи тенкови били погађани и уништавани након лета ракете који је трајао и по више од двадесет секунди.

Type 99 такође је опремљен ласерским уређајем велике снаге који служи за ометање противоклопних ракета вођених ласерским или

инфрацрвеним системима, а може и, с обзиром на снагу, ослепити непријатељског нишанџију и то трајно. Овакви системи нису никад употребљени у борбеним условима, тако није могуће проверити њихову ефикасност.

Нови тенк Type 99A2 опремљен је и ласерским комуникационим системом који служи за идентификовање својих, туђих возила и емитовање шифрованих података у уском снопу.

Руски Т-90 ослања се на активни одбрамбени систем Shtora („soft kill") који, осим ометања ласерских уређаја својим ометачем, испаљује аеросолна експлозивна пуњења ради стварања облака непробојног за ласере око возила.

Амерички тенк M1 Abrams није опремљен уређајем за детекцију ласерског озрачења, активним системом одбране или експлозивно реактивним оклопом (што се показало као кобно у Јемену), али је у току рад на модернизацијама које ће увести неке од ових уређаја.

M1A2 се ослања на свој изванредни композитни оклоп Chobham који је мењан током година и за који се верује да представља еквивалент дебљини од 800 мм ваљаног челика заштите против дејства поткалибарног пројектила или дебљини од 1300 мм против дејства противоклопне кумулативне ракете. Поређења ради, верује се да је руски тенк Т-90 опремљен оклопом еквивалента дебљина од око 650 мм ваљаног челика заштите против дејства поткалибарног пројектила. Амерички Abrams има посебно складиште муниције, што га спасава од катастрофалних детонација по којима су се руски тенкови серија Т-72 „лоше прославили". Мада и такво решење има својих граница, што се опет може видети на снимцима са интернета несрећних саудијских тенкова Abrams који су остајали без купола.

Претпоставља се да је кинески тенк Type 99 опремљен комбинацијом композитног и модуларног оклопа и да је такав ниво оклопне заштите сличан или једнак оклопу америчког тенка Abrams. Војни извори тврде да се ради од заштити еквивалентној дебљини од 1.200 мм ваљаног челика заштите против дејства поткалибарног пројектила, иако су званични подаци недоступни.

Покретљивост

Кинески тенк је дефинитивно најбржи, максимална брзина му је преко 50 миља на сат на отвореном путу. Амерички M1 Abrams и индијски T-90MS постижу између 42 и 45 миља на сат, док руски тенк Т-90А достиже само 35 миља на сат. Са друге стране, амерички M1A2, захваљујући својој гасној турбини, може прећи само 240 миља без допуне горивом, док кинески и руски тенкови Type 99 и Т-90 имају радијус дејства око 300 миља. Поред тога, амерички тенк M1A2 је и много тежи, што отежава транспорт.

Тенк Type 99 опремљен је и новим дигиталним системима за одржавање сличним онима којима је опремљена нова верзија америчког тенка Abrams.

Може се закључити да је Abrams најбољи у погледу ватрене моћи, Type 99 је, чини се, најбоље заштићен захваљујући вишеслојном одбрамбеном систему, а бржи је и има већи радијус дејства.

Руски тенк T-90A је декласиран у односу на ова два тенка, али је T-90MS са оклопом Relikt, унапређеним нишанским и осматрачким уређајима и снажнијим моторима, и даље веома озбиљан противник.

Све то треба прихватити са одређеном резервом, јер док су M1 и T-90 коришћени у борбеним дејствима, Type 99 није. Такође, многи детаљи технологија употребљених у кинеском тенку нису доступни, па је тим пре овакво поређење само начелно. С друге стране, на недавно одржаном бијатлону у Русији, кинески тенк Type 99 имао је одређених проблема са испадањем погонског точка, па је брзо замењен, али…

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Војна парада Северне Кореје[23]

Осмог фебруара 2018. године у Пјонгјангу је одржана војна парада Северне Кореје поводом прославе седамдесете годишњице Корејске народне армије. Севернокорејске оружане снаге приказале су велики број нових борбених возила, укључујући тенкове, оклопне транспортере пешадије, артиљеријска оруђа, системе противваздухопловне одбране и балистичке ракетне системе.

Тенкови

Songun-ho представља нову верзију севернокорејског тенка која је заснована на тенку Pokpung-ho, а који је први пут приказан на војној паради 2010. године. На паради одржаној у фебруару 2018. године, тенк Songun-ho представљен је са реактивним оклопом на челу куполе и са сваке бочне стране у односу на основно наоружање. Кров куполе је, такође, опремљен додатним оклопом.

[2] World Defence News 11.02.2018
[3] Defence Blog 08.02.2018

Војна парада у Пјонгјангу поводом седамдесете годишњице Корејске народне армије која је одржана 8 фебруара 2018. године

Основно наоружање састоји се од топа 125 мм који личи на руски топ 2А46 од 125 мм којим је наоружана руска серија тенкова Т-72. Тенк је опремљен и сличним аутоматским пуњачем као и руска верзија. Тенк Songun-ho је овог пута приказан са новим секундарним наоружањем које се састоји од два ручна преносива противваздухопловна ракетна система РППРС, још једном новином – лансером за две противоклопне вођене ракете ПОВР који је монтиран на левом отвору куполе, али и са још два бацача граната на предњем делу десног отвора куполе.

Тенк Pokpung-ho IV

Тенк Pokpung-ho је развијен током деведесетих година прошлог века и користи технологију совјетске серије тенкова Т-62, Т-72, кинеских тенкова Type 88 и севернокорејског тенка Chonma-ho I.

Најновију верзију представља тенк Pokpung-ho IV на којем се налазе и неки новији уређаји који се налазе на совјетским тенковима Т-72, Т-80 и Т-90. Овај тенк такође је наоружан топом 125 мм, а претпоставља се да се ради о копији руског топа 2А46. Секундарно наоружање састоји се од лансера два РППРС типа SA-16 који се налазе на крају куполе, два лансера ПОВР типа АТ-5 монтираних на левој страни куполе и два аутоматска бацача граната који се налазе на челу куполе, изнад топа.

Тенк Songun-ho на паради одржаној у фебруару 2018. године у Пјонгјангу

Тенк Pokpung-ho IV

Оклопна возила точкаши

Оклопни транспортер пешадије М-2010 6х6

М-2010 6х6 је оклопни транспортер точкаш заснован на руском оклопном транспортеру BTR-80, али само са три осовине, једној на предњој страни возила и две на задњој страни. Ово возило је први пут приказано на војној паради 2010. године. Овај транспортер опремљен је куполом за једног члана посаде која је наоружана са два митраљеза 14,5 мм и коаксијалним митраљезом од 7,62 мм. Возило је наоружано и једним једноструким РППРС монтираним на задњем крају куполе.

Оклопни транспортер М-2010 6х6

Оклопни транспортер М-2010 8х8

Оклопни транспортер М-2010 8х8 је точкаш заснован на руском оклопном транспортеру BTR-80. Ово возило први пут је приказано на војној паради 2010. године.

Верзија 8х8 има исту куполу и наоружање као и верзија 6х6.

Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp.695-716

Оклопни транспортер М-2010 8x8

Артиљеријска оруђа

Самоходна хаубица Chuche-Po М-1991 122 мм опремљена је куполом на задњем делу возила са гусеницом коју покреће шест точкова. Основно наоружање састоји се од топа D-74 122 мм. Ово артиљеријско оруђе је у ствари совјетска вучна хаубица D-74 122 мм која је развијена још касних педесетих година прошлог века. Домет хаубице је 24 километра.

Током војне параде у фебруару 2017. године, ово возило је приказано наоружано са два РППРС монтирана на левој страни куполе и два бацача граната на десној страни куполе. Купола је опремљена и са по четири бацача димних граната који се налазе са сваке стране куполе.

Ова самоходна хаубица пројектована је и произведена у Северној Кореји. Амерички војни аналитичари означили су је ознаком М-1978 и Koksan, јер су те године у месту Koksan први пут снимили самоходну хаубицу. Ово возило засновано је на шасији кинеског тенка Type 59 са пет ходних точкова и видним растојањем између првог и другог точка. Погонски точак налази се на задњој страни гусеница. Основно наоружање састоји се од топа 170 мм, а посада није заштићена куполом.

Самоходна хаубица Chuche-Po M-1991 122 мм

Самоходна хаубица Chuch'ep'o M-1989 Koksan 170 мм

Модификована верзија система противваздухопловне одбране кратког домета SA-13 са новом оружном станицом

На војној паради први пут је приказана нова верзија совјетског система противваздухопловне одбране кратког домета SA-13. Купола је слична основном моделу, али је модернизована новом ракетом земља-ваздух са по четири ракете на свакој страни куполе. Возило је први пут приказано током војне параде у априлу 2017. године.

Модификована верзија система противваздухопловне одбране кратког домета SA-13 са новом оружном станицом

Вишецевни бацач ракета RM-70 122 мм

Северна Кореја купила је коришћене вишецевне бацаче ракета – ВБР које је пројектовала и произвела Република Чешка под ознаком RM-70. Овај систем наоружан је са 40 ракета 122 мм на покретној платформи монтираној на задњи крај камиона *Tatra* 813 8x8. Максимални домет ракета износи 20 километара.

Вишецевни бацач ракета RM-70 122 мм

Вишецевни бацач ракета М-1991 240 мм

Вишецевни бацач ракета М-1991 240 мм добио је ознаку по години када су амерички војни аналитичари први пут опазили оружје.

Овај ВБР опремљен је са 22 ракете и користи исте ракете од 240 мм као и ВБР М-1985. Ракетни лансер је смештен на задњем делу камиона одмах иза кабине. Ракетни лансер М-1991 има два реда са по 8 цеви и један ред са 6 цеви.

Максималан домет је 30 км, а за верзију ракете Juche 100 – 60 км.

Модернизовани ВБР KN-09 300 мм

Овај ВБР је пројектован и произведен у Северној Кореји. Ракетни систем је монтиран на шасију камиона Sinotruk HOWO 6x6. Прва верзија система KN-09 први пут је приказана 2015. године, а нова верзија је опремљена оклопљеном кабином. Ракетни лансер састоји се од две групе по четири ракете. ВБР користи ракете које се могу наводити путем руског сателитског навигационог система GLONASS или путем кинеског навигационог система Beidou.

Вишецевни бацач ракета М-1991 240 мм

Модернизовани ВБР KN-09 300 мм

Интерконтиненталне балистичке ракете Северне Кореје

На војној паради одржаној 8. фебруара 2018. године Северна Кореја је први пут приказала своје нове интерконтиненталне балистичке ракете типа Hwasong-14 и Hwasong-15.

Ракета Hwasong-14, која се још води под америчком ознаком KN20, мобилна је интерконтинентална балистичка ракета коју је развила Северна Кореја. Први пут је летела 4. јула 2017. године, али то је први пут да је овај систем приказан на камиону. Северна Кореја је нешто раније приказала ову ракету на специјалном теренском возилу Wanshan Special Vehicle WS51200 са осам осовина и специјалном рампом за лансирање.

Hwasong-15 је нова интерконтинентална балистичка ракета, коју је Америка означила као KN22 и такође је пројектована и произведена у Северној Кореји. Амерички аналитичари истичу да је основна одлика ове ракете конфигурација погонског дела првог степена који се пуни течним ракетним горивом. За разлику од ракете Hwasong-14 која користи једну погонску комору са четири мања мотора „vernier" која служе за управљање, ракета Hwasong-15 користи двокоморне потискиваче без додатних мотора за управљање, а војни извори наводе да нова ракета Hwasong-15 може носити терет од 150 до 1.000 кг на даљину до 13.000 км.

Hwasong-15

Лидер Северне Кореје Ким Џонг Ун јавно је објавио да ракете Hwasong-14 и Hwasong-15 могу испоручити свој (нуклеарни) терет било где у континенталном делу САД.

Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp.695-716

Hwasong-14

Балистичка ракета средњег домета Hwasong-12/KN-17

Hwasong-12 је мобилна верзија балистичке ракете средњег домета коју транспортује камион сличан руском MAZ-547A (MKZT-7916) са 12 точкова, али је возило оклопљено са додатним оклопним плочама на бочним странама. Са возила се лансира ракета.

Ова ракета први пут је приказана јавности на војној паради Северне Кореје априла 2017. године. Први ватрени тест одржан је у мају исте године, а претпоставља се да је домет ракете од 3.600 до 6.000 км.

Балистичка ракета средњег домета Hwasong-12/KN-17

Балистичка ракета средњег домета KN-15 Pukguksong-2

Ракета је заснована на балистичкој ракети која се лансира са подморница типа Pukguksong-1 америчке ознаке KN-11. Копнена верзија ракете монтирана је на шасију оклопног гусеничара који истовремено служи и као лансер.

Ракета може носити конвенционалну или нуклеарну бојеву главу и има домет до 1.200 км. Први пут је тестирана 12. фебруара 2017. године, а у мају исте године лансирана је са приказаног лансера када је летела на даљину до 500 км и достигла висину до 560 км.

Балистичка ракета средњег домета KN-15 Pukguksong-2

Нови мобилни балистички ракетни систем кратког домета

Северна Кореја приказала је нови мобилни тактички балистички систем кратког домета, само дан пре отварања зимских олимпијских игара у Јужној Кореји. Ради се балистичком ракетном систему који је монтиран на возилу са погоном на четири осовине.

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Нови мобилни балистички ракетни систем кратког домета

Нови ракетни систем личи на руски балистички ракетни систем Iskander (9K720), али је мањи. Опремљен је са две вођене ракете које погони мотор на чврсто гориво. Ракете, такође, личе на руске типа 9M723 и 9M723-1. Поменуте руске ракете могу бити наоружане различитим бојевим главама: парчадног дејства, пробојног дејства, са аеросолним пуњењем, али и са електромагнетним пулсним дејством и, наравно, са потенцијалним нуклеарним пуњењем. Ракету покреће једностепени мотор на чврсто гориво.

Свака ракета са лансирног возила може бити независно нациљана, а претпоставља се да би радијус дејства ових ракета био око 400 км.

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Нове ваздушне платформе за рано упозоравање и поморско надгледање[4]

Иако је компанија „Saab" врло ангажована на пољу производње ваздушних платформи за рано упозоравање и контролу (AEW&C – Airborne early warning and control aircraft) и авиона за поморску контролу (MPA – maritime patrol aircraft), овај пут је одустала од својих турбопропелерских ваздушних платформи и одлучила се за много ефикасније пословне млазњаке.

Нова ваздушна платформа за AEW&C биће смештена на новом авиону Bombardier Global 6000, а авион за поморску контролу биће израђен на бази летелице Swordfish.

Авион за рано упозоравање и контролу GlobalEye

Нови авион за рано упозоравање и контролу GlobalEye представља кулминацију развојног процеса који је започет још са фиксним радарским уређајима и који је напредовао преко ваздушних платформи Erieye. Већ је обезбеђена продаја три авиона Уједињеним Арапским Емиратима.

Данашње окружење пуно је циљева које је све теже открити, а који су све мањи и бржи. Данас постоје нове мисије летећих радара у компликованом и опасном окружењу са наглашеним могућностима за електронско ратовање.

Први авион за рано упозоравање SAAB 2000 GlobalEye настао је са платформе Erieye Extended Range (ER) која је радила са радаром на таласној дужини C (2-4 Ghz). Компанија је оставила радар на истом (леђном) месту авиона, али је он опремљен потпуно новом технологијом. Ради се о радарским модулима за примање и одашиљање сигнала са активним електронским скенирањем са модулима на бази галијум-нитрида. То решење је много боље од стандардног силикона и омогућава много боље управљање снагом уређаја.

Компанија тврди да овај систем омогућава много већи отпор на ометање, дуплирање радарске снаге, функционисање у свим временским условима и у свим доменима (ваздушно, морско и копнено надзирање) и изузетно висок ниво детекције положаја циљева, технологију радиофреквентних транзистора и обраду сигнала и података.

Ваздушни радар GlobalEye има чак до 70% већи домет. Не ради се само о домету већ радар који ради на C таласним дужинама може открити мање и брже циљеве, али и већи број њих. Ваздушни радар сада може откривати и хеликоптере у режиму лебдења, што је до сада било врло тешко са оваквим типом уређаја.

[4] Jane's International Defence Review February 2018

Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp.695-716

Ваздушни радар GlobalEye

GlobalEye користи велики број разних метода за филтрирање података. Прво, он разликује пријатељске од непријатељских циљева. Такође, употребљава аутоматско зависно надзорно емитовање (Automatic Dependent Surveillance-Brodcast ADS-B), копнени командни и контролни систем (ground based command and control – C2), аутоматски идентификацијски систем (Automatic Identification System – AIS), мере електронске подршке (electronic support measures – ESM) и синтетички радар (synthetic aperture radar (SAR)/inverse –SAR – ISAR) или електрооптички комплет ради ближег надзора.

Систем C2 унапређен је тако да аутоматизацијом процеса омогућава боље резултате, али и скраћује потребно време за обуку. Могуће је упоређивати разне мапе, а могуће је и поређење са сателитским снимцима. Нови радар омогућава откривање бржих и мање уочљивих мета, па чак и „невидљивих" циљева. Радар GlobalEye омогућава различита решења у ваздушном, копненом и поморском домену.

Радар GlobalEye може вршити надзор истовремено над циљевима у ваздушном, морском и копненом домену. Компанија SAAB наводи да радар има радијус дејства већи од 600 км у ваздушном простору, а с обзиром на то да је у питању AESA радар могуће је драстично повећати радијус дејства уколико се енергија усмери на одређено подручје, што омогућава откривање „невидљивих" циљева. У поморском моду побољшане су могућности рада X таласних дужина, што омогућава

покривање области до 400 км са висине од 30.000 фита. То омогућава откривање објеката величине перископа, као и малих и брзих објеката као што су џет ски. Када су у питању мисије поморског надзора, летелица је опремљена најмодернијим мултифункционалним радаром класе AESA Leonardo Seaspray 7500E, као и увлачећом куполом за електрооптички и инфрацрвени надзор Star SAFIRE 380-HD.

Осим режима рада у надзору ваздушног и морског пространства, радар GlobalEye је опремљен и за надзор над копном помоћу синтетичког радара SAR и уређаја за индикацију копнених покретних мета на великим даљинама (Ground moving target indication – GMTI). Ваздушна платформа опремљена је и интегрисаним системом за прикупљање и одашиљање података: Communication intelligence – COMINT long range high precision electronic intelligence – ELINT.

Кабински простор система GlobalEye опремљен је напредним авионским инструментима, унапређеним и синтетичким системом осматрања и системом за пренос података на стаклу кабине (Head up display – HUD), док у задњем делу авиона посада има пет радних станица са опцијом додавања још једног или два седишта по потреби. У преосталом делу авиона има места за још шест седишта предвиђених за ротацију посаде или за неке друге намене.

Иако се ради о војном систему, систем GlobalEye ће већину оперативног циклуса провести у миру, где може бити употребљен у многе сврхе, као што су контрола ваздушног саобраћаја, борба против пирата, против кријумчара људи и наркотика, у операцијама спасавања, заштити врло важних личности, заштити рибарских бродова и нафтних бушотина и слично.

Авион за поморску контролу Swordfish

Постоје два фактора који одређују тржиште авиона за поморску контролу – геополитичка ситуација (до 2020. године очекује се да ће бити чак 120 оперативних подморница у свету) и застаревање постојећих авиона у тој намени.

Компанија SAAB очекује да ће нови авион имати до 70% трошкова летења који важе за његове супарнике, као што је Boeing P-8, као и да неће достићи више од 50% трошкова одржавања летелице током њеног радног циклуса.

Компанија је до фебруара 2018. године завршила 80% послова у вези с развојем авиона Swordfish и то кроз развој авиона GlobalEye с обзиром на то да се ради о истом авиону, истом поморском радару и електрооптичким инструментима.

Swordfish има носивост до 1.200 кг терета на свакој од четири унутрашња и четири спољашна носача, а компанија тренутно ради на могућности уграђивања ракета ваздух-море типа RBS-15 и торпеда

DCNS-EuroTorp MU90 Mk 3. Очекује се да ће типична конфигурација бити: две ракете ваздух-море типа RBS-15 у унутрашњем спремишту и два торпеда DCNS-EuroTorp MU90 Mk 3, а могуће комбинације биле би и четири ракете RBS-15 или осам торпеда MU90.

Авион за поморску контролу Swordfish

Иако Swordfish има много опреме сличне опреми авиона GlobalEye, као авион за поморску контролу он поседује детектор магнетских аномалија. Нови детектор биће тежак до 3,7 кг, што је огромна разлика у односу на сличан уређај на авиону типа Nimrod који је имао масу до 40 кг. Домет детектора повећан је на 1.200 м , па је сада омогућена потврда циља са вертикалног и хоризонталног аспекта.

У операцијама у којима је укључен детектор магнетских аномалија, Swordfish може понети више од 200 акустичних бова НАТО стандарда А, Ф и Г. Бове се избацују путем гравитационог лансирног система, што значи да је елиминисан посебан уређај за избацивање бова – Sonobouy Loading Case, који је саставни део опреме авиона Nimrod MR2 и MRA4, што снижава цену самог система и повећава број бова у употреби.

Оба авиона заснована су на пословном млазњаку Global 6000, а експлоатациони трошкови су смањени за једну трећину у односу на оперативне трошкове америчког P-8. Ове летелице су мање, што значи да нису потребне и дуге аеродромске писте, док су могућности ношења опреме и наоружања повећане, а ваздушна платформа има већи радијус дејства и може понети више наоружања и опреме.

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ПОЗИВ И УПУТСТВО АУТОРИМА
ПРИГЛАШЕНИЕ И ИНСТРУКЦИИ ДЛЯ АВТОРОВ РАБОТ
CALL FOR PAPERS AND INSTRUCTIONS FOR AUTHORS

ПОЗИВ И УПУТСТВО АУТОРИМА О НАЧИНУ ПРИПРЕМЕ ЧЛАНКА

Упутство ауторима о начину припреме чланка за објављивање у *Војнотехничком гласнику* урађено је на основу Акта о уређивању научних часописа, Министарства за науку и технолошки развој Републике Србије, евиденциони број 110-00-17/2009-01, од 09. 07. 2009. године. Примена овог Акта првенствено служи унапређењу квалитета домаћих часописа и њиховог потпунијег укључивања у међународни систем размене научних информација. Засновано је на међународним стандардима ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999 и ISO 5122, односно одговарајућим домаћим стандардима.

Војнотехнички гласник / Vojnotehnički glasnik / Military Technical Courier (втг.мо.упр.срб, www.vtg.mod.gov.rs, ISSN 0042-8469 – штампано издање, e-ISSN 2217-4753 – online, UDC 623+355/359) јесте мултидисциплинарни научни часопис Министарства одбране Републике Србије, који објављује научне и стручне чланке, као и техничке информације о савременим системима наоружања и савременим војним технологијама. Часопис прати јединствену интервидовску техничку подршку Војске на принципу логистичке системске подршке, области основних, примењених и развојних истраживања, као и производњу и употребу средстава наоружања и војне опреме, 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 2017. годину:

за област технолошки развој:

– на листи часописа за материјале и хемијске технологије:

категорија водећи научни часопис националног значаја **(М51)**,

– на листи часописа за електронику, телекомуникације и информационе технологије:

категорија научни часопис националног значаја **(М52)**,

– на листи часописа за машинство:

категорија научни часопис националног значаја **(М52)**,

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику:

категорија научни часопис **(М53)**.

Усвојене листе домаћих часописа за 2017. 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 2018. 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*.

Војнотехнички гласник омогућава и примењује Creative Commons (CC BY) одредбе о ауторским правима. Детаљи о ауторским правима могу се видети на сајту часописа, страница *Ауторска права и политика самоархивирања*.

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 часописима се разврставају у следеће категорије:

Научни чланци:

1. оригиналан научни чланак (рад у којем се износе претходно необјављивани резултати сопствених истраживања научним методом);

2. прегледни чланак (рад који садржи оригиналан, детаљан и критички приказ истраживачког проблема или подручја у којем је аутор остварио одређени допринос, видљив на основу аутоцитата);

3. кратко или претходно саопштење (оригинални научни рад пуног формата, али мањег обима или прелиминарног карактера);

4. научна критика, односно полемика (расправа на одређену научну тему, заснована искључиво на научној аргументацији) и осврти.

Изузетно, у неким областима, научни рад у часопису може имати облик монографске студије, као и критичког издања научне грађе (историјско-архивске, лексикографске, библиографске, прегледа података и сл.) – дотад непознате или недовољно приступачне за научна истраживања.

Радови класификовани као научни морају имати бар две позитивне рецензије.

Ако се у часопису објављују и прилози ваннаучног карактера, научни чланци треба да буду груписани и јасно издвојени у првом делу свеске.

Стручни чланци:

1. стручни чланак (прилог у којем се нуде искуства корисна за унапређење професионалне праксе, али која нису нужно заснована на научном методу);

2. информативни прилог (уводник, коментар и сл.);

3. приказ (књиге, рачунарског програма, случаја, научног догађаја, и сл.).

Језик рада

Језик рада може бити српски, 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 уредништава и аутора да сажетак садржи термине који се често користе за индексирање и претрагу чланака. Саставни делови сажетка су циљ истраживања, методи, резултати и закључак. Сажетак треба да има од 100 до 250 речи и треба да се налази између заглавља (наслов, имена аутора и др.) и кључних речи, након којих следи текст чланка. Ако је рад написан на српском 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*.

Адреса редакције:
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066/8700-118

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, 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 2017 год:

Категории в области технологического развития:

– Область материалов и химической технологии:

ведущий научный журнал национального значения **(M51)**,

– Область электроники, телекоммуникаций и информационных технологий: научный журнал национального значения **(M52),**

– Область механики:

научный журнал национального значения **(M52)**.

Категории в области основных исследований:

– Область математика, компьютерные науки, технические науки:

научный журнал **(M53)**.

С информацией относительно категоризации за 2017 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 2018 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:

1. оригинальная научная статья (работа, в которой приводятся ранее неопубликованные результаты собственных исследований, полученных научным методом);

2. обзорная статья (работа, содержащая оригинальный, детальный и критический обзор исследуемой проблемы или области, в который автор внёс определённый вклад, видимый на основе автоцитат);

3. краткое сообщение (оригинальная научная работа полного формата, но меньшего объёма или имеющая предварительный характер);

4. 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:

1. профессиональная работа (приложения, в которых предлагаются опыты, полезные для совершенствования профессиональной практики, но которые не должны в обязательном порядке быть обоснованы на научном методе);

2. информативное приложение (передовая статья, комментарий и т.п.);

3. 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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CALL FOR PAPERS AND ARTICLE FORMATTING INSTRUCTIONS

The instructions to authors about the article preparation for publication in the *Military Technical Courier* are based on the Act on scientific journal editing of the Ministry of Science and Technological Development of the Republic of Serbia, No 110-00-17/2009-01 of 9th July 2009. This Act aims at improving the quality of national journals and raising the level of their compliance with the international system of scientific information exchange. It is based on international standards ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999 and ISO 5122 and their national equivalents.

The Military Technical Courier / Vojnotehnički glasnik (www.vtg.mod.gov.rs/index-e.html, втг.мо.упр.срб, ISSN 0042-8469 – print issue, e-ISSN 2217-4753 – online, UDC 623+355/359) is a multidisciplinary scientific journal of the Ministry of Defence of the Republic of Serbia. It publishes scientific and professional papers as well as technical data 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 electronics, telecommunications and IT,
category: scientific periodical of national interest **(M52)**,

– on the list of periodicals for mechanical engineering,
category: scientific periodical of national interest **(M52)**,

in the field fundamental research:

– on the list of periodicals for mathematics, computer sciences and mechanics,
category: scientific periodical **(M53)**.

The approved lists of national periodicals for the year 2017 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 2018).

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*.

Military Technical Courier enables open access and applies the Creative Commons Attribution (CC BY) licence provisions on copyright. The copyright details can be found on the *Copyright notice and Self-archiving policy* page of the journal's website.

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:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on scientific methods);

2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);

3. Short or preliminary communication (original scientific paper of full format but of a smaller extent or of a preliminary character);

4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on scientific argumentation) and commentaries.

Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Papers classified as scientific must have at least two positive reviews.

If the journal contains non-scientific contributions as well, the section with scientific papers should be clearly denoted in the first part of the Journal.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);

2. Informative contribution (editorial, commentary, etc.);

3. Review (of a book, software, case study, scientific event, etc.)

Language

The article can be in Serbian, 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 Cite-Matcher 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

Војнотехнички гласник постао члан Одбора за етичност у издаваштву - Committee on Publication Ethics (COPE)

Одбор за етичност у издаваштву (Committee on Publication Ethics - COPE) одобрио је 2. маја 2018. године чланство Војнотехничком гласнику у својој организацији. COPE својим члановима омогућује водећу улогу при разматрању питања етичности у издаваштву, обезбеђује практичне ресурсе за едукацију и подршку члановима и нуди да се њихов професионални глас чује у актуелним дебатама.

COPE је посвећен обуци и подршци уредницима, издавачима и осталима који се баве питањима етичности у издаваштву с циљем да се издавачки процес усклади са нормама етичке праксе као саставног дела издавачке културе. Приступ Одбора чврсто је усмерен на утицај кроз образовање, ресурсе и подршку члановима уз подстицање професионалне дебате у ширем друштву.

COPE својом праксом и политиком усмерава уредништва часописа и издаваче, како би се постигли највиши стандарди у етичности у издаваштву. Та активност подразумева саветодавну делатност, усмеравање, образовање и семинаре.

Више детаља доступно је на страници https://publicationethics.org/members/vojnotehnicki-glasnik-military-technical-courier.

Журнал «Военно-технический вестник» присоединился к Комитету по издательской этике (Committee on Publication Ethics — COPE).

Комитет по издательской этике (Committee on Publication Ethics - COPE) 2 мая 2018 года подтвердил вступление журнала «Военно-технический вестник» в эту организацию. COPE консультирует членов организации по всем вопросам издательской этики, он также предоставляет своим членам площадку для обсуждений конкретных случаев, спонсирует исследования в сфере издательской этики, публикует информационные бюллетени и организует семинары.

COPE проводит обучение и предоставляет поддержку редакторам, издателям и другим заинтересованным лицам в издательской этике. Цель обучения заключается в том, чтобы привести издательский процесс в соответствие с этическими нормами, являющимися неотъемлемой частью издательской культуры. Благодаря своей программе обучения Комитет оказывает сильное влияние на делопроизводство своих членов,

поддерживает их и содействует в проведении публичных профессиональных дебатов.

На основании своего опыта и в соответствии с политикой качества COPE направляет редакторов и издателей на достижение наивысших норм в издательской этике. Деятельность Комитета наряду с вышеперечисленным, включает и проведение консультаций, обучения и семинаров.

Ознакомиться с более подробной информацией можно, перейдя по ссылке:

https://publicationethics.org/members/vojnotehnicki-glasnik-military-technical-courier.

The Military Technical Courier became a member of Committee on Publication Ethics (COPE)

On 2 May 2018, the Committee on Publication Ethics (COPE) approved a membership of the Military Technical Courier in its organization. COPE provides leadership in thinking on publication ethics, practical resources to educate and support members, and offers a professional voice in current debates.

COPE is committed to educate and support editors, publishers and those involved in publication ethics with the aim of moving the culture of publishing towards one where ethical practices become the norm and part of the publishing culture. Our approach is firmly focused on influencing through education, resources and support of our members alongside the fostering of professional debate in the wider community.

COPE practices are the policies and practices journals and publishers need in order to reach the highest standards in publication ethics. The activities include counseling, guidance, education and events.

More details are available on the website page https://publicationethics.org/members/vojnotehnicki-glasnik-military-technical-courier.

C O P E

Member since 2018

JM13603

Министарство просвете, науке и технолошког развоја Републике Србије објавило категоризацију Војнотехничког гласника за 2017. годину

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 2017. годину:

за област технолошки развој:

– на листи часописа за материјале и хемијске технологије: категорија водећи научни часопис националног значаја (М51),
– на листи часописа за електронику, телекомуникације и информационе технологије: категорија научни часопис националног значаја (М52),
– на листи часописа за машинство: категорија научни часопис националног значаја (М52),

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику: категорија научни часопис (М53).

Усвојене листе домаћих часописа за 2017. годину могу се видети на страници сајта *Категоризација часописа* (http://www.vtg.mod.gov.rs/kategorizacija-casopisa.html).

Детаљније информације могу се пронаћи и на сајту Министарства просвете, науке и технолошког развоја Републике Србије.

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).

Министерство образования, науки и технологического развития Республики Сербия утвердило категоризацию журнала «Военно-технический вестник» за 2017 год

Министерством образования, науки и технологического развития Республики Сербия согласно решению по ст. 27 абзац 1, пункт 4 и по полученному толкованию ст. 25 абзац 1 пункт 5 Закона о научно-исследовательской деятельности («Службени гласник РС» № 110/05, 50/06-испр. и 18/10) утверждена категоризация журнала «Военно-технический вестник» за 2017 год:

Категории в области технологического развития:

– Область материалов и химической технологии: ведущий научный журнал национального значения (М51),
– Область электроники, телекоммуникаций и информационных технологий: научный журнал национального значения (М52),
– Область механики: научный журнал национального значения (М52).

Категории в области основных исследований:

Область математика, компьютерные науки, технические науки: научный журнал (М53).

С информацией о категоризации за 2017 год можно ознакомиться на странице *Категоризация вестника* (http://www.vtg.mod.gov.rs/kategorizacia-vestnika.html).

Более подробно с информацией можно ознакомиться на сайте Министерства образования, науки и технологического развития Республики Сербия.

Категоризация журнала проведена в соответствии с Регламентом о порядке и методах категоризации научно-исследовательских результатов, утвержденного Национальным комитетом по науке и технологиям (Службени гласник РС, № 38/2008).

В соответствии с вышеуказанными положениями Регламента и таблицей по классификации и категоризации индивидуальных научно-исследовательских результатов (являющихся неотъемлемой частью Регламента), работа, опубликованная в журнале «Военно-технический вестник», оценивается следующим образом: 2 балла (категория М51), 1,5 баллов (категория М52) и 1 балл (категория М53).

Ministry of Education, Science and Technological Development of the Republic of Serbia classified the Military Technical Courier for the year 2017

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 electronics, telecommunications and IT, category: scientific periodical of national interest (M52),
- on the list of periodicals for mechanical engineering, category: scientific periodical of national interest (M52),

in the field Fundamental Research:

- on the list of periodicals for mathematics, computer sciences and mechanics: category: scientific periodical (M53).

The approved lists of national periodicals for the year 2017 can be viewed on the web page *Journal categorization* (http://www.vtg.mod.gov.rs/journal-categorisation-1.html).

More detailed information can be found on the website of the Ministry of Education, Science and Technological Development of the Republic of Serbia. 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).

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).

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