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1 2021

НАУЧНИ ЧАСОПИС МИНИСТАРСТВА ОДБРАНЕ И ВОЈСКЕ СРБИЈЕ

ВОЈНОТЕХНИЧКИ ГЛАСНИК

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ВОЕННО-ТЕХНИЧЕСКИЙ ВЕСТНИК

1 2021

Vol. 69, Issue 1

2021

MILITARY TECHNICAL COURIER

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1 2021

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ВОЛУМЕН 69•БРОЈ 1•ЈАНУАР – МАРТ 2021.

NAUČNI ČASOPIS MINISTARSTVA ODBRANE I VOJSKE SRBIJE

VOJNOTEHNIČKI GLASNIK

VOLUMEN 69•BROJ 1•JANUAR – MART 2021.

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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

THE SECOND COVID-19 WAVE OF 2020 IN ITALY: A BRIEF ANALYSIS

Nicola Fabiano[a], *Stojan* N. Radenović[b]

[a] Independent researcher, Rome, Italy,
e-mail: nicola.fabiano@gmail.com, **corresponding author,**
ORCID iD: https://orcid.org/0000-0003-1645-2071

[b] University of Belgrade, Faculty of Mechanical Engineering,
Belgrade, Republic of Serbia,
email: radens@beotel.rs,
ORCID iD: https://orcid.org/0000-0001-8254-6688

Abstract:

Introduction/purpose: Based on the results obtained previously, the second wave of Covid-19 infection is analyzed and some predictions on its evolution are given.

Methods: A model of population growth giving a differential equation has been used to describe the pandemic wave.

Results: The second wave of infection is essentially on its peak in the middle of November 2020 and will not decrease very soon.

Conclusions: The second wave is not going to end in the year 2020 and it will take some time before a status of relative normality is restored.

Key words: Coronavirus, COVID-19, differential equation, data fit.

Equation and Fit

The equation we have used in the model of Covid–19 evolution of a number of cases in time (Verhults, 1838) is given by (Fabiano & Radenović, 2020a)

$$\frac{dx(t)}{dt} = \frac{x(t)}{a} \left[1 - \frac{x(t)}{b} \right] , \qquad (1)$$

where the total number of cases $x(t)$ at a given time is given by

1

$$x(t) = \frac{c}{1 + \exp[(b - t)/a]} \ , \tag{2}$$

while the growth of cases is given by its derivative

$$\frac{dx(t)}{dt} = \frac{c}{a} \left\{ \frac{\exp[(b - t)/a]}{(1 + \exp[(b - t)/a])^2} \right\} \ . \tag{3}$$

The parameter a is related to the growth rapidity, c is the asymptotic total number of cases, and b indicates the peak position of the growth of cases.
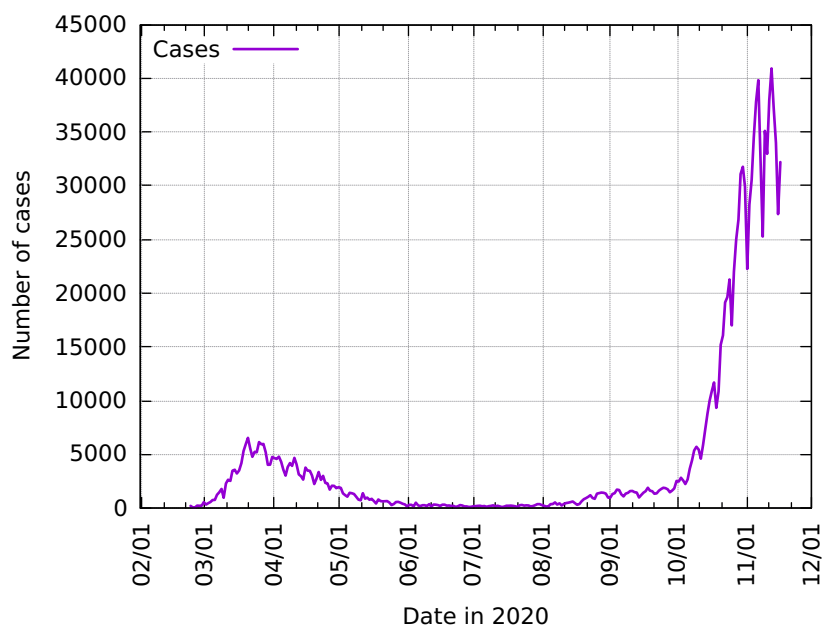
Figure 1 – Number of new cases of coronavirus per day with respect to the date for the year 2020
Рис.1 − Количество новых случаев зараженных коронавирусом за сутки по датам в 2020 году
Слика 1 – Број нових случајева заражених вирусом корона дневно у односу на датуме 2020. године

Figure 1 shows the number of new cases per day of coronavirus in Italy with respect to the date. One can clearly see two peaks corresponding to two different waves of the disease, the first with a maximum of around 6000

cases on the 26th of March, and the second one with around 40000 cases on the 13th of November.

In (Fabiano & Radenović, 2020b) we have compared the current coronavirus pandemic to the influenza pandemic of 1918 and gave some predictions on the possible future waves. Notably, in accordance with the data of 1918, it has been predicted in Table 5 of the above mentioned article that the second wave of the pandemic would have a peak number of new cases per day that has a fivefold increase of the peak of the first wave. According to the above mentioned data the accuracy of this prediction is astonishingly good.

In order to determine the parameters a, b, c of equations 1, 2, 3 for the second wave, we have done a fit to the most recent data available for the coronavirus disease in Italy, available at the GitHub account (Ministero della Salute, 2020).

The minimum value of new cases has been encountered on the 14th of July with 114 new patients on that day. This will be the starting point of the second peak. The results of the fit are shown in Table 1.

Table 1 – Fit for the parameters a, b, c of the second wave
Таблица 1 – Распределение по параметрам a, b, c во второй волне
Табела 1 – Поклапање параметара a, b и c другог таласа

Parameter	Value	Error	Error %
a	9.88343	0.332	3.359
b	119.106	0.558	0.4685
c	1.40299×10^6	4.605×10^4	3.282

The maximum of the peak is obtained from the value of $c/(4a)$, the parameters a and c are linked respectively to the height and width of the bell-shaped function of equation 3, while b traslates in time the position of the peak.

As expected, the values of the parameters are much bigger than the one found in Table 1 of (Fabiano & Radenović, 2020a), because the peak of the second wave is much larger as discussed above, and the rise of the peak is much sharper than the one of the first wave. Observe also that according to the value of c obtained, the total number of cases so far is expected to be not less than 1.4 million, more than 2% of the population.

Figure 2 shows the data of the second wave and the fit to the function 3 with respect to the number of days since the 14th of July. The fit is prolonged
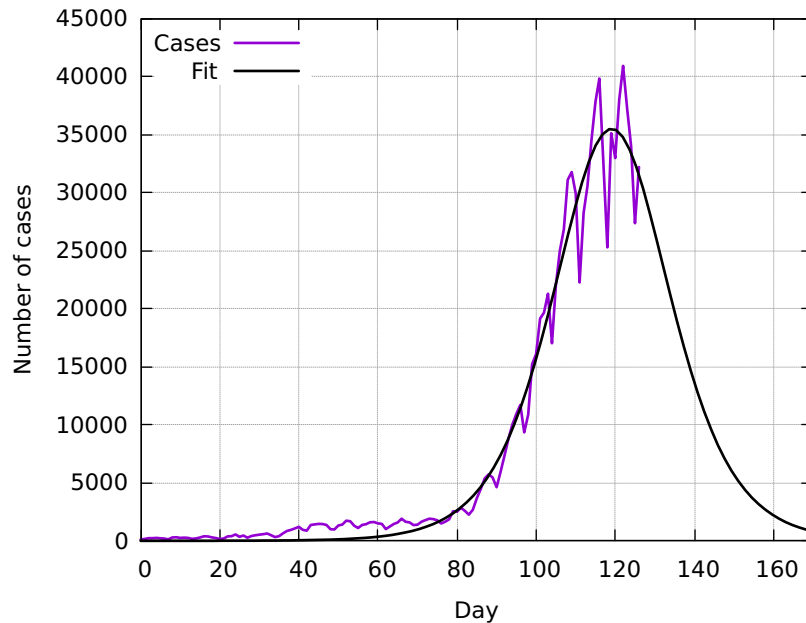
Figure 2 – Number of new cases of coronavirus per day with respect to the numbers of days starting from the 14th of July 2020 and ending on 31st of December 2020

Рис. 2 – Количество новых случаев зараженных коронавирусом за сутки с 14 июля 2020 г. по 31 декабря 2020 года

Слика 2 – Број нових случајева заражених вирусом корона по дану у односу на број дана почевши од 14. јула 2020. године и закључно са 31. децембром 2020. године

beyond the current date of 17th of November, that is 127 days in order to give some insight of the future situation.

The bell–shaped curve is symmetric around the peak, therefore a quick raise provides also a fast decline of the number of cases, albeit with a caveat that will be discussed later on.

The limit of 5000 new cases per day is crossed again on the 152th day, i.e. around the half of December. On the last day of 2020, i.e. on the 170th day, there will still be more than 800 cases per day, resembling the same situation already encountered in May. Depending on how many new cases per day is considered acceptable, we will not reach again a "normal" status before the half of January 2021.

Yet there is a caveat. Considering again the global situation in Figure 1 and carefully observing the first peak, it is clear that it is not completely symmetric, having a decreasing side lasting longer than the increasing one. This is probably due to the fact that the quarantine rules employed are not static in time, and are progressively relaxed, as the pandemic situation turns better, for various reasons, mainly due to the concern about the worsening of the economic situation. It is also worth mentioning the fact that a part of the population tends not to abide by the quarantine rules after a longer period of time, as it has been observed particularly in the past summer when the pandemic was considered ended by many sources, some of them apparently respectable.

Conclusion

Cosidering all the reasons discussed before it is reasonable to conclude that the obtained fit given for equation 3 and shown in Figure 2 is actually an estimate from below for the return time to a normal situation, and even though we have apparently reached the peak of the second covid infection wave, it is not going to end completely in the year 2020.

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ВТОРАЯ ВОЛНА COVID-19 2020 ГОДА В ИТАЛИИ: КРАТКИЙ АНАЛИЗ

Никола Фабиано[a], *Стоян* Н. Раденович[б]

[a] независимый исследователь, Рим, Италия, **корреспондент**,

[б] Белградский университет, Машиностроительный факультет,
 г. Белград, Республика Сербия

Резюме:

Введение/цель: Основываясь на полученные ранее результаты, в статье проведен анализ второй волны инфекции Covid-19 и приведены некоторые прогнозы ее развития.

Методы: Для описания волны пандемии использовалась модель роста населения, дающая дифференциальное уравнение.

Результаты: Вторая волна заражения фактически достигла своего пика в середине ноября 2020 года и в ближайшее время не уменьшится.

Выводы: В этом 2020 году вторая волна не закончится, поэтому нам придется подождать, когда наступит безопасное время и мы сможем вернуться к состоянию относительной нормальности.

Ключевые слова: коронавирус, COVID-19, дифференциальное уравнение, соответствие данных.

ДРУГИ ТАЛАС ИНФЕКЦИЈЕ COVID-19 U 2020. ГОДИНИ У ИТАЛИЈИ: КРАТКА АНАЛИЗА

Никола Фабиано[a], *Стојан* Н. Раденовић[б]

[a] независни истраживач, Рим, Италија, **аутор за преписку**,

[б] Универзитет у Београду, Машински факултет, Београд, Република
 Србија

Сажетак:

Увод/циљ: На основу претходно добијених резултата, анализиран је други талас инфекције COVID-19 и дата су нека предвиђања о његовој еволуцији.

Методе: Модел раста становништва који даје диференцијалну једначину коришћен је за описивање пандемијског таласа.

Резултати: Други талас инфекције налази се на врхунцу средином новембра 2020. године, и не очекује се да ће до његовог смањења доћи врло брзо.

Закључак: Други талас се неће завршити у 2020. години, па ће проћи извесно време пре него што се вратимо у статус релативне нормалности.

Кључне речи: коронавирус, COVID-19, диференцијална једначина, уклапање података.

SOME NEW OBSERVATIONS ON FIXED POINT RESULTS IN RECTANGULAR METRIC SPACES WITH APPLICATIONS TO CHEMICAL SCIENCES

Mudasir Younis[a], *Nicola* Fabiano[b], *Zaid* M. Fadail[c],
Zoran D. Mitrović[d], *Stojan* N. Radenović[e]

[a] University Institute of Technology - RGPV,
   Department of Applied Mathematics, Bhopal, M.P, India,
   e-mail: mudasiryouniscuk@gmail.com,
   ORCID iD: https://orcid.org/0000-0001-5499-4272

[b] Independent researcher, Rome, Italy,
   e-mail: nicola.fabiano@gmail.com,
   ORCID iD: https://orcid.org/0000-0003-1645-2071

[c] Thamar University, Faculty of Education,
   Department of Mathematical Science, Thamar, Republic of Yemen,
   e-mail: zaid.fadail@tu.edu.ye,
   ORCID iD: https://orcid.org/0000-0003-0899-0056

[d] University of Banja Luka, Faculty of Electrical Engineering,
   Banja Luka, Republic of Srpska, Bosnia and Herzegovina,
   e-mail: zoran.mitrovic@etf.unibl.org, **corresponding author**,
   ORCID iD: https://orcid.org/0000-0001-9993-9082

[e] University of Belgrade, Faculty of Mechanical Engineering,
   Department of Mathematics, Belgrade, Republic of Serbia,
   e-mail: radens@beotel.rs,
   ORCID iD: https://orcid.org/0000-0001-8254-6688

Abstract:

Introduction/purpose: This paper considers, generalizes and improves recent results on fixed points in rectangular metric spaces. The aim of this paper is to provide much simpler and shorter proofs of some new results in rectangular metric spaces.

Methods: Some standard methods from the fixed point theory in generalized metric spaces are used.

Results: The obtained results improve the well-known results in the literature. The new approach has proved that the Picard sequence is Cauchy in rectangular metric spaces. The obtained results are used to prove the existence of solutions

to some nonlinear problems related to chemical sciences. Finally, an open question is given for generalized contractile mappings in rectangular metric spaces.

Conclusions: New results are given for fixed points in rectangular metric spaces with application to some problems in chemical sciences.

Key words: fixed point, rectangular metric space, contractive map, Green function.

Introduction and Preliminaries

It is well known that the Banach contraction principle (Banach, 1922) is one of the most important and attractive results in nonlinear analysis and mathematical analysis in general. The whole fixed point theory is a significant subject in different fields: geometry, differential equations, informatics, physics, economics, engineering, and many others. After solutions are guaranteed, numerical methodology is established to obtain the approximated solution. The fixed point of functions depends heavily on considered spaces defined using intuitive axioms. In particular, variants of generalized metric spaces are proposed, e.g. partial metric space, *b*-metric, partial *b*-metric, extended *b*-metric, rectangular metric, rectangular *b*-metric, G-metric, G_b-metric, S-metric, S_b-metric, cone metric, cone *b*-metric, fuzzy metric, fuzzy *b*-metric, probabilistic metric, etc. For more details on all variants of generalized metric spaces, see (Budhia et al, 2017), (Collaco & Silva, 1997).

In this paper, we will discuss some results recently established in (Alsulami et al, 2015) and (Budhia et al, 2017). Firstly, we give the basic notion of a rectangular metric space (g.m.s or RMS by some authors).

Definition 1. *Let X be a nonempty set and let $d_r : X \times X \to [0, +\infty)$ satisfy the following conditions: for all $x, y \in X$ and all distinct $u, v \in X$ each of them different from x and y.*

    (i) $d_r(x, y) = 0$ if and only if $x = y$,

    (ii) $d_r(x, y) = d_r(y, x)$,

    (iii) $d_r(x, y) \leq d_r(x, u) + d_r(u, v) + d_r(v, y)$ (quadrilateral inequality).

Then the function d_r is called a rectangular metric and the pair (X, d_r) is called a rectangular metric space (RMS for short).

Notice that the definitions of convergence and Cauchyness of the sequences in rectangular metric spaces are the same as the ones found in

the standard metric spaces. Also, a rectangular metric space (X, d_r) is complete if each Cauchy sequence in it is convergent. Samet et al. (Samet et al, 2012) introduced the concept of $\alpha - \psi -$ contractive mappings and proved the fixed point theorems for such mappings. In (Karapınar, 2014), Karapınar gave contractive conditions to obtain the existence and uniqueness of a fixed point of $\alpha - \psi$ contraction mappings in rectangular metric spaces. Salimi et al. (Salimi et al, 2013) introduced modified $\alpha - \psi$ contractive mappings and obtained some fixed point theorems in a complete metric space. Alsulami et al. (Alsulami et al, 2015) established some fixed point theorems for $\alpha - \psi -$ rational type contractive mappings in a rectangular metric space.

Let Ψ be the family of all functions $\psi : [0, +\infty) \to [0, +\infty)$ such that ψ is nondecreasing and $\sum\limits_{n=1}^{+\infty} \psi^n(t) < +\infty$ for each $t > 0$. Obviously, if $\psi \in \Psi$, then $\psi(t) < t$ for each $t > 0$.

Definition 2. *(Salimi et al, 2013) Let T be a self mapping on a metric space (X, d_r) and let $\alpha, \eta : X \times X \to [0, +\infty)$ be two functions. It is called an $\alpha-$admissible mapping with respect to η if $\alpha(x, y) \geq \eta(x, y)$ implies that $\alpha(Tx, Ty) \geq \eta(Tx, Ty)$ for all $x, y \in X$.*

If $\eta(x, y) = 1$ for all $x, y \in X$, then T is called an $\alpha-$admissible mapping.

It is called a triangular $\alpha-$admissible mapping if for all $x, y, z \in X$ holds: $(\alpha(x, y) \geq 1$ and $\alpha(y, z) \geq 1)$ implies $\alpha(x, z) \geq 1$.

Otherwise, a rectangular metric space (X, d_r) is $\alpha-$regular with respect to η if for any sequence in X such that $\alpha(x_n, x_{n+1}) \geq \eta(x_n, x_{n+1})$ for all $n \in \mathbb{N}$ and $x_n \to x$ as $n \to +\infty$, then $\alpha(x_n, x) \geq \eta(x_n, x)$.

For more details on a triangular $\alpha-$admissible mapping, see (Karapınar et al, 2013), pages 1 and 2. In this paper, we will use the following result:

Lemma 1. *(Karapınar et al, 2013), Lemma 7. Let T be a triangular $\alpha-$admissible mapping. Assume that there exists $x_0 \in X$ such that $\alpha(x_0, Tx_0) \geq 1$. Define the sequence $\{x_n\}$ by $x_n = T^n x_0$. Then*

$$\alpha(x_m, x_n) \geq 1 \text{ for all } m, n \in \mathbb{N} \cup \{0\} \text{ with } m < n.$$

In (Budhia et al, 2017), the authors proved the following result:

Theorem 1. *Let (X, d_r) be a Hausdorff and complete rectangular metric space, and let $T : X \to X$ be an $\alpha-$admissible mapping with respect to*

η. *Assume that there exists a continuous function $\psi \in \Psi$ such that*

$$x, y \in X, \alpha\left(x, y\right) \geq \eta\left(x, y\right) \text{ implies } d_r\left(Tx, Ty\right) \leq \psi\left(M\left(x, y\right)\right),$$

where

$$M\left(x, y\right) = \max \left\{ d_r\left(x, y\right), d_r\left(x, Tx\right), d_r\left(y, Ty\right), \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(x, y\right)}, \right.$$

$$\left. \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(Tx, Ty\right)} \right\}.$$

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $\alpha\left(x_0, Tx_0\right) \geq \eta\left(x_0, Tx_0\right),$
2. for all $x, y, z \in X, \left(\alpha\left(x, y\right) \geq \eta\left(x, y\right) \text{ and } \alpha\left(y, z\right) \geq \eta\left(y, z\right)\right)$ implies $\alpha\left(x, z\right) \geq \eta\left(x, z\right),$
3. either T is continuous or X is $\alpha-$regular with respect to η.

Then T has a periodic point $a \in X$ and if $\alpha\left(a, Ta\right) \geq \eta\left(a, Ta\right)$ holds for each periodic point, then T has a fixed point. Moreover, if for all $x, y \in F\left(T\right)$, we have $\alpha\left(x, y\right) \geq \eta\left(x, y\right),$ then the fixed point is unique.

Taking $\eta\left(x, y\right) = 1$ for $x, y \in X$, the authors obtained the following corollary:

Corollary 1. *Let $\left(X, d_r\right)$ be a Hausdorff and complete rectangular metric space, and let $T : X \to X$ be an $\alpha-$admissible mapping. Assume that there exists a continuous function $\psi \in \Psi$ such that*

$$x, y \in X, \alpha\left(x, y\right) \geq 1 \text{ implies } d_r\left(Tx, Ty\right) \leq \psi\left(M\left(x, y\right)\right)$$

where

$$M\left(x, y\right) = \max \left\{ d_r\left(x, y\right), d_r\left(x, Tx\right), d_r\left(y, Ty\right), \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(x, y\right)}, \right.$$

$$\left. \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(Tx, Ty\right)} \right\}.$$

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $\alpha\left(x_0, Tx_0\right) \geq 1$,
2. for all $x, y, z \in X$ $\left(\alpha\left(x, y\right) \geq 1 \text{ and } \alpha\left(y, z\right) \geq 1\right)$ implies $\alpha\left(x, z\right) \geq 1$,
3. either T is continuous or $\left(X, d_r\right)$ is $\alpha-$regular.

Then T has a periodic point $a \in X$ and if $\alpha\left(a, Ta\right) \geq 1$ holds T has a fixed point. Moreover, if for all $x, y \in F\left(T\right)$, we have $\alpha\left(x, y\right) \geq 1$, then the fixed point is unique.

Further, taking $\alpha\left(x, y\right) = 1$ for $x, y \in X$ authors obtained the following corollary:

Corollary 2. *Let $\left(X, d_r\right)$ be a Hausdorff and complete rectangular metric space, and let $T : X \to X$ be an $\alpha-$admissible mapping. Assume that there exists a continuous function $\psi \in \Psi$ such that*

$$x, y \in X, 1 \geq \eta\left(x, y\right) \text{ implies } d_r\left(Tx, Ty\right) \leq \psi\left(M\left(x, y\right)\right)$$

where

$$M\left(x, y\right) = \max\left\{d_r\left(x, y\right), d_r\left(x, Tx\right), d_r\left(y, Ty\right), \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(x, y\right)}, \right.$$

$$\left. \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(Tx, Ty\right)}\right\}.$$

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $1 \geq \eta\left(x_0, Tx_0\right)$,
2. for all $x, y, z \in X$ $\left(1 \geq \eta\left(x, y\right) \text{ and } 1 \geq \eta\left(y, z\right)\right)$ implies $1 \geq \eta\left(x, z\right)$,
   For $\psi\left(t\right) = kt, 0 < k < 1$ then the authors obtained

Corollary 3. *Let $\left(X, d_r\right)$ be a Hausdorff and complete rectangular metric space, and let $T : X \to X$ be an $\alpha-$admissible mapping with respect to η. Assume that*

$$x, y \in X, \ \alpha\left(x, y\right) \geq \eta\left(x, y\right) \text{ implies } d_r\left(Tx, Ty\right) \leq kM\left(x, y\right),$$

where

$$M\left(x, y\right) = \max\left\{d_r\left(x, y\right), d_r\left(x, Tx\right), d_r\left(y, Ty\right), \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(x, y\right)}, \right.$$

$$\left. \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(Tx, Ty\right)} \right\}.$$

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $\alpha\left(x_0, Tx_0\right) \geq \eta\left(x_0, Tx_0\right),$

2. for all $x, y, z \in X$ $\left(\alpha\left(x, y\right) \geq \eta\left(x, y\right)$ and $\alpha\left(y, z\right) \geq \eta\left(y, z\right)\right)$ implies $\alpha\left(x, z\right) \geq \eta\left(x, z\right),$

3. either T is continuous or (X, d_r) is $\alpha-$regular.

Then T has a periodic point $a \in X$ and if $\alpha\left(a, Ta\right) \geq \eta\left(a, Ta\right)$ holds, T has a fixed point. Moreover, if for all $x, y \in F\left(T\right),$ we have $\alpha\left(x, y\right) \geq \eta\left(x, y\right),$ then the fixed point is unique.

The following two lemmas are a rectangular metric space modification of a result which is well known in the metric space, see, e.g, (Radenović et al, 2012), Lemma 2.1. Many known proofs of fixed point results in rectangular metric spaces become much more straightforward and shorter using both lemmas. Also, in the proofs of the main results in this paper, we will use both lemmas:

Lemma 2. *(Kadelburg & Radenović, 2014a), (Kadelburg & Radenović, 2014b) Let (X, d_r) be a rectangular metric space and let $\{x_n\}$ be a sequence in it with distinct elements ($x_n \neq x_m$ for $n \neq m$). Suppose that $d_r\left(x_n, x_{n+1}\right)$ and $d_r\left(x_n, x_{n+2}\right)$ tend to 0 as $n \to +\infty$ and that $\{x_n\}$ is not a Cauchy sequence. Then there exists $\varepsilon > 0$ and two sequences $\{m\left(k\right)\}$ and $\{n\left(k\right)\}$ of positive integers such that $n\left(k\right) > m\left(k\right) > k$ and the following sequences tend to ε as $k \to +\infty :$*

$$\left\{d_r\left(x_{n(k)}, x_{m(k)}\right)\right\}, \ \left\{d_r\left(x_{n(k)+1}, x_{m(k)}\right)\right\}, \ \left\{d_r\left(x_{n(k)}, x_{m(k)-1}\right)\right\},$$

$$\left\{d_r\left(x_{n(k)+1}, x_{m(k)-1}\right)\right\}, \ \left\{d_r\left(x_{n(k)+1}, x_{m(k)+1}\right)\right\}.$$

Lemma 3. *Let $\{x_{n+1}\}_{n \in \mathbb{N} \cup \{0\}} = \{Tx_n\}_{n \in \mathbb{N} \cup \{0\}} = \{T^n x_0\}_{n \in \mathbb{N} \cup \{0\}}, T^0 x_0 = x_0$ be a Picard sequence in a rectangular metric space (X, d_r) induced by the mapping $T : X \to X$ and the initial point $x_0 \in X$. If $d_r\left(x_n, x_{n+1}\right) < d_r\left(x_{n-1}, x_n\right)$ for all $n \in \mathbb{N}$ then $x_n \neq x_m$ whenever $n \neq m$.*

Proof. Let $x_n = x_m$ for some $n, m \in \mathbb{N}$ with $n < m$. Then $x_{n+1} = Tx_n = Tx_m = x_{m+1}$. Further, we get

$$d_r (x_n, x_{n+1}) = d_r (x_m, x_{m+1}) < d_r (x_{m-1}, x_m) < ... < d_r (x_n, x_{n+1}),$$

which is a contradiction. $\square$

In some proofs, we will also use the following interesting as well as significant result in the context of rectangular metric spaces:

Proposition 1. *(Kirk & Shahzad, 2014), Proposition 3. Suppose that $\{q_n\}$ is a Cauchy sequence in a rectangular metric space (X, d_r) and suppose $\lim_{n \to +\infty} d_r (q_n, q) = 0$. Then $\lim_{n \to +\infty} d_r (q_n, p) = d_r (q, p)$ for all $p \in X$. In particular, $\{q_n\}$ does not converge to p if $p \neq q$.*

Main results

In this section, we generalize and improve Theorem 2 and all its corollaries. The obtained generalizations extend the result in several directions. Namely, we will use only one function $\alpha : X \times X \to [0, +\infty)$ instead of two α and η as in (Budhia et al, 2017), Definition 2.3. and Definition 3.1. This is possible according to the (Mohammadi & Rezapour, 2013), Page 2, after Theorem 1.2. Note that we assume neither that the rectangular metric space is Hausdorff, nor that the mapping d_r is continuous.

The authors (Alsulami et al, 2015), page 6, line 6+, say that the sequence $\{x_n\}$ in a rectangular metric space (X, d_r) is a Cauchy if $\lim_{n \to +\infty} d_r (x_n, x_{n+k}) = 0$, for all $k \in \mathbb{N}$. However, it is well know that this claim is dubious. Therefore, we also improve the proof that the sequence $\{x_n\}$ is Cauchy

Our first new result in this paper is the following:

Theorem 2. *Let (X, d_r) be a complete rectangular metric space and let $T : X \to X$ be a triangular $\alpha-$admissible mapping. Assume that there exists continuous function $\psi \in \Psi$ such that*

$$x, y \in X, \ \alpha (x, y) \geq 1 \text{ implies } d_r (Tx, Ty) \leq \psi (M (x, y)), \qquad (1)$$

where

$$M (x, y) = \max \left\{ d_r (x, y), d_r (x, Tx), d_r (y, Ty), \frac{d_r (x, Tx) d_r (y, Ty)}{1 + d_r (x, y)}, \right.$$

$$\left. \frac{d_r\left(x, Tx\right) d_r\left(y, Ty\right)}{1 + d_r\left(Tx, Ty\right)} \right\} .$$

Also, suppose that the following assertions hold:

    1. there exists $x_0 \in X$ such that $\alpha\left(x_0, Tx_0\right) \geq 1$,
    2. either T is continuous or $\left(X, d\right)$ $\alpha-$regular.

Then T has a fixed point. Moreover, if

$$\text{for all } x, y \in F\left(T\right) \text{ implies } \alpha\left(x, y\right) \geq 1,$$

then the fixed point is unique.

Proof. Given $x_0 \in X$ such that

$$\alpha\left(x_0, Tx_0\right) \geq 1 . \tag{2}$$

Define a sequence $\{x_n\}$ in X by $x_n = Tx_{n-1} = T^n x_0$ for all $n \in \mathbb{N}$. If $x_{k+1} = x_k$ for some $k \in \mathbb{N}$, then $Tx_k = x_k$, i.e., x_k is a fixed point of T and the proof is finished. From now on, suppose that $x_n \neq x_{n+1}$ for all $n \in \mathbb{N} \cup \{0\}$. Using (2) and the fact that T is an $\alpha-$admissible mapping, we have

$$\alpha\left(x_1, x_2\right) = \alpha\left(Tx_0, Tx_1\right) \geq 1.$$

By induction, we get

$$\alpha\left(x_n, x_{n+1}\right) \geq 1 \text{ for all } n \in \mathbb{N} \cup \{0\} .$$

In the first step, we will show that the sequence $\{d_r\left(x_n, x_{n+1}\right)\}$ is nonincreasing and $d_r\left(x_n, x_{n+1}\right) \to 0$ as $n \to +\infty$. From (1), recall that

$$d_r\left(x_n, x_{n+1}\right) = d_r\left(Tx_{n-1}, Tx_n\right) \leq \psi\left(M\left(x_{n-1}, x_n\right)\right), \tag{3}$$

where

$$M\left(x_{n-1}, x_n\right) = \max \left\{ d_r\left(x_{n-1}, x_n\right), d_r\left(x_{n-1}, x_n\right), d_r\left(x_n, x_{n+1}\right), \right.$$

$$\left. \frac{d_r\left(x_{n-1}, x_n\right) d_r\left(x_n, x_{n+1}\right)}{1 + d_r\left(x_{n-1}, x_n\right)}, \frac{d_r\left(x_{n-1}, x_n\right) d_r\left(x_n, x_{n+1}\right)}{1 + d_r\left(x_n, x_{n+1}\right)} \right\}$$

$$\leq \max \left\{ d_r\left(x_{n-1}, x_n\right), d_r\left(x_n, x_{n+1}\right) \right\} .$$

15

Now from (3) follows

$$d_r \left(x_n, x_{n+1} \right) \leq \psi \left(\max \left\{ d_r \left(x_{n-1}, x_n \right), d_r \left(x_n, x_{n+1} \right) \right\} \right). \qquad (4)$$

If $\max \left\{ d_r \left(x_{n-1}, x_n \right), d_r \left(x_n, x_{n+1} \right) \right\} = d_r \left(x_n, x_{n+1} \right)$, we get a contradiction. Indeed, (4) implies

$$d_r \left(x_n, x_{n+1} \right) \leq \psi \left(d_r \left(x_n, x_{n+1} \right) \right) < d_r \left(x_n, x_{n+1} \right).$$

Therefore, we get that $d_r \left(x_n, x_{n+1} \right) < d_r \left(x_{n-1}, x_n \right).$ This means that there exists $\lim_{n \to +\infty} d_r \left(x_n, x_{n+1} \right) = d_r^* \geq 0$. If $d_r^* > 0$, then from (3) follows

$$d_r^* \leq \psi \left(\max \left\{ d_r^*, d_r^*, d_r^*, \frac{d_r^{*2}}{1 + d_r^*}, \frac{d_r^{*2}}{1 + d_r^*} \right\} \right)$$

$$\leq \psi \left(\max \left\{ d_r^*, d_r^* \right\} \right) < d_r^*,$$

which is a contradiction. Hence $\lim_{n \to +\infty} d_r \left(x_n, x_{n+1} \right) = 0$.

Further, we will also show that $\lim_{n \to +\infty} d_r \left(x_n, x_{n+2} \right) = 0$. Firstly, we have that $\alpha \left(x_{n-1}, x_n \right) \geq 1$, i.e., $\alpha \left(x_{n-1}, x_{n+1} \right) \geq 1$, because T is a triangular $\alpha-$admissible mapping. Therefore,

$$d_r \left(x_n, x_{n+2} \right) = d_r \left(T x_{n-1}, T x_{n+1} \right) \leq \psi \left(M \left(x_{n-1}, x_{n+1} \right) \right),$$

where

$$M \left(x_{n-1}, x_{n+1} \right) = \max \left\{ d_r \left(x_{n-1}, x_{n+1} \right), d_r \left(x_{n-1}, x_n \right), d_r \left(x_{n+1}, x_{n+2} \right), \right.$$

$$\left. \frac{d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right)}{1 + d_r \left(x_{n-1}, x_{n+1} \right)}, \frac{d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right)}{1 + d_r \left(x_n, x_{n+2} \right)} \right\}.$$

Since $\frac{d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right)}{1 + d_r \left(x_{n-1}, x_{n+1} \right)} \leq d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right)$ and $\frac{d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right)}{1 + d_r \left(x_n, x_{n+2} \right)} \leq d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right)$ we get that

$$M \left(x_{n-1}, x_{n+1} \right) \leq \max \left\{ d_r \left(x_{n-1}, x_{n+1} \right), d_r \left(x_{n-1}, x_n \right), \right.$$

$$\left. d_r \left(x_{n+1}, x_{n+2} \right), d_r \left(x_{n-1}, x_n \right) d_r \left(x_{n+1}, x_{n+2} \right) \right\}$$

that is,

$$M \left(x_{n-1}, x_{n+1} \right) \leq \max \left\{ d_r \left(x_{n-1}, x_{n+1} \right), d_r \left(x_{n-1}, x_n \right), d_r^2 \left(x_{n-1}, x_n \right) \right\}$$

$$\leq \max\left\{d_r\left(x_{n-1}, x_{n+1}\right), d_r\left(x_{n-1}, x_n\right)\right\}.$$

The last relation follows from the fact that $d_r\left(x_{n-1}, x_n\right) \to 0$ as $n \to +\infty$. Hence, for some $n_1 \in \mathbb{N}$, we have that

$$d_r\left(x_n, x_{n+2}\right) \leq \max\left\{d_r\left(x_{n-1}, x_{n+1}\right), d_r\left(x_{n-1}, x_n\right)\right\},$$

whenever $n \geq n_1$. Since, $d_r\left(x_{n-1}, x_n\right) \to 0$ as $n \to +\infty$ it is not hard to check that also $d_r\left(x_n, x_{n+2}\right) \to 0$ as $n \to +\infty$.

In order to prove that the sequence $\{x_n\}$ is a Cauchy one, we use Lemma 6. Namely, since according to Lemma 1, $\alpha\left(x_{n(k)}, x_{m(k)}\right) \geq 1$ if $m(k) < n(k)$, then, by putting in (1) $x = x_{n(k)}, y = x_{m(k)}$, we obtain

$$d_r\left(x_{n(k)+1}, x_{m(k)+1}\right) \leq \psi\left(M\left(x_{n(k)}, x_{m(k)}\right)\right), \tag{5}$$

where

$$M\left(x_{n(k)}, x_{m(k)}\right) =$$
$$= \max\left\{d_r\left(x_{n(k)}, x_{m(k)}\right), d_r\left(x_{n(k)}, x_{n(k)+1}\right), d_r\left(x_{m(k)}, x_{m(k)+1}\right),\right.$$
$$\left.\frac{d_r\left(x_{n(k)}, x_{n(k)+1}\right) d_r\left(x_{m(k)}, x_{m(k)+1}\right)}{1 + d_r\left(x_{n(k)}, x_{m(k)}\right)}, \frac{d_r\left(x_{n(k)}, x_{n(k)+1}\right) d_r\left(x_{m(k)}, x_{m(k)+1}\right)}{1 + d_r\left(x_{n(k)+1}, x_{m(k)+1}\right)}\right\}$$
$$\underset{k \to +\infty}{\to} M\left(x_{n(k)}, x_{m(k)}\right) = \max\left\{\varepsilon, 0, 0, \frac{0 \cdot 0}{1+\varepsilon}, \frac{0 \cdot 0}{1+\varepsilon}\right\} = \varepsilon.$$

Now, taking in (5) the limit as $k \to +\infty$ follows

$$\varepsilon \leq \psi\left(\varepsilon\right) < \varepsilon,$$

which is a contradiction. The sequence $\{x_n\}$ is hence a Cauchy one. Since (X, d_r) is a complete rectangular metric space, there exists a point $x^* \in X$ such that $x_n \to x^*$ as $n \to +\infty$. If T is continuous, we get that $x_{n+1} = Tx_n \to Tx^*$ as $n \to +\infty$. Let $Tx^* \neq x^*$. Since $d_r\left(x_n, x_{n+1}\right) < d_r\left(x_{n-1}, x_n\right)$ for all $n \in \mathbb{N} \cup \{0\}$, then, according to Lemma 7, we have that all x_n are distinct. Therefore, there exists $n_2 \in \mathbb{N}$ such that $x^*, Tx^* \notin \{x_n\}_{n \geq n_2}$. Further, by (iii) follows:

$$d_r\left(x^*, Tx^*\right) \leq d_r\left(x^*, x_n\right) + d_r\left(x_n, x_{n+1}\right) + d_r\left(x_{n+1}, Tx^*\right),$$

whenever $n \geq n_2$, taking the limit, we obtain $d_r\left(x^*, Tx^*\right) = 0$, i.e. $x^* = Tx^*$, which is a contradiction.

In the case that (X, d_r) is $\alpha-$regular, we get the following: Since $\alpha(x_n, x^*) \geq 1$ for all $n \in \mathbb{N}$, then from (1) follows

$$d_r(Tx_n, Tx^*) \leq \psi(M(x_n, x^*)), \qquad (6)$$

where

$$M(x_n, x^*) = \max\{d_r(x_n, x^*), d_r(x_n, x_{n+1}), d_r(x^*, Tx^*),$$

$$\frac{d_r(x_n, x_{n+1}) d_r(x^*, Tx^*)}{1 + d_r(x_n, x^*)}, \frac{d_r(x_n, x_{n+1}) d_r(x^*, Tx^*)}{1 + d_r(x_{n+1}, Tx^*)}\} \xrightarrow[n \to +\infty]{} d_r(x^*, Tx^*).$$

By taking in (6) the limit as $n \to +\infty$ and by using Proposition 8 and the continuity of the function ψ, we get $d_r(x^*, Tx^*) \leq \psi(d_r(x^*, Tx^*)) < d_r(x^*, Tx^*)$ if $x^* \neq Tx^*$., which is a contradiction. Hence, x^* is a fixed point of T.

Now, we show that the fixed point is unique if $\alpha(x, y) \geq 1$ whenever $x, y \in F(T)$. Indeed, in this case, by contractive condition (1), for such possible fixed points x, y we have

$$d_r(x, y) = d_r(Tx, Ty) \leq \psi(M(x, y)), \qquad (7)$$

where

$$M(x, y) = \max\left\{d_r(x, y), d_r(x, Tx), d_r(y, Ty), \frac{d_r(x, Tx) d_r(y, Ty)}{1 + d_r(x, y)},\right.$$

$$\left.\frac{d_r(x, Tx) d_r(y, Ty)}{1 + d_r(Tx, Ty)}\right\}$$

$$= \max\left\{d_r(x, y), 0, 0, \frac{0 \cdot 0}{1 + 0}, \frac{0 \cdot 0}{1 + 0}\right\} = d_r(x, y).$$

Hence, (7) becomes

$$d_r(x, y) \leq \psi(d_r(x, y)) < d_r(x, y),$$

which is a contradiction. The proof of Theorem 9 is complete. $\square$

Remark 1. In the proof of case 2 on Page 96, the authors used the fact that the rectangular metric d_r (see condition (3.12)) is continuous, which is not given in the formulation of (Budhia et al, 2017), Theorem 3.2.

By putting in (1) instead of $M(x, y)$, one of the following sets

$$\{d_r(x, y)\}, \ \max\{d_r(x, y), d_r(x, Tx), d_r(y, Ty)\},$$

$$\max\left\{\frac{d_r(x, Tx)\, d_r(y, Ty)}{1 + d_r(x, y)}, \frac{d_r(x, Tx)\, d_r(y, Ty)}{1 + d_r(Tx, Ty)}\right\},$$

immediately follows as a consequence of Theorem 9.

Corollary 4. *Let (X, d_r) be a complete rectangular metric space and let $T : X \to X$ be a triangular $\alpha-$admissible mapping. Assume that there exists a continuous function $\psi \in \Psi$ such that*

$$x, y \in X, \alpha(x, y) \geq 1 \text{ implies } d_r(Tx, Ty) \leq \psi(d_r(x, y)). \qquad (8)$$

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $\alpha(x_0, Tx_0) \geq 1$,
2. either T is continuous or (X, d_r) is $\alpha-$regular.

Then T has a fixed point. Moreover, if for all $x, y \in F(T)$, we have $\alpha(x, y) \geq 1$, then the fixed point is unique.

Corollary 5. *Let (X, d_r) be a complete rectangular metric space and let $T : X \to X$ be a triangular $\alpha-$admissible mapping. Assume that there exists a continuous function $\psi \in \Psi$ such that for $x, y \in X$,*

$$\alpha(x, y) \geq 1 \text{ yields } d_r(Tx, Ty) \leq \psi(\max\{d_r(x, y), d_r(x, Tx), d_r(y, Ty)\}).$$
$$(9)$$

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $\alpha(x_0, Tx_0) \geq 1$,
2. either T is continuous or (X, d_r) is $\alpha-$regular.

Then T has a fixed point. Moreover, if for all $x, y \in F(T)$, we have $\alpha(x, y) \geq 1$, then the fixed point is unique.

Corollary 6. *Let (X, d_r) be a complete rectangular metric space and let $T : X \to X$ be a triangular $\alpha-$admissible mapping. Assume that there exists a*

continuous function $\psi \in \Psi$ such that for $x, y \in X, \alpha(x, y) \geq 1$

yields $d_r(Tx, Ty) \leq \psi\left(\max\left\{\dfrac{d_r(x, Tx)\, d_r(y, Ty)}{1 + d_r(x, y)}, \dfrac{d_r(x, Tx)\, d_r(y, Ty)}{1 + d_r(Tx, Ty)}\right\}\right).$

(10)

Also, suppose that the following assertions hold:

1. there exists $x_0 \in X$ such that $\alpha(x_0, Tx_0) \geq 1$,
2. either T is continuous or (X, d_r) is $\alpha-$regular.

Then T has a fixed point. Moreover, if for all $x, y \in F(T)$, we have $\alpha(x, y) \geq 1$, then the fixed point is unique.

In the book (Ćirić, 2003), Ćirić collected various contractive mappings in the usual metric spaces, see also (Rhoades, 1977) and (Collaco & Silva, 1997). The next three contractive conditions are well known in the existing literature:

• Ćirić 1: Ćirić's generalized contraction of first order: there exists $k_1 \in [0, 1)$ such that for all $x, y \in X$ holds:

$$d(Tx, Ty) \leq k_1 \max\left\{d(x, y), \frac{d(x, Tx) + d(y, Ty)}{2}, \frac{d(x, Ty) + d(y, Tx)}{2}\right\}.$$

(11)

• Ćirić 2: Ćirić's generalized contraction of second order: there exists $k_2 \in [0, 1)$ such that for all $x, y \in X$ holds:

$$d(Tx, Ty) \leq k_2 \max\left\{d(x, y), d(x, Tx), d(y, Ty), \frac{d(x, Ty) + d(y, Tx)}{2}\right\}.$$

(12)

In both cases, (X, d) is a metric space, $T : X \to X$ is a given self-mapping of the set X.

In (Ćirić, 2003), Ćirić introduced one of the most generalized contractive conditions (so-called quasicontraction) in the context of a metric space as follows:

• Ćirić 3: The self-mapping $T : X \to X$ on a metric space (X, d) is called a quasicontraction (in the sense of Ćirić) if there exists $k_3 \in [0, 1)$ such that for all $x, y \in X$ holds:

$$d(Tx, Ty) \leq k_3 \max\{d(x, y), d(x, Tx), d(y, Ty), d(x, Ty), d(y, Tx)\}.$$

(13)

Since,

$$\frac{d\left(x,Tx\right)+d\left(y,Ty\right)}{2} \leq \max\left\{d\left(x,Tx\right),d\left(y,Ty\right)\right\}$$

and

$$\frac{d\left(x,Ty\right)+d\left(y,Tx\right)}{2} \leq \max\left\{d\left(x,Ty\right),d\left(y,Tx\right)\right\}$$

it follows that (11) implies (12) and (12) implies (13).

In (Ćirić, 2003), Ćirić proved the following result:

Theorem 3. *Each quasicontraction T on a complete metric space (X,d) has a unique fixed point (say) z. Moreover, for all $x \in X$, the sequence $\{T^n x\}_{n=0}^{+\infty}, T^0 x = x$ converges to the fixed point z as $n \to +\infty$.*

Now we can formulate the following notion and one open question:

Definition 3. *Let (X,d_r) be a rectangular metric space and let $\alpha : X \times X \to [0,+\infty)$ be a mapping. The mapping $T : X \to X$ is said to be a modified triangular $\alpha-$admissible mapping if there exists a continuous function $\psi \in \Psi$ such that*

$$x,y \in X, \alpha\left(x,y\right) \geq 1 \text{ implies } d_r\left(Tx,Ty\right) \leq \psi\left(M\left(x,y\right)\right), \qquad (14)$$

where $M\left(x,y\right)$ is one of the sets:

$$\max\left\{d_r\left(x,y\right), \frac{d_r\left(x,Tx\right)+d_r\left(y,Ty\right)}{2}, \frac{d_r\left(x,Ty\right)+d_r\left(y,Tx\right)}{2}\right\}$$

$$\max\left\{d_r\left(x,y\right), d_r\left(x,Tx\right), d_r\left(y,Ty\right), \frac{d_r\left(x,Ty\right)+d_r\left(y,Tx\right)}{2}\right\}$$

$$\max\left\{d_r\left(x,y\right), d_r\left(x,Tx\right), d_r\left(y,Ty\right), d_r\left(x,Ty\right), d_r\left(y,Tx\right)\right\}.$$

An open problem

A suggestion for further research - it is logical to ask the following question:

Problem 0.1. *Let T be a modified triangular $\alpha-$admissible mapping defined on a complete rectangular metric space (X,d_r) such that T is continuous or (X,d_r) is $\alpha-$regular. Show that T has a fixed point.*

21

Applications

In this section, we will focus on the applicability of the obtained results.

An application to chemical sciences

Consider a diffusing substance placed in an absorbing medium between parallel walls such that δ_1, δ_2 are the stipulated concentrations at walls. Moreover, let $\Omega(r)$ be the given source density and $\Xi(r)$ be the known absorption coefficient. Then the concentration $\varkappa(r)$ of the substance under the aforementioned hypothesis governs the following boundary value problem

$$\begin{cases} -\varkappa'' + \Xi(r)\varkappa = \Omega(r) \quad ; r \in [0,1] = I \\ \qquad \varkappa(0) = \delta_1, \varkappa(0) = \delta_2, \end{cases} \tag{1}$$

Problem (1) is equivalent to the succeeding integral equation

$$\varkappa(r) = \delta_1 + (\delta_2 - \delta_1)r + \int_0^1 \Theta(r,\varpi)\left(\Omega(\varpi) - \Xi(\varpi)\varkappa(\varpi)\right), \quad r \in [0,1], \tag{2}$$

where $\Theta(r,\varpi) : [0,1] \times \mathbb{R} \to \mathbb{R}$ is the Green's function which is continuous and is given by

$$\Theta(r,\varpi) = \begin{cases} r(1-\varpi) & 0 \le r \le \varpi \le 1, \\ \varpi(1-r) & 0 \le \varpi \le r \le 1. \end{cases} \tag{3}$$

Suppose that $C(I,\mathbb{R}) = X$ is the space of all real valued continuous functions defined on I and let X be endowed with the rectangular b-metric d_r defined by

$$d_r(\varkappa, \varkappa^*) = \|(\varkappa - \varkappa^*)\|,$$

where $\|\varkappa\| = \sup\{|\varkappa(r)| : r \in I\}$. Obviously (X, d_r) is a complete rectangular metric space.

Let the operator $\Xi : X \to X$ be defined by

$$\Xi\varkappa(r) = \varkappa(r) = \delta_1 + (\delta_2 - \delta_1)r + \int_0^1 \Theta(r,\varpi)\left(\Omega(\varpi) - \Xi(\varpi)\varkappa(\varpi)\right).$$

Then $\varkappa^*$ is a unique solution of (2) if and only if it is a fixed point of Ξ. The subsequent Theorem is furnished for the assertion of the existence of a fixed point of Ξ.

Theorem 4. *Consider problem ([2]) and suppose that there exists $\wp > 0$ and a continuous function $\Xi(\varpi) : I \to \mathbb{R}$ such that the following assertion holds:*

$$\alpha(\varkappa(\varpi), \varkappa^*(\varpi)) \geq 1 \Longrightarrow 0 \leq |\Xi(\varpi)\varkappa(\varpi) - \Xi(\varpi)\varkappa^*(\varpi)| \leq \varkappa^*(\varpi) - \varkappa(\varpi).$$

Then the integral equation ([2]) and, consequently, the boundary value problem ([1]) governing the concentration of the diffusing substance has a unique solution in X.

Proof. Clearly, for $\varkappa \in X$ and $r \in I$, the mapping $\Xi : X \to X$ is well defined. Also Ξ is triangular α-admissible.

$$\begin{aligned}
&|\Xi\varkappa(r) - \Xi\varkappa^*(r)| \\
&= \left| \int_0^1 \Theta(r, \varpi)\left(\Omega(\varpi) - \Xi(\varpi)\varkappa(\varpi)\right) d\varpi - h(r) \right. \\
&\quad \left. - \int_0^1 \Theta(r, \varpi)\left(\Omega(\varpi) - \Xi(\varpi)\varkappa^*(\varpi)\right) d\varpi \right| \\
&\leq \int_0^1 \Theta(r, \varpi)\left|(\Omega(\varpi) - \Xi(\varpi)\varkappa(\varpi)) - (\Omega(\varpi) - \Xi(\varpi)\varkappa^*(\varpi))\right| d\varpi \\
&= \int_0^1 \Theta(r, \varpi)\left|\Xi(\varpi)\varkappa(\varpi) - \Xi(\varpi)\varkappa^*(\varpi)\right| d\varpi \\
&\leq \int_0^1 \Theta(r, \varpi)\left|\varkappa(\varpi) - \varkappa^*(\varpi)\right| d\varpi \\
&\leq \int_0^1 \Theta(r, \varpi)\|(\varkappa(\varpi) - \varkappa^*(\varpi))\| d\varpi \\
&\leq \|(\varkappa - \varkappa^*)\| \sup_{r \in [0,1]} \int_0^1 \Theta(r, \varpi) d\varpi.
\end{aligned}$$

Since $\int_0^1 \Theta(r, \varpi) d\varpi = \frac{r - r^2}{2}$ and so $\sup_{r \in [0,1]} \int_0^1 \Theta(r, \varpi) d\varpi = \frac{1}{8}$.

Hence for all $\varkappa, \varkappa^* \in X$, we obtain

$$d_r(\Xi\varkappa, \Xi\varkappa^*) \leq \frac{d_r(\varkappa, \varkappa^*)}{8} \leq \frac{M(\varkappa, \varkappa^*)}{8},$$

where

$$M(\varkappa, \varkappa^*) = \max\left\{ d_r\left(\varkappa, \varkappa^*\right), d_r\left(\varkappa, T\varkappa\right), d_r\left(\varkappa^*, T\varkappa^*\right), \right.$$

$$\frac{d_r\left(\varkappa, T\varkappa\right) d_r\left(\varkappa^*, T\varkappa^*\right)}{1 + d_r\left(\varkappa, \varkappa^*\right)}, \frac{d_r\left(\varkappa, T\varkappa\right) d_r\left(\varkappa^*, T\varkappa^*\right)}{1 + d_r\left(T\varkappa, T\varkappa^*\right)}\Bigg\}$$

Taking $\psi(M(\varkappa, \varkappa^*)) = \frac{1}{8}$, we obtain

$$d_r(T\varkappa, T\varkappa^*) \leq \psi\Big(M(\varkappa, \varkappa^*)\Big)$$

Hence, all the hypotheses of Theorem 2 are contented. We conclude that $\varXi$ has a unique fixed point $\varkappa$ in X, which guarantees that the integral equation (2) has a unique solution and, consequently, the boundary value problem (1) has a unique solution. $\qquad\square$

Application to a class of integral equations for an unknown function

We present the application of the existence of a fixed point for a generalized contraction to the following class of integral equations for an unknown function u:

$$u(t) = g(t) + \int_a^b \chi(t, z) f(z, u(z)) dz, \quad t \in [a, b], \tag{4}$$

where $f : [a, b] \times \mathbb{R} \to \mathbb{R}$, $K : [a, b] \times [a, b] \to [0, \infty)$, $g : [a, b] \to \mathbb{R}$ are the given continuous functions.

Let X be the set $C[a, b]$ of real continuous functions defined on $[a, b]$ and let $d_r : X \times X \to [0, \infty)$ be equipped with the metric defined by

$$d_r(u, v) = \sup_{a \leq t \leq b} |u(t) - v(t)|. \tag{5}$$

One can easily verify that (X, d_r) is a complete rectangular metric space. Let the self map $T : X \to X$ be defined by

$$Tu(t) = g(t) + \int_a^b \chi(t, z) f(z, u(z)) dz, \quad t \in [a, b], \tag{6}$$

then u is a fixed point of T if and only it is a solution of (4). Also, we can easily check that T is triangular α-admissible. Now, we formulate the following subsequent theorem to show the existence of a solution of the underlying integral equation.

Theorem 5. *Assume that the following assumptions hold:*
(1) $\sup_{a \leq t \leq b} \int_a^b |\chi(t, z)| dz \leq \frac{1}{b-a}$;
(2) Suppose that for all $x, y \in \mathbb{R}$,

$$\alpha(x(t), y(t)) \geq 1 \implies |f(z, x) - f(z, y)| \leq \frac{1}{2}|x(t) - y(t)|.$$

Then integral equation (4) has a solution.

Proof. Employing conditions $(1) - (2)$ along with inequality (4), we have

$$d_r(Tu_1, Tu_2) = \sup_{a \leq t \leq b} |Tu_1(t) - Tu_2(t)|$$

$$= \sup_{a \leq t \leq b} \left| g(t) + \int_a^b \chi(t, z) f(z, u_1(z)) dz - \left(g(t) + \int_a^b \chi(t, z) f(z, u_2(z)) dz \right) \right|$$

$$= \sup_{a \leq t \leq b} \left\{ \left| \int_a^b \left(\chi(t, z) f(z, u_1(z)) - \chi(t, z) f(z, u_2(z)) \right) dz \right| \right\}$$

$$\leq \sup_{a \leq t \leq b} \left\{ \int_a^b |\chi(t, z)| dz \cdot \int_a^b \left| f(z, u_1(z)) - f(z, u_2(z)) \right| dz \right\}$$

$$= \left\{ \sup_{a \leq t \leq b} \int_a^b |\chi(t, z)| dz \right\} \cdot \left\{ \int_a^b \left| f(z, u_1(z)) - f(z, u_2(z)) \right| dz \right\}$$

$$= \left\{ \sup_{a \leq t \leq b} \int_a^b |\chi(t, z)| dz \right\} \cdot \left\{ \int_a^b \left| f(z, u_1(z)) - f(z, u_2(z)) \right| dz \right\}$$

$$\leq \left\{ \frac{1}{b-a} \right\} \cdot \left\{ \frac{1}{2} \int_a^b |u_1(z) - u_2(z)| dz \right\}$$

$$\leq \frac{1}{2(b-a)} \int_a^b \sup_{a \leq t \leq b} |u_1(t) - u_2(t)| dz$$

$$= \frac{1}{2} \sup_{a \leq t \leq b} |u_1(t) - u_2(t)|$$

i.e $d_r(Tu_1, Tu_2) = \frac{1}{2} \left(d_r(u_1, u_2) \right) \leq \frac{M(u_1, u_2)}{2}$. Which amounts to say that

$$d_r(Tu_1, Tu_2) \leq \frac{M(u_1, u_2)}{2},$$

where

$$M(u_1, u_2) = \max \left\{ d_r(u_1, u_2), d_r(u_1, Tu_1), d_r(u_2, Tu_2), \right.$$

$$\frac{d_r\left(u_1, Tu_1\right) d_r\left(u_2, Tu_2\right)}{1 + d_r\left(u_1, u_2\right)}, \frac{d_r\left(u_1, Tu_1\right) d_r\left(u_2, Tu_2\right)}{1 + d_r\left(Tu_1, Tu_2\right)} \Bigg\}.$$

Taking $\psi(M(u_1, u_2)) = \frac{1}{2}$, the above inequality turns into

$$d_r(Tu_1, Tu_2) \leq \psi\Big(M(u_1, u_2) \Big)$$

Thus, all the hypotheses Theorem 2 are satisfied and we conclude that T has a unique fixed point x^* in X, which amounts to say that integral equation (4) has a unique solution which belongs to $X = C[a, b]$. □

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ПРИМЕЧАНИЯ К НЕКОТОРЫМ РЕЗУЛЬТАТАМ В ОБЛАСТИ НЕПОДВИЖНЫХ ТОЧЕК В ПРЯМОУГОЛЬНЫХ МЕТРИЧЕСКИХ ПРОСТРАНСТВАХ, С ИХ ПРИМЕНЕНИЕМ В ХИМИИ

Мудасир Йоунис[а], *Никола* Фабиано[б], *Заид* М. Фадаил[в],
Зоран Д. Митрович[г], *Стоян* Н. Раденович[д]

[а] Университетский технологический институт - РГПВ,
кафедра прикладной математики, г. Бхопал, М.П, Индия

[б] независимый исследователь, г. Рим, Италия

[в] Дамарский университет, педагогический факультет,
кафедра математических наук, г. Дамар, Йеменская Республика

[г] Университет в г. Баня-Лука, электротехнический факультет,
г. Баня-Лука, Республика Сербская, Босния и Герцеговина,
корреспондент,

[д] Белградский университет, Машиностроительный факультет,
г. Белград, Республика Сербия

Резюме:

Введение/цель: В данной статье обсуждаются, суммируются и улучшаются недавние результаты о неподвижных точках в прямоугольных метрических пространствах. Целью данной статьи является представление гораздо более простых и коротких доказательств некоторых новых результатов в области прямоугольных метрических пространств.

Методы: В статье применены стандартные методы теории неподвижной точки в обобщенных метрических пространствах.

Результаты: Полученные результаты данного исследования улучшают известные результаты существующей литературы. Благодаря новому подходу доказана последовательность Коши-Пикара в прямоугольных метрических пространствах. Полученные результаты также используются для доказательства экзистенциальных решений некоторых нелинейных задач, относящихся к химическим наукам. В конце статьи задается открытый вопрос в связи с обобщенными сжатыми отображениями в прямоугольных метрических пространствах.

Выводы: В статье приведены новые результаты, касающиеся теории неподвижных точек в прямоугольных метрических пространствах, примененные в решении некоторых проблем в области химических наук.

Ключевые слова: неподвижная точка, прямоугольное метрическое пространство, сжатое отображение, функция Грина.

НАПОМЕНЕ О НЕКИМ РЕЗУЛТАТИМА О НЕПОКРЕТНИМ ТАЧКАМА У ПРАВОУГАОНИМ МЕТРИЧКИМ ПРОСТОРИМА СА ПРИМЕНАМА У ХЕМИЈИ

Мудасир Јоунис[а], *Никола* Фабиано[б], *Заид* М. Фадаил[в],
Зоран Д. Митровић[г], *Стојан* Н. Раденовић[д]

[а] Универзитетски институт за технологију - РГПВ,
   Одељење за примењену математику, Бопал, М. П, Индија

[б] независни истраживач, Рим, Италија

[в] Универзитет Тамар, Педагошки факултет,
   Одељење за математичке науке, Тамар, Република Јемен

[г] Универзитет у Бањој Луци, Електротехнички факултет,
   Бања Лука, Република Српска, Босна и Херцеговина,
   аутор за преписку

[д] Универзитет у Београду, Машински факултет,
   Београд, Република Србија

ОБЛАСТ: математика

ВРСТА ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: У овом раду се разматрају, уопштавају и побољшавају недавни резултати о непокретним тачкама у оквиру правоугаоних метричких простора. Циљ овог рада је да пружи много једноставније и краће доказе о неким новим резултатима у правоугаоним метричким просторима.

Методе: Користе се стандардне методе из теорије непокретне тачке у генерализованим метричким просторима.

Резултати: Добијени резултати побољшавају добро познате резултате у литератури. Користећи нови приступ доказује се да је Пикаров низ Кошијев у оквиру правоугаоних метричких простора. Добијени резултати користе се за доказ егзистенције решења неких нелинеарних проблема који се примењују у хемијским наукама. На крају се даје једно отворено питање за генерализована контрактивна пресликавања у правоугаоним метричким просторима.

Закључак: Дати су нови резултати за непокретне тачке у правоугаоним метричким просторима са применом на неке проблеме у хемијским наукама.

Кључне речи: непокретна тачка, правоугаони метрички простор, контрактивно пресликавање, Гринова функција.

DESCRIPTION OF THE PROCESS OF TUNNELING Q SIGNALING IN PRIVATE TELECOMMUNICATION NETWORKS

Slađan M. Svrzić[a], *Zoran* M. Miličević[b], *Zoran* S. Perišić[c]

[a] Tesla Systems Ltd, Belgrade, Republic of Serbia,
 e-mail: milosavljevic_svrzic@hotmail.com, **corresponding author**,
 ORCID iD: https://orcid.org/0000-0003-4525-9844

[b] Serbian Armed Forces, General Staff, Directorate for IT and
 Telecommunications (J-6), Belgrade, Republic of Serbia,
 e-mail: zoranmilicko@gmail.com,
 ORCID iD: https://orcid.org/0000-0003-3512-4188

[c] Serbian Armed Forces, General Staff, Directorate for IT and
 Telecommunications (J-6), Belgrade, Republic of Serbia,
 e-mail: zperisic@gmail.com,
 ORCID iD: https://orcid.org/0000-0003-3803-4786

Abstract:

Introduction/purpose: The article should specify the network signaling type Q-SIG, which is standardized especially for implementation in digital telecommunication networks of integrated services (ISDN), emphasizing the possibility of its further application in the Private Telecommunications Network of Integrated Services of the Serbian Armed Forces (PISN of SAF), i.e. in the Private Automatic Telephone Network of the Serbian Armed Forces (PATN of SAF).

Methods: An analysis of the existing standards was performed: ECMA-355 and ECMA-336 and a synthesis of the possibilities of their application in the PATN of SAF.

Results: The procedure for the application of Q-SIG is processed in a situation when the peripheral parts of the PISN of SAF, which operate on the principle of transmission and circuit switching by TDM (Time Division Multiplexing), are connected via a central Core network with the IP (Internet Protocol), which operates on the principle of packet transmission and switching with the SIP (Session Initiation Protocol). A method of the application of the tunneling of encapsulated Q-SIG messages through the IP network, defined by ECMA-355 Standard, has been developed. The necessary functions for mapping the transmission of tunneled signaling messages Q-SIG and mapping voice (and other audio) information to media streams during VoIP

(Voice over IP) communication through that network, which are defined by ECMA-336 Standard, are described.

Conclusion: The application of ECMA-355 and ECMA-336 Standards is a new solution in the PATN of SAF with the use of the IP network to connect the IP PINX using the Q-SIG tunneling procedures and mapping functions for their transmission and transmission of audio signals. This then opens up a whole range of new possibilities that, with the growth of the Core network and their application, will rapidly contribute to the creation of a broad Telecommunication information system backbone for the implementation of real-time multimedia communications and the transition to Unified Communications (UC).

Key words: PATN SAF, Q-signaling, PISN, PINX, Internet protocol, SIP, ECMA standard, Q-SIG tunneling, encapsulation, mapping functions.

Introduction

The *Serbian Armed Forces* (SAF) in peace have extremely high requirements in terms of the use of modern telecommunications solutions, which primarily refers to the sufficiently fast and quality processing and transmission of accurate and protected information (*spoken* and *non-spoken*). At the same time, it is very important to offer a wide range of modern telecommunication customer services and network services to the users of the SAF through the transmission of this information, whose technical support it should provide, not only on TDM (*Time Division Multiplexing*) but also on the IP (*Internet Protocol*) platform, modernly organized and functionally oriented *Private Telecommunications-Information System* (PTIS). As such, the PTIS SAF should be a unique telecommunications-information platform, which, in addition to the fixed part, integrates the *Mobile component of the PTIS* (MC of PTIS), primarily intended for communication on the ground and in combat conditions. Due to its complexity, organization, achieved degree of technical integration and geographical distribution, the PTIS SAF coincides with the performance, determinants, and standards of the modern CTN (*Corporate Telecommunication Network*) (University of Belgrade, 2001). This then means that it is not completely closed and self-centered, but that, through different and geographically disparate interconnections, it is connected to the *Public Switched fixed* and *Public Mobile Telecommunications Networks* (PSTN and PMTN), as well as to the existing *Functional, digital trunking mobile radio network TETRA* (*Terrestrial Trunked Radio*) (Svrzić & Ćosović, 2002).

After significant modernization and growth of the mobile component of the system, the basic assumption is that the existing fixed part of the PTIS and, within it, the fixed *Private Automatic Telephone Network Serbian Armed Forces* (PATN SAF) must be adequately and efficiently integrated into the rapidly growing *Integrated Telecommunications-Information System SAF* (ITIS SAF), so that, for them, they represent a modern, completely appropriate and stimulating stationary telecommunication-information basis. At the same time, the accepted international obligations of the Republic of Serbia and the commitment to international military integration, require that the fixed PATN SAF be interoperable with adequate systems (networks) of other countries and military organizations (Ministry of Defense of Norwey, 2004). Due to such requirements (for organization, modernity and interoperability), there is a constant obligation to regularly perform comprehensive analyzes of its condition in the PATN SAF and to find principles and methods for necessary selective improvements. Thus, at the beginning of 2005, the existing complex and heterogeneous solution of the *Network signaling system* in the PATN *Serbian* and *Montenegro Armed Forces* (SMAF) (Svrzić, 2019) was comprehensively observed and it was found out that it did not have sufficient power for application in modern conditions. Through the synthesis for the solution of the observed problem, the completely new, towards the ISDN (*Integrated Services Digital Network*) oriented and globally standardized, *System of digital network signaling* type Q-SIG (*Q-Signalization*) was imposed (and later in practice proved to be optimal). The International Telecommunication Union-*Telecommunication Standardization Sector* (ITU-T) has intended and designed such signaling specially for use in CTN, that is, in private ISDNs, the so-called PISNs, which the *PTIS Serbian Armed Forces* certainly is (InterConnect Communications, 1995).

The Q-SIG standard corresponds to the framework of the international standards for open system interconnection and the IPNS ISDN PBX (*Private Branch Exchange*) network specifications, which define how to connect private digital automatic telephone exchanges of integrated services, so-called PINX (*Private Integrated services Network eXchange*), within PISN (*Private Networks of Integrated Services*).

Q-SIG standard in private telecommunications networks

The name Q-SIG came from the fact that it is realized in the "Q" reference point of the ITU-T ISDN reference model, i.e. at the logical

level of a digital switching system, which in fact defines the distinction between two connected *Digital automatic telephone exchanges* (DPABX) in an ISDN. Such DPABXs are then called PINXs, because the integration of standardized services is realized through them in the network. In the extended ITU-T ISDN reference model, two new points are identified: *Reference point "Q"* and *Reference point "C"*. The *Reference point "Q"* is the logical point of realization of signaling between two PINX, which means that signaling (i.e. Q-SIG) messages are generated, sent, received and processed on it. The *Reference point "C"* represents the interface through which a physical connection is established with the participating PINX. For the transmission of Q-SIG messages, as a transport or so-called IVN (*Intervening Network*), dedicated channels (*analog* or *digital*), 2 Mb/s digital multiplex group from TDM or switched connections for VPN (*Virtual Private Networks*) are used. Different interface-dependent protocols may appear at the *Reference point "C"*, which also depends on the type of IVN. These IVNs do not necessarily have to be ISDNs, but are generally assumed to be digital channels, as Q-SIG is primarily intended for use when operating on TDM CCS (*Common Channel Signaling*), using the G.703 interface in the *Reference point "C"* (InterConnect Communications, 1995).

Several individual Q-SIG standards precisely define the signaling system at the *"Q" reference point*, so that it will work successfully in any suitable way of connecting PINX equipment. The Q-SIG protocol stack (*Steck Q-SIG*) is identical to the structure of the DSS1 protocol (*Digital System Signaling 1*), as both follow the *ISO reference model* and can have identical *Layer 1* and *Layer 2* (*Layer 2 - LAPD*). However, at the third level, i.e. on *Layer 3*, which is divided into three sublayers here, Q-SIG and DSS1 differ significantly. A simplified messaging sequence, which according to the specifications of ECMA-142/143 Standard takes place on the first sublayer of the *network Layer 3* (Ecma International, 2001a), (Ecma International, 2001b), when establishing Q-SIG BC (*Q-SIG Basic Call*) between the end PINX "X" and "Z", and via the transit PINX "Y", is shown in Figure 1.

The second sublayer of *Layer 3* is the Q-SIG GF (*Q-SIG Generic Fuctional Protocol*), according to the specifications of ECMA-165 Standard (Ecma International, 2001c), which provides a standardized mechanism for exchanging signal information for managing additional services and the ANF (*Additional Network Feature*). The procedures for each of the standard supplementary services are defined in other individual standards presented through *Appendix D* (InterConnect Communication, 1995).
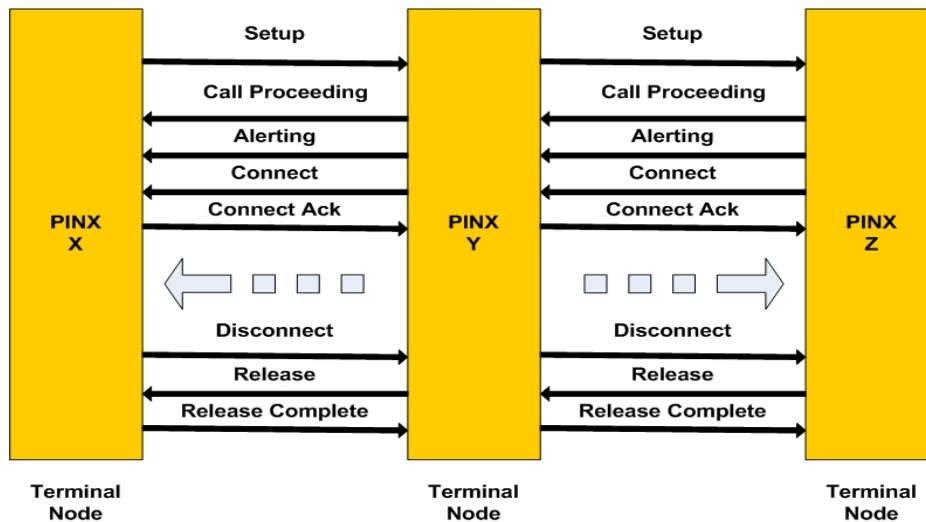
Figure 1 – Sequence of messaging at Q-SIG BC which includes the transit node in the network (InterConnect Communication, 1995)
Рис. 1 – Последовательность обмена сообщениями в Q-SIG BC, включающая транзитный узел в сети (InterConnect Communication, 1995)
Слика 1 – Секвенца размена порука при Q-SIG BC која обухвата и транзитни чвор у мрежи (InterConnect Communication, 1995)

The third sublayer of *Layer 3* defines specific Q-SIG procedures in the *"Q" reference point* for individual additional services. Within it, CTN users and the world's leading manufacturers of a particular type of PBX have specified some additional services as *proprietary*. In addition to the right of priority use of standardized services, they also demanded the retention of the right to the possibility of innovative extensions to improve their business performance, so ITU-T defined the methodology of standardization of all additional Q-SIG services in Recommendation I.130 (InterConnect Communications, 1995).

Application of Q-SIG in the PATN of the Serbian Armed Forces

At the time of the aforementioned Q-signaling testing, the Army PATN was a complex and heterogeneous functional network of automatic telephony, most of which consisted of dozens of DPABXs and the newly introduced ISDN PABX (*Private Automaticlly Branch Exchange*) of various manufacturers (only a few were partially IP oriented). These ISDN PABXs in the network were connected by a mixed

architecture of "*stars*" and "*loops*", with a multi-level structure: *end*, *node*, *transit* and *main transit* DPABX. By applying Q-SIG as a CCS-oriented network signaling system, at the beginning, between ISDN DPABXs of different manufacturers in the fixed PATN of the Army, the possibility for their interoperability was first provided. Later, interoperability was provided between these DPABXs and the switching centers within the MC of PTIS, as well as the switching center of the *Digital Mobile Radio Network TETRA* (Svrzić & Ćosović, 2002). In that way, interoperability was ensured in advance with the PINX from the PTN (*Private Telecommunication Networks*) of other armies or military alliances, with which will later be in telecommunication interconnection, and with the switching nodes of public mobile telephony operators. Today, the PATN SAF has achieved complete independence from various ISDN DPABX manufacturers and high integration of the planned scope of implementation of basic and additional user services and network services specified by Q-SIG, which have become available to the users of that network, regardless of which switching node is connected (Svrzić, 2019).

However, when it comes to further continuous application of Q-SIG in the PATN SAF, as a large part of the ITIS SAF which today contains the PISN (*Private Integrated Services Network*) in combination with the Private IP network SAF (*Intranet SAF*) based on the SIP (*Session Initiation Protocol*), the following is undoubtedly the most important priority for the SAF: to ensure that these services are realized in the most economical way, not only on its homogeneous ISDN parts, but also on parts with the IP / SIP transport networks (the IP networks from the framework of the Intranet). In this case, the switching equipment of any of the present manufacturers must not be technologically outdated in the near future, but must be used when the IP platform is the dominant medium for signal transmission between them.

In connection with such obligations, in the last few years a number of node and transit DPABXs have been modernized or completely replaced, which have become interoperable (at the IP/SIP level) with the newly built IP network-*Intranet SAF*, which offers a packet switching mode and transmission of all services (without connection) based on the IP (*Internet Protocol*), as a network layer protocol. This primarily refers to modern hybrid IP/digital switching systems, the so-called IP PINX, which are specially designed to work in the PISN and, using an integrated Gateway, are capable of interacting with both the ISDN and IP/SIP environment, and with the possibility of continuing the successful application of network signaling type Q-SIG. Such IP PINXs today play

the role of main entities in the PISN SAF, while successfully supporting networking with the use of Q-SIG, in accordance with ECMA-142 (Ecma International, 2001a), ECMA-143 (Ecma International, 2001b), and ECMA-165 (Ecma International, 2001c), as well as the implementation of all additional services and *Additional network functions*-ANF in accordance with the relevant individual Q-SIG standards (*Annex D* from the literature (InterConnect Communications, 1995) and (Svrzić, 2019).

Description of the Q-SIG tunneling principle via the SIP

ECMA-355 Standard (Ecma International, 2008) is in charge of defining the Q-SIG interconnection of services and signaling protocols in modern CTNs, which also contain transport IP boundaries within their PISNs. Specifically, *ECMA-355 Standard* specifies the procedure of *tunneling Q-SIG messages* via the SIP (*Session Initiation Protocol*) defined by Recommendations RFC 3261J and RFC 3311 (Rosenberg et al, 2002), (Rosenberg, 2002). The SIP is an application layer protocol for establishing, terminating and modifying multimedia sessions and is commonly transmitted over the IP, as defined by Recommendations RFC 760 and RFC 791J (University of Southern California, 1980a), (Deering & Hinden, 1998), where telephone calls are considered a type of multimedia session in which only audio signals are exchanged.

The application of the *Q-SIG message tunneling* procedure allows calling between PINX, i.e. "islands" within PISN parts with circuit-switched circuits using Q-SIG, including the case when they are interconnected by a transport IP network (using the SIP), without losing Q-SIG functionality. This means that even in such situations, they provide their participants with a *basic Q-SIG call*, as well as additional services and all ANF. Namely, this innovated standard facilitates the introduction of improved SIP and SDP functionalities (*Session Description Protocol*) described by Recommendation RFC 3264J (Rosenberg & Schulzrinne, 2002), which include the possibility of using encryption of useful signal and mechanisms for more functional exchange of information (offers and responses) within the functioning of the SDP. Among other things, a more functional exchange of information implies mandatory renegotiation (i.e. negotiation in the opposite direction) during the exchange of bids/responses with the SDP, and, in order to achieve compatibility with the earlier issue of standards, an indicator was introduced to detect changes in signaling procedures. This indicator dynamically detects the need for withdrawal and application of signaling procedures in

accordance with the previous edition of the standard (*Annex A*, *ECMA-355*).

Large CTNs often contain marginal PISNs that use Q-SIG, as well as their own central IP networks (*Core network*) that use the SIP, so in terms of telephony within their framework, two different cases may occur:

1) *Q-SIG call* or *Signaling connection independent of Calls* (SCIoCs) can originate from a user connected to the PISN and end up with a user connected to an IP network or vice versa. In both situations, the Gateway is a network entity that provides Q-SIG and SIP interconnection at the boundary between the PISN and the IP network. The realization of the basic interactive call via the Gateway for such communication, i.e. for the *mode of mutual operation*, is specified in *ECMA-339 Standard* (Ecma International, 2006).

2) *Q-SIG calls* or only SCIoCs, which originate from the "A" user connected to the PISN, pass through the IP network using the SIP, and end with the "B" user connected to another PISN (or another part of the same PISN). *ECMA-355 Standard* deals with just such a case, because in such a connection case all the possibilities of Q-SIG are retained during transport through the IP network. This is achieved by applying the process of *tunneling Q-SIG messages* within SIP requests and SIP responses, which are exchanged in the context of a specified SIP dialogue.

It should be noted that according to *ECMA-339 Standard*, each Gateway can provide a *mode of interaction* between the PISN and the IP network, but only the realization of the *basic Q-SIG call* is enabled (Ecma International, 2006). Thus, this standard specifies the interoperability of the PISN (with Q-SIG) and the IP network (with the SIP), only for the service of the *basic Q-SIG call*, which is then implemented according to the procedures specified in *ECMA-143 Standard* (Ecma International, 2001b). Other features of Q-SIG (support for additional services and ANF), which are specified in other individual ECMA standards for Q-SIG, as well as specifications specific to a particular manufacturer of a particular type of PINX, are not covered by such connections. Some of these additional Q-SIG services are suitable for interconnection with the SIP and are considered by other individual ECMA standards, while others are not suitable for this, as there are no appropriate elements in the SIP (or these services are provided within the SIP in a way that is not compatible with Q-SIG). (Ecma International, 2008), (Svrzić, 2019)

Architecture applicable in practice

From the point of view of the application of *ECMA-355 Standard*, both globally and within the modernized PATN SAF, it is interesting to mention the network scenario indicated in the second case of connection realization, in the *basic Q-SIG call* or only SCIoCs, which is achieved by using the Gateway at each crossing, between the PISN (which uses Q-SIG) and the IP network (which uses the SIP). In this sense, the Gateway is an IP network entity, which acts as a Q-SIG transit PINX, where the Q-SIG is transmitted via a *circuit-switched connection*, within the PISN (at both ends), and *tunneling via the SIP*, within the IP network (i.e. on the *Core part*) from the PTN. Such an architecture of an interesting part of the heterogeneous PTN is shown in Figure 2.
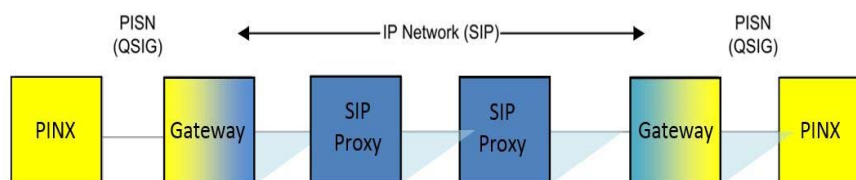
Figure 2 – Arrangement of entities when making calls from Q-SIG, via the SIP, to Q-SIG (Ecma International, 2008)
Рис. 2 – Расположение сущностей при осуществлении звонков от Q-SIG, через SIP, к Q-SIG (Ecma International, 2008)
Слика 2 – Распоред ентитета при реализацији позива од Q-SIG, преко SIP, на Q-SIG (Ecma International, 2008)

In general, the interoperability between the displayed parts of the network with Q-SIG and the SIP will be limited on the Gateway itself, i.e. only those Q-SIG capabilities that have sufficiently compatible equivalents in the SIP will be transferred, as each of them requires a separate implementation in the Gateway. Therefore, a typical Gateway can provide interoperability of Q-SIG and SIP networks, only for that subset of Q-SIG capabilities for which it possesses the necessary SIP interoperability implementations. This then necessarily implies a possibility of losing some of the possibilities within the realization of Q-SIG calls, both in the direction from Q-SIG to the SIP, and in the opposite direction. Also, for a case similar to the one shown in Figure 2, some of the Q-SIG capabilities may be lost if the two participating Gateways are of different types (from different manufacturers), since only those Q-SIG

capabilities that are common to both Gateways enable "*end-to-end*" connectivity.

The practical application of *ECMA-355 Standard* (which is also the case in the PATN SAF), which defines the procedure for *tunneling Q-SIG messages* through an IP network, i.e. their integration (*encapsulation*) within SIP messages, solves such situations and there is no possibility to lose parts of Q-SIG in the mentioned "*end-to-end*" connection. In this case, one of the two Gateways creates a SIP dialog with the other Gateway, and the SIP messages within that dialog are used to *tunnel Q-SIG messages*. Through the use of the SDP, the SIP dialog also establishes a session in which media streams carry user information between two "Q-SIG Gateways", which then function as Q-SIG transit PINX, transmitting both user information and Q-SIG messages, with little or no modification.

In a conventional PISN (meaning TDM/ISDN) that uses Q-SIG, the two PINXs are connected using an IPC (*inter-PINX connection*), which contains CCS signaling (which carries Q-SIG messages) and usually one channel that carries user information (*speech*, *modem information*, or *data*). However, in the present *Q-SIG tunneling solution*, the IP network provides an IPC between the two Gateways, which can then function as transit PINXs. *The tunnel*, which provides the SIP for Q-SIG messages within an IP, acts as a signaling transmission channel, while the established media streams function as separate receiving and transmitting channels for transmitting user information. The audio stream, or other user information, is transmitted in UDP (*User Datagram Protocol*) packets, as described in RFC 768 Recommendation (Postel, 1980), in which case they contain RTP (*Real Time Transport Protocol*) packets, described by RFC Recommendation 1889 (Schulzrinne et al, 1996). Such transmission is performed in both directions of the connection between the participating Gateways, through an established SIP session, when a pair of media streams is usually established, i.e. one media stream for each direction of communication.

The role of *ECMA-355 Standard* to solve the modernization of Q-SIG use in the PATN SAF is such that it covers only the case of the IPC type in which a single dialogue between two Gateways is used to realize one *Q-SIG call* or one *Signaling connection independent of calls*, as defined in *ECMA-165* (Ecma International, 2001c). This then means that *ECMA-355* in the PATN SAF will only apply to situations where the SIP dialog is established at the beginning of the establishment of a *Q-SIG call*, or SCIoC, and deleted upon their initiation (or termination). An improved scenario, according to which one SIP dialogue would be

maintained in the long run and used to *tunnel* multiple *Q-SIG calls*, or multiple SCIoCs, with the possibility to accept them at any time (including those that are just being generated), is not supported in the specifications of the said standard, so it cannot be applied either within the PATN SAF. (Ecma International, 2008), (Svrzić, 2019)

Realization of the basic Q-SIG call during tunneling via the SIP

When the Ingress Gateway (*Input Gateway*), which manages the establishment of an initiated *Q-SIG call* in the direction of PISN-IP networks, receives from the PISN the initial Q-SIG message "SETUP" (request to establish a *basic Q-SIG call*), it sequentially, according to the IP network, must generate a SIP "INVITE" request using the Request-URI. Within the SIP dialogue procedure, i.e. SIP request/SIP response sessions, the Ingress Gateway will route the request over the IP network to the appropriate Egress Gateway (*Output Gateway*), which will manage the establishment of the *Q-SIG call* at the far end, in the direction from the IP network to the PISN (Figure 2). This then means that the Request-URI within the SIP request must, in some way, be derived from the defined destination of the Q-SIG call (as the indicated number of the called party, in the information of the received Q-SIG message "SETUP"). With its existence, the Request-URI can act in two different ways: 1) to explicitly determine the Egress Gateway for the requested connection, or 2) to simply determine the desired end destination of the connection, without specifying the Egress Gateway.

To act in the first case, there must be some capacity in the Ingress Gateway with the ability to search for addresses online, in order to explicitly determine the Egress Gateway. However, to act in the second case, algorithmic mapping of the called page number in the Request-URI may be sufficient, but this then represents a task for the SIP proxy, that it needs to select the appropriate Egress Gateway. In such a situation, the SIP proxy can, for example, route an "INVITE" request to the UAS (*User Agent Server*), which is not the Egress Gateway for Q-SIG, in which case *Q-SIG tunneling* will not be possible. Enabling the realization of *Q-SIG calls* in this way is undesirable, because it creates a situation in which the *mode of mutual operation* via the SIP is more suitable for operation. To prevent such a possibility, an adequate mechanism is defined in the system, initiated only by the presence of "INVITE" requests, which explicitly implies the *Q-SIG tunneling mode*. Namely, the mechanism will be manifested in such a way that the request "INVITE" will be rejected by the *Exit Gateway*, if it does not support this possibility. Otherwise, it

would imply a situation where the Ingress Gateway must simultaneously map the Q-SIG message "SETUP" to the SIP request "INVITE", both in accordance with *ECMA-355 Standard* and in accordance with *ECMA-339 Standard* (Ecma International, 2006), (Ecma International, 2008), (Svrzić, 2019).

Although this situation seems to be only partially feasible, it is architecturally very problematic, because by applying the *Q-SIG tunneling mode* the Input Gateway should behave like a Q-SIG transit PINX, while when applying the *mutual mode operation*, according to (Ecma International, 2006), it should act as a *Q-SIG Outgoing Gateway* PINX. The *Incoming Gateway* will then not know for sure which behavior to accept, until the SIP response "200 OK" arrives, and therefore will not know how to manage information related to certain Q-SIG user capabilities from the Q-SIG message SETUP "(*Additional services*, ANF and *specific capabilities of the manufacturer*). For this reason, *ECMA-355* and *ECMA-339 Standards* require that the *Input Gateway* have the ability to make a precise decision between the application of the *Q-SIG tunneling mode* or the *interoperability mode*, respectively. (Ecma International, 2008)

Call realization using independent signalization during tunneling through the SIP

It should be noted immediately that the determinant of *ECMA-355 Standard*, according to which it also refers to the case of establishing a call by type: only *Signaling connection independent of the call*, should be understood that it also applies to *Q-SIG calls* where only transmission, i.e. transport, signaling information, and without the procedure of establishing voice communication (without media flows).

When the *Input Gateway* from the PISN receives the initial Q-SIG message "FACILITY", as a request for the realization of the communication type SCIoC only, it should generate a SIP "INVITE" request using the Request-URI, which will direct this request to the appropriate *Output Gateway*. So, in this case as well, the Request-URI must be derived in some way from the defined destination from the Q-SIG "FACILITY" message (as the indicated number of the called party). Of course, techniques similar to those described used in making the *basic Q-SIG call* will be used on this occasion as well. Note that even with the implementation of this type of connection (by type of signaling transport without audio connection), it may happen that, based on the requested destination from the Q-SIG "FACILITY" message, the *Input Gateway* finds that the desired destination is not accessible via *Q-SIG*

tunneling through an IP network. In this case, the Q-SIG *Input Gateway* can either direct the message further to the PISN or discard it. (Ecma International, 2008), (Svrzić, 2019)

Encapsulation of Q-SIG messages in SIP messages

When performing any of the procedures provided for the *Q-SIG tunneling* process via the SIP, the participating Gateways will behave as a Q-SIG transit PINX, as specified in standard (Ecma International, 2008) and by Recommendation RFC 3264J (Rosenberg & Schulzrinne, 2002), but also somewhat modified, as will be described below.

When *encapsulating a Q-SIG message* within a SIP message, the Gateway first includes that Q-SIG message in the MIME body of the SIP request or the SIP response (according to RFC Recommendation 3204 (Zimmerer et al, 2001), using a media/Q-SIG application, which means that Q-SIG message segmentation does not apply here. If it is necessary to use any other MIME body (e.g. from an SDP offer/response), the Gateway will use a multiple MIME body. In the case of a single MIME body, the Gateway will include the "*Content-Disposition*" header field, which indicates "*signal*" and "*handling = required*", as the SIP request/SIP response header field. In the case of a multiple MIME body, the Gateway will include the "*Content-Disposition*" header field as the header field of only that MIME body, from the SDP bid/response that contains the Q-SIG message. (Ecma International, 2008), (Svrzić, 2019)

Management of Q-SIG "SETUP" messages on the Ingress Gateway

To monitor the workflow of the Ingress Gateway after receiving the Q-SIG message "SETUP", when establishing a Q-SIG call from Q-SIG via SIP to Q-SIG, the flow chart from Figure 3 should be followed.

Sending SIP requests "INVITE"

Upon a receipt of the Q-SIG message "SETUP" from the *calling PINX*, suitable for *tunneling via the SIP* through the IP network to the *Output Gateway*, the *Input Gateway* must generate an initial SIP "INVITE" request, which contains a Request-URI and must be suitable for routing to the Gateway. In doing so, the *Input Gateway* necessarily encapsulates the incoming Q-SIG message "SETUP" within the initial SIP "INVITE" request. The Request-URI is then derived from the information about the called party number in the Q-SIG message

"SETUP", so that the relevant *Output Gateway* can be explicitly identified based on it.
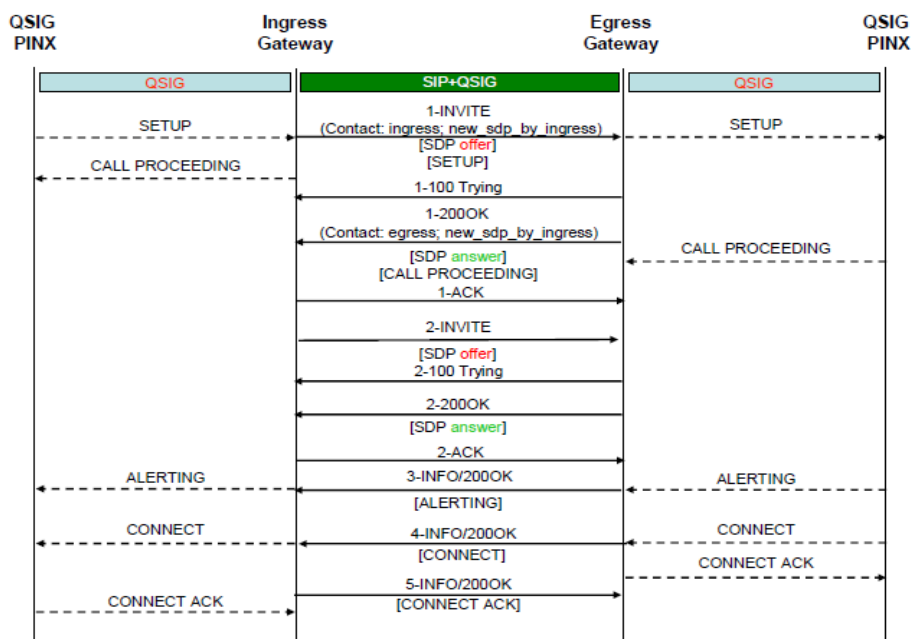
Figure 3 – Establishing a basic Q-SIG call from Q-SIG, via the SIP, to Q-SIG (Ecma International, 2008)
Рис. 3 – Установление базового вызова Q-SIG от Q-SIG через SIP к Q-SIG (Ecma International, 2008)
Слика 3 – Успостављање основног Q-SIG позива од Q-SIG, преко SIP, на Q-SIG (Ecma International, 2008)

In a SIP "INVITE" request, the "*From*" field is the message header, which identifies the *Incoming Gateway* or the calling party (derived from the Q-SIG "*Calling party*" information element), while the "*Contact*" field is the header of the same SIP "INVITE" messages, which must include information on the capabilities of the UA (*User Agent*), in accordance with Recommendation RFC 3840 (Rosenberg et al, 2004), and the URI parameter type:
"+ *U.ecma-international.org/ecma355/new_sdp_by_ingress*",
which then indicates that there is support for the implementation of the procedures defined under *ECMA-355 Standard*.

Thus, the *encapsulated Q-SIG message* "SETUP" may differ slightly from the received "SETUP" message PINX, all in accordance with an

acceptable modification to the Q-SIG Transit PINX (example of changing the element of channel identification). In particular, both the channel number field and the priority/exclusive field should contain the value "*1*" (exclusive).

Also, in the case of establishing a *basic Q-SIG call*, the SIP "INVITE" request must contain an SDP offer, which proposes a pair of media streams, i.e. one stream in each direction ("*a = sendrecv*"), so that the *Input Gateway* can later map them in the user information channel, which is specified in the channel identification information element in the received Q-SIG message. Media streams will be suitable for use in accordance with the carrier capability information element from the received Q-SIG message "SETUP". It should be noted that in the case of establishing a SCIoCs-only call, the "INVITE" request must contain a different SDP offer, which contains the zero "*m*" line ("*m = 0*") (Rosenberg & Schulzrinne, 2002).

After sending the SIP "INVITE" request, the *Incoming Gateway* will not encapsulate any further message received from the Q-SIG media, until it receives the SIP response "1-200 OK" from the IP media (i.e. from the Output Gateway) with the *encapsulated Q-SIG message* "SETUP ACKNOVLEDGE" or "CALL PROCEEDING". The SIP response "1-200 OK" also contains an adequate SDP response to the initiated negotiation procedure. (Ecma International, 2008), (Svrzić, 2019)

Receipt of a response to the SIP request "INVITE"

The usual way of the UA managing the SIP response, upon the request "INVITE", means that the *Input Gateway*, upon receipt of the final SIP response type "*4-xx*", "*5-xx*" or "*6-xx*", with the *encapsulated return Q-SIG message*, must take an alternative action: 1) to route *Q-SIG calls/* SCIoC calls, or 2) to delete them. The routing method is not described by *ECMA-355 Standard*, while the deletion activity is performed using the corresponding causal value in the "*Cause*" information element, from the encapsulated Q-SIG message for disconnection ("DISCONNECT", "RELEASE" or "RELEASE COMPLETE").

Therefore, when the SIP response contains the *encapsulated Q-SIG message* "RELEASE COMPLETE", the *Input Gateway* should use the causal value, from the "*Cause*" information element in that message, to define the causal value for the implementation of Q-SIG or SCIoC call deletion activities. The *Input gateway* then defines a causal value that reflects the fact that the next PINX is unavailable (e.g., causal value "*3*" = "*No route to destination*"). In case the selected UAS does not support the

encapsulated Q-SIG, the final SIP response can be expected in the form of a SIP message: "*415*" = "*Unsupported media type*".

By receiving the SIP response "1-200 OK" with the *encapsulated Q-SIG message* "CALL PROCEEDING" and containing the SDP response, the *Input Gateway* receives an order to perform normal SIP processing, including the generation and transmission of pure SIP requests "1-ACK", and to continue acting on each *encapsulated Q-SIG message*. In this regard, the *Input Gateway* first checks for the presence of a URI parameter in the "*Contact*" field of the SIP response header "1-200 OK": "*+ U.ecma-international.org/ecma355/new_sdp_ by_ingress*".

If the URI parameter is present, then the *Input Gateway* must immediately generate a SIP request "re-INVITE", in which the same SDP bid data from the initial SIP "INVITE" request is used again. After that, the *Input Gateway* must continue to operate in accordance with the definition in the standard (Ecma International, 2008), and continue to accept incoming SIP responses "INFO", from the established *tunnel* of Q-SIG information on the IP network, regardless of the fact it is still waiting for a response to its SIP request "re-INVITE". However, if the URI parameter is not present, the *Input Gateway* will not immediately generate a "re-INVITE" SIP request. Namely, when the received SDP response on the line "*m*" indicates "*port = 0*", the *Input Gateway* will wait with the sending of the SIP request "re-INVITE" (with the new SDP offer included) to the *Output Gateway*, and will then act in accordance with (Rosenberg et al, 2002). This means that the *Input Gateway* will continue to accept incoming SIP responses of the "INFO" type, including those with an *encapsulated Q-SIG message*.

At this stage, the *Input Gateway* will only try to realize the connection of the Q-SIG channel of user information with the media flows specified in the SDP response. Namely, in the case when the line "*m*" means "*port = 0*", the *Input Gateway* will not be able to establish a two-way media flow through the IP network, for the directions of receiving and transmitting user information, so the required two-way connection will be achieved only after successful completion the SIP transaction requires "re-INVITE" or "UPDATE". Also, if by the time of receiving the Q-SIG message "CONNECT" the *Input Gateway* has not received a non-zero port "*m*" line for establishing media streams, it will not act on the received *encapsulated Q-SIG message* "CONNECT" from the SIP response "4-INFO/200 OK "and will act as if the Q-SIG timer "*T301*"has expired. (Ecma International, 2008), (Svrzić, 2019)

Manage Q-SIG "SETUP" messages on the Egress Gateway

To monitor the workflow of the Engress Gateway after receiving the Q-SIG message "SETUP", when establishing a Q-SIG call from Q-SIG via SIP to Q-SIG, the flow chart from Figure 3 should be followed again.

Receipt of the SIP request "INVITE"

Upon receipt of the initial SIP request "INVITE", which contains an *encapsulated Q-SIG message* "SETUP" and an SDP offer, the *Output Gateway* orders to check the presence of the URI parameters:
"+ *U.ecma-international.org / ecma355 / new_sdp_by_ingress*",
in the "*Contact*" field of its header, and sends an SIP response "1-200 OK". If the URI parameter is present, then the SIP response "1-200 OK", together with the SDP response, will contain the URI parameter in the "*Contact*" field of the header:
"+ *U.ecma-international.org/ecma355/new_sdp_by_ingress*.

If this parameter is not present, the *Output Gateway* must omit the URI parameter from the SIP response "1-200 OK". The contained SDP response (in the SIP response "1-200 OK") with its parameters should enable the establishment of symmetrical media flows, unless the received SDP bid contained zero on the "*m*" line, "*m = 0*" (and then benchmark for establishing a connection by the type of SCIoC call, when there is no establishment of media streams). However, if the *Output Gateway* cannot determine the appropriate SDP parameters at the time of sending the SDP response, it will send an SDP response in which the line is "*m = 0*". In this case, the IP address in the "*c =*" line is irrelevant. It can only be important if it indicates the SIP signaling part of the *Output Gateway*.

When the received Q-SIG message "SETUP" is acceptable for further routing to the PISN (according to the called PINX), the *Output Gateway* must select CCS for signaling to the PISN side and forward the Q-SIG message "SETUP" to it. The forwarded Q-SIG "SETUP" message may differ from the received "SETUP" message according to an acceptable modification to the Q-SIG Transit PINX. In particular, the channel identification information element must reflect the TDM channel selected for the transmission of user information. To establish a *Q-SIG call*, the *Output Gateway* must also connect the established IP page streams to the selected user information channel in the PISN TDM transmission system. The *Output Gateway* in the SIP response "1-200 OK", to the initial SIP request "INVITE", may include an *encapsulated Q-SIG message*: "SETUP ACKNOVLEDGE" or "CALL PROCEEDING". Otherwise, the *Output Gateway* will transmit the first later, corresponding

Q-SIG message only in one of the next SIP messages of the type "x-INFO/200 OK" (*x = 3,4,5*).

Further procedures on the *Output Gateway* depend on whether a URI parameter was present in the "*Contact*" header field from the initial "INVITE" SIP request. If it was present, then the *Output Gateway* will wait to receive the "re-INVITE" SIP request from the *Input Gateway*, regardless of whether valid SDP parameters can be determined earlier. In the event that valid SDP parameters are still not present, the *Output Gateway* will acknowledge a receipt of the SIP "re-INVITE" request by sending a "provisional" SIP response: "2-100 Traying". However, when valid SDP parameters are available in this situation, or will become available at a later stage of establishing a *Q-SIG call*, the *Output Gateway* will, upon receiving the SIP request "re-INVITE", use these SDP parameters for a later SDP response within the SIP answers "2-200 OK". In this case, the *Output Gateway* may (upon the SIP request "re-INVITE") include an *encapsulated Q-SIG message* in the SIP response frame "2-200 OK", combined with the SDP response.

If the specified URI parameter was not present, then the *Output Gateway* in the SIP negotiation process will not receive a SIP "re-INVITE" request. Only when the SDP parameters become available at a later stage of establishing a *Q-SIG call*, the *Output Gateway* will have to renegotiate media flows by sending a SIP request "re-INVITE" or a SIP request "UPDATE" with an SDP offer that reflects these parameters. Of course, it should be immediately noted that this approach, which represents a return to the procedures of early editions of the standard, can cause problems with the specific behavior of certain SDP extensions such as key management and SDP negotiation options.

Note that the *Output Gateway* can reject the SIP request "INVITE" in accordance with (Rosenberg et al, 2002). For example, if the SIP UAS does not support the *encapsulated Q-SIG*, and therefore is not able to play the role of an *Output Gateway*, the SIP response with the code "*415*" = "*Unsupported Media Type*" will be applied. If the SIP UAS is unable to accept the SDP offer, the SIP code "*488*" = "*Not Acceptable*" will apply. However, the *Exit Gateway*, which is not able to confirm the SDP offer from the initial SIP request "INVITE", will still accept the SDP offer before sending the SIP response "2-200 OK", but will use the parameters of the SDP offer received to negotiate media flows. as part of the SIP request "re-INVITE". Of course, the *Output Gateway*, which is compatible with the early release of this standard, would send a SIP request "re-INVITE" or a SIP request "UPDATE" to re-negotiate the Media stream. (Ecma International, 2008), (Svrzić, 2019)

Rejection of a Q-SIG message from the "INVITE" request

If the *Output Gateway* receives an "INVITE" request with an *encapsulated Q-SIG message* that is not acceptable (eg: "SETUP" message that is not suitable for further routing; inappropriate Q-SIG message; "SETUP" message for a *Q-SIG call* for which appropriate media streams cannot be established), the *Output Gateway* further sends a Q-SIG response message according to standards (Ecma International, 2001b) or (Ecma International, 2001c) (e.g.: "RELEASE COMPLETE" message containing the corresponding value in the Q-SIG information element "*Cause*"). The corresponding *encapsulated Q-SIG message* will be sent either in a SIP message of the "INFO" type or in the SIP message "BYE", in the case of the Q-SIG message "RELEASE COMPLETE". If there is an unresolved SIP request "re-INVITE" at the time of refusing to accept the *Q-SIG call*, the *Output Gateway* will terminate the pending transaction by sending the SIP response: "*487*" = "*Request completed*". (Ecma International, 2008), (Svrzić, 2019)

Subsequent Q-SIG messages

After transmitting the SIP response "200 OK", to the initial SIP request "INVITE" (*Output Gateway*), or transmitting the SIP message information "ACK", after receiving the SIP response "200 OK" (*Input Gateway*), both Gateways must be able to send and receive from the opposite gateway the following *encapsulated Q-SIG messages* in the body of the SIP request and the SIP response "INFO" ("ALERTING", "CONNECT", "CONNECT ACK") (Donovan, 2000), (Ecma International, 2008). Exceptions to these situations are the SIP request "BYE", which can *encapsulate the Q-SIG message*: "RELEASE COMPLETE" and the SIP request "re-INVITE" or the SIP request "UPDATE" (Rosenberg, 2002), which can *encapsulate the Q-SIG message* on waiting during the process of establishing a new *Q-SIG call* or during the renegotiation process while the active *Q-SIG call* is in progress. (Ecma International, 2008), (Svrzić, 2019)

End of the SIP dialog

When disconnecting a Q-SIG call or SCIoC call, the participating gateways exchange the SIP request "1-INFO" with the encapsulated Q-SIG message "DISCONNECT" and the SIP response "2-INFO" with the encapsulated Q-SIG message " RELEASE "(these Q-SIG messages are transmitted to the end PINX through the PINS at both ends), as shown in the flow chart in Figure 4.
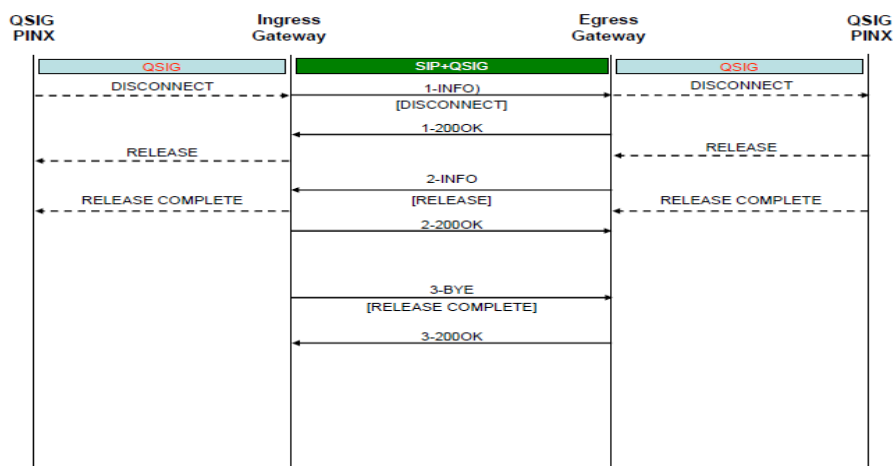
Figure 4 – Termination of a Q-SIG call from Q-SIG, via the SIP, to Q-SIG (Ecma International, 2008)
Рис. 4 – Завершение вызова Q-SIG от Q-SIG через SIP к Q-SIG (Ecma International, 2008)
Слика 4 – Раскидање Q-SIG позива од Q-SIG, преко SIP, на Q-SIG (Ecma International, 2008)

When the *Incoming Gateway* determines that a *Q-SIG call* or connection by the SCIoC call type is terminated, it will terminate the established SIP session by transmitting the SIP request "BYE". If in that case, according to the procedure, the *Input Gateway* sends the final message "RELEASE COMPLETE", it can *encapsulate* that *Q-SIG message* within the SIP request "BYE". After the final Q-SIG message is sent or received, the Gateway typically forwards the SIP request "BYE" without *encapsulating* that Q-SIG message. If a "re-INVITE" SIP request is pending during the end of the SIP dialog, the *Output Gateway* will terminate the transaction with the SIP response: "*487*" = "*Request Terminated*". (Ecma International, 2008), (Svrzić, 2019)

Manage Q-SIG messages to establish independent signaling calls on the Input Gateway

When establishing a call with an SCIoC, the Q-SIG message "FACILITY" (including addressing elements) is used, as specified in the standard (Ecma International, 2001c). The SIP request "INVITE" is used to *tunnel the Q-SIG message* "FACILITY", but the full negotiation session described earlier when establishing the *basic Q-SIG call* is not established. Namely, immediately after receiving the Q-SIG message

"FACILITY", in this case the SIP request "INVITE" is rejected, and the flow diagram has a slightly different, simplified scenario. "INVITE" actually avoids the load, which is created when establishing the SIP dialogue for media streams, as the call establishment process is released from it. (Ecma International, 2008), (Svrzić, 2019)

Description of the mapping functions for tunneling Q-SIG through an IP network

To define the mapping functions required for the use of network intervention scenarios, within the IP switching systems from the PISN, use *ECMA-336 Standard* (Ecma International, 2002). This standard specifies the mapping functions for the use of a packet network within the Internet Protocol (University of Southern California, 1980a), (Deering & Hinden, 1998), as a network layer protocol, and the UDP (*User Datagram Exchange Protocol*) (Postel, 1980) and the TCP (*Transmission Management Protocol*) (University of Southern California, 1980b), as a transport layer protocol, to interconnect the two IP PINXs that make up the PTN entities composed of the edge PISN and central IP networks— *Core networks* (a scenario similar to that shown in Figure 2). Interconnection is achieved by transmitting the inter-PINX signaling protocol, directly via the TCP, and inter-PINX user information (e.g. *speech*), via the RTP (*Real-Time Transmission Protocol*) (Schulzrinne et al, 1996), whereby the RTP is transmitted within the UDP. Of course, the Q-SIG functions as an inter-PINX signaling protocol, as stated in ECMA-143 (Ecma International, 2001b), ECMA-165 (Ecma International, 2001c) and other ECMA standards. Thus, the standard is applied to IP PINXs that can be interconnected to form a PISN, using Q-SIG as the inter-PINX signaling protocol. (Ecma International, 2002), (Svrzić, 2019)

To comply with *ECMA-336 Standard*, each IP PINX must constructively and functionally meet the reference configuration, defined in *ECMA-133* (Ecma International, 1998) and the requirements set out in the PICS (*Implementation Conformance Statement Proforma*). The text and format of the PICS are presented in the *Annex A* of *ECMA-336*. Within *ECMA-336 Standard*, the previously adopted terms: service/service and signaling, defined according to ITU-T Recommendation I.112, Glossary of terms for ISDN (ITU, 1988), as well as some other terms, are used as follows:
- *Caller IP PINX*, entity which sends the initial Q-SIG message "SETUP" via the IPL (*Inter PINX link*), to establish a *basic Q-SIG call* or SIoC *connection*.

- *Called IP PINX*, entity which receives the Q-SIG message "SETUP" via the IPL, to establish a *basic Q-SIG* call or SIoC *connection*.
- *A channel* is a medium for two-way transmission of user or signal information between two points in a PTN. The D$_Q$ channel is used to transmit call management information (signaling) between the *"Q" reference points*, two directly connected IP PINXs. The *U$_Q$ channel* is used to transfer user information between the *"Q" reference points*, the two end-participant PINXs of the established Q-SIG call ("*peer to peer*"). (Ecma International, 2002), (Svrzić, 2019)

Reference configuration and specific scenarios

The PISN, the IP PINX reference configuration and the connecting IVN, are defined in ECMA-133 Standard (Ecma International, 1998). The switching and call management functions on the participating IP PINXs communicate logically via the "Q" reference point instance. This communication between two connected IP PINXs is known as an IPL (Inter-PINX link) and contains a signal D$_Q$ channel and one or more U$_Q$ channels for user information. Through an IVN, one or more IPLs can be established in many ways between the same pair of connected IP PINXs. The IP PINX connects to the IVN at the Reference point "C", which provides the connections defined as IPC between the cooperating IP PINXs. The mapping functions, which exist within each of the IP PINX, serve to map the D$_Q$ channel and U$_Q$ channels in the Reference point "Q" to one (or more) of the IPCs thus established. The concept of this standard is illustrated in Figure 5.

ECMA 336 Standard specifies mapping functions when the IVN is IP-based and when the established IPC is implemented: 1) TCP connection, which is used to transmit signal information and resource control information-RCI (Resource Control Information), and which are exchanged between the connected IP PINXs for the purpose of establishing UDP streams, and 2) establishing a pair of UDP streams, one stream in each direction, for the transmission of user information via the RTP. In doing so, one IPL requires one TCP connection, to support the D$_Q$ channel, and one pair of UDP streams, to support the U$_Q$ channels. In addition to transmitting Q-SIG protocol messages, a TCP connection is also required to transmit resource control information-RCI, which is essential for establishing a pair of UDP streams.
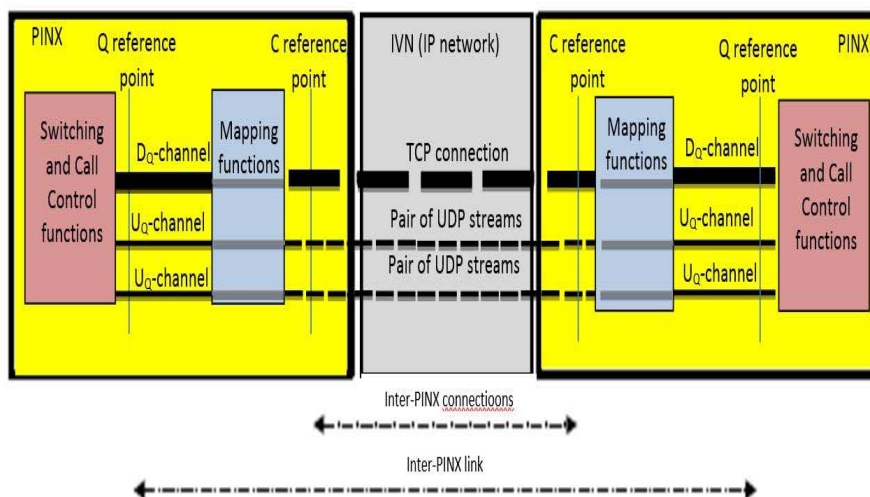
Figure 5 – IPC concept for "Semi-permanent" TCP connection (Ecma International, 2002)
Рис. 5 – Концепция IPC для «полупостоянного» TCP-соединения (Ecma International, 2002)
Слика 5 –Концепт IPC за „Semi-permanent" TCP конекцију (Ecma International, 2002)

ECMA 336 Standard supports two types of IPCs between the PINX "peers", i.e. interconnections between the participating IP PINX: 1) "on demand", where one TCP connection (for Q-SIG transmission) and a pair of UDP streams (for user information transmission) are established at the beginning of each call and deleted at the end of that call, and 2) "semi-permanent", where one TCP connection, with unlimited duration, transmits Q-SIG for many calls. In this case, a TCP connection can support zero, one or more calls at the same time, while a pair of UDP streams (for user information) is established at the beginning of each call and deleted at the end of that call. (Ecma International, 2002), (Svrzić, 2019)

Possibilities at the reference point "Q"

One *signal channel* (D$_Q$) is provided for each instance of the *Reference point "Q"*, for the transmission of the *Layer 3* protocol signal between the IP PINX, and zero, one or more user *channels* (U$_Q$) for the media streams. On this occasion, the following basic capabilities are provided for the *U$_Q$ channel*: circuit transmission mode; information transfer rate of 64 kbit/s; ability to transmit speech information or 3.1 kHz audio; and *Layer 1* user layer protocol: codec G.711 A (or "μ"), while

other carrier capabilities are outside the scope of this standard. The following basic capabilities are provided for the *Dǫ channel*: packet transmission mode; implementation-dependent information transfer rate; and ability to transmit unlimited digital information. In the special case of the interconnection "*on demand*", and when it is used only for SCIoC calls, *Uǫ channels* for media streams are not established, but only a *signaling Dǫ channel* is established. (Ecma International, 2002), (Svrzić, 2019)

Possibilities at the reference point "C"

The PINX mapping functions must meet the following requirement for a TCP connection: the IP PINX must be able to support the IP packet network interface, which is suitable for communication according to the TCP (*Transmission Control Protocol*), and according to IETF Recommendation RFC 761 (University of Southern California, 1980b). The protocol stack, used in this standard, is shown in the graph in Figure 6.

QSIG	RCI
QPKT	
TPKT	
TCP	
IP	
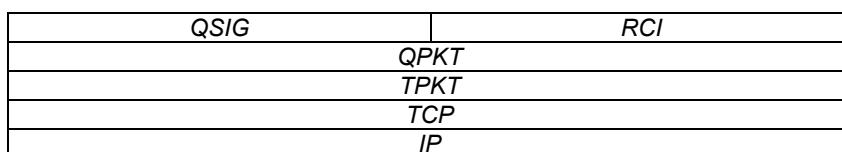
Figure 6 – Mapping protocol / IP protocol stack - Q-SIG (Ecma International, 2002)
Рис. 6 – Протокол сопоставления / IP Стек протоколов - Q-SIG (Ecma International, 2002
Слика 6 – Стек протокола за мапирање / IP - Q-SIG (Ecma International, 2002)

The TPKT is the format of the ISO Protocol package at the *top of TCP* (ITOT) defined by Recommendation IETF RFC 2126 (Pouffary & Young, 1997). It is used to delimit individual UDP messages within a TCP stream, which provides a continuous stream of octets (bytes) without explicit boundaries. The TPKT packet consists of a version number field (8 bits long), followed by one reserved field (8 bits), then a field for determining the length of the entire TPKT (16 bits), and finally the "*actual data*". The version number field contains the value *"3"*, while the reserved field contains the value *"0"*. The length determination field should contain information about the length of the entire TPKT package, which includes: the version number field, the reserved and the length field, as well as the large final 16-bit codeword ("*actual data*").

The QPKT is a packet format consisting of a "*len*" length field (of 16 bits), followed by an entire Q-SIG message, followed by the RCI. The

RCI parameter provides the information needed to establish the path (s) of the media stream. The first octet of the Q-SIG message will be immediately after the "*len*" length field, while its last octet will be the octet immediately preceding the RCI. The "*len*" field is important because it indicates the length of the Q-SIG message and thus indicates the beginning of the RCI. In cases where no stream media is established, the RCI field may be omitted.

At the *Reference point "C"*, the *Dǫ channel* is mapped to a known TCP port ("*4029*") or to a dynamically assigned port, and the RCI parameter must comply with the *Annex B*, *ECMA-336*.

The PINX mapping functions must meet the following requirements for UDP streams: *Uǫ channels* are mapped to receive UDP and transmit UDP streams, each of which carries RTP packets. The receiving UDP stream must be received at the local IP address and the port, as indicated in the broadcast RCI, and the transmitting UDP stream is transmitted to the remote IP address and the port, as indicated in the received RCI. The IP PINX can use the RTCP to monitor the quality of the RTP transmission over the UDP streams, as defined in IETF Recommendation RFC 1889 (Schulzrinne et al, 1996). (Ecma International, 2002), (Svrzić, 2019)

Functions for Dǫ and Uǫ channel mapping

When an IPC is established at the *Reference point "C"*, the functions for mapping *Dǫ* and Uǫ *channels* are implemented. For the *Dǫ channel* transmission, the complete Q-SIG message and the RCI will be embedded in the QPKT packet within the TPKT packet, which means that the segmentation and reassembly procedures of Q-SIG messages, provided by ECMA-143, will not be used. The RCI parameter implicitly refers to the same call as the Q-SIG message, so it will be included in the first forwarded and the first remaining Q-SIG message of each call and will no longer be included in subsequent messages. The RCI parameter will not be included in the messages transmitted during *Q-SIG calls* of the SCIoC type.

Each *Uǫ channel* must be mapped to a pair of one-way UDP streams, with the appropriate transport capabilities defined by the RCI. The mapping function is responsible for proper packaging, unpacking, transcoding, etc. media data. (Ecma International, 2002), (Svrzić, 2019)

IPC control functions

Procedure for establishing and deleting Dǫ channels

To establish an IPC for a *Dǫ channel*, the calling IP PINX, which initiates the TCP connection, must know the IP address of the second-

called IP PINX. For the "*on demand*" scenario, the calling IP PINX will establish a TCP connection for the *Dq channel* following the procedure specified by IETF Recommendation RFC 761 (University of Southern California, 1980b), and whenever necessary establish or delete a *basic Q-SIG call* or SCIoC type call.

For a "*semi-permanent*" scenario, when a *basic Q-SIG call* or a SSIoC needs to be established, if there is already a previously established *Dq channel* (or TCP connection) between the end IP PINXs, the *calling IP PINX* will use that *Dq channel*. If there is no already established *Dq channel* between the end IP PINXs, the *calling IP PINX* will establish a TCP connection for the *Dq channel* following the procedure specified by RFC 761 (University of Southern California, 1980b). The issue of implementation was previously mentioned, and it refers to the moment when the TCP connection should be deleted, since it is important that it is not deleted while it is still used for *Q-SIG call* or SCIoC *connection.* (Ecma International, 2002), (Svrzić, 2019)

Procedure for establishing and deleting Uq channels

The establishment of a *Uq channel* will occur each time a *Q-SIG call* is established, when both the *calling* and *called IP PINX* will send an RCI in accordance with the *Annex B*, *ECMA-336*. The *calling IP PINX* will transmit the RCI in the same QPKT packet as the Q-SIG message: "SETUP". The *called IP PINX* will check if the received RCI information is acceptable and if so, it will forward the RCI in the same QPKT return packet as the Q-SIG message: "SETUP ACKNOVLEDGE" or "CALL PROCEEDING", whichever is first transmitted. Also, if the first response to the message "SETUP" is not "SETUP ACKNOVLEDGE", nor "CALL PROCEEDING" (but, for example, "RELEASE COMPLETE"), the RCI information will not be returned to the *calling IP PINX*. After transmitting the RCI information, the *calling IP PINX* will be ready to receive the RTP packet at the IP address and the port specified in its transmitting RCI information.

The *called IP PINX* will include in its transmitting RCI the same type of codec and payload period, as specified in the RCI information previously received from the *calling IP PINX*. After sending the RCI, and as soon as the media stream becomes available, the *called IP PINX* will start transmitting RTP packets to the IP address and the port which are specified in the received RCI, and according to the codec type and payload period, as specified in the received RCI . The *called IP PINX* will also be prepared to receive RTP packets at the IP address and the port specified in its transmitting RCI.

After receiving the RCI parameter in the first response message, and after receiving the Q-SIG message "CONNECT", the *calling IP PINX* will start transmitting RTP packets to the IP address and the port which are specified in the received RCI, and according to the type codec and payload period, also specified in the received RCI. If, when establishing a *Uq channel*, any IP PINX (*calling* or *called*) receives unacceptable content in the RCI, that IP PINX will behave as specified in ECMA-143, in case the content of the channel identification information element is unacceptable.

Before sending a *Q-SIG call* clear message ("DISCONNECT", "RELEASE" or "RELEASE COMPLETE"), the IP PINX will stop transmitting RTP packets and ignore the contents of any further received RTP packets. After transmitting or receiving the Q-SIG message "RELEASE COMPLETE", the IP PINX should release the resources associated with the *Uq channel.* (Ecma International, 2002), (Svrzić, 2019).

Conclusion

The important standards *ECMA-355*, for *tunneling encapsulated messages from Q-SIG*, and *ECMA-336*, for *defining mapping functions in PISN switching systems*, were used to organize automatic telephone traffic in the SAF, connecting two modern transit IP PINXs via the SIP transmission beam, through its own IP network (*Intranet*) in the part of the Automatic Telephone Network SAF, which is a novelty in the organization and functioning of its PTN (Svrzić et al, 2019a), (Svrzić et al, 2019b). The use of the CCS network signaling system type Q-SIG, previously applied and proven in practice, via its tunneling and transmission without degradation through the mentioned IP network with the SIP (*encapsulation of Q-SIG messages in SIP dialogue messages*), contributed to the PATN SAF without degrading the previously built PISN status, including parts where its TDM/ISDN parts connect to the *IP Proxy*. In this regard, it can be said that high integration has been achieved today in the PATN SAF, both in terms of complete independence from various ISDN PBAX manufacturers, and in terms of achieving the planned scope of implementation of basic and complementary customer services and network services specified by relevant ECMA standards for Q -SIG. Basic and complementary customer services and network services have now become available to PATN SAF users, regardless of which network switching node they are connected to.

In addition to the above, the new solution using the IP network to connect IP PINXs using the Q-SIG tunneling procedures, in the PATN SAF (Svrzić et al, 2019a), (Svrzić et al, 2019b), opens up a whole range of new possibilities that will undoubtedly contribute rapidly to the growth of the *Core network* and their application, creating a broad backbone of the system for the implementation of real-time multimedia communications and the transition to unified communications UC (*Unifed Communications*).

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ОПИСАНИЕ ПРОЦЕССА ТУННИЛИРОВАНИЯ Q-СИГНАЛОВ В ЧАСТНЫХ ТЕЛЕКОМУНИКАЦИОННЫХ СЕТЯХ

Сладжан М. Сврзич[а], *Зоран* М. Миличевич[б],
Зоран С. Перишич[б]

[а] ООО "Тесла системи", г. Белград, Республика Сербия, **корреспондент**

[б] Вооруженные силы Республики Сербия, Генеральный штаб, Управление информатики и телекоммуникаций (J-6), г. Белград, Республика Сербия

Резюме:

Введение/цель: Цель статьи заключалась в составлении классификации видов сетевой сигнализации Q-SIG, которая специально приспособлена к применению в цифровых телекоммуникационных сетях с интегрированными услугами (ISDN), и в выявлении возможностей ее дальнейшего применения в частных телекоммуникационных сетях с интегрированными услугами Вооруженных сил Республики Сербия (PISN SAF), т.е. в частной автоматической телефонной сети Вооруженных сил Республики Сербия (PATN SAF)

Методы: В статье приведен анализ существующих стандартов: ECMA-355 и ECMA-336 и синтезирования возможностей их применения в PATN SAF.

Результаты: Процедура применения Q-SIG обрабатывалась в ситуации, когда периферийные части PISN SAF, действующие по принципу передачи и коммутации каналов по TDM (Time Division Multiplexing), были соединены через центральное ядро сети с IP (Internet Protocol), работающей по принципу передачи пакетов и коммутации с помощью SIP (Session Initiation Protocol). Разработан метод применения туннелирования инкапсулированных сообщений Q-SIG через IP-сеть, предписанный Стандартом ECMA-355. В статье также описаны необходимые функции для сопоставления передачи туннелируемых сигнальных сообщений Q-SIG и сопоставления голосовой (и другой аудио) информации с медиапотоками во время связи VoIP (Voice over IP) через ту сеть, в соответствии со стандартом ECMA-336.

Выводы: Применение стандартов ECMA-355 и ECMA-336 − это новое решение в PATN SAF при использовании IP-сети для подключения IP PINX и при применении туннелирования Q-SIG и сопоставления функций отображения и передачи, в том числе звуковых сигналов. Это влечет за собой целый ряд новых возможностей, которые по мере роста ядра сети и по мере их применения будут способствовать созданию широкой магистрали телекомуникационно-информационной системы связи для осуществления мультимедийной коммуникации в реальном времени и переходу к унифицированной системе связи (UC).

Ключевые слова: Q-сигнализация, PISN, PINX, интернет-протокол, SIP, стандарт ECMA, туннелирование Q-SIG, инкапсуляция, функции отображения.

ОПИС ПОСТУПКА ТУНЕЛОВАЊА Q СИГНАЛИЗАЦИЈЕ У ПРИВАТНИМ ТЕЛЕКОМУНИКАЦИОНИМ МРЕЖАМА

Слађан М. Сврзић[а], *Зоран* М. Миличевић[б],
Зоран С. Перишић[б]

[а] Тесла системи д.о.о., Београд, Република Србија, **аутор за преписку**

[б] Војска Србије, Генералштаб, Управа за телекомуникације и
    информатику (J-6), Београд, Република Србија

ОБЛАСТ: телекомуникације
ВРСТА ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: У чланку је специфицирана мрежна сигнализација типа Q-SIG, која је стандардизована специјално за примену у дигиталним телекомуникационим мрежама интегрисаних сервиса (ISDN), уз потенцирање могућности за њену даљу употребу у Приватној телекомуникационој мрежи интегрисаних услуга Војске Србије (PISN ВС), односно у Приватној аутоматској телефонској мрежи Војске Србије (ПАТлМр ВС).

Методе: Вршена је анализа постојећих стандарда: ECMA-355 и ECMA-336 и синтеза могућности њихове примене у ПАТлМр ВС.

Резултати: Обрађен је поступак за примену Q-SIG у ситуацији када се рубни делови PISN ВС, који функционишу на принципу преноса и комутације кола по TDM (Time Division Multiplexing), повезују путем централне Core мреже са IP (Internet Protocol), а која функционише на принципу преноса и комутације пакета са SIP (Session Initiation Protocol). Разрађен је начин примене поступка тунеловања енкапсулираних Q-SIG порука кроз IP мрежу, који је дефинисан стандардом ECMA-355. Описане су неопходне функције за мапирање преноса тунелованих сигнализационих порука Q-SIG и мапирање говорних (и других аудио) информација на медија-токове током VoIP (Voice over IP) комуникације кроз ту мрежу, а које су дефинисане стандардом ECMA-336.

Закључак: Примена стандарда ECMA-355 и ECMA-336 ново је решење у ПАТлМр ВС уз коришћење IP мреже за повезивање IP PINX, применом поступака туневловања Q-SIG, и мапирање функција за њихов пренос и пренос аудиосигнала. То отвара читав низ нових могућности које ће нарастањем Core мреже и њеном применом убрзано допринети стварању широке окоснице телекомуникационо-информационог система ВС и послужити за имплементацију мултимедијалних комуникација у реалном времену и прелазак на обједињене комуникације UC (Unified Communications).

Кључне речи: PATIMr VS, Q-сигнализација, PISN, PINX, интернет протокол, SIP, стандард ECMA, туневловање Q-SIG, енкапсулација, мапирање функција.

MODELLING AND PERFORMANCE ANALYSIS OF THE BVP M-80A HYBRID DRIVE

Stefan V. Milićević[a], *Slavko* R. Muždeka[b]

[a] Serbian Armed Forces, Central Logistics Base, 1st Logistics center,
  Belgrade, Republic of Serbia,
  e-mail: stefanm9670@gmail.com, **corresponding author**,
  ORCID iD: https://orcid.org/0000-0003-4837-9067

[b] University of Defence in Belgrade, Military Academy, Department of
  Mechanical Engineering, Belgrade, Republic of Serbia
  e-mail: slavko.muzdeka@va.mod.gov.rs,
  ORCID iD: https://orcid.org/0000-0002-6189-9473

Abstract:

Introduction: Hybrid technology has been successfully incorporated into the industry of passenger and commercial vehicles. Driven by the success and benefits that hybrid technology brings, many defense organizations around the world invest in the development of hybrid technology for combat vehicles and develop prototypes of tracked combat vehicles which have lower fuel consumption, better performance, better exhaust emission, and additional onboard electric power. However, various technical challenges must be resolved before it comes to the introduction of hybrid tracked combat vehicles in operational use. Several successful tests of prototypes have been conducted so far, but there are still restrictions on key technologies such as electric motors, electronics, and storage of electricity. In such conditions, where finance is limited, mistakes cannot be allowed nor spending a lot of resources on planning, building prototypes, and testing.

Method: Therefore, it is clever to run the simulation software with which it is possible to examine various parameters in simulated conditions which more or less mimic real operating conditions. This paper aims to show one of possible solutions concerning the selection of appropriate technologies of hybrid drive, to propose a system solution for a hybrid BVP M80A, and to display a simulation hybrid drive model and the results obtained from the model devised in Simulink.

Results: The results obtained by the simulation show that the proposed hybrid drive solution provides better performance while retaining key drivetrain elements of the vehicle.

Conclusion: Only turning parameters are considered during the simulation but it is clear that the hybrid drivertrain has advantages related to straight-line motion as well. Also, sound projections about the drivetrain performance and control can be made with the use of the proposed model.

Key words: hybrid drive, combat vehicle, tracked vehicle performance, hybridization, MATLAB, Simulink.

Introduction

In the case of wheeled vehicles, in general, the drive (propulsion) and steering functions are separated and the change of direction does not significantly affect the traction and braking performance of the vehicle. In contrast to this, in the case of tracked vehicles, the steering control is performed by achieving a difference in the speed of rewinding of the tracks, i.e. lateral drift. This way of steering significantly affects the traction performance of the vehicle because, as a rule, the resistance when making turns increases compared to the straight-line movement. Also, the control function built into the power transmission system affects the load distribution and power balance within the power transmission system itself (Muždeka et al, 2004). The turning performance and the effects of various elements of the transmission design on the performance have been the subject of numerous research papers. However, vehicle hybridization, which has recently experienced rapid development in the military industry, raises many unanswered questions (Khalil, 2009). Numerous states and defense organizations, guided by the advantages of hybrid vehicles such as improvement of mobility and fuel economy, higher specific power, silent mobility and silent watch capabilities, enhancement of onboard electric power generation, etc. invest significant resources in the development and testing of prototype hybrid vehicles (Bhatia, 2015), (Kramer & Parker, 2011), (Dalsjø, 2008). Some papers deal with the design of such vehicles (Johnson & Dueck, 2001), (Nederhoed & Walker, 2009) but, to the best of the authors'knowledge, there are no papers that deal with the performance of such a vehicle except one paper (Taira et al, 2018). The paper presents the conceptual hybrid drive solution for the infantry fighting vehicle BVP M-80A, analyzes the power flow, defines the model of turning resistance acting on the vehicle implemented in the Matlab Simulink software environment, and develops a model for simulating the vehicle drivetrain. The results of the comparative analysis of the symmetrical and asymmetrical turning mechanisms are presented because hybrid drive

enables a selection of the kinematic parameter. The introduction is an introductory part of the article.

Influence of hybrid drive on the turning system

In addition to the advantages hybrid drive offers, which relate to the specific power of the vehicle, additional onboard electric power to meet power requirements of the vehicle subsystems and armament, silent mobility, etc., the question arises as to how vehicle hybridization affects the turning system and the turning performance. One of the assumptions is that, due to the existence of a braking force on the inner track, electricity will be generated during the turn because the electric motor will act as a driven machine - generator. Also, if it is made with two electric motors, hybrid drive allows not only an infinite number of calculated turning radii but also the possibility of choosing the kinematic turning parameter.

There are several possible conceptual solutions for the hybridization of the BVP M80A drive, and in this paper a solution was chosen that should not imply radical design changes to the conventional transmission. Therefore, it is a parallel hybrid architecture, with two electric motors installed in the auxiliary drive. The kinematic schemes of both conventional and hybrid transmissionsare given in Figure 1.

Unlike the conventional transmission, described in detail in (Vesić & Muždeka, 2007), which has a single-stage transmission in the auxiliary drive, the hybrid transmission has two independent power sources in the auxiliary drive in the form of two electric motors. The change in the rewinding speed of tracks is achieved by activating one or both electric motors whose angular velocities can be precisely controlled. For this reason, such a transmission offers several possibilities that the conventional transmission cannot fulfill. First of all, electric motors are additional drive units and thus increase the specific power of the whole vehicle, enabling the vehicle to overcome higher resistances or to achieve better acceleration, etc. Since two electric motors with a precise adjustment of their angular velocities are in the auxiliary drive as two independent drive units, it is possible to provide an infinite range of turning radii without power losses due to friction in the transmission elements. Also, since electric motors can easily change the angular velocity direction, such a turning system can be both symmetrical and asymmetrical, depending on the control method. If the electric motor of the outer track is held stiff, and the electric motor of the inner track is acted upon by the electric motor in the sense of reducing the speed of

rewinding, it is an asymmetrical turning system. If the electric motors are acting upon the outer and inner track with the same angular velocity intensity, but in the opposite direction, it is a symmetrical turning system.
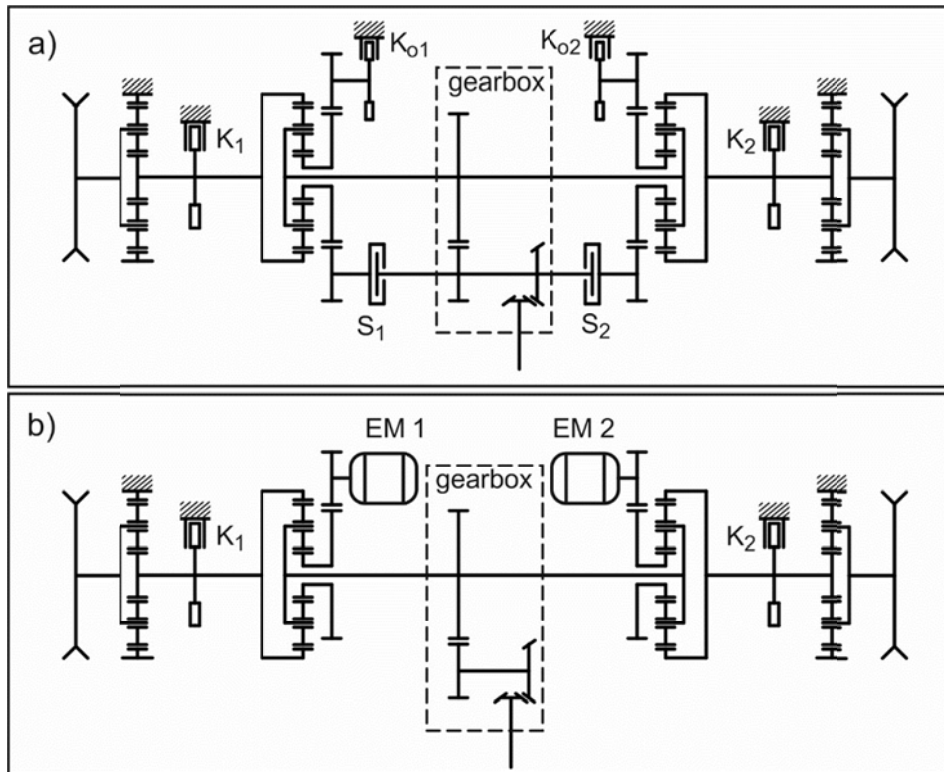
Figure 1 – Kinematic scheme of the conventional (a) and the hybrid (b) drive system
Рис. 1 – Кинематическая схема конвенционального (а) и гибридного (б) приводного двигателя
Слика 1 – Кинематска шема конвенционалног (а) и хибридног погона (b)

This fact is very important from the aspect of performance. The possibility of simulating the vehicle turn by using both system types opens up a possibility of comparing the performance of turning and making a conclusion about which control algorithm for electric motors is the best.

Power flow analysis

The electric motors can fine-tune angular velocity, in both directions, independent of the internal combustion engine (ICE) which means that electric motors can have a wide range of angular velocities, from a

maximum angular velocity with a negative sign to a maximum angular velocity with a positive sign without any dependence on the ICE. For that reason, when determining power flows, it is necessary to pay attention to the direction of the sun gear angular velocity and to the possibility that the sun gear angular velocity is that much higher than the carrier angular velocity that the ring gear angular velocity changes direction. This case is precisely the flexibility offered by the independent auxiliary drive that gives the option to select (adjust) the kinematic turning parameter.

Since vehicle turns are most often performed with a turning radius smaller than the radius at which the inner track force equals zero ("free" radius Rs), power flow was analyzed only for that case. The power flow when turning with a radius smaller than Rs is shown in Figure 2.
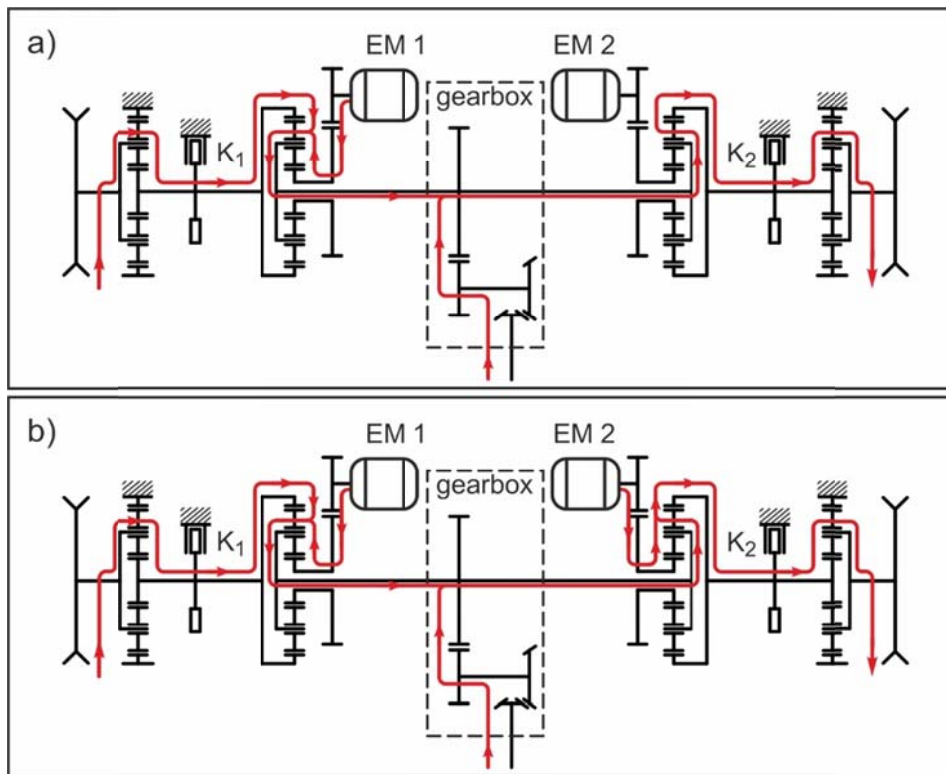
Figure 2 – Power flow during asymmetrical (a) and symmetrical turning (b) at a turning radius smaller than Rs
Рис. 2 – Поток мощности при асимметричном (а) и симметричном вращении (б) при радиусе поворота меньше Rs
Слика 2 – Токови снаге код несиметричног (а) и симетричног заокрета (b) са полупречником мањим од слободног Rs

In the case of an asymmetrical turn with a radius smaller than Rs, the power flow is identical to the conventional transmission for the radius at which there is no power loss due to friction in the drivetrain (the "calculated" radius Rp). The calculated radius is achieved by activating the clutch S1 (Figure 1a), with the difference that the auxiliary drive supplies the electric motor power and not the ICE power as in the conventional transmission. The recuperation power from the inner track, which enters the transmission via the ring gear, is added to the power of the auxiliary drive and transmitted to the outer track via the driven gearbox shaft. In the case of a turn with a radius greater than Rs, the power of the ICE is divided into two when it reaches the carrier; one part goes to the sun gear while the other part goes to the ring gear, where the electric motor works as a generator. The situation on the planetary gear set of the outer track is the same in both cases as in the case of the straight-line motion when the vehicle is powered only by the ICE.

The hybrid transmission, unlike the conventional one, offers several flexibilities that can be used in a turn: in addition to the classic asymmetric turn with inner track deceleration, it is possible to achieve an asymmetric turn with outer track acceleration, as well as a symmetrical turn. The possibility of an asymmetrical turn with the acceleration of the outer track is not justified due to high power demand, but the possibility of a symmetrical turn certainly enables the improvement of the vehicle's turning flexibility and performance.

With a symmetrical turn, the case with the inner track is the same as with the asymmetrical turn, where the rewinding speed of the inner track decreases, but the case with the outer track is not. For the outer track to accelerate, it is necessary for the sun gear of the planetary gear set to be driven with a velocity of the negative sign. In this case, the drive of the outer track is done by summing the power of the outer track electric motor and the ICE power in the main drive.

What attracts attention in the analysis of power flow is the fact that there is no regenerative braking during a turn with a radius smaller than Rs. With this kinematic configuration of the transmission, regenerative braking is achieved only at turns with a radius greater than Rs, but since the vehicle is in such a mode for a very short time, regenerative braking would be negligible.

Hybrid drivetrain model

In order to analyze the performance of different variants of hybridized transmission operation, a Simulink model of the M80A infantry

fighting vehicle drive compartment with the hybridized transmission was developed. The basic structure of the drive group model is shown in Figure 3. Before the formation of the drive group simulation model, the basic components of the electric drive were selected, which is described in more detail in (Milićević, 2019).
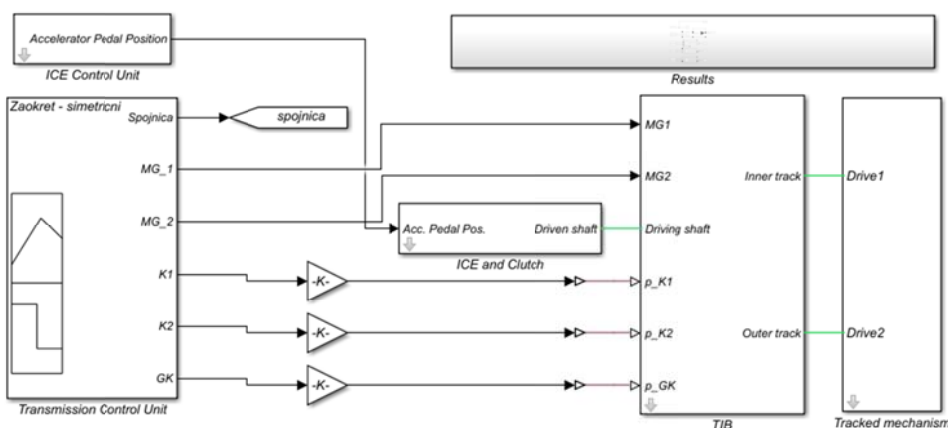
Figure 3 – BVP M-80A hybrid drive topology in Simulink
Рис. 3 – Структура имитационной модели гибридного двигателя БВП М-80А
Слика 3 – Структура симулационог модела хибридног погона БВП М-80А

Drivetrain model control is achieved with the "ICE Control Unit" and "Transmission Control Unit" blocks. The key element of the "ICE Control Unit" block is the standard Simulink *Longitudinal Driver block* based on literature (MacAdam, 1980). The main function of this block is to define the required speed of the vehicle, which is achieved by adjusting the accelerator pedal position so that the preset speed is reached as soon as possible. The transmission control unit is modeled in the form of control signals which adjust the transmission parameters according to a predefined scenario. As the subject of the paper is not the automation of electric motor control, it was adopted to control them by speed signals that are set according to the predefined control scenario. In addition to the signals controlling the electric motors, the block also includes the control signals for the clutch and the main brakes. The clutch control signal allows the simulation of the vehicle when it starts to accelerate from the point of zero velocity, while the brake control signals in this particular simulation are not used, since brakes are not activated in the considered turning mode.

The "ICE and Clutch" block consists of a standard Simulink *Generic Engine* block and a hydraulically activated friction clutch model (Krsmanović, 2008), (Grkić et al, 2009). The ICE parameters are set in accordance with the power curve of the BVP M80A engine (10V003), with the initial angular speed of 900 min^{-1} and the regulation of the maximum speed at 2500 min^{-1}. The friction clutch model contains a standard Simulink block *Fundamental Friction Clutch* with parameters selected so that it is possible to simulate the acceleration of the vehicle from the point of zero velocity, without in-detail dealing with the process of engaging the clutch.

The *TIB* block (Figure 4) includes the mechanical transmission elements and the auxiliary electric drive. The gearbox is modeled as a gear pair because the simulation involves movement in one gear, and the parameters of the gears (gear ratios) correspond to the parameters of the real transmission. The only difference between the mechanical model shown in Figure 4 and the real model is the KM brake which simulates the braking of the ICE drive shaft in the case of starting the vehicle from the place only by employing an electric motor. Also, the main brakes K1 and K2 were modeled within the transmission model.
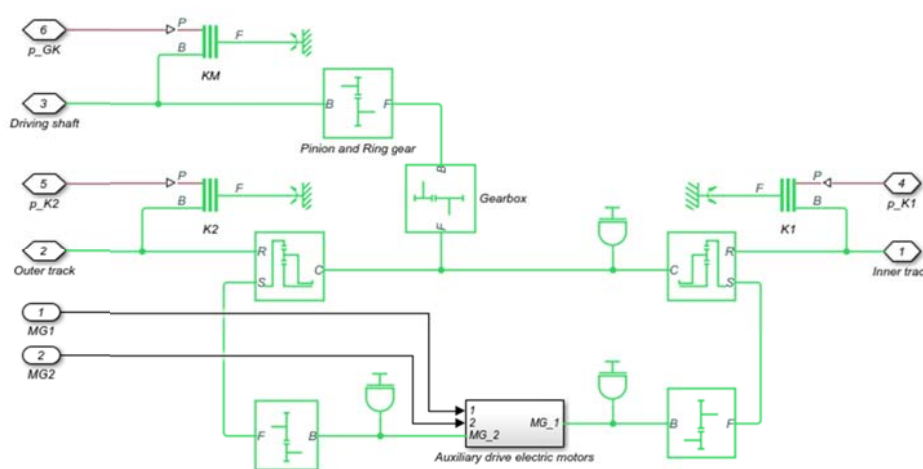
Figure 4 – TIB (Transmission in Block) model in Simulink
Рис. 4 – Модель ТВБ (трансмиссия в блоке) в Simulink
Слика 4 – Модел ТУБ (трансмисије у блоку) у Simulink-у

The "Auxiliary drive electric motors" block includes a power supply unit (battery) and electric motors. For the battery model whose scheme is shown in Figure 5, an existing generic lithium-ion battery model was

71

adopted (Balch et al, 2001), (Gao & Ehsani, 2012), represented by the equations (Tremblay & Dessaint, 2009):

– discharge model (i* > 0)

$$f_1\left(i_t, i*, i\right) = Eo - K \cdot \frac{Q}{Q - i_t} \cdot i* - K \cdot \frac{Q}{Q - i_t} \cdot i_t + A \cdot e^{(-B \cdot i_t)} \qquad (1)$$

– charge model (i* < 0)

$$f_2\left(i_t, i*, i\right) = Eo - K \cdot \frac{Q}{i_t + 0.1 \cdot Q} \cdot i* - K \cdot \frac{Q}{Q - i_t} \cdot i_t + A \cdot e^{(-B \cdot i_t)} \qquad (2)$$

And the battery charge status (State of Charge - SOC%) is calculated from the following equation:

$$SOC = 100 \left(1 - \frac{1}{Q} \int_0^t i(t) dt \right) [\%] \qquad (3)$$

where: E_0 - constant voltage [V]; K - polarization constant[V/Ah], or polarization resistance [Ω]; $i*$ - low-frequency current dynamics [A]; i - battery current [A]; i_t - extracted capacity [Ah]; Q - maximum battery capacity [Ah]; A-exponential voltage [V]; and B - exponential capacity [Ah^{-1}].
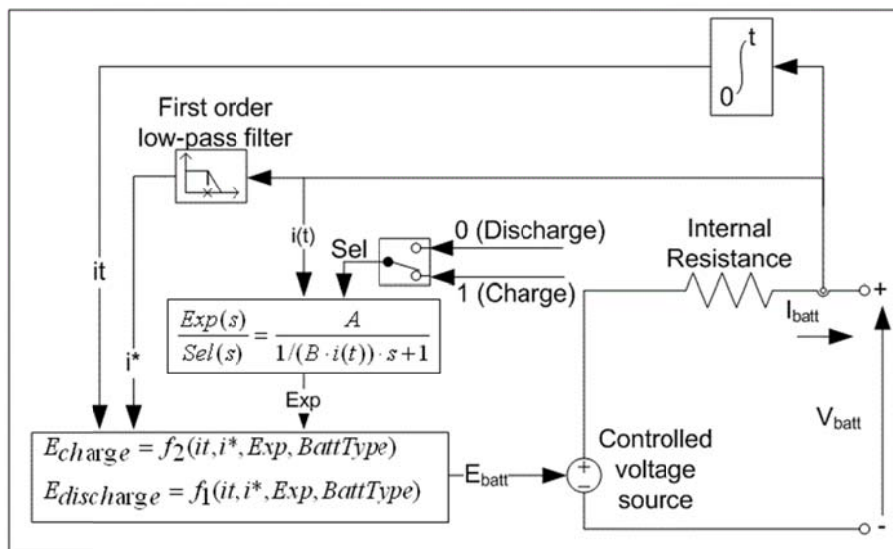
Figure 5 – Equivalent battery circuit presented by equations (1), (2), and (3)
Рис. 5 – Эквивалентная схема модели батареи, представленная уравнениями (1), (2) и (3)
Слика 5 – Еквивалентно коло модела батерије представљене једначинама (1), (2) и (3)

The electric motor model is a *DTC Induction motor drive* model from the Simulink library modified so that its input is direct current. In Figure 6, a block diagram of a drive with the DTC control is displayed (Rosić, 2016).
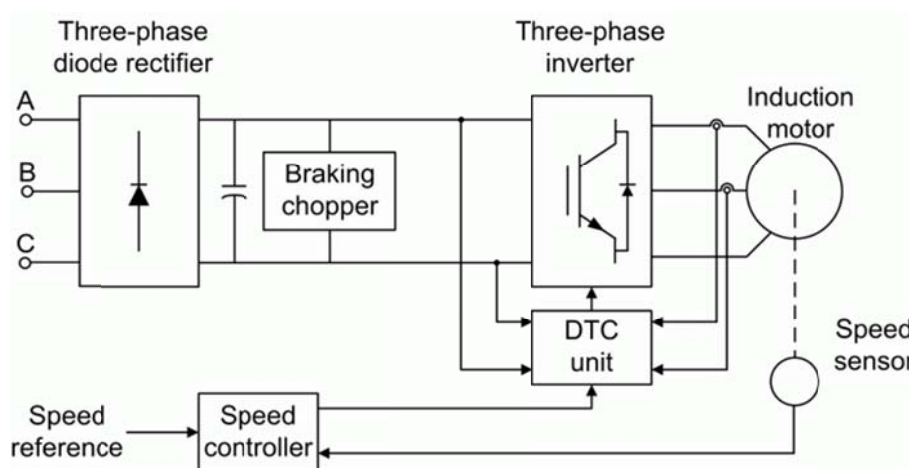
Figure 6 – Block diagram of the conventional DTC drive
Рис. 6 – Эквивалентная схема модели батареи
Слика 6 – Еквивалентно коло модела батерије

The "Tracks" block (Figure 7) is a subsystem of the Simulink model which represents resistance loads of the drive compartment, i.e. the resistance to the movement of the vehicle when performing a turn. Resistances to movement have a complex nature and depend on the type of soil, slope, distribution of specific pressures on the soil, turning radius, etc. (Muždeka et al, 2004). For this paper, a simplified turning resistance model is considered in the analysis of turning performance with the following assumptions:

- the turn is achieved on a hard horizontal surface, at low speed, so that the influence of the centrifugal force is not considered,
- the center of gravity is in the middle of the contact surface of the track so that the specific pressure of the track on the soil is rectangular, and
- track slip under the influence of the brake and traction forces is not considered.
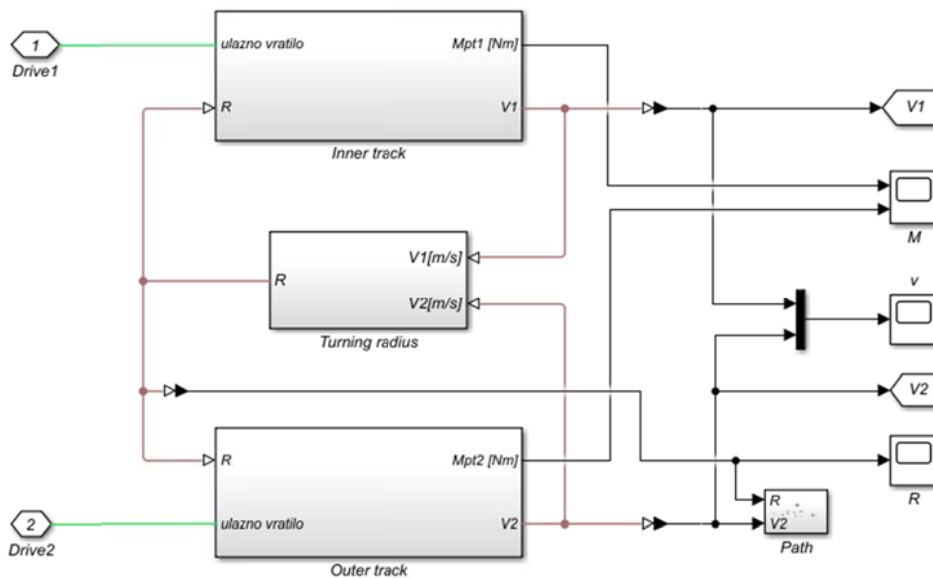
Figure 7 – Simulink model of tracks
Рис. 7 – Simulink модель гусеничных лент
Слика 7 – Simulink модел гусеничних кретача

The turning radius of a tracked vehicle is obtained from the following equation:

$$R = \frac{B}{2} \cdot \frac{v_2 + v_1}{v_2 - v_1} \qquad (4)$$

where: *V1, V2* – the rewind speed of the inner and outer tracks and B – the track width.

Figure 8 shows the forces acting on the vehicle during turning under the conditions described above. Based on the presented mechanical model, the equations for determining the required forces on the tracks are obtained as follows:

$$F_2 = R_{k2} + \frac{M_c}{B}$$

$$F_1 = R_{k1} - \frac{M_c}{B} \qquad (5)$$

where: R_{k1}, R_{k2} – the straight-line motion resistance and M_c – the turning resistance.
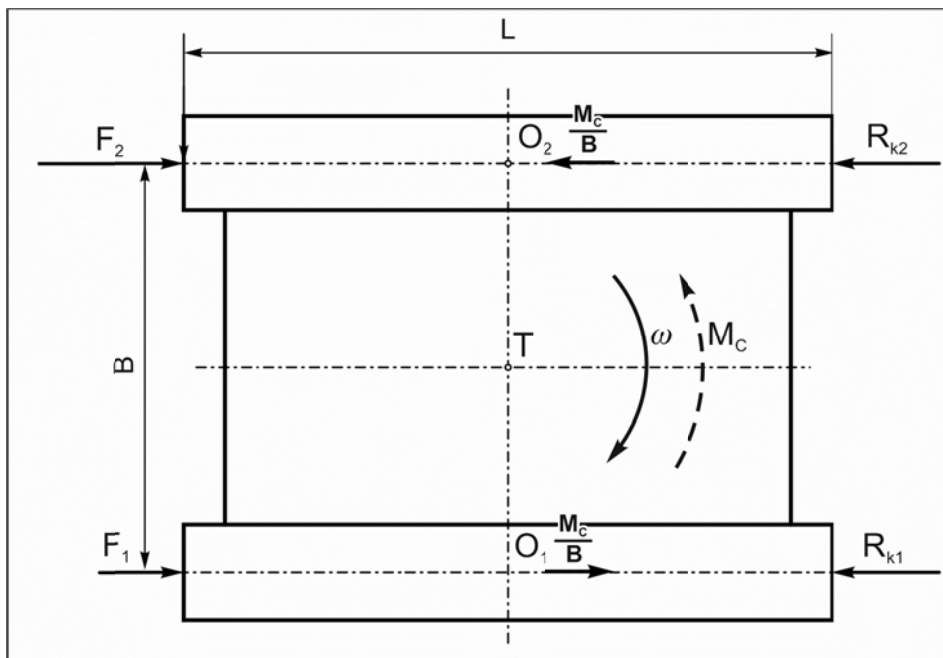
Figure 8 – Forces and moments acting on the tracked vehicle during a steady state turn
Рис. 8 – Силы и моменты, действующие на гусеничной машине во время
поворота
Слика 8 – Силе и моменти који делују на гусенично возило приликом заокрета

In the case of the uniform turn of the tracked vehicle at low speeds on a horizontal surface, the straight-line motion resistances, which are a consequence of the surface deformation, are calculated from the expressions:

$$R_{k1} = fN_1$$
$$R_{k2} = fN_2$$
(6)

where: f – the rolling resistance coefficient (adopted value $f = 0.07$) and N_1, N_2 – the surface reaction forces.

For the considered case of turning, the normal surface reactions are equal to half the weight of the vehicle:

$$R_{k1} = R_{k2} = f\frac{G}{2}$$
(7)

The turning resistance is obtained as follows:

$$M_c = \frac{\mu G L}{4} \qquad (8)$$

where: μ – the turning resistance coefficient and G, L – the vehicle weight and the contact surface length, respectively.

The turning resistance coefficient μ (Nikitin & Sergeev, 1962) is calculated using the following expression:

$$\mu = \frac{\mu_{max}}{a + (1-a)\left(\dfrac{R}{B} + \dfrac{1}{2}\right)} \qquad (9)$$

where: R – the turning radius; μ_{max} – the coefficient value when $R = \dfrac{B}{2}$ (adopted value $\mu_{max} = 0,85$), and a – the experimental coefficient ($a = 0.8 \div 0.85$, adopted value $a = 0.85$).

After adopting the values of the coefficients, the final expression for the coefficient of resistance to rotation is obtained:

$$\mu = \frac{0.85}{0.85 + 0.15\left(\dfrac{R}{B} + \dfrac{1}{2}\right)} \qquad (10)$$

The final inner and outer track forces expressions:

$$\begin{aligned}
F_2 &= R_{k2} + \frac{M_c}{B} = \frac{fG}{2} + \frac{\mu G L}{4B} \\
F_1 &= R_{k1} - \frac{M_c}{B} = \frac{fG}{2} - \frac{\mu G L}{4B}
\end{aligned} \qquad (11)$$

The track forces are radius dependent as shown in Figure 9. It can be seen that the outer track force has a positive sign, i.e. it is a tractive force at all turning radii, while the inner track force is a tractive force at radii larger than Rs, while it is a braking force at smaller ones.
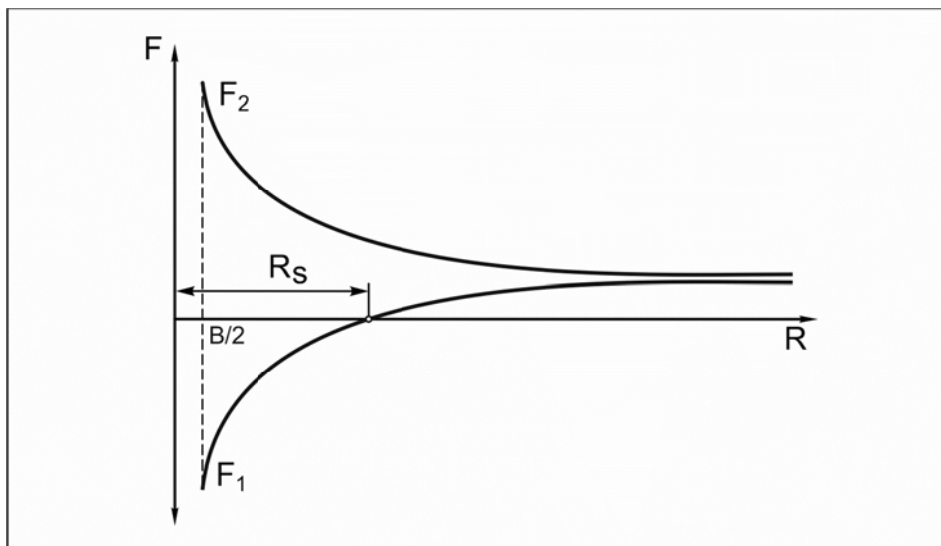
Figure 9 – Dependence relation of the track forces on the turning radius
Рис. 9 – Зависимость силы не гусеничной ленте от радиуса поворота
Слика 9 – Зависност сила на гусеницама од полупречника заокрета

In addition to external resistances, internal resistances have an important influence on the tracked vehicles' power balance. For a vehicle performance analysis, losses in transmission and electric motors can be neglected, but losses in the tracked mechanism cannot, so they are taken into account through the efficiency coefficient of the tracked mechanism. The efficiency coefficient of the tracked mechanism in the general case depends on the magnitude of the force on the track, the speed of movement, the type of hinge, and the like. A simple calculation can use a linear dependence from the equation (Muždeka et al, 2004)

$$\eta_{gm} = 0.95 - 0.018 \cdot V \qquad (12)$$

where: η_{gm} – the efficiency coefficient of the tracked mechanism and V – the vehicle speed.

To be able to simulate the impact of losses in the tracked mechanism, it is necessary to express the efficiency coefficient in relation to the torque. In the case where the force on the track is tractive, the losses in the tracked mechanism increase the required power, so that the

torque at the sprocket wheel that represents the resistance is increased and calculated from the expression:

$$M_{pt} = \frac{F_i \cdot r_{pt}}{\eta_{gm}}$$

(13)

In the case where there is a braking force on the track, the resistances of the tracked mechanism cause the torque at the sprocket wheel to be reduced and calculated from the expression:

$$M_{pt} = F_i \cdot r_{pt} \cdot \eta_{gm}$$

(14)

On the outer track, the torque on the sprocket wheel is always calculated from expression (13), and on the inner track from expressions (13) and (14), depending on the sign of the force on the track. The block diagram of the load model on the inner track is shown in Figure 10.
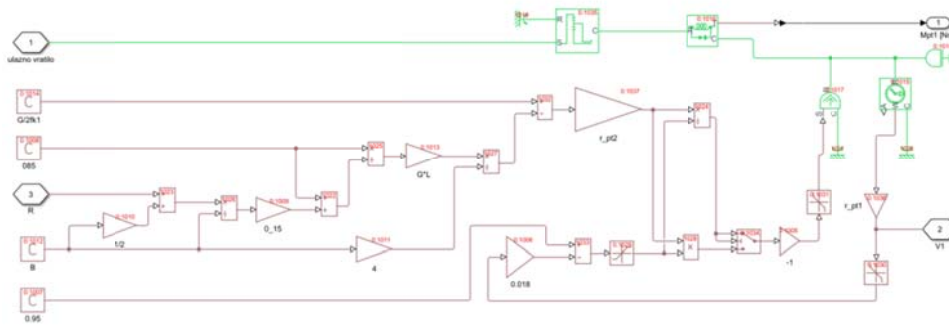
Figure 10 – Inner track load model
Рис. 10 – Модель сопротивления на внутренней гусенечной ленте
Слика 10 – Модел отпора на унутрашњој гусеници

Simulation results

Based on the developed model, the simulation of the vehicle movement with the hybridized transmission during turning was performed. In order to see the hybridization influence on the turning performance, a simulation was performed in three motion modes: turning with the deceleration of the internal track - asymmetric turn (case A), turning with the deceleration of the inner and acceleration of the outer track, with a turning radius as in the previous case - symmetrical turn with a lower initial speed (case B), and turning with the deceleration of the inner and acceleration of the outer track but without reducing the speed of the vehicle - symmetrical turn (case C). The first case is completely

78

equivalent to the behavior of the conventional transmission and it is a reference case for assessing the hybridization impact on the performance of turning. It is important to note that even though the turn is performed equivalent to the conventional system, there are significant advantages over the conventional system. The main advantage is the fact that the rotation is continuous, i.e. it is achieved without power losses due to friction in the transmission elements. The B and C cases of turning are not possible with the conventional transmission. In contrast, the hybrid transmission allows such cases of turning by choosing the way of controlling electric motors in the auxiliary drive, which means that the possibility of their use is realistic. The B case represents the rotation of the vehicle with the same radius as in the A case, and since the rotation is essentially symmetrical, it is achieved with a lower initial speed. The C case is a classical symmetrical turn and is achieved at the same initial speed as in the A case. The diagram, Figure 11, shows the change of the turning radius for all three considered cases, where the previous statements are confirmed.
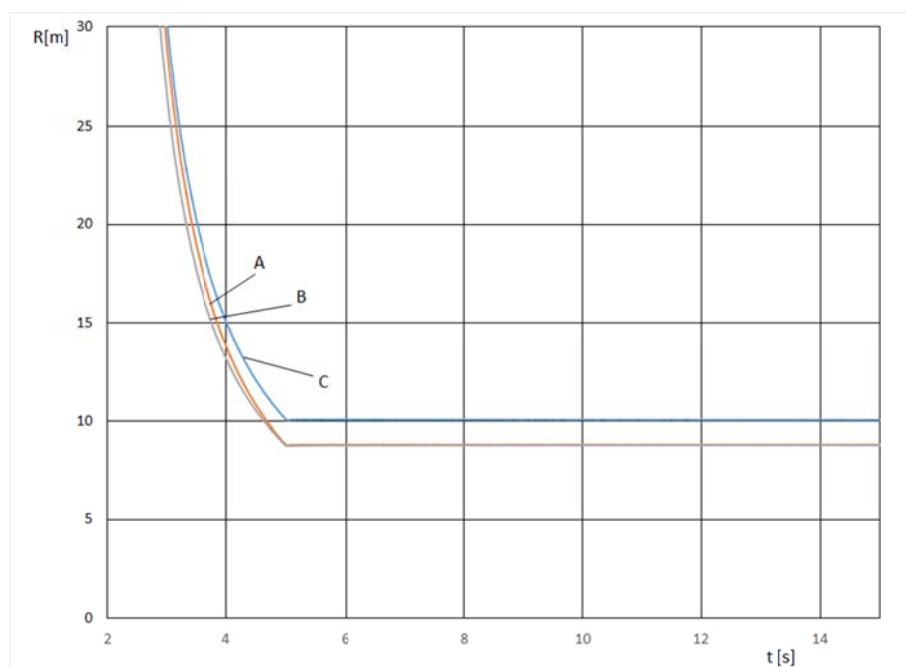
Figure 11 – Turning radius change in time for the A, B, and C cases
Рис. 11 – Изменение радиуса поворота в случаях A, B и C
Слика 11 – Промена полупречника заокрета за случајеве A, B и C

Figure 12 shows the speeds of the vehicle during the simulation of the turning process. The simulation includes starting the vehicle from the point of zero velocity, moving at a constant speed, entering a turn, and moving in a turn with a constant radius. It can be seen that from the aspect of changing the speed of movement, the B and C cases are favorable because there is no change in the speed of the turn.
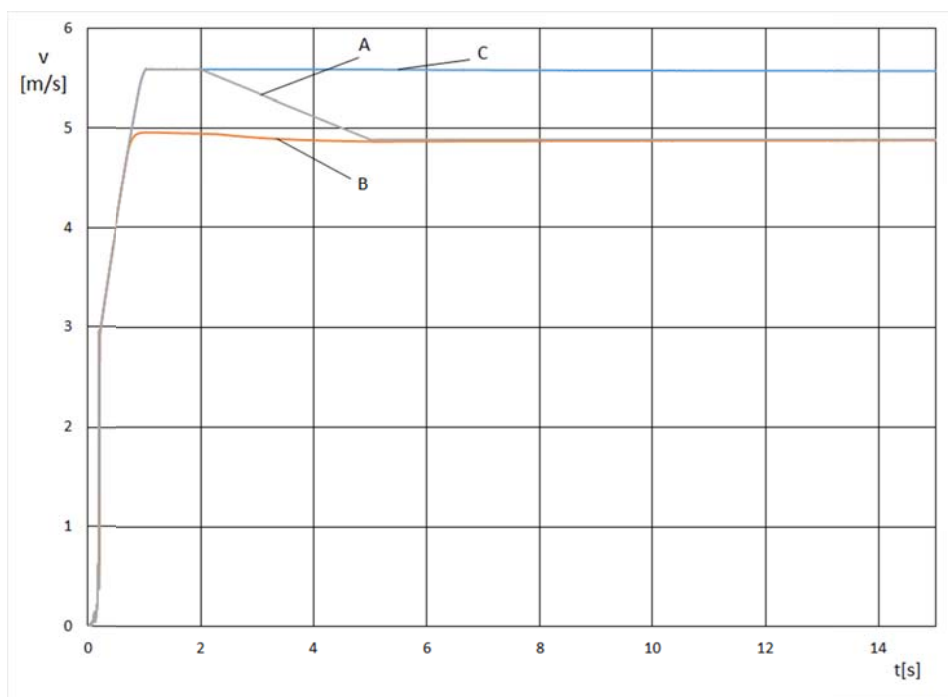
Figure 12 – Change of the vehicle speed during the turn for the A, B, and C cases
Рис. 12 – Изменение скорости машины во время поворота в случаях А, В и С
Слика 12 – Промена брзине возила у заокрету за случајеве А, В и С

In order to perceive the performance of the turn, it is necessary to analyze the power needed for individual cases of the turn. As the power of the basic drive unit - diesel engine and the power of the electric motor in the auxiliary drive - is engaged in the turn, it is necessary to analyze the value of these powers, as well as their ratio. Figure 13 shows the total power engaged to perform the turn. In the C case, the greatest power is engaged, bearing in mind that the turn takes place at a higher initial speed, but it is important to note that, in this case, the turning radius is larger, which is even more unfavorable. In the cases of A and B, practically the same power is engaged, but two facts must be taken into

account: 1) the initial speeds are different and 2) the same turning radius is achieved. As the movement speed directly affects the number of revolutions of the ICE, it is important to analyze the relationship between the power of the drive motor and the power that is supplied to the transmission via the auxiliary drive, i.e. via the electric motor.
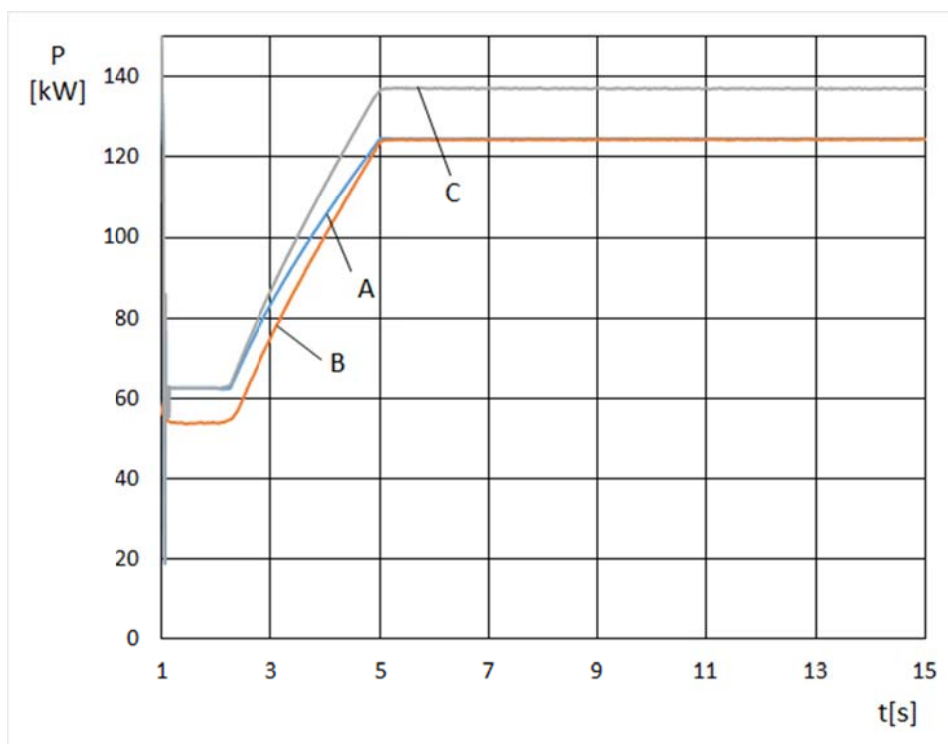
Figure 13 – Total power needed for turning
Рис. 13 – Общая мощность, необходимая для поворота
Слика 13 – Укупна снага потребна за извођење заокрета

Figure 14 shows the ratio of the power engaged by the diesel engine (P_{DM}) and the power of the electric motor (P_{EM}) for the A case and the B case, which are performed with the same turning radius. It can be seen that the power balance is more favorable because less diesel engine power is used when turning, which is a consequence of the fact that in this case two electric motors are working.
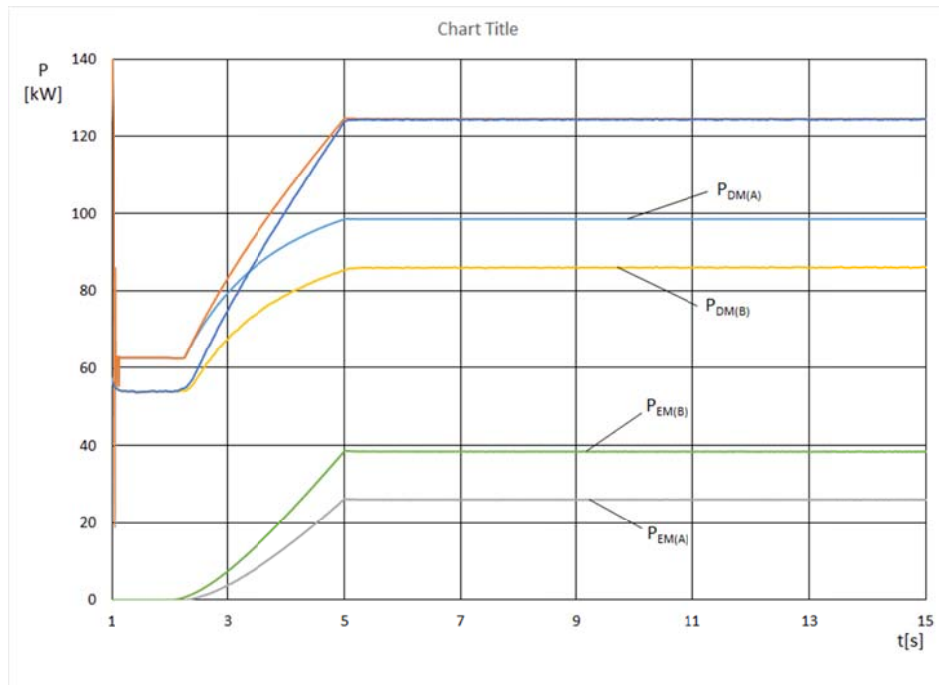
Figure 12 – Total power needed for turning
Рис. 12 – Общая мощность, необходимая для поворота
Слика 12 – Укупна снага потребна за извођење заокрета

Conclusion

Based on the results presented in the paper, it can be concluded that the proposed hybridization model of the BVP M80A powertrain would provide a significant improvement in vehicle performance while retaining the key components of the powertrain. The developed Simulink model provides a simulation of the vehicle movement both in straight-line motion and in turn, with the fact that loads of the drive group are real only with a uniform movement. The simulation results show significant advantages of hybrid drive when performing turns, although it is clear that hybridization also has advantages related to straight-line motion, use of combined drive when starting the vehicle, silent mobility, regenerative braking, etc. Another important application of the Simulink model is its application in the development of an appropriate transmission control system, where it is necessary to integrate mechanical, electrical, and hydraulic components in order to obtain an optimal control system of the proposed hybridized drive group solution.

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МОДЕЛИРОВАНИЕ И АНАЛИЗ РАБОТЫ ГИБРИДНОГО ПРИВОДА BVP M-80A

Стефан В. Миличевич[а], *Славко* Р. Муждека[б]

[а] Вооружённые Силы Республики Сербия, Центральная логистическая база, 1. логистический центр, г. Белград, Республика Сербия, **корреспондент**,

[б] Университет обороны в г. Белград, Военная академия, департамент военного механического инжиниринга, г. Белград, Республика Сербия

РУБРИКА ГРНТИ: 78.00.00 ВОЕННОЕ ДЕЛО:
        78.25.00 Вооружение и военная техника;
        78.25.09 Военная автомобильная техника,
        78.25.10 Бронетанковая техника
ВИД СТАТЬИ: оригинальная научная статья

Резюме:

Введение/цель: Гибридная технология успешно применяется в автопромышленности легковых и коммерческих автомобилей. Руководствуясь успехом и преимуществами гибридных технологий, многие оборонные организации по всему миру инвестируют в разработку гибридных технологий для боевых машин и разрабатывают прототипы гусеничных бронемашин, которые расходуют намного меньше топлива, отличаются лучшей производительностью, меньшим выбросом выхлопных газов и дополнительными возможностями. Однако перед вводом в боевую эксплуатацию гибридных гусеничных бронемашин необходимо решить различные технические проблемы. На данный момент был проведен целый ряд испытаний прототипов, но все еще существуют ограничения, относящиеся к ключевым технологиям, таким как: электродвигатели, проводниковая электроника и накопители электроэнергии. В условиях финансовых ограничений нельзя допускать ошибок и тратить много ресурсов на планирование, создание прототипов и испытания.

Методы: Следовтельно, разумным решением было запустить программное моделирование, с помощью которого можно исследовать различные параметры в имитационных условиях, которые более или менее имитируют реальные условия эксплуатации. В данной статье было представлено одно из возможных решений, касающихся выбора соответствующих технологий гибридного привода, предложено системное решение для гибридного привода бронемашины М-80А. В целях осуществления данног плана, была разработана имитационную модель гибридного привода с помощью программы MatlabSimulink.

Результаты: Результаты, полученные при моделировании, показывают, что предлагаемое решение гибридного привода обеспечивает лучшую производительность транспортного средства.

Выводы: При моделировании проверялись только параметры поворота, но эта модель может быть успешно примененав испытанияхпараметров при прямолинейном движении. Кроме того предложенную модельможно применять для испытания параметров и алгоритмов котроля трансмиссии.

Ключевые слова: гибридный привод, боевая машина, параметры гусенечных машин, гибридизация, MATLAB, Simulink.

СИМУЛАЦИОНИ МОДЕЛ И АНАЛИЗА ПЕРФОРМАНСИ ХИБРИДНОГ ПОГОНА БВП М-80А

Стефан В. Милићевић[a], *Славко* Р. Муждека[б]

[a] Војска Србије, Централна логистичка база, 1. логистички центар, Београд, Република Србија, **аутор за преписку**

[б] Универзитет одбране у Београду, Војна академија, Катедра војномашинског инжењерства, Београд, Република Србија

ОБЛАСТ: машинство
ВРСТА ЧЛАНКА: оригинални научни рад

Сажетак:

Увод: Хибридна технологија је успешно инкорпорирана у индустрији путничких и комерцијалних возила. Вођени успехом и предностима које она доноси, многе одбрамбене организације широм света улажу у развој хибридне технологије за борбена возила. Развијају и прототипове гусеничних борбених возила која имају мању потрошњу горива, боље перформансе, бољу издувну емисију и више електричне енергије која се може искористити за различите елементе надградње. Међутим, постоје различити технички изазови који морају бити решени пре увођења хибридног гусеничног борбеног возила у оперативну употребу. Спроведено је неколико успешних испитивања прототипова, али још увек постоје ограничења у вези са кључним технологијама као што су електромотори, складиште електричне енергије и проводничка електроника. У таквим условима, у којима су финансије ограничене, не може бити много грешака ни трошења пуно ресурса на планирање, изградњу прототипова и њихово тестирање.

Метода: Рационално је развити софтверску симулацију помоћу које је могуће испитати различите параметре у симулираним условима који, мање или више, опонашају реалне услове експлоатације. У раду је приказано једно од могућих решења избора одговарајућих технологија хибридног погона и предложено системско решење хибридног погона за борбено возило пешадије М-80А. За усвојено решење развијен је симулациони модел хибридног погона у програмском окружењу MatlabSimulink.

Резултати: Резултати добијени симулацијом показују да предложено решење хибридног погона обезбеђује знатно боље перформансе погонске групе возила.

Закључак: Разматрани су само параметри заокрета, али модел се може успешно применити и при анализи перформанси праволинијског кретања. Поред тога, модел је могуће

користити и за испитивање перформанси и алгоритама контроле трансмисије.

Кључнеречи: хибридни погон, борбена возила, перформансе гусеничних возила, хибридизација, MATLAB, Simulink.

CAUSE-EFFECT RELATIONSHIP BETWEEN AIR QUALITY AND PUBLIC HEALTH IN THE CITY OF NOVI SAD BASED ON THE DPSEEA MODEL

Emina S. Kričković
University of Belgrade, Faculty of Geography,
Belgrade, Republic of Serbia,
e-mail: memina1989@gmail.com,
ORCID ID: https://orcid.org/0000-0002-0737-5636

Abstract:

Introduction/purpose: The research subject in this article is the status of the air quality in the city of Novi Sad and its impact on the health of the population. The relation between these two points will be presented using the DPSEEA model. The research aim of this article is to apply proper measures in order to mitigate negative effects on human health, based on scientific knowledge related to air quality influence on the health of the Novi Sad population. The basic hypothesis of this research implies that air quality affects Novi Sad's population health.

Methods: The following methods were used in this article: modeling, analysis-synthesis, statistic method, classification method, combining method, geographic-ecological method, method of geographic-medical description, method of the medical geography forecast as well as cartographic method.

Results: Based on the DPSEEA model and the example of the air pollution in the city of Novi Sad, the following was identified: air pollution driving forces, pressures, state of the air quality, population exposure to air pollution, effects on human health as well as measures and actions that should be conducted. The mentioned model was also used to present the relationship between these segments.

Conclusion: The given model deals with a wide spectrum of potential forces (harmful effects) and necessary community actions, bringing together professionals, people in the field and those from laboratories as

88

well as managers in the area of environment and public health management, in order to tackle emerging problems in a comprehensive manner.

Key words: air quality, city of Novi Sad, DPSEEA model, health effects, protecting measures.

Introduction

The purpose of this article is to apply the existing scientific knowledge in the area of medical geography in the scientific description and merging of the data on the air quality and the health of the population of the city of Novi Sad. Medical geography studies the relation between the geographic environment and health, especially estimating the way natural and social environments shape the health and well-being of every individual (Cromley&McLafferty, 2012). According to the World Health Organisation (WHO), health is not just the absence of disease, but the reflection of social and mental well-being of individuals in communities as well (World Health Organisation, 2020). The field of medical geography has developed rapidly in the last decade acknowledging that the concept of "location" plays an important role in understanding the health of individuals (Kwan, 2012, pp.891-892), while the progress in spatial modelling has eased the spatial analysis in different segments, spatial as well as temporal (Cromley&McLafferty, 2012).

An important segment is certainly air quality as it represents an important factor in evaluating not only the environment, but the life quality of the population in any state. The relationship between air quality and human health is not only of national significance but a global issue as well. The commonly known fact is that polluted air could be spread through the atmosphere to other states, causing serious consequences on the environment and human health. Life quality, living conditions and the quality of all components and segments of the environment, air quality being one of them, represent an imperative of social development. The relationship between air quality and human health has been known through history and negative effects have already been determined. However, development and survival of society in general still lead to a continuous increase in air pollution although negative pressures have already been determined. The example is certainly the territory of Novi Sad and the entire Autonomous Province of Vojvodina.

Modelling is a case-dependent reduction (abstraction) of a real-world problem to its relevant aspects. Models reduce complex problems to

simpler shapes, easier to manage. The skill of the model definition is in finding a formal system whose behaviour will successfully simulate the behaviour of specific aspects of the real world (Kričković, 2018, p.28).

According to a WHO working group, feasibility was pointed out as the key determinant in choosing the Environmental (public) Health Indicators (EHIs), as well as the proportion of their usability in multinational analyses which connect information collected from the environment and health systems (Matić et al, 2013, p.10). The same group of experts established a model which could be used in an Environmental Health Programme information system. The model is named by the starting letters of its structure elements (the DPSEEA-model): D – driving force; P – pressure; S – situation (environment status); E – exposure; E – effects, and A – actions (should be conducted in a public health system) (Matić et al, 2016, p.5). Figure 1 shows the DPSEEA model, which describes how driving force, pressure, state of the environment, exposure, and effects affect actions, e.g. measures which should be conducted in order to protect human (public) health.
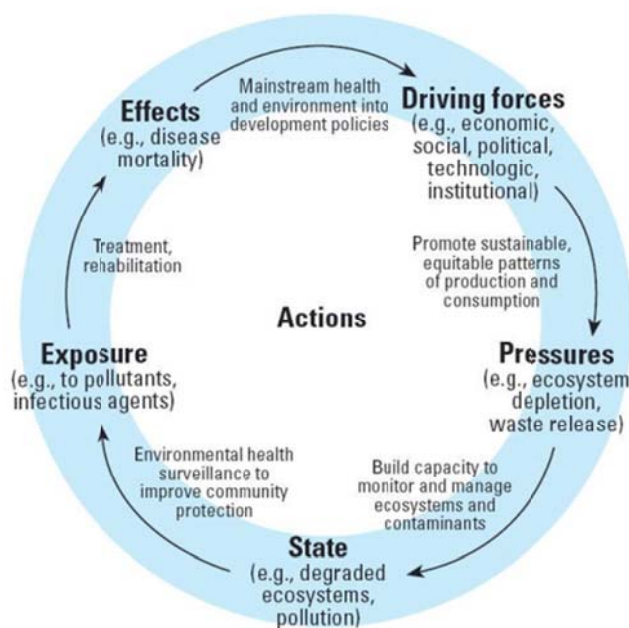
Figure 1 – DPSEEA model - framework scheme (Carneiro et al, 2006)
Рис. 1 – Модель DPSEEA - контурная диаграмма (Carneiro et al, 2006)
Слика 1 – Модел DPSEEA – оквирна шема (Carneiro et al, 2006)

Results of the research and the discussion

If the DPSEEA model could be shown using air pollution as an example, its elements would have the following meanings:

D = industry; the usage of fossil fuels in traffic; the number of kilometres per passenger in traffic;
P = emission of pollutants in the air;
S = the concentration of pollutants in the air (emission);
E = population exposure to pollutants; the number of inhabitants exposed to excessive air pollution; the number of days with excessive pollution;
E = quantified health effects of the polluted air; the number of respiratory and cardiovascular diseases; and
A = imposed measures by the public health service in order to reduce air pollution as well as harmful effects on public health (Matić et al, 2016, p.6).

The DPSEEA model used in this article presents the biggest contaminant - industry as a driving force of air pollution in Novi Sad, while particles of sulphur and nitrogen oxides, as well as PM_{10} и $PM_{2.5}$ particles, whose concentration is measured, present pressure on the health of the population. Pollutants from individual household heating systems during cold weather and PCDF/D particles, whose concentration is not measured, also present pressure on public health. One of big pressures on the environment, as well as on air quality, is certainly traffic i.e., the usage of fossil fuels as well as the number of kilometres per passenger in traffic. However, there is no statistical data which could show this segment; therefore, it is not considered in this work. The emission of pollutants, i.e. their average annual values, is presented as a situation. Excessive values of pollutants represent exposure to harmful effects in the environment; long-term exposure to pollutants is related to numerous chronic diseases, such as lung cancer and cerebrovascular diseases as well as children respiratory diseases. The number of patients with respiratory and cardiovascular diseases represents an effect on public heath due to exposure to pollutants. The measures imposed by public health officials represent activities conducted in the public health system in order to mitigate air pollution effects. Figure 2 shows the relationship between air quality and public (population) health in Novi Sad together with the segments of the mentioned model.

Respiratory diseases:
12,7%,
Cardio vascular diseases:
15,2 %.
Respiratory diseases mortality:
17,2%,
Cancer mortality:
19,3%,
Cardio vascular diseases mortality:
30,4%.

Legislation regulation related to environmental protection

Novi Sad's Industry:
Oil industry - NIS,
Chemical industry „Albus",
Rubber industry „Gumins",
Metallurgy complex „Pobeda",
Electric machines and cables „Novkabel",
Leather industry „Novitet",
Construction industry.

Public health protection

Actions - measures:
Limit pollutants emission,
Alternative sources of energy,
Cleaner industry processes,
Reducing traffic – using public transport, bicycles etc.

Sustainable development and proper production–consumption relation reduces pressures.

Novi Sad's population:
356.126
Number of days exceeding PM$_{10}$: 35
Number of days exceeding O$_3$: 21

Concentration of SO$_2$, NO$_X$, PM$_{10}$, PM$_{2,5}$, CO, O$_3$ is measured.

Concentration of PCDF/D, pollutants from household boilers during heating season IS NOT measured.

Monitoring of environment state in order to protect population

Emission of pollutants - average year values:
SO$_2$: 8 µg/m³,
NO$_2$: 16,4 µg/m³,
PM$_{2,5}$: 28,5 µg/m³
PM$_{10}$: 33 µg/m³,
CO: 0,33 mg/m³,
O$_3$: 78,2 µg/m³.

Building capacity for measuring all air pollutants

Figure 2 – Air quality - public (population) health in Novi Sad relation model
Рис. 2 – Моделирование взаимосвязи между состоянием качества воздуха в Нови-Саде и здоровьем населения
Слика 2 – Моделовање везе између стања квалитета ваздуха у Новом Саду и здравља становништва

It is necessary to consider air quality as one of the factors affecting public health. In order to represent the most real situations, it is necessary to optimize air quality measures. The established automatic air quality measuring stations monitor air quality; quantity and the basic principles of the measuring stations will be described later in this article. Also, the responsibilities of national and local authorities for these stations will be specified.

According to the Development Strategy of AP Vojvodina 2014-2020, air quality in urban areas is affected by energy facilities, increasing number of vehicles, and industry. The geographic-ecological method makes it possible to conclude that air pollution in Novi Sad has its origins mostly in stationary and mobile pollution sources, and less in closed

space. The main stationary pollution sources are the oil refinery, power plants and heating plants, chemical industry facilities, fuel combustion products in households and individual heating boiler rooms, construction industry, inappropriate storing of raw materials, landfills, etc. (Službeni list APV, 13/2014, p.150). The problem of air pollution caused by heating plants is one of the most significant environmental problems of large cities, and also that of Novi Sad, the second largest city in Serbia (Petrović, 2017, p.6).

The important sources of air pollution in Novi Sad are: NIS Gazpromneft, Chemical industry Novi Sad, Albus (detergents and cosmetics industry facility), Gumins (rubber processing, as part of chemical complex industry, developed for producing tractor tires and production of rubber-technical goods), metallurgy complex Pobeda, Novkabel (in the area of electric machines and cables), textile industry, leather industry complex Novitet, Neimar (construction industry) as well as Buducnost (Chamber of Commerce and Industry of Vojvodina, 2020).

The public enterprise Naftna Industrija Srbije, NIS – Oil Industry of Serbia from Novi Sad unites production of oil, gas and oil products - engine and industry fuels, lubricants and other products based on oil. In oil refinery processes, there is significant air pollution due to the presence of easy-to-evaporate hydrocarbons and other aromatic compounds. Heating plants which use fossil fuels (lignite) and oil and oil products industry are the most significant environmental pollutants. Environmental pollution could be present in any process of electric industry: coal production (mining and surface mines), production and distribution of electric power, oil and gas sectors, starting from research and then exploitation and especially in oil processing and transport (Službeni glasnik Republike Srbije, 44/2005).

Besides being caused by old technology used in production processes, absence of exhaust filtering or poorly efficient existing filters, irrational usage of raw materials and energy, as well as poor maintenance, significant air pollution is also caused by inadequate storing and disposal of by-products. It is considered that vehicles are one of the most significant air pollutants in Novi Sad. Exhaust gasses emissions release sulphur dioxide, carbon monoxide, nitrogen oxide, ozone, and particles into the atmosphere. The data on vehicle emissions are still missing both for the city of Novi Sad and for Vojvodina province (Službeni list APV, 13/2014, p.150).

Air quality state on the territory of the city of Novi Sad and pressures on the environment

Data on air quality and possible health effects are taken from the Report on the air quality state for 2018, as well as from the Report on the environment for 2018 issued by the Serbian Environmental Protection Agency (SEPA) in 2019. Data on health effects are taken from the Report on Public Health for the City of Novi Sad for 2018 issued by the Institute of Public Health of Vojvodina in 2019 as well as from the Health-Statistic Yearbook for 2018 issued by the Institute of Public Health dr Milan Jovanovic Batut.

According to the Report on the environment for 2018, air quality is estimated based on available data in compliance with the regulations and recommendations from the Environment Accession Project – ENVAP. The available results from referent monitoring in national and local networks of measuring stations are used for estimating air quality in 2018. According to the Report on the air quality state for 2018, "urban agglomeration Novi Sad" covers the territory of the city of Novi Sad (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019a, p.12).

There is no national cadastral of air pollutants in urban areas in Vojvodina province. Neither there is a list of polychlorinated dibenzofurans and dioxins (PCDF/D) which are significant pollutants and whose sources are uncontrolled municipal waste incineration, metallurgy and open fires after harvesting. Monitoring of air pollutants emission from individual heating boiling rooms and domestic fireplaces in heating seasons is also missing. (Službeni list APV, 13/2014, p.150)

According to the Report on the environment for 2018, the air in Novi Sad was clean or slightly polluted. It is important to note that, in the beginning of 2018, the automatic measuring station was switched off due to big construction works. The air quality in the city of Novi Sad varies, but since 2016 it has been in the first category, i.e. clean or slightly polluted. According to the Report on the air quality state for 2018, increased content of heavy metals in analyses was from PM_{10} samples taken from the Novi Sad – Liman (161) measuring station, part of SEPA's national network of measuring stations. (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.28).

Based on the statistical method, the average annual values of pollutants concentration in two measuring stations in Novi Sad are shown in Table 1 and it could be noticed that the number of days with excessive values of pollutants was 35 for PM_{10}, and 21 for O_3. Therefore, the air quality was in the First category according to the classification method. The question remains whether it is possible that only two measuring stations monitor the air quality in a city as big as Novi Sad.

Urban agglomeration, ZONE	Station	Air quality (category)	Average annual concentration of air pollutants												
			SO_2		NO_2		PM_{10}		$PM_{2,5}$	C_6H_6	CO		O_3	
			$\mu g/m^3$	Number of days> 125 $\mu g/m^3$	$\mu g/m^3$	Number of days>85 $\mu g/m^3$	$\mu g/m^3$	Number of days>50$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	mg/m^3	Number of days>5 mg/m^3	$\mu g/m^3$	Number of days>120 $\mu g/m^3$
Novi Sad	Novi Sad Liman	I	8.00	0	16.4	0	33.0	35			0.33	0	78.2	21
	Novi Sad Sangaj (L)	I	8.00	0										

Табле 1 – Average annual concentration of air pollutants (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.42), adjusted
Таблица 1 – Годовая концентрация загрязняющих веществ в воздухе (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.42), адаптировано
Табела 1 – Годишња концентрација загађујућих материја у ваздуху (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.42), прилагођено

A combination of methods, i.e. the classification method and the analysis of the Report on the air quality state for 2018, and the comparison of the air quality categories for the last 9 years made it possible to conclude that in 2010 and 2011 the air quality in Novi Sad was in the third category.

During 2012 to 2014, the air quality was in the first category; in 2015, it was in the second category, while in the period from 2016 to 2018, the air quality was in the first category. When the air quality categories are concerned, it is important to notice that there are specific warnings and recommendations to the population for certain categories of air quality.

Increased concentrations of pollutants during winter are not surprising regarding increased usage of coal, fuel oil or gas for heating, i.e. heating plants (Institute of Public Health of Vojvodina, 2019a, p.7). The assumption is that the increased concentration of PM_{10} and CO_2 particles during the winter period is caused by the usage of these fossil fuels. This relation between pollutants and weather parameters, not just during the heating season but during the whole year as well, points out to a possible source of pollution in Novi Sad, i.e. to a possible influence of weather on air quality.

When possible sources of pollutants related to urban areas (traffic/household heating) are considered, the results show that traffic has a more significant influence on air quality during the summer period. This implies a bigger influence of household heating and heating plants during winter.

Also, according to the same study, air quality is more related to weather parameters during the summer period, when humidity is lower and there are conditions for spreading air pollutants characteristic for urban areas whilst during winter, due to higher air pressure, there are conditions for an increased number of PM_{10} particles (Institute of Public Health of Vojvodina, 2019a, p.9).

The cartographic method, Figure 3 and Figure 4, shows the spatial distribution of SO_X and NO_X emissions by municipalities and quadrants of 25x25 kilometres. The data used for this model are taken from the National Register of Pollution Sources (NRIZ) as an information subsystem of the Environmental Information System of the Republic of Serbia. According to Figure 3, the average annual SO_X emission for Novi Sad is in the range from 1 to 100 tons per year, and according to Figure 4 the average annual NO_X emission is in the range from 100 to 1,000 tons per year.

Sox emission in t/year, 2018
Емисије SOx у t/god, 2018.
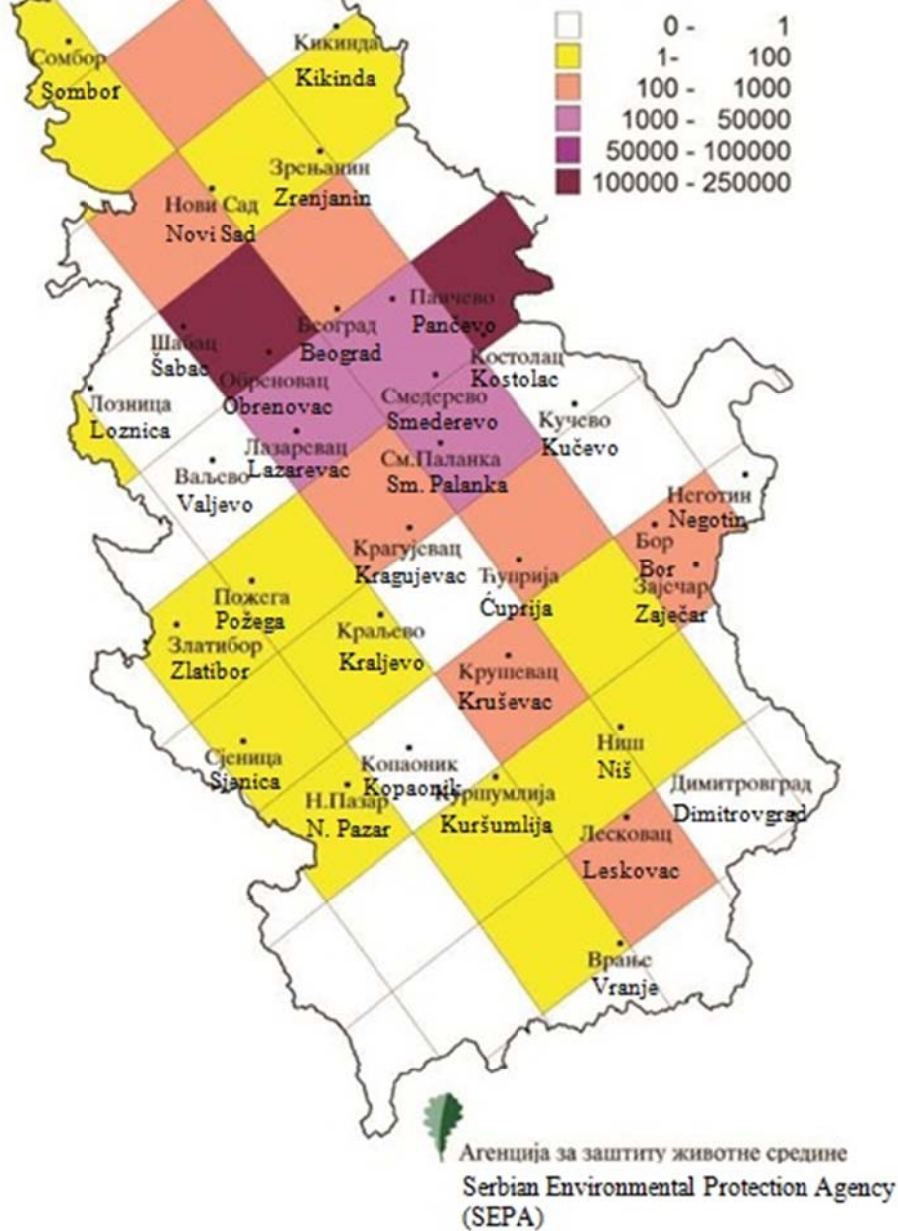
	0 -	1
	1-	100
	100 -	1000
	1000 -	50000
	50000 -	100000
	100000 -	250000

Агенција за заштиту животне средине
Serbian Environmental Protection Agency
(SEPA)

*Figure 3 – Spatial distribution of sulphide oxides by municipalities in Serbia
(Environmental Protection Agency of the Ministry of Environmental Protection of the
Republic of Serbia, 2019b, p.19), adjusted
Рисунок 3 – Пространственное распределение выбросов оксида серы по
муниципалитетам в Сербии (Environmental Protection Agency of the Ministry of
Environmental Protection of the Republic of Serbia, 2019b, p.19), адаптировано
Слика 3 – Просторна расподела емисија сумпорних оксида по општинама у Србији
(Environmental Protection Agency of the Ministry of Environmental Protection of the
Republic of Serbia, 2019b, p.19), прилагођено*

NOx emission in t/year, 2018
Емисије NOx y t/god, 2018.

	0 - 1
	1 - 100
	100 - 1000
	1000 - 5000
	5000 - 10000
	10000 - 36000

Агенција за заштиту животне средине

Serbian Environmental Protection Agency
(SEPA)

NOx emission in t/year, 2018
Емисије NOx у t/god, 2018.

	0 - 1
	1 - 100
	100 - 1000
	1000 - 5000
	5000 - 10000
	10000 - 36000

Sombor
Kikinda
Zrenjanin
Novi Sad
Beograd
Pančevo
Šabac
Kostolac
Obrenovac
Smederevo
Loznica
Kučevo
Lazarevac
Sm. Palanka
Valjevo
Negotin
Bor
Kragujevac
Čuprija
Zaječar
Požega
Kraljevo
Zlatibor
Kruševac
Sjenica
Kopaonik
Niš
N. Pazar
Kuršumlija
Dimitrovgrad
Leskovac
Vranje

Serbian Environmental Protection Agency SEPA)
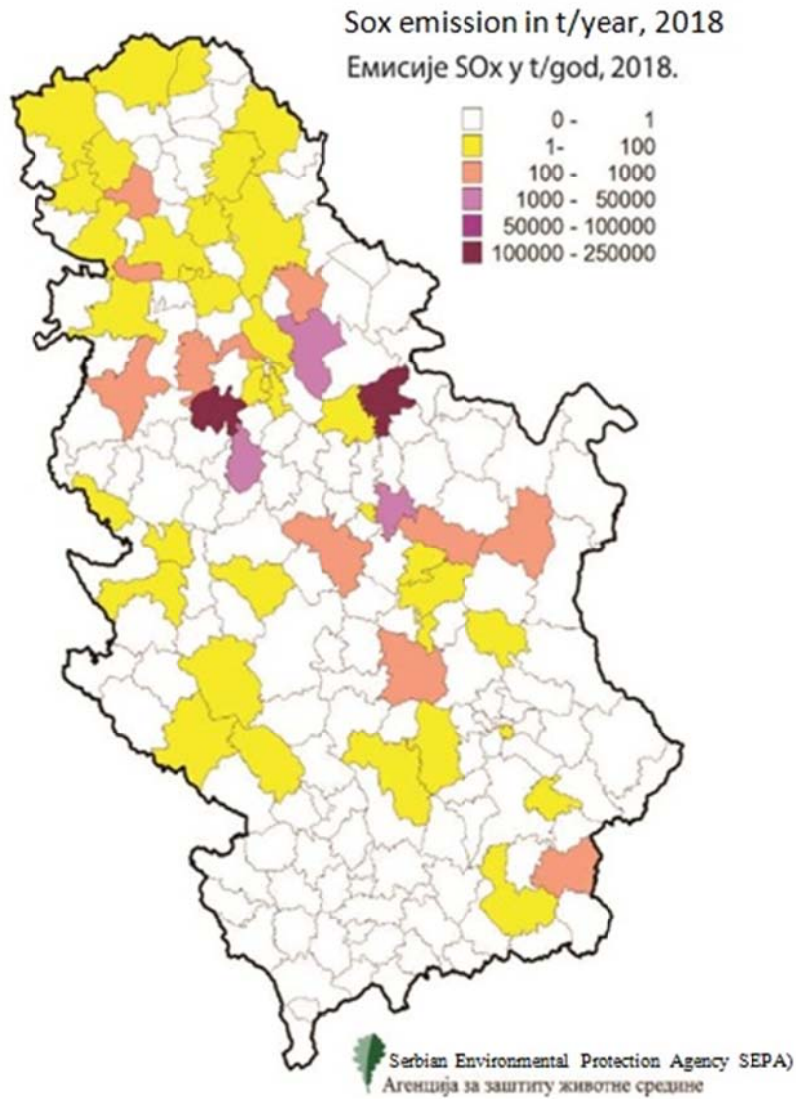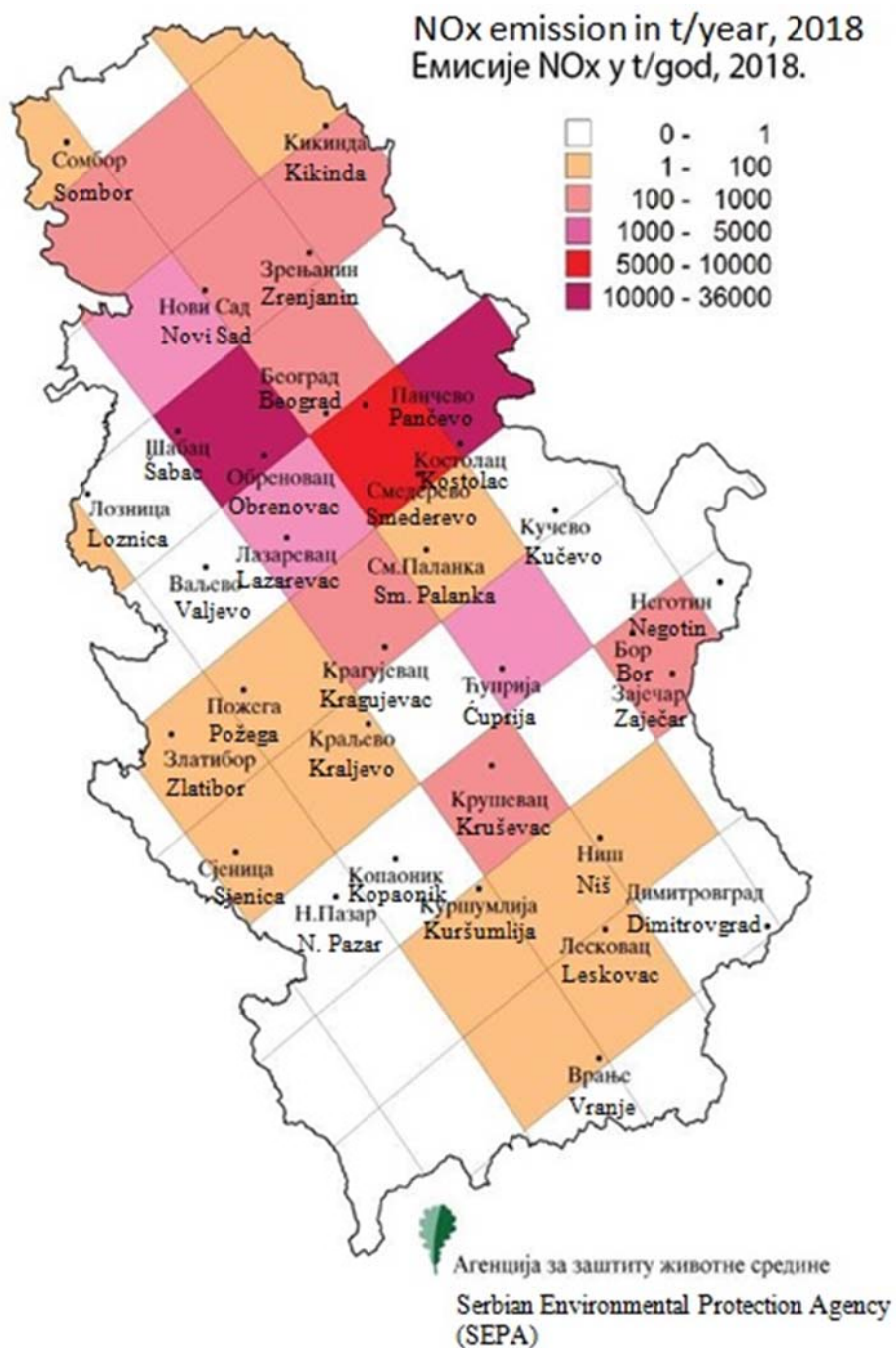Агенција за заштиту животне средине
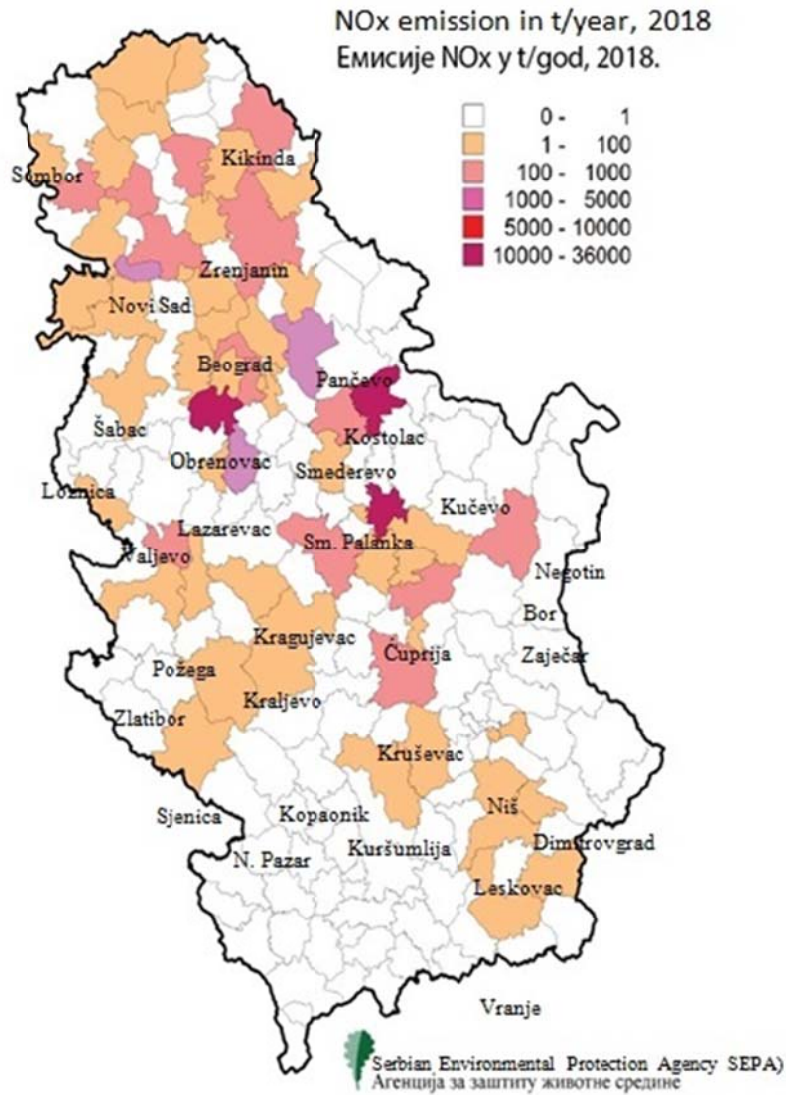
Figure 4 – Spatial distribution of nitrogen oxides by municipalities in Serbia (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.19), adjusted
Рис. 4 – Пространственное распределение выбросов оксида азота по муниципалитетам в Сербии (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.19), адаптировано
Слика 4 – Просторна расподела емисија азотних оксида по општинама у Србији (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b, p.19), прилагођено

Novi Sad's population exposure to variable air quality

According to the Statistical Office of the Republic of Serbia in 2017, Novi Sad had the population of 356,126 inhabitants, which is 55,000 more inhabitants than in the census of 2002. From the Report on Population Health in Novi Sad for 2018, it is clear that excessive values of the following pollutants were determined in Novi Sad: $PM_{2.5}$ suspended particles exceeded the limit values by 12% (the limit value is 25 $\mu g/m^3$), $PM_{2.5}$ suspended particles exceeded the permissible values by 8 % (the permissible value is 26.4 $\mu g/m^3$) and the concentration of benzo(a)pyrene in PM_{10} suspended particles exceeded the prescribed values in 69% (the prescribed value is 1 ng/m^3) (Institute of Public Health of Vojvodina, 2019b, p.110).

The values exceeding the prescribed concentrations of air pollutants in Novi Sad during one year period are presented using the cartographic method in Figure 5. Urban areas are shown in black, while suburban areas are shown in purple. The City's Direction for Environment's data is used for this method and provided by the Institute of Public Health of Vojvodina.

According to the same report, exceedances of the limit values of air pollutants are determined daily: limit/permissible concentration value (50/50 $\mu g/m^3$) for PM_{10} suspended particles during 14 days, which is 25% of 112 controlled days. Exceeded values were in the range from 52 to 88 $\mu g/m^3$; daily limit/permissible value (85/97 $\mu g/m^3$) for nitrogen oxide during 10 days, limit values (2.77%) and 7 days, permissible values (1.94%) out of 361 controlled days (Institute of Public Health of Vojvodina, 2019b, p.111).

The concentrations of nitrogen-dioxide exceeding daily limits were in the range from 85.5 to 134 $\mu g/m^3$; the concentrations of ozone exceeded the prescribed value (120 $\mu g/m^3$) during five days out of 350 controlled days.

These exceeded values were in the range from 121.5 to 205 $\mu g/m^3$. According to the Report on Public Health in Novi Sad for 2018, due to national regulation, daily concentrations of $PM_{2.5}$ particles are analysed only annually.
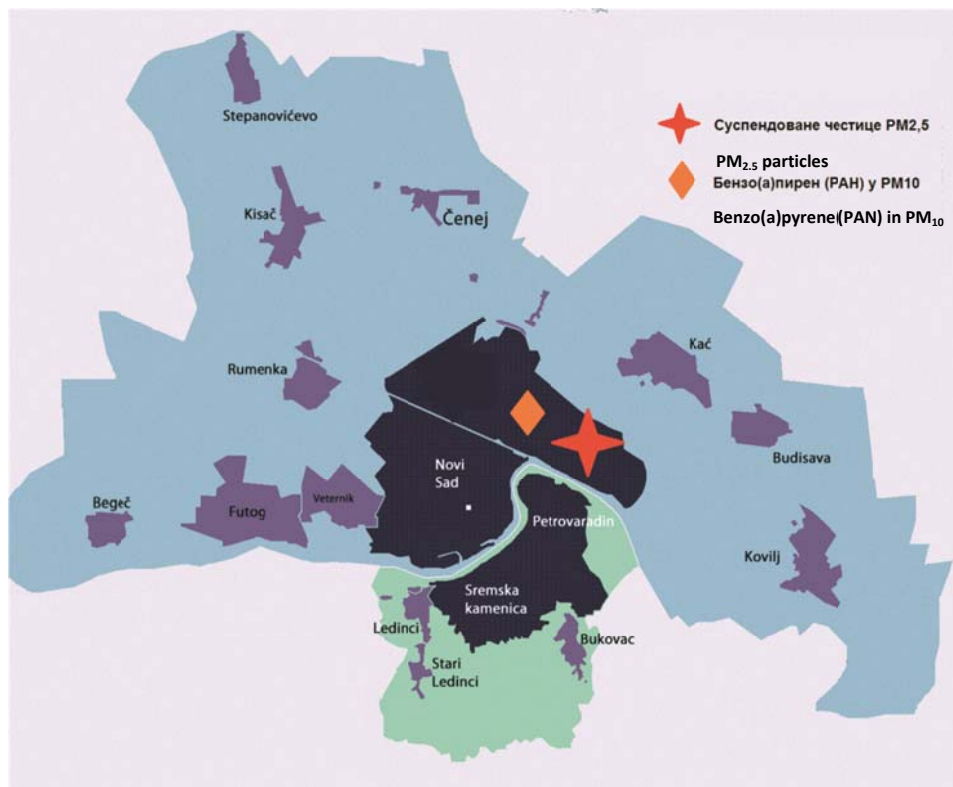
Figure 5 – Values exceeding the prescribed concentrations of air pollutants in Novi Sad during one year period (Institute of Public Health of Vojvodina, 2019b, p.110), adjusted
Рис. 5 – Ежегодное превышение предписанных концентраций загрязняющих веществ в воздухе города Нови-Сад (Institute of Public Health of Vojvodina, 2019b, p.110), адаптировано
Слика 5 – Прекорачење прописаних концентрација загађујућих материја из ваздуха града Новог Сада на годишњем нивоу(Institute of Public Health of Vojvodina, 2019b, p.110), прилагођено

The cartographic methodis used in Figure 6 to show exceedances of daily concentrations of air pollutants in Novi Sad during 2018. Urban areas are marked in black, and suburban areas are marked in purple. This method used the data from the City's Direction for Environment, provided by the Institute of Public Health.

Figure 6 – Exceedances of the prescribed concentrations of air pollutants in Novi Sad on a daily basis during 2018 (Institute of Public Health of Vojvodina, 2019b, p.111), adjusted
Рис. 6 – Превышение предписанных концентраций загрязняющих веществ в воздухе города Нови-Сад на ежедневной основе в течение 2018 года (Institute of Public Health of Vojvodina, 2019b, p.111), адаптировано
Слика 6 – Прекорачење прописаних концентрација загађујуће материје из ваздуха града Новог Сада на дневном нивоу током 2018. године (Institute of Public Health of Vojvodina, 2019b, p.111), прилагођено

Effects of degraded air quality on the population health in Novi Sad

Medical disorders caused by air pollution (inner and external) in urban and rural areas in both developed and undeveloped regions of the world could be due to acute or chronic exposure (Pirić et al, 2018, p.29).

Based on the medical-geographic description method and the analysis of the Report on Public Health in Novi Sad for 2018, the leading causes of deaths are chronic non-infectious diseases (cardio vascular and malignant diseases, respiratory and digestive system diseases, diseases related to endocrine system, nutrition and metabolism) which

make 86.2% of mortality. The most significant public health problem of Novi Sad is chronic non-infectious diseases (Institute of Public Health of Vojvodina, 2019b, p.8). According to the same report, almost half of the morbidity rates outside of the Novi Sad health system are due to diseases related to the cardiovascular system, the respiratory system, skin, muscles, bones and the digestive system. The leading causes of diseases among children in Novi Sad are diseases related to the respiratory system (Institute of Public Health of Vojvodina, 2019b, p.8).

The total registered morbidity in primary care in Novi Sad during 2018 was 368,023 cases, with the leading diseases related to the cardiovascular system (15.2%) and the respiratory system (12.7%) (Institute of Public Health of Vojvodina, 2019b, p.36). Occupational medicine provides primary health care for working population. This service registered 122,764 cases of morbidity. The leading causes of diseases were diseases related to the respiratory system (16.9%) and the cardiovascular system (10.4%) (Institute of Public Health of Vojvodina, 2019b, p.37). The pre-school health services registered 105,630 cases of diseases. The majority of those were diseases related to the respiratory system (49%) and the upper tract (17.1%) (Institute of Public Health of Vojvodina, 2019b, p.38). The total registered morbidity in school health services was 81,337 cases. The leading causes were diseases related to the respiratory system (40.8%) (Institute of Public Health of Vojvodina, 2019b, p.39). The leading death causes of hospitalized patients in Novi Sad in 2018 were diseases related to the cardiovascular system with 30.4% in the total number of deaths. Tumours were in the second place (19.3%) while diseases related to the respiratory system were in the third place (17.2%) (Institute of Public Health of Vojvodina, 2019b, p.42).

The pollution caused by traffic reduces the efficiency of the defence mechanisms of the respiratory system and increases sensitivity to respiratory infections. The presence of certain concentrations of nitrogen oxides, carbon-monoxides and benzenes in the air lead to risks of cough, bronchitis and asthma, especially with children. The most harmful to health are emissions of suspended particles with a diameter smaller than 2.5 micrometres ($PM_{2.5}$). The medical geography forecast method is helpful in concluding that these particles can go deep into the lungs causing acute inflammatory processes. Long-term exposure to these particles is related to various chronic diseases in adults, including coronary artery disease, lung cancer and cerebrovascular diseases, as well as children respiratory diseases (Obradović-Arsić, 2014).

According to the "Identification of Environmental Risk Factors Important for the Prevention of Chronic Obstructive Pulmonary Disease among the Population of the City of Novi Sad" study conducted by the Institute of Public Health of Vojvodina, during the summer period women are more sensitive to pollutant exposure. Likewise, it is established that beside heavy metals, spores of rust fungi and pollen as immunogenic substances are often found in PM_{10} particles. It is well known that these particles worsen asthma symptoms. Due to these facts, it is clear that summer periods present risks for potential interactions of air pollutants with allergens. These results could be explained by the fact that children are longer and more frequently outside than the adults, as well as by mutual influence of weather factors and PM10 particles, especially in the mentioned period (if relative humidity is lower, the concentration of PM_{10} particles is higher). According to the same study, epidemiologic research indicates a strong relation between PM_{10} and $PM_{2.5}$ particles and respiratory morbidity and mortality (Institute of Public Health of Vojvodina, 2019a, p.12).

Protection measures

Numerous health effects present in the subject territory certainly indicate the current state of air quality. Air pollution reduction and the limitation of pollutant emissions should be of greater importance in the future, as well as the promotion of alternative sources of energy, clean industry, the principle of "pollutant paying", traffic reduction, bicycle use, etc.

Services in charge of monitoring the air quality in the territory of the city of Novi Sad are obliged to continually monitor air quality and send data to the competent institution. This institution combines and unites data from different areas of Serbia and its name is the Serbian Environmental Protection Agency (SEPA).

The network of automated monitoring of the air quality in Vojvodina province is presented in Figure 7 with the cartographic method. It shows that there are three measuring stations in the territory of Novi Sad – two are established by SEPA and one by the Provincial Secretariat for Urban Planning and Environmental Protection (PSUPEP). These three automated measuring stations continually monitor pollutants along with the basic weather parameters and send hourly average measured concentrations using ADSL/GPRS in real time, for further processing in the central data processing systems.

By the EU Exchange of Information Decisions (EoI), air quality data are defined together with the process of informing the public as well as

the exchange of data with other member states (Larssen et al, 1999, p.4). In accordance with the EoI classification, these three measuring stations are located in:

- Novi Sad – Rumenacka; this station measures the influence of traffic in an urban area with residential/commercial characteristics and SEPA is in charge of it;
- Novi Sad – Liman; this static station is in an urban area with potential agglomeration, with SEPA being in charge of it; and
- Novi Sad – Sangaj; this static station in a suburban area with residential characteristics measures the influence of specific industrial pollution, with PSUPEP being in charge of it (PSUPEP. More information at http://www.ekourbapv.vojvodina.gov.rs).

The analysis-synthesis method shows (Figure 7) that the agglomeration of Novi Sad is covered with only three permanent air quality measuring stations. For a city of the size of Novi Sad with the population of over 350,000, it can be said these are good locations, but still inadequate for a real situation regarding the air quality in Novi Sad.

According to the "Identification of environmental risk factors important for the prevention of chronic obstructive pulmonary disease among the population of the City of Novi Sad" study, conducted by the Institute of Public Health of Vojvodina, air quality measuring is significant in the efforts for preventing obstructive pulmonary disease, as the air quality is one of the factors for the mentioned disease. Every air quality assessment related to population diseases, e.g. assessment of the environmental factors influencing population health, is very important for the policy of improving the protection of population health and managing air quality. According to the same study, the following is necessary:

- Institutional networking and stronger capacity for air quality monitoring with a view to assessing population exposure;
- Assessing the influence of air quality on public health using models with a wider spectrum of air pollutants and environmental factors, during a multi-year period;
- Improving the information system (health statistics and environmental data networking);
- Informing the public using the Air Quality Index; and
- Increasing the level of ecological awareness and education through establishing special programs.

THE NETWORK OF AUTOMATED AIR MONITORING
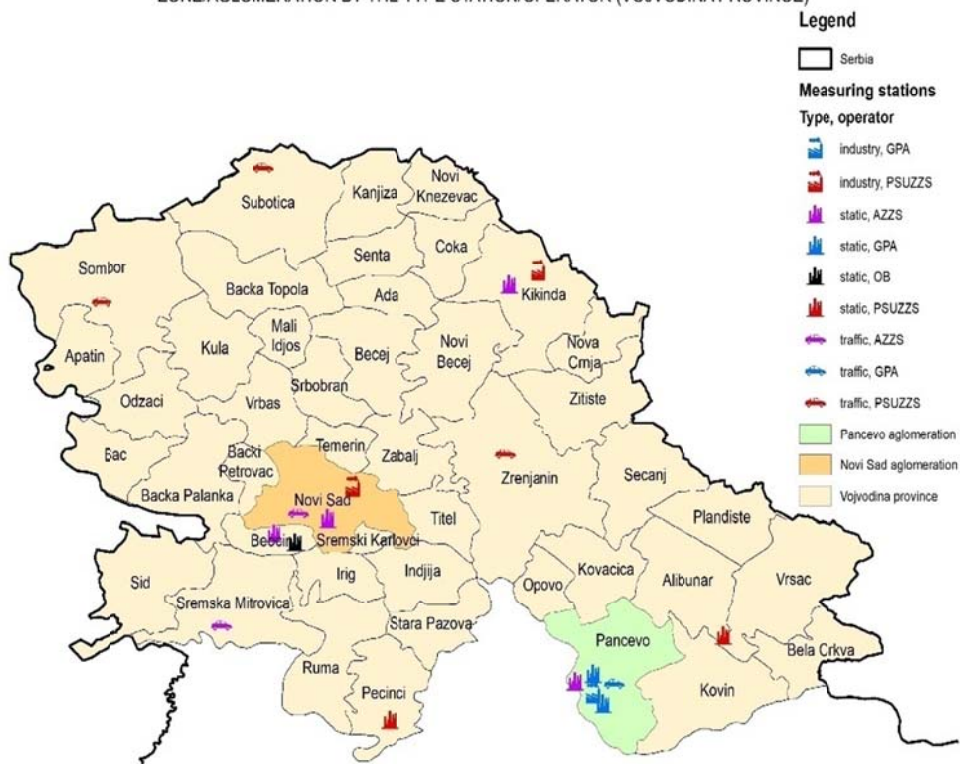ZONE/AGLOMERATION BY THE TYPE STATION/OPERATOR (VOJVODINA PROVINCE)

Figure 7 – Network of automated air monitoring in Vojvodina province; by the type of the station and its operator (Pokrajinski sekretarijat za urbanizam i zaštitu životne sredine, 2020), adjusted
Рис. 7 – Сеть автоматического мониторинга атмосферного воздуха в АПВ; по типу станции и оператору (Pokrajinski sekretarijat za urbanizam i zaštitu životne sredine, 2020), адаптировано
Слика 7 – Мрежа аутоматског мониторинга амбијенталног ваздуха у АПВ, по типу станице и оператеру (Pokrajinski sekretarijat za urbanizam i zaštitu životne sredine, 2020), прилагођено

If the Air Quality Index shows unhealthy air, it is necessary to adhere to proper warnings and recommendations. Special attention and limitations for outdoor activities should be directed to specific population categories, such as children and the elderly.

According to the Report on Air Quality State for 2018, weather parameters affect the maximum pollen concentration in the air, notably air temperature, humidity, and precipitation. Besides weather conditions,

proper and timely trimming of grass and weeds has a positive effect in reducing pollen concentrations in the air. It is necessary to increase controlled extermination of aggressive weeds such as common ragweed (Ambrosia artemisiifolia) as a reliable measure in reducing the concentration of this strongest allergen in the air (Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia, 2019b).

Conclusion

In order to fulfil the WHO's aim – health for everyone, the progress should not be focused only on reducing cases of diseases related to air quality, but it is necessary to prevent them and define measures for the prevention of air pollution in the whole territory as well.

It is important to emphasize differences in individual immune systems as well as in the quantity and types of harmful agents. People also differ in body response to an infectious dose, depending on their predispositions (age, general state of health, and other factors). It is necessary to properly manage health risks through defining the prevention measures and the measures for population protection. In case of negative effects and emerging diseases related to air pollution, it is necessary to adopt the measures for suppressing diseases in the territory in question (Kričković et al, 2019, pp.61-76).

According to the WHO, a public health care system, aiming at reducing the risk of emerging diseases and promoting good relations in the community, needs to monitor many social and environmental factors (World Health Organisation, 2020). The DPSEEA model has a wide use in all segments of environmental and medical geography. Therefore, it is possible to use this model for the identification of potential hazardous risks in the environment alongside with health side effects in order to protect public health and avoid negative effects.

In this article, the cause-effect relationship between polluted air and public health is presented through driving forces, pressures on the environment, state of the air quality, population exposure to pollution, the effects of pollution to public and individual health, as well as actions which should be applied in order to reduce air pollution and increase the health of Novi Sad's population.

Identifying industry as one of the driving forces and pressures affecting the environment is only the first step in order to assess air quality. The absence of statistical data for the usage of fossil fuels in traffic as well as for the number of miles per inhabitant is compensated

by measuring pollutants from traffic, so the average particle concentrations per year are mentioned, as well as the number of days with exceeded concentrations of pollutants such as particles. Diseases morbidity and mortality among Novi Sad's population related to air pollution are also shown. Finally, preventive and protection measures are presented as actions which should be adopted in order to improve the health of Novi Sad's population.

In accordance with the Health Environment Indicators in the Republic of Serbia in 2015 report, the DPSEEA model starts from the basics because it is primarily focused on population health and the environment, as the driving forces are a product of pressures themselves (mechanism of harmful effects). This model is beneficial since it comprises a wide spectrum of potential forces (harmful effects) and the ensuing public actions, bringing together professionals, field workers, laboratory work force as well as managers in the field of environment managing and public health in order to deal with emerging problems in a comprehensive manner.

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ПРИЧИННО-СЛЕДСТВЕННАЯ СВЯЗЬ МЕЖДУ СОСТОЯНИЕМ КАЧЕСТВА ВОЗДУХА В НОВИ-САДЕ И ЗДОРОВЬЕМ НАСЕЛЕНИЯ С ИСПОЛЬЗОВАНИЕМ МОДЕЛИ DPSEE

Эмина С. Кричкович

Белградский университет, географический факультет,
г. Белград, Республика Сербия

Резюме:

Введение/цель: Исследовательской проблемой данной статьи является здоровье населения города Нови-Сад. Предметом исследования является состояние качества воздуха. В статье представлена взаимосвязь между этими сегментами с помощьюмодели DPSEEA. Цель данной статьи заключается в привлечении внимания кнеобходимости сохранения здоровья населения Нови-Сада. Социальная цель исследования должна обеспечить предоставление населению Нови-Сада научных данныхо влиянии качества воздуха, а на основании этих данных должны быть предприняты надлежащие меры для смягчения негативного воздействия на здоровье населения. Основная

гипотеза настоящего исследования отталкивается от факта, что качество воздуха влияет на здоровье населения в городе Нови-Сад.

Методы: В статье применялись следующие методы: моделирование, анализ-синтез, статистический метод, метод классификации, метод комбинирования, географо-экологический метод, метод географо-медицинского описания, метод медико-географического прогноза, а также картографический метод.

Результаты: Используя модель DPSEEA на примере загрязнения воздуха в городе Нови-Сад, были выявлены следующие факторы: движущие силы загрязнения воздуха, давление и состояние качества воздуха, подверженность населения загрязнению воздуха, влияние на здоровье человека, а также меры и действия, которые следует предпринять. С помощью вышеупомянутой модели также была представлена взаимосвязь между этими сегментами.

Вывод: Применение настоящей модели включает широкий спектр потенциального влияния (негативного воздействия) и, как следствие, вынужденных действий сообщества, объединяя экспертов, полевых и лабораторных специалистов, а также руководителей (менеджеров) в области управления окружающей средой и общественным здравоохранением с целью всестороннего устранения возникших проблем.

Ключевые слова: качество воздуха, город Нови-Сад, модель DPSEEA, источники загрязнения, здоровье населения, меры защиты.

УЗРОЧНО-ПОСЛЕДИЧНА ВЕЗА ИЗМЕЂУ СТАЊА КВАЛИТЕТА ВАЗДУХА У НОВОМ САДУ И ЗДРАВЉА СТАНОВНИШТВА ПРИМЕНОМ МОДЕЛА DPSEEA

Емина С. Кричковић

Универзитет у Београду, **Г**еографски факултет,
Београд, Република Србија

Сажетак:

Увод/циљ: Предмет истраживања овог рада јесте стање квалитета ваздуха у граду Новом Саду и његов утицај на здравље становништва. У раду је представљена веза између ових сегмената применом модела DPSEEA.Основни циљ истраживања јесте да се на основу научних сазнања у вези са утицајем квалитета ваздуха на здравље становништва Новог Сада,

предузму одређене мере ради отклањања негативних последица по здравље. Основна хипотеза истраживања полази од чињенице да квалитет ваздуха утиче на здравље становништва Новог Сада.

Методе: У истраживању су коришћене следеће методе истраживања: метод моделовања, метод анализа-синтеза, статистички метод, метод класификације, комбиновани метод, географско-еколошки метод, метод медицинско-географског описивања, метод медицинско-географске прогнозе, као и картографски метод.

Резултати: Применом модела DPSEEA на примеру загађења ваздуха на територији Новог Сада идентификовани су покретачи загађења ваздуха, притисци и стање квалитета ваздуха, изложеност популације загађењу, здравствени ефекти, као и мере заштите и акције које би требало спровести. Такође, применом наведеног модела представљена је веза између наведених сегмената.

Закључак: Примена овог модела обухвата широки спектар потенцијалних сила (штетних дејстава) и акција заједнице које из њих произилазе, доводећи у везу професионалне кадрове, људе са терена и из лабораторија, као и руководиоце (менаџере) из области управљања животном средином и јавног здравља, са циљем да се на свеобухватнији начин баве решавањем наведених проблема.

Кључне речи: квалитет ваздуха, град Нови Сад, модел DPSEEA, извори загађења, здравље становништва, мере заштите.

HIGH-YIELDING AND CHEMICALLY ENRICHED MAIZE HYBRIDS BRED IN SERBIA - THE BEST BASIS FOR SUPER QUALITY FEED AND FOOD

Čedomir N. Radenović[a], *Nenad* S. Delić[b],
Milica M. Radosavljević[c], *Života* V. Jovanović[d],
Mile D. Sečanski[e], *Aleksandar* S. Popović[f],
Miloš S. Crevar[g], *Nebojša* D. Radosavljević[h]

[a] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia;
University of Belgrade, Faculty of Physical Chemistry,
Belgrade, Republic of Serbia,
e-mail: radenovic@sbb.rs, **corresponding author**,
ORCID iD: https://orcid.org/0000-0002-4997-7635

[b] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: ndelic@mrizp.rs,
ORCID iD: https://orcid.org/0000-0003-4020-0114

[c] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: rmilica@mrizp.rs,
ORCID iD: https://orcid.org/0000-0002-1026-4582

[d] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: zjovanovic@mrizp.rs,
ORCID iD: https://orcid.org/0000-0002-4492-8797

[e] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: msecanski@mrizp.rs,
ORCID iD: https://orcid.org/0000-0003-2070-4366

[f] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: dobropoljac@yahoo.com,
ORCID iD: https://orcid.org/0000-0002-4569-6799

[g] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: mcrevar@mrizp.rs,
ORCID iD: https://orcid.org/0000-0002-8828-4946

[h] Maize Research Institute „Zemun Polje", Belgrade, Republic of Serbia,
e-mail: 1965neboj@gmail.com,
ORCID iD: https://orcid.org/0000-0002-4131-3148

FIELD: Physical chemistry, Biophysics, Genetics, Biochemistry and
Technologies for processing plant raw materials
ARTICLE TYPE: Original scientific paper

Abstract:

Introduction/purpose: This paper presents the results of several different research studies. The inbred lines ZPPL 146 and ZPPL 159 and the maize hybrids ZP 633, ZP 735, and ZP 737 are primarily intended for human and livestock nutrition. Their selection took about four decades.

Methods: Spectral bands were registered using the method of resonant Raman spectroscopy of the leaves of inbred maize lines. These spectral bands indicate the conformational characteristics of not only carotenoid molecules but also other compounds (phosphate, gluten, and amide III) in the leaf.

Results: A systematic examination of the inbred lines ZPPL 146 and ZPPL 159 and their maize hybrids ZP 633, ZP 735, and ZP 737 was performed in this paper. It was stated that the new inbred lines of corn, i.e. ZPPL 146 and ZPPL 159, are rich in carotenoids and yellow pigments. These lines also have significant quantities of other valuable bioactive compounds and good physical characteristics. The lines have an upright position of the top leaves and belong to the group of maize lines with significant characteristics of the photosynthetic model. They are resistant to high temperatures and are drought tolerant.

Conclusion: This paper presents the relevant properties, characteristics and parameters of the new studied inbred maize lines that can be used in selection processes in the future. High-yielding and high-quality maize hybrids, i.e. ZP 633, ZP 735, and ZP 737, have been created from the mentioned inbred maize lines. They are recognizable by their qualities. The hybrid ZP633 is especially noteworthy for human consumption (children and the elderly). Further, from the agronomic-veterinary point of view, it is confirmed that the hybrids ZP 735 and ZP 737 are the most suitable for livestock feeding with the programmed use of corn silage. The relevant agronomic, morphological and nutritional properties of the maize hybrids ZP 633, ZP 735, and ZP 737 are also presented in this paper. The results regarding the grain structure and yield height for grain and silage for the hybrids ZP 677 and ZP 684, produced in Serbia and the countries of Southeastern Europe, are also given.

Key words: Delayed chlorophyll fluorescence, Raman spectroscopy of leaves, photosynthetic model, Zea mays L, inbred lines, hybrids, thylakoid membrane, pigment properties, nutritive values, good quality food and feed.

Introduction

The period from 1978 to the present day (2020) has become historically significant because a tremendous success in maize breeding and high quality hybrid seed production was achieved. Because of such

activities, over 1500 grain and silage hybrids have been derived (Duvick, 1984), (Sprague, 1984), (Trifunović, 1986), (Dumanović, 1986), (Hallauer, 1988) and (Ivanović et al, 1995).

Modern technical and technological prerequisites were provided for carrying out the process of breeding, efficient production of hybrid maize seeds and significant amounts of seeds of commercial and silage hybrids (Kojić & Ivanović, 1986), (Petrović et al, 1992), (Pejić, 1994), (Jovanović, 1996, 1998), (Bekrić, 1997, 1999), (Dumanović & Pajić, 1998), (Jovanović et al, 2000), (Radenović & Somborac, 2000), (Antov et al, 2004), (Dinić & Đorđević, 2005).

In the context of the stated dynamics of the development, interdependent studies of many scientific disciplines (physiology, biochemistry, biophysics, biotechnology, breeding, photosynthesis, Raman spectroscopy, infrared spectra of grain, processing technology of cereals, silage production practices, silage utilisation and food science) have been linked with the aim of modernising and efficient implementation of contemporary programmes on maize breeding and seed production (Radenović, 1994), (Pajić et al, 1995), (Radenović et al, 2004, 2008, 2009), (Radenović & Somborac, 2000), (Konstantinov et al, 2010). In addition to the outstanding results achieved in the selection of standard grain and maize silage hybrids, there was a pressing need to develop new inbred lines and better quality maize hybrids with an improved chemical composition of the grain, especially in essential bioactive compounds. Moreover, the intensive work has been carried on the improvement and development of new methods for the preservation of plants, especially maize hybrid plants in the form of silage of the whole plant and grain. Silage is biologically fermented or chemically preserved feed of a plant origin. Silage maize growing practices differ, to a certain extent, from the practices used in the commercial maize cultivation. Namely, it is very important to produce the maximum quantity of silage per area unit and it is necessary that the produced silage be of high quality. Therefore, in order to succeed in this, it is necessary to select a plot with good soil properties, use high quality seed, apply the necessary amount of mineral fertilisers, perform proper and timely sowing and apply tested herbicides that have no residual effects and toxic effects on silage mass. All this has to provide silage that contains approximately 50% grain, as it is a prime quality part. Furthermore, it is important that the crop be disease free, so that there are no adverse effects in feeding ruminants and no negative effects on their health, quality of meat and milk, and dairy products. Nowadays, silage is the basis of cost-effective and contemporary animal husbandry and the closest substitute for green

forage (Bekrić, 1997, 1999), (Dumanović & Pajić, 1998), (Pejić, 1994), (Jovanović, 1996, 1998), (Jovanović et al, 2000), (Antov et al, 2004), (Dinić & Đorđević, 2005), (Liu, 2007), (Strati et al, 2012), (Radenović, 2002, 2013), (Bacchetti et al, 2013), (Buxton & Russel, 1988), (Đorđević & Dinić, 2003), (Grubić et al, 1995), (Kurlich & Juvik, 1999), (Lazarević et al, 1999), (Luo & Wang, 2012), (Maksimović et al, 1971, 1997).

To meet many demands, justifiable and increased needs for functional and quality nutrition of people (mainly children and the elderly) and livestock (primarily cows and sheep), it was necessary to select new maize inbred lines with significantly richer pigment-complex properties and the exceptional nutritional value. This aim was achieved with the increased content of carotenoids and other bioactive compounds. With such inbred lines, it was possible to develop high-quality maize hybrids which would meet requirements of medicine, veterinary medicine and agronomy and be necessary for healthy food and feed, which was the objective of the present study.

Materials and methods

Plant material – The genetic and breeding studies of the new maize inbred lines have been performed for over 40 years. These inbreds, future parental forms, primarily ZPPL 146 and ZPPL 159, have increased chemical compositions, whereas the hybrids of high yields and extra quality derived from these inbreds are used as follows: ZP 633 - standard in nutrition of children, the elderly and athletes; products: flour, semolina; ZP 737 - standard in nutrition of fattening chickens up to 1.5-3kg and laying hens; products: ground maize, coarse meal, flour and grain silage; and ZP 735 - standards in nutrition of calves, fattening heifers, dairy cows, sheep, goats and pigs; products: coarse meal, ground maize, grain silage, ear silage and the whole plant silage. In recent times, the hybrids ZP 677 and ZP 684 have also been used for silage. Figure 1 shows the actual appearance of the elite maize inbred lines with erect top leaves, i.e. ZPPL 146, ZPPL 159, and high-quality maize hybrids ZP 633, ZP 735, and 737 with their erect top leaves.

The observed maize inbred lines and hybrids have the increased content of carotenoids and other bioactive compounds. They have been developed and owned by the Maize Research Institute, Zemun Polje, Belgrade, Serbia.
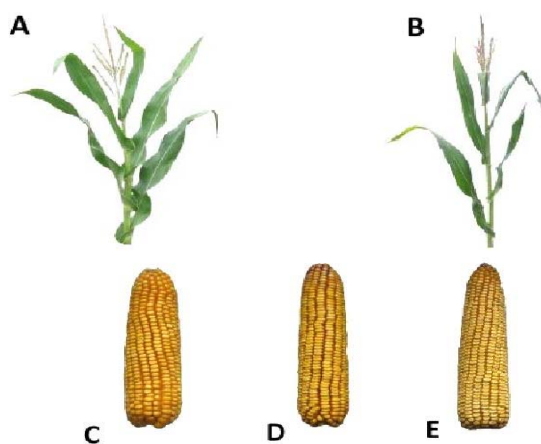
Figure 1 – Actual appearance of the elite maize inbred lines with erect top leaves ZPPL 146 (A) and ZPPL 159 (B) and the high-quality maize hybrids ZP 633 (C), ZP 735 (D) and ZP 737 (E) with their erect top leaves.
Рис. 1 – Внешний вид элитных инбредных линий кукурузы с прямостоячими верхними листьями ZPPL 146 (A), ZPPL 159 (B) и их высококачественных гибридов, ZP 633 (C), ZP 735 (D) и ZP 737 (E) с прямостоячими верхними листьями
Слика 1 – Стварни изглед елитних инбред-линија кукуруза са усправним положајем вршних листова: ZPPL 146 (A) и ZPPL 159 (B) и њихових високо-квалитетних хибрида кукуруза: ZP 633 (C), ZP 735 (D) и ZP 737 (E) са усправним положајем вршних листова

Methods – Overall studies of the stated new inbred lines and hybrids with erect top leaves developed from these inbreds encompassed several series of experiments in which new and standard methods and procedures were applied.

1. Chemical compositions of the new inbred lines and high-quality maize hybrids

The methods applied to determine the grain chemical composition of the maize inbred lines and hybrids are generally accepted and standardised and already described in detail in previous papers (Radosavljević et al, 2000), (Bekrić, 1997), (White & Jonson, 2003), (AACC, 2013), (Strati et al, 2012), (Radenović et al, 2010).

2. Resonance Raman spectroscopy method applied to the maize inbred lines

The measurements of resonance Raman spectroscopy of the maize inbred line leaves were done in accordance with the procedure and the

method was described in our previously published papers (Radenović et al, 1994, 1998).

3. The measurement of the angle and the leaf area of the maize inbred lines

This series of experiments was related to studying the erect position of top leaves in the maize inbred lines. A specially designed protractor was used to measure the angle between the position of the above-ear leaf and the position of the plant stalk on the maize inbred lines. The leaf area was measured by the LI-3000 Portable Leaf Area Meter (LI-COR Biosciences, USA). The measurements of the angle between the above-ear leaf and the stalk and the leaf areas were carried out on 122 plants for each maize inbred line during the three-year period. These methical procedures were described in the previously published papers (Radenović et al, 2009, 2010).

4. Photosynthetic fluorescence measurements

This series of the experiments was related to photosynthetic-fluorescence studies, including thermal processes of delayed chlorophyll fluorescence, critical temperatures (phase transitions), and activation energies. The test maize inbreds were grown in the experimental field of the Maize Research Institute, Zemun Polje. The plants were brought from the experimental field to the laboratory between 7 a.m. and 8 a.m. These plants sampled in the field were transversally cut in the ground internode. In the laboratory, the plants were placed in water along the length of one internode. Prior to the fluorescence experiment, all plants were kept under the black ball glass for two hours. A segment of intact above ear leaves was taken from such plants and placed into a chamber of the phosphoroscope. The intact leaf segments were kept in the chamber (in the dark) for at least 15 minutes, and then the thermal processes of delayed chlorophyll fluorescence were measured. These tests were performed on 111 plants of each maize inbred line. An improved, noninvasive photosynthetic-fluorescence method was applied for these measurements. This method was developed at the Maize Research Institute and was described in the previously published papers (Radenović et al, 2002, 2004, 2007, 2008, 2010, 2013).

5. Survey of the breeding and seed production properties of the new maize inbred lines

Since these maize inbred lines with efficient photosynthesis, rich in pigments and with exceptional nutritive qualities are promising, a broad

survey of their relevant breeding and seed production properties, traits and parameters obtained by standard methods of ranking (Radenović et al, 2007, 2008, 2009, 2013) are presented in this article.

6. Functional dependence of the yield of the studied maize grain and silage hybrids

Numerous and long-term studies on the yields (t ha-1) of the three high-yielding and high-quality grain and maize silage hybrids (ZP 633, ZP 735, ZP 737) were performed in many locations in Serbia and other countries of Southeastern Europe. Standard methods for maize production, tinning and processing were applied in these studies (Pejić, 1994), (Bekrić, 1997, 1999), (Jovanović, 1996, 1998), (Jovanović et al, 2000), (Antov et al, 2004), (Đorđević & Dinić, 2003), (Dinić & Đorđević, 2005), (Videnović et al, 2011), (Radenović, 2013).

7. Medical, veterinary, agronomic, and nutrition estimation of the need for human and animal nutrition with products based on maize hybrids bred for a specific purpose

7.1. Human nutrition with products based on maize hybrids enriched with pigments and other nutrition ingredients

Empirical efforts to acquire knowledge about the need for maize diet in human nutrition were initiated a long time ago, perhaps 300-400 years ago. Much later, in the 1950s, the scientific literature related to this topic emerged, primarily in medical institutions. However, the authors of this study became interested in this topic in the early 1990s (Radenović, 1991).

7.2. Animal nutrition with products based on maize hybrids bred for silage

It is believed that 1150 years have passed since the first procedures of preserving green crops (Goffart, 1877) and (Fry, 1885). Modern and improved technology of preserving crops by ensiling flourished as late as the early second half of the 20th century (1955-1965) (Cross & Jenny, 1976), (Bekrić, 1997, 1999), (Pejić, 1994), (Jovanović, 1998), (Jovanović et al, 2000), (Đorđević & Dinić, 2003), (Dinić & Đorđević, 2005). Modern, intensive and cost-effective production in cattle husbandry can no longer be imagined without silage. Furthermore, the advantages of such feed have been growing in goat and sheep breeding and to a lesser extent in pig breeding (Pejić, 1994), (Jovanović, 1996, 1998), (Jovanović et al, 2000), (Đorđević & Dinić, 2003), (Dinić & Đorđević, 2005), (Radenović, 2013). The authors of this paper became interested in this topic at the beginning of the 21st century (in 2002). At that time, a great number of

high-quality maize hybrids intended for production of high-quality silage were developed with the aim to regulate metabolic processes in domestic animals thus improving their growth and quality of meat and milk (Radenović, 2002).

Results and discussion

1. Chemical composition and physical traits of grain of maize inbred lines and high-quality maize hybrids

The results of the studies of the chemical composition and physical traits of the grains of the observed maize inbred lines and hybrids are presented in Table 1. The obtained results relate to important chemical and physical constituents.

Table 1 – Results obtained in the analyses of the chemical composition and physical traits of the grain of maize inbred lines and hybrids (Zea mays L.) (three-year average, trial field of the Maize Research Institute, Zemun Polje, Belgrade, Serbia)
Таблица 1 – Результаты анализа химического состава и физических характеристик зерна элитных инбредных линий и гибридов кукурузы (Zea mays L.) (в среднем за 3 года, опытное поле Института кукурузы «Земун Поле», г. Белград, Сербия)
Табела 1 – Резултати просечно трогодишњих анализа хемијског састава и физичких карактеристика зрна инбред-линија и хибрида кукуруза (Zea mays L.) (огледно поље Института за кукуруз, Земун Поље, Београд, Србија)

Chemical composition and physical traits of the maize (*Zea mays* L.) grain	Published data*		Average data of the observed grain for storage in silos of the elite maize (*Zea mays* L.) inbred lines and hybrids				
			Inbred lines		Hybrids		
	Range	Average	ZPPL 146	ZPPL 159	ZP 633	ZP 735	ZP 737
Moisture (%, wet basis[a])	7-23	16.0	10.24	10.12	9.90	9.84	10.15
Starch (%)	61-78	71.7	67.80	66.26	68.23	64.39	67.86
Protein (%)	6-12	9.5	10.22	12.57	11.11	12.27	11.57
Fat (oil) (%)	1.0-5.7	4.3	7.53	5.38	6.11	5.82	7.16
Ash (%)	1.1-3.9	1.4	1.48	1.45	1.51	1.54	1.47
Cellulose (%)	-	3.0	2.26	2.33	2.37	2.43	2.00
Pentosans (as xylose), %	5.8-6.6	6.2	–	–	–	–	–
Fibres, %	8.3-11.9	9.5	–	–	–	–	–
Cellulose + lignin, %	3.3-4.3	3.3	–	–	–	–	–
Sugars, total (as glucose), %	1.0-3.0	2.6	–	–	–	–	–
Yellow pigment, (µg βCE/g d.m.)**	–	–	19.00	18.10	27.30	21.90	21.60
Total carotenoids (mg/kg)	12-36	26.0	33.20	31.80	32.40	28.30	27.80
1000-kernel weight (g)	217-438	343.70	277.45	283.03	333.82	295.81	296.95

Chemical composition and physical traits of the maize (*Zea mays* L.) grain	Published data*		Average data of the observed grain for storage in silos of the elite maize (*Zea mays* L.) inbred lines and hybrids				
	Range	Average	Inbred lines		Hybrids		
			ZPPL 146	**ZPPL 159**	**ZP 633**	**ZP 735**	**ZP 737**
Test weight (kg/m³)	693-843	791.00	829.84	844.96	809.03	808.27	817.07
Density (g/cm³)	1.21-1.38	1.26	1.27	1.29	1.27	1.28	1.28
Flotation index (%)	0-68	27.10	10.56	10.68	25.12	13.36	7.91
Grinding resistance (%)	7.0-25.8	15.90	8.77	14.33	15.80	13.27	11.07
Hard endosperm fractions (%)	54.3-71.3	59.20	11.00	10.67	9.67	11.33	9.67
Soft endosperm fractions (%)	45.7-28,7	40.80	23.33	18.66	23.33	21.67	23.33
Water absorption index	0.180-0.284	0.245	0.245	0.237	0.215	0.237	0.227

* Source: P.J. White & L.A. Jonson (White & Jonson,, 2003).
** Done by the AACC Methods 14-50.01 (AACC, 2013).

2. Conformational changes in carotenoid molecules in the leaf of mxe maize inbred lines

The Raman spectra are very suitable for studying photosynthetic pigments in terms of conformational changes of carotenoid molecules. The authors of the present study have been dealing with this topic for a long period of time (Radenović et al 1994, 1995, 1998).

However, this study will highlight some conformational changes in molecules of carotenoids in the leaf of the observed maize inbred lines. Thus, the following six characteristic resonance Raman spectral bands were established within the 900 cm^{-1}-1800 cm^{-1} interval of Raman frequencies: 962, 1026, 1160, 1187, 1206, and 1520 cm^{-1}, Figure 2.
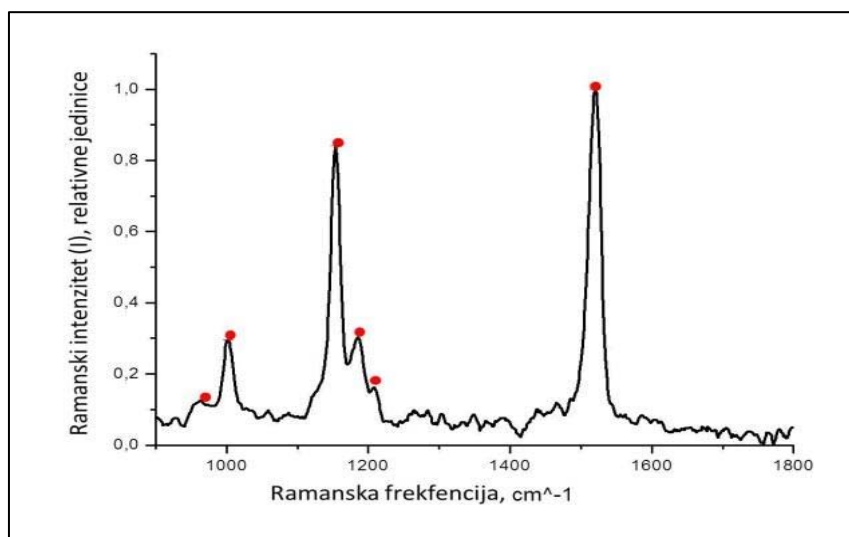
*Figure 2 – Resonance Raman spectrum of the leaf of the maize inbred lines ZPPL 146
and ZPPL 159*
*Рис. 2 – Резонансная рамановская спектроскопия листа инбредной линии
кукурузы ZPPL 146 и ZPPL 159.*
*Слика 2 – Резонантни Раманов спектар листа инбред-линија ZPPL 146
и ZPPL 159*

Four spectral bands with lower intensities (I_{926}, I_{1026}, I_{1187}, I_{1206}) were caused by conformational changes of phosphates, glycogens, and amides III. The remaining two spectral bands with significantly higher intensities (I_{1160}, I_{1520}) have been regularly analysed in relation to the conformational changes in the carotenoid molecule. It is common to analyse the differences in the intensities of spectral bands (I_{1520} and I_{1160}) and even more often the differences in their ratio (I_{1520}/I_{1160}). The resonance Raman spectrum of the leaf of the observed inbred lines with dominant spectral bands (I_{1520} and I_{1160}) is presented. This spectrum conditions the carotenoid molecules placed in the non-polar phase of the thylakoid membrane of the leaf of the inbred lines. In this paper, the effort was made to emphasize the application of resonance Raman spectroscopy in studying important vital functions of leaves of maize inbred lines, especially under agroecological conditions atypical for the maize growing region. Carotenoid molecules (β caroten, $C_{40}H_{56}$, with the activity of vitamin A, but also two xanthophylls: cryptoxanthin $C_{40}H_{56}O$ and zeaxanthin $C_{40}H_{56}O_2$), since localised in the non-polar phase of the

123

thylakoid membrane of maize inbred leaves, showed to be a very suitable natural probe, capable of contributing to registering not only higher and more significant, but also smaller and finer conformational changes. These changes in the molecular structure of carotenoids may be expressed in the form of bending, stretching, compressing, and physical disruption of chemical bonds, which is caused by intensive actions of environmental factors, unfavourable critical temperatures in the first place. In the end, each conformational change in the carotenoid molecule unconditionally changes the function not only of the carotenoid molecule but also of the thylakoid membrane in leaves of maize inbred lines. Conformational changes in chemical bonds – C = C – are reflected in the spectral band at $1520cm^{-1}$. In addition, conformational changes in chemical bonds = C – C = are reflected in the spectral band at $1160cm^{-1}$ (Karnauhov, 1988).

3. The measure of the angle and the area of the above-ear leaf of maize inbred lines

The results of the measurements of the angles between the above-ear leaf and the stalk are presented in Table 2 as well as the average leaf areas. Based on the obtained angle measurement results, it can be stated that the observed maize inbred lines belong to the group of contemporary inbred lines with erect top leaves and the status of the photosynthetic model.

Table 2 – Angle between the above-ear leaf and the stalk and the leaf area of maize inbred lines with efficient photosynthesis
Таблица 2 – Угол наклона первого листа над початком и поверхности листьев новых инбредных линий кукурузы с эффективным фотосинтезом
Табела 2 – Величина угла првог листа изнад клипа и лисне површине нових инбред-линија кукуруза са ефикасном фотосинтезом

Maize inbred line[*]	FAO maturity group	Heterotic origin of the inbred line[*]	Angle of the above-ear leaf, (^{o})		Leaf area of the above-ear leaf (cm^2)	
			$\overline{X}$	σ	$\overline{X}$	σ
ZPPL 146	650-700	BSSS, USA Zemun Polje	20.8°	1.2	3762.7	238
ZPPL 159	550-600	Landrace from Argentina (S13) crossed to the in-bred PE 25-10-1, Zemun Polje	21.3°	1.2	2378.1	241

[*]The observed maize inbred lines represent good heterotic pairs which have good combining abilities for grain yield and silage as well as good propagation and high yield. These inbreds are rich in pigments and have extraordinary nutritive qualities.

4. Empirical procedure for photosynthetic and fluorescence studies on the above-ear leaf of maize inbred lines bred for the production of healthy food

The thermal processes of delayed chlorophyll fluorescence of the observed maize inbred lines intentionally selected for developing maize hybrids to be used in the production of various feed and food products were studied in detail.

The thermal curve is a curve that shows the changes in the delayed chlorophyll fluorescence level intensity depending on temperature. The trend of its establishment is most often analogous to changes in the duration in seconds for the segments designated with a, b, c, d, e, f, and g, Figure 3, which was determined by the empirical procedure (Radenović et al, 2008, 2009, 2010).

Monitoring the course of the thermal curve and the analysis of the duration of certain segments provided data on the existence of a greater number of critical temperatures (phase transition temperatures) at which greater or smaller structural and functional changes occurred in the thylakoid membrane of the observed maize inbred lines.

In accordance with such information, it is possible to draw a conclusion on their different responses to the phenomena of resistance, drought and high temperature as well as on the phenomenon of their adaptation.

5. The exact temperature dependence of the delayed chlorophyll fluorescence intensity for the thylakoid membrane of new maize inbred lines bred for the production of healthy food

The changes in the intensity of the stationary level of delayed chlorophyll fluorescence (I_{DF}) depending on temperature which ranges from 25 °C to 60 °C were measured. The dynamics of the changes of the temperature dependence for the observed maize inbred lines is presented in Figures 4a and 4b.
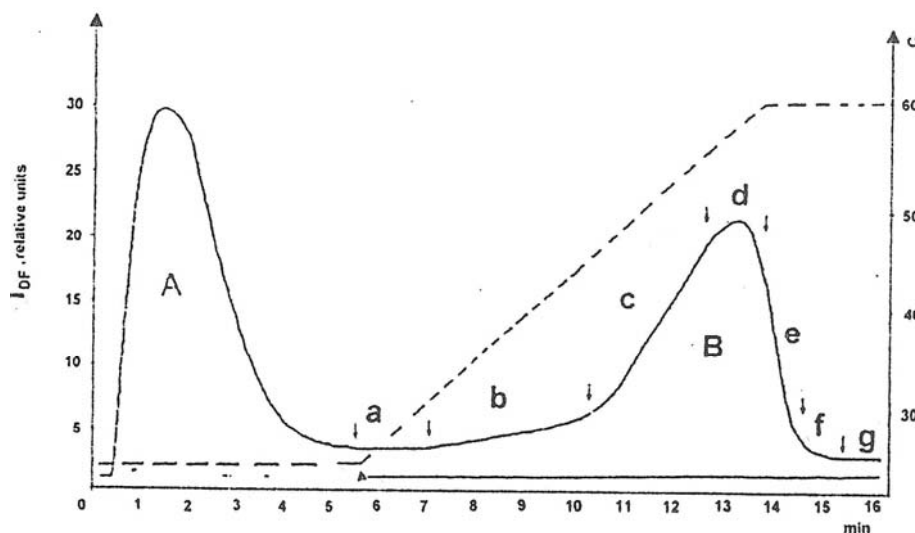
Figure 3 – Schematic presentation of the empirical procedure of typical changes of delayed chlorophyll fluorescence intensities (I_{DF}) on the intact above-ear leaf of the observed maize inbred lines with significant breeding properties (solid line) and changes of temperatures (dashed line): the curve A indicates induction processes of delayed chlorophyll fluorescence, while the curve B encompasses photosynthetic fluorescence thermal processes of delayed chlorophyll fluorescence. Typical temporal segments (a, b, c, d, e, f, and g) on the thermal curve B correspond to the dynamics of I_{DF} changes at the time of delayed chlorophyll fluorescence formation. Conformational and functional changes in the thylakoid membrane of the observed maize inbred lines with erect top leaves occur at the interception points of typical temporal segments.

Рис. 3 – Схематическое изображение типичных изменений интенсивности замедленной флуоресценции хлорофилла на интактных листьях наблюдаемых инбредных линий кукурузы (сплошная линия) и изменениями температуры (пунктирная линия): кривая А обозначает индукционные процессы замедленной флуоресценции хлорофилла, а кривая В − тепловые процессы замедленной флуоресценции хлорофилла. Типичные временные сегменты (a, b, c, d, e, f и g) на тепловой кривой В соответствуют динамике изменений I_{DF} во время образования замедленной флуоресценции хлорофилла. Конформационные и функциональные изменения тилакоидной мембраны наблюдаемых инбредных линий кукурузы с прямостоячими верхними листьями происходят в точках пересечения типичных временных сегментов.

Слика 3 – Схематски приказ типичних промена интензитета закаснеле флуоресценције хлорофила на интактном листу проучаваних инбред-линија кукуруза (пуна линија) и промене температуре (испрекидана линија): крива А означава индукционе процесе дела криве закаснеле флуоросценције хлорофила, а крива В обухвата термалне процесе дела криве закаснеле флуоресценције хлорофила. Типични временски сегменти (a, b, c, d, e, f, и g) на термалној кривој В одговарају динамици промена I_{DF} за време формирања закаснеле флуоросценције хлорофила. До конформационих и функционалних промена у тилакоидној мембрани проучаваних инбред-линија кукуруза са усправним положајем вршних листова долази у тачкама интерцепције типичних временских сегмената.
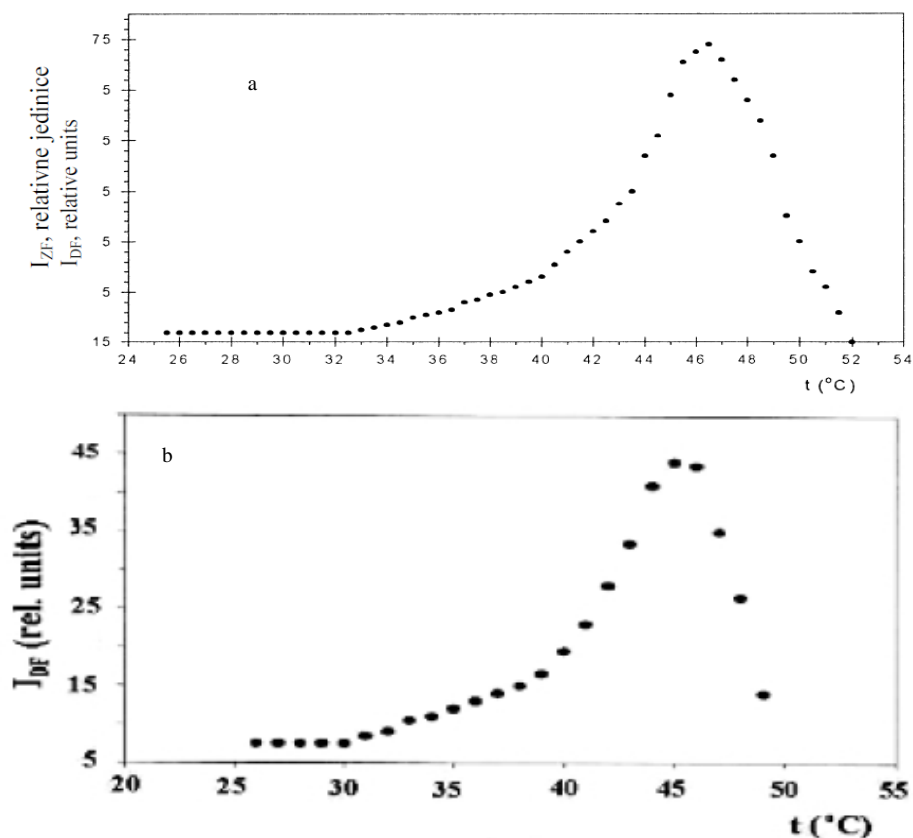
Figure 4 – Changes in the intensity of the delayed chlorophyll fluorescence (I_{DF}) of the thermal processes depending on temperature in the thylakoid membrane and chloroplasts of the intact above-ear leaf of the new air dried maize inbred lines ZPPL 146 (a) and ZPPL 159 (b).

Рис. 4 – Изменение интенсивности замедленной флуоресценции (I_{DF}) тепловых процессов в зависимости от температуры в тилакоидной мембране и хлоропластах интактного первого листа над новыми початками инбредных линий кукурузы ZPPL 146 (а) и ZPPL 159 (б), обработанных воздушной сушкой

Слика 4 – Промене интензитета закаснеле флуоресценције хлорофила (I_{DF}) термалних процеса у зависности од температуре у тилакоидној мембрани и хлоропластима интактног првог листа изнад клипа нових инбред-линија кукуруза ZPPL 146 (а) и ZPPL 159 (b) третираних ваздушним сушењем

127

5.1. The Arrhenius plot for the determination of critical temperatures and conformational changes in chloroplasts and thylakoid membranes of the new maize inbred lines bred for the production of healthy food

The Arrhenius plot is based on the linearisation of the delayed chlorophyll fluorescence exact temperature dependence of the observed maize inbreds. Critical temperatures (phase transition temperatures) at which conformational changes occur in chloroplasts and the thylakoid membrane are determined by the application of the Arrhenius plot. Figures 5a and 5b present the results of the Arrhenius plot application to the observed maize inbred lines.

Such dependence (Figures 5a and 5b) is known as the Arrhenius plot for the determination of critical temperatures that cause conformational and functional changes, of chemical nature, in chloroplasts and the thylakoid membrane. Using the Arrhenius plot and linearisation of the exact temperature dependence of DF chlorophyll, all critical temperatures (phase transition temperatures) at which even the smallest conformational change occurred in the thylakoid membrane of the new air dried maize inbred lines were determined.

The values of critical temperatures in °C, their frequency and inter-distance characterise the observed new inbred lines with erect top leaves in relation to their tolerance, resistance and adaptability to increased and high temperatures as well as to drought (Radenović et al, 2013). The Arrhenius plot is based on the existence of straight lines. Each Arrhenius's straight line represents activation energy (Ea). The intercept of two straight lines is denoted by the critical temperature.

The results of Ea values in the ascending and descending parts of the thermal curve are explained by the fact that with the temperature increase, smaller or larger conformational and functional changes occur in pigment molecules (chlorophyll, carotenoids) in the thylakoid membrane and chloroplasts. Due to the changes, these molecules became more reactive thus acquiring additional energy which was used in the recombination process of DF chlorophyll formation (Radenović et al, 2013).
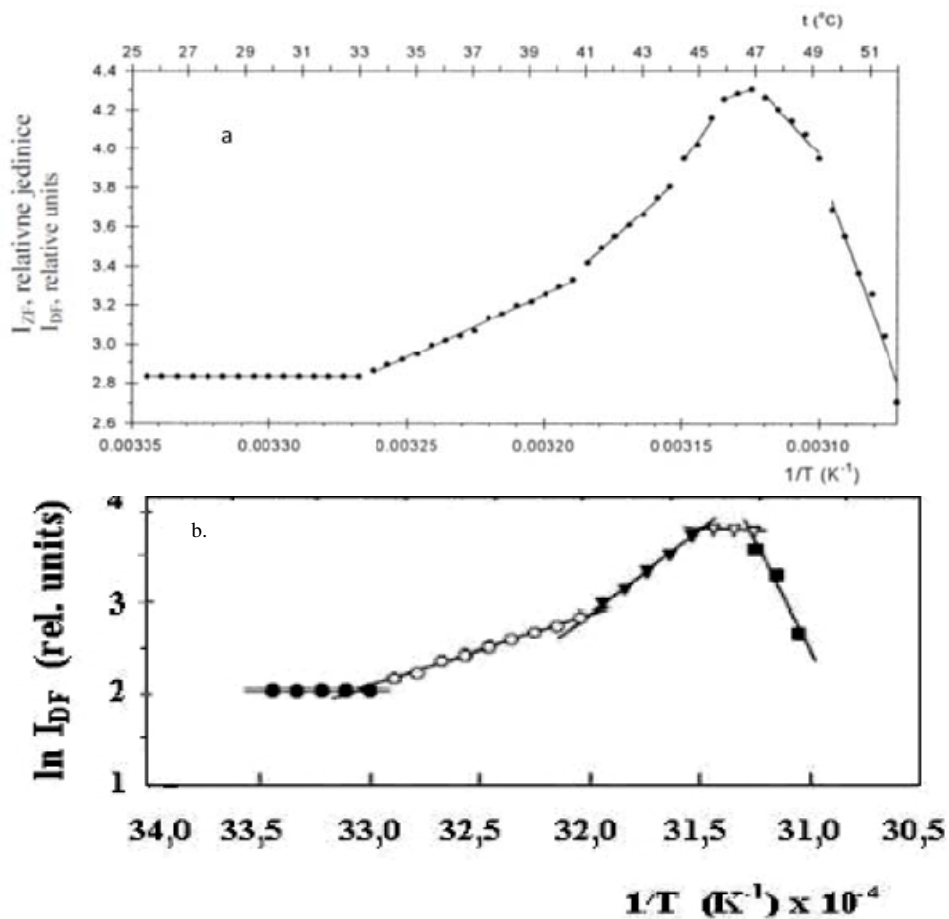
Figure 5 – The change of the logarithm of the delayed chlorophyll fluorescence intensity (ln I_DF) of the thermal processes as a function of the reciprocal temperature value in the thylakoid membrane and chloroplasts of the intact above-ear leaf of the observed air dried maize inbred lines ZPPL 146 (a) and ZPPL 159 (b).

Рис. 5 – Изменение логарифма интенсивности замедленной флуоресценции хлорофилла (Lₙ Iₐf) тепловых процессов в зависимости от обратного значения температуры в тилакоидной мембране и хлоропластах интактного первого листа над початками наблюдаемых инбредных линий кукурузы ZPPL 146 (а) и ZPPL 159 (б), обработанных воздушной сушкой

Слика 5 – Промене логаритма интензитета закаснеле флуоресценције хлорофила (Lₙ Iₐf) термалних процеса у зависности од реципрочне вредности температуре у тилакоидној мембрани и хлоропластима интактног првог листа изнад клипа проучаваних инбред-линија кукуруза ZPPL 146 (a) и ZPPL 159 (b) које су третиране ваздушним сушењем

129

5.2. Activation energy and critical temperatures in the thylakoid membrane of the observed maize inbred lines bred for the production of healthy food

Detailed studies of the thermal processes of delayed chlorophyll fluorescence, and especially the analysis of the experimental thermal curve, encompassed not only the temperature dependence and the Arrhenius plot, but also the estimation of the values of activation energies (E_a) for the critical temperatures (phase transition temperatures) in chloroplasts and the thylakoid membranes of the observed maize inbreds bred for the production of healthy food, i.e. ZPPL 146 (a) and ZPPL 159 (b). The obtained results are shown in Table 3.

Table 3 – Changes in activation energies (Ea) and critical temperatures (t °C) during the thermal processes in chloroplasts and the thylakoid membrane of the intact above-ear leaf of air dried maize inbred lines
Таблица 3 – Изменение энергий активации (Eₐ) и критических температур (t° C) при тепловых процессах в хлоропластах и тилакоидной мембране интактного листа над початком инбредных линий, обработанных воздушной сушкой
Табела 3 – Промена енергија активације (Eₐ) и критичних температура (t°C) за време термалних процеса у хлоропластима и тилакоидној мембрани интактног првог листа изнад клипа инбред-линија кукуруза третираног ваздушним сушењем

ZPPL 146		ZPPL 159	
Ea, kJ/mol	t °C	Ea, kJ/mol	t °C
/	33.5	/	25
54.5	40.0	32.0	30
105.0	44.0	100.3	38
174.0	46.0	176.7	42
41.0	47.0	259.9	47
128.5	49.0	/	50
326.0	/		

6. Brief survey of the breeding and seed production traits of the new maize inbred lines with efficient photosynthesis

The observed new maize inbred lines ZPPL 146 and ZPPL 159 are very promising in the process of maize breeding. For these reasons, some relevant observations of their selected traits, performances, and parameters are presented in Table 4.

Table 4 – Relevant breeding and seed production traits of the new maize inbred lines with photosynthetic efficiency
Таблица 4 – Релевантные селекционные и семеноводческие признаки новых инбредных линий кукурузы с эффективным фотосинтезом
Табела 4 – Релевантна селекциона и семенарска својства нових инбред-линија кукуруза са ефикасном фотосинтезом

Ordinal numeral	Name and definition of a trait	Brief description of the breeding and seed production traits of the maize inbred lines	
		ZPPL 146	ZPPL 159
1.	Heterotic origin	BSSS, USA, Zemun Polje	Landrace from Argentina (S13), crossed to the inbred PE 25-10-1, Zemun Polje
2.	FAO maturity group	650-700	550-600
3.	Grain yield ha^{-1} in kg at 14% moisture a) dry land farming b) irrigation	3500 5000	2000 3000
4.	Number of plants ha^{-1} at harvest a) dry land farming b) irrigation	50000 60000	50000 60000
5.	Stalk properties	Stalk is moderately high with a prolific trait. Tassel has an elongated central branch with fewer side branches	Stalk is short. Tassel has closed side branches that shed for a long time
6.	Stalk resistance to lodging	Inbred is resistant to lodging	Inbred is resistant to lodging
7.	Erect position of above ear leaves	first leaf < 20.8° second leaf < 17.9° third leaf < 15.3°	first leaf < 21.3° second leaf < 18.1° third leaf < 15.4°

Ordinal numeral	Name and definition of a trait	Brief description of the breeding and seed production traits of the maize inbred lines	
		ZPPL 146	ZPPL 159
8.	Stay green	Leaf remained green until harvest	Leaf remained moderately green until harvest
9.	Tolerance of the inbred to stress factors (drought and high temperatures, etc.)	Inbred is tolerant to drought and high temperatures	Inbred is tolerant to drought and high temperatures
10.	Kernel traits and cob colour	Semi-dent type, orange kernels, white cob	Semi-flint, orange kernels, red cob
11.	% grain moisture at harvest	20-25	20-25
12.	Dry down rate in the stage of grain maturing	Dry down rate is not fast, but hybrids are suited for silage	Dry down rate is not fast, but hybrids are suited for silage
13.	Harvest of inbreds	Harvest is easy	Harvest is easy
14.	Emergence of inbreds	Inbred emerges well	Inbred emerges well
15.	Early growth of inbreds	Early growth is moderate	Early growth is moderate
16.	Suitability of the hybrid grain for nutrition of ruminants and nonruminants	Grain of the hybrid developed from this inbred is suitable for nutrition of ruminants, nonruminants, human nutrition and for industrial processing	Grain of the hybrid developed from this inbred is suitable for nutrition of ruminants, nonruminants, human nutrition and for industrial processing
17.	Carotene content in the inbred grain	33.2 (mg/kg)	a) 31.8 (mg/kg)
18.	Suitability of the inbred for the development of silage hybrids	Inbred is very suitable for developing silage hybrids	Inbred is very suitable for developing silage hybrids
19.	Digestibility of hybrids	Hybrids developed from this inbred have good digestibility of the whole plant and of the grain	Hybrids developed from this inbred have good digestibility of the whole plant and of the grain

6. Functional dependence of the yield of the observed grain and maize silage hybrids

The high-yielding and high-quality maize hybrids ZP 735, ZP 737, ZP 677, and ZP 684 are mainly intended for grain and silage production of grain, ear and the whole plant, under the agroecological conditions of Southeastern Europe. According to our studies and good agricultural practice, the hybrid ZP 633 is very suitable for human diet (Radenović, 1991). However, the hybrids ZP 735, ZP 737, ZP 677, and ZP 684 are significantly better for nutrition of domestic animals through high-quality grain silage and even more often the whole plant silage. The important agronomic and morphological traits of these hybrids are presented in Tables 5 - 9.

Table 5 – Agronomic traits of the observed maize hybrids
Таблица 5 – Агрономические характеристики испытуемых гибридов кукурузы
Табела 5 – Агрономске карактеристике испитиваних хибрида кукуруза

Agronomic traits	Hybrid		
	ZP 633	ZP 735	ZP 737
Hybrid type	SC	SC	SC
FAO maturity group	550-650	750-850	750-850
Plant height (cm)	250	280	290
Ear height (cm)	120	130	135
1000-kernel weight (g)	380	370	370
Kernel type	semi-dent	dent	dent
Sowing density of silage hybrid ($\times 10^3$ plants ha^{-1})	60-70	70-75	70-75
Leaf position on the plant	semi-erect to erect	semi-erect to erect	semi-erect to erect
Tolerance to drought	good	good	good
Tolerance to diseases	good	good	good
Leaf appearance at harvest	stay green	stay green	stay green
Hybrid growing regions (altitude, m)	300-400	250-400	250-400
Hybrid biomass yield (t ha^{-1})	60-65	75-80	75-80
Hybrid grain yield (t ha^{-1})	7.819*	8.108**	12.732**

[*] Hybrid yield achieved in 30 locations in Serbia in the 2008-2011 period
[**] Hybrid yield achieved in 6 locations in Greece in the 2006-2009 period

Table 6 – Ear morphological traits of the observed maize hybrids with a grain structure
Таблица 6 – Морфологические характеристики испытуемых початка и структуры строения зерна гибридов кукурузы
Табела 6 – Морфолошке карактеристике клипа испитиваних хибрида кукуруза са структуром зрна

Traits	Hybrid		
	ZP 633	ZP 735	ZP 737
Grain moisture (%)	18	19	20
Ear length (cm)	22	25	25
Ear weight (g)	252.3	286.4	226.7
Rows per ear	16	18	18
Kernel row number	700	800	850
Kernel weight on ear (g)	228.4	248.4	200.4
% kernel pericarp on ear	5.3	6.5	4.6
% kernel embryo on ear	11.3	12.1	10.7
% kernel endosperm on ear	83.4	81.4	84.7

Table 7 – Whole plant silage yield depending on the maize hybrid sowing density
Таблица 7 – Выход цельнозернового силоса в зависимости от плотности посева гибрида кукурузы
Табела 7 – Приноси силаже целе биљке у зависности од густине усева испитиваних хибрида кукуруза

Hybrid	Sowing density (000/ha)				Grain moisture in silage period (%)
	55	60	65	70	
	Whole plant silage yield (t/ha)	Whole plant silage yield (t/ha)	Whole plant silage yield (t/ha)	Whole plant silage yield (t/ha)	
ZP 677	66.60	71.80	76.20	78.60	28.5
ZP 684	56.10	61.80	66.09	72.40	29.3
ZP 735	62.42	67.62	72.82	77.28	31.4
ZP 737	64.50	69.50	74.70	78.90	32.1

The results of the silage yields of the whole plant as a function of the sowing density of the observed maize hybrids (Table 7) should be taken conditionally. They indicate a possible trend of silage yield increase of the whole plant depending on the crop densities. It should be noted that the silage yield of the whole plant depended, to a large extent, on the type of soil, supply of nutrients, crop protection products, water and other measures within contemporary crop growing practices (Jovanović, 1996, 1998),

(Jovanović et al, 2000), (Antob et al, 2004), (Dinić & Đorđević, 2005), (Radenović, 2013), (Đorđević & Dinić, 2003).

Table 8 – Yield of fresh matter, dry matter and digestible dry matter of the observed maize hybrids sown at the common sowing density under arid conditions
Таблица 8 – Выход зеленой массы, сухого и легкоусвыояемого вещества из испытуемых гибридов кукурузы, засеянных при обычной густоте посева в условиях засухи
Табела 8 – Принос зелене масе биљака, суве материје и сварљиве суве материје за проучаване хибриде кукуруза на уобичајеној густини биљака у аридним условима

| Hybrid | Fresh matter yield (t·ha^{-1}) | Dry matter yield | | | |
		Whole plant yield (t·ha^{-1})	Plant without ear yield (t·ha^{-1})	Ear yield (t·ha^{-1})	Digestible dry matter yield (t·ha^{-1})
ZP 677	76,2	29,7	11,8	17,9	19,9
ZP 684	66,0	29,0	11,1	17,9	19,1
ZP 735	64,2	23,7	10,8	12,9	12,2
ZP 737	66,1	25,1	13,8	11,3	15,9

Table 9 – Content of dry matter, lignocellulosic fibres and dry matter digestibility of the observed maize hybrids[*]
Таблица 9 – Содержание сухого вещества, лигноцеллюлозных волокон и усвояемость сухого вещества испытуемых гибридов кукурузы [*]
Табела 9 – Садржај суве материје и лигноцелулозних влакана и сварљивост суве материје проучаваних хибрида кукуруза

| Hybrid | Whole plant dry matter content (%) | Content of lignocellulosic fibres (%) | | | | | Dry matter digestibility (%) |
		NDF[*]	ADF[*]	ADL[*]	Hemice llulose[*]	Cellulos e[*]	
ZP 677	38.96	41.09	19.51	1.68	21.58	17.83	68.29
ZP 684	44.02	39.46	18.40	1.50	21.06	16.90	65.85
ZP 735	35.58	60.10	32.07	3.06	28.03	29.01	51.30
ZP 737	38.00	42.90	22.01	3.54	18.58	18.58	63.51

*Source of data, abbreviations and explanations: The analyses of contents of NDF, ADF and ADL were performed according to the method of Van Soest P. J. (Van Soest, 1963); dry matter content was established according to the Rulebook on Sampling Methods and Methods of Physical, Chemical and Microbiological Analyses of Animal Feed (Službeni list SFRJ, 15/87) and dry matter digestibility was obtained by the INRA method, whereas the content of hemicellulose and cellulose was computed (Hemicellulose = NDF – ADF, and Cellulose = ADF - ADL). NDF – neutral detergent fibres; ADF – acid detergent fibres; ADL - acid detergent lignin (72% sulphuric acid)

135

According to the data presented in Tables 5-9, it is noticeable that the observed hybrids belong to long-season hybrids with a modern architecture, leaves that remain green and are rich in lignocellulosic fibres. Moreover, these hybrids have more than 50% of grain dry matter in dry matter of the whole plant, which is very important for silage quality. In addition, the embryo content in grain amounts to above 10%, which is especially important for the quality of nutritive values of hybrids in nutrition of people (especially children and the elderly) (Radenović, 1991) but also in nutrition of livestock (particularly cows and sheep, chicks and laying hens) (Jovanović, 1996, 1998), (Jovanović et al, 2000). The results on silage yields of grain, ear and the whole plant and grain moisture in the silage period are important for dry matter yield, digestible matter yield and the content of dry matter and lignocellulosic fibres (Tables 7-9).

After 1950, from the initial procedures of plant ensiling, the technology of fodder tinning by ensiling flourished only in the period from 1955 to 1965. Modern, intensive and economical production in cattle breeding can no longer be imagined without ensiled fodder. Moreover, the importance of such feed has been increasing in sheep and goat breeding, and to a lesser extent in pig breeding (Pejić, 1994), (Jovanović, 1996, 1998), (Jovanović et al, 2000), (Dinić & Đorđević, 2005), (Radenović et al, 2013), (Đorđević & Dinić, 2003). The authors of this study became interested in this topic in the beginning of 2002. Since then, a large number of quality maize hybrids have been developed for the production of high-quality silage in order to regulate the metabolic processes of domestic animals and thus improve their gain in weight and the quality of meat and milk (Radenović et al, 2002), (Radenović, 2002).

It is well known that maize is one of the most suitable field crops for the production of silage for ruminants. This is important for several reasons. First, very high yields of green mass are recorded in maize. It is also important that more than 50% of grain dry matter participate in the dry matter of the whole plant, which is an excellent prerequisite for the production of high quality silage. Ruminants need lignocellulosic fibres for the activity of the rumen microflora and these fibres are mainly found in maize stalks, leaves, husk, and cobs (lignocellulosic parts of the plant) (Table 9). On the other hand, starch, proteins and oils are predominantly found in the maize grain (Table 1). With the addition of some other micronutrients, maize silage prepared in this way presents a modern way of ruminants feeding. It is particularly important that such a way of animal feeding is very economical, because the process of silage preparation is completely mechanised, while the way of storing and its taking during the use is also simple.

According to the previous studies (Jovanović, 1996, 1998), (Jovanović et al, 2000), the observed hybrids (ZP 677, ZP 684, ZP 735 and ZP 737) have significantly better digestibility than some short-season hybrids, and therefore they belong to the group of the highest quality silage hybrids. It is this fact that indicates the higher nutritional value of these hybrids, which directly affects the productive performances of ruminants. Based on our studies (Radenović, 2002, 2013), the hybrids ZP 677, ZP 684, ZP 735, and ZP 737 had satisfactory yields of green mass silage under the conditions of Leskovac with the application of standard cropping practices and without irrigation. According to the obtained results, the highest yield of green mass was recorded in the maize hybrid ZP 677. However, to draw the final conclusion on which hybrid is more suitable for silage, grain yield as well as silage digestibility should be taken into account. Since these are long-season hybrids (FAO maturity group 750-850), they have a very developed leaf mass and the intensive photosynthetic activity. This, among other things, classifies them into a group of hybrids most suitable for the silage production under the climate conditions of Serbia and Southeastern Europe (Greece, Bulgaria, and Turkey).

As already mentioned, a huge success has been achieved in maize breeding and the production of high quality foundation seed and hybrid seed in the last 42 years. Furthermore, a great success was achieved in modern technologies for the commercial maize production. Since 1978, the number of maize plants per area unit has been significantly increased by the application of the new maize breeding programme. This programme, known as a "plant density" breeding programme, directly affected the increase of yield of both foundation and hybrid seeds as well as the yield of commercial maize (Radenović et al, 2004, 1978). A few years later, the breeding programme for the development of maize inbred lines with erect top leaves - inbreds with more efficient photosynthesis - was implemented (Radenović et al 2004, 2008, 2009, 2007). Some of these inbred lines with the erect top leaves were thought to be the closest to the assumed photosynthetic maize model. At the same time, the breeding programme for maize inbreds rich in pigments and other chemical properties and excellent nutritional values was initiated (Kojić & Ivanović, 1986), (Petrović et al, 1992), (Pejić, 1994), (Jovanović, 1996, 1998), (Dumanović & Pajić, 1998), (Jovanović et al, 2000), (Dinić & Đorđević, 2005), (Pajić et al, 1995), (Liu, 2007), (Strati et al, 2012, (Tyutyaev et al, 2015), (Đorđević & Dinić, 2003), (Kurlich & Juvik, 1999), (Granado et al, 2003), (Luo & Wang, 2012).

This study was an attempt to answer the following question by using different interdependent tests and analyses: „Is there a reliable and dominant trait (one or more) of the observed maize inbred lines rich in the pigment complex that would be the basis for the development of new extra-quality maize hybrids that would be suitable for human diet and nutrition of domestic animals?" The analysis of the presented overall results, obtained in the series of experiments, can easily give the positive answer to this question. Consequently, the new maize inbred lines (ZPPL 146 and ZPPL 159) and the hybrids developed from them (ZP 633, ZP 735 and ZP 737) are the best confirmation of the stated. The bred inbred lines and hybrids developed from them are rich in pigments, have significant nutritive values, especially of carotenoids that give the colour (Abdel-Aal et al, 2006) to cereal kernels used in the nutrition of poultry. Carotenoids have many biological functions in both people and animals (Strati et al, 2012), (Kurlich & Juvik, 1999), (Granado et al, 2003), (Bacchetti et al, 2013). This aspect of the observed maize inbred lines and hybrids will get priority within the healthy extra-quality maize-based diet for people and nutrition for animals.

Conclusions

Based on the presented numerous and diverse results of the studies of the new inbred lines (ZPPL 146 and ZPPL 159) and the maize hybrids developed from these inbreds (ZP 633, ZP 735 and ZP 737) that have high nutritive values, are rich in pigments and, in accordance with their chemical composition, have efficient photosynthesis and other relevant parameters characteristic for the best standard maize hybrids (ZP 677 and ZP 684) for silage of grain, ear and the whole plant, the following can be concluded:

- Selected new, unique maize inbred lines (ZPPL 146 and ZPPL 159), rich in carotenoids, yellow pigments, also have significant amounts of other relevant bioactive compounds and good physical traits.
- Observed inbred lines have erect top leaves and are classified into a group of maize inbreds with significant properties of the photosynthetic model - they are high yielding and tolerant to high temperatures and drought.
- Spectral bands pointing to the conformational characteristics of molecules of carotenoids but also other compounds (phosphates, glutens, and amides III) were established by the resonance

Raman spectroscopy method applied to the leaf of the maize inbred lines.

- Relevant traits, properties and parameters of the observed new maize inbred lines that can be successfully used in the breeding process are presented.
- These maize inbred lines were used to develop high yielding and extra quality maize hybrids (ZP 633, ZP 735 and ZP 737) that are recognisable for their quality. The hybrid ZP 633 is particularly recognisable in human nutrition (children and the elderly). Furthermore, in relation to veterinary and agronomic estimations, the hybrids ZP 735 and ZP 737 are the most suitable for feeding domestic animals with a programmed use of maize silage, ground maize and coarse meal.
- Relevant agronomic, morphological and nutritive properties of the maize hybrids ZP 677, ZP 684, ZP 735 and ZP 737 are presented. Moreover, the results regarding the grain structure and grain and silage yields obtained in the regions of Serbia and Southeastern Europe (Greece, Bulgaria, and Turkey) are also displayed.
- All studied maize hybrids (ZP 633, ZP 735, ZP 737, ZP 677, and ZP 684) are intended for large-scale production of flour, semolina, ground maize, silage of grain, ear and the whole plant, which provides healthy and extra quality food and feed.

Special acknowledgement

breeding would have been even more successful. Even so, he will be always remembered for his deeds - the Serbian maize breeding has a leading place in Europe.

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ВЫСОКОУРОЖАЙНЫЕ И ХИМИЧЕСКИ ОБОГАЩЕННЫЕ ГИБРИДЫ КУКУРУЗЫ СЕРБСКОЙ СЕЛЕКЦИИ − ЛУЧШАЯ ОСНОВА ДЛЯ ВЫСОКОКАЧЕСТВЕННЫХ ПРОДУКТОВ ПИТАНИЯ И КОРМОВ ДЛЯ ДОМАШНИХ ЖИВОТНЫХ

Чедомир. Н. Раденович[а,б], *Ненад*. С. Делич[а], *Милица* М. Радосавлевич[а], *Живота* В. Йованович[а], *Миле* Д. Сечански[а], *Александар* С. Попович[а], *Милош* С. Цревар[а], *Небойша* Д. Радосавлевич[а]

[а] Институт кукурузы „Земун Поле", г. Белград, Республика Сербия

[б] Белградский университет, факультет физической химии, г. Белград, Республика Сербия, **корреспондент**

Резюме:

Введение/цель: В данной статье представлены результаты ряда различных исследований. Селекция инбредных линий ZPPL 146 и ZPPL 159, произведенная на основе гибридов кукурузы, предназначенных в первую очередь для производства продуктов питания и кормов для домашних животных, заняла около четырех десятилетий: ZP 633, ZP 735 и ZP 737.

Методы: В исследовании применялся метод резонансной рамановской спектроскопии листьев инбредных линий кукурузы, с

помощью которой были обнаружены спектральные полосы, которые указывают на конформационные характеристики молекул каротиноидов, а также других соединений (фосфата, глютена и амида III).

Результаты: На основании проведенного систематического исследования инбредных линий: ZPPL 146 и ZPPL 159 и гибридов кукурузы: ZP 633, ZP 735 и ZP 737 выявлено, что новые инбредные линии кукурузы: ZPPL 146 и ZPPL 159 богаты каротиноидами и желтыми пигментами. Эти линии в большом объеме обладают и другими важными биологически активными соединениями и благоприятными физическими характеристиками. Изучаемые инбредные линии кукурузы отличаются прямостоячим положением верхних листьев и относятся к группе линий кукурузы со значительными характеристиками модели фотосинтеза. Это жаростойкие и засухоустойчивые растения.

Выводы: В данной статье представлены релевантные свойства, характеристики и параметры изученных новых инбредных линий кукурузы, которые в перспективе могут быть использованы в процессе селекции. С помощью вышеуказанных инбредных линий кукурузы созданы высокоурожайные и высококачественные гибриды кукурузы: ZP 633, ZP 735 и ZP 737, отличающиеся по своим качествам. Особенно узнаваем гибрид ZP 633, предназначенный для производства продуктов питания (для детей и пожилых людей).

Ключевые слова: замедленная флуоресценция хлорофилла, рамановская спектроскопия, модель фотосинтеза, Zea mays L, инбредная линия, гибрид, тилакоидная мембрана, пигментные свойства, пищевая ценность, продукты питания и корма для домашних животных.

ВИСОКОПРИНОСНИ И ХЕМИЈСКИ ОБОГАЋЕНИ ХИБРИДИ КУКУРУЗА СРПСКЕ СЕЛЕКЦИЈЕ КАО НАЈБОЉА ОСНОВА ЗА НАЈКВАЛИТЕТНИЈУ ХРАНУ

Чедомир. Н. Раденовић[а,б], *Ненад*. С. Делић[а], *Милица* М. Радосављевић[а], *Живота* В. Јовановић[а], *Миле* Д. Сечански[а], *Александар* С. Поповић[а], *Милош* С. Цревар[а], *Небојша* Д. Радосављевић[а]

[а] Институт за кукуруз „Земун Поље“, Београд, Република Србија

[б] Универзитет у Београду, Факултет за физичку хемију, Београд, Република Србија, **аутор за преписку**

ОБЛАСТ: физичка хемија, биофизика, генетика, биохемија и технологије за прераду биљних сировина
ВРСТА ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: У овом раду излажу се резултати више различитих истраживања. Констатује се да је око четити деценије трајало селекционисање инбред-линија ZPPL 146 и ZPPL 159 и са њима створених хибрида кукуруза: ZP 633, ZP 735 и ZP 737, првенствено намењених за исхрану људи и домаћих животиња.

Методе: Применом методе резонантне Раманове спектроскопије листа инбред-линија кукуруза регистроване су спектралне траке које указују на конформационе карактеристике молекула каротеноида, али и других једињења (фосфата, глутена и амида III) у листу.

Резултати: У раду је извршено систематско испитивање инбред-линија: ZPPL 146 и ZPPL 159 и хибрида кукуруза: ZP 633, ZP 735 и ZP 737. Констатовано је да су нове инбред-линије кукуруза: ЗППЛ 146 и ЗППЛ 159 богате каротеноидима и жутим пигментима. Те линије имају, у знатним количинама и вредностима, и друга релевантна биоактивна једнињења и добре физичке карактеристике. Проучаване инбред-линије кукуруза имају усправан положај вршних листова и спадају у групу линија кукуруза са значајним карактеристикама фотосинтетичког модела. Оне су отпорне на високу температуру и толерантне су на сушу.

Закључак: У раду су изложена релевантна својства, карактеристике и параметри проучаваних нових инбред-линија кукуруза која се могу користити у будућности у селекционом процесу. Са наведеним инбред-линијама кукуруза створени су високоприносни и квалитетни хибриди кукуруза: ZP 633, ZP 735 и ZP 737, који су препознатљиви по својим квалитетима,а нарочито хибрид ZP 633 за исхрану људи (деце и старијих лица). Исто тако, са агрономско-ветеринарског становишта је потврђено да су хибриди ZP 735 и ZP 737 најпогоднији за исхрану домаћих животиња уз програмирано коришћење кукурузне силаже. Такође, изложена су релевантна агрономска, морфолошка и нутритивна својства хибрида кукуруза ZP 633, ZP 735 и ZP 737. Презентовани су и резултати о структури зрна и висини приноса за зрно и силажу и код хибрида ZP 677 и ZP 684, који се производе у Србији и земљама југоисточне Европе.

Кључне речи: закаснела флуоресценција хлорофила, Раманова спектроскопија листа, фотосинтетички модел, Zea mays L, инбред-линија, хибрид, тилакоидна мембрана, пигментна својства, нутритивна вредност, храна за људе и животиње.

SAFETY IN RESIDENTIAL BUILDINGS - EVACUATION FROM RESIDENTIAL BUILDINGS WITHOUT FIRE ESCAPE STAIRS

Radoje B. Jevtić

Secondary School of Electrical Engineering "Nikola Tesla",
Niš, Republic of Serbia,
e-mail: milan.jvtc@gmail.com,
ORCID iD: https://orcid.org/0000-0002-0179-1321

Abstract:

Introduction/purpose: Safety in high residential buildings presents a very important and always actual task. In case of some unforeseen and dangerous occurrences, their residents must be evacuated. Fire, earthquakes, and terrorism are only some of such situations. The speed of evacuation from high residential buildings depends on many different factors. A particularly difficult and complex evacuation task concerns buildings without fire escape stairs.

Methods: The modeling method was used in this paper. Based on a real object – a residential building, an appropriate simulation model was realized in appropriate simulation software.

Results: The results of this paper have shown that, out of four scenarios, the fastest evacuation was for the evacuation speed of 1.75 m/s. The first two scenarios did not report any jams, unlike the third and fourth scenario; in the third scenario, the occupants' speeds were 0.75 m/s and 1.25 m/s while in the fourth scenario, the simulated occupants' speeds were from 0.75 m/s to 1.75 m/s.

Conclusion:The usage of appropriate simulation software enables fast, precise, safe and cheap calculation of evacuation times and it can significantly improve evacuation procedures and evacuation strategies.

Key words: evacuation, building, human, simulation.

Introduction

An evacuation presents the most important measurement for population protection. This measurement generally comprises a planned and organized relocation of humans, animals, material properties, state

authorities etc., from an endangered area to a safe area. Depending on a vulnerability degree and current damage, evacuation can be temporary or permanent. The reasons for evacuation can be different: fire, earthquake, floods, terrorism, nuclear disaster, tsunami, whirlwind, etc. Namely, it is important to note that there are differences between evacuation, displacement, and relocation of population.

Residential buildings present specific objects for evacuation, mostly because of a huge number of residents of different age. Besides this important factor, there are also other factors such as building construction and location, possibilities for fire fighters to approach the site, presence or absence of evacuation stairs, presence or absence of an escape rescue system, behavior of residents under stress, etc. For example, in the United States, in the period from 2007 to 2011, fire units had 15400 interventions because of fire in high buildings. These fires caused 46 victims, 530 civil injuries and more than 200 million dollars of damage, on the year level. It is interesting to note that 45 % of all fires were caused in apartments; 3 % of all fires were caused in hotels; 2 % of all fires were caused in offices, and 1 % of all fires was caused in elderly care objects (Mumović, 2019).

One very important event related to safety evacuation in high buildings was, unfortunately, the terrorist's attacks on the World Trade Centre in New York, on 11 September 2001. According to analyses, the evacuations of 87 % of all occupants were realized in less than two hours. However, evacuation times were pretty different and complex to explain. Because of that reason, many different experts agreed that safety in high buildings would be much improved with a better understanding and analysis of human behavior in panic and stress situations. In addition, several very important factors influenced occupant behavior in general. Taking into account demographic characteristics, it was noted that 58 % of all occupants were male with an average age of 44; 90 % of all occupants were well educated, 56 % of all occupants lived outside New York while 32 % of all occupants lived in the neighborhood. Health and injury status of occupants were also important - it was noted that 23 % of all occupants reported some medical problem. Familiarity with the building and installed fire safety measurements were very poor - it was confirmed that only 20 % of all occupants were introduced with proper actions after the alarm sounded (Gershon et al, 2011).

Regardless of building construction characteristics, evacuation from residential buildings can be realized in several ways: first, by stairs, and then by elevators or their combinations. Modern residential buildings built in recent times have several new and modern ways for evacuation, such

as special security equipment, transport helicopters or some new construction solutions (connections between buildings or similar). In many cases, evacuation by stairs presents the only possible way for evacuation. Many high buildings have standard staircases and emergency stairs, many not. The realization of staircases demands detailed research about many factors, such as the position of the staircase, the material the stairs are made of, the staircase dimensions (width, riser and tread dimensions), stairs fire resistance, etc. (Pauls, 2005).

Although in the last twenty years fire protection systems and evacuation systems have significantly improved, accidents in high residential buildings have occurred. As an example, fires in residential buildings are presented in Figure 1 (a and b).

a)   b)

Figure 1 – Huge fire in a residential building in Sao Paolo, Brazil, in 2018 (a) (Fos Media, 2018) and a huge fire in the residential building Grenfell Tower in London, UK, in 2017 (b) (Hartley-Parkinson, 2019)
Рис. 1 – Крупный пожар в жилом здании в г.Сан-Паулу, Бразилия (а) (Fos Media, 2018) и крупный пожар в здании Гренфелл-тауэр в Лондоне, ОК, 2017 (б) (Hartley-Parkinson, 2019)
Слика 1 – Велики пожар у стамбеној згради у Сао Паолу, Бразил, (а) (Fos Media, 2018) и велики пожар у стамбеној згради у Grenfell Tower-у у Лондону, УК, 2017(б) (Hartley-Parkinson, 2019)

The usage of elevators for evacuation is questionable for many different reasons: the lack of power supply, collapse capabilities, the

possibilities of dangerous gases penetration (especially carbon monoxide (CO)), the lack of space, etc. Because of the noted reasons, many different evacuation approaches do not recommend elevators usage for evacuation (Glavinić & Rasković, 2016).

The occupant behavior under stress and panic presents a very complex factor hard to define and predict. It is almost impossible to predict occupants' behavior in stress situations, no matter how educated or familiar with safety precautions they are. Occupants are, in normal conditions, aware and ready to find the best options, even in the cases when they should aid someone (help someone with disabilities, help children, etc.). However, are they able to do all this in the presence of smoke, flame, heat, crashes, explosions or other stress situations? A different age of occupants is also important and brings new moments of complexity and unpredictability (Ronchi & Nilsson, 2013), (Jevtić, 2016).

It is obvious that successful evacuation in an accident, especially from a complex object such as a residential building, must be realized in the early stage of the accident. Of course, it implies the timely detection of an accident or a disaster. Because of that, it is important to predict, as closely as possible, all potential evacuation scenarios and situations. One of the best ways to predict evacuation situations and calculate time needed for evacuation is the usage of simulation software. The usage of simulation software and the analysis of potential evacuation scenarios for different evacuation factors present a new, effective, safe, and "all in" approach in building architecture. Powerful computers enable detailed analyses of evacuation by simulation and prediction of almost all potential scenarios. The given facts show that this topic has a great importance, primarily in the protection of human lives. On the other hand, a timely and well-planned evacuation enables a fast evacuation of occupants and a fast approach of fire fighters, which can significantly decrease damage to material properties. This paper was written to show the prediction of evacuation scenarios and the calculation of evacuation times in the case of a building without emergency stairs, using adequate simulation software.

Pathfinder simulation software

A successful and safely realized evacuation as well as saving lives and material properties can be significantly improved by using simulation software. The reasons for simulation software usage lie in the fact that such usage is, above all, safe and economically cost-effective. In addition, it has potentials to predict many different evacuation scenarios

and calculations of evacuation times. There is a number of simulation software for evacuation on the market. One of them is Pathfinder. This simulation software is based on human movement. Until today, several different versions of this program have been developed. This powerful simulator enables a graphical user interface for simulation design and execution. It is possible to simulate human movements through objects, in elevators, on stairs, etc. The Pathfinder environment presents a 3D triangulated mesh designed to match the real dimensions of a building model. This software can support two different simulation ways: the steering mode and the SFPE mode. In addition, this software has a very important ability to import files from different programs such as FDS, 3D Cad and PyroSim, what enables much faster drawing of a simulation model and the usage of the existent simulation models with minor remakes. The Pathfinder version used for this paper was 2020 version (Thunderhead, 2014).

Simulation model

The object simulated in this paper was the building in the Bulevar Nemanjića Street, with numbers from 58 to 64. This object actually presents four buildings connected in one. The object has four exits/entrances without emergency stairs. The main advantage of such objects is in their great stability in case of earthquakes. Every building has the basement, the ground floor, ten floors and a roof terrace. The buildings are connected via terraces. The connected terraces serve for evacuation in case that residents cannot get out through the entrance/exit.

Every building, taken separately, has two elevators, vault rooms, a loft and four flats on every floor started from the ground floor to the tenth floor. This means that every building, taken separately, has forty-four flats, i.e. there are one hundred and seventy six flats in total. There are two different flat types per floor, one with an approximate surface of 66 m^2 and one with an approximate surface of 50 m^2. Every building separately has two different elevators: one with a total capacity of four persons and one with a total capacity of six persons. The elevators have different speeds. These speeds were measured, and, for a smaller elevator type, the speed was 1. 1 m/s, while the speed of a bigger elevator was 0.92 m/s. The maximum distance between the floors is approximately 2. 6 m, which means that the total height of the object is approximately 36-38 m (measured from the ground to the elevator machine room on the top of the building). Related to this object, a proper

simulation model with all its real dimensions was constructed in Pathfinder software.

The positions of the residents were per floors and in flats, based on the resident lists. Because of visibility, the HIDE function from Pathfinder was used. This means that only some elements were visible, such as stairs, doors, elevators, etc. The total number of residents was 699, which was confirmed from the resident lists for every of four buildings separately (179 residents in the entrance/exit with number 58, 168 residents in the entrance/exit with number 60, 169 residents in the entrance/exit with number 62, and 183 residents in the entrance/exit with number 64).

After the construction of the simulation model, it was decided to simulate four different scenarios. The first simulation scenario included all entrances/exits opened, with enabled and disabled elevators. The second simulation scenario included one entrance/exit blocked while other three entrances/exits were open (all potential 9 cases), with enabled and disabled elevators. The third simulation scenario included two entrances/exits blocked while other two entrances/exits were open (all potential 12 cases), with enabled and disabled elevators. The fourth simulation scenario was based on three entrances/exits blocked while one entrance/exit was open (all potential 8 cases), with enabled and disabled elevators. Each of four scenarios was realized for different speeds of occupants: 0.75 m/s, 1 m/s, 1.25 m/s, and 1.5 m/s and 1.75 m/s (Jevtić, 2018), (Jevtić, 2019a).

The residential building in Bulevar Nemanjića Street, from 58 to 64, Niš, is presented in Figure 2 (a), while the appropriate Pathfinder simulation model of the residential building in Bulevar Nemanjića Street is presented in Figure 2 (b).

Simulation results

The complete simulation results are presented from Table 1 to Table 30. The simulation results for the first scenario are presented in Tables 1 and 2. The simulation results for the second scenario are presented in Tables from 3 to 10. The simulation results for the third scenario are presented in Tables from 11 to 22. The simulation results for the fourth scenario are presented in Tables from 23 to 30. All simulations of the evacuation were realized on a laptop Honor MagicBook 15 with AMD Ryzen 5 3500U processor at 3.7 GHz and 6 MB of CASH memory and 8 GB DDR4 2667 MHz. It is desirable to possess a strong hardware configuration for any kind of computer simulation.

a)   *b)*
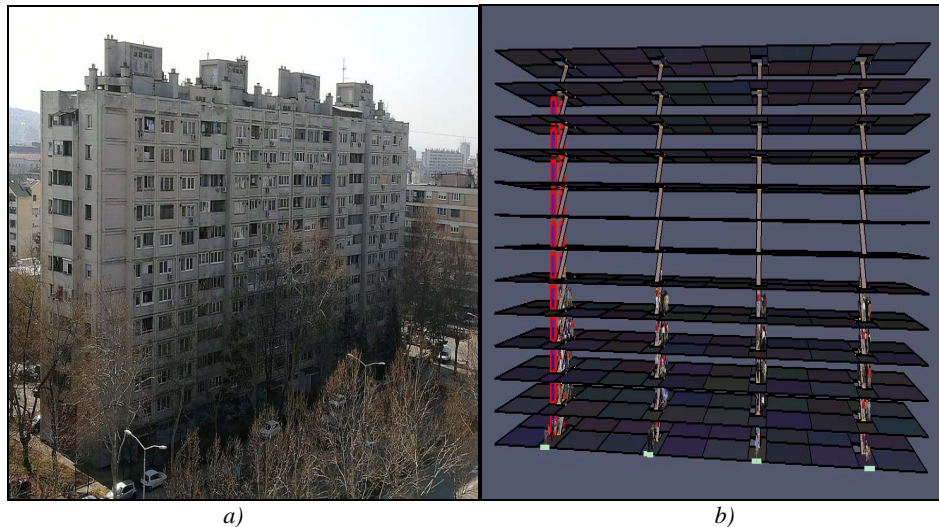
Figure 2 – Building in Bulevar Nemanjića Street, from 58 to 64 (a) and the Pathfinder simulation model of the residential building in Bulevar Nemanjića Street (b)
Рис. 2 – Здание на Бульваре Неманича с 58 по 64 (а) и имитационная модель в жилом здании Pathfinder на Бульваре Неманича (б)
Слика 2 – Зграда у Булевару Немањића, од броја 58 до 64 (а), и симулациони модел у Pathfinder-у стамбене зграде у Булевару Немањића (б)

Table 1 — Simulation results in seconds for the first scenario, with elevators enabled and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 1 – Результаты симуляции, выраженные в секундах по первому сценарию, с лифтами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 1 – Симулациони резултати у секундама за први сценарио, са лифтовима и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	133	183	230	286	332	365
Time for speed of occupants 1 m/s	0	105.7	141.6	183.4	221	256	293
Time for speed of occupants 1.25 m/s	0	84	127	159	197	234	256
Time for speed of occupants 1.5 m/s	0	72.2	105.8	148	176	209	236
Time for speed of occupants 1.75 m/s	0	50	79	123	140	180	209

Table 2 − Simulation results in seconds for the first scenario, with elevators disabled and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 2 – Результаты симуляции, выраженные в секундах по первому сценарию, без лифта, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 2 – Симулациони резултати у секундама за први сценарио, без лифтова и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	145	203	255	313	351	442
Time for speed of occupants 1 m/s	0	123	177.6	219.4	257	292	334
Time for speed of occupants 1.25 m/s	0	113	156	188	226	263	288
Time for speed of occupants 1.5 m/s	0	95.2	128.8	171	199	232	267.6
Time for speed of occupants 1.75 m/s	0	74	88.7	133	150	187	232

Table 3 − Simulation results in seconds for the second scenario, with elevators enabled and the first entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 3 – Результаты симуляции, выраженные в секундах по второму сценарию, с лифтами и первым заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 3 – Симулациони резултати у секундама за други сценарио, са лифтовима и са првим блокираним улазом⁄излазом и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	190	225	291	398	562	796
Time for speed of occupants 1 m/s	0	160	195	254	342	501	627
Time for speed of occupants 1.25 m/s	0	134	165	231	311	472	554
Time for speed of occupants 1.5 m/s	0	118	136	201	284	420	499
Time for speed of occupants 1.75 m/s	0	100	120	172	235	367	434

Table 4 − Simulation results in seconds for the second scenario, with elevators enabled and the second entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 4 – Результаты симуляции, выраженные в секундах по второму сценарию, с лифтами и вторым заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 4 – Симулациони резултати у секундама за други сценарио, са лифтовима и са другим блокираним улазом/излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	184	213	275	380	546	772
Time for speed of occupants 1 m/s	0	155	184	239	320	487	600
Time for speed of occupants 1.25 m/s	0	128	155	218	295	455	530
Time for speed of occupants 1.5 m/s	0	113	126	190	266	406	468
Time for speed of occupants 1.75 m/s	0	95	110	166.4	221	351	422

Table 5 − Simulation results in seconds for the second scenario, with elevators enabled and the third entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 5 – Результаты симуляции, выраженные в секундах по второму сценарию, с лифтами и третьим заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 5 – Симулациони резултати у секундама за други сценарио, са лифтовима и са трећим блокираним улазом/излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	199	225	290	397	566	789
Time for speed of occupants 1 m/s	0	167	199	253	336	506	615
Time for speed of occupants 1.25 m/s	0	136	174	234	311	475	543
Time for speed of occupants 1.5 m/s	0	122	150	202	280	422	480
Time for speed of occupants 1.75m/s	0	104	132	180	235	369	432

Table 6 − Simulation results in seconds for the second scenario, with elevators enabled and the fourth entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 6 – Результаты симуляции, выраженные в секундах по второму сценарию, с лифтами и четвертым заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1,75 м/с

Табела 6 – Симулациони резултати у секундама за други сценарио, са лифтовима и са четвртим блокираним улазом/излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	210	239	306	415	588	811
Time for speed of occupants 1 m/s	0	178	213	269	354	526	639
Time for speed of occupants 1.25 m/s	0	147	185	250	330	496	566
Time for speed of occupants 1.5 m/s	0	135	164	217	297	444	503
Time for speed of occupants 1.75 m/s	0	116	144	194	253	390	457

Table 7 − Simulation results in seconds for the second scenario, with elevators disabled and the first entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 7 – Результаты симуляции, выраженные в секундах по второму сценарию, без лифта и с первым заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1,75 м/с

Табела 7 – Симулациони резултати у секундама за други сценарио, без лифтова и са првим блокираним улазом/излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	270	306	372	480	642	873
Time for speed of occupants 1 m/s	0	240	278	337	420	582	700
Time for speed of occupants 1.25 m/s	0	215	248	315	390	553	634.9
Time for speed of occupants 1.5 m/s	0	199	217	281.3	363	499	579.5
Time for speed of occupants 1.75 m/s	0	181	200	250	313	447	515

Table 8 — Simulation results in seconds for the second scenario, with elevators disabled and the second entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 8 – Результаты симуляции, выраженные в секундах по второму сценарию, без лифта и со вторым заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 8 – Симулациони резултати у секундама за други сценарио, без лифтова и са другим блокираним улазом⁄излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	220	250	313.6	418.4	580	812
Time for speed of occupants 1 m/s	0	193.4	223	280.9	361.6	528.2	642
Time for speed of occupants 1.25 m/s	0	162	192	260	330	493	569
Time for speed of occupants 1.5 m/s	0	152	168	229.5	302	443	525
Time for speed of occupants 1.75 m/s	0	133.7	149	205.3	260	390.4	460

Table 9 — Simulation results in seconds for the second scenario, with elevators disabled and the third entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 9 – Результаты симуляции, выраженные в секундах по второму сценарию, без лифта и с третьим заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 9 – Симулациони резултати у секундама за други сценарио, без лифтова и са трећим блокираним улазом⁄излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	264.4	295	357.4	462	620	856
Time for speed of occupants 1 m/s	0	237.6	267.6	324.4	402	567	684
Time for speed of occupants 1.25 m/s	0	206.6	237.6	303	370.4	537	613
Time for speed of occupants 1.5 m/s	0	197.4	224.6	276.4	345	481	569
Time for speed of occupants 1.75 m/s	0	149	198.5	248.6	305	434	503.5

Table 10 − Simulation results in seconds for the second scenario, with elevators disabled and the fourth entrance/exit blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 10 – Результаты симуляции, выраженные в секундах по второму сценарию, без лифта и с четвертым заблокированным входом/выходом, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 10 – Симулациони резултати у секундама за други сценарио, без лифтова и са четвртим блокираним улазом/излазом, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	292	330	393	494	657	893
Time for speed of occupants 1 m/s	0	274	304	361	439	603	720.2
Time for speed of occupants 1.25 m/s	0	243	273	340	405.3	573.5	649
Time for speed of occupants 1.5 m/s	0	214	258	314.4	382	525.6	606
Time for speed of occupants 1.75 m/s	0	195	234	284.4	341	471.5	541.5

Table 11 − Simulation results in seconds for the third scenario, with elevators enabled and the first and the second entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 11 – Результаты симуляции, выраженные в секундах по третьему сценарию, с лифтами и с первым и вторым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 11 – Симулациони резултати у секундама за трећи сценарио, са лифтовима и са првим и другим блокираним улазима/излазима , и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	314	357	416	517	679	915
Time for speed of occupants 1 m/s	0	296	325	384	460	624	742
Time for speed of occupants 1.25 m/s	0	264	294.6	360.9	426.7	595.2	671
Time for speed of occupants 1.5 m/s	0	235.2	278.7	336	402	547.7	627
Time for speed of occupants 1.75 m/s	0	216	254	304	361	494	565

Table 12 — Simulation results in seconds for the third scenario, with elevators enabled and the first and the third entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 12 – Результаты симуляции, выраженные в секундах по третьему сценарию, с лифтами и с первым и третьим заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 12 – Симулациони резултати у секундама за трећи сценарио, са лифтовима и са првим и трећим блокираним улазима/излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	326	369	428	529	691	927
Time for speed of occupants 1 m/s	0	308	337	396	472	636	754
Time for speed of occupants 1.25 m/s	0	276	306.6	373.4	439	607.2	683
Time for speed of occupants 1.5 m/s	0	248	290.7	348	414	560.2	639
Time for speed of occupants 1.75 m/s	0	228	266	316	373	506	577

Table 13 — Simulation results in seconds for the third scenario, with elevators enabled and the first and the fourth entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 13 – Результаты симуляции, выраженные в секундах по третьему сценарию, с лифтами и с первым и четвертым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 13 – Симулациони резултати у секундама за трећи сценарио, са лифтовима и са првим и четвртим блокираним улазима/излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	353	397	453	558.4	718.3	952.9
Time for speed of occupants 1 m/s	0	334.4	364	423	500	661.6	782.1
Time for speed of occupants 1.25 m/s	0	304	331	401.8	465	635.6	709
Time for speed of occupants 1.5 m/s	0	274	318.3	374	440	591	665
Time for speed of occupants 1.75 m/s	0	254.7	292	342	400.5	532	605

Table 14 – Simulation results in seconds for the third scenario, with elevators enabled and the second and the third entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 14 – Результаты симуляции, выраженные в секундах по третьему сценарию, с лифтами и со вторым и третьим заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 14 – Симулациони резултати у секундама за трећи сценарио, са лифтовима и са другим и трећим блокираним улазима⁄излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	298	340	400	500	663	899
Time for speed of occupants 1 m/s	0	281	310	369	445	609	727
Time for speed of occupants 1.25 m/s	0	249	279.6	345.9	411.7	579.8	656
Time for speed of occupants 1.5 m/s	0	220.2	263.7	320.5	387	531.2	612
Time for speed of occupants 1.75 m/s	0	201	240.4	290.2	345.5	479	550

Table 15 – Simulation results in seconds for the third scenario, with elevators enabled and the second and the fourth entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 15 – Результаты симуляции, выраженные в секундах по третьему сценарию, с лифтами и со вторым и четвертым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 15 – Симулациони резултати у секундама за трећи сценарио, са лифтовима и са другим и четвртим блокираним улазима⁄излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	337	380	439	541.5	702	938
Time for speed of occupants 1 m/s	0	319	348	407	483	647	765
Time for speed of occupants 1.25 m/s	0	287	317.6	385.7	450	618.2	694
Time for speed of occupants 1.5 m/s	0	259	302	359	426.2	574	650
Time for speed of occupants 1.75 m/s	0	239	278.3	327	384	517	588

Table 16 − Simulation results in seconds for the third scenario, with elevators enabled and the third and the fourth entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 16 – Результаты симуляции, выраженные в секундах по третьему сценарию, с лифтами и с третьим и четвертым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 16 – Симулациони резултати у секундама за трећи сценарио, са лифтовима и са трећим и четвртим блокираним улазима⁄излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	346	390.5	448	551	711	947
Time for speed of occupants 1 m/s	0	328	358.4	416	493	656	775.3
Time for speed of occupants 1.25 m/s	0	297.4	325	394	459	628	703
Time for speed of occupants 1.5 m/s	0	268	311	368	434	584.3	659
Time for speed of occupants 1.75 m/s	0	248	286	335.8	393	526	598.3

Table 17 − Simulation results in seconds for the third scenario, with elevators disabled and the first and the second entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 17 – Результаты симуляции, выраженные в секундах по третьему сценарию, без лифта и с первым и вторым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 17 – Симулациони резултати у секундама за трећи сценарио, без лифтова и са првим и другим блокираним улазима⁄излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	366	410.4	570	569	731	966
Time for speed of occupants 1 m/s	0	348	377.5	436	511.9	676	794
Time for speed of occupants 1.25 m/s	0	316	346.6	413.34	479	648	723
Time for speed of occupants 1.5 m/s	0	288	331.6	388	454	600	679
Time for speed of occupants 1.75 m/s	0	268	306	356.11	413	546	617

Table 18 – Simulation results in seconds for the third scenario, with elevators disabled and the first and the third entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 18 – Результаты симуляции, выраженные в секундах по третьему сценарию, без лифта и с первым и третьимм заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 18 – Симулациони резултати у секундама за трећи сценарио, без лифтова и са првим и трећим блокираним улазима/излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	377.45	420	479	580	742	977
Time for speed of occupants 1 m/s	0	359	388	447	523	687.4	805
Time for speed of occupants 1.25 m/s	0	327	358	424.4	425	659	734.7
Time for speed of occupants 1.5 m/s	0	299.11	341.7	399	465	611.2	691.3
Time for speed of occupants 1.75 m/s	0	279	316.7	367	424	557	628

Table 19 – Simulation results in seconds for the third scenario, with elevators disabled and the first and the fourth entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 19 – Результаты симуляции, выраженные в секундах по третьему сценарию, без лифта и с первым и четвертым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 19 – Симулациони резултати у секундама за трећи сценарио, без лифтова и са првим и четвртим блокираним улазима/излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	403.4	447	503	608.4	768.3	1003
Time for speed of occupants 1 m/s	0	384.4	414.56	473	550	711.6	832.1
Time for speed of occupants 1.25 m/s	0	354	383.1	451.8	516.67	685.6	759
Time for speed of occupants 1.5 m/s	0	325	368.3	424	491.34	641	715
Time for speed of occupants 1.75 m/s	0	304.7	342	392.5	450.5	582	655.33

Table 20 ─ Simulation results in seconds for the third scenario, with elevators disabled and the second and the third entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 20 – Результаты симуляции, выраженные в секундах по третьему сценарию, без лифта и со вторым и третьим заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 20 – Симулациони резултати у секундама за трећи сценарио, без лифтова и са другим и трећим блокираним улазима⁄излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	347	390.66	449	549	711.71	948.2
Time for speed of occupants 1 m/s	0	330.34	359.67	418	493.98	658	777
Time for speed of occupants 1.25 m/s	0	298	328.6	394.9	461.5	628.8	705.29
Time for speed of occupants 1.5 m/s	0	269.2	312.7	369.5	436	580.2	661
Time for speed of occupants 1.75 m/s	0	251.12	289.4	339.2	394.5	529.45	599

Table 21 ─ Simulation results in seconds for the third scenario, with elevators disabled and the second and the fourth entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 21 – Результаты симуляции, выраженные в секундах по третьему сценарию, без лифта и со вторым и четвертым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 21 – Симулациони резултати у секундама за трећи сценарио, без лифтова и са другим и четвртим блокираним улазима⁄излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	383	428	487	590	750	989
Time for speed of occupants 1 m/s	0	368	396	455	531	695	813
Time for speed of occupants 1.25 m/s	0	335.7	364	434.29	498	667	742
Time for speed of occupants 1.5 m/s	0	307.56	350	407	474.2	622	698
Time for speed of occupants 1.75 m/s	0	287.2	326.3	376.06	432.22	566.45	636

Table 22 ─ Simulation results in seconds for the third scenario, with elevators disabled and the third and the fourth entrances/exits blocked and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 22 – Результаты симуляции, выраженные в секундах по третьему сценарию, без лифта и с третьим и четвертым заблокированными входами/выходами, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 22 – Симулациони резултати у секундама за трећи сценарио, без лифтова и са трећим и четвртим блокираним улазима/излазима, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	393.23	438	496.6	599.3	758	995.27
Time for speed of occupants 1 m/s	0	374.9	405.37	463.78	541.12	703	822.3
Time for speed of occupants 1.25 m/s	0	344.4	372.3	441	506	674.88	750.31
Time for speed of occupants 1.5 m/s	0	317	358	415	481	631.3	707.3
Time for speed of occupants 1.75 m/s	0	296.6	335	382.8	440	573	645.3

Table 23 ─ Simulation results in seconds for the fourth scenario, with elevators enabled and the first entrance/exit opened, while the second, the third and the fourth entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 23 – Результаты симуляции, выраженные в секундах по четвертому сценарию, с лифтами и с первым открытым входом/выходом, в то время как второй, третий и четвертый входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 23 – Симулациони резултати у секундама за четврти сценарио, са лифтовима и са првим отвореним улазом/излазом, док су други, трећи и четврти улази/излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	443.6	678.3	915.9	1150.7	1388.3	1623
Time for speed of occupants 1 m/s	0	322	496.5	672	846.3	1021.8	1198.3
Time for speed of occupants 1.25 m/s	0	310	470	620	780	834	992
Time for speed of occupants 1.5 m/s	0	304	432.6	594	700	800	900
Time for speed of occupants 1.75 m/s	0	274	373.4	474.9	585.5	689	794

Table 24 ─ Simulation results in seconds for the fourth scenario, with elevators enabled and the second entrance/exit opened, while the first, the third and the fourth entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 24 – Результаты симуляции, выраженные в секундах по четвертому сценарию, с лифтами и со вторым открытым входом/выходом в то время как первый, третий и четвертый входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 24 – Симулациони резултати у секундама за четврти сценарио, са лифтовима и са другим отвореним улазом∕излазом, док су први, трећи и четврти улази∕излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	483.2	718.8	949.6	1183	1414.3	1646.5
Time for speed of occupants 1 m/s	0	335	515	694	869	1044.6	1220.3
Time for speed of occupants 1.25 m/s	0	286	426.4	566.8	707.8	849.1	988.6
Time for speed of occupants 1.5 m/s	0	263	404.5	531.6	651.7	772.6	890.3
Time for speed of occupants 1.75 m/s	0	242.3	355.2	463.2	569.8	675.7	780.2

Table 25 ─ Simulation results in seconds for the fourth scenario, with elevators enabled and the third entrance/exit opened, while the first, the second and the fourth entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s
Таблица 25 – Результаты симуляции, выраженные в секундах по четвертому сценарию, с лифтами и с третьим открытым входом/выходом, в то время как первый, второй и четвертый входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с
Табела 25 – Симулациони резултати у секундама за четврти сценарио, са лифтовима и са трећим отвореним улазом∕излазом, док су први, други и четврти улази∕излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	443.7	680	917.6	1152.5	1390.2	1623.6
Time for speed of occupants 1 m/s	0	336.6	510	686	861.6	1036.5	1204.7
Time for speed of occupants 1.25 m/s	0	264.8	400	540.8	681.4	823.4	962.8
Time for speed of occupants 1.5 m/s	0	247.4	387.5	519.6	641.4	763.7	884.5
Time for speed of occupants 1.75 m/s	0	241.3	351.7	460	565.3	669.6	800

Table 26 ─ Simulation results in seconds for the fourth scenario, with elevators enabled and the fourth entrance/exit opened, while the first, the second and the third entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 26 – Результаты симуляции, выраженные в секундах по четвертому сценарию, с лифтами и с четвертым открытым входом/выходом, в то время как первый, второй и третий входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 26 – Симулациони резултати у секундама за четврти сценарио, са лифтовима и са четвртим отвореним улазом∕излазом, док су први, други и трећи улази∕излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	446	677	910	1145	1376.9	1603.6
Time for speed of occupants 1 m/s	0	332	509.6	709	857.6	1032.1	1206
Time for speed of occupants 1.25 m/s	0	320	487	683	832	992	1132
Time for speed of occupants 1.5 m/s	0	302	457	588.4	714.5	836.6	953.7
Time for speed of occupants 1.75 m/s	0	295.4	406.7	539.5	648.6	754.7	860

Table 27 ─ Simulation results in seconds for the fourth scenario, with elevators disabled and the first entrance/exit opened, while the second, the third and the fourth entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 27 – Результаты симуляции, выраженные в секундах по четвертому сценарию, без лифта и с первым открытым входом/выходом, в то время как второй, третий и четвертый входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 27 – Симулациони резултати у секундама за четврти сценарио, без лифтова и са првим отвореним улазом∕излазом, док су други, трећи и четврти улази∕излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	550.3	787	1021.9	1257.4	1493.5	1729.3
Time for speed of occupants 1 m/s	0	428	602	778.5	953	1126.9	1302
Time for speed of occupants 1.25 m/s	0	416.1	576	726.54	885.3	940	1099.3
Time for speed of occupants 1.5 m/s	0	410.32	538	701.5	806.4	906.2	1006
Time for speed of occupants 1.75 m/s	0	380.5	480	580.9	693.4	795	900.02

Table 28 ─ Simulation results in seconds for the fourth scenario, with elevators disabled and the second entrance/exit opened, while the first, the third and the fourth entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 28 – Результаты симуляции, выраженные в секундах по четвертому сценарию, без лифта и со вторым открытым входом/выходом, в то время как первый, третий и четвертый входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 28 – Симулациони резултати и секундама за четврти сценарио, без лифтова и са другим отвореним улазом⁄излазом, док су први, трећи и четврти улази⁄излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	547	781	1019.9	1255	1493	1727
Time for speed of occupants 1 m/s	0	426.2	600	776	951	1126	1303.5
Time for speed of occupants 1.25 m/s	0	413.34	574.7	723.4	882.4	938.4	1096.71
Time for speed of occupants 1.5 m/s	0	408	539.17	699.8	804	904	1003.4
Time for speed of occupants 1.75 m/s	0	378	476.6	579	890	793	898

Table 29 ─ Simulation results in seconds for the fourth scenario, with elevators disabled and the third entrance/exit opened, while the first, the second and the fourth entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 29 – Результаты симуляции, выраженные в секундах по четвертому сценарию, без лифта и с третьим открытым входом/выходом, в то время как первый, второй и четвертый входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 29 – Симулациони резултати у секундама за четврти сценарио, без лифтова и са трећим отвореним улазом⁄излазом, док су први, други и четврти улази⁄излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	545.02	781.4	1018.6	1254	1492	1725
Time for speed of occupants 1 m/s	0	438	612.11	787	963.9	1137	1305
Time for speed of occupants 1.25 m/s	0	365.16	500.31	643.2	787	925	1064.8
Time for speed of occupants 1.5 m/s	0	349	489	621.7	743	867.5	986
Time for speed of occupants 1.75 m/s	0	343.6	453	561	667.8	771	902.3

Table 30 — Simulation results in seconds for the fourth scenario, with elevators disabled and the fourth entrance/exit opened, while the first, the second and the third entrances/exits are blocked, and for the occupants' speeds from 0.75 m/s, 1 m/s, 1.25 m/s, 1.5 m/s, and 1.75 m/s

Таблица 30 – Результаты симуляции, выраженные в секундах по четвертому сценарию, без лифта и с четвертым открытым входом/выходом, в то время как первый, второй и третий входы/выходы заблокированы, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с

Табела 30 – Симулациони резултати у секундама за четврти сценарио, без лифтова и са четвртим отвореним улазом∕излазом, док су први, други и трећи улази∕излази блокирани, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s

Number of occupants	669	500	400	300	200	100	0
Time for speed of occupants 0.75 m/s	0	543.6	776.7	1009	1243	1476	1702
Time for speed of occupants 1 m/s	0	431.31	608.29	808.3	955	1130	1306.8
Time for speed of occupants 1.25 m/s	0	417.23	587.6	782	931	1091	1231.4
Time for speed of occupants 1.5 m/s	0	401.5	556.9	688	811.3	936.24	1053
Time for speed of occupants 1.75 m/s	0	394	504.75	636.18	746	850.53	959

Results analysis

The realized simulation results for the first scenario (Tables 1 and 2) have shown that the elevators usage increases the evacuation of the complete object. The fastest evacuation time was for the occupants' speed of 1.75 m/s and the elevators enabled (209 seconds, in Table 1), while the slowest evacuation time was for the occupants' speed of 0.75 m/s and the elevators disabled (442 seconds, in Table 2). In this scenario, the occupants left the building via their own entrance/exit. There were no jams for simulated occupants' speeds.

The realized simulation results for the second scenario (Tables from 3 to 10) have shown that the fastest evacuation time was realized when the occupants' speed was 1.75 m/s, the second entrance/exit blocked and the elevators enabled (422 seconds, in Table 4). The slowest evacuation time was realized when the occupants' speed was 0.75 m/s, the fourth entrance/exit blocked and the elevators disabled (893 seconds, in Table 10). In this scenario, the occupants from the building with the blocked entrance/exit had to use the building roof terraces to reach the

nearest stairs that lead to the open entrance/exit. There were no jams for the simulated occupants' speeds. Some simulation scenes from the second scenario are presented in Figure 3 (a and b).

a)   *b)*
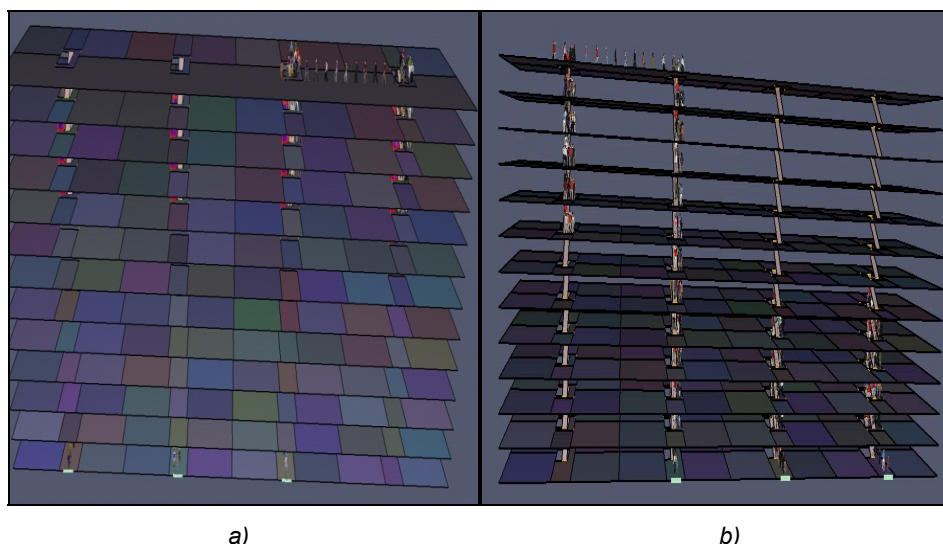
Figure 3. Simulation scene for the second scenario where the first entrance/exit was blocked and the elevators were enabled and for the occupants' speeds of 1 m/s (a) and the simulation scene for the second scenario where the fourth entrance/exit was blocked and the elevators were disabled and for the occupants' speeds of 0.75 m/s (b)

Рис. 3 — Имитационные сцены по второму сценарию, в котором первый вход/выход заблокирован и есть лифты, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с (а), и имитационные сцены по второму сценарию, в котором четвертый вход/выход заблокирован и нет лифта, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с (б)

Слика 3 — Симулационе сцене из другог сценарија где је први улаз∕излаз блокиран и са лифтовима и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s (а), и симулационе сцене из другог сценарија где је четврти улаз∕излаз блокиран и без лифтова, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s (б)

The realized simulation results for the third scenario (Tables from 11 to 22) have shown that the fastest evacuation time was realized when the occupants' speed was 1.75 m/s, the second and the third entrances/exits blocked and the elevators enabled (550 seconds, in Table 14). The slowest evacuation time was realized when the occupants' speed was 0.75 m/s, with the first and the fourth entrances/exits blocked and the elevators disabled (1003 seconds, in Table 19). In this scenario, the occupants from the buildings with the blocked entrances/exits had to use the building roof terraces to reach the nearest stairs that lead to the open entrance/exit. The simulations showed that jams can occur, mostly for

the occupants' speed of 0.75 m/s and 1.25 m/s. Some simulation scenes from the third scenario are presented in Figure 4 (a and b).

a)   b)
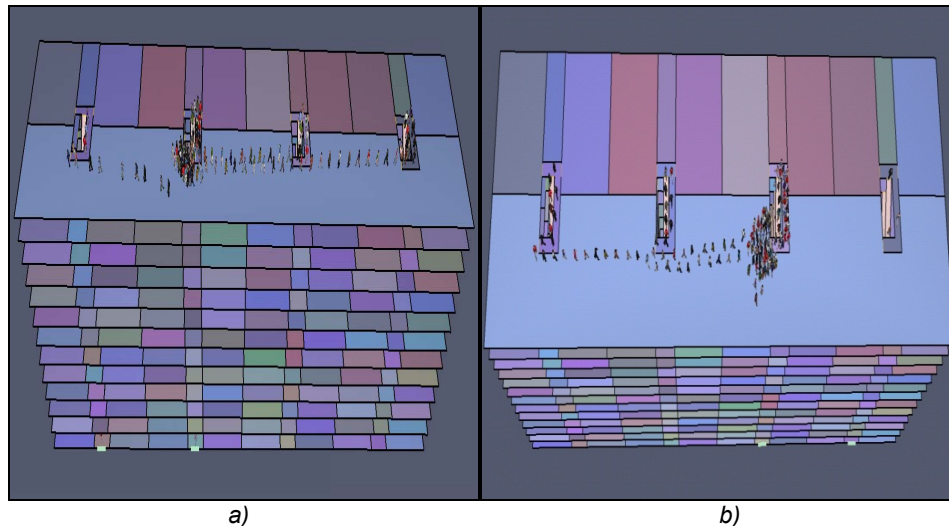
Figure 4 — Simulation scene for the third scenario where the first and the second entrances/exits were blocked and the elevators were enabled and for the occupants' speeds of 1.25 m/s (a) and a simulation scene for the third scenario where the third and the fourth entrances/exits were blocked and the elevators were disabled and for the occupants' speeds of 1.5 m/s (b)

Рис. 4 — Имитационные сцены по третьему сценарию, в котором первый и второй входы/выходы заблокированы и есть лифты, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с (а) и имитационные сцены по третьему сценарию, в котором третий и четвертый входы/выходы заблокированы и нет лифта, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с (б)

Слика 4 — Симулационе сцене из трећег сценарија где су први и други улази/излази блокирани и са лифтовима и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s (а), и симулационе сцене из трећег сценарија, где су трећи и четврти улази/излази блокирани и без лифтова, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s (б)

The realized simulation results for the fourth scenario (Tables from 23 to 30) have shown that the fastest evacuation time was realized when the occupants' speed was 1.75 m/s, the first entrance/exit opened and the second, the third and the fourth entrances/exits blocked and the elevators enabled (794 seconds, in Table 23). The slowest evacuation time was realized when the occupants' speed was 0.75 m/s; with the first entrance/exit opened, and with the second, the third and the fourth entrances/exits blocked and the elevators disabled (1729.3 seconds, in

Table 27). In this scenario, the occupants with the blocked entrances/exits had to use the building roof terraces to reach the nearest stairs that lead to the single open entrance/exit. The simulations showed that jams can occur, mostly for the occupants' speed of 0.75 m/s. The simulations showed that jams in this scenario can occur and that these jams can be significant, for every occupants' speed from 0.75 m/s to 1.75 m/s. Some simulation scenes from the fourth scenario are presented in Figure 5 (a and b).

a)   b)
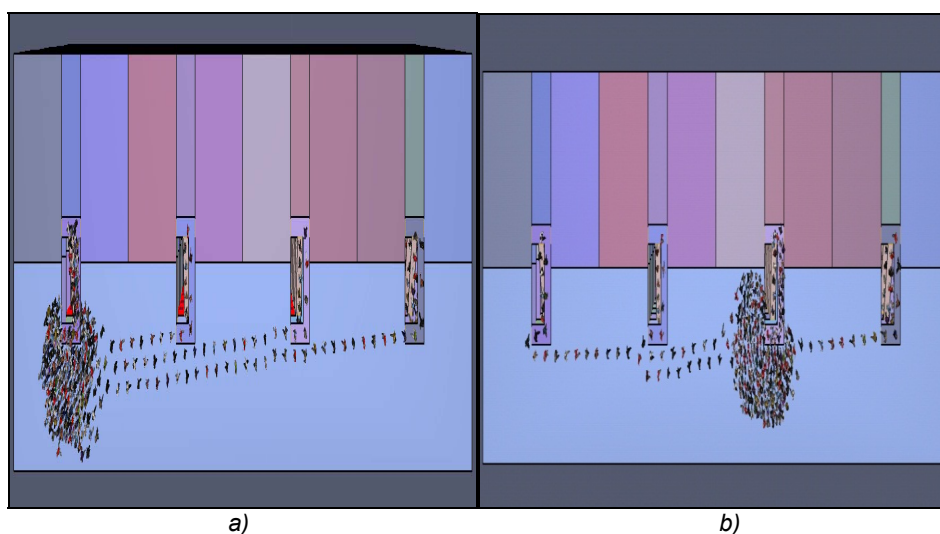
Figure 5 – Simulation scene for the fourth scenario where the fourth entrance/exit was opened while other entrances/exits were blocked, the elevators enabled and for the occupants' speeds of 0.75 m/s (a) and a simulation scene for the fourth scenario where the second entrance/exit was opened while other entrances/exits were blocked, the elevators disabled and for the occupants' speeds of 1.75 m/s (b)

Рис. 5 – Имитационные сцены по четвертому сценарию, в котором четвертый вход/выход открыт, а остальные входы/выходы заблокированы и есть лифты, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с (а) и имитационные сцены входы/выходы заблокированы и нет лифта, учитывая скорость жильцов: 0.75 м/с, 1 м/с, 1.25 м/с, 1.5 м/с и 1.75 м/с (б)

Слика 5 – Симулационе сцене из четвртог сценарија где је четврти улаз⁄излаз отворен, док су остали улази⁄излази блокирани, са лифтовима и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s (а), и симулациони улази⁄излази блокирани, без лифтова, и за брзине станара: 0,75 m/s, 1 m/s, 1,25 m/s, 1,5 m/s и 1,75 m/s (б)

The realized simulations have shown that times needed for an evacuation increased depending on the number of blocked entrances/exits and on whether the elevators were used or not. In reality,

many of potential evacuation situations imply that elevators are not used and that was the main reason why every of four scenarios was analysed with enabled and disabled elevators. The factors that are important for elevators usage are, most frequently, the floor level where occupants are located and the acceptable waiting time. Experience and research have shown that higher locations in residential buildings are more likely to imply elevator usage than usage of ordinary or emergency stairs. It is also important to note that the acceptable waiting time increases according to the height of the floor level (Kinateder et al, 2014).

One very important factor that has a great influence on the evacuation time is panic. Panic causes fearful and chaotic behaviour which is, most frequently, demonstrated with an increase of speed of occupants. This speed increment results in crowds and jams that can be very unpredictable and very hard to solve. It means that the evacuation time can be significantly extended, which the simulation results proved.

It is also important to note that, in reality, every occupant has his/her own speed, while in the simulation all occupants had the same speed. Also, in reality, occupants' personal characteristics are very different and can affect the overall evacuation time and cause problems in the crowd (Kady & Davis, 2009), (Jevtić, 2019b).

Disccussion

The usage of simulation software for simulating the evacuation in high-rise buildings is becoming more frequent and more extensive. The main reasons for that are: increase of safety in order to protect as many human lives as possible; increasingly frequent construction of high-rise buildings with a huge number of occupants; prediction and determination of optimal evacuation routes; prediction of potential occupants' behaviors, etc.

There are many residential buildings with and without emergency stairs. Very often, emergency stairs in residential buildings can be useless because of many reasons (fire, earthquake, smoke, jams, etc.) so that the only way to the exit is via ordinary stairs and elevators. As it has been noted before, the usage of elevators in many crises that need evacuation, such as fires or earthquakes, is not recommended. It does not mean that elevators should not be used at all but that there is a significant risk if they are used. This is a very important reason why evacuation simulations should be considered for cases with and without elevators usage. In some situations that can occur in high residential buildings or other objects with a significant presence of immobile

persons, it is almost impossible to realize evacuation without elevators usage. The obtained results confirmed that the evacuation times were shorter in the cases where the elevators were enabled.

One very important factor in every evacuation is a so-called „human factor". This factor presents a very complex factor in sense of prediction and calculation. For example, people will not behave in the same way individually and in a group. During evacuation, parents will always tend to run towards their children which can significantly complicate the evacuation. Frequently, occupants in high residential buildings in disaster cases show apathetic behavior and non-acceptance of obvious facts. Taking ino account many important factors related to occupants in simulations (occupants physical dimensions, occupants' reduction factor, occupant comfort distance, occupants slow factor, speed, and many others) presents a very important task that demands knowledge from different sciences and disciplines.

The obtained simulation results were in the range of the obtained simulation results in similar cases. It is a very good and accurate way to compare the obtained simulation results with calculated results and experimental results, since it is not always possible to carry out such experiments in reality (Ding et al, 2017), (Poon, 1994), (Kasereka et al, 2018), (Rozo et al, 2019), (Xing & Tang, 2012).

Conclusion

The results obtained in this paper have shown the maximum evacuation times in a building without emergency stairs with and without elevators usage. In reality, it is unlikely that, for example, all three entrances/exits are blocked, maybe only in case of a huge fire or a huge earthquake. However, it is very important to predict as many evacuation scenarios as possible and calculate adequate evacuation times.

Calculation of evacuation time and prediction of the best evacuation route presents a very complex and responsible task. Very often, it is almost impossible to predict every potential situation than can occur during evacuation. Because of that reason, usage of simulation software presents a very good, effective, cheap, and safe way for predicting potential evacuation situations in many different objects, which gives this topic great importance and motivation in order to save human lives and material properties. The main contributions of this paper are in its potential to determine optimal evacuation routes and calculate evacuation times in high buildings with or without emergency stairs, taking into consideration the influence of many different mentioned

factors that can affect the evacuation progress and complete the evacuation epilogue.

Future investigations will relate to a simulation of evacuation with the presence of immobile persons of varying degrees of immobility, a simulation of evacuation via spiral staircases, a simulation of evacuation under different conditions, etc.

The usage of simulation software for the prediction and calculation of optimal evacuation routes can significantly improve the procedures and strategies of evacuation from some specific objects such as residential buildings.

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ПОЖАРНАЯ БЕЗОПАСНОСТЬ ЖИЛЫХ ЗДАНИЙ - ЭВАКУАЦИЯ ИЗ ЖИЛЫХ ЗДАНИЙ БЕЗ ПОЖАРНОЙ ЛЕСТНИЦЫ

Радое Б. Евтич

Электротехнический техникум «Никола Тесла»,
г. Ниш, Республика Сербия

Резюме:

Введение/цель: Безопасность в высотных жилых зданиях является очень важной и всегда актуальной задачей. В случае возникновения непредвиденных и опасных происшествий, жильцов необходимо эвакуировать. Пожары, землетрясения и терроризм − лишь некоторые из таких ситуаций. Скорость эвакуации из высотных жилых зданий зависит от множества различных факторов. Эвакуация во многом усложняется, если в зданиях нет пожарных лестниц.

Методы: В данной статье применялся метод моделирования. На основе реального объекта − жилого здания была создана соответствующая имитационная модель с помощью соответствующей имитационной программы.

Результаты: Результаты исследования показали, что из четырех сценариев наиболее быстрая эвакуация была при скорости жильцов 1,75 м / с. В первых двух сценариях не было выявлено ни одного затора, в отличие от третьего и четвертого сценариев; в третьем сценарии скорости жильцов составляли 0,75 м / с и 1,25 м / с, а в четвертом сценарии смоделированные скорости жильцов составляли от 0,75 м / с до 1,75 м / с.

Выводы: Применение соответствующего программного обеспечения для моделирования позволяет быстро, точно, безопасно и дешево рассчитать время эвакуации и может значительно улучшить процесс и стратегию эвакуации.

Ключевые слова: эвакуация, здание, люди, моделирование.

БЕЗБЕДНОСТ У СТАМБЕНИМ ЗГРАДАМА – ЕВАКУАЦИЈА СТАМБЕНЕ ЗГРАДЕ БЕЗ ПОЖАРНИХ СТЕПЕНИЦА

Радоје Б. Јевтић

Електротехничка школа „Никола Тесла", Ниш, Република Србија

Сажетак:

Увод/циљ: Безбедност у високим стамбеним зградама представља веома важан задатак. У случају неке непредвиђене и опасне појаве, станари тих зграда морају бити евакуисани. Пожар, земљотрес и терористичке акције само су неке од таквих ситуација. Брзина евакуације из високе стамбене зграде зависи од много различитих фактора. Задатак евакуације је посебно тежак и компликован уколико зграда нема пожарне степенице.

Методе: У овом раду коришћена је метода моделовања. На основу реалног објекта – стамбене зграде, реализован је одговарајући симулациони модел у одговарајућем симулационом софтверу.

Резултати: Резултати овог рада показали су да је најбржа евакуација остварена за сваки од четири сценарија при брзини станара од 1,75 m/s, с тим да за прва два сценарија нису забележени застоји, али су за трећи и четврти сценарио застоји уочени.Наиме, у трећем сценарију до застоја је дошло при брзини станара од 0,75 m/s и 1,25 m/s, а у четвртом сценарију за све симулиране брзине станара од 0,75 m/s до 1,75 m/s.

Закључак: Употреба одговарајућег симулационог софтвера омогућава брзо, прецизно, безбедно и јефтино израчунавање евакуационих времена и може знатно побољшати евакуационе процедуре и евакуациону стратегију.

Кључне речи: евакуација, зграда, станари, симулација.

IDENTIFICATION OF SOLDIERS AND WEAPONS IN MILITARY ARMORY BASED ON COMPARISON IMAGE PROCESSING AND RFID TAG

Dušan Lj. Bogićević[a], *Ivan* A. Tot[b],
Radomir I. Prodanović[c], *Bojan* J. Todorović[d]

[a] Serbian Armed Forces, General Staff, Department for
  Telecommunication and Informatics (J-6),
  Center for C4 and IT support, Belgrade, Republic of Serbia;
  University of Niš, Faculty of Electronic Engineering,
  Niš, Republic of Serbia,
  e-mail: dusan.bogicevic@gmail.com,
  ORCID iD: http://orcid.org/0000-0002-4300-2490

[b] University of Defence in Belgrade, Military Academy,
  Department for information systems and telecommunication
  engineering, Belgrade, Republic of Serbia,
  e-mail: ivan.tot@va.mod.gov.rs, **corresponding author**,
  ORCID iD: http://orcid.org/0000-0002-5862-9042

[c] Serbian Armed Forces, General Staff, Department for
  Telecommunication and Informatics (J-6),
  Center for Applied Mathematics and Electronics,
  Belgrade, Republic of Serbia,
  e-mail: radomir.prodanovic@vs.rs,
  ORCID iD: http://orcid.org/0000-0002-2067-2758

[d] Serbian Armed Forces, General Staff,
  Military Police Detachment for Special Purposes "Kobre",
  Belgrade, Republic of Serbia,
  e-mail: todorovicbojan@yahoo.com,
  ORCID iD: https://orcid.org/0000-0002-7028-274X

FIELD: Computer sciences, IT
ARTICLE TYPE: Professional paper

Abstract:

Introduction/purpose: The process of issuing and retrieving weapons in the military should be fast enough and should provide immediate availability of accurate information on the status of weapons.

Methods: This paper deals with the problem of digitizing the recording of issuing and returning weapons through the use of modern Edge computing technology. The problem is presented through two approaches. The first approach is based on the application of machine learning algorithms for recognizing the serial number of a weapon based on the camera image, while the second approach concerns the application of RFID technology. User authentication is based on the application of biometrics.

Results: The results obtained from testing the architecture for identifying weapons using a camera indicate that such an architecture is not suitable for identifying weapons. A weapon identification solution using RFID technology overcomes the problems of the previously mentioned solution. However, RFID technology requires additional modifications regarding the implementation of tags on or into weapons so that readings can be made.

Conclusion: The implemented weapon identification solution based on RFID technology and a user identification solution with biometric authentication enables easy and reliable identification, speed of issuing and retrieval of weapons, network relieving, and real-time monitoring of the weapon status.

Keywords: image processing, fingerprint, RFID, artificial intelligence, Internet of Things, Raspberry Pi.

Introduction

The process of issuing and retrieving weapons in the military should be fast enough and should provide immediate availability of accurate information on the weapon status. Manual maintaining records of weapons issuing and returning is slow and error-prone. This approach is inappropriate for a military organization. Therefore, it is necessary to develop a system based on state-of-the-art technologies that will enable rapid and accurate record keeping of the weapon status, as well as information on when the weapon was taken, returned, and who used the weapon.

In (Lien, 2011), the author describes the implementation of active and passive RFID tags in the military to improve accountability and accuracy. The paper cites its price as one of the advantages of a system based on RFID tags. On the other hand, in (Nicholls, 2017), the author describes what would be the advantages and disadvantages of

implanting RFID tags in military personnel. The authors in (Chattaraj et al, 2009) see the implementation of RFID tags in traffic control. In terms of authentication of military personnel, in addition to RFID tags that would be embedded in them, biometrics can also be applied. Biometrics can be used for authentication to improve various systems as presented in (Kour et al, 2016), who see the application of biometrics as the key to the future of cyber security.

It is necessary first to identify the weapon which has to be issued or returned. One way to do it is by using a camera as a sensor and the Optical Character Recognition (OCR) technique. Using the OCR, we can extract the text or the serial number of the weapon from the image. Algorithms that allow a text to be read from an image are machine learning algorithms and fall under the domain of Artificial Intelligence (AI). The authors in (Hanmandlu et al, 2017) used an image of a finger knuckle for the personnel authentication.

This paper explores the possibility of improving the process of keeping records of weapons issued and returned. The possibility of identifying weapons and identifying users is being explored. Weapon identification is considered by identifying the serial number by processing the image obtained from the camera as well as processing data from the RFID sensor in the process of weapon identification. User identification is considered through the application of one of the biometric techniques, such as fingerprint identification.

The authors developed an architecture for identifying weapons using RFID technology and identifying weapons users using fingerprint recognition. The architecture allows collection and processing of identification data in real time because processing is performed on the device itself, where the data is generated.

Material and methods

The problem with weapons identification, in terms of research, can be classified as the Internet of Things (IoT). The IoT is a term that refers to connecting various devices to a network. These devices are present at the edge of the network, where real-time data is generated and processed. The amount of data generated at the edge of a network can be large. The architecture where data processing is done on Edge devices is called Edge computing (Reale, 2017). Edge computing provides: privacy, delay reduction, data filtering, and pre-processing.

Conversion of a text from paper to a digital text is known as Optical Character Recognition (OCR). This conversion method has been

explored for decades (Prajapati et al, 2018). Artificial intelligence is used for image processing and text recognition, and OCR is one of the branches of artificial intelligence (Pawar et al, 2019). One of the AI techniques used for text recognition is the Artificial Neural Network (ANN) (Prajapati et al, 2018). There are a number of currently implemented OCR software programs. Common to all software programs currently developed is that they cannot read every text without making an error. In the case of a handwritten text, the Intelligent Character Recognition (ICR) technique is used (SimpleSoftware, 2020). One of the software solutions that can beused for OCR is the Tesseract engine (Pyimagesearch, 2018).

Radio Frequency Identification (RFID) belongs to a group of short-range wireless communications. This type of communication is based on the RFID reader and the RFID tag. The reader emits a radio signal, to which the tag, if within the range of the reader, responds by sending its code (tag). Depending on the tag power type, there are a passive reader (powered by the power it receives from the reader), a semi-passive reader (has a battery that powers the processor), and an active reader (has its own power). The frequency bands 125-134.2 kHz and 140-148.5 kHz belong to the LF-Low Frequency readers and their range is less than 0.5 meters. The range 6.775-6.795 MHz belongs to midrange readers. The high frequency group includes readers with a frequency higher than 13.553 MHz (HF-High Frequency) and their range can go up to one meter, and if the frequency range 858-930 MHz (UH-Ultra High Frequency) is used, it can go up to 10 meters. Using self-powered tags can increase the range of the reader in all operating ranges, and in the case of using the UHF range, the range can go up to 500 meters (Electronicsnotes, 2020), (SkyRFIDInc, 2020).

The Fingerprint is one of the biometric recognition techniques and it can be used for face, iris, voice, or palm recognition (Maltoni et al, 2009). Technologies which can be used to digitize fingerprints can be grouped in optical (Frustrated Total Internal Reflection), electrical (capacitive, thermal, electric field, and piezoelectric), and ultrasound (Maltoni et al, 2009). One of the problems with finger digitization is the storage of a large number of prints. In order to optimize the memory space needed for storage, compression mechanisms have been created. The most famous is Wavelet Scalar Quantization (WSQ). This algorithm was developed by the FBI, the National Institute of Standards and Technology (NIST), and the Los Alamos National Laboratory (Thakkar, 2020). Biometric data are lefton most of the objects people touch. This fact represents one of the

biggest flaws, which is reflected in the generation of a false fingerprint (Nogueira et al, 2016).

An Edge computing architecture was proposed in this paper for research purposes. Edge devices were used to digitize the process of keeping records of weapons issuing and returning. These devices should be able to process image and data from RFID and biometric readers.

The Edge device used is the Raspberry PI 3 (Processor: 64 bits, 4 cores, 1.2GHz; RAM 1 GB) which has 4 USB ports and 40 GPIO pins, Ethernet, Wi-Fi, Bluetooth. Due to the possibility of connecting a greater number of different devices and sensors, its small dimensions (85 x 49 mm), price, as well as satisfactory performances, this device was chosen. The Raspberry Pi Camera (5-megapixel OV5647 sensor) and Tesseract Engine for OCR and OpenCV software were used to test the serial number recognition on the image. The NFC-tag (Ntag213) and the RFID reader RC522 were used to test the possibility of applying RFID technology.

Results

Two approaches have been used to address the problem of identification of weapons and keeping their records. The first approach to solving the problem of identifying a weapon is based on something possessed by the weapon, while the second approach is based on something attached to the weapon. In the first approach, a camera was used to read the existing serial number of the weapon, while in the second approach, RFID technology was used.

Analysis of proposed solutions

For the purpose of the research, two weapons identification architectures were created. The architectures are based on a Raspberry Pi computer, a monitor, and a data acquisition device (camera or RFID reader), as shown in Figure 1.

A weapon identification architecture that uses a camera to read a weapon's serial number is shown in Figure 1a. With this architecture, the user brings in a weapon facing the serial number towards the camera. After generating the image, the computer processes the image by trying to identify the serial number of the weapon.

Before testing the image processing from the camera, the architecture was tested by recognizing the text from the previously processed image. The aim was to determine whether the Raspberry Pi could extract a text from the image. During testing, we determined that

the Raspberry Pi could read a text from an image for 2s to 8s depending on the image quality. However, the percentage of read characters of the serial number from the image ranged from 78% to 100%. The whole serial number recognition rate is 28% of all attempts (75 attempts, 21 serial numbers recognized).
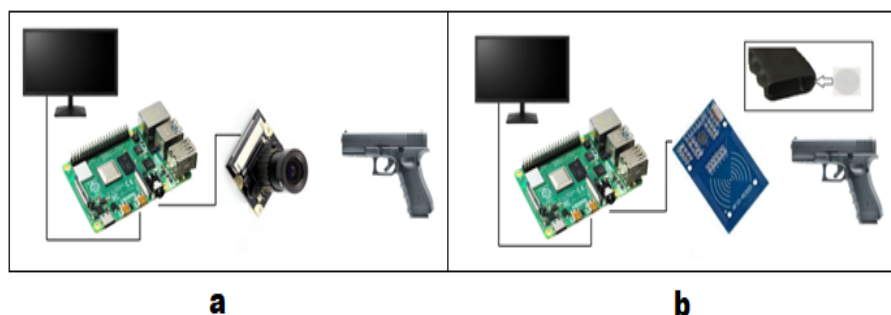
Figure 1 – System architecture: (a) for image testing, (b) for RFID tag processing)
Рис. 1 – Системная архитектура: (a) проверка изображений, (б) для обработки RFID-меток
Слика 1 – Системска архитектура, (a) за тестирање слика, (b) за процесирање RFID тага

We then tested the reading of the serial number of the weapon from the image generated by the camera. Figure 2 shows the images of the weapon serial numbers.

Figure 2 – Weapon serial numbers
Рис. 2 – Серийные номера оружия
Слика 2 – Серијски бројеви наоружања

The time required to recognize a serial number is greater than that of the image previously processed and ranged from 5s to 20s. The precision was much lower and ranged from 0 to 70% of the maximum read characters of the serial number. The reading results are shown in Table 1. Characteristically, the whole serial number of the weapon was not recognized in any of the 150 recognition attempts. One possible solution to solving image processing speed and serial number recognition quality would be to use a server that recognizes the image as described in (Saleous et al, 2016).

Table 1 – Comparative overview of weapons serial number readings
Таблица 1 – Сравнительный обзор считывания серийных номеров оружия
Табела 1 – Компаративни преглед очитавања серијских бројева наоружања

Type of Weapon	Serial Number length	Number of letters	Image						RFID	
			Prepared			Not-prepared			Distance (mm)	
			No. of attempt	No. of read characters		No. of attempt	No. of read characters		start reading	in weapon
				MIN	MAX		MIN	MAX		
Pistols	6	3	5	5	5	10	2	4	25	15
	6	3	5	5	5	10	1	3	25	15
	7	3	5	4	6	10	1	3	26	12
	7	4	5	5	7	10	1	2	26	11
	7	1	5	6	6	10	2	4	24	15
	7	1	5	4	4	10	0	3	25	12
	7	1	5	4	4	10	2	4	25	12
Rifle	5	0	5	4	4	10	1	2	30	3
	5	0	5	5	5	10	2	3	30	3
	5	0	5	5	5	10	3	4	30	3
	6	0	5	3	3	10	0	2	27	5
	8	0	5	7	8	10	4	6	30	4
	8	0	5	8	8	10	5	6	30	4
	9	0	5	7	7	10	5	6	30	3
	9	0	5	6	7	10	1	5	30	3

The second approach to problem solving was to use RFID readers. When testing the RFID weapons identification architecture, an NFC-tag test environment (Ntag213) was developed and the RFID reader RC522 was used. The architecture of the test system for processing RFID tags is

shown in Figure 1b. A flexible NFC tag with a diameter of 25mm is placed inside the weapon. Figure 1b, as a separate section, shows the handrail and the exact location of the NFC tag. During testing, the response was found to depend on the tag distance from the RFID reader as well as where the tag was placed. Table 1 shows that the maximum distance from which RFID tag readings start is 25 to 30 mm, depending on the position of the tag in the weapon.

Based on the performed testing, Table 2 shows a comparative overview of the two architectures. Based on the analysis, the architecture for weapons identification using RFID technology was selected.

Table 2 – Comparative overview of the advantages and disadvantages of the tested architectures
Таблица 2 – Сравнительный анализ преимуществ и недостатков испытанных архитектур
Табела 2 – Компаративна анализа предности и недостатака тестираних архитектура

Weapon identification	Advantages	Disadvantages
Using the camera	No weapon modifications. It can be used to identify the weapon type. The ability to use the camera to authenticate the person.	Low serial number recognition accuracy. It requires a computer with better performances. It requires more time to identify the weapon.
Using RFID	Reliability in reading weapon identifiers. Processing speed of read data.	Providing tags and labeling weapons. Non-uniform tag placement on different types of weapons.

In terms of person authentication, finger, iris, and facebiometrics was considered as well as RFID tag-based authentication. It was concluded that in order to achieve adequate reliability and speed of authentication based on iris and face biometrics, additional conditions were required. These conditions apply to the lighting and hardware on which the authentication would be performed (Maltoni et al, 2009). We opted for solutions that did not require special environmental conditions and were not hardware-demanding. The solutions that could be implemented are the fingerprint and the RFID tag. As RFID tags are not embedded in persons, it is suggested that person identification should be based on fingerprint authentication.

Proposed architecture for identifying weapons and users

Based on the results of the testing and comparative analysis of weapons identification architectures, a combined architecture for weapons and user identification is proposed. This architecture uses RFID technology for weapon identification while user identification is based on the fingerprint method. In addition to visual notification of the identification of a user and weapon on the monitor, voice notification is also proposed for faster release or return dynamics. The architecture of the proposed solution is shown in Figure 3.
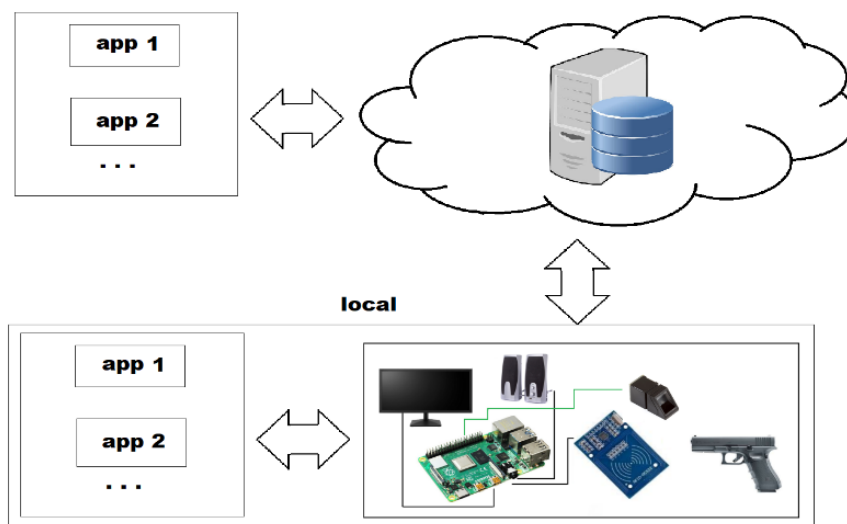
Figure 3 – Proposed weapon and user identification architecture
Рис. 3 – Предлагаемая архитектура для идентификации оружия и пользователя
Слика 3 – Предложена архитектура за идентификацију наоружања и корисника

Weapon and user identification is done as follows:
– The user logs on to the system with a fingerprint. When a person logs in, he or she has 30s to read their weapon, otherwise they need to log back in,
– When a person is logged in, the weapon tag is read and the status of the weapon changes (issued or returned by the user),
– After each change, the system notifies the status of the weapon or a new person.

The system allows the verification of weapon data (weapon type, model, serial number) based on RFID tags even if the user is not logged in. The weapon and user identification algorithm is shown in Figure 4.

PRESENT IN DATABASE (WEAPON) — READ RFID — NO / YES — SHOW NTAG — SHOW WEAPON DATA — IS PERSON VERIFIED — NO / YES — <30s OF LAST RFID READ — NO — LOGOUT PERSON — YES — UPDATE STATE OF WEAPON — NOTIFY ABOUT NEW STATE OF WEAPON

PRESENT IN DATABASE (PERSON) — READ FINGER PRINT — NO / YES — CURRENT PERSON — UPDATE CURRENT PERSON — SHOW NEW PERSON DATA AND NOTIFY
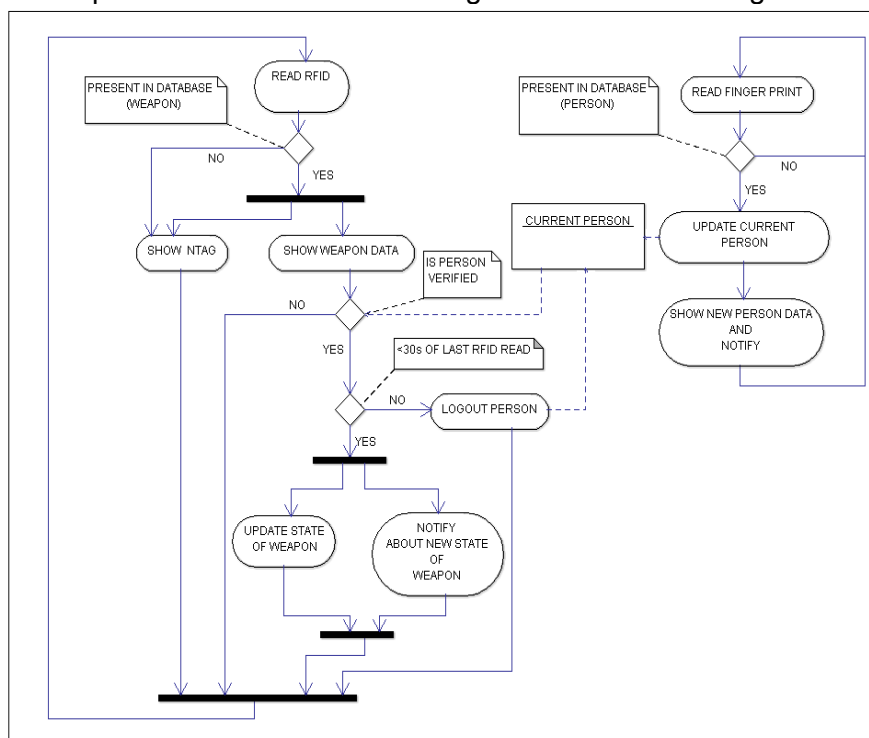
Figure 4 – Weapon and user identification algorithm
Рис. 4 – Алгоритм идентификации оружия и пользователя
Слика 4 – Алгоритам за идентификацију наоружања и корисника

The architecture consists of the Raspberry Pi computer, which is an integrator of the whole system, to which status notification devices (monitor, speakers) and data acquisition devices (RFID reader and fingerprint reader) are connected. The architecture also includes a database, which allows records to be kept. In order to enable faster logging in and logging out, data processing and database are hosted on the Raspberry Pi. In this way, most of the data processing is done at the edge of the network. This kind of approach in the architecture relieves network resources.

EDGE architecture takes data processing near the source. In this work, we use the Raspberry Pi as a local server. The layers which are

above the local layer use Containerization and Orchestration to receive data from multiple different sources. In the upper layers, it is possible to apply some of the techniques such as AI and Machine learning. These techniques can lead to better analyses and recommendations for some organizational changes and also changes regarding weapons which are in use in a unit, which in return can provide better efficiency of the unit.

The Raspberry PI enables applications on all layers of architecture to exchange information. This architecture reduces latency and provides reliability. In terms of security, it decreases potential weaknessess in cecommunication with the main server is reduced. In military systems, it is important to reduce communication because military band widths are often limited.

Implementation of the proposed solution

The architecture was practically designed by deploying the Raspberry Pi computer inside each weapon warehouse with data collection and notification devices. The Raspberry Pi is connected to the network. An online service has been implemented enabling the collection of data on the current status, processing and exchange of data, presentation of data and remote administration of the system.

Each weapon is intended to have an RFID tag as an identifier. The implemented architecture enables the exchange of data with a central database. In this way, the network is relieved and information processing is provided as close as possible to the source, which is the tendency in similar systems that belong to the concept of the Internet of Things.

All the needed hardware introduced as System architecture and presented in Figure 3 is housed in a special shielded box. The process of registering an individual is shown in Figure 5a, and begins with the person pointing his or her finger at the fingerprint reader. The application identifies the person, and if the identification is successful, the person's information is displayed on the monitor or spoken through the speakers. We used the text-to-speech library FreeTTS (Freetts.Sourceforge, 2017) to ensure that the person's name was read.

The process of identifying the weapon is shown in Figure 5b and is carried out by moving the weapon to the side where the RFID tag is attached to the RFID reader. After reading the RFID tag, the application checks for the existence of such a weapon and records it as being issued or returned. Figure 5c shows the place selected for the RFID tag placement.
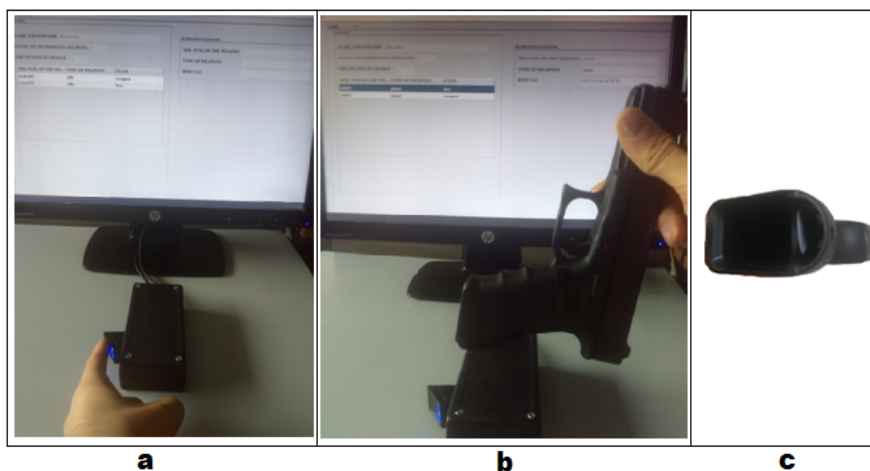
Figure 5 – Implemented solution: (a) registering, (b) weapon identification, (c) tag placement)
Рис. 5 – Внедренное решение: (a) регистрация, (b) идентификация оружия, (c) нанесение метки
Слика 5 – Имплементирано решење: (a) регистрација, (b) идентификација наоружања, (c) постављање тага

Discussion

The results obtained from testing the architecture for identifying weapons using a camera indicate that such an architecture is not suitable for identifying weapons. The test results show that there was no successful reading of all characters of the serial number regardless of the number of characters and the number of attempts. The reasons for the unsuccessful reading are due to the following problems: determining the most suitable distance between the weapon and the camera, poor visibility of the serial number due to the color of the print, wear, or concealment of accessories that can be mounted on the weapon. Another issue which makes this architecture a not so good solution is the problem of image processing speed which recognizes a serial number from an image. Testing has shown that the processing speed is low, which can create a problem of crowding when taking or returning a weapon form or to a weapon warehouse. One solution that can fix the results of processing the image obtained from a camera is to paste stickers with a serial number or an OCR code onto the weapon on its outside.

A weapon identification solution using RFID technology overcomes the problems of the previously mentioned solution. RFID technology

requires additional modifications regarding the implementation of tags on or into weapons so that readings can be made. The position of the tag in the weapon affects the distance required to read. However, in the event that the weapon is propped up against the reader, a secure reading is made, thereby achieving system reliability.

The weapons used for testing are newer generation weapons. They have places where plastic-like materials can be used to include the stock (where wood was commonly used) or grips. Such places are suitable for tagging.

The Fingerprint is one of the most commonly used authentication methods. In military processes where reliability and speed are required, the fingerprint can meet the requirements. There are fingerprint sensors on the market that do not require high-performance computers. On the other hand, the amount of memory required to store a fingerprint is small, so that fingerprint readers can store the prints in their memory.

Conclusion

The implemented weapon identification solution based on RFID technology and a user identification solution with biometric authentication enables easy and reliable identification, speed of issuing and retrieval of weapons, network relieving, and real-time monitoring of weapon status. In this way, a solution can be implemented to improve the process of recording and monitoring weapons in weapon warehouses.

Tracking the development of science in fields such as the IoT, AI, and Edge computing is certainly of interest in military applications. This paper shows the disadvantages of using AI in weapons image processing. The main drawback is a low degree of reliability. RFID systems are reliable systems for keeping track of things. By combining more techniques and technologies such as RFID, IoT, and AI, it is possible to increase the performance of military systems. Digitization of basic military processes results in better use of time as a resource.

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ИДЕНТИФИКАЦИЯ СОЛДАТ И ВООРУЖЕНИЯ НА СКЛАДЕ ОРУЖИЯ, ОСНОВАННАЯ НА СРАВНИТЕЛЬНОЙ ОБРАБОТКЕ ИЗОБРАЖЕНИЙ И RFID-МЕТОК

Душан Л. Богичевич[а], *Иван* А. Тот[б],
Радомир И. Проданович[в], *Боян* Й.Тодорович[г]

[а] Вооружённые Силы Республики Сербия, Генеральный штаб,
  Управление информатики и телекоммуникаций (J-6), ЦКИСИП,
  г. Белград, Республика Сербия;
  Нишский университет, факультет электроники,
  г. Ниш, Республика Сербия

[б] Университет обороны в г. Белград, Военная академия,
  кафедра телекоммуникаций и информатики,
  г. Белград, Республика Сербия, **корреспондент**

[в] Вооруженные силы Республики Сербия, Генеральный штаб,
  Управление информатики и телекоммуникаций (J-6),
  Центр прикладной математики и электроники,
  г. Белград, Республика Сербия

[г] Вооружённые Силы Республики Сербия, Батальон военной полиции
  специального назначения «Кобры», г. Белград, Республика Сербия

РУБРИКА ГРНТИ: 78.00.00 ВОЕННОЕ ДЕЛО:
               78.21.49 Военная электроника и кибернетика
ВИД СТАТЬИ: профессиональная статья

Резюме:

Введение/цель: Процедура выдачи и возврата оружия в армии должна проводиться быстро и обеспечивать немедленный доступ точной информации о состоянии оружия.
Методы: В данной статье рассматривается проблема о цифровки регистрации выдачи и возврата оружия с использованием современных компьютерных технологий Edge. В статье представлены два подхода к решению данной проблемы. Первый подход основан на применении алгоритмов машинного обучения для распознавания серийного номера оружия по изображению, сделанного камерой, а второй подход относится к применению технологии RFID. Идентификация пользователя проводится с помощью биометрической аутентификации.

Результаты: Результаты, полученные тестированием архитектуры идентификации вооружения с помощью камеры, показывают, что такая архитектура не подходит для идентификации оружия. Решение для идентификации оружия с использованием технологии RFID преодолевает проблемы вышеупомянутого решения. Однако для более успешного считывания информации технология RFID требует дополнительных модификаций, касающихся внедрения метокс оружия.

Выводы: Внедренное решение идентификации оружия на основании технологии RFID и биометрическая аутентификация обеспечивают простую и надежную идентификацию, скорость выдачи и возврата оружия, разгрузку сети и наблюдение за состоянием оружия в реальном времени.

Ключевые слова: обработка изображений, отпечаток пальца, RFID, искусственный интеллект, интернет вещей, Raspberry Pi.

ИДЕНТИФИКАЦИЈА ВОЈНИКА И НАОРУЖАЊА У МАГАЦИНУ НАОРУЖАЊА ЗАСНОВАНА НА ПОРЕЂЕЊУ ПРОЦЕСИРАЊА СЛИКА И RFID ТАГОВА

Душан Љ. Богићевић[а], *Иван* А. Тот[б],
Радомир И. Продановић[в], *Бојан* Ј.Тодоровић[г]

[а] Војска Србије, Генералштаб, Управа за телекомуникације и
  информатику (J-6), ЦКИСИП, Београд, Република Србија;
  Универзитет у Нишу, Електронски факултет,
  Ниш, Република Србија

[б] Универзитет одбране у Београду, Војна академија,
  Катедра телекомуникација и информатике,
  Београд, Република Србија, **аутор за преписку**

[в] Војска Србије, Генералштаб, Управа за телекомуникације и
  информатику (J-6), Центар за примењену математику и електронику,
  Београд, Република Србија

[г] Војска Србије, Генералштаб, Батаљон војне полиције
  специјалне намене „Кобре", Београд, Република Србија

ОБЛАСТ: рачунарске науке, информационе технологије
ВРСТА ЧЛАНКА: стручни рад

Сажетак:

Увод/циљ: Процес издавања и враћања наоружања у војсци треба да буде довољно брз, као и да омогући доступност тачних информација о стању наоружања.

Методе: У овом раду разматра се проблем дигитализације записивања података о издавању и враћању наоружања, коришћењем савремене рачунарске технологије Едге. Проблем је разматран на два начина. Први се заснива на примени алгоритама машинског учења за препознавање серијског броја наоружања коришћењем слике израђене помоћу камере, док други начин разматра примену RFID технологије. Корисничка аутентификација заснива се на примени биометрије.

Резултати: Резултати добијени након тестирања архитектуре за идентификацију наоружања коришћењем камере показују да таква архитектура није одговарајућа. Решење за идентификацију наоружања коришћењем RFID технологије превазилази проблеме претходно наведеног решења. Међутим, RFID технологија захтева додатне модификације које се односе на имплементацију ознака на наоружању како би њихово очитавање било успешно.

Закључак: Имплементирано решење за идентификацију наоружања засновано на RFID технологији, уз примену биометрије за аутентификацију корисника, омогућава једноставну и поуздану идентификацију, брзину при издавању и враћању наоружања, растерећење рачунарске мреже, као и надзор над статусом наоружања у реалном времену.

Кључне речи: процесирање слика, отисак прста, RFID, вештачка интелигенција, интернет ствари, Raspberry Pi.

Bogićević, D. et al, Identification of soldiers and weapons in military armory based on comparison image processing and RFID tag, pp.179-195

PROSPECTS FOR USING REMOTE SENSING DATA IN THE ARMED FORCES, OTHER TROOPS AND MILITARY FORMATIONS OF THE REPUBLIC OF KAZAKHSTAN

Erlan S. Zakiev[a], *Serikhan* K. Kozhakhmetov[b]

[a] National Defence University named after the First President of the Republic of Kazakhstan - Elbasi, Faculty of Digital Technology and Security of Information Systems, Department of Simulation and Information Systems, Nur-Sultan, Republic of Kazakhstan, e-mail: zakiev-astana@bk.ru, **corresponding author**, ORCID iD: https://orcid.org/0000-0002-4518-3985

[b] National Defence University named after the First President of the Republic of Kazakhstan - Elbasi, Faculty of Logistics Troops, Department of Logistics, Nur-Sultan, Republic of Kazakhstan, e-mail: skozhahmetov@bk.ru, ORCID iD: https://orcid.org/0000-0001-9038-8165

Abstract:

Introduction/aim: This article is written to acquaint readers with the development of a space system of Earth remote sensing in the Republic of Kazakhstan using remote sensing data to support the Armed Forces, other troops and military formations of the Republic of Kazakhstan.

Methods: An analytical approach to the study of the development of space and information technologies has led to qualitative changes in the field of remote sensing of the Earth. Conclusions were also made based on the analysis of the historical aspects of the formation and development of space systems for remote sensing of the Earth. This article deals with significant improvements in the field of geoinformation support to the Armed Forces, other troops and military formations in the interests of the security of the Republic of Kazakhstan using high-resolution satellite images from domestic spacecraft to create digital state topographic maps of the entire scale series with simultaneous updating.

Results: The article provides a brief overview of remote sensing systems using geoinformation technologies in foreign countries and in the Republic of Kazakhstan.

Conclusions: A special unit "Photogrammetric center for remote sensing and UAV data processing" is capable of processing data of remote

sensing and UAVS for the armed forces, other troops and military units of the Republic of Kazakhstan. Data processing technologies have little in common with traditional processing and representation of geographical data, and finally, geographical data serves only as a basis for solving a large number of applied problems.

Keywords: space remote sensing systems, aviation and space facilities, satellites, spatial resolution, radiometric resolution, spectral range.

Introduction

The development of modern armies, as well as the development of modern society as a whole, is based on the introduction and development of information technologies. The most important component of most technologies is the means of processing digital information about the terrain in conjunction with a variety of data about the enemy and their troops.

Nowadays, owing to the benefits of digital image, sound and communication, topogeodesic software simply cannot stay away from technological progress.

It becomes obvious that geoinformation support is a topogeodesic support of the 21st century. It includes aerospace, optoelectronic exploration, satellite communications, and digital computer technology, as well as classical methods of geodesy, cartography, and photogrammetry. An analysis of the tasks solved by topographic services of associations of the Armed Forces, other troops and military formations of the Republic of Kazakhstan in the preparation and during operations and combat operations, as well as the means and methods of solving them, indicates that there is a serious lag in these issues behind the armies of developed countries.

With the development of science, knowledge about the Earth, natural resources, geology and geography, geoinformatics in many countries of the world was previously understood as "a specialized section of computer science dealing with geography" (Ivanov & Markus, 1999, pp.36-37).

Effective work of modern GIS is difficult to imagine without satellite methods of studying the territories of our planet. Remote satellite sensing has found wide application in geoinformation technologies, both in connection with the rapid development and improvement of space technology, and with the curtailment of aviation and ground-based monitoring methods.

Background of remote sensing systems

The history of remote sensing is inextricably linked to two scientific achievements: photography and aeronautics, as their combination marked the beginning of a new powerful means of exploring the Earth – the Aerial methods. The history of photography dates back to the emergence of the concept of camera obscura (lat. cameraobscura – "dark room"), mentioned in the works of Aristotle (336-323 BC) (Surdin & Kartashev, 1999), but may have deeper roots – back to 5th – 4th century BC according to some sources (Needham, 1962).

The explanation of the operation of the pinhole camera is attributed to Ibn al-haysam (Algazen) of Basra (1038 ad), who used special tents to observe eclipses of the Sun. Later, in 1267, Roger Bacon used these principles to create optical illusions with sunlight, and in the 90s of the 15 century, Leonardo da Vinci gave a detailed description of the pinhole camera and used it for sketches from nature.

The 17th century was marked by the discoveries of Angelo Sala related to the darkening of silver under the influence of sunlight (1614), experiments of Isaac Newton with a prism and the creation of the theory of light (1666), and the discovery of lenses by Johann Christoph Sturm (Khorram et al, 2016)

The end of the 18th and the beginning of the 19th century were the key periods in the formation of photography in the form in which it is known today. In 1777, Vilhelm Carl Scheele discovered that the exposed chromate of silver can be washed away with ammonia while leaving the dark recorded areas. In 1800, Frederick William Herschel measured the temperature of light and actually discovered the infrared region of the spectrum, and in 1802 Thomas Jung presented his work on the theory of light and colors, including it in the context of human vision. Finally, the studies of Joseph Nicephore Niepce and Louis Jacques Mande Daguerre (1827– 1839) led to the appearance of full-fledged photos.

Further work of the scientists of the 19th century was aimed at improving and reducing the cost of the image acquisition process, with the names of William Henry Fox Talbot, Niepce de Saint-Victor, and Frederick Scott Archer being associated with this time. Also during this period, the phenomenon of stereoscopy was discovered, and in 1855, Scottish physicist James Clerk Maxwell described the quantitative theory of colors which marked the beginning of color photography.

In contrast to the history of the development of photography, the sources on remote sensing practically do not consider the topic of improving the theory of aeronautics, and, as a rule, the key point for a

further analysis is identified in 1858 – the flight of Gaspard Felix Tournachon.

However, besides paying tribute to these prerequisites, we should also emphasize the projects for the creation of aircraft by Leonardo da Vinci (1475), Francesco Lana de Terzi (1670), Bartolomeu Lawrence de Guzman (1709), as well as Mikhail Vasilyevich Lomonosov (1754). It is also worth mentioning that the research that formed the basis of aeronautics is that of Isaac Newton (1687), Daniel Bernoulli (1738), Jean leron d'alembert (1744) and Leonard Euler (1755), who were devoted to the motion of fluids and bodies in it.

Recognized pioneers of aeronautics are the brothers Joseph and Etienne Montgolfier, who, in 1783, in the French city of Annonay, first launched a balloon filled with hot air and thus proved a possibility of free flight. In September of the same year, an experiment was conducted with animals being carried in a ballon, and on November 21, the very first manned free flight took place, the pilots being Pilatre de Rosier and the Marquis d'Arlandes in the Montgolfier ballon.

On September 16, 1804, Joseph Louis Gay-Lussac, working together with Jean Baptiste Biot, made two balloon flights, during which he conducted studies of the Earth's magnetic field and atmospheric parameters. After these experiments, scientists began to show great interest in studying the atmosphere using aeronautics (Hallion, 2003).

Historical aspects of the formation and development of remote sensing of the Earth

The 1st period of development of remote sensing: late 18th - early 20th century (The birth of aerial photography)

Before proceeding to describe the first successes in using aerial photography, it is necessary to note another event which occurred after the flight of Nadar and which had a significant impact on the formation of remote sensing. It is the research of E. Lossed, engineer major of the corps of engineers of the French army, who developed the ideas laid down by Johann Heinrich Lambert (1759) and Botan-Beaupray (1791) and in 1859 developed a way to "deploy" a photo taken from a balloon into a plan. He called this method metrophotography, and in 1867 the term acquired its current name "photogrammetry" (the so-called scientific and technical discipline that studies the theory and develops practical ways to determine the shape, size and position of objects from their photographic and other images).

In fact, with the help of Lossed's invention, one of major drawbacks of images of that time was overcome – the lack of perspective, which was the beginning of the development of aerial photo reconnaissance.

A panoramograph, a device designed by Richard Yulievich in 1898, can be considered as the next technical achievement which at that time was the most advanced multi-camera in the world designed for aerial photography.

Alternative ways to get aerial photos of that time included using kites, birds, and rockets. So already in 1882, English meteorologist E. D. Archibald obtained successful images using a kite. The name of Julius Gustav Neubronner is associated with achievements in pigeon photography (1903), and the first successful experiments in obtaining images using rockets belong to Alfred Nobel (1897).

The first experience of aerial reconnaissance in combat conditions dates from 1904 to 1905 (Russian-Japanese war). The experience is largely questionable, since the quality of images taken from unguided balloons left much to be desired, but then it became clear that aerial photography was the future - it only remained to find a suitable carrier.

It is important to remember that 1900 was the year of the Wright brothers' triumph, when their first airplane in the world took off. And three years later, it was time for the first controlled human flight on a heavier-than-air vehicle with an engine. Wilbur Wright is also considered to be the first person to take a photo from an airplane (1909).

The possibility of controlled flights opened up new horizons for remote sensing. By a decree of Emperor Nicholas II in 1910, the Russian air fleet was created, and a year later the first positive results were obtained (V. Gelgar's survey of fortifications on the Bosphorus).

Aerial photography developed especially during the First World War of 1914 – 1918; for example, many note its important role in the preparation of the Brusilovsky breakthrough. It should be noted that, in Russia, the Central Body Engaged in Aerial Photography then became the Aerial Photography Park, where V. I. Sreznevsky and V. F. Potte worked (the creator of the first semi-automatic camera for planned shooting, 1913). To manage the photometric units, a special Aerophotogrammetric Department was established, with a school for officers.

The importance of aerial reconnaissance was also understood in the West. During the First World War, all parties to the conflict used aerial photographs to get information about the enemy. There is evidence that at the end of the war, the entire front line was photographed at least twice a day (PAPA, 2007).

At the end of the described period in 1919, S. O. Hoffman made the first aerial images in the infrared range (Estes, 2005).

The 2nd period of development of remote sensing: 1920s - 1940s. (Use of aerial photography for civil purposes)

At the end of the First World War, aerial photography began to be used more and more for civil purposes, in national economies in particular. At the same time, industry institutions were formed along with aerial photography as a scientific discipline.

The year 1921 is important since that year the USGS began using aerial surveys for forestry inventory. The obtained materials were interpreted and a few were later initiated into account water resources and works on geographical and geobotanical research.

It is worth noting that, in this period, North American and European countries had different approaches to remote sensing. It is possible to say that the size of the country determined the main tasks facing aerial photography. For the unexplored territories of Canada and the United States, the speed of data acquisition was of primary importance, even taking into account the loss of information quality (small-scale aerial photography, multi-camera cameras, simplified methods of processing aerial images). European countries were characterized by an approach in which aerial photography was mainly aimed at refining the existing topographic maps, bringing them to the current state (large-scale photography).

The development of remote sensing leads to the emergence of the first specialized departments and industry institutes. The introduction of courses in photogrammetry dates back to 1920 (Nikolai Mikhailovich Aleksapolsky), and in 1925 the first Department of Photogrammetry was organized at the Moscow Boundary Institute (Tyuflin, 2011).

In 1929, the Research Institute of Aerial Photography (later the Central Research Institute of Geodesy, Aerial Photography and Cartography, Tsniigaik) was organized under the leadership of Alexander E. Fersman and the production of Soviet photogrammetric equipment was established (Vinogradov, 1941).

So, in the 30s of the twentieth century, the multi-objective aerial camera of F. V. Drobyshev (1932) and the first model of a topographic stereometer (1933) were created as well as the first wide-angle aerial lens "liar-5" by M. M. Rusinov (1933), which marked the beginning of a series of wide-angle and ultra-wide-angle lenses "Russar", and the slit aerial camera of V. S. Semenov (1936) (Tyuflin, 2011, p.5)

Until 1936, aerial photography was used in the USSR not so much for continuous mapping of the country, but at the request of individual organizations. However, the formation of specialized state-owned enterprises created for aerial surveys in certain sectors of the economy (agricultural aerial survey, forest aviation trust, a network of aerial photo-geodesic trusts, etc.) enabled continuous coverage of territories paid for from the state budget. The result is an avalanche – like increase in the volume of aerial survey work over the period 1925 – 1938 when it increased almost 80 times. (Vinogradov, 1941)

It is worth noting that at this time (1936) in the West, Captain Albert W. Stevens obtained the first images reflecting the actual curvature of the Earth and the boundary of the stratosphere. The survey was conducted from a height of 22 km.

In 1939, the Second World War broke out, in which aerial reconnaissance began to play a leading role, providing the armies of the warring parties with the necessary materials about the enemy.

The 3rd development period: late 1940s - 1980s (The development of methods for aerospace research)

This period is one of the most significant ones in the history of remote sensing. It is during these years that space sensing of the Earth began, programs of the most famous satellite groupings started, and the research base was actively developing.

Military industry remained the main engine of the progress of remote sensing in the 40s. In 1945, the first photograph of the Earth's surface was obtained from space. It was made using a camera mounted on a Fau2 ballistic missile (USA, White Sands test site) (Zamshin, 2014).

The beginning of the Cold war spurred the parties to create new ways to monitor a likely enemy. In 1954, flights of American Lockheed U-2 reconnaissance aircraft equipped with highly informative aerial cameras began.

It is worth noting that during the 50 – 60s, most of images were panchromatic (black and white) and their evaluation was carried out using visual methods. All the more important are the achievements of Colwell (1956), who already at this time proposed the use of color infrared technology (CIR) in photography to control the incidence of plants (in such photos, diseased vegetation looks more dim).

The foundations for image analysis by spectral characteristics were thus laid (Thenkabail, 2015).

In 1959, the first session of the US Congress presented a report describing the main features of the space system and options for

satellites intended for remote sensing of the Earth (ERS) for both civil and military purposes. Since that time, remote monitoring of the Earth using space aircraft has developed.

In the same year, the Corona program (US military satellites) began, and in 1960, it provided the first successful photos from space (using cameras with film canisters that were dropped to the Earth in capsules, and then caught in the air by aircraft).

Focused civilian developments in Earth exploration began in 1959 with the launch of the Explorer VII satellites, designed to measure the amount of heat emitted and reflected by the Earth.

The TIROS 1 weather satellite (TV and Infrared observation satellite, USA) was launched in 1960 and transmitted back the first satellite image of the Earth's cloud cover. The transmission was carried out over a radio channel, i.e. almost in the same way as the transmission of information from modern satellites is carried out.

In March 1961, the Vostok spacecraft (Sputnik-9) was launched with the AFA-39 aerial camera installed; it was with its help that the first photos from space were taken in the Soviet Union.

On April 12, 1961, Yuri Gagarin became the first person to make a space flight. Shortly after Yuri Gagarin's flight in August 1961, Soviet cosmonaut G. S. Titov took the first "manual" photography of the Earth from space from the Vostok-2 spacecraft (Estes, 2005).

With a small lag behind the Soviet Union, there was the US Mercury manned flight program (1961-1963), as part of which images of the Earth were also obtained. (Kapralov et al, 2005)

In 1962, the first Zenith remote sensing spacecraft (military intelligence, USSR) was launched successfully. Three types of equipment were installed on board: photographic, phototelevision, and radio equipment.

In 1964, the United States launched the first Nimbus satellite (weather satellites). In the Soviet Union, the first operational meteorological satellite (meteor) was launched in June 1966.

The development of military vehicles continued. In 1964, the Zenit-2 complex (USSR) was adopted, and in 1965, thanks to the improvement of its optical system, the Zenit-4 complex of detailed photo observation was developed and adopted (Sukhorukov, 2011).

The United States continued its manned space flight programs with the launch of Gemini (1965-1966) which provided a systematic collection of remote sensing data throughout the project (Kapralov et al, 2005) while the next, Apollo, program was equipped with even more powerful remote sensing equipment. So Apollo 9, launched in 1968, captured the

first multispectral images using its camera with four lenses taking photos that were later subject to digitization (Lavender & Lavender, 2015).

The year 1972 is an outstanding one in the history of remote sensing of the Earth: the National Aeronautics and Space Administration (NASA) launched Landsat 1, originally named the Earth Resource Observation Satellite. It was this satellite which initiated the first continuous archive of Earth observation data for scientific research, still being updated at the present time. Landsat 1 images (four spectral ranges and a pixel size of 80 m) opened up plenty of opportunity for scientists to study vast territories. These images were small-scale, which allowed the creation of appropriate maps in a short period of time and reflected extensive geographical information about the structure of the Earth.

The first special equipment for multi-zone shooting on a spacecraft of the Soviet Union was installed in 1973 (Soyuz-12). Soviet cosmonaut pilots V. G. Lazarev and O. G. Makarov performed a significant amount of filming in six and nine zones of the electromagnetic wave spectrum. This flight proved the effectiveness of multi-zone space sensing for mapping, geological research, studying vegetation, soils, shallow sea waters, and decoding natural formations based on their spectral reflectivity. As a result of decoding multi-zone images from Soyuz-12, experimental complex mapping was carried out for the first time, discovering oil and gas-bearing structures, previously unknown crystal faults, and desert territories with shallow fresh ground water (Zamshin, 2014, p.68).

In the same year, a landmark event in remote sensing data processing technology took place - John Rouse used the normalized difference vegetation index (NDVI) in his work. Through a series of experiments, it was found that green vegetation has a high reflectivity in the near-infrared region of the spectrum and absorbs radiation well in the red range. At the same time, the reflectivity of soils and reservoirs in these ranges remains almost the same. A simple formula expressed in the operation of dividing channels made a breakthrough in determining the vegetation cover in satellite images. (Kapralov et al, 2005)

The national oceanic and atmospheric administration of the United States launches the NOAA-4 (meteorological) satellite in 1974, particularly for carrying a very high-resolution radiometer (VHRR) on board. In addition, the information from this satellite was available to everyone if they had the opportunity to receive it. It is obvious, though, that ordinary users did not have the computer capacity to process data at that time. (Thenkabail, 2015, p.680)

The survey materials from space stations continued to produce tangible results. Salyut-3 (1974-1975) – in one of the regions of the country, 67 oil and gas structures were identified, including underwater ones, and a number of intersections of large faults promising for exploration of valuable minerals (Thenkabail, 2015). Salyut-4 (1974-1977) – multi-zone and multi-scale photography covered about 4.5 million square kilometers of the South of the country, and a number of regional photo maps were created covering the Northern Caspian region, Kyrgyzstan, Tajikistan, the Crimean Peninsula, and Kalmykia.

Launched in the United States, LAGEOS 1 (1976) was used by scientists to accurately track the movement of the Earth's surface, and the data obtained from it made a great contribution to understanding the processes of earthquakes and other geological activities.

Returning to the topic of meteorological satellites, we note the launch of TIROS-N (NOAA, USA) in 1978. The satellite contained an advanced very high-resolution radiometer (AVHRR), which, in addition to observing Earth's weather events, was also used to monitor the state of objects on the Earth's surface (Thenkabail, 2015, p.681)

The year 1978 as a whole turned out to be very successful for launching space projects. This was confirmed by the NASAHCMM satellite, used to measure the Earth's temperature from space, helping in climate change research, then by the Seasat satellite intended (as its name probably implies) for monitoring the oceans, and, of course, by the Nimbus-7 satellite with a Full Ozone Layer mapping spectrometer (TOMS) on board, which helped confirm the existence of the Antarctic ozone hole. Moreover, the data from TOMS formed the scientific basis of the Montreal Protocol (1989) and other treaties banning production using ozone-depleting chemicals. The CCS scanner was also installed on the same Nexus -7, and the data from it is widely used to study the links between the biology of the oceans and the Earth's climate (Graham, 1999).

In the late 1980s, other countries also began to feel the need for their own remote sensing satellites, which eventually led to a rapid increase in data availability. In 1986, SPOT-1 was launched, the first of a series of French multispectral satellites developed by the National Center for Space Research (CNES) in collaboration with Belgium and Sweden. India launched its first satellite called IRS (1988). The 1990s saw the China /Brazil (CBERS) satellite as well as Japan's one (ADEOS).

These events prompted further development of data processing methods, special software, and rapid discoveries in the world of computer technology allowed ordinary users to apply image processing methods.

The 4th period of development of remote sensing: the beginning of the 1990s up to the present time. (Remote sensing data as the main component of geographic information systems)

This period of development is characterized primarily by the fact that remote sensing has become an integral component of geographical information systems, the main supplier of spatial information for them.

The development of computer technologies in the 90s greatly simplified the digitization of remote sensing data, and the global development of GIS systems and personal receiving stations allowed any user to receive and process spatial data, which was a huge step in scientific and technological progress and the development of remote sensing in general.

Geographic information systems (GIS) allow converting images into electronic maps, with drawing on them not only geographical, but also statistical, thematic, and other information, as well as applying a variety of analytical operations. GIS can reveal hidden trends and relationships that are difficult or impossible to detect when processing satellite images "with the naked eye". Remote sensing and geographic information systems have formed a very effective method for conducting spatial analyses of the Earth's surface. (Glushkov, 2012)

Under the leadership of R. Tomlinson, Canadian GIS (QGIS) was created to analyze data from the Canadian land inventory in the field of land using rationalization. (Kapralov et al, 2005)

In the period of remote sensing development under consideration, the main breakthrough in GIS development occurred due to the saturation of the market with appropriate software, especially designed for personal computers, which dramatically increased the scope of GIS technologies and required significant sets of digital geodata. To understand what new geodata the scientific community had in the 90s, let us look at the launch history of this time.

Also, the 90s were marked by one interesting fact in the history of remote sensing development. In addition to sensing satellites, a whole group of spacecraft that were part of the Global navigation satellite system (GNSS) operated in space, including GPS (USA), GLONASS (Russia), Galileo (Europe), and Compass (China). Of course, the initial use of these satellites was associated with the positioning of objects on the Earth, but soon this attitude was revised and a new direction in remote sensing was born, known as GNSS reflectometry (GNSS-R). It is a well-known fact that due to atmospheric refraction, GPS signals travel

through the Earth's atmosphere along a slightly curved path and with a small delay in speed, and at first this was considered a source of error, but thanks to the work of a number of scientists, it is now used to determine the level of the ocean surface, the speed and direction of wind above the ocean surface, soil moisture, or snow and ice thickness. (Jin & Komjathy, 2010)

In addition to government programs, a private commercial remote sensing market is also emerging. Private companies launch their own satellites with the subsequent sale of images, and also provide licenses for the right to receive information from their space systems. The created market gave a huge boost to the appearance of a wide variety of satellite images offered. It became possible to order images for any territory of interest, almost any spatial resolution and in any required range. (Glushkov, 2012)

The development of tools for remote sensing data processing also proceeded quite quickly: ERDAS Imagine (1992), ENVI (1994), MapInfo Professional (1995), ArcGIS (1999) – all these are well-known software products that are today the leaders of GIS software. Versions of products that had a graphical interface are listed, which greatly simplified the process of using them.

Software power of modern computers already allow for processing images, and cheaper remote sensing was facilitated by involving not only professionals but also ordinary users in the process of working with geodata.

There is a need for space survey materials with ultra-high spatial resolution, which was previously the prerogative of aerial photography. It is this segment that is beginning to be most actively developed by private companies. The United States, Israel, France, and India are beginning to build effective schemes of interaction between the state and the private sector in this area.

The developers of the first ultra-high-resolution satellites were exclusively American companies, but since 2006, launches of such devices have been carried out: Israel (Eros-B), Russia (Resurs-DC), Korea (COMP-2) and India (Cartosat-2). Nevertheless, the United States still retains its technological leadership, as evidenced by the launch of such devices as the IKONOS satellite (1999), geo-Oko-1 (2008), WorldView-1 satellite (2007) and WorldView-2 satellite (2009) with a resolution of 0.4–0.5 m.

An important feature of 2007-2010 is the increase in the number of launches of spacecraft with high-resolution radars. Radar images can be obtained regardless of weather conditions and light conditions in the

target area and allow making requests for shooting within a few days. In addition, space–based radar images make it possible to create digital terrain models, and special interferometric imaging technologies make it possible to detect minor ground movements.

The existing radar space systems RADARSAT-1 (Canada), ERS-2, ENVISAT-1 (both ESA) and ALOS (Japan) provided an area resolution of no better than 8 m, which did not meet modern requirements, so the launch of the civilian satellite TerraSAR-X (Germany, 2007), which provided radar shooting with a resolution of 1 m, was a landmark event. At the same time, the Italian COSMO-Skymed satellite program was implemented. (Lavrov, 2010)

Current state of remote sensing and development prospects in the Republic of Kazakhstan

Today, more and more new satellites with modern sensor systems are being put into the orbit. The last of NASA's Landsat series satellites (number 8), was launched in early 2013 and today continues to provide a continuous archive of data from this mission. Other satellites, such as SMAP (USA) or FLEX (ECO), are very important for environmental monitoring.

SMAP was launched in early 2015 and carries SAR (synthetic aperture radar, L-band, 1.2 – 1.4 GHz) and a radiometer that measure soil moisture and monitor the continuous water cycle in nature. The antenna covers a 1000-kilometer range, providing global coverage of the Earth in just a few days.

FLEX is a derivative of ESA's eighth research mission and is intended to provide global fluorescent vegetation maps. The FLORIS (Fluorescence Imaging Spectrometer) is an on-board instrument that measures the emission of waves in the range of 500 to 800 nm with a bandwidth of 0.1 nm to 2 nm, which allows images to be obtained with a 150-kilometer range and a pixel size of 300 m. This information will allow a thorough study of the vegetation cover in dynamics. FLEX is scheduled to be launched in 2022.

Another American future mission suitable for processing Earth data is the large-scale hyperspectral GEO-CAPE (scheduled for launch in 2020). The GET-CAPE should become an improved MODIS receiver and provide continuous data acquisition for a variety of application areas, such as water resources, agriculture, disaster prevention, and environmental monitoring.

Another hyperspectral satellite, HyspIRI, is currently under development. HyspIRI will include two instruments: a spectrometer (in the spectrum from VIS to TIR) and a multispectral imaging unit (in the SWIR and TIR spectra); these data could be used in many areas, but primarily for monitoring the carbon cycle, ecosystems, and the Earth's surface.

To support today's much-needed high-resolution environmental monitoring, the European Union recently launched the Copernicus programme (formerly known as GMES). Copernicus is the European flagship of Earth exploration, adapted for environmental monitoring. Copernicus includes two types of missions: the Sentinel programme (Sentinel 1 - 6) and related space programmes. There are approximately 30 active or planned satellite space programmes operating under the auspices of ESA, EU member States such as EUMETSAT, and other global countries.

The launch of Sentinel-1A in 2014 provided new opportunities in the field of microwave radiation, offering global data for study with a repeated cycle of 12 days, which will be reduced to 6 days with the launch of the Sentinel-1B satellite. Thanks to the public data access policy, they are supposed to expand the scope of microwave methods. Subsequent SAR data for this area will be provided by the AMOS-2 satellite group (Japan, 2014), as well as two planned SAOCOM satellites (Argentina, launches 2016 and 2017) and the RADARSAT Constellation mission (Canada, 2018).

Since there is a demand for high-resolution data in the commercial market, new satellites are likely to be launched as private or national initiatives over the next decade to replace the current generation of TerraSAR-X and CosmoSkyMed sensors.

A pair of Sentinel-2 satellites (2015, 2016) will provide images with medium spatial resolution. Sentinel-2 guarantees continuous spot observation with the ability to improve spectral resolution and temporal illumination. The multispectral imaging unit (MSI) on Sentinel-2 covers the VIS, NIR, and SWIR spectral regions in 13 bands with a spatial resolution of 10 m × 10 m (point observation), 6 groups of 20 m × 20 m, and 3 groups of 60 m × 60 m. The increased width of the row, approximately 290 km, together with the presence of two satellites in orbit at the same time, will reduce the re-coverage of the territory to 2-3 days. This will make it possible to monitor rapid changes in the environment, such as crop maturation, especially during the agricultural season, and improve methods for detecting such changes.

The Sentinel-3 project was created for the purpose of monitoring the marine environment and was launched in 2016. This system carries both ocean monitoring tools and an OLCI scanner, which is the successor of MERIS, but with improved wavelength groups (21 compared to 15 on MERIS) and a spatial resolution of 300 m × 300 m.

The German En MAP (launched in 2018) will be a satellite with a spatial resolution similar to Landsat, but with an increased number of bands in the VIS and SWIR spectra (244), and a rotation time of less than 4 days. (Thenkabail, 2015)

In addition to promising classical satellite programmes, it is time to use small spacecraft (MCAS). One of the most promising is "CubeSat" – nanosatellites of a certain design created at Stanford University. The size of the basic element of the satellite structure is 10x10x10 cm. The launch is performed using Poly-Picosatellite Orbital Deployer (P-POD). The standard allows combining two or more standard cubes as part of a single satellite (designated 2U, 3U, etc.). The development of modern high-tech industries has made it possible to create small-sized spacecraft at a relatively low cost of time and money. Despite the fact that they do not have the lifetime of larger satellites, they offer fantastic potential for testing new sensors or making specific short-term measurements, and are capable of solving serious scientific, technical, research, and industrial tasks. In fact, a new segment of the space industry is being formed. However, the biggest challenge to expanding the use of small spacecraft is the problem of putting them into orbit. Currently, ICAS are often put into orbit as a passing cargo. (Prokopyev et al, 2014)

There are many promising ways to improve existing remote sensing mechanisms. In addition to the obvious, i.e. improving the technical stuffing of devices (robotization, design simplification, high-efficiency solar panels, etc.), new technologies for autonomous operation of spacecraft are being developed such as those for improving the launch formation (swarm), i.e., types of missions in which several vehicles fly at a short distance (up to several hundred meters) from each other. In contrast to the traditional orbital grouping of satellites, where the devices act independently, performing a common task, in the spacecraft formation flying they act together, distributing individual functions and elements of the task between individual devices. In fact, this is a creation of distributed satellite systems. (Prokopyev et al, 2014)

In addition to satellites, other types of remote sensing devices are becoming more popular (for example, fixed–wing aircraft, helicopters and quadrocopters, unmanned aerial vehicles-drones), they are most often

used for shooting at low altitudes and are test platforms for space instruments. (Lavender & Lavender, 2015)

As mentioned earlier, remote sensing and data generated by it are now an integral part of geographic information systems. GIS have many classifications, but from the point of view of the prospects for use, we are only interested in the possibility of using this system on the Internet.

The migration of desktop software products to the network is a general trend in the software development market. For quite a long time, users can use Google Docs instead of MS Word, or Yandex mail instead of Outlook. Naturally, this approach requires a network connection, but it does not depend on platforms at all, and makes programs and data available from any computer and from any place.

The market for Web GIS systems is experiencing quite rapid development. There are many proprietary developments, for example, ArcGISServer, and no less freely distributed analogues (MapServer, GeoServer, etc.), the functionality of which improves from version to version, and almost always involves support for the WMS, WCS, and WFS standards.

Today, it is still more convenient to conduct primary data preparation in desktop GIS, thanks to the remote sensing information processing mechanisms developed over many years (image filters, classification plugins, etc.), but quite serious steps are already being taken to transfer this functionality to the network, i.e. full implementation of OGCWFS-T and WPS standards.

Based on the prerequisites for the transition of geoinformation systems that work with remote sensing data to the category of Internet services, the use of almost unlimited computer power, known as cloud computing, in the tasks of processing satellite images is becoming more and more obvious.

Until recently, only specialized scientific organizations had access to powerful supercomputers, which severely limited the ability of data processing (including remote sensing data) by ordinary users. Moreover, today even the expert community is not able to cope with the processing and decryption of constantly incoming information in a timely manner. For example, Digitalglobe's constellation of satellites – QuickBird, WorldView-1, and WorldView-2 – Collectively capture ultra-high-resolution images of about 1.5 million km per day. (PAPA, 2007) However, thanks to the appearance of services such as, for example, Amazon Elastic Compute Cloud, it is now possible to use its capabilities to implement remote sensing tasks. Fast work with ultra – high-resolution data (several meters), spectral data with hundreds of channels, daily

updated data, implementation of image processing algorithms in the cloud software environment, storage and archiving of very large volumes of data - all this is the future of remote sensing. (Thenkabail, 2015)

Continuing the idea of a promising vector for the development of remote sensing, it is necessary to note the increasing role of crowdsourcing in the analysis of remote sensing data. When a large number of people use the Internet to access information received from satellites, there are amazing opportunities in using the capabilities of the human brain to solve spatial problems. Despite the ever-increasing performance of software systems for image analysis, nothing can replace the intuition and perception of the human brain. Cognitive tasks that are simple to us are very difficult for a machine.

There are several advantages of using crowdsourcing in remote sensing:

– quick analysis of images by hundreds and thousands of people. Even if they are not experts in a particular field, but the right task in this case can overcome this disadvantage.

– leveling the problem of a large amount of data. What an expert can analyze in a week, a large group of people will do in a day.

– full use of human cognitive capabilities, according to the classification of objects. No matter how advanced machine image recognition algorithms are, they cannot detect all possible variations of objects on the Earth.

– reliability of the information received. This is, of course, an effect that translates a quantitative assessment into a qualitative one, using confidence analysis algorithms. Everyone makes mistakes, but if a lot of people come to an agreed opinion on a particular issue, the reliability of such information is considered significantly higher. (DigitalGlobe, 2014)

The last thing worth noting is the increasing role of standardization in the provision of remote sensing data. Of course, remote sensing data itself is also standardized, especially in terms of names and metadata (Tyuflin, 2011), but the most important aspect is the transmission aspect, since operating with unified protocols allows the creation of spatial data infrastructures that provide information to any user on the Internet. This is about the growing support of leading manufacturers of remote sensing data and their derivatives for OGC standards (Open Geospatial Consortium – a non-core, international, voluntary organization for the development of standards in the field of geoinformation services). Map services and services on the Internet that support the WCS, WFS, and WMS standards make it possible to operate remote sensing data as if they are locally available, which opens up unlimited opportunities for

comprehensive analysis of such data, highlighting the necessary information, and, ultimately, making the right management decisions.

The current level of scientific and technical development in the field of geodetic and cartographic activities, associated with the use of satellite geodetic methods, the widespread introduction of new technical means and technologies for creating digital cartographic products, and geoinformation systems, requires highly qualified specialists who can solve complex production and scientific problems in the field of geodesy and cartography.

The current stage of development of geodesy and cartography in Kazakhstan is characterized by reaching a fundamentally new level of production automation, which has caused fundamental changes in the applied technologies, technical means, devices and equipment. Namely, the implementation of cartographic and geodetic works is carried out using: satellite radio navigation technologies (GPS NAVSTAR (American) and GLONASS (Russian)) (Fig. 1), satellite surveys, digital mapping methods, and GIS technologies.

a)   b)
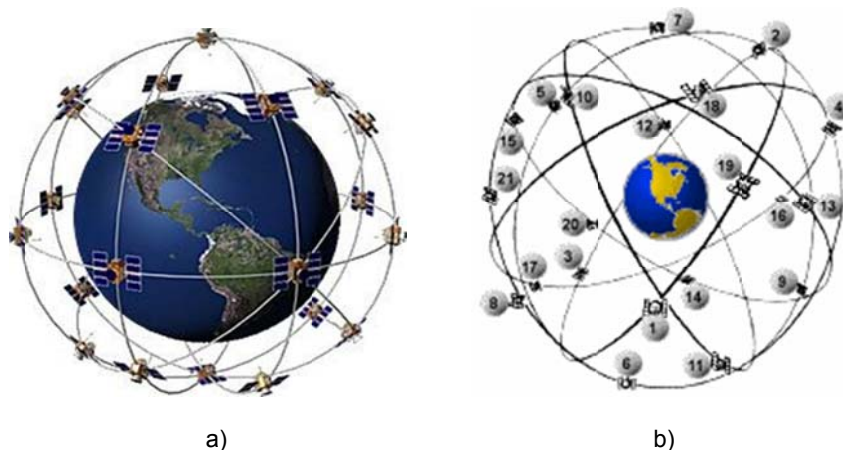
Figure 1 – Global satellite radio navigation systems: a – GLONASS, b – NAVSTAR
Рис. 1 – Глобальные спутниковые радионавигационные системы:
a – ГЛОНАСС, b – NAVSTAR
Слика 1 – Глобални сателитски радио-навигациони системи:
a) ГЛОНАСС, б) NAVSTAR

Currently, the greatest attention is paid to the introduction of remote sensing data and high-resolution satellite imagery materials from the domestic KazEOSat-1 spacecraft to create and simultaneously update digital state topographic maps of the entire scale range.

Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-1

Figure 2 – Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-1
Рис. 2 – Космический аппарат дистанционного зондирования KazEOSat-1 (Республика Казахстан)
Слика 2 – Свемирска летелица KazEOSat-1 за даљинску детекцију (Република Казахстан)

The Law of the Republic of Kazakhstan No. 528-IV of January 6, 2012 "On Space Activities" stipulates that, by the decree of the Government of the Republic of Kazakhstan dated May 31, 2012, the joint-stock company "National Company Kazakhstan Gharysh Sapary" is the national operator of the space system for remote sensing of the Earth.

In 2014, Kazakhstan acquired its own space system for remote sensing of the Earth. Two vehicles were launched into orbit sequentially: high-resolution KazSat-1 and medium-resolution KazEOSat-2.

The KazEOSat-1 (Kazakhstan Earth Observation Satellite) is the first Kazakh satellite for remote sensing of the Earth, created by the order of the government.

On April 30, 2014, the KazEOSat-1 satellite was launched into orbit from the European Space Agency's Kourou spaceport in French Guiana. The device, which has an almost record spatial resolution of 1 meter per pixel for satellites of this level, was developed for our country by the French aerospace concern Airbus Defense and Space (PAPA, 2007), which was called EADS Astrium before the rebranding.

Figure 3 – KazEOSat-1 Satellite At the Kourou cosmodrome before launch (Photo by ESA-CNES-Arianespace Optique Video du CSG)
Рис. 3 – Спутник KazEOSat-1 на космодроме Куру перед запуском (Фото ESA-CNES-ARIANESPACE Optique video du CSG)
Слика 3 – Сателит KazEOSat-1 на космодрому Куру пред лансирање (Фотографија ESA-CNES-Arianespace Optique Video du CSG)

As a payload, the satellite is equipped with a scanning device "NAOMI" (New Astro Sat Optical Modular Instrument), which enables taking photos with a resolution of up to 1 meter (in the panchromatic mode) and up to 4 meters (in the multispectral mode).

The survey capacity of the KazEOSat-1 spacecraft is 220,000 square kilometers per day.

The maximum length of the shooting lane is 2000 km.

Table 1 – The characteristics of the imaging system KazEOsat-1
Таблица 1 – Характеристики съемочной аппаратуры KazEOSat-1
Табела 1 – Карактеристике система KazEOsat-1 за снимање сателита

The diameter of the aperture	640 mm		
Spectral channel	Panchromatic 0.45-0.75 μm	Multispectral Blue - 0.45-0.52 μm Green - 0.53-060 μm	Red - 0.62-0.69 μm infrared - 0.76-0.89 μm
Spatial resolution	1 m	4 m	
Capture band	12 bit		
Deviation from Nadir	20 km		

Radiometric resolution	+/- 35 degrees	
Tool weight	150 kg	
Possibility to get a stereo pair	Yes, from one turn	
Customer		JSC "NC "Kazakhstan Gharysh Sapary»
Manufacturer		Airbus Defence and Space (EADS Astrium)
Platform		Leostar-500-XO
Orbit		Sun-synchronous, H=750 km, inclination 98.5 degrees
Sizes		2.10 m x 3.70 m
Power		1200 W
Data rate		270 Mbit/s in the X-band
Modulation of transmitted data		QPSK
Weight		820 kg
Estimated duration of stay in orbit		7 years

Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-2
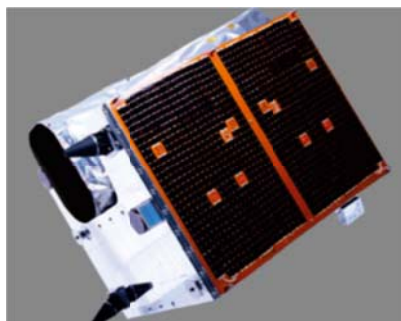
Figure 4 – Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-2
Рис. 4 – Космический аппарат дистанционного зондирования KazEOSat-2 (Республика Казахстан)
Слика 4 – Свемирска летелица KazEOSat-2 за даљинску детекцију (Република Казахстан)

Already in June 2014, the second medium-resolution remote sensing satellite KazEOSat-2 went into orbit. It was built by a subcontractor of Airbus Defence and Space – the British company Surrey Satellites Technology Ltd (Estes, 2005).

The KazEOSat-2 (Kazakhstan Earth Observation Satellite) is the second Kazakh satellite for remote sensing of the Earth, created by the order of the government of the Republic of Kazakhstan on the basis of the SSTL – 150+ satellite platform by the British company SSTL. The SSTL is a subsidiary of Airbus, Figure 5.

Figure 5 – Photo ESA-CNES-Arianespace Optique video du CSG
Рис. 5 – Фото ESA-CNES-Arianespace Optique video du CSG
Слика 5 – Фотографија ESA-CNES-Arianespace Optique video du CSG

The KazEOSat-2 medium-resolution remote sensing spacecraft was launched on June 20, 2014, from the Russian launch base Yasny (Orenburg region, Russia).

The KEIS (Kazakh Earth Imaging System) scanning device, also known as "JSS-56" (Jena-Optronik Spaceborne Scanner-56) or "MSI" (multispectralimager) is installed on board of the KazEOSat-2 satellite as a payload.

The survey capacity of the KazEOSat-2 spacecraft is 1,000,000 square kilometers per day.

217

Table 2 – The characteristics of the imaging system KazEOsat-2
Таблица 2 – Характеристики съемочной аппаратуры KazEOsat-2
Табела 2 – Карактеристике система KazEOsat-2 за снимање сателита

The diameter of the aperture	145 mm	
Focal length	633 mm	
Spectral channel	blue - 0.45-0.52 μm green - 0.53-060 μm red - 0.62-0.69 μm	Extreme red - 0.69 – 0.73 μm infrared - 0.76-0.89 μm
Spatial resolution	6,5 m (in Nadir)	5 m (when creating an orthophoto)
Capture band	12 bit	
Deviation from Nadir	77 km	
Radiometric resolution	+/- 35 degrees	
Tool weight	150 kg	
Possibility to get a stereo pair	Yes, from one turn	
Customer		Kazakhstan Gharysh Sapary (KGS)
Manufacturer		SSTL
Platform		SSTL-150+
Orbit		Sun-synchronous, H=630 km, inclination 98 degrees
Sizes		700 mm x 800 mm x 900 mm
Data rate		160 Mbit/s in the X-band
Weight		180 kg
Estimated duration of stay in orbit		7 years

Under the contract with the French side, a fairly serious ground infrastructure was created in the capital of Kazakhstan to service satellites. It includes a spacecraft control system, a ground-based target system, and antenna systems, Figure 6.

The antenna systems are two autonomous systems for full control of telemetry, issuing commands to satellites and receiving information that they transmit to the Earth. The antenna of the Kazsat-1 satellite is mounted on the top of a three-story tower in a special spherical case built of radio-transparent material. It protects the device from atmospheric disturbances, precipitation, and sunlight. The dome of the KazEOsat-2 antenna system is made in the form of an icosahedron geometric shape. This shape improves the electromagnetic background in the antenna area, Figure 6.
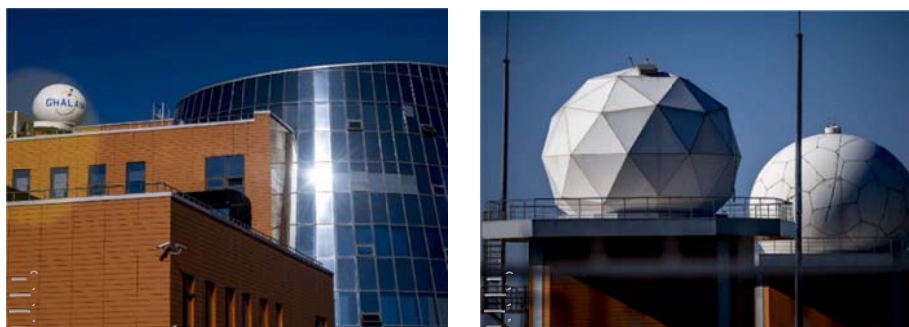
Figure 6 – Building of the National space center in Nur-Sultan, where the control and data processing systems KazEOSat-1 and KazEOSat-2 are located
(Photo by Grigory Bedenko)
Рис. 6 – Здание Национального космического центра в г. Нур-Султан, где находятся системы управления и обработки данных KazEOSat-1 и KazEOSat-2
(Фото Григория Беденко)
Слика 6 – Зграда Националног центра за свемир у Нур Султану где су лоцирани системи за управљање и обраду података сателита KazEOSat-1 и KazEOSat-2
(Фотографија: Григориј Беденко)

Both satellites move in so-called sun-synchronous orbits. This is when the device flies from one pole of the planet to the other and is always on the illuminated side of the Earth. The radio visibility zone of the KazEOSat-1 satellite extends over a huge territory of the continent – from the Taimyr Peninsula and almost to Northern India. In total, the satellite makes 15 orbits per day, Figure 7.

Three day and three night sessions are held with it in the radio visibility zone. One communication session lasts 10-12 minutes. During this time, a package of program commands is transmitted to the satellite, and the information accumulated by the device is reset. The spatial resolution of the KazEOsat-1 satellite is one meter, and the survey is performed in panchromatic and multispectral modes.

The device simultaneously covers the territory of 20 by 20 km. The shooting period is 3-5 days. Capacity – 220,000 square kilometers per day.

The angle of inclination of KazEOsat-2's orbit is 98 degrees. And in 98 minutes, it makes a complete revolution around the Earth. It performs 14-15 revolutions per day. Of these, 5-6 times the satellite is in the radio visibility zone of the antenna.
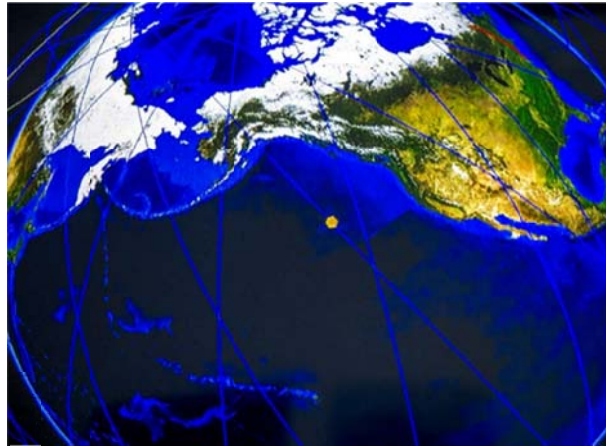
Figure 7 – KazEOSat-1 Ballistics calculated based on telemetry data
(Photo by Grigory Bedenko)
Рис. 7 – Баллистика KazEOSat-1, рассчитанная на основе данных телеметрии
(Фото Григория Беденко)
Слика 7 – Балистика израчуната на основу телеметријских података сателита
KazEOSat-1 (Фотографија: Григориј Беденко)

So-called flywheels are used to orientate KazEOSat-2 in space. This is a system of gyroscopes that record the position of the device relative to any static objects. And already for orbit correction, an ion engine running on xenon is used. The orbit is adjusted approximately once a month. There was already a case when the device evaded space debris. At an altitude of 600-800 kilometers, there is a lot of it.

The Kazsat-2 radio visibility Zone covers an area of 3 by 4 thousand square kilometers. Tracking the vehicle starts when it is only 5° above the horizon. The antenna orientation is performed by an automated system. The spatial resolution of Kazsat-2 is 6.5 meters per pixel. The shooting mode is multispectral. The stage size is 77 by 77 kilometers. The shooting period is 3-5 days. Productivity – one million square kilometers per day.

Images obtained from satellites are received at the Group for Photogrammetric Processing. The Department receives the original data. First, the primary processing is performed – unpacking and decoding.

The primary product gets the code L-1 A. Next, a geometric correction of the image is performed. It eliminates distortions caused by inaccuracy of geo-linking, curvature of the Earth, and terrain. Distortion –

optical distortions - is also eliminated. All software for this complex processing is developed by French manufacturers, Figure 8.

Figure 8 – KazEOSat-2 satellite is controlled from here (Photo by Grigory Bedenko)
Рис. 8 – Центр управления спутником KazEOSat-2
(Фото Григория Беденко)
Слика 8 – Центар за управљање сателитом KazEOSat-2
(Фотографија: Григориј Беденко)

As a result, specialists receive three types of products:

L-3 – orthorectified image. This is when the objects in the image are seen in the vertical plane. To do this, the corresponding orientation of each pixel is made;

L-4 – digital terrain or terrain model; and

L-5 – stitched mosaic.

As a result, a single whole image is obtained, which has the widest range of applications, in particular, when monitoring territories or mapping.

The information is sent to the server and processed within two hours. After that, the data is written to special storage media for permanent storage. The server also has an array of RAM in which snapshots are stored up to a certain period. The server receives up to 12 terabytes of data per day. One medium is designed for 1.5 terabytes.

Remote sensing data obtained from the orbiting satellites is most reliable. In addition, this information is available on the whole territory of

Kazakhstan. All hard-to-reach territories that are difficult to control are clearly seen from space.

A special role is assigned to satellite information in geographic information systems (GIS), where remote sensing of the Earth"s surface from space is a regularly updated source of data necessary for the formation of natural resource inventories and other applications, covering a very wide range of scales (from 1:10000 to 1:1000000).

At the same time, remote sensing information enables to quickly assess reliability and, if necessary, update the graphic layers used (maps of the road network, communications, etc.), and can also be used as a raster "substrate" in a number of GIS applications, without which modern economic and military activities are unthinkable today.

Use of remote sensing data in the armed forces, other troops and military formations of the Republic of Kazakhstan

Worldwide, the main consumers of remote sensing data (80%) are law enforcement agencies and government agencies. Kazakhstan is no exception. In Kazakhstan, 90% of consumers of the total volume of satellite data are government agencies. In particular, 72% of the total volume is presented to law enforcement agencies across the MD of RK.

To date, only Russia and Kazakhstan have their own satellite systems in space among the CIS countries.

The Resolution of the Government of the Republic of Kazakhstan dated May 31, 2012, No. 722, *On approval of the rules for planning space surveys, receiving, processing and distributing remote sensing data by the national operator of the space system for remote sensing of the Earth:*

General provisions

A division of the Ministry of Defense of the Republic of Kazakhstan is authorized to conduct control viewing procedures - remote sensing data and to plan space surveys together with the remote sensing system operator.

For the state bodies and the Armed Forces, other troops and military formations of the Republic of Kazakhstan, data obtained from the domestic remote sensing satellites are used to solve the following tasks:

- detection of forest fires, large emissions of pollutants into the natural environment;

- monitoring of man-made and natural emergencies, including natural hydrometeorological events;

- monitoring of agricultural activities and natural (including water and coastal) resources;
- land-use;
- operational observation of specified areas of the Earth's surface;
- monitoring the territory of possible hotbeds of hostilities and violations within the state; and
- production of derived materials for space surveys.

The Center for Mlitary Space Programs of the Defense Ministry produces a procedure of the control view - remote sensing data and, in conjunction with the operator COP ERS to plan satellite imagery and remote sensing data, provides the staffs and the management bodies of the Armed Forces, other troops and military formations.

To fully solve all of the above tasks, it is necessary to create a unit capable of processing data in the DZ Forces, other troops and military formations of the Republic of Kazakhstan.

The photogrammetric analysis of remote sensing and UAV data encompasses:
- photogrammetric thickening of the reference point network;
- the transformation or artifact repository space images (photos);
- decryption of satellite images (photos); and
- creating original updates (quickly corrected vector topographic and special maps of large scales and creating a 3-d terrain Model based on remote sensing and UAV data).

Training of specialists is possible at the National Defense University named after the First President of the Republic of Kazakhstan – Elbasy, together with the Center for Military Space Programs of the Ministry of Defense of the Republic of Kazakhstan.

Thus, in the future, the Republic of Kazakhstan needs to create a new generation of ultra-high-resolution mini-satellites such as fiber-optic gyrostabilization systems, spacecraft equipped with the most modern systems of unprecedented maneuverability, and train specialists for the "Photogrammetric data processing center for remote sensing and UAVS".

Conclusion

Analyses of modern military conflicts in the Persian Gulf and Yugoslavia shows that contactless methods of armed struggle are coming to the fore. The winner is the one who has highly accurate and

up-to-date information about the enemy, ranging from a digital description of the terrain of its territory, the location of troops and vital objects to the climatic and weather conditions of the areas of combat operations.

Data from remote sensing of the Earth is part of the information required by the management bodies and headquarters of the Armed Forces, other troops and military units in the course of their activities. In addition to terrain data, there is a growing flow of operational-tactical, intelligence, meteorological and geophysical information used in the process of managing troops, which must be analyzed and taken into account when preparing and conducting operations.

Integration of geographic information systems with rapidly developing remote sensing systems will dramatically increase the capabilities of modern GIS, allowing real-time updating of spatial information, especially in the field of making important decisions.

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ПРИМЕНЕНИЕ ДАННЫХ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ В ВООРУЖЕННЫХ СИЛАХ РЕСПУБЛИКИ КАЗАХСТАН

Ерлан С. Закиев[а], *Серикхан* К. Кожахметов[б]

[а] Национальный университет обороны имени Первого Президента Республики Казахстан − Елбасы,
Факультет цифровых технологий и безопасности информационных систем,
кафедра имитационного моделирования и информационных систем,
г. Нур-Султан, Республика Казахстан, **корреспондент**,

[б] Национальный университет обороны имени Первого Президента Республики Казахстан − Елбасы,
Факультет материально-технического обеспечения войск,
кафедра тылового обеспечения,
г. Нур-Султан, Республика Казахстан

Резюме:

Введение/цель: Данная статья написана с целью ознакомления читателей с перспективами развития космической системы дистанционного зондирования Земли в Республике Казахстан и использования данных ДЗЗ в процессе организации топогеодезического обеспечения Вооруженных Сил, других войск и воинских формирований Республики Казахстан.

Методы: Применяя аналитический подход при исследовании причин, развитие космической и информационной технологий привели к качественным изменениям в отрасли дистанционного зондирования Земли. Выводы были сделаны и на основании анализа исторических аспектов становления и развития космической системы дистанционного зондирования Земли. В данной статье рассматриваются вопросы кардинального улучшения ситуации в области геоинформационного обеспечения Вооруженных Сил, других войск и воинских формирований в интересах безопасности Республики Казахстан с использованием материалов космической съемки высокого разрешения с отечественного космического аппарата для создания с одновременным обновлением цифровых государственных топографических карт всего масштабного ряда.

Результаты: В статье приведен краткий обзор систем дистанционного зондирования Земли с использованием

геоинформационных технологий зарубежных государств и Республики Казахстан.

Выводы: Создание специального подразделения «Фотограмметрического центра обработки данных ДЗЗ и БЛА» способных обрабатывать данные ДДЗ и БЛА для Вооруженных Сил, других войск и воинских формирований Республики Казахстан, так как технологии обработки данных имеют мало общего с традиционной обработкой и представлением географических данных, однако географические данные могут послужить базой для решения большого числа прикладных задач.

Ключевые слова: космические системы дистанционного зондирования, авиационные и космические средства, спутники, пространственное разрешение, радиометрическое разрешение, спектральный диапазон.

ПРИМЕНА ПОДАТАКА ДОБИЈЕНИХ ДАЉИНСКОМ ДЕТЕКЦИЈОМ У ВОЈСЦИ РЕПУБЛИКЕ КАЗАХСТАН

Ерлан С. Закијев[а], *Серикхан* К. Кожахметов[б]

[а] Народни универзитет одбране „Први председник
  Републике Казахстан – Елбаси",
  Факултет информационих технологија и безбедности информационих система,
  Катедра симулационог моделовања и информационих система,
  Нур-Султан, Република Казахстан, **аутор за преписку**,

[б] Народни универзитет одбране „Први председник
  Републике Казахстан – Елбаси",
  Факултет војне логистике, Одељење логистике,
  Нур-Султан, Република Казахстан

Сажетак:

Увод/циљ: Циљ овог рада јесте упознавање са перспективама будућег развоја свемирских система даљинске детекције Земље у Републици Казахстан. Коришћени су подаци даљинског истраживања у процесу организовања топографске и геодетске подршке Оружаним снагама, осталим трупама и војним јединицама Републике Казахстан.

Методе: У раду се разматра низ круцијалних питања у вези с побољшањем стања у области геоинформационе подршке Оружаним снагама, осталим трупама и војним јединицама а односе се на безбедносне интересе Републике Казахстан. Коришћени су

сателитски снимци високе резолуције који су снимљени са домаће свемирске летелице ради израде и ажурирања дигиталних државних топографских мапа за целокупан размерни низ.

Резултати: Рад садржи кратак преглед система даљинске детекције Земље који користе како стране геоинформационе технологије, тако и геоинформационе технологије Републике Казахстан.

Закључак: Неопходно је формирање посебног одељења („Центар за фотограметријску обраду података прикупљених уз помоћ даљинске детекције са беспилотних летелица") које би се бавило обрадом прикупљених података за потребе Оружаних снага, осталих трупа и војних јединица Републике Казахстан, с обзиром на то да технологије обраде података немају много заједничког са конвенционалном обрадом и презентацијом географских података. Поред тога, прикупљени географски подаци могу да послуже као основ за решавање великог броја актуелних проблема.

Кључне речи: свемирски системи за даљинско детектовање, ваздухопловна и свемирска средства, сателити, просторна резолуција, радиометричка резолуција, спектрални распон.

REMEDIATION OF THE AREAS CONTAMINATED BY DEPLETED URANIUM AMMUNITION

Dejan R. Inđić

University of Defence in Belgrade, Military Academy,
Department of Tactics, Belgrade, Republic of Serbia,
e-mail: indjicrdejan@gmail.com,
ORCID iD: https://orcid.org/0000-0001-9111-0472

Abstract:

Introduction/purpose: The consequences of the NATO aggression on the Republic of Serbia (then part of FR Yugoslavia) in 1999 are still being considered, especially from the aspect of the use of illicit means such as cluster and graphite bombs, depleted uranium ammunition (DUA), etc. There is no doubt that the use of depleted uranium, as a type of weapon of mass destruction (radiological weapon) is mostly in the focus of public interest. The amount of DUA used and the consequences of its use have not yet been fully proven (even after 20 years), but it can be said with certainty that it has caused certain side effects. The units of the Yugoslav Army at that time were mostly the target of this type of ammunition and certainly suffered the greatest consequences. However, DUA also targeted infrastructure facilities, base stations, television transmitters, and agricultural land.

Methods: Special scientific methods (mainly analysis and synthesis methods) and empirical methods (content analysis method and observation method) were used in the paper.

Results: The consequences of the effect of DUA on people, material goods, and environmental degradation are considered as well as the directions of further work in this area.

Conclusion: The paper presents the results of the radiological reconnaissance and radiological decontamination of the contaminated DUA areas, which were carried out by ABH service units (then ABHO) with the help of other branches and services of the Serbian Army, as well as the institutions of the Republic of Serbia (INS „Vinča", MMA, etc.).

Key words: uranium, depleted uranium ammunition, ABH service, reconnaissance, decontamination.

Introduction

Uranium-238 (^{238}U or U-238) is the most common uranium isotope that can be found in nature (about 99.3% of the mass of natural uranium is uranium-238). Unlike uranium-235, it is not subject to fission, which means that it cannot sustain a chain reaction. However, it is flexible for fast neutrons and fertile, which means that it can be converted into fission plutonium-239. The half-life of this element is 1.41 $\times$ 1017 seconds (4.468 $\times$ 109 years, i.e. ~ 4.5 billion years). Due to its distribution in nature and half-life in relation to other radioactive elements, uranium-238 produces ~ 40% of the radioactive heat produced inside the Earth. (Arevalo et al, 2009, pp.361-369)

Depleted uranium is a toxic by-product of the natural uranium enrichment process and is highly hazardous radioactive waste. It was stored until the beginning of the seventies of the last century, after which it began to be used for the production of projectile penetrators. This is the main reason for the public attention this type of weapon has gained in the last thirty years, starting from its first official use in 1991 in Iraq, and then through the Republic of Srpska (RS/BiH), the Republic of Serbia, Libya and others countries. It is certainly necessary to state that this type of radiological weapon indiscriminately, inhumanely and insidiously causes consequences for both the winners and the losers. (Rajković, 2001, pp.167-182)

The harmful effects of depleted uranium have been known to a narrow circle of experts in the United States for a very long time. It is estimated that in the United States alone, close to 900,000 people were exposed to the harmful effects of depleted uranium between 1945 and 1995 (uranium miners, their families, laboratory workers in Los Alamos and Oak Ridge, residents of the regions around nuclear power plants, residents of the Marshall Islands, members of the U.S. military, etc.).

During the NATO aggression on FR Yugoslavia, thousands of depleted uranium projectiles were fired from A-10 Thunderbolt II aircraft targeting army units as well as certain facilities.

According to NATO data, this ammunition was fired at: 84 locations on the territory of Kosovo and Metohija (KiM), 10 locations on the territory of the Republic of Serbia and 1 location on the territory of the Republic of Montenegro with a total of 112 DUA strikes. Data from the then Yugoslav Army (YA) show: 85 locations on the territory of Kosovo and Metohija, 4 locations on the territory of the Republic of Serbia and 1 location on the territory of the Republic of Montenegro with a total of 99 DUA strikes.

From the above we can conclude that there are different data on the use of DUA in the area of the Republic of Serbia, but certainly the data of the YA (now the Serbian Army) must be taken as valid, because they were verified in the field (by conducting radiological surveys of the affected areas).

Immediately after DUA strikes and after a certain period of time, army units (mainly ABH services) performed radiological (R) reconnaissance of the contaminated areas. After reviewing the consequences, preparations were made for the subsequent elimination of the consequences of the application of DUA with a focus on radiological decontamination.

The paper aims to show the way of realization of these tasks, the problems that the Army units encountered, but also to highlight the successes that have been achieved in the remediation of the areas contaminated with DUA. The Serbian Army (YA, AS, and MN) is the first to completely remediate the consequences of the use of DUA in the world, especially in the segment of radiological decontamination. (Inđić & Filipović, 2018, pp.259-281)

Basic characteristics of depleted uranium

As already mentioned, uranium (U, lat. Uranium) is a chemical element from the group A actinoids of group III B. Among the elements that occur naturally on Earth, it has the largest atomic number a (92) and it is weakly radioactive. Natural uranium occurs in the form of 3 isotopes: ^{238}U (99.284%), ^{235}U (0.711%) and slightly ^{234}U (0.0058%). The isotope ^{235}U undergoes spontaneous nuclear separation under the influence of thermal neutrons. The isotope ^{238}U receives neutrons, as a result of which it is converted into ^{239}Pu (plutonium). Also, the artificial isotope ^{233}U separates the nucleus, and is obtained by bombarding ^{232}torium with neutrons. (Meija et al, 2016, pp.265-291)

Uranium is a relatively soft, silvery-light metal of high density. It occurs in three allotropic modifications, Table 1 (Binder, 1999, pp.674-682).

Powdered uranium is self-igniting. Most acids dissolve uranium in a metallic form, while bases do not "attack" it. On exposure to air, a layer of oxide is formed on the surface of uranium metal, which protects it from further oxidation. (Brauer, 1975, p.1195)

Uranium builds a whole series of compounds in which it can be in states from +2 to +6. The color of the uranium complex, as a rule, strongly depends on the oxidation number, but also on the ligand in the

environment. The following combinations of color and oxidation state most often occur in aqueous solutions, as well as in solid compounds: U^{3+} (purple), U^{4+} (green), $U^VO_2^+$ (pink), and $U^{VI}O_2^{2+}$ (yellow). (Holleman et al, 2007)

Table 1 - Modifications of uranium at atmospheric pressure
Таблица 1 - Модификации урана при атмосферном давлении
Табела 1 – Модификације уранијума при атмосферском притиску

Phase	Stable temperature range	Crystal system
α- uranium	to the 688 °C	orthorhombic (a=285.4 pm, b=586.9 pm, c=495.6 pm)
β- uranium	between 688 °C and 776 °C	tetragonal (a=1075.9 pm, c=565.6 pm)
γ- uranium	above 776 °C	cubic (a=352.5 pm)

Uranium is present in the form of chemical compounds in the amount of 2.4 ppm in the nature. It can be found in rocks, water, plants, animals, and even in the human body. It also occurs in larger quantities in minerals, the most important of which are:
- uranium U_3O_8 and
- $K_2(UO_2)_2(VO_4)_2 \cdot 2H_2O$.

Uranium is an extremely toxic element, very similar to mercury and arsenic. The degree of toxicity depends on the chemical composition and solubility of the compound it forms. Toxicity depends, among other things, on their solubility. Easily soluble salts of uranium are the most toxic, while sparingly soluble oxides are less toxic. Uranium is teratogenic, i.e. causes deformities and / or damage to the fetus in the womb. The most toxic are compounds in which uranium is hexavalent. Uranium is at the same time a radioactive element, so that it has a harmful effect on the organism by alpha-gamma emission.

Humans can be contaminated with uranium during all phases of exploitation, processing and use in several ways:
- by inhalation (via the respiratory system),
- ingestion (via food and water, through the digestive system), and
- through the skin, both healthy and damaged (wound) or diseased.

Regardless of the route of contamination, the ingested uranium binds to proteins, bicarbonates and erythrocyte membranes (red blood cells) in the blood. Only an hour later, 95% of the matured uranium

disappears from the blood, out of which over 50% is excreted through the kidneys and urinary tract. The remaining uranium is deposited in the body. As we can see, the most important way to eliminate uranium from the body is through the kidneys and urinary tract.

Depleted uranium concentrations can be determined by several methods:

1. gamma spectrometric method,
2. alpha spectrometry,
3. alpha radiometry,
4. atomic absorption spectrometry, with a flame detector, and
5. neutron activation analysis using gamma spectrometry.

All methods except the gamma spectrometric analysis require a very complicated sample preparation or are very expensive. The gamma spectrometric analysis enables a very simple sample preparation which requires only its homogenization. This method can be used to analyze all types of samples: soil, vegetation, water, air, food, and urine. The sensitivity of the method is 80 μg. (Đurić & Popović, 2000, pp.50-52)

If an increased degree of radioactive contamination (above 0.5 μGy/h) has been determined in a certain area, the area should be marked with a contaminated soil marking kit (CSM kit) or hand tools and samples should be taken for analysis. Samples are taken from the place where the greatest contamination was determined and from the place of the outer borders of the marked contaminated area, i.e. from 3 to 5 places. All samples should weigh about 1.5 kg. Sampling is realized as follows:

1. Soil - it is necessary to take two samples, individual masses of about 1.5 kg:

Sample I: the surface layer of vegetation or soil with an area of 1 m^2.

Sample II: another sample of the soil layer is taken from the same surface to a depth of 2 cm. (Serbian Armed Forces - General Staff, 2000, pp.14-15)

2. Water - it is necessary to take 40 l of previously turbid water.

3. Air sample is taken by special devices (e.g. chemical detectors), through a cellulose-asbestos filter (the sample is the filter itself). The aerosol sample is taken as soon as possible and as close as possible to the place of explosion, and it can be taken later in the period of up to 2 weeks from the moment of strike.

4. Food sample of plant and animal origin is taken in the amount of about 1.5kg, taking into account the volume.

5. Urine - the exposed person collects a 24-hour urine sample in a special container.

6. Parts of the projectile - due to the large specific weight of the material from which the projectile was made and the required geometry of measurement, it is necessary to take several smaller pieces, with a total weight of about 1.5 kg.

All samples should be:
- packed in PVC bags or containers (which have been checked for contamination),
- closed and marked well (date and place of the sampling, date of strike, quantity, who took the sample, etc.), and
- submitted to the competent institution for analysis, with the necessary supporting documentation which is adequately completed.

The main application of uranium is the use of its ^{235}U isotopes as a material for the production of nuclear bombs, nuclear reactors in nuclear power plants, as well as for the launch of submarines.
Other applications of uranium:
• used for painting ceramics, but no longer used due to its radiation;
• ^{238}U is converted to plutonium in atomic reactors;
• uranium metal is used as a shield in X-ray generators due to its large atomic mass;
• also used in photography and chemical analyses.

Natural uranium has three isotopes (^{234}U (0.006%), ^{235}U (0.71%), and ^{238}U (99.28%)) but only ^{235}U (as a natural nuclear fuel) is important for nuclear energy, while its content does not fall below 0.2-0.3 %. When this happens, it is called depleted uranium ^{235}U (depleted as a nuclear fuel, but not harmless from the aspect of protecting the human population). It occurs most often:
• as a by-product of the process of enrichment of natural uranium for the needs of nuclear reactors and nuclear weapons (^{238}U) and
• when extracting plutonium from the spent fuel of nuclear reactors.

Due to its characteristics of action: high mechanical (penetrating) effect, high temperature when hitting an object (pyrogenic effect), and consequences on people (radiological effect), depleted uranium began to be used by the NATO alliance in almost all armed conflicts after 1990 (Iraq, Republic of Srpska (Bosnia & Herzegovina), Republic of Serbia, Libya, Somalia, Haiti, etc.).

The following calibers of this type of ammunition are most often used for military purposes (Figure 1):
- 25 mm (BVP M2A2 and M3A3 Bradley - 85 g),
- 30 mm (aircraft A-10 Thunderbolt II - 298 g),
- 105 mm (tank Abrams M1, Leopard - from 2200 to 3700 g), 120 mm (tank Abrams M1A2, Leclerc, Challenger - 5 kg). (Serbian Armed Forces - General Staff, 2000, pp.25)

Figure 1 – Means for the application of DUA: A-10 Thunderbolt II aircraft and tank Abrams M1A2
Рисунок 1 – Средства для применения БОУ: авиация A-10 Thunderbolt II и танк Abrams M1A2
Слика 1 – Средства за примену МОУ: ваздухоплов A-10 Thunderbolt II и тенк Abrams M1A2

Certainly, the biggest problem for people when coming into contact with this type of illicit weapon (in addition to inhaling uranium oxide) is the delayed effect of DUA, and the consequences can be felt even after a few years.

Reconnaissance of the areas contaminated with depleted uranium ammunition

In the introduction, it was mentioned that the territory of the Republic of Serbia (without AP KiM) was targeted with DUA at 4 locations, namely: Pljačkovica (near Vranje), Borovac (near Bujanovac), Bratoselce, and Reljan (near Preševo), Figure 2. (Inđić, 2018, p.143)
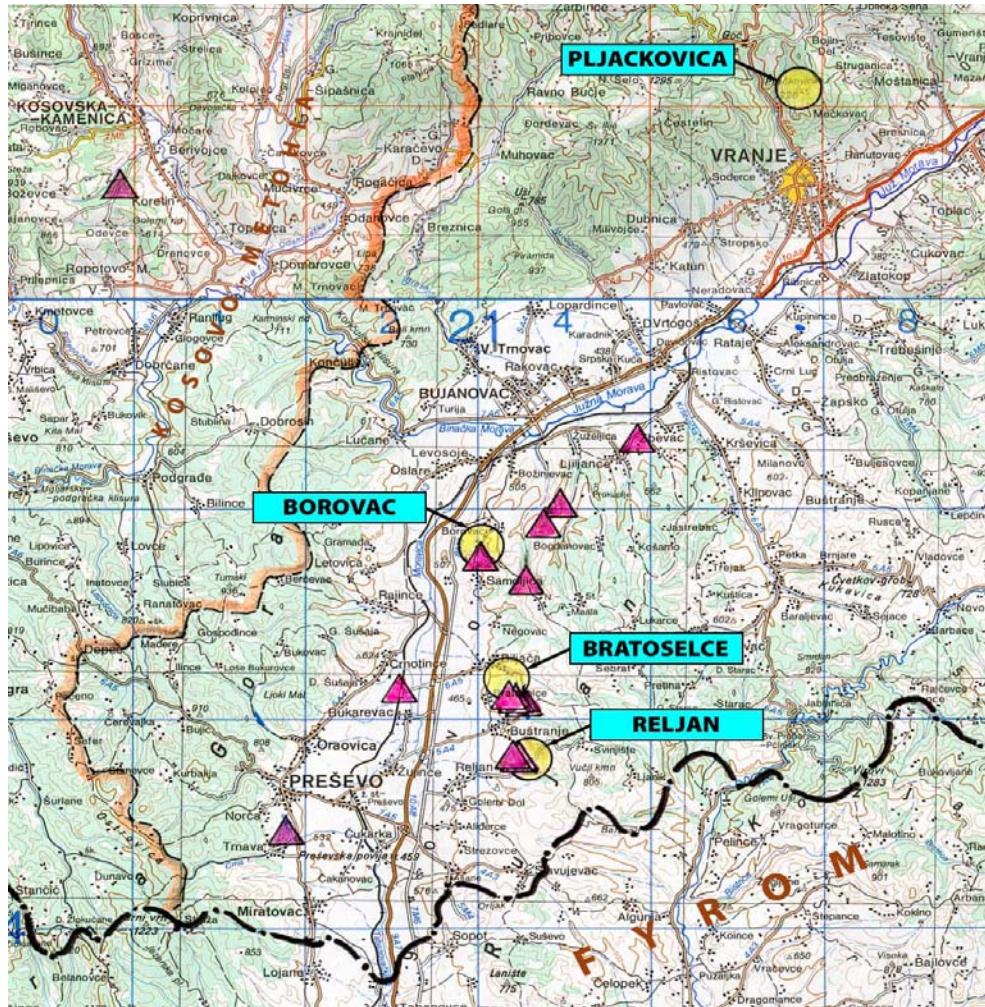
*Figure 2 – Areas contaminated with depleted uranium ammunition in the area of
R. Serbia (without AP Kosovo and Metohija) during the 1999 NATO aggression
Рисунок 2 – _ Зоны, пораженные боеприпасами с обедненным ураном в районе
Р. Сербия (без АК Косово и Метохия) во время агрессии НАТО в 1999 г.
Слика 2 – Рејони контаминирани муницијом са осиромашеним уранијумом на
подручју Р. Србије (без АП КиМ) током НАТО агресије 1999. године*

Units of the ABHO (then the Yugoslav Army) performed a radiological survey of the mentioned areas and marked the contaminated ground for the purpose of later remediation of the consequences. On that occasion, the following was established at the above locations:

• Location 1 - "Pljačkovica", contaminated area: about 2500 m^2, radioactivity: from 5500 to 235000 Bq / kg (Figure 3),

• Location 2 - "Borovac", contaminated area: approx 1500 m^2, radioactivity: over 250 Bq / kg (Figure 4),

• Location 3 - "Bratoselce", contaminated area: about 5500 m^2, radioactivity: from 1800 to 23400 Bq / kg (Figure 5), and

• Location 4 - "Reljan", contaminated area: about 6800 m^2, radioactivity: over 200 Bq / kg (Figure 6).

Figure 3 – Location 1 "Pljačkovica"
Рисунок 3 – Локация 1 «Плячковица»
Слика 3 – Локација 1 – „Пљачковица"

Figure 4 – Location 2 "Borovac"
Рисунок 4 – Локация 2 «Боровац»
Слика 4 – Локација 2 – „Боровац"

Figure 5 – Location 3 "Bratoselce"
Рисунок 5 – Локация 3 «Братоселце»
Слика 5 – Локација 3 – „Братоселце"

Figure 6 – Location 4 "Reljan"
Рисунок 6 – Локация 4 «Релян»
Слика 6 – Локација – 4 „Рељан"

The radiological reconnaissance was performed in accordance with the then valid rules and instructions of the ABHO units, and after the experiences gained on that occasion, the appropriate tactical actions of the ABHO units were changed and a new Instruction was issued.

For the radiological reconnaissance (R reconnaissance) of a location of DUA strikes, a group (reconnaissance body) is formed, consisting

generally of: radiological reconnaissance scout and group commander at the same time; chemical reconnaissance scout; explosive technician; physician, and reconnaissance vehicle driver. The equipment for R reconnaissance includes calibrated detectors of the type of radioactive contamination meter (RCM M-87), detector from the radiometric laboratory M2 (KOMO-TM), and general purpose radioactive radiation detector (GPRRD) or radiological detector (RD-M3). The detector probe window (KOMO-TM, RD-M3) must be open. RCM and GPRRD detectors must be protected by a plastic bag secured with an adhesive tape (rubber band). (Serbian Armed Forces - General Staff, 2014, pp.48-50)

For chemical reconnaissance (X reconnaissance), manual and semi-automatic chemical detectors should be provided, which in addition to formation detectors must also have indicator tubes (IT) for qualitative detection and quantitative determination of toxic gases produced as a product of explosives combustion (CO_2, CO, NOx, HCN).

A shovel, a sampling set (KUM-1), plastic bags or sacks, metal containers with lids (so that they can hold a minimum of 1.5 kg of samples) and labels for marking samples are carried for sampling. A set of vehicle decontamination equipment (VDE) or a group decontamination device (GDD), and personal decontamination equipment (PDE M-3) are carried in case decontamination is needed. It is important to note that the physician must have medical supplies to provide for first aid for injuries from explosives and toxic chemicals (TC).

After receiving the order and preparing the equipment, the reconnaissance body puts the protective equipment in the preparatory mode and starts the reconnaissance. During the movement to the area of DUA action, the natural background of gamma radiation is occasionally controlled (from the vehicle). (Inđić, 2018, pp.141-144)

Upon arrival in the wider area of operation, the radiological reconnaissance scout turns on the KOMO-TM, while keeping the RCM M-87 in a pouch on a belt placed over the protective suit, and the chemical reconnaissance scout turns on the semi-automatic chemical detector (SACD) with a formation IT and prepares a hand-held chemical detector with a specific IT. About 300 m from the DUA strike site, the vehicle stops. Upon exiting the vehicle, the scouts put protective equipment in a protective position. The scout for R reconnaissance, at a distance of 10m from the vehicle, controls the natural background of gamma radiation and the degree of soil contamination. The control is repeated in several places around the crater of the explosion, i.e. the place of DUA strike (in each place, 3 measurements are carried out and

the mean value is taken), Figures 7 and 8. (Serbian Armed Forces - General Staff, 2014, pp.48-50)

Figure 7 – Radiological reconnaissance of the place of DUA strike
Рисунок 7 – Изображение радиологической разведки участки БОУ
Слика 7 – Приказ радиолошког извиђања места дејства МОУ

Figure 8 – Measurement of the radioactive contamination of DUA samples on the ground
Рисунок 8 – Измерение радиоактивного загрязнения образцов БОУ на почве
Слика 8 – Мерење радиоактивне контаминације узорака МОУ на земљишту

During R reconnaissance, special attention must be paid to the altitude and the location where the measurements are performed,

because the natural background of radioactive radiation can be 5 to 10 times higher than the average value for the territory of R. Serbia, which is about 0.1 μGy/h. After that, the degree of contamination is measured with the radiological device KOMO-TM (or RD-M3) with an open probe (the scout lowers the cable with the probe next to the foot, taking care not to touch the grass and other plants).

If there is a significant deviation from the typical natural background (deviation values greater than 0.5 μGy / h), from that point the scout for X reconnaissance takes soil samples as follows:

• first, the layer of vegetation is removed from the surface of 1 m^2 with an ax and thus the first sample is formed;

• another sample is taken from the same surface by removing soil about 2 cm deep.

The mass of each sample must be up to 1.5 kg, and soil samples are taken from the place where the greatest contamination was determined (3 to 5 places). Air sampling is taken with a special device (chemical detector) and filtering through a cellulose-asbestos filter with a minimum of 100 m^3 of air. The area in which the increased degree of radioactive contamination was determined is marked with a set of CSM. The value of radiation taken as the limit of the contamination area is 0.5 μGy/h. (Serbian Armed Forces - General Staff, 2014, pp.48-50)

The scout for X reconnaissance controls the presence of TC with the help of SACD, and determines a possible presence and concentration of other toxic substances with a hand-held chemical detector (Figure 9).

Figure 9 – Method of detection of toxic chemicals
Рисунок 9 – Метод обнаружения токсичных химикатов
Слика 9 – Начин детекције отровних хемијских супстанци

After the R and H reconnaissance of the areas contaminated with DUA, it was possible to eliminate the consequences with a focus on radiological decontamination.

Two important facts must be stated here:

• first, during the R and X reconnaissance, the DUA effects on the flora and fauna in the contaminated areas were not considered, which is of exceptional importance from the aspect of complete protection (humans, flora and fauna, as well as the environment), and

• second, several years passed from the moment of the reconnaissance of the areas contaminated with DUA to the moment of the remediation or radiological decontamination of the area (3 to 8 years).

Decontamination of the areas contaminated with depleted uranium ammunition

Starting in 2001, with the adoption of the then unique algorithm of work on decontamination of areas contaminated with depleted uranium ammunition, the remediation work began as follows:

• Cape "Arza" in R. Montenegro, remediated in 2001 and 2002,
• location "Bratoselce", remediated in 2002 and 2003,
• location "Pljačkovica", remediated in 2004,
• two locations in the area of "Borovac", remediated in 2005, and
• location "Reljan", remediated in 2006 and 2007.

The manner in which the remediation i.e. decontamination of the areas contaminated with DUA was performed will be shown on the example of the "Bratoselce" area. The Proposal of CGS YA to the President of the State and the Prime Minister of the Republic of Serbia for the permanent solution of the remediation of contaminated areas (at the beginning of 2002) preceded the creation of the Contaminated Soil Remediation Project at the "Bratoselce" location and its submission to the then Federal Government for adoption.

After the adoption of the project, the realization started with the participation of units and institutions of the then AS and MN and members of the Institute of Nuclear Sciences "Vinca" (INS "Vinca"). The project was managed by an expert team: three members from AS and MN and three members from the INS "Vinca". The engagement in the implementation of this activity was as follows:

• ABHO SA Management (project implementation management);
• ABHO SA units (performing R decontamination);

• INS "Vinča" (professional assistance and participation in R decontamination);

• MMA (medical supervision and examination of personnel);

• Engineering units (communication and R decontamination assistance);

• other AS and MN units (security and logistics).

The dosimetric control of the contaminated area began in mid-September 2002 with the aim of:

• finding depleted uranium ammunition,

• removal of DUA and contaminated soil and their disposal in the special facilities of INS "Vinča",

• removal of fences and danger signs and return of land to its original purpose.

The efficiency of detection and decontamination was influenced by the following factors:

• knowledge of microlocation (traces of strikes after three years were not noticeable);

• soil characteristics - increased concentration of natural uranium and geological composition made it difficult to detect and decontaminate (projectiles were detected at depths of 50 to 100 cm);

• characteristics of the measuring equipment – it was mainly domestic equipment, because the procurement of foreign equipment was very difficult (as a whole, domestic equipment showed satisfactory results);

• detection methods - radiological search of the surface part by sectors (very difficult due to low surface contamination), removal of the surface layer and re-detection and finally digging of characteristic sections to a depth of 1 m.

The decontamination works began with the arrangement and preparation of the area of works and the organization of security. The following were engaged in the realization of the task: the working team for work on decontamination (professional members of ABHO and the Military Academy, as well as the experts from the INS "Vinca") and the unit for security and logistics (from the ABHO unit then AS and MN).

The working team worked in three groups:

• clearing group,

• dosimetric examination group, and

• penetrator removal group.

With this work organization, a probability of finding contamination was higher than 90% and a possibility of "failure" in finding and extracting depleted uranium projectiles was almost certainly ruled out.

For more efficient work on the decontamination of DUA contaminated areas, the members of engineering units also participated with engineering machines in field preparation (construction of access communications) and R decontamination (removal of the upper layer of contaminated soil), Figure 10.

Figure 10 – Soil decontamination using engineering machines
Рисунок 10 – Обеззараживание почвы инженерными машинами
Слика 10 – Деконтаминација земљишта употребом инжињеријских машина

Due to a large volume of work and unfavorable weather conditions, the works had to be stopped at the end of 2002 and continued in the spring of 2003 (Figure 11), when the area of the village of Bratoselce was completely decontaminated from depleted uranium.

ЛЕГЕНДА:
- Извршена дозиметријска претрага
- Површина чиста, без контаминација
- Површина прекопана до дубине од 1 m и деконтаминирана
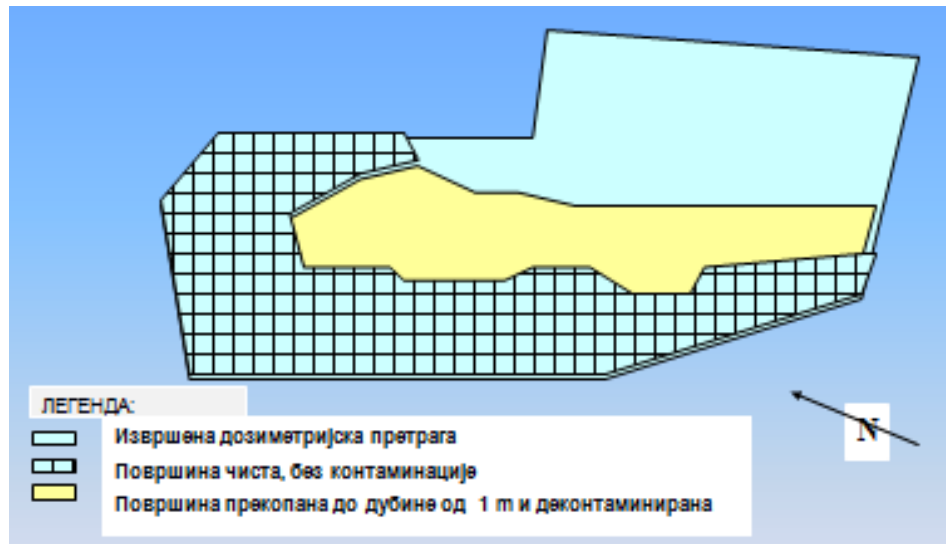
CAPTION:

- Dosimetry applied
- Clean surface, without contamination
- Surface layer removed up to the depth of 1m and decontaminated

ПОЯСНЕНИЕ:

- Произведены дозиметрические исследования
- Участок чист, контаминации нет
- Участок был раскопан и обезврежен до 1 м вглубь

Figure 11 – Scheme of the contaminated land in the village of Bratoselce
Рисунок 11 – Схема загрязненной почвы в деревне Братоселце
Слика 11 – Шема контаминираног земљишта у селу Братоселце

The results and experiences in the remediation of the consequences of the DUA use in the area of the village of Bratoselce can be presented as follows:

• complete decontamination of the contaminated soil (area of 54 ares) was performed;

• over 320 penetrators and more than 300 shells from depleted uranium projectiles were found (the largest number at a depth of 50 to 100 cm);

• about three tons of contaminated soil were collected;

• parts of DUA and contaminated soil were deposited in the special warehouse of the INS "Vinča";

• Members of the army achieved high competency by applying the experience from the decontamination of Cape Arza in R. Montenegro;

• measuring instruments of domestic production were used (KOMO-TM, RCM, SACD, etc.);

• due to the acquired experiences and characteristics of the soil, the following tasks were realized much faster (remediation of the Pljačkovica region near Vranje, Borovac near Bujanovac and the Reljan region near Preševo).

After performing gamma spectrometric analyzes on 25 samples taken from the area of the village of Bratoselce, it was proven that the site was completely decontaminated, i.e. the effects of depleted uranium were remediated according to the requirements of the construction project.

Once again, it must be pointed out that more than three years passed from the moment of DUA strikes to the decontamination of the area, which could have resulted in the pollution of the flora and fauna as well as the environment at the said location.

Conclusion

The use of depleted uranium ammunition by the NATO countries has led to serious consequences for people and the environment in the countries targeted by this type of prohibited weapon. The goal of using this type of weapon, in addition to the military one, is certainly to solve the problem of radioactive waste in the NATO countries that possess it, especially when the half-life of uranium (about 4.5 billion years) is taken into account.

Even after several decades of the application of DUA in the area of the Republic of Serbia, conclusions are drawn about the scope and severity of the consequences of its application. To that end, in 2018, the Assembly of the Republic of Serbia formed a Commission to investigate the consequences of the NATO bombing in 1999 on the health of citizens and the environment (Čekerevac, 2018). The task of the commission, among other things, is to determine the negative effects of toxic chemical substances in the destroyed facilities of the process industry ("Petrohemija" and "Azotara" Pancevo, facilities of the oil industry of

Serbia, facilities of military industry in Baric, Lucani, Kragujevac and many others) south R. Serbia, etc. (Inđić, 2012, pp.288-307)

Faced with the problem of a new type of weapon, the units of the Serbian Army (YA, AS and MN) decisively and bravely chose the optimal method of implementation, first radiological reconnaissance, and later radiological decontamination of the areas contaminated with depleted uranium. The competent institutions of the Republic of Serbia, such as the INS "Vinča", the MMA and others, provided them with great help in the realization of the mentioned tasks.

Certain problems that arose during the implementation of the remediation of the areas contaminated with DUA were:

• delayed effect of DUA (radiological decontamination was realized much later than the use of DUA);

• soil characteristics - increased concentration of natural uranium and geological composition made detection and decontamination difficult (projectiles were detected at depths over 50 cm);

• characteristics of the measuring equipment - mainly domestic equipment was used (which showed good results);

• detection methods - radiological search of the surface area by sectors (very difficult due to low surface contamination);

• work for a longer period of time with protective equipment in a protective position (so radiological decontamination was mostly realized in late autumn or early spring);

• insufficient experience in working on remediation of DUA consequences, etc.

Despite the mentioned problems, the units of the army, together with competent state institutions, successfully realized the remediation of the areas contaminated with depleted uranium on the entire territory of the Republic of Serbia (without the autonomous province of Kosovo and Metohija). It must be especially emphasized that the Army of Serbia (YA, AS and MN) was the first in the world to completely perform radiological decontamination of areas contaminated with depleted uranium ammunition, without the help of other countries.

The experience gained at that time served for further improvement of tactical actions and procedures of ABH service units in eliminating the consequences of the use of radiological weapons, as well as for training in eliminating the consequences of nuclear and chemical accidents in peacetime. (Inđić et al, 2015, pp.215-239)

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ВОССТАНОВЛЕНИЕ МЕСТНОСТИ, ПОРАЖЕННОЙ СНАРЯДАМИ С ОБЕДНЕННЫМ УРАНОМ

Деян Р. Инджич

Университет обороны в г. Белград, Военная академия, кафедра тактики, г. Белград, Республика Сербия

Резюме:

Введение/цель: Последствия агрессии НАТО против Республики Сербия в 1999 году (в то время входившей в состав Союзной Республики Югославия) рассматриваются до сих пор. Особое внимание посвящено вопросу применения запрещенных средств, таких как: кассетные и графитовые бомбы, боеприпасы с обедненным ураном (БОУ) и пр. Безусловно, что применение обедненного урана как вида оружия массового поражения (радиологического оружия) находится в центре общественного внимания. Несмотря на то, что количество используемого БОУ и последствия от их применения до сих пор не утверждены (хотя и прошло 20 лет), можно с уверенностью сказать, что их применение вызвало определенные побочные эффекты. Подразделения Югославской армии являлись главной мишенью данных снарядов и, безусловно, именно у армии выявлено наибольшее количество негативных последствий. Однако снарядами БОУ также были поражены объекты инфраструктуры, базовые станции, телевизионные башни и сельскохозяйственные угодья.

Методы: В работе применялись специальные научные методы (в основном методы анализа и синтеза) и эмпирические методы (метод контент-анализа и метод наблюдения).

Результаты: В статье проведен анализ последствий воздействия БОУ на население, материальное имущество и разрушение окружающей среды, а также рассмотрены возможные направления дальнейшей работы в данной области.

Выводы: В статье представлены результаты радиологической разведки и радиологического обезвреживания пораженной БОУ местности, которые были выполнены подразделениями РХБ (тогда РХБЗ) с помощью других подразделений и служб сербской армии, а также государственных учреждений Республики Сербия (НИИ «Винча», ВМА и пр.).

Ключевые слова: уран, боеприпасы с обедненным ураном, войска РХБ, разведка, обезвреживание.

САНАЦИЈА ПОДРУЧЈА КОНТАМИНИРАНИХ МУНИЦИЈОМ СА ОСИРОМАШЕНИМ УРАНИЈУМОМ

Дејан Р. Инђић

Универзитет одбране у Београду, Војна академија, Катедра тактике,
Београд, Република Србија

Сажетак:

Увод/циљ: Последице НАТО агресије на Републику Србију (тада у саставу СР Југославије) 1999. године још увек се разматрају, посебно са аспекта употребе недозвољених средстава, попут касетних и графитних бомби, муниције са осиромашеним уранијумом (МОУ) и др. Свакако да је употреба осиромашеног уранијума, као једне врсте оружја за масовно уништавање (радиолошко оружје), највише у фокусу интересовања јавности. Количина коришћене МОУ и последице њене употребе још увек (и после 20 година) нису у потпуности доказане, али се са сигурношћу може рећи да је она проузроковала одређене нежељене ефекте. Тадашње јединице Војске Југославије биле су главни циљ дејства овом врстом муниције, па су претрпеле и највеће последице. Међутим, дејством МОУ гађани су и објекти инфраструктуре, базне станице, телевизијски предајници и пољопривредно земљиште.

Методе: У раду су коришћене посебне научне методе (тежишно метода анализе и синтезе) и емпиријске методе (метода анализе садржаја и метода посматрања).

Резултати: Сагледане су последице дејства МОУ на људе, материјална добра и деградирање животне средине, као и правци даљег рада у овој области.

Закључак: Приказани су резултати радиолошког извиђања и радиолошке деконтаминације подручја контаминираних МОУ, које су реализовале јединице АБХ службе (тада рода АБХО) уз помоћ осталих родова и служби Војске Србије, као и институција Републике Србије (ИНН „Винча", ВМА и др.).

Кључне речи: уранијум, муниција са осиромашеним уранијумом, АБХ служба, извиђање, деконтаминација.

251

Анализа: најмодерније самоходне хаубице точкаши[1]

Веб сајт *Army Recognition* представља анализу најмодернијих самоходних хаубица точкаша у конфигурацији 6x6 које су у оперативној употреби или су спремне за серијску производњу. Самоходна хаубица је артиљеријски оружани систем опремљен својим погоном. Основна предност оваквог артиљеријског система у односу на вучну артиљерију је у брзини употребе. Данас постоје три основне врсте мобилних артиљеријских система које укључују вучну хаубицу, самоходну хаубицу на бази оклопног возила гусеничара и самоходну хаубицу на шасији војног камиона или точкаша у конфигурацији 8x8 или 6x6.

Анализа најмодернијих самоходних хаубица у конфигурацији 6x6

Које су разлике између самоходних хаубица гусеничара и точкаша?

Самоходна хаубица гусеничар је тежа и омогућава употребу хаубичких оруђа већег калибра које постижу веће домете и већи експлозивни ефекат. Овакво артиљерисјко оруђе је оклопљено и пружа већу заштиту посади

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[1] World defence news 08 September 2020

против ватре пешадијског наоружања и артиљеријских гелера. Гусеничари су покретљивији у блату и снегу.

Самоходна хаубица точкаш поседује неке елементе самоходне хаубице гусеничара, али је много лакша. Мобилнија је и лакше се транспортује војним транспортним авионима. Могу је користити снаге за брзо реаговање које имају потребу за артиљеријском подршком.

Самоходна хаубица точкаш CAESAR 155mm 6x6 (Фото: Army Recongition)

Caesar – Француска

CAESAR (CAmion Equipe d'un Système d'Artillerie – артиљеријски систем на камиону) јесте самоходна хаубица 155 мм са цеви дужине 52 калибра, коју је пројектовала француска компанија Nexter Systems. Прва верзија система CAESAR била је монтирана на шасију камиона Mercedes-Benz Unimog U2450L у кофигурацији 6x6 и продата је клијенту на Средњем истоку. Најновија верзија базирана је на шасији возила Renault Sherpa у конфигурацији 6x6 са додатно оклопљеном кабином. Сам хаубички систем може бити монтиран и на друге камионске шасије по захтеву купца. Овај самоходни артиљеријски систем носи 18 граната и обично га опслужује пет чланова посаде. Међутим, уколико је потребно, систем CAESAR могу опслуживати само три члана посаде, а преносив је транспортним авионима типа C-130 или A400M. Радијус дејства је 42 км гранатама продуженог домета типа Extended Range, Full Bore (ERFB), и преко 50 км гранатама потпомогнутим ракетним мотором. CAESAR поседује потпуно интегрисан компјутеризован систем за управљање ватром који обезбеђује висок степен аутоматизације.

Технички подаци

Наоружање: хаубица 155мм/52 калибра и један митраљез у калибру 7,62 или 12,7 мм.

Домет хаубице: стандардна муниција: 19 до 40 км, продужени домет: 40 км, граната потпомогнута ракетним мотором: 55 км, директно гађање: 2 км.

Маса: Мање од 18.000 кг

Димензије: дужина: 9,94 м, ширина: 2,55 м, висина: 3,2 м.

Archer – Шведска

Самоходна хаубица Archer 155mm у конфигурацији 6x6

Самоходна хаубица Archer опремљена је артиљеријским оруђем 155мм FH77 који су пројектовале и произвеле компаније Bofors и BAE Systems. Хаубица има домет до 40 км када испаљује стандардну муницију и 60 км када користи муницију M982 Excalibur. Такође, испаљује пројектиле за напад на врх мете (Bonus top attack rounds) које су пројектовале компаније Bofors и Giat (сада Nexter). Возило је Volvo A30D у конфигурацији 6×6. Кабина и моторни део су потпуно оклопљени, а прозори су такође непробојни за пешадијску муницију и гелере. Возило носи 21 гранату 155 мм у аутоматском пуњачу. Поновно пуњење овог пуњача, помоћу уграђене наменске справе, траје до 10 минута. Домет са гранатама *BAE Bofors/Nexter Bonus* износи 35 км, а са прецизном навођеном муницијом *Raytheon/Bofors XM982 Excalibur* до 60 км.

Технички подаци

Наоружање: хаубица 155мм/52 калибра.

Домет хаубице: стандардном муницијом: 35 км; продужени домет: 60 км прецизном навођеном муницијом   *Raytheon/Bofors XM982 Excalibur*; гранатом потпомогнутом ракетним мотором: 55 км; директно гађање: 2 км.

Маса: 30.000 кг.

Димензије: дужина: 14,1 м, ширина: 3 м, висина: 4 м.

Atmos – Израел

ATMOS самоходна хаубица точкаш са хаубицом Soltam Systems 155mm/52 (Фото: Army Recongition)

ATMOS је самоходна хаубица точкаш са хаубицом Soltam Systems 155mm/52 towed TIG 2000 system. Систем ATMOS развила је израелска компанија Soltam Systems као приватни пројекат. Артиљеријски систем је монтиран на камионској шасији у конфигурацији 6x6. Хаубичке системе покреће хидраулични уређај. Хаубица има цев калибра 155 мм, дужине 52 калибра. Максимални домет до 41 км постиже се гранатом типа Extended Range Full-Bore – Base Bleed (ERFB-BB). Домет до 30 км постиже се гранатом L15 High Explosive (HE), а домет до 24,5 км старијим пројектилом M107 HE. ATMOS 2000 носи до 27 граната 155 мм, а посаду чине четири члана посаде, од којих су два пуниоца који се налазе један наспрам другог са стране колевке хаубице. Систем омогућава каденцу ватре између 4 и 9 граната у минуту.

Технички подаци

Наоружање: хаубица 155мм/52 калибра.

Домет хаубице: до 41 км гранатом типа *ERFB-BB* до 35 км гранатом типа *L15 High Explosive*, до 24,5 км гранатом типа *M107 HE.*

Маса: 22.000 кг.

Димензије: дужина: 9,5 м, ширина: 2,5 м, висина: нема податка.

Bohdana 2S22 – Украјина

Bohdana 2S22 155mm у конфигурацији 6x6

Bohdana 2S22 је самоходна хаубица 155 мм развијена у Украјини. Налази се на шасији камиона *KrAZ-6322* у конфигурацији 6×6. Поседује оклопљену кабину и довољно простора за складиштење до 20 граната. Хаубица има максимални домет до 40 км, док минимални домет износи 780 м. Максимални домет постиже муницијом HE/AP потпомогнутом ракетним мотором. Просечно испаљује до 5 граната у минуту.

Технички подаци

Наоружање: хаубица 155 мм.

Домет хаубице: 35 до 41 км гранатом типа *HEIAP*, 45 до 60 км гранатом типа RAP.

Маса: 28.000 кг.

Димензије: нема података.

Brutus – САД

Brutus је самоходна хибридна хаубица меког трзаја коју су заједнички развиле америчке компаније *AM General* и *Mandus Group*. Опремљена је истом хаубицом као и систем *M777,* али са хидрауличним умањивачем трзаја ради монтирања на средње камионске шасије *FMTV (Family of Medium Tactical Vehicles truck)*. *Brutus* 155mm је монтиран на шасију петотонског камиона *M1083* са спољним стабилизаторима. Иначе, серија камиона *FMTV* спада у стандардне тактичке камионе америчке војске. Самоходна хаубица погађа мете на даљинама до 24,7 км стандарном муницијом и постиже даљине гађања до 30 км муницијом потпомогнутом ракетним моторима. Користи све гранате компатибилне са топом *M777*.

257

Самоходна хаубица Brutus AM General 155mm у конфигурацији 6x6

Технички подаци

Наоружање: хаубица *M 777* са стандардном муницијом 30 км, до 30 км муницијом потпомогнутом ракетним моторима.

Маса: 13.435 кг.

Димензије: дужина: 7,6 м, ширина: 2,44 м, висина: 3,5 м.

D-30 Ural 4320-1911-30 – Египат

Током децембра 2018. године, на изложби наоружања *EDEX* у Египту, локални произвођач је приказао нови артиљеријски систем – вучну хаубицу *D-30 122mm* монтирану на камион *Ural 4320-1911-30* у конфигурацији 6x6 са ојачаном шасијом и хидрауличним стабилизаторима. Возило је први пут приказано 3. маја 2016. године за време војних вежби египатских оружаних снага. *D-30 122mm* је совјетска хаубица која је ушла у оперативну употребу током шездесетих година. Ради се о робустном оружју које се може користити у свим условима. Хаубица има максимални домет до 15,4 км и преко 21 км муницијом потпомогнутом ракетним мотором.

Технички подаци

Наоружање: хаубица 122 мм.

Домет хаубице: 15,4 км стандардном муницијом, 21 км муницијом потпомогнутом ракетним моторима.

Маса: нема података.

Димензије: нема података.

Самоходна хаубица D-30 122mm Ural 4320-1911-30 у конфигурацији 6x6 (Фото: Army Recongition)

D-30 на камиону Mercedes Zetros 2733A – Алжир

Алжир је пројектовао нову самоходну хаубицу у конфигурацији 6x6 по угледу на совјетску вучну хаубицу *D-30 12mm* монтирану на измењену камионску шасију *Mercedes-Benz Zetros 2733a*. Камион *Mercedes-Benz Zetros* је теренски камион за операције у екстремним условима. Први пут је приказан током 2008. године на изложби наоружања *Eurosatory* у Паризу. Камион се производи у Мерцедесовој фабрици у Немачкој. Компатибилан је са транспортним камионом *Hercules C-130* и одговара стандардним немачким железничким вагонима. Хаубица има максимални домет до 15,4 км и до 21,9 км кинеском муницијом потпомогнутом ракетним мотором.

Технички подаци

Наоружање: хаубица 122 мм.

Домет хаубице: 15,4 км стандардном муницијом, 21 км муницијом потпомогнутом ракетним моторима.

Маса: нема податка.

Димензије: дужина: 6,2 м, ширина: 2,45, висина: нема податка.

D-30 на камиону Mercedes Zetros 2733A – Алжир

EVA – Словачка

EVA 155mm у конфигурацији 6x6 (Фото: Army Recongition)

EVA је словачка самоходна хаубица у конфигурацији 6x6, компаније *Konstrukta Defence* и први пут је приказана 2015. године. Базирана је на камиону *Tatra 815* у конфигурацији 6x6, али артиљеријски систем може бити монтиран и на шасији 8x8. Наоружана је хаубицом 155 mm/L52, а максималан домет joj је 41 км муницијом типа *ERFB-BB*. Возило носи 24 гранате од којих је 12 спремно за паљбу.

Технички подаци

Наоружање: хаубица 155 мм.

Домет хаубице: 41 км муницијом типа *ERFB-BB.*

Маса: 22.000 кг.

Димензије: дужина: 11,2 м, ширина: 2,55 м, висина: 3,33 м.

G6 Rhino – Јужна Африка

G6 Rhino 155mm у конфигурацији 6x6 (Фото: Army Recongition)

260

Јужноафричку самоходну хаубицу *G6* пројектовала је и произвела компанија *Denel*. У јужноафричкој војсци хаубица је позната под називом *G6 Rhino* (носорог). Наоружана је хаубицом 155 мм, дужине 45 калибара. Испаљује пуну палету муниције, као што су гранате типа НЕ, димне, осветљавајуће, касетне, као и гранате пуњене пропагандним материјалом. *G6 Rhino* носи до 45 граната 155 мм, а максимални домет је 50 км.

Технички подаци

Наоружање: хаубица 155 мм, дужина цеви: 45 калибара.

Домет хаубице: 30 км стандардном муницијом, 39 км муницијом потпомогнутом ракетним моторима, 50 км муницијом продужене даљине.

Маса: 37.000 кг.

Димензије: дужина: 9,2 м, ширина: 3,4 м, висина: 3,3 м.

HM-41 155mm у конфигурацији 6х6 – Иран

Photo:Vahid Reza Alaei   FARS NEWS AGENCY
Самоходна хаубица HM-41 155mm у конфигурацији 6х6

Током октобра 2017. године иранска одбрамбена индустрија приказала је нову верзију домаће самоходне хаубице 155 мм. Мобилни артиљеријски систем састоји се од иранске вучне хаубице *HM-41* и камиона типа *IVECO Trakke*р. Иранска хаубица *HM-41* је, иначе, модернизована верзија америчке хаубице *M114*. По свом изгледу ирански систем *HM41* врло је сличан јужнокорејској хаубици *KH179155мм*/39 калибара коју је пројектовала корпорација *WIA.* Иранска одбрамбена индустрија наводи да је максимални домет хаубице 30 км, а да је каденца ватре до 4 гранате у минути.

Технички подаци

Наоружање: хаубица 155 мм, дужина цеви: 39 калибара.

Домет хаубице: 30 км са стандардном муницијом.

Маса: нема податка.

Димензије: нема података.

K105HT – Јужна Кореја

Самоходна хаубица K105HT 105mm у конфигурацији 6x6 (Фото: Army Recongition)

Самоходну хаубицу *K105HT 105mm* произведела је компанија *Hanwha Land Systems* у Јужној Кореји. Возило је базирано на камионској шасији *Kia KM500* (6x6), носивости 5 тона, опремљеној америчком хаубицом 105 мм *M101A1.* Оруђе је унапређено системом GPS и системом за управљање ватром ради редуцирања броја посаде и времена „спремног за паљбу". Конвенционалној хаубици 105 мм потребно је 10 минута да буде спремна за паљбу, док је систему *K105HT* за исту радњу потребно само 5 минута. Артиљеријски систем има посаду од четири члана – возача, помоћника нишанџије, нишанџије и командира. Возило има борбену масу до 19 тона и максималну брзину до 90 км/час. Носи 60 граната и има максималну каденцу ватре од 10 граната у минути. Максимална даљина дејства је 11,3 км.

Технички подаци
Наоружање: хаубица 105 мм.
Домет хаубице: 11,3 км стандардном муницијом.
Маса: 20.000 кг.
Димензије: дужина: 7,76 м, ширина: 2,24 м, висина: нема података.

Khalifa-1 – Судан

Khalifa GHY02 је артиљеријски систем који је развила суданска војна индустријска корпорација. Ради се о комбинацији вучне хаубице, совјетске D-30 монтиране на руски камион *KamAZ* у конфигурацији 6x6. Овај артиљеријски систем први пут је приказан 2013. године. Његов максималан домет износи до 17 км. Хаубица има могућност и непосредног гађања. Максимална каденца ватре је 8 граната у минуту. Возило носи до 45 граната.

Технички подаци
Наоружање: хаубица 122 мм.

Домет хаубице: 17 км стандардном муницијом.
Маса: 20.500 кг.
Димензије: дужина: 9 м, ширина: 2,67 м, висина: 3,49 м.

Khalifa-1 (Фото: Army Recongition)

КМО Aselsan – Турска

КМО Aselsan у конфигурацији 6x6 (Фото: Army Recongition)

Самоходну хаубицу *КМО* развиле су турска војска и турска компанија *Aselsan*. Прототип овог артиљеријског система приказан је у мају 2017. године на изложби наоружања IDEF. На задњој страни система *Aselsan КМО* монтиран је комплетан оружни систем 155 мм/52 калибра који се налази на самоходној хаубици *Firtina 155mm* која се налази у оперативној употреби у турским оружаним снагама. Нови *КМО* користи стандардну НАТО муницију на максималним даљинама до 30 км. Овај артиљеријски систем носи укупно 21 гранату које су смештене у самом камиону.

Технички подаци
Наоружање: хаубица 155 мм/52 калибра.
Домет хаубице: 30 км стандардном муницијом.
Маса: 26.000 кг.
Димензије: дужина: 11 м, ширина: 2,58 м, висина: 3,5 м.

Kryl – Пољска

Kryl 155mm у конфигурацији 6x6

Kryl је лака самоходна хаубица 155 мм, коју је пројектовала пољска компанија *Huta Stalowa Wola (HSW).* Хаубица је монтирана на камион *Jelcz 663.32* у конфигурацији 6×6. Ради се о артиљеријском систему *Atmos 2000* који је развила израелска компанија *Elbit Systems,* а цев је дужине 52 калибра. Систем за контролу ватре састоји се од балистичког компјутера, компјутера топовског система и дисплеја за командира и нишанџију. Оружје има до 18 граната у спремишту и каденцу ватре од шест граната у минути. Може гађати са елевацом од -2° to 70°, где је азимут ватре 50°. Минимални домет је до 5 км, а максимални до 40 км.

Технички подаци
Наоружање: хаубица 155 мм/52 калибра.
Домет хаубице: 5 км до 40 км.
Маса: 23.000 кг.
Димензије: дужина: 10,3 м, ширина: 2,55 м, висина: 3,44 м.

Otaman у конфигурацији 6x6 – Украјина

Otaman је самоходна хаубица у конфигурацији 6x6 коју је пројектовала украјинска компанија *NGO Practika,* а први пут је приказана на индијској изложби наоружања *Defexpo* током 2016. године. Возило је опремљено куполом наоружаном топом 122 мм *2A18* који је такође употребљен у совјетској хаубици D-30. Максималан домет је 15,4 км, а постиже 21,9 км гранатама потпомогнутим ракетним мотором.

Технички подаци
Наоружање: хаубица 122 мм.
Домет хаубице: 5 км до 40 км.
Маса: 16.000 кг.
Димензије: дужина: 6,5 м, ширина: 2,66 м, висина: нема податка.

Otaman 122mm у конфигурацији 6x6

PLC-181 – Кина

PLC-181 155mm у конфигурацији 6x6

PLC-181 је кинеска самоходна хаубица 155 мм чији је произвођач кинеска компанија *NORINCO.* Монтирана је на камионску шасију *Taian GM* у конфигурацији 6X6 са топом 152 мм дужине цеви 52 калибра на задњој страни камиона. Хаубица има домет до 40 км конвенционалном муницијом

и до 72 км муницијом продуженог домета. Борбени комплет чини 27 граната. Ова самоходна хаубица налази се у региону југозападне Кине, у аутономној области Тибета.

Технички подаци

Наоружање: хаубица 155 мм.

Домет хаубице: 40 км стандардном муницијом и до 72 км муницијом продуженог домета.

Маса: нема податка.

Димензије: нема података.

RUM II – Јордан

Самоходна хаубица RUM II 155mm 6x6 (Фото: Army Recongition)

Јорданска компанија *KADDB (King Abdullah II Design and Development Bureau)* приказала је своју најновију самоходну хаубицу под називом *RUM II* на изложби наоружања *SOFEX* 2018 у Аману, у Јордану. Ова хаубица базирана је на камиону DAF у конфигурацији 6x6, а на овој камионској шасији налази се хаубица *M126 155 mm/L23*. Ради се о топу са самоходне хаубице гусеничара *M109,* али са новим системом против трзаја. Максимална даљина дејствовања самоходне хаубице *RUM II* је до 27,7 км.

Технички подаци

Наоружање: хаубица 155 мм, дужина цеви: 39 калибара.

Домет хаубице: 27,7 км стандардном муницијом.

Маса: нема податка.

Димензије: нема података.

SH-1 – Кина

SH1 је самоходна хаубица точкаш калибра 155 мм, коју је пројектовала и произвела кинеска компанија *North Industries Group Corporation Limited (Norinco)*. Овај артиљеријски систем заснован је на камиону *WS5252* у конфигурацији 6×6, а хаубица је монтирана на задњој страни возила. Ради се о вучној хаубици 155-mm/L5 која је компатибилна са стандардном НАТО муницијом. Испаљује муницију продуженог домета, високо експлозивну,

муницију потпомогнуту ракетним мотором и муницију типа *Extended-Range Full-Bore, Base-Bleed, High-Explosive (ERFB-BB/HE)* која има домет до 53 км. Хаубица испаљује и полуактивне ласерски навођене пројектиле 155 мм које је развила компанија NORINCO, а која је заснована на технологији руске гранате152mm Krasnopol, компаније *Russian Instrument Design Bureau (KBP).*
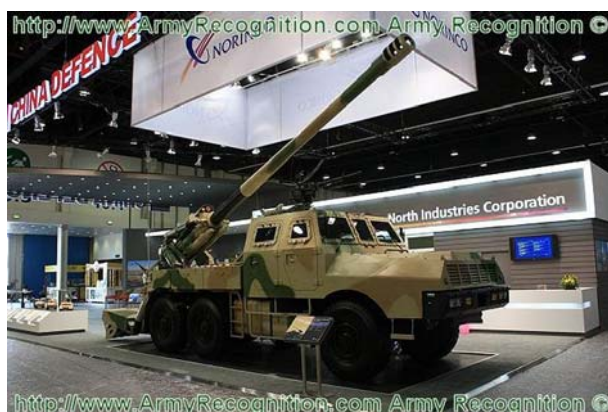
SH-1 155mm 6x6 (Фото: Army Recongition)

Технички подаци
Наоружање: хаубица 155 мм, дужина цеви: 39 калибара.
Домет хаубице: 40 км стандардном муницијом, 53 км муницијом продуженог домета.
Маса: 22.000 кг.
Димензије: дужина: 9,68 м, ширина: 2,58 м, висина: 3,5 м.

SH-15 – Кина

Кинеска компанија *Norinco* приказала је нову самоходну хаубицу 155 мм на изложби наоружања у граду Зуаји у Кини током 2018. године. SH15 се налази на шасији камиона *Shaanxi* који има оклопљену предњу кабину, као и задњи део на којем је монтирана топ-хаубица 155 мм. Артиљеријски систем заснован је на хаубици *AH-2* 155 mm/L52 која испаљује стандардну НАТО муницију. Хаубица има максимални домет до 20 км стандардном муницијом и до 53 км муницијом потпмогнутом ракетним мотором. Максимална каденца ватре је 4 до 6 пројектила у минути. Са обе стране камионске шасије налазе се спремишта за муницију и експлозивна пуњења.
Технички подаци
Наоружање: хаубица 155 мм, дужина цеви: 52 калибра.
Домет хаубице: 20 км стандардном муницијом, 53 км муницијом продуженог домета.
Маса: 22.000 кг.
Димензије: дужина: 6,5 м, ширина: 2,66 м, висина: нема податка.

SH-15 155mm 6x6 (Фото: Army Recongition)

Yavuz MKE – Турска

Yavuz MKE 155mm 6x6

Yavuz је самоходна хаубица точкаш 155 мм коју је пројектовала и произвела турска компанија *MKE,* а која је приказана на међународном сајму наоружања у Турској током 2017. године. Заснована је на немачком камиону типа *MAN* 6x6 са хаубицом калибра 155 мм/52 на задњем крају возила. Ради се о вучној хаубици *Panter 155mm*, коју производи турска компанија *MKE,* а налази се у оперативној употреби у турским оружаним снагама. Хаубица је опремљена полуаутоматским системом за пуњење са укупно 18 граната у спремиштима која се налазе са обе стране камиона. Даљина гађања је до 40 км.

Технички подаци

Наоружање: хаубица 155 мм.

Домет хаубице: 40 км стандардном муницијом.

Маса: 20.000 кг.

Димензије: дужина: 10,8 м, ширина: 2,6 м, висина: 4,1 м.

Soko – Србија

Soko 122mm 6x6

SOKO SP RR (познат и под називом SOKO самоходна хаубица за брзи одговор) самоходна је хаубица точкаш коју је произвела српска компанија Југоимпорт. Ради се о интеграцији хаубице 122 мм дужине цеви 35 калибара D-30 на шасију камиона у конфигурацији 6×6. Максимални домет износи до 21 км, а каденца ватре је 6 граната у минути.

Технички подаци
Наоружање: хаубица 122 мм.
Домет хаубице: 17,3 км гранатама типа HE и 21 км гранатама типа HE/BB.
Маса: 17.000 кг.
Димензије: дужина: 8,38 м, ширина: 3,09 м, висина: 3,17 м.

Драган М. Вучковић (*Dragan* M. Vučković),
e-mail: draganvuckovic64@gmail.com,
ORCID iD: http://orcid.org/0000-0003-1620-5601

Србија тестирала домаћу противавионску ракету кратког домета *RLN-IC/170*[2]

Војнотехнички институт у Београду, као део Министарства одбране Србије, пројектовао је, 22. маја 2020. године, противавионску ракету кратког домета са инфрацрвеним навођењем *RLNIC/170.*

Тестирање противавионске ракете кратког домета са инфрацрвеним навођењем RLNIC/170

Као део троделног програма модернизације Копнене војске Србије, тестирање самоходног хибридног оклопног артиљеријског и противваздухопловног система *PASARS* извршено је на полигону Пасуљанске ливаде близу Ћуприје. Модификовани мобилни оружани систем *PASARS FM-1* лансирао је ракету типа *RLN-IC/170* на мету – минобацачку осветљавајућу мину.

Циљ теста била је провера захвата ракете у прелансирној и лансирној фази ради потврђивања аеродинамичке конфигурације и самонавођења у реалном времену и успостављање новоинсталираних подсистема ракете *RLN-IC/170*.

Вршилац дужности помоћника министра одбране за материјалне ресурсе Ненад Милорадовић изјавио је да је ракета *RLN-IC/170* унапређена верзија старије ракете *RLN-IC*, домаће верзије руске ракете ваздух-ваздух кратког домета *R-13M* којом су били наоружани српски авиони типа *MiG-21*. Ракета *RLN-IC/170* има нови ракетни мотор са чврстим горивом, модернизовану самонавођену инфрацрвену самоновођену главу, дигиталну контролну електронику и реконфигурисану већу бојеву главу. Милорадовић је, такође, навео да су ове нове компоненте, као и ракетни мотор, развијени у Војнотехничком институту и његовим подуговорачима.

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[2] Janes Defence International June 2020

Платформа *PASARS* је први пут приказана октобра 2016. године под претпоставком да вучни топови Копнене војске *Bofors L/70 40 mm*, домета до 3,7 км, могу бити модернизовани као део противваздухопловних батаљона Копнене војске Србије. Иницијална верзија система *PASARS-16 Terminato*р била је наоружана топовима *Bofors L/70 40 mm* и са по две ракете *RLN-IC*.

Током новембра 2019. године, ВТИ је приказао три развојне конфигурације *PASARS* које ће бити наоружане ракетама *RLN-IC/170*, системом *MBDA Mistral 3* и модификованом ракетом *Šilo*, домаћом ознаком за ракету типа *9K38 Igla (SA-18 Grouse), /9K310 Igla-1 (SA-16 Gimlet).* Милорадовић је изјавио да ће све верзије система *PASARS* бити упарене са модернизованим противваздухопловним радарским системом Копнене војске типа M85 Žirafa (радар *Ericsson Giraffe M75* монтиран на југословенски камион FAP 2026) са командним и контролним способностима типа C2.

Драган М. Вучковић (*Dragan* M. Vučković),
e-mail: draganvuckovic64@gmail.com,
ORCID iD: http://orcid.org/0000-0003-1620-5601

ПОЗИВ И УПУТСТВО АУТОРИМА

ПРИГЛАШЕНИЕ И ИНСТРУКЦИЯ ДЛЯ АВТОРОВ РАБОТ

CALL FOR PAPERS AND INSTRUCTIONS FOR AUTHORS

ПОЗИВ И УПУТСТВО АУТОРИМА О НАЧИНУ ПРИПРЕМЕ ЧЛАНКА

Упутство ауторима о начину припреме чланка за објављивање у Војнотехничком гласнику урађено је на основу Правилника о категоризацији и рангирању научних часописа Министарства просвете, науке и технолошког развоја Републике Србије ("Службени гласник РС", број 159/20). Примена овог Правилника првенствено служи унапређењу квалитета домаћих часописа и њиховог потпунијег укључивања у међународни систем размене научних информација.

Војнотехнички гласник / Vojnotehnički glasnik / Military Technical Courier (втг.мо.упр.срб, www.vtg.mod.gov.rs, ISSN 0042-8469 – штампано издање, e-ISSN 2217-4753 – online, UDC 623+355/359, DOI: 10.5937/VojnotehnickiGlasnik; https://doi.org/10.5937/VojnotehnickiGlasnik), јесте мултидисциплинарни научни часопис Министарства одбране и Војске Србије. Часопис објављује научне и стручне чланке из области основних истраживања (математике, рачунарских наука и механике) и технолошког развоја (електронике, телекомуникација, информационих технологија, машинства, материјала и хемијских технологија), 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. Часопис објављује и остала теоријска и практична достигнућа која доприносе усавршавању свих припадника српске, регионалне и међународне академске заједнице, а посебно припадника војски и министарстава одбране.

Уређивачка политика Војнотехничког гласника заснива се на препорукама Одбора за етичност у издаваштву (COPE Core Practices), као и на најбољим прихваћеним праксама у научном издаваштву. Војнотехнички гласник је члан COPE (Committee on Publication Ethics) од 2. маја 2018. године.

Министарство просвете, науке и технолошког развоја Републике Србије утврдило је дана 18. 12. 2020. године категоризацију Војнотехничког гласника, за 2020. годину:

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику:
категорија национални часопис **(М53)**,

за област технолошки развој:

– на листи часописа за електронику, телекомуникације и информационе технологије:
категорија истакнути национални часопис **(М52)**,

– на листи часописа за машинство:
категорија истакнути национални часопис **(М52)**,

– на листи часописа за материјале и хемијске технологије:
категорија истакнути национални часопис **(М52)**.

Усвојене листе домаћих часописа за 2020. 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 2021. 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 категоризацији и рангирању научних часописа Министарства просвете, науке и технолошког развоја Републике Србије ("Службени гласник РС", број 159/20).

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 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 апстракт са кључним речима на енглеском и руском језику (без нумерације наслова и поднаслова). Обим чланка треба да буде око једног ауторског табака (16 страница формата А4 са проредом Single), а највише 24 странице.

Чланак треба да буде написан на обрасцу за писање чланка, који се у електронској форми може преузети са сајта на страници *Образац за писање чланка*.

Наслов

Наслов треба да одражава тему чланка. У интересу је часописа и аутора да се користе речи прикладне за индексирање и претраживање. Ако таквих речи нема у

наслову, пожељно је да се придода и поднаслов. Наслов треба да буде преведен и на енглески и руски језик.

Ови наслови исписују се испред сажетка на одговарајућем језику.

Текући наслов

Текући наслов се исписује са стране сваке странице чланка ради лакше идентификације, посебно копија чланака у електронском облику. Садржи презиме и иницијал имена аутора (ако аутора има више, преостали се означавају са „et al." или „и др."), наслове рада и часописа и колацију (година, волумен, свеска, почетна и завршна страница). Наслови часописа и чланка могу се дати у скраћеном облику.

Име аутора

Наводи се пуно име и презиме (свих) аутора. Веома је пожељно да се наведу и средња слова аутора. Имена и презимена домаћих аутора увек се исписују у оригиналном облику (са српским дијакритичким знаковима), независно од језика на којем је написан рад.

Назив установе аутора (афилијација)

Наводи се пун (званични) назив и седиште установе у којој је аутор запослен, а евентуално и назив установе у којој је аутор обавио истраживање. У сложеним организацијама наводи се укупна хијерархија (нпр. Универзитет одбране у Београду, Војна академија, Катедра природно-математичких наука). Бар једна организација у хијерархији мора бити правно лице. Ако аутора има више, а неки потичу из исте установе, мора се, посебним ознакама или на други начин, назначити из које од наведених установа потиче сваки од наведених аутора. Афилијација се исписује непосредно након имена аутора. Функција и звање аутора се не наводе.

Контакт подаци

Адреса или е-адреса свих аутора даје се поред имена и презимена аутора.

Категорија (тип) чланка

Категоризација чланака обавеза је уредништва и од посебне је важности. Категорију чланка могу предлагати рецензенти и чланови уредништва, односно уредници рубрика, али одговорност за категоризацију сноси искључиво главни уредник.

Чланци у *Војнотехничком гласнику* класификују се на научне и стручне чланке.

Научни чланак је:

– оригиналан научни рад (рад у којем се износе претходно необјављени резултати сопствених истраживања научним методом);

– прегледни рад (рад који садржи оригиналан, детаљан и критички приказ истраживачког проблема или подручја у којем је аутор остварио одређени допринос, видљив на основу аутоцитата);

– кратко или претходно саопштење (оригинални научни рад пуног формата, али мањег обима или прелиминарног карактера);

– научна критика, односно полемика (расправа на одређену научну тему, заснована искључиво на научној аргументацији) и осврти.

Изузетно, у неким областима, научни рад у часопису може имати облик монографске студије, као и критичког издања научне грађе (историјско-архивске,

лексикографске, библиографске, прегледа података и сл.), дотад непознате или недовољно приступачне за научна истраживања.

Радови класификовани као научни морају имати бар две позитивне рецензије.

Ако се у часопису објављују и прилози ваннаучног карактера, научни чланци треба да буду груписани и јасно издвојени у првом делу свеске.

Стручни чланак је:

– стручни рад (прилог у којем се нуде искуства корисна за унапређење професионалне праксе, али која нису нужно заснована на научном методу);

– информативни прилог (уводник, коментар и сл.);

– приказ (књиге, рачунарског програма, случаја, научног догађаја, и сл.).

Језик рада

Језик рада може бити српски, руски или енглески.

Текст мора бити језички и стилски дотеран, систематизован, без скраћеница (осим стандардних). Све физичке величине морају бити изражене у Међународном систему мерних јединица – SI. Редослед образаца (формула) означава се редним бројевима, са десне стране у округлим заградама.

Сажетак

Сажетак јесте кратак информативан приказ садржаја чланка који читаоцу омогућава да брзо и тачно оцени његову релевантност. У интересу је уредништва и аутора да сажетак садржи термине који се често користе за индексирање и претрагу чланака. Саставни делови сажетка су увод/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.

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.

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.

Изјава о ауторству

Поред чланка доставља се *Изјава о ауторству* у којој аутори наводе свој појединачни допринос у изради чланка. Такође, у тој изјави потврђују да су чланак урадили у складу са *Позивом и упутством ауторима* и *Изјавом о етичком поступању часописа*.

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:
Војнотехнички гласник
Вељка Лукића Курјака 33
11042 Београд
e-mail: vojnotehnicki.glasnik@mod.gov.rs.

Главни и одговорни уредник
мр *Небојша* Гаћеша, дипл. инж.
nebojsa.gacesa@mod.gov.rs,
https://orcid.org/0000-0003-3217-6513,
тел: војни 40-260 (011/3603-260),
       066/8700-123

ПРИГЛАШЕНИЕ И ИНСТРУКЦИЯ ДЛЯ АВТОРОВ О ПОРЯДКЕ ПОДГОТОВКИ СТАТЬИ

Инструкция для авторов о порядке подготовки статьи к опубликованию в журнале «Военно-технический вестник» разработана согласно Регламенту о категоризации и ранжировании научных журналов Министерства образования, науки и технологического развития Республики Сербия («Службени гласник РС», № 159/20). Применение этого Регламента способствует повышению качества отечественных журналов и их более полному вовлечению в международную систему обмена научной информацией.

Военно-технический вестник (**Vojnotehnički glasnik / Military Technical Courier**), втг.мо.упр.срб, www.vtg.mod.gov.rs/index-ru.html, ISSN 0042-8469 – печатное издание, e-ISSN 2217-4753 – online, UDK 623+355/359, DOI: 10.5937/VojnotehnickiGlasnik; https://doi.org/10.5937/VojnotehnickiGlasnik, является мультидисциплинарным научным журналом Министерства обороны и Вооруженных сил Республики Сербия.. В журнале публикуются научные и профессиональные статьи, исследующие такие области как: математика, компьютерные науки и механика, а также области технологического развития: электроника, телекоммуникации, информационные технологии, машиностроение, материалы и химические технологии, в журнале также публикуется: техническая информация 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. В журнале публикуются и прочие теоретические и практические достижения, которые способствуют повышению квалификации представителей сербского, регионального и международного академического сообщества, особенно военнослужащих Министерства Обороны и Вооружённых сил.

Редакционная политика журнала «Военно-технический вестник» основана на рекомендациях Комитета по этике научных публикаций (COPE Core Practices), а также на лучшей практике в научно-издательской деятельности. «Военно-технический вестник» является членом COPE со 2 мая 2018 года.

Министерством образования, науки и технологического развития Республики Сербия утверждена 18 декабря 2020 г. категоризация журнала «Военно-технический вестник» за 2020 год:

Категории в области основных исследований:

– Область математика, компьютерные науки, технические науки:
национальный журнал **(М53)**.
Категории в области технологического развития:

– Область электроники, телекоммуникаций и информационных технологий:
высококачественный национальный журнал **(М52)**.

– Область механики:
высококачественный национальный журнал **(М52)**.

– Область материалов и химической технологии:
высококачественный национальный журнал **(М52)**.

С информацией относительно категоризации за 2020 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 2021 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 Регламенту о категоризации и ранжировании научных журналов Министерства образования, науки и технологического развития Республики Сербия («Службени гласник РС», № 159/20)

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 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 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 резюме 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 резюме на соответствующем языке.

Текущий заголовок

Текущий заголовок пишется в титуле каждой страницы статьи с целью упрощения процесса идентификации, в первую очередь копий статьей в электронном виде. Заголовок содержит в себе фамилию и инициал имени автора (в случае если авторов несколько, остальные обозначаются с «et al.» или «и др.»), название работы и журнала (год, том, выпуск, начальная и заключительная страница). Заголовок статьи и название журнала могут быть приведены в сокращенном виде.

ФИО автора

Приводятся полная фамилия и полное имя (всех) авторов. Желательно, чтобы были указаны инициалы отчеств авторов. Фамилия и имя авторов из Республики Сербия всегда пишутся в оригинальном виде (с сербскими диакритическими знаками), независимо от языка, на котором написана работа.

Наименование учреждения автора (аффилиация)

Приводится полное (официальное) наименование и местонахождение учреждения, в котором работает автор, а также наименование учреждения, в котором автор провёл исследование. В случае организаций со сложной структурой приводится их иерархическая соподчинённость (напр. Военная академия, кафедра военных электронных систем, г. Белград). По крайней мере, одна из организаций в иерархии должна иметь статус юридического лица. В случае если указано несколько авторов, и если некоторые из них работают в одном учреждении, нужно отдельными обозначениями или каким-либо другим способом указать в каком из приведённых учреждений работает каждый из авторов. Аффилиация пишется непосредственно после ФИО автора. Должность и специальность по диплому не указываются.

Контактные данные

Электронный адрес автора указываются рядом с его именем на первой страницы статьи.

Категория (тип) статьи

Категоризация статьей является обязанностью редакции и имеет особое значение. Категорию статьи могут предлагать рецензенты и члены редакции, т.е. редакторы рубрик, но ответственность за категоризацию несет исключительно главный редактор. Статьи в журнале распределяются по следующим категориям:

Научные статьи:

– оригинальная научная статья (работа, в которой приводятся ранее неопубликованные результаты собственных исследований, полученных научным методом);

– обзорная статья (работа, содержащая оригинальный, детальный и критический обзор исследуемой проблемы или области, в который автор внёс определённый вклад, видимый на основе автоцитат);

– краткое сообщение (оригинальная научная работа полного формата, но меньшего объёма или имеющая предварительный характер);

– научная критическая статья (дискуссия-полемика на определённую научную тему, основанная исключительно на научной аргументации) и научный комментарий.

Однако, в некоторых областях знаний научная работа в журнале может иметь форму монографического исследования, а также критического обсуждения научного материала (историко-архивного, лексикографического, библиографического, обзора данных и т.п.) – до сих пор неизвестного или недостаточно доступного для научных исследований. Работы, классифицированные в качестве научных, должны иметь, по меньшей мере, две положительные рецензии.

В случае если в журнале объявляются и приложения, не имеющие научный характер, научные статьи должны быть сгруппированы и четко выделены в первой части номера.

Профессиональные статьи:

– профессиональная работа (приложения, в которых предлагаются опыты, полезные для совершенствования профессиональной практики, но которые не должны в обязательном порядке быть обоснованы на научном методе);

– информативное приложение (передовая статья, комментарий и т.п.);

– обзор (книги, компьютерной программы, случая, научного события и т.п.).

Язык работы

Работа может быть написана на сербском, русском или английском языке.

Текст должен быть в лингвистическом и стилистическом смысле упорядочен, систематизирован, без сокращений (за исключением стандартных). Все физические величины должны соответствовать Международной системе единиц измерения – СИ. Очередность формул обозначается порядковыми номерами, проставляемыми с правой стороны в круглых скобках.

Резюме

Резюме является кратким информативным обзором содержания статьи, обеспечивающим читателю быстроту и точность оценки её релевантности. В интересах редакции и авторов, чтобы резюме содержало термины, часто используемые для индексирования и поиска статей. Составными частями резюме являются введение/цель исследования, методы, результаты и выводы. В резюме должно быть от 100 до 250 слов, и оно должно находится между титулами (заголовок, ФИО авторов и др.) и ключевыми словами, за которыми следует текст статьи.

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 (резюме), и на английском языке. В статье они пишутся непосредственно после резюме.

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.

Авторское заявление

Авторское заявление предоставляется вместе со статьей, в нем авторы заявляют о своем личном вкладе в написание статьи. В заявлении авторы подтверждают, что статья написана в соответствии с *Приглашением и инструкциями для авторов*, а также с *Кодексом профессиональной этики 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*.

Почтовый адрес редакции:
«Војнотехнички гласник»
ул. Велька Лукича Куряка 33
11042 Белград, Республика Сербия
e-mail: vojnotehnicki.glasnik@mod.gov.rs.

Главный и ответственный редактор
Кандидат технических наук *Небойша* Гачеша
nebojsa.gacesa@mod.gov.rs
https://orcid.org/0000-0003-3217-6513
тел: +381 11 3603 260, +381 66 8700 123

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 Regulations on categorization and ranking of scientific journals of the Ministry of Education, Science and Technological Development of the Republic of Serbia (Official Gazette of the Republic of Serbia, No 159/20). This Regulations aims at improving the quality of national journals and raising the level of their compliance with the international system of scientific information exchange.

The Military Technical Courier / Vojnotehnički glasnik (www.vtg.mod.gov.rs/index-e.html, втг.мо.упр.срб, ISSN 0042-8469 – print issue, e-ISSN 2217-4753 – online, UDC 623+355/359, DOI: 10.5937/VojnotehnickiGlasnik; https://doi.org/10.5937/VojnotehnickiGlasnik) is a multidisciplinary scientific journal of the Ministry of Defence and the Serbian Armed Forces. The journal publishes scientific and professional papers covering fundamental research (mathematics, computer science and mechanics) and technological development (electronics, telecommunications, information technologies, mechanical engineering, material science and chemical technologies) 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. Also, the journal publishes other theoretical and practical achievements leading to professional development of all members of Serbian, regional and international academic communities as well as members of the military and ministries of defence in particular.

The editorial policy of the Military Technical Courier is based on the COPE Core Practices and the journal articles are consistent with accepted best practices in their subject areas. As of 2 May 2018, the Military Technical Courier is a member of COPE (Committee on Publication Ethics).

The Ministry of Education, Science and Technological Development of the Republic of Serbia classified the Military Technical Courier for the year 2020, on December 18, 2020

in the field fundamental research:
– on the list of periodicals for mathematics, computer sciences and mechanics, category: national journal **(M53)**,
in the field technological development:
– on the list of periodicals for electronics, telecommunications and IT, category: quality national journal **(M52)**,
– on the list of periodicals for mechanical engineering, category: quality national journal **(M52)**,
– on the list of periodicals for materials and chemical technology, category: quality national journal **(M52)**.

The approved lists of national periodicals for the year 2020 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 2021).

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 categorization and ranking of scientific journals of the Ministry of Education, Science and Technological Development of the Republic of Serbia (Official Gazette of the Republic of Serbia, No 159/20). 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 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 and references (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

285

initial (for multiple authors add "et al"), article title, journal title and collation (year, volume, issue, first and last page). The journal and article titles can be given in a shortened form.

Author's name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form (with diacritic signs if in Serbian).

Author's affiliation

The full official name and seat of the author's affiliation is given, possibly with the name of the institution where the research was carried out. For organizations with complex structures, give the whole hierarchy (for example, University of Defence in Belgrade, Military Academy, Department for Military Electronic Systems). At least one organization in the hierarchy must be a legal entity. When some of multiple authors have the same affiliation, it must be clearly stated, by special signs or in other way, which department exactly they are affiliated with. The affiliation follows the author's name. The function and title are not given.

Contact details

The postal addresses or the e-mail addresses of the authors are given in the first page.

Type of articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification.

Journal articles are classified as follows:

Scientific articles:

‒ Original scientific papers (giving the previously unpublished results of the author's own research based on scientific methods);

‒ Review papers (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution demonstrated by self-citation);

‒ Short communications or Preliminary communications (original scientific full papers but shorter or of a preliminary character);

‒ Scientific commentaries or discussions (discussions on a particular scientific topic, based exclusively on scientific argumentation) and opinion pieces.

Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Papers classified as scientific must have at least two positive reviews.

If the journal contains non-scientific contributions as well, the section with scientific papers should be clearly denoted in the first part of the Journal.

Professional articles:

‒ Professional papers (contributions offering experience useful for improvement of professional practice but not necessarily based on scientific methods);

‒ Informative contributions (editorial, commentary, etc.);

‒ Reviews (of a book, software, case study, scientific event, etc.)

Language

The article can be in Serbian, Russian or English.

The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and summary

An abstract is a concise informative presentation of the article content for fast and accurate evaluation of its relevance. It contains the terms often used for indexing and article search. A 100- to 250-word abstract has the following parts: introduction/purpose of the research, methods, results and conclusion.

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is, the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

For this purpose, the ASSISTANT system uses a special tool KWASS for the automatic extraction of key words from disciplinary thesauruses/dictionaries by choice and the routine for their selection, i.e. acceptance or rejection by author and/or editor.

Article acceptance date

The date of the reception of the article, the dates of submitted corrections in the manuscript (optional) and the date when the Editorial Board accepted the article for publication are all given in a chronological order at the end of the article.

Acknowledgements

The name and the number of the project or programme within which the article was realised is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programme.

Article preliminary version

If an article preliminary version has appeared previously at a meeting in a form of an oral presentation (under the same or similar title), this should be stated in a separate note at the bottom of the first page. An article published previously cannot be published in the *Military Technical Courier* even under a similar title or in a changed form.

Tables and illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by Arabic numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

For figures and graphs, proper data plot is recommended i.e. using a data analysis program such as Excel, Matlab, Origin, SigmaPlot, etc. It is not recommended to use a screen capture of a data acquisition program as a figure or a graph.

Citation in the text

Citation in the text must be uniform. The Military Technical Courier applies the Harvard Referencing System given in the Harvard Style Manual. When citing sources within your paper, i.e. for in-text references of the works listed at the end of the paper, place the year of publication of the work in parentheses and optionally the number of the page(s) after the author's name, e.g. (Petrovic, 2012, pp.10-12). A detailed guide on citing, with examples, can be found on Military Technical Courier website on the page *Instructions for Harvard Style Manual*. In-text citations should follow its guidelines.

For checking in-text citations, the ASSISTANT system uses a special tool CiteMatcher to find out quotes left out within papers and in reference lists.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.

Reference list (Literature)

The cited literature encompasses bibliographic sources such as articles and monographs and is given in a separate section in a form of a reference list.

References are not translated to the language of the article.

In compiling the reference list and bibliography, the Military Technical Courier applies the Harvard System – Harvard Style Manual. All bibliography items should be listed alphabetically by author's name, without numeration. A detailed guide for listing references, with examples, can be found on Military Technical Courier website on the page *Instructions for Harvard Style Manual*. Reference lists at the end of papers should follow its guidelines.

In journal evaluation systems, non-standard, insufficient or inconsequent citation is considered to be a sufficient cause for denying the scientific status to a journal.

Authorship Statement

The Authorship statement, submitted together with the paper, states authors' individual contributions to the creation of the paper. In this statement, the authors also confirm that they followed the guidelines given in *the Call for papers* and the *Publication ethics and malpractice statement of the 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.

Address of the Editorial Office:
Vojnotehnički glasnik / Military Technical Courier
Veljka Lukića Kurjaka 33
11042 Belgrade, Republic of Serbia
e-mail: vojnotehnicki.glasnik@mod.gov.rs.

Editor in chief
Nebojša Gaćeša MSc
nebojsa.gacesa@mod.gov.rs
https://orcid.org/0000-0003-3217-6513
tel.: +381 11 3603 260, +381 66 8700 123

ОБАВЕШТЕЊА САРАДНИЦИМА И ЧИТАОЦИМА

СООБЩЕНИЯ ДЛЯ АВТОРОВ И ЧИТАТЕЛЕЙ

INFORMATION FOR CONTRIBUTORS AND READERS

Министарство просвете, науке и технолошког развоја Републике Србије објавило категоризацију „Војнотехничког гласника" за 2020. 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 дана 18. 12. 2020. године категоризацију „Војнотехничког гласника" за 2020. годину:

за област основна истраживања:
– на листи часописа за математику, рачунарске науке и механику: категорија национални часопис (М53),

за област технолошки развој:
– на листи часописа за електронику, телекомуникације и информационе технологије: категорија истакнути национални часопис (М52),
– на листи часописа за машинство: категорија истакнути национални часопис (М52),
– на листи часописа за материјале и хемијске технологије: категорија истакнути национални часопис (М52).

Усвојене листе домаћих часописа за 2020. 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 2020 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 («Служебни гласник РС» № 110/05, 50/06-испр. и 18/10) утверждена 18 декабря 2020 г. категоризация журнала «Военно-технический вестник» за 2020 год:

Категории в области основных исследований:
– Область математика, компьютерные науки, технические науки: национальный журнал (М53).

Категории в области технологического развития:
– Область электроники, телекоммуникаций и информационных технологий: высококачественный национальный журнал (М52),
– Область механики: высококачественный национальный журнал (М52),
– Область материалов и химической технологии: высококачественный национальный журнал (М52).

С информацией о категоризации за 2020 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 (Служебни 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 2020

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 2020, on December 18, 2020

in the field Fundamental Research:
– on the list of periodicals for mathematics, computer sciences and mechanics:
category: national journal (M53),

in the field Technological Development:
– on the list of periodicals for electronics, telecommunications and IT, category: quality national journal (M52),
– on the list of periodicals for mechanical engineering, category: quality national journal (M52),
– on the list of periodicals for materials and chemical technology, category: quality national journal (M52).

The approved lists of national periodicals for the year 2020 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).

СПИСАК РЕЦЕНЗЕНАТА ВОЈНОТЕХНИЧКОГ ГЛАСНИКА

СПИСОК РЕЦЕНЗЕНТОВ ЖУРНАЛА «ВОЕННО-ТЕХНИЧЕСКИЙ ВЕСТНИК»

LIST OF REFEREES OF THE MILITARY TECHNICAL COURIER

СПИСАК РЕЦЕНЗЕНАТА *ВОЈНОТЕХНИЧКОГ ГЛАСНИКА*

Име, средње слово и презиме	Област компетенције (научног интересовања)	ⓘ ORCID iD	ᴾ Publons identifier
Марко Д. Андрејић	логистика	ⓘ https://orcid.org/0000-0002-6753-9786	ᴾ https://publons.com/a/1597995
Милош Ж. Арсић	логистички менаџмент	ⓘ https://orcid.org/0000-0001-7853-0819	ᴾ https://publons.com/a/1604531
Ђорђе Б. Баралић	алгебарска топологија, геометрија и комбинаторика	ⓘ https://orcid.org/0000-0003-2836-7958	ᴾ https://publons.com/a/3574650
Саша Т. Бакрач	заштита животне средине, процена еколошких ризика, екоменаџмент	ⓘ https://orcid.org/0000-0003-0211-3765	ᴾ https://publons.com/a/1597282
Војислав Ј. Батинић	опште машинске конструкције	ⓘ https://orcid.org/0000-0001-6786-7846	ᴾ https://publons.com/a/1643029
Драгана Бечејски-Вујаклија	пословни информациони системи, пословна интелигенција, ERP, IT менаџмент	ⓘ https://orcid.org/0000-0002-9615-3620	ᴾ https://publons.com/a/1623502
Дарко И. Божанић	вишекритеријумско одлучивање, менаџмент у одбрани	ⓘ https://orcid.org/0000-0002-9657-0889	ᴾ https://publons.com/a/1524010
Бобан П. Бонџулић	дигитална обрада слике, дигитална обрада сигнала и њене примене, сједињавање слика, процена квалитета слике и видео сигнала	ⓘ https://orcid.org/0000-0002-8850-9842	ᴾ https://publons.com/a/1603131
Мирко А. Борисов	геодетско инжењерство, геоматика, географски информациони системи, дигитални модели терена, картографија, геодезија, мултимедијална картографија, веб картографија	ⓘ https://orcid.org/0000-0002-7234-6372	ᴾ https://publons.com/a/1613254
Угљеша С. Бугарић	операц. истраживања, масовно опслуживање, теротехнологија-одржавање, транспортни и складишни системи	ⓘ https://orcid.org/0000-0003-2459-2656	ᴾ https://publons.com/a/1596666

Име, средње слово и презиме	Област компетенције (научног интересовања)	ORCID iD	Publons identifier
Славиша И. Влачић	ваздушни саобраћај, системска контрола; аутоматска контрола; навигација возила; морнарички борбени и навигациони системи; симулација	https://orcid.org/0000-0001-9336-0512	https://publons.com/a/1604062
Драгољуб А. Вујић	примењена механика, дијагностика, софистицирани системи одржавања техничких система	https://orcid.org/0000-0001-6999-6828	https://publons.com/a/1627346
Иван Б. Вулић	информациони системи, географски информациони системи	https://orcid.org/0000-0002-5161-5422	https://publons.com/a/1606268
Љубомир Ј Гиговић	географија, географски информациони систем, геопросторна анализа	https://orcid.org/0000-0002-8388-3624	https://publons.com/a/1418283
Миро Ј. Говедарица	геоинформатика	https://orcid.org/0000-0003-1698-0800	https://publons.com/a/1539597
Горан Д. Дикић	системи аутоматског управљања, праћење циљева, системи вођења и управљања ракета	https://orcid.org/0000-0002-0858-1415	https://publons.com/a/1634756
Снежана М. Драгићевић	енергетска ефикасност, машинство, соларна енергија, термоинжењеринг	https://orcid.org/0000-0002-6244-0111	https://publons.com/a/1604121
Чедомир В. Дубока	мотори, моторна возила	https://orcid.org/0000-0003-2944-2278	https://publons.com/a/1627827
Бобан Д. Ђоровић	процеси и методе у саобраћају и транспорту, транспортне мреже, организација транспорта	https://orcid.org/0000-0001-8133-2389	https://publons.com/a/1633020
Владо П. Ђурковић	примењена механика крутог и деформабилног тела	https://orcid.org/0000-0002-5064-4117	https://publons.com/a/1622194
Дејан Р. Инђић	тактика АБХ службе, оружје за масовно уништавање, тероризам оружјем за масовно уништавање, нуклеарни и хемијски удеси	https://orcid.org/0000-0001-9111-0472	https://publons.com/a/1616130

Име, средње слово и презиме	Област компетенције (научног интересовања)	ⓘ ORCID iD	℗ Publons identifier
Дамир Д. Јерковић	наоружање, нумеричка анализа, CFD симулација, спољна балистика, балистика, балистика на циљу, интеграција наоружања	ⓘ https://orcid.org/0000-0001-5182-7057	℗ https://publons.com/a/1500127
Бориша Ж. Јовановић	информационе технологије, софтверско инжењерство, безбедност рачунарских система, рачунарске мреже	ⓘ https://orcid.org/0000-0002-9353-724X	℗ https://publons.com/a/3851268
Митар Т. Јоцановић	трибологија и теорија подмазивања, одржавање технолошких система, хидраулички системи	ⓘ https://orcid.org/0000-0003-1088-5028	℗ https://publons.com/a/1596778
Радован М. Каркалић	хемијске технологије (нуклеарно-хемијско-биолошка заштита, детекција, идентификација и деконтаминација)	ⓘ https://orcid.org/0000-0002-8074-7264	℗ https://publons.com/a/1602667
Владимир А. Катић	енергетска електроника, електричне машине, електромоторни погони, квалитет електричне енергије, обновљиви извори електричне енергије	ⓘ https://orcid.org/0000-0002-0138-8807	℗ https://publons.com/a/1318533
Мирко С. Козић	механика флуида, нумеричка динамика флуида, аеродинамичка оптерећења	ⓘ https://orcid.org/0000-0002-7287-0780	℗ https://publons.com/a/1627334
Комлен Г. Лаловић	информационе технологије, програмирање, заштита података	ⓘ https://orcid.org/0000-0002-4590-2185	℗ https://publons.com/a/1610913
Марија З. Малнар	електротехника, телекомуникације	ⓘ https://orcid.org/0000-0003-1416-8253	℗ https://publons.com/a/3269205
Бојан Ч. Милановић	микроталасна техника, антене	ⓘ https://orcid.org/0000-0003-0683-4500	℗ https://publons.com/a/1604390

Име, средње слово и презиме	Област компетенције (научног интересовања)	ORCID iD	Publons identifier
Зоран Ђ. Миљковић	технологија машинске обраде, роботика, вештачка интелигенција, аутономни системи и машинско учење, вештачке неуронске мреже, интелигентни технолошки системи и процеси, методе одлучивања	https://orcid.org/0000-0001-9706-6134	https://publons.com/a/1410489
Надица С. Миљковић	биомедицинска обрада сигнала, е-здравље, електротехника, биомедицински инжењеринг, електрофизиологија	https://orcid.org/0000-0002-3933-6076	https://publons.com/a/1628814
Срђан Т. Митровић	мобилни роботи, управљање у реалном времену, фази логика, фази управљање, микропроцесорски системи, управљање системима (аутоматика), алгоритми навигације возила, бродски борбени и навигациони системи	https://orcid.org/0000-0002-1287-2792	https://publons.com/a/1467408
Дејан М. Мицковић	конструкција класичног наоружања, аутоматска оружја, унутрашња балистика	/	/
Драган Д. Младеновић	информациона безбедност, сајбер безбедност, сајбер сукоби, сајбер ратовање, информационе технологије, међународно право, нове технологије	https://orcid.org/0000-0003-4530-633X	https://publons.com/a/1604465
Славко Р. Муждека	моторна возила, борбена возила	https://orcid.org/0000-0002-6189-9473	https://publons.com/a/1599773
Бобан З. Павловић	телекомуникационе мреже, квалитет сервиса, телекомуникациони саобраћај	https://orcid.org/0000-0002-5476-7894	https://publons.com/a/1606407

Име, средње слово и презиме	Област компетенције (научног интересовања)	ORCID iD	Publons identifier
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Сретен Р. Перић	машинство	https://orcid.org/0000-0002-7270-5187	https://publons.com/a/1620400
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Југослав Р. Радуловић	муниција, менаџмент, квалитет	https://orcid.org/0000-0002-4003-7209	https://publons.com/a/1611389
Влада С. Соколовић	одржавање, техничка подршка, интегрисани навигацијски системи, GPS, GNSS, сателитски системи, логистика	https://orcid.org/0000-0003-0782-0506	https://publons.com/a/1559198
Наем Салем	математика	https://orcid.org/0000-0002-1485-6163	https://publons.com/a/1716462
Жељко Р. Стевић	вишекритеријумско одлучивање, логистика, fuzzy логика, ланац снабдевања, теорија грубих скупова, транспорт, саобраћај, одрживо инжењерство, управљање отпадом, SERVQUAL модел	https://orcid.org/0000-0003-4452-5768	https://publons.com/a/1499829
Љубиша К. Танчић	унутрашња балистика, наоружање	https://orcid.org/0000-0003-1242-9333	https://publons.com/a/1623091
Иван А. Тот	базе података, информациони системи, заштита информационих система	https://orcid.org/0000-0002-5862-9042	https://publons.com/a/1558155
Обрад Т. Чабаркапа	индустријска својина, заштита интелектуалне и индустријске својине, патентна заштита, управљање пројектима, машинство, наоружање, пројект менаџмент	https://orcid.org/0000-0002-3949-8227	https://publons.com/a/1600393

Име, средње слово и презиме	Област компетенције (научног интересовања)	ORCID iD	Publons identifier
Нада М. Читаковић	физика	https://orcid.org/0000-0003-2813-2323	https://publons.com/a/1601584
Томислав Б. Шекара	управљање процесима са концентрисаним и распоређеним параметрима; оптимални индустријски регулатори; фракциони закони управљања са применом у индустрији; карактеризација процеса; адекватна дискретизација и обрада сигнала; сензори и актуатори; компензација и уштеда електричне енергије у дистрибутивним електроенергетским системима	https://orcid.org/0000-0001-8031-3135	https://publons.com/a/1596795
Горан П. Шимић	информациони системи, рачунарство, програмирање, базе података, вештачка интелигенција	https://orcid.org/0000-0002-7563-699X	https://publons.com/a/1600386

СПИСОК РЕЦЕНЗЕНТОВ ЖУРНАЛА *«ВОЕННО-ТЕХНИЧЕСКИЙ ВЕСТНИК»*

ФИО	Области научной деятельности	ORCID iD	Publons identifier
Марко Д. Андреич	логистика	https://orcid.org/0000-0002-6753-9786	https://publons.com/a/1597995
Милош Ж. Арсич	управление логистикой	https://orcid.org/0000-0001-7853-0819	https://publons.com/a/1604531
Джордже Б. Баралич	алгебраическая топология, геометрия и комбинаторика	https://orcid.org/0000-0003-2836-7958	https://publons.com/a/3574650
Саша Т. Бакрач	охрана окружающей среды, оценка экологических рисков, экологический менеджмент	https://orcid.org/0000-0003-0211-3765	https://publons.com/a/1597282
Воислав Й. Батинич	общие машиностроительные конструкции	https://orcid.org/0000-0001-6786-7846	https://publons.com/a/1643029
Драгана Бечейски-Вуяклия	бизнес-информационные системы, бизнес-аналитика, ERP, управление ИТ	https://orcid.org/0000-0002-9615-3620	https://publons.com/a/1623502
Дарко И. Божанич	принятие многокритериальных решений, управление в области обороны	https://orcid.org/0000-0002-9657-0889	https://publons.com/a/1524010
Бобан П. Бонджулич	цифровая обработка изображений, обработка цифрового сигнала и его приложения, оценка качества изображения и видео, слияние изображений	https://orcid.org/0000-0002-8850-9842	https://publons.com/a/1603131
Мирко А. Борисов	геодезическая инженерия, геоматика, геоинформационные системы, цифровые модели местности, картография, геодезия, мультимедийная картография, веб-картография	https://orcid.org/0000-0002-7234-6372	https://publons.com/a/1613254
Углеша С. Бугарич	исследование операций, теория массового обслуживания, теротехнология обслуживания, транспортно-складские системы	https://orcid.org/0000-0003-2459-2656	https://publons.com/a/1596666

ФИО	Области научной деятельности	ORCID iD	Publons identifier
Славиша И. Влачич	воздушное движение, управление системой; автоматическое управление; автомобильная навигация; морские боевые и навигационные системы; моделирование	https://orcid.org/0000-0001-9336-0512	https://publons.com/a/1604062
Драголюб А. Вуич	прикладная механика, диагностика, сложные системы технического обслуживания	https://orcid.org/0000-0001-6999-6828	https://publons.com/a/1627346
Иван Б. Вулич	информационные системы, географические информационные системы	https://orcid.org/0000-0002-5161-5422	https://publons.com/a/1606268
Любомир Й. Гигович	география, географическая информационная система, геопространственный анализ	https://orcid.org/0000-0002-8388-3624	https://publons.com/a/1418283
Миро Й. Говедарица	геоинформатика	https://orcid.org/0000-0003-1698-0800	https://publons.com/a/1539597
Бобан Д. Джорович	транспортные процессы и методы, транспортные сети, организация транспорта	https://orcid.org/0000-0001-8133-2389	https://publons.com/a/1633020
Владо П. Джуркович	прикладная механика твердых и деформируемых тел	https://orcid.org/0000-0002-5064-4117	https://publons.com/a/1622194
Горан Д. Дикич	системы автоматического управления, прицеливания, системы наведения и телеуправления ракет	https://orcid.org/0000-0002-0858-1415	https://publons.com/a/1634756
Снежана М. Драгичевич	энергоэффективность, машиностроение, солнечная энергия, теплотехника термоинженерия	https://orcid.org/0000-0002-6244-0111	https://publons.com/a/1604121

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Чедомир В. Дубока	двигатели, автомобили	https://orcid.org/0000-0003-2944-2278	https://publons.com/a/1627827
Дамир Д. Еркович	вооружение, численный анализ, CFD вычислительная гидродинамика, внешняя баллистика, баллистика, терминальная баллистика, интегрирование вооружения	https://orcid.org/0000-0001-5182-7057	https://publons.com/a/1500127
Деян Р. Инджич	тактика ядерно-химической биологической защиты, оружие массового уничтожения, терроризм с оружием	https://orcid.org/0000-0001-9111-0472	https://publons.com/a/1616130
Бориша Ж. Йованович	информационные технологии, программная инженерия, безопасность компьютерных систем, компьютерные сети	https://orcid.org/0000-0002-9353-724X	https://publons.com/a/3851268
Митар Т. Йоцанович	трибология и теория смазки, техническое обслуживание технологических систем, гидравлических систем	https://orcid.org/0000-0003-1088-5028	https://publons.com/a/1596778
Радован М. Каркалич	химическая технология (ядерно-химическая-биологическая защита, обнаружение, идентификация и дезактивация)	https://orcid.org/0000-0002-8074-7264	https://publons.com/a/1602667
Владимир А. Катич	силовая электроника, электрические машины, электрические приводы, качество электроэнергии, возобновляемые источники энергии	https://orcid.org/0000-0002-0138-8807	https://publons.com/a/1318533
Мирко С. Козич	механика жидкостей, вычислительная динамика жидкостей, аэродинамические нагрузки	https://orcid.org/0000-0002-7287-0780	https://publons.com/a/1627334
Комлен Г. Лалович	информационные технологии, программирование, защита данных	https://orcid.org/0000-0002-4590-2185	https://publons.com/a/1610913

ФИО	Области научной деятельности	ⓘ ORCID iD	Ⓟ Publons identifier
Мария З. Малнар	электротехника, телекоммуникации	ⓘ https://orcid.org/0000-0003-1416-8253	Ⓟ https://publons.com/a/3269205
Боян Ч. Миланович	микроволновая техника, антенны	ⓘ https://orcid.org/0000-0003-0683-4500	Ⓟ https://publons.com/a/1604390
Зоран Дж. Милькович	технология производства, процессы обработки, робототехника, искусственный интеллект, автономные системы и машинное обучение, искусственные нейронные сети, интеллектуальные производственные системы и процессы, принятие решений	ⓘ https://orcid.org/0000-0001-9706-6134	Ⓟ https://publons.com/a/1410489
Надица С. Милкович	обработка биомедицинских сигналов, электронное здравоохранение, электротехника, биомедицинская инженерия, электрофизиология	ⓘ https://orcid.org/0000-0002-3933-6076	Ⓟ https://publons.com/a/1628814
Срджан Т. Митрович	мобильные роботы, управление в реальном времени, нечеткая логика, нечеткое управление, микропроцессорные системы, управление системами автоматики, алгоритмы навигации транспорта, навигационные системы для судов и боевого транспорта	ⓘ https://orcid.org/0000-0002-1287-2792	Ⓟ https://publons.com/a/1467408
Деян М. Мицкович	конструкция классического конвенционального вооружения, автоматическое оружие, внутренняя баллистика	/	/
Драган, Д. Младенович	информационная безопасность, кибербезопасность, кибер-конфликт, кибер-война, информационные технологии, международное право	ⓘ https://orcid.org/0000-0003-4530-633X	Ⓟ https://publons.com/a/1604465

ФИО	Области научной деятельности	ⓘ ORCID iD	ⓟ Publons identifier
Славко Р. Муждека	транспортные средства, боевые транспортные средства	ⓘ https://orcid.org/0000-0002-6189-9473	ⓟ https://publons.com/a/1599773
Бобан З. Павлович	телекоммуникационные сети, качество обслуживания, телекоммуникационный трафик	ⓘ https://orcid.org/0000-0002-5476-7894	ⓟ https://publons.com/a/1606407
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Югослав Р. Радулович	боеприпасы, менеджмент, качество	ⓘ https://orcid.org/0000-0002-4003-7209	ⓟ https://publons.com/a/1611389
Наем Салем	математика	ⓘ https://orcid.org/0000-0002-1485-6163	ⓟ https://publons.com/a/1716462
Влада С. Соколович	техническое обслуживание, техническая поддержка, интегрированные навигационные системы, GPS, GNSS, спутниковые системы, логистика	ⓘ https://orcid.org/0000-0003-0782-0506	ⓟ https://publons.com/a/1559198
Желко Р. Стевич	принятие многокритериальных решений (mcdm), логистика, нечеткий набор, цепочка поставок, грубый набор, транспорт, проектирование движения, устойчивое проектирование, управление отходами, модель SERVQUAL	ⓘ https://orcid.org/0000-0003-4452-5768	ⓟ https://publons.com/a/1499829
Любиша К. Танчич	внутренняя баллистика, вооружение	ⓘ https://orcid.org/0000-0003-1242-9333	ⓟ https://publons.com/a/1623091
Иван А. Тот	базы данных, информационные системы, защита информационных систем	ⓘ https://orcid.org/0000-0002-5862-9042	ⓟ https://publons.com/a/1558155

ФИО	Области научной деятельности	ORCID iD	Publons identifier
Обрад Т. Чабаркапа	промышленная собственность, защита интеллектуальной и промышленной собственности, патентная защита, управление проектами, машиностроение, вооружение, управление проектами	https://orcid.org/0000-0002-3949-8227	https://publons.com/a/1600393
Нада М. Читакович	физика	https://orcid.org/0000-0003-2813-2323	https://publons.com/a/1601584
Томислав Б. Шекара	управление процессами концентрированных и распределенных параметров, оптимальные промышленные регуляторы, фракционные методы управления в промышленном секторе, характеризация процессов, соответствующая дискретизация и обработка сигналов, сенсоры и актуаторы, компенсация и сбережение электроэнергии в распределительных электроэнергетических системах	https://orcid.org/0000-0001-8031-3135	https://publons.com/a/1596795
Горан П. Шимич	информационные системы, информатика, программирование, базы данных, искусственный интеллект	https://orcid.org/0000-0002-7563-699X	https://publons.com/a/1600386

LIST OF REFEREES OF THE MILITARY TECHNICAL COURIER

Name, middle initial and surname	Scientific research competence area	ⓘ ORCID iD	P Publons identifier
Marko D. Andrejić	logistics	ⓘ https://orcid.org/0000-0002-6753-9786	P https://publons.com/a/1597995
Miloš Ž. Arsić	logistics management	ⓘ https://orcid.org/0000-0001-7853-0819	P https://publons.com/a/1604531
Đorđe B. Baralić	algebraic topology, geometry and combinatorics	ⓘ https://orcid.org/0000-0003-2836-7958	P https://publons.com/a/3574650
Saša T. Bakrač	environmental protection, environmental risk assessment, eco-management	ⓘ https://orcid.org/0000-0003-0211-3765	P https://publons.com/a/1597282
Vojislav J. Batinić	general mechanical engineering constructions	ⓘ https://orcid.org/0000-0001-6786-7846	P https://publons.com/a/1643029
Dragana Bečejski-Vujaklija	business information systems, business intelligence, ERP, IT management	ⓘ https://orcid.org/0000-0002-9615-3620	P https://publons.com/a/1623502
Boban P. Bondžulić	digital image processing, digital signal processing and its applications, image and video quality assessment, image fusion	ⓘ https://orcid.org/0000-0002-8850-9842	P https://publons.com/a/1603131
Mirko A. Borisov	geodetic engineering, geomatics, geographic information systems, digital terrain models, cartography, geodesy, multimedia cartography, web mapping	ⓘ https://orcid.org/0000-0002-7234-6372	P https://publons.com/a/1613254
Darko I. Božanić	multi-criteria decision making, management in defense	ⓘ https://orcid.org/0000-0002-9657-0889	P https://publons.com/a/1524010
Uglješa S. Bugarić	operational research, mass service, terotechnology – maintenance, transportation and storage systems	ⓘ https://orcid.org/0000-0003-2459-2656	P https://publons.com/a/1596666
Obrad T. Čabarkapa	industrial property, protection of intellectual and industrial property, patent protection, project management, mechanical engineering, armaments, project management	ⓘ https://orcid.org/0000-0002-3949-8227	P https://publons.com/a/1600393
Nada M. Čitaković	physics	ⓘ https://orcid.org/0000-0003-2813-2323	P https://publons.com/a/1601584

Name, middle initial and surname	Scientific research competence area	ORCID iD	Publons identifier
Goran D. Dikić	automatic control systems, target tracking, missile guidance and control systems	https://orcid.org/0000-0002-0858-1415	https://publons.com/a/1634756
Snežana M. Dragićević	energy efficiency, mechanical engineering, solar energy, thermal engineering	https://orcid.org/0000-0002-6244-0111	https://publons.com/a/1604121
Čedomir V. Duboka	engines, motor vehicles	https://orcid.org/0000-0003-2944-2278	https://publons.com/a/1627827
Boban D. Đorović	processes and methods in traffic and transportation, transportation networks, transport organization	https://orcid.org/0000-0001-8133-2389	https://publons.com/a/1633020
Vlado P. Đurković	applied mechanics of rigid and deformable bodies	https://orcid.org/0000-0002-5064-4117	https://publons.com/a/1622194
Ljubomir J. Gigović	geography, geographic information system, geospatial analysis	https://orcid.org/0000-0002-8388-3624	https://publons.com/a/1418283
Miro J. Govedarica	geoinformatics	https://orcid.org/0000-0003-1698-0800	https://publons.com/a/1539597
Dejan R. Inđić	tactic of Nuclear Chemical Biological Defense, weapons of mass destruction, terrorism with weapons of mass destruction, nuclear and chemical incidents	https://orcid.org/0000-0001-9111-0472	https://publons.com/a/1616130
Damir D. Jerković	weapons, numerical analysis, CFD simulation, external ballistics, ballistics, terminal ballistics, weapons integration	https://orcid.org/0000-0001-5182-7057	https://publons.com/a/1500127
Mitar T. Jocanović	tribology and theory of lubrication, maintenance of technological systems, hydraulic systems	https://orcid.org/0000-0003-1088-5028	https://publons.com/a/1596778
Boriša Ž. Jovanović	IT, software engineering, computer systems security, computer networks	https://orcid.org/0000-0002-9353-724X	https://publons.com/a/3851268
Radovan M. Karkalić	chemical technology (nuclear-chemical-biological protection, detection, identification and decontamination)	https://orcid.org/0000-0002-8074-7264	https://publons.com/a/1602667

Name, middle initial and surname	Scientific research competence area	ORCID iD	Publons identifier
Vladimir A. Katić	power electronics, electric machines, electric power systems and stations, electric power quality, renewable energy sources	https://orcid.org/0000-0002-0138-8807	https://publons.com/a/1318533
Mirko S. Kozić	mechanics of fluids, computational fluid dynamics, aerodynamic load	https://orcid.org/0000-0002-7287-0780	https://publons.com/a/1627334
Komlen G. Lalović	information technology, programming, data protection	https://orcid.org/0000-0002-4590-2185	https://publons.com/a/1610913
Marija Z. Malnar	electrical engineering - telecommunications	https://orcid.org/0000-0003-1416-8253	https://publons.com/a/3269205
Dejan M. Micković	construction of classic weapons, automatic weapons, internal ballistics	/	/
Bojan Č. Milanović	microwave engineering, antennas	https://orcid.org/0000-0003-0683-4500	https://publons.com/a/1604390
Nadica S. Miljković	biomedical signal processing, e-health, electrical engineering, biomedical engineering, electrophysiology	https://orcid.org/0000-0002-3933-6076	https://publons.com/a/1628814
Zoran Đ. Miljković	manufacturing technology, machining processes, robotics, artificial intelligence, autonomous systems and machine learning, artificial neural networks, intelligent manufacturing systems and processes, decision-making methods	https://orcid.org/0000-0001-9706-6134	https://publons.com/a/1410489
Srđan T. Mitrović	mobile robots, real time control, fuzzy logic, fuzzy control, microprocessing systems, system control (automation), vehicle navigation algorithms, naval combat and navigation systems	https://orcid.org/0000-0002-1287-2792	https://publons.com/a/1467408
Dragan D. Mladenović	information security, cyber security, cyber conflict, cyber warfare, information technology, international law, emerging technologies	https://orcid.org/0000-0003-4530-633X	https://publons.com/a/1604465
Slavko R. Muždeka	motor vehicles, combat vehicles	https://orcid.org/0000-0002-6189-9473	https://publons.com/a/1599773

Name, middle initial and surname	Scientific research competence area	ORCID iD	Publons identifier
Dragan S. Pamučar	traffic engineering, operational research	https://orcid.org/0000-0001-8522-1942	https://publons.com/a/3169556
Boban Z. Pavlović	telecommunication networks, quality of service, telecommunication traffic	https://orcid.org/0000-0002-5476-7894	https://publons.com/a/1606407
Sreten R. Perić	mechanical engineering	https://orcid.org/0000-0002-7270-5187	https://publons.com/a/1620400
Miroslav V. Popović	computer engineering	https://orcid.org/0000-0002-1118-6491	https://publons.com/a/1558230
Jugoslav R. Radulović	ammunition, management, quality	https://orcid.org/0000-0002-4003-7209	https://publons.com/a/1611389
Naeem Saleem	mathematics	https://orcid.org/0000-0002-1485-6163	https://publons.com/a/1716462
Vlada S. Sokolović	maintenance, technical support, integrated navigation systems, GPS, GNSS, satellite systems, logistics	https://orcid.org/0000-0003-0782-0506	https://publons.com/a/1559198
Željko R. Stević	multi-criteria decision making (mcdm), logistics, fuzzy set, supply chain, rough set, transport, traffic engineering, sustainable engineering, waste management, SERVQUAL model	https://orcid.org/0000-0003-4452-5768	https://publons.com/a/1499829
Tomislav B. Šekara	control of processes with concentrated and distributed parameters, industrial regulators with optimum performance, fraction laws of control in industrial application, process characterisation, adequate signal discretisation and processing, sensors and actuators, electric energy compensation and saving in electric energy distribution systems	https://orcid.org/0000-0001-8031-3135	https://publons.com/a/1596795
Goran P. Šimić	Inform. systems, computer science, programming, databases, artificial intelligence	https://orcid.org/0000-0002-7563-699X	https://publons.com/a/1600386
Ljubiša K. Tančić	internal ballistics, armaments	https://orcid.org/0000-0003-1242-9333	https://publons.com/a/1623091
Ivan A. Tot	databases, inform.systems, information system security	https://orcid.org/0000-0002-5862-9042	https://publons.com/a/1558155

Name, middle initial and surname	Scientific research competence area	ORCID iD	Publons identifier
Slaviša I. Vlačić	air traffic, system control, automatic control, vehicle navigation, naval combat and navigation systems, simulation	https://orcid.org/0000-0001-9336-0512	https://publons.com/a/1604062
Dragoljub A. Vujić	applied mechanics, diagnostics, sofisticated systems for technical system maintenance	https://orcid.org/0000-0001-6999-6828	https://publons.com/a/1627346
Ivan B. Vulić	information systems, geographic information systems	https://orcid.org/0000-0002-5161-5422	https://publons.com/a/1606268

ИЗЈАВА ВОЈНОТЕХНИЧКОГ ГЛАСНИКА О ЕТИЧКОМ ПОСТУПАЊУ

Објављивање чланака након стручне рецензије основна је делатност научног часописа *Војнотехнички гласник*. Неопходно је постићи сагласност о етичким начелима у поступцима свих учесника приликом објављивања чланака, од аутора, Редакције часописа и стручних рецензената до издавача.

Обавезе Редакције *Војнотехничког гласника*

Уредништво *Војнотехничког гласника* не тражи од аутора плаћање накнаде за аплицирање чланка за објављивање. Читав поступак уређивања и објављивања чланка за ауторе је потпуно бесплатан.

Редакција *Војнотехничког гласника* одговорна је за доношење одлуке који ће од приспелих чланака бити одабран за објављивање. Уредник не сме имати сукоб интереса у вези са рукописима које разматрају. Ако такав сукоб интереса постоји, о избору рецензената и судбини рукописа одлучује уредништво. Чланови уређивачког одбора код којих постоји сукоб интереса дужни су да се повуку из процедуре.

Редакција треба да поступа у складу с политиком Уређивачког одбора *Војнотехничког гласника* као и у складу са законским прописима који се односе на клевету, кршење ауторских права и плагијате. Редакција може да се консултује са члановима Уређивачког одбора или рецензентима при доношењу одлуке.

Редакција процењује садржај рукописа независно од расе, пола, полне оријентације, религијских уверења, етничког порекла, политичких уверења и државне припадности аутора.

У свом раду, према препоруци Центра за евалуацију у образовању и науци (ЦЕОН), Редакција користи електронски систем уређивања АСИСТЕНТ, који омогућава транспарентност и јавност рада, подразумевајући пуну одговорност за прихватање и објављивање чланка.

Пре слања на рецензију Редакција проверава да ли је садржај рукописа плагијат, коришћењем сервиса iThenticate (CrossRef и CrossCheck). Према стандардима које часопис примењује, плагирање, односно преузимање туђих идеја, речи или других облика креативног израза и представљање као својих, представља грубо кршење научне и издавачке етике. Плагирање може да укључује и кршење ауторских права, што је законом кажњиво. Плагијат обухвата: дословно или готово дословно преузимање или смишљено парафразирање (у циљу прикривања плагијата) делова текстова других аутора без јасног указивања на извор или обележавање копираних фрагмената (на пример, коришћењем наводника); копирање слика или табела из туђих радова без правилног навођења извора и/или без дозволе аутора или носилаца ауторских права. Рукописи код којих постоје јасне индиције да се ради о плагијату биће аутоматски одбијени.

Часопис примењује „двоструки слепи поступак рецензије" чланака, који подразумева да аутори не знају ко су им рецензенти, нити су рецензентима познати аутори.

Нико из уређивачке куће не сме да открије ниједну информацију о пристиглом рукопису икоме, осим аутору, рецензентима, потенцијалним рецензентима, другим саветницима уређивачке куће и издавачу, према потреби.

Необјављен материјал из пристиглих рукописа не сме да се користи за истраживачки рад уређивача, осим са изричитим писменим одобрењем аутора.

Редакција се обавезује да ће повући већ објављени чланак у случају накнадног откривања следећих околности у вези рада:

– плагијаризам,

– аутоплагијаризам,

– рад је већ објављен у другом часопису или некој другој публикацији,

– нетачни подаци о ауторству (присвајање туђег рада, навођење аутора који нису учествовали у писању рада, изостављање аутора који су учествовали у писању рада),

– сукоб интереса,

– лажирање или фабриковање резултата,

– недозвољене техничке интервенције на сликама,

– озбиљнија техничка грешка, као што је изостављање делова текста, грешка у репродукцији илустративног материјала.

Стандарди за разрешавање ситуација када мора доћи до повлачења рада дефинисани су од стране библиотека и научних тела, а иста пракса је усвојена и од стране часописа: у електронској верзији изворног чланка (оног који се повлачи) успоставља се веза (HTML линк) са обавештењем о повлачењу. Повучени чланак се чува у изворној форми, али са воденим жигом на PDF документу, на свакој страници, који указује да је чланак повучен (RETRACTED).

Опозиви и исправке се публикују према захтевима ЦЕОН-а (http://www.ceon.rs/pdf/postupanje_s_nelegitimnim_radovima.pdf) као издавача националног цитатног индекса где се метаподаци опозива и опзваних радова морају означити одговарајућим упозорењима и међусобно повезати унакрсним линковима.

Обавезе рецензената

Рецензенти су дужни да стручно, аргументовано, непристрасно и у задатим роковима доставе уреднику оцену научне вредности рукописа. Рецензенти евалуирају радове у односу на усклађеност теме рада са профилом часописа, релевантност истраживане области и примењених метода, оригиналност и научну релевантност података изнесених у рукопису, стил научног излагања и опремљеност текста научним апаратом.

Стручни рецензент помаже Редакцији у доношењу одлуке, а посредством контаката са ауторима преко Редакције може да помаже и ауторима на побољшавању текста рада.

Уколико изабрани рецензент сматра да није довољно квалификована да изврши рецензију истраживања у рукопису или је пак спречен да заврши и достави рецензију у договореном року, о томе треба благовремено да обавести Редакцију.

Сваки рукопис прихваћен на рецензију мора да се третирати као поверљив документ. Не сме се показивати трећим лицима нити дискутовати са њима, осим када то одобри Редакција.

Рецензија треба да буде објективна. Неприхватљива је лична критика аутора. Рецензенти треба јасно да образложе своје ставове и поткрепе их аргументима.

Рецензенти треба да идентификују релевантне постојеће радове које аутор није цитирао. Свака претходно јавно саопштена тврдња или аргумент треба да буду

пропраћени одговарајућим цитатом. Дужност рецензента је да скрене пажњу уреднику на значајна поклапања или сличност рукописа са већ објављеним радом, уколико о томе има лична сазнања.

Информације и идеје до којих се дошло стручном рецензијом поверљивог су карактера и не смеју се користити за сопствене потребе. Рецензенти не би требало да примају рукописе који их доводе у сукоб интереса на основу конкуренције, заједничког рада или других односа с било којим аутором, компанијом или институцијом повезаним с радом.

Обавезе аутора

Аутори гарантују да рукопис представља њихов оригиналан допринос, да није објављен раније и да се не разматра за објављивање на другом месту. Истовремено предавање истог рукописа у више часописа представља кршење етичких стандарда. Такав рукопис се моментално искључује из даљег разматрања.

Када аутори пишу о оригиналном истраживању треба прецизно да прикажу обављени рад и да објективно изложе његов значај. Подаци треба да буду прецизно наведени. Чланак треба да садржи довољно детаља и референци да би могао да се репродукује. Лажне или намерно нетачне тврдње представљају неетичко поступање и неприхватљиве су.

Аутори треба да обезбеде необрађене податке у вези са чланком и пруже их на увид Редакцији, као и јавни приступ тим подацима, ако је то могуће, и да, у сваком случају, буду спремни да сачувају те податке у разумном року после објављивања.

Аутори треба да напишу потпуно оригиналне радове, а ако су користили радове и/или формулације других, онда то треба да наведу на одговарајући начин.

У принципу, аутори би требало да објаве рукопис који се суштински бави истим истраживањем само у једном часопису или примарној публикацији. Слање истог рукописа у више редакција часописа у исто време представља неетичко понашање и неприхватљиво је.

Обавезно је да аутор наведе радове које је користио у писању рукописа, као и да цитира публикације које су утицале на његов рад.

Ауторство треба да буде ограничено на оне који су значајно допринели идеји, њеном обликовању, извођењу или интерпретацији у датом истраживању. Сви који су значајно допринели раду треба да буду наведени као коаутори. Ако су појединци били битни у појединим аспектима истраживачког пројекта, треба им у захвалници одати признање за допринос.

Аутор треба да се постара да сви коаутори буду наведени као такви, као и да међу наведеним нема оних који то не заслужују. Ауторова дужност је да сви коаутори виде и одобре финалну верзију рада, као и да одобре његово објављивање.

Ако се у истраживању појављују хемијска једињења, поступци или опрема који су опасни по здравље људи или животиња, аутор то мора јасно да назначи у рукопису.

Сваки аутор треба да наведе у рукопису све врсте финансијских и осталих значајних конфликата интереса који би могли да утичу на резултате или интерпретацију његовог рада. Сви извори финансијске подршке треба да буду такође наведени.

Када аутор открије материјалну грешку или нетачност у свом објављеном раду, његова је дужност да одмах обавести Редакцију часописа или издавача и да сарађује са Редакцијом при повлачењу или кориговању рада.

Разрешавање спорних ситуација

Сваки појединац или институција могу у било ком тренутку да уреднику и/или уредништву пријаве сазнања о кршењу етичких стандарда и другим неправилностима и да о томе доставе неопходне информације/доказе. Поступак провере изнесених доказа одвијаће се у складу са следећим принципима: уредништво ће донети одлуку о покретању поступка који има за циљ проверу изнесених навода и доказа; током тог поступка сви изнесени докази сматраће се поверљивим материјалом и биће предочени само оним лицима која су директно укључена у поступак; лицима за која се сумња да су прекршила етичке стандарде биће дата могућност да одговоре на оптужбе изнесене против њих; ако се установи да је заиста дошло до неправилности, процениће се да ли их треба окарактерисати ако мањи прекршај или грубо кршење етичких стандарда. Ситуације окарактерисане као мањи прекршај решаваће се у директној комуникацији са лицима која су прекршај учинила, без укључивања трећих лица, нпр.: обавештавањем аутора/рецензената да је дошло до мањег прекршаја који је проистекао из неразумевања или погрешне примене академских стандарда; слањем упозорења аутору/рецензенту који је учинио мањи прекршај. У случају грубог кршења етичких стандарда, уредништво доноси одлуке о даљим акцијама. Мере које ће предузети могу бити следеће (и могу се примењивати појединачно или истовремено): објављивање саопштења или уводника у ком се описује случај кршења етичких стандарда; слање службеног обавештења руководиоцима или послодавцима аутора/рецензента; повлачење објављеног рада у складу са процедуром описаном под Повлачење већ објављених радова; ауторима ће бити забрањено да током одређеног периода шаљу радове у часопис; упознавање релевантних стручних организација или надлежних органа са случајем како би могли да предузму одговарајуће мере. Приликом разрешавања спорних ситуација редакција часописа редакција се руководи смерницама и препорукама Одбора за етику у издаваштву (Committee on Publication Ethics – COPE): http://publicationethics.org/resources/.

Одрицање одговорности

Изнесени ставови у објављеним радовима не изражавају ставове уредника и чланова редакције часописа. Аутори преузимају правну и моралну одговорност за идеје изнесене у својим радовима. Издавач неће сносити никакву одговорност у случају испостављања било каквих захтева за накнаду штете.

Рекламирање

Није дозвољено рекламирање у *Војнотехничком гласнику.*

КОДЕКС ПРОФЕССИОНАЛЬНОЙ ЭТИКИ ЖУРНАЛА
«ВОЕННО-ТЕХНИЧЕСКИЙ ВЕСТНИК»

Публикация статьей после их профессиональной рецензии является основной деятельностью научного журнала «*Военно-технический вестник*». В первую очередь необходимо достичь договоренности об этических нормах и принципах, применяемых ко всем участникам в процессе выпуска журнала, начиная с автора, Редакционной коллегии, профессиональных рецензентов до издателя.

Обязанности редакторов «*Военно-технического вестника*»

Редакция журнала «*Военно-технический вестник*» сообщает, что не взымает с авторов плату за публикацию их статей, то есть, все действия, связанные с редактированием и размещением статей в Вестнике являются абсолютно бесплатными.

Редакция «*Военно-технического вестника*» несет ответственность за принятие решений о публикации представленных в адрес журнала статей. При наличии конфликта интересов редактор не принимает участия в процессе рассмотрения рукописи. В таком случае решение о выборе рецензента и публикации рукописи принимает редколлегия. При наличии конфликта интересов члены редколлегии не принимают участия в процессе рассмотрения рукописи.

Редакция обязана соблюдать политику Редакционной коллегии *«Военно-технического вестника*», а также положения действующего законодательства, регулирующие вопросы распространения заведомо ложных сведений, порочащих честь и достоинство другого лица или подрывающих его репутацию и несоблюдения авторских прав. Редакция имеет право проконсультироваться с Редакционной коллегией или рецензентами относительно принятия решений о публикации статьи.

Редакция отбирает и оценивает материалы независимо от пола, религии, расы, национальности, политических убеждений автора.

По рекомендациям Центра поддержки развития образования и науки (ЦПРОН), редакция журнала в своей работе пользуется электронной системой редактирования ASSISTANT, обеспечивающей транспарентность и доступность информации о текущем соотоянии рукописи, а также подразумевает полную ответственность за принятие решения о её публикации.

Путём использоваия системы iThenticate (CrossRef и CrossCheck) редакция до момента представления статьи рецензентам проверяет её содержание на плагиат. В соответствии со стандартами журнала, плагиат, то есть присвоение чужих идей, высказываний либо другой формы творческого выражения и представление их как своих собственных представляет собой грубое нарушение научной и редакционной этики. Плагиат является уголовно наказуемым нарушением авторских прав. С точки зрения редакции, плагиатом является: дословное копирование работы другого лица, либо цитирование работы другого лица без указания его авторства, ссылки на источник; некорректное перефразирование произведения другого лица без ссылки на источник; использование элементов работы (рисунков, таблиц, графиков, диаграмм) другого лица без указания авторства, ссылки на источник; авторы должны получить разрешение владельца авторских прав на использование элементов его работы. В случае возникновения обоснованного сомнения в том, что работа является плагиатом, редакция отказывает автору в публикации.

Редакция журнала проводит конфиденциальное рецензирование, применяя «двойной слепой метод». Авторы статьи и рецензенты не знают друг друга.

Никто из работников издательской компании не имеет право раскрывать любые сведения о представленной научной статье, за исключением случаев, если они по мере потребности нужны автору, рецензентам, возможным рецензентам и другим советникам редакторов и издателя.

Неопубликованными материалами нельзя воспользоваться для исследовательских работ без согласия автора.

Редакция обязуется исключить из публикации принятую статью, в случае следующих нарушений:

– плагиат,

– автоплагиат,

– повторная публикация в данном или другом издании,

– неверные данные об авторе (присвоение чужой работы, указание автора не принимавшего участия в написании работы),

– конфликт интересов,

– фальсификация результатов исследования,

– неправильно оформленные рисунки (графики, иллюстрации) и таблицы,

– крупные технические ошибки в оформлении текста, на-пример, пропуск частей текста.

Стандарты регламентирующие процедуру снятия опубликованной работы с публикации, которые применяет «Военно-технический вестник» предписаны Национальной библиотекой Сербии (НБС) и другими научными учреждениями. За статьей (определённой к снятию) в электронном формате закрепляют HTML ссылку с уведомлением о её снятии с публикации. Изъятая статья хранится в исходном виде, но каждая страница ПДФ формата визируется печатью, свидетельствующей о снятии статьи с публикации (RETRACTED).

Отзывы и исправления публикуются в соответствии с требованиями ЦПРОН – Сербского индекса научного цитирования (СЦИндекс/SCIndex) (http://www.ceon.rs/pdf/postupanje_s_nelegitimnim_radovima.pdf), при этом метаданные отозванных и снятых с публикации статей должны быть обозначены соответствующим предупреждением и соединены между собой ссылками.

Обязанности рецензентов

Рецензенты должны профессионально и объективно аргументировать свою позицию и в указанный срок предоставить редактору оценку научной ценности рукописи.

Рецензенты, рассматривая работы оценивают соответствие темы работы с профилем журнала, релевантность исследуемой области и примененных методов, оригинальность и научную значимость результатов, представленных в рукописи, стиль научного изложения, а также использование в тексте научного аппарата.

Профессиональный рецензент оказывает поддержку Редакции при принятии решений о публикации статьей, а также, оказывает содействие авторам в целях улучшения качества их работы. Взаимодействие рецензента с авторами осуществляется путём контактов с ними через Редакцию.

В случае если рецензент считает, что он в достаточной степени не обладает качествами, необходимыми для осуществления профессиональной рецензии работы, или не сможет её осуществить во время, то ему необходимо об этом проинформировать Редакцию.

Любая работа, представленная на рецензию, является конфиденциальным документом и её нельзя показывать третьим лицам без одобрения Редакции.

Рецензия должна базироваться на объективных условиях. Не допускается личная критика автора. Рецензенты должны обосновать и доказать свои позиции по отношению к статье.

Рецензенты обязаны идентифицировать релевантные существующие работы, которые автор не цитировал. По любому общему сведению или аргументу приведенным в работе должны быть указаны соответствующие цитаты. Рецензент обязан обратить внимание редактору на эвентуальные сходства работы с другими опубликованными работами, в случае если такое будет обнаружено.

Мнение и выводы о рукописи статьи, к которым пришли рецензенты является конфиденциальной информацией и ей нельзя воспользоваться для личных потребностей. Рецензентам рекомендуется не рецензировать работы, которые могут вызвать коллизию интересов (конкуренты, совместная работа, или иные другие отношения с автором, компанией или учреждением связанными с работой).

Обязанности авторов

В своей исследовательской работе авторы должны придерживаться принципов четкости, разборчивости, понятности с целью объективного растолкования значения данной работы. Факты и показатели должны быть четко указаны. Работа должна содержать в достаточной степени фактов и деталей, чтобы она могла репродуцироваться. Неправильные или неточные утверждения являются примером неэтического поведения и не будут приняты.

Авторы должны обеспечит Редакцию первичными, необработанными данными, относящимися к работе, и представить их на рассмотрение Редакции, и обеспечить к ним доступ всем заинтересованным лицам, если это является возможным. Также, авторы должны после публикации статьи хранить в разумные сроки полученные результаты.

Авторы должны в своих работах заниматься полностью оригинальными вопросами. В случае если они в своей работе использовали данные или факты других авторов, то об этом необходимо указать в работе.

Также, авторы должны свои работы публиковать только в одном научном журнале, или размещать публикации на сайте с прямыми ссылками. Публикация одной и той же работы в нескольких научных журналах считается неэтичным поведением и является недопустимой.

Авторы работ обязаны указать в своих работах все материалы, которыми они воспользовались при исследовании, в том числе все публикации, которые повлияли на результаты их исследований.

Авторство должно быть ограничено только теми лицами, которые в значительной степени участвовали в процессе исследования и получения результатов работы. Имена, отчества, фамилии всех лиц, участвующих в значительной степени в процессе исследования и получения результатов работы, должны быть указаны в работе в качестве соавторов, и их необходимо поблагодарить за содействие.

Автор должен обеспечить условия, чтобы имена, отчества, фамилии всех соавторов, действительно участвующих в процессе исследования и содействующих получению результатов, были указаны в работе. Также, обязанностью автора является предоставление окончательной версии работы соавторам на согласование.

В случае появления в процессе исследования необходимости контакта с опасными веществами, т.е. веществами, обладающими потенциальной опасностью в отношении человека, животных и окружающей среды, то автор об этом должен четко указать в работе.

Каждый автор обязан в работе указать на все виды потенциальных финансовых или других конфликтов интересов, которые могли бы повлиять на результаты исследования или их интерпретацию. Все источники финансовой поддержки должны быть указаны в работе.

В случае обнаружения автором в работе существенные ошибки или какие-либо неточности, он обязан об этом незамедлительно сообщить Редакции журнала или издателю, также оказать содействие в их исправлении.

Разрешение спорных ситуаций

Любое лицо, либо учреждение вправе в любой момент предъявить претензию редактору или редколлегии в связи с нарушением этических стандартов и авторских прав, подкрепив ее достоверными доказательствами.

По получении претензии, подкрепленной доказательствами, редакционная комиссия проведет расследование, в соответствии со следующими принципами: редколлегия принимает решение о проведении проверки по поводу выдвинутых жалоб и доказательств о нарушении редакционной этики; в процессе рассмотрения доказательств, все материалы считаются конфиденциальными и будут предоставлены только тем лицам, которые непосредственно причастны к процессу проверки; подозреваемым лицам в нарушении этических норм будет предоставлена возможность ответить на выдвинутое против них обвинение; в случае выявления нарушения, характеризуется его степень, как грубого или негрубого нарушения этических норм.

В случае негрубого нарушения, редакция напрямую, без содействия третьих лиц, обращается к нарушителю, следующим образом: путем уведомления автора/рецензента о наличии негрубого нарушения, произошедшего вследствие недопонимания, либо несоответственного применения академических стандартов; путем предупреждения автора/рецензента, допустившего негрубое нарушение.

В случае грубого нарушения этических норм, редакция принимает решение о дальнейших мерах. Редакция вправе предпринять следующие меры (одновременно, поочередно или в отдельности): обнародование сообщения, в котором описывается случай нарушения этических стандартов; официальное уведомление руководителей или работодателей автора/рецензента; снятие опубликованной статьи с публикации, в соответствии с предписаниями; авторы-нарушители определенный период времени не будут допускаться к публикации в журнале; уведомление релевантных профессиональных организаций и соответствующих учреждений о случае, в целях привлечения нарушителя к ответственности.

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IN MEMORIAM

IN MEMORIAM
мр Небојша Кујунџић 1976 – 2020.

Наш колега Небојша Кујунџић, магистар дизајна, ликовно-графички уредник „Војнотехничког гласника", изненада је преминуо 25. новембра 2020. године у Београду. Вест смо примили с неверицом, јер је тих дана извршавао и свој последњи радни задатак – ликовно-графичко уређење и припрему за штампу новог броја нашег часописа.

Његовом смрћу Министарство одбране изгубило је једног од изузетних и талентованих стручњака из области ликовно-графичког дизајна, у време његове највеће стваралачке и уметничке снаге и домета.

Рођен је 4. септембра 1976. године у Београду. У својој радној каријери прешао је веома успешан пут. На службу у Министарство одбране, где је провео свој радни век на радним местима ликовно-графичког уредника, ступио је септембра 2004. године.

Небојша је био човек посвећен послу. Своју љубав према струци и жељу за сталним усавршавањем доказао је преданим и надахнутим радом, као и завршетком магистарских студија и одбраном магистарског рада 2003. године на Факултету примењених уметности у Београду.

Био је ведрог духа, увек спреман за шалу, чиме је стицао наклоност својих колега. Пленио је својом скромношћу, марљивошћу, несебичношћу и добротом.

Редакција „Војнотехничког гласника" опрашта се од свог ликовно-графичког уредника Небојше Кујунџића са изразима најдубље захвалности за драгоцену сарадњу и са осећајем ненадокнадивог губитка.

<div align="right">Небојша Гаћеша</div>

Художественный редактор

Магистр дизайна, *Небойша* Куюнджич ,
Мария Марич, e-mail: marija.maric@mod.gov.rs

Технический редактор
Кандидат технических наук *Небойша* Гачеша, e-mail: nebojsa.gacesa@mod.gov.rs,
https://orcid.org/0000-0003-3217-6513

Корректор
Добрила Милетич,
e-mail: miletic.dobrila@gmail.com

Перевод на английский язык
Ясна Вишнич,
e-mail: jasnavisnjic@yahoo.com, https://orcid.org/0000-0003-1728-4743

Перевод на русский язык
Д.филол.н. *Карина* Кареновна Авагян,
e-mail: karinka2576@mail.ru

Перевод на немецкий язык
Гордана Богданович,
e-mail: gordana.bogdanovic@yahoo.com

Перевод на французский язык
Драган Вучкович,
e-mail: draganvuckovic64@gmail.com, https://orcid.org/0000-0003-1620-5601

According to the Opinion of the Ministry of Science and Technological Development No 413-00-1201/2001-01 of 12th September 2001, the *Military Technical Courier* is a publication of special interest for science.

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