NBP - JOURNAL OF CRIMINALISTICS AND LAW

NBP – ŽURNAL ZA KRIMINALISTIKU I PRAVO

IZDAVAČ
Kriminalističko-policijska akademija, Cara Dušana 196, Zemun

INPRESS
Beograd

TIRAŽ
300 primeraka

PDF VERZIJA ČASOPISA
casopis@kpa.edu.rs

UDK 351.74 **ISSN 0354-8872**

ACADEMY OF CRIMINALISTIC AND POLICE STUDIES,
BELGRADE – THE REPUBLIC OF SERBIA
KRIMINALISTIČKO – POLICIJSKA AKADEMIJA,
BEOGRAD – REPUBLIKA SRBIJA

NBP
JOURNAL OF CRIMINALISTICS AND LAW

NBP
ŽURNAL ZA KRIMINALISTIKU I PRAVO

KRIMINALISTIČKO – POLICIJSKA AKADEMIJA,
BEOGRAD – 2009

SADRŽAJ

GEL-COMBUSTION SYNTHESIS OF $COSB_2O_6$ AND ITS REDUCTION TO POWDERY SB_2CO ALLOY

*Ilic D.[1], Dasic M.[2], Holl K.[1], Mentus S.[2]

[1]*Varta Microbattery GMBH- Daimlerstrasse 1, 73479 Ellwangen, Germany*
[2]*Belgrade University, Faculty of Physical Chemistry, Studentski trg 1, 11000 Belgrade, Serbia*

Abstract: The Sb_2Co alloy in powdery form was synthesized via reduction with gaseous hydrogen of oxide $CoSb_2O_6$ obtained by citrate gel-combustion technique. The precursor was an aqueous solution of antimony nitrate, cobalt nitrate and citric acid. The precursor solution with mole ratio Co(II)/Sb(V) of 1:2 was gelatinized by evaporation of water. The gel was heated in air up to the temperature of self-ignition. The product of gel combustion was a mixture of oxides, and it had to be additionally thermally treated in order to be converted to pure $CoSb_2O_6$. The reduction of $CoSb_2O_6$ by gaseous hydrogen yielded powdery Sb_2Co as a sole phase. The process of oxide reduction to alloys was controlled by thermo-gravimetry, while X-ray diffractometry was used to control phase compositions of both oxides and alloys.

Keywords: $CoSb_2O_6$, gel-combustion, inter-metallic compound, thermo-gravimetry, Sb_2Co, X-ray diffractometry

1. Introduction

The sol-gel techniques and their variances, gel-combustion techniques, are widely used to produce nano-dispersed, simple or combined, oxides serving as high temperature superconductors (Pederson, Maupin, Weber, McReady, Stephens, 1991), ferrites (Huang, Zhuang, Li, 2003; Wang, Gui, Shu, Zhou, 2002), electrode materials for lithium batteries (Jugovic, Cvjeticanin, Kusigerski, Mentus, 2003), catalysts (Jiao, Wu, Qin, Xu, 2003; Yoshimura, Sato, Shimada, Matsubayashi, Imamura, Nishijima, Higo,Yoshitomi, 1996), etc. The reduction of oxides by heating in hydrogen atmosphere presents an already known procedure of powder metallurgy, enabling the synthesis of powders of pure metals or alloys (Okamoto, Ishikawa, 1989; Kim, Lee, Sohn, Hwang Lee, 2002; Benton, Emmett,

* Corresponding author:Email- dilic@arri.de

1924; Rodriguez, Hanson, Frenkel, Kim, Perez, 2002; Richardson, Scates, Twigg, 2003; Jankovic, Adnadjevic, Mentus, 2007; Konstanchuk, Ivanov, Boldyrev, 1984; Ressler, Wienold, Jentoft, 2001; Morales, 2003).

The sol-gel techniques, being faster and more effective, replace more and more classical solid-state synthesis procedures. Namely, low mobility of atoms in solids is basic obstacle in the synthesis of solid materials through classic solid-state reactions, where relatively coarse starting mixtures of solid compounds require either long time or high temperatures to achieve inter-diffusional homogenization to a molecular level. Sol-gel techniques enable to obtain intimate precursor mixture homogeneous to molecular level, leading to a final product with only little additional treatment. The citrate gel-combustion method was already used to synthesize complex oxide compounds LiMn2O44 and $NiWO_4$ (Mentus, Majstorović, Tomić, Dimitrijević,2005), while the two-step procedure involving both gel-combustion synthesis of oxide mixtures and their reduction to alloys was used recently to obtain Ni-W (Mentus, Majstorović, Tomić, Dimitrijević, 2005) and Ni-Mo (Mentus, Tomić-Tucaković, Majstorović, Dimitrijević, 2008) alloys. The hypothesis underlying this two-step route may be expressed as follows: gel-combustion procedure provides a mixture of oxides homogeneous to a molecular level, which, upon reduction, yields immediately a thermodynamically stable alloy. This idealized performance assumes low temperature synthesis of an alloy, without the need for any additional thermal treatment to relax its structure.

The inter-metallic compound $CoSb_2$ is the representative of arsenopyrite class of compounds (Caillat,1995). This alloy is known also as semiconductor material of relatively low thermal conductivity and high thermoelectric power (Liu, Jiuxing, Dong,2007; Feschotte, Lorin, 1989). For semiconductor investigations, large crystals of $CoSb_2$ were synthesized earlier by Feschotte et al. (Feschotte, Lorin, 1989) by gradient-freeze technique The inter-metallic compound $CoSb_2$ have become additionally interesting recently as an anodic material of Li-ion batteries, being characteristic of high theoretical faradic capacity (amounting to even 530 mAg^{-1}) as well as nice cyclability, if prepared in nano-dispersed or amorphous for (Aboulaich, Mouyane, Robert, Lippens, Olivier-Fourcade, Willmann, Jumas,2006; Xie, Zhao, Cao, Zhong, Zhao, Tu, 2005; Xie, Cao, X.B. Zhao, Zhong, Zhao, 2004; Lippens, Olivier-Fourcade, Jumas, ,2006; Chevrier, Dahn, 2006). Xie et al. (Xie, Zhao, Cao, Zhong, Zhao, Tu, 2005) published the synthesis of nano-dispersed alloy based on levitation melting and ball milling of solidified bulk alloy. Somewhat later, Xie et al. (Xie, Cao, Zhao, Zhong, Zhao, 2004) published the solvothermal synthesis: the solution of $CoCl2\times6H_2O$, $SbCl_3$ and $NaBH_4$ in anhydrous ethanol, placed in the autoclave and thermostated certain time, yielded Sb_2Co alloy as a precipitate, which was filtered, washed, and vacuum-dried.

The intention of the present study was to synthesize Sb2Co alloy in powdery form, by reduction of a mixed oxide $CoO\text{-}Sb_2O_5$ synthesized by combustion of corresponding citrate gel. This is an attempt to surmount the disadvantages of a classic metallurgical melt-solidification route, which requires closed conditions due to a pronounced ability of antimony to sublimate (Xie, Zhao, Cao, Zhong, Zhao, Tu, 2005; Chevrier, Dahn, 2006), as well as to avoid relatively complex solvothermal synthesis (Xie, Cao, Zhao, Zhong, Zhao, 2004).

2. The experiment

The chemicals used in this study: Sb, $Co(NO_3)_2x\ 6H_2O$ and citric acid, were purchased from Merck. 1 g of metallic powdery Sb (8.214 mmol) was mixed with 5.178 g of citric acid (24.6 mmol) and 1 ml of concentrated nitric acid, and 2 ml of distilled water was added. The antimony was dissolved quantitatively under slight heating. Then 1.1952 g of $Co(NO_3)_2x\ 6H_2O$ (4.107 mmol) was added to the solution, to obtain mole ratio Sb : Co = 2 : 1. The solution was dried at 80^o C during 24 h to gelatinize. Dry gel was heated in air up to the self-ignition, which happened at about 300^o C, yielding a dark-gray powder, which was expected to be oxide mixture. This powder was isothermally treated for 30 min in air, at a predetermined temperature, in order to remove traces of carbon, which unavoidably consolidated the crystal structure, too. A small part of the oxide sample was used to prove thermo-gravimetrically the conditions of reduction with gaseous hydrogen. TA Instruments Model 2090 TG-DTA device was used to obtain TG diagram under flow of gas mixture $Ar + H_2$ (25 vol.%). By means of TG curve the final temperature of reduction was determined. Then, the whole oxide mass was placed in a quartz tube which was protruded through a horizontal furnace, and the reduction gas stream ($Ar+H_2$ (25 vol. %)) of a constant flow rate of 70 ml min^{-1} was established through the tube. After heating up to the temperature required for the complete reduction, the gray powder was obtained, which was expected to be Sb_2Co. The X-ray analysis for the purposes of this study was performed by means of Philips PW 1710 diffractometer, using $CuK_{\alpha 1,2}$ line (λ = 1,54056 Å) in the $15 – 70^o$ 2θ, in steps 0.05 with exposition of 3 s. The morphology of alloy was observed by scanning electron microscope JEOL JSM-840A.

3. Result and discussion

As known from inorganic chemistry, CoO and Sb_2S_5 may build up a complex oxide compound $CoSb_2O_6$. This compound was expected to be the direct product of gel-combustion synthesis described in the experimental section, in view of the hypothesis that gel-combustion procedure provides homogenization

on a molecular level. The powdery product of gel-combustion procedure described in the Experiment section, treated isothermally at 700^o C during 30 min in order to remove traces of carbon, was subjected to X-ray diffractometry in order to examine the phase composition. The XRD diffractogram (Figure 1) evidenced not only the expected pure $CoSb_2O_6$, but a mixture of $CoSb_2O_6$, Sb_2O_3 and CoO, identified on the basis of JCPDS cards 18-0403, 72-1854, and 75-0418 (Powder Diffraction Files,1987) respectively. The appearance of the compound $CoSb_2O_6$ confirms the expectation that the gel-combustion procedure leads to very intimate mixture of oxides, able to react mutually and to build a thermodynamically stable compound. However, the appearance of free simple oxides indicates that the temperature developed during gel combustion, was insufficient to provide complete conversion of simple oxides to their product, $CoSb_2O_6$. The appearance of lower-valence oxide Sb_2O_3 is most probably due to the partial reduction of Sb_2O_5 by carbon appearing as a product of incomplete combustion of citric acid. In order to examine whether the obtained oxide mixture, in spite of its complexity, may yield the expected Sb_2Co alloy, the complete product of gel-combustion was undergone to reduction. Namely, the lower the temperature used in the procedure, the lower the mean particle radius of the resulting product may be expected. The procedure of reduction was checked firstly by thermo-gravimetry. For this purpose, the oxide mixture was subjected to reduction within a thermo-balance, in a stream of gaseous mixture Ar + H_2 (25%). Figure 2 presents the mass change during the linearly programmed heating. Obviously, the reduction accompanied by mass loss proceeds in one step and finishes at 650^o C. This TG curve shows that the mass loss amounts to 20%, confirming that a part of Sb existed as Sb_2O_3 in the initial product. Namely, the mass loss which corresponds to the conversion $CoSb_2O_6 \rightarrow Sb_2Co$ amounts to 24%. The TG data in Figure 2 show that the temperature of at least 650^o C is required to finalize the reduction of oxides. Having this fact in mind, the whole amount of the oxide product obtained by gel-combustion was reduced in a stream of gaseous mixture H_2(25 vol.%)+Ar at 800 ^{o}C, and then cooled to room temperature, keeping it permanently under the reducing gas stream to avoid re-oxidation. The X-ray diffractogram of the obtained alloy, shown in Figure 3, evidences that the resulting alloy presented a mixture of Sb_2Co (monoclinic, JCPDS card No 29-0126 (Powder Diffraction Files, 1987)) and SbCo (JCPDS card No 33-0097 (Powder Diffraction Files, 1987)). On the basis of relative intensities, Sb_2Co appears to be in excess. A real explanation for the complexity of the phase composition illustrated in Figure 3 is the presence of simple oxides in the initial oxide mixture, as visible in Figure 1. At least free antimony oxide present in the initial mixture yields elementary Sb during reduction, which may evaporate at 800^o C and deteriorate the expected mole ratio Sb:Co of 2:1. This explains the appearance of SbCo besides Sb_2Co in the final alloy. To avoid these

obstacles, an attempt was made to simplify the phase composition of oxides by an additional thermal treatment. Therefore, the oxide product obtained upon gel-combustion was treated isothermally at the temperature of 1000^o C, in an air stream, during 30 min, under the expectation that the simple oxides CoO and Sb_2O_3, appearing together with $CoSb_2O_6$, will react mutually via solid-state reaction, yielding pure $CoSb_2O_6$. After this treatment, the oxide product was examined by X-ray diffractometry, and the diffractogram, shown in Figure 4, actually evidenced only one phase, $CoSb_2O_6$. The mono-phase powder $CoSb_2O_6$ was then subjected to reduction. A thermo-gravimetric curve of reduction of a small sample of the same oxide presented in Figure 5, shows mass loss of 24%, which is in accordance with the calculated value for the complete reduction of $CoSb_2O_6$ to metal. Generally, there is no remarkable difference in the shape between this TG curve of mono-phase oxide, and the one presented in Figure 2 for multiphase oxide mixture. Therefore, the oxide $CoSb_2O_6$ was reduced in the same way, by heating in air Ar $+H_2$ (25%) stream at 800^o C during 30 min. Upon cooling to room temperature the mass was undergone to X-ray diffractometry and SEM examinations. The X-ray diffractogram presented in Figure 6 indicates the presence of Sb_2Co only, although relatively low signal-to-noise ratio indicates its low crystallinity degree. Its SEM picture shows that the particle diameter amounts to few micrometers, and that the relatively high temperature of 800^o C, needed to oxide reduction, causes partial particle agglomeration by sintering.

4. Conclusion

The intention of this study was first to synthesize the intimate mixture of CoO and Sb_2O_5, expecting to obtain $CoSb_2O_6$, and reduce it to an inter-metallic compound Sb_2Co in powdery form. The gel-combustion procedure was used for oxide mixture synthesis. The conditions of oxide reduction were controlled thermo-gravimetrically, while the phase composition of solid products was controlled by X-ray diffractometry. For the product of gel-combustion, purified from carbon residues by heating in air at 700^o C, the X-ray diffractometry evidenced a multiphase system, consisting of mixture of $CoSb_2O_6$ + CoO + Sb_2O_3. Its reduction in hydrogen atmosphere at 800^o C yielded two-phase metallic product composed of SbCo and Sb_2Co. In order to improve the procedure, the oxide mixture obtained by gel-combustion procedure was treated additionally by annealing at 1000^o C. This treatment provided the mono-phase oxide $CoSb_2O_6$. Its reduction in hydrogen atmosphere at 800^o C yielded mono-phase alloy, Sb_2Co. This method requires a reduced number of time consuming steps in comparison to solvo-thermal method.

5. References

1. A. Aboulaich, M. Mouyane, F. Robert, P-E. Lippens, J. Olivier-Fourcade, P. Willmann, J-C. Jumas, (2006), in *Meeting Abstracts, International Meeting on Lithium Batteries*, Biarritz, France Abst. No 285
2. A.F. Benton, P.H. Emmett, (1924), *J. Am. Chem. Soc*. 46 2728
3. B. Jankovic, B. Adnadjevic, S. Mentus, (2007), *Thermochim. Acta*, **456** 48
4. D.Jugovic, N.Cvjeticanin, V.Kusigerski, S.Mentus, (2003), *J. Optoelectronics and Advanced Materials*, **5** 343
5. H.-J. Kim, J.-H. Lee, I.-H.Sohn, T.-J. Hwang K.-Y.Lee, (2002), *Korea-Australia Rheol. J.* **14** 71
6. H.Okamoto, A.Ishikawa, (1989), *Appl. Phys. Letters* **55** 19239
7. I.K. Konstanchuk, E.Yu.Ivanov, V.V. Boldyrev, (1984), *Mat. Res. Bull*. **19** 769
8. J.A. Rodriguez, J.C. Hanson, A.I. Frenkel, J.Y. Kim, M. Perez, (2002), *J. Am. Chem. Soc*. **124** 346
9. J. Huang, H. Zhuang, WenLan Li, (2003), *Mat. Res. Bull*. **38** 149
10. J.T. Richardson, R. Scates, M.V. Twigg, (2003), *Appl. Phys. A: General* **246** 137
11. J. Xie, G.S. Cao, X.B. Zhao, Y.D. Zhong, M.J. Zhao, (2004), *J. Electrochem. Soc.,* **151** A1905
12. J.Xie, X.B.Zhao, G.S. Cao, Y.D. Zhong, M.J. Zhao, J.P. Tu**,** (2005), *Electrochim. Acta,* **50** 1903
13. K. Liu, Z. Jiuxing, X.Dong, (2007), *Journal of Materials Processing Technology*, 184 257
14. L.R. Pederson, G.D. Maupin, W.J. Weber, D.J. McReady, R.W. Stephens, (1991), *Mat. Lett*. **10** 437
15. P.-E. Lippens, J. Olivier-Fourcade, J.-C. Jumas, (2006), in *Meeting Abstracts, International Meeting on Lithium Batteries*, Biarritz, France Abst. No 232
16. P.Feschotte, D.Lorin, J., (1989), Less-Common Metals, 155 255
17. Powder Diffraction Files, (1987), Joint Committee on Powder Diffraction Standards, International Center for Diffraction Data, Swarthmore, PA
18. R. Morales, (2003), Scan. *J. Metallurgy* **32** 263
19. S. Mentus, B. Tomić-Tucaković, D. Majstorović, R. Dimitrijević, (2008), *Mater. Chem. Phys.,* in press
20. S. Mentus, D. Majstorović, B. Tomić, R. Dimitrijević, (2005), *Mat. Sci. Forum* **494** 345
21. T.Caillat, (1995), Journal of Physics and Chemistry of Solids 59 61
22. T. Ressler, J. Wienold, R.E. Jentoft, (2001), *Solid State Ionics* **141-142**, 243-251
23. V. Chevrier, J.R. Dahn, (2006), in *Meeting Abstracts, International Meeting on Lithium Batteries*, Biarritz, France Abst. No 277

24. X.-H.Wang, L.L.Z.Gui, S. Shu, J. Zhou, (2002), *Mat.Chem.Phys*. **77** 248
25. Y.Yoshimura, T.Sato, H.Shimada, N.Matsubayashi, M.Imamura, A.Nishijima, M.Higo, S.Yoshitomi, (1996), *Catal. Today* **29** 221
26. Z. Jiao, M. Wu, Z. Qin, H. Xu, (2003), *Nanotechnology,* **14** 458

FIGURES

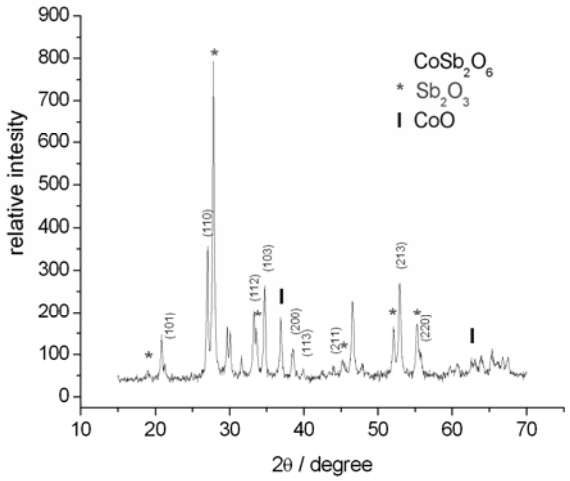


Figure 1- X-ray diffractogram of oxide mixture obtained by citrate gel-combustion, upon thermal treatment at 500^{o} C. The diffraction lines of $CoSb_2O_6$, Sb_2O_3 and CoO are labeled by Miller indices ($CoSb_2O_6$) or by marks, shown in the inserted legend

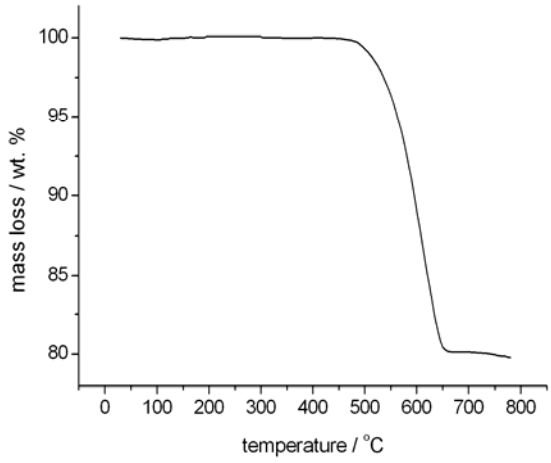


Figure 2 – Thermo-gravimetric curve of mass change during the heating of oxide mixture $CoSb_2O_6$, Sb_2O_3 and CoO in a H_2(25vol.%)+Ar stream, at heating rate 15 C min^{-1}.

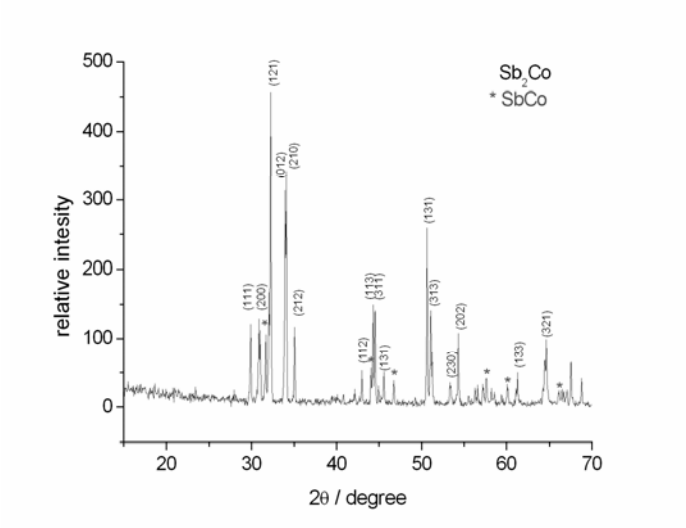


Figure 3 - X-ray diffractogram of alloy obtained by chemical reduction of the product of gel-combustion procedure. The diffraction lines of Sb_2Co are labeled by Miller indices, while those of SbCo are labeled by asterisk.

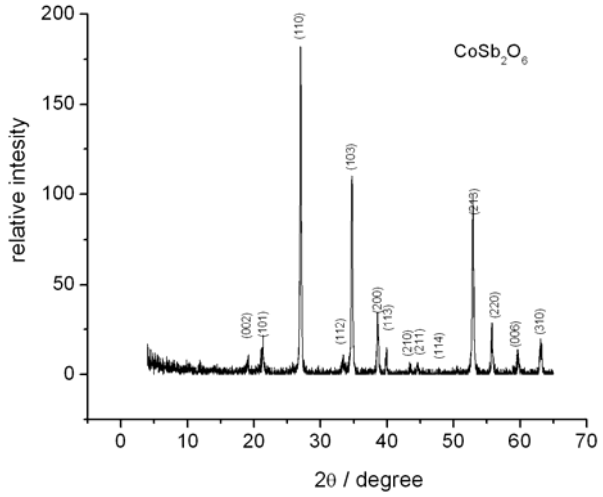


Figure 4 - X-ray diffractogram of the product of gel-combustion, after a thermal treatment at 1000^o C. Only the reflections of $CoSb_2O_6$ labeled by Miller indices may be observed.

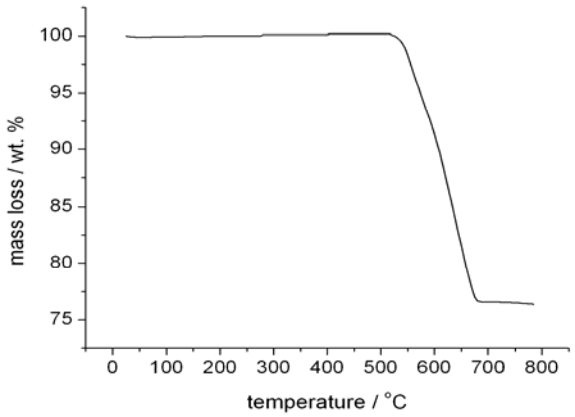


Figure 5 – Thermo-gravimetric curve of mass change during the heating of stoichiometric oxide $CoSb_2O_6$ in a H_2(25vol.%)+Ar stream, at heating rate 15^o C min^{-1}.

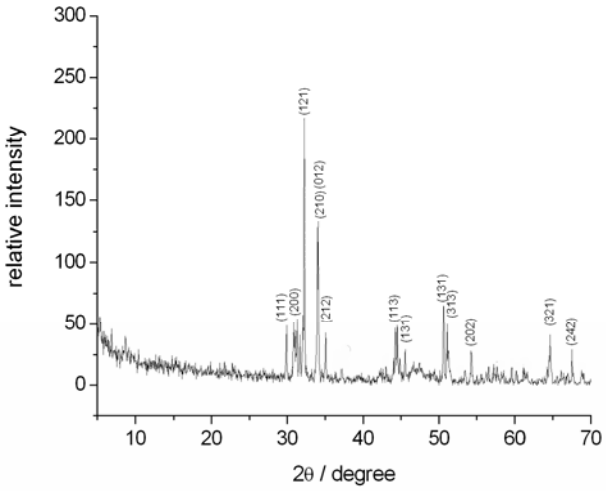


Figure 6 - X-ray diffractogram of the product of reduction of $CoSb_2O_6$. The reflections from different crystallographic planes of Sb_2Co were labeled by corresponding Miller indices.

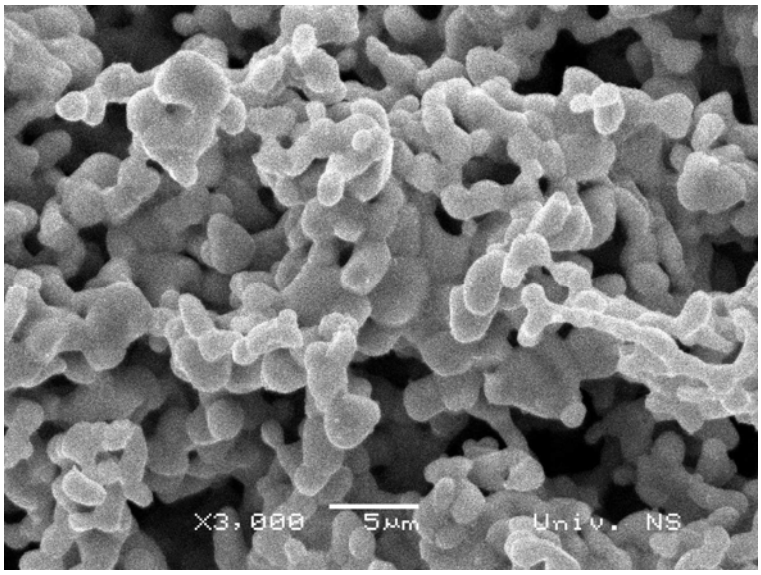


Figure 7 - The SEM microphotograph of Sb_2Co alloy.

REZIME

Sol-gel tehnike i njihove varijante, tehnike sagorevanja gela, u širokoj su primeni prilikom proizvodnje nano-disperzivnih, jednostavnih ili kombinovanih oksida koji se koriste za visokotemperaturne superprovodnike, ferite, elektrodne materijale za litijumske baterije, katalizatore, itd. Ove metode su brže i efikasnije; one sve više zamenjuju postupke klasične sinteze u čvrstom stanju. Namera ovog istraživanja bila je da se sintetizuje praškasta legura Sb2Co redukcijom mešovitog oksida CoO-Sb2O5 koji je sintetizovan sagorevanjem odgovarajućeg citratnog gela. Praškasta legura Sb_2Co sintetizovana je putem redukcije sa gasovitim hidrogenom oksida $CoSb_2O_6$ koji je dobijen tehnikom sagorevanja citratnog gela. Prekursor je činio vodeni rastvor antimon nitrata, kobalt nitrata i limunske kiseline. Prekursor rastvor sa molarnim odnosom Co(II)/Sb(V) od 1:2 želatiniziran je ispravanjem vode. Gel se zagrejavao na vazduhu do temperature samozapaljivanja. Proizvod sagorevanja gela bio je mešavina oksida koja je morala dodatno da se tretira toplotom kako bi se konvertovala u čist $CoSb_2O_6$.

Proces redukcije oksida u leguru kontrolisan je termo-gravimetrijom, dok je rentgenska difraktometrija korišćena za kontrolu faze sjedinjavanja kako oksida tako i legura.

SUMMARY

The sol-gel techniques and their variances, gel-combustion techniques, are widely used to produce nano-dispersed, simple or combined, oxides serving as high temperature superconductors, ferrites, electrode materials for lithium batteries, catalysts, etc. They are faster and more effective; they replace more and more classical solid-state synthesis procedures. The intention of the present study was to synthesize Sb2Co alloy in powdery form, by reduction of a mixed oxide $CoO\text{-}Sb_2O_5$ synthesized by combustion of corresponding citrate gel. The Sb_2Co alloy in powdery form was synthesized via reduction with gaseous hydrogen of oxide $CoSb_2O_6$ obtained by citrate gel-combustion technique. The precursor was an aqueous solution of antimony nitrate, cobalt nitrate and citric acid. The precursor solution with mole ratio Co(II)/Sb(V) of 1:2 was gelatinized by evaporation of water. The gel was heated in air up to the temperature of self-ignition. The product of gel combustion was a mixture of oxides, and it had to be additionally thermally treated in order to be converted to pure $CoSb_2O_6$.

The process of oxide reduction to alloys was controlled by thermo-gravimetry, while X-ray diffractometry was used to control phase compositions of both oxides and alloys.

FORENSIC METHODS IN RISK THEORY

Mašković Lj.
Criminal Justice and Police Academy, Belgrade, Serbia

Abstract: Investigations presented in this paper have shown that fire and explosion risk could be realistically and logically assessed using the analogy with the action minimization in the mechanics. This was achieved by the risk investigation in general case as well as by investigation of standard fire behaving and shock wave explosions. In addition, the explosion risk of the soliton shock waves was also investigated. It was shown that the destruction risk is higher in the case of soliton waves. Apart from the evident fact that analogy with the mechanics could be successfully used in the risk theory, the obtained results enable us to choose parameters of the system field + room, leading to the avoidance or, at least, to the significant reduction of fire and explosion destructions.

Key words: risk minimization, mechanical action, shock wave, explosion, fire.

1. Introduction

Risk is wide and ubiquitous concept. It is present in life, at work, in sports and in any kind of activity, and has uncertain consequences. Therefore, it is very difficult to create a general risk theory. Risk could be successfully decreased by detailed analysis of its specific characteristics. The basic goal of our analysis is risk minimization. Dependent on the parameters characterizing the risk, there is a wide choice of the methodologies available for its minimization. For example, risk at the stock exchange depends on a few thousand parameters, while the number of parameters in factories and workshops is not so high. Those are usually temperature and pressure.

Regardless of a small number of parameters, which determine the risk in plant processing section (Shouman, 1998) risk investigations are necessary because the number of accidental situations can be very high as well as human and material losses (Bedford, Cooke, 2001). In such situations even small contributions to risk minimization can have significant contribution to safety at work (Fisal, Abbasi, 1999).

In general approach the risk will be estimated by the function of a number of risk parameters p_i:

$$\mathbf{Z}(p_1, p_2, p_3, ..., p_N) \equiv \mathbf{Z}(p_i), i = 1,2,3, ...N \tag{1.1}$$

Each change of p_i parameters increases or decreases risk and, generally speaking, the investigation of risk consists of analysis of change of $\mathbf{Z}$ function caused by changes of parameters. If

$$p_i \to p_i + \delta p_i \tag{1.2}$$

The function $\mathbf{Z}$ has to be expanded into the series:

$$\mathbf{Z}(p_i + \delta p_i) = \mathbf{Z}(p_i) + (dp_i \nabla_i)\mathbf{Z} + \frac{1}{2}(dp_i \nabla_i dp_i \nabla_i)\mathbf{Z} \tag{1.3}$$

where

$$\nabla_i = \sum_{i=1}^{N} \vec{e}_i \frac{\partial}{\partial p_i} \tag{1.4}$$

The difference

$$\mathbf{Z}(p_i + \delta p_i) - \mathbf{Z}(p_i) \tag{1.5}$$

represents the measure for risk estimation. It should be pointed out that in (1.3) repeated index indicates summation. This paper will mainly investigate the risks in factories, oil refineries and surrounding areas. This means that basic parameters of $\mathbf{Z}$ function will be pressure and temperature. The basic problem of risk theory is the risk minimization. One of the possible ways of minimization is the use of ideas of action minimization. The importance of this method in mechanics is well known: the Lagrange equations are obtained by action minimization.

Our attempts for risk minimization presented in the paper are based on the analogy with minimization of mechanical action. These attempts have four parts. In the first part general risk assessment from the destruction caused by the external field is performed. Second part refers to the fire risk which is minimized based on the triangle model for temperature field. In the third part triangle model for pressure in the case of a standard shock wave is used. The fourth part investigates the destruction risks coming from the soliton shock wave (trapezium model). This risk is compared to the risk coming from standard shock wave.

2. General approach to minimization problem

In order to use the analogy with the minimization of the mechanical action (where the action depends on coordinates and their derivatives with respect to time), it is necessary, for the risk measure, to be dependent on certain characteristic parameter and its derivative with respect to time. This risk measure has to be minimized. Since this paper will investigate fire and explosion risks, the

risk measure for fire appearance must be dependent on temperature and its derivative with respect to time, while the explosion risk measure has to be expressed through the pressure and its time derivative.

In almost all practical cases, both the temperature as a function of time and the pressure are continual and everywhere positive functions within range $t \in (0,\infty)$, fulfilling the conditions:

$$\lim_{t \to o} F(t) = \lim_{t \to \infty} F(t) = 0 \tag{2.1}$$

Due to the above conditions $F(t)$ function must have at least one extreme within the mentioned time interval. It is in accordance with Roll's theorem: between two equal neighboring values of continual, differentiable function its derivative must have at least one zero. In the described situation it is most appropriate to consider the area between the curve $F(t)$ and constant F_0 as the risk measure. Parameters F_0, if we talk about temperature T, would represent the ignition temperature T_P of the materials in the room, while in case of explosion, F_0 would represent the pressure P_R above which the certain parts of the room or the whole room could be destructed.

Generally speaking, the area taken as the risk measure cannot be expressed through parameters $F(t)$ and $\dot{F}(t) \equiv dF(t)/dt$. Due to this reason an analogous risk measure will be used. For this purpose the following function will be introduced:

$$f(t) = \ln(F(t)/F_0) \tag{2.2}$$

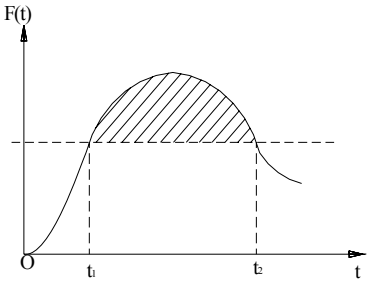
Based on the mentioned characteristics of the $F(t)$ function, the following characteristics of the function $f(t)$ are obvious:

$$\lim_{t \to 0} f(t) = \lim_{t \to \infty} f(t) = -\infty \tag{2.3}$$

$$f(t_1) = f(t_2) = 0 \tag{2.4}$$

where t_1 and t_2 are the time points at which line F_0 intersects the curve. Through the function $f(t)$, risk measure could be expressed as area between t_1 and t_2.

Behavior of the curves $F(t)$ and $f(t)$ is presented in Figure 1(a) and Figure 1(b):



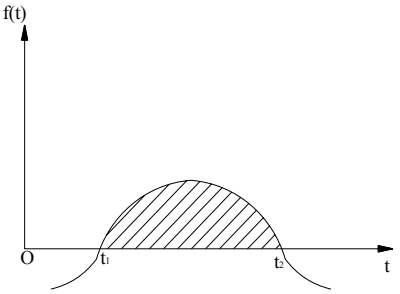


Figure 1(a) - Risk measure presented by means of **F** function

Figure 1 (b) - Risk measure presented by means of **f** function

Having in mind the previous statements, the risk measure can be defined as:

$$S = \int_{t_1}^{t_2} dtf(t) = \int_{t_1}^{t_2} dt \ln \frac{F(t)}{F_0} = \int_{t_1}^{t_2} dt \ln \Phi(t) \tag{2.5}$$

where :

$$\Phi(t) = \frac{F(t)}{F_0} \tag{2.6}$$

In integral (2.5), partial integration could be performed. So, we obtain:

$$S = \int_{t_1}^{t_2} dt \ln \Phi = t \ln \Phi \Big|_{t_1}^{t_2} - \int_{t_1}^{t_2} dt \frac{\dot{\Phi}}{\Phi} t$$

In accordance with (2.4), the first term in the obtained expression is equal to zero. So we get:

$$S = \int_{t_1}^{t_2} dt L(t, \Phi, \dot{\Phi}) \tag{2.7}$$

where:

$$L(t, \Phi, \dot{\Phi}) = -t \dot{\Phi}(t) / \Phi(t) \tag{2.8}$$

Regarding the obtained result, it is necessary to point out the following facts:

- Since we are looking for the extreme of the negative L function, the result will correspond to risk maximum.
- The L function, which is analogue with the Lagrange function in the mechanics, depends not only on variables $F(t)$ and $\dot{F}(t)$, but also on time t. In mechanics this would correspond to minimization of the action of non-conservative systems, but it doesn't change the conditions defining the extreme.

Condition defining the extreme is obtained by equating of variation of the function S with zero, i.e.:

$$\delta S = \int_{t_1}^{t_2} dt(\delta t \frac{\partial L}{\partial t} + \delta\Phi \frac{\partial L}{\partial \Phi} + \delta\dot{\Phi} \frac{\partial L}{\partial \dot{\Phi}}) = 0 \tag{2.9}$$

Since dt and variation ∂t are infinitesimal values of the first order of variable t, the first component in (2.9) can be discarded, and the above expression reduces to:

$$\delta S = \int_{t_1}^{t_2} dt(\delta\Phi \frac{\partial L}{\partial \Phi} + \delta\dot{\Phi} \frac{\partial L}{\partial \dot{\Phi}}) = 0 \tag{2.10}$$

From (2.10), with the completely analogous calculation as in mechanics, the condition defining the extreme is the following:

$$\frac{\partial L}{\partial \Phi} - \frac{d}{dt}\frac{\partial L}{\partial \dot{\Phi}} = 0 \tag{2.11}$$

Determining partial derivatives on the basis of (2.8) and finding the total derivative $\partial L / \partial \dot{\Phi}$,
we obtain:

$$1/\Phi(t) = 0 \tag{2.12}$$

As we can see, the condition (2.12), corresponding to the maximum risk, is logical since it corresponds to the infinite value of the function $F(t)$. Having in mind the previously mentioned characteristics of the function $F(t)$ it is obvious that condition (2.12) could never be fulfilled. Therefore, as the basis for the risk assessment, minimum value of the function $1/\Phi(t)$ is used. This minimum value depends on parameters which characterize the risk source, and on parameters characterizing the area where the risk exists. Risk minimum could be determined from the requirement that minimum $1/\Phi(t)$ is as distant as possible from the zero value. In order to make this last statement clearer, we shall illustrate the risk assessment by a concrete example. We shall consider the function:

$$F(t) = \frac{F_M}{\Omega} \frac{t}{t^2 - t_0^2} \tag{2.13}$$

where ratio F_M / Ω is dimensional parameter and t_0 is time characterizing the maximum value of risk source. Function $F(t)$ is, as it can be seen, continuous, and everywhere positive and fulfills the condition (2.1). The risk assessment is performed through function $F_0 / F(t) = 1/\Phi(t)$. In further steps the function:

$$\frac{1}{\Phi(t)} = \frac{\Omega}{F_M} F_0 \frac{t^2 - t_0^2}{t} \tag{2.14}$$

will be analyzed. The first and second time derivatives of (2.14) are:

$$\frac{d}{dt}\left[\frac{F_0}{F(t)}\right]=\frac{\Omega F_0}{F_M}\frac{t^2-t_0^2}{t^2} \tag{2.15}$$

$$\frac{d^2}{dt^2}\left[\frac{F_0}{F(t)}\right]=\frac{2\Omega F}{F_M}\frac{t_0^2}{t^3} \tag{2.16}$$

Based on the obtained expressions, it could be concluded that for $t>0$ the first derivative is equal to zero at the moment $t=t_0$. For this same value of time the second derivative is positive, and it could be written as:

$$\min\left[F_0/F(t)\right]=(2\Omega/F_M)F_0t_0 \tag{2.17}$$

As it can be seen, this minimum value is expressed by parameters which characterize the field of the function $F(t)$, and those are Ω/F_M and t_0 but also through the parameter F_0 which characterize materials in the room. As it was mentioned before, minimum of the function $F_0/F(t)$ should be as large as possible, because its increase decreases the risk. The result presented by formula (2.17) shows that the risk is lower when Ω/F_M is higher, and when time t_0 for achieving the extreme is longer. Parameter F_0 which characterizes the material in the room must also have the high value. All mentioned conditions are completely logical, because it means that the risk is lower if the field $F(t)$ is weaker and if the material in the room is characterized by high value F_0, at which the damage effects appear.

2. Model for thermal risk minimization

Thermal risk is the risk for a heated room to be caught by fire (Horng,Ching, Yung, 2000). We will define the measure of the thermal risk and minimize it afterwards, using the method analogous with minimization of action in theoretical mechanics, presented in Section 2.

Temperature field is usually presented by the following expression (El Harbawi, et al., 2008) :

$$T(t)\sim t^{-\frac{3}{2}}e^{-\frac{(\vec{r}-\vec{r}_0)^2}{Dt}} \tag{3.1}$$

in which D is diffusion coefficient, $\vec{r}$ is the spatial coordinate and t is time. The function $T(t)$ is presented in Figure 2:

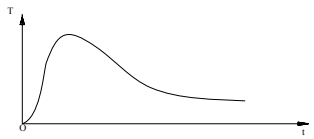


Figure 2 - Usual form of temperature field

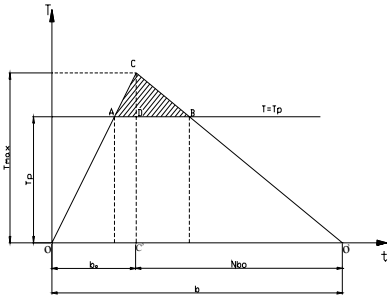


Figure 3 - The triangle model for temperature field with risk measure

This form of temperature field will serve for the introduction of the model temperature field presented by triangle in Figure 3.

As it is shown at the diagram of model temperature, the continuous curve in Figure 2 is replaced by the curve with breaking point in $t = b_0$. The fact has been taken into account that temperature field increases very rapidly towards the maximum and decreases significantly slower with time increase. The use of a triangle model of temperature field with fixed triangle basis and variable ordinate $T_{\max}$, presents relatively rough approximation of the behavior of temperature field shown in Figure 2 (the time-dependence of temperature is presented by smooth curve; the triangle model is not based on smooth curve), but its introduction enables us to express the risk measure, presented with the area of the triangle ABC (area above the horizontal line $T(t) = T_P$) as the function of temperature and its time derivative (the latter appears in equations of lines).

Using the equations of lines going through the points O and C and O' and C', we get that risk measure is presented by:

$$S_{ABC} = \frac{1}{2}\left[T(t) - T_p\right]\left[b - (N+1)\frac{T_P}{\dot{T}(t)}\right] \tag{3.2}$$

The minimization condition can be found by equating of the variation of:

$$\Re = \int_{t_1}^{t_2} dtL\left[T(t), \dot{T}(t)\right] \tag{3.3}$$

with zero. Parameter L, (3.3) is given by:

$$L = \frac{S_{ABC}}{b} = \frac{1}{2}\left[T(t) - T_p\right]\left[1 - \frac{(N+1)}{b}\frac{T_P}{\dot{T}(t)}\right] \tag{3.4}$$

Equating the variation $\delta\Re$ with zero, we obtain the condition for the risk minimization in the following form:

$$\frac{\partial L}{\partial T(t)} - \frac{d}{dt}\frac{\partial L}{\partial \dot{T}(t)} = 0 \tag{3.5}$$

Since the parameter L is positive, this condition defines the minimum risk.

Using (3.4), we find the partial derivatives $\partial L / \partial T(t)$ and. $\partial L / \partial \dot{T}(t)$. By means of these derivatives, we reduce the minimization condition (3.5) to:

$$\frac{\ddot{T}(t)}{\dot{T}^3(t)} - \frac{1}{T(t)-T_p}\frac{1}{\dot{T}(t)} + \frac{b}{2(N+1)T_p}\frac{1}{T(t)-T_p} = 0 \tag{3.6}$$

$$\dot{T}(t) \equiv \frac{dT(t)}{dt} = Y, \ddot{T}(t) \equiv \frac{d^2T(t)}{dt^2} = Y\frac{dY}{dT(t)} \tag{3.7}$$

After the replacement of (3.7) into (3.6) Bernoulli equation is obtained :

$$\frac{1}{Y^2}\frac{dY}{dT(t)} - \frac{1}{T(t)-T_p}\frac{1}{Y} = -\frac{b_0}{2T_p}\frac{1}{T(t)-T_p} \tag{3.8}$$

By means of substitution $1/Y = \theta$, Bernoulli equation (3.8) becomes non-homogenous linear equation of first order:

$$\frac{d\theta}{dT(t)} + \frac{1}{T(t)-T_p}\theta = \frac{b_0}{2T_p}\frac{1}{T(t)-T_p} \tag{3.9}$$

General solution of this equation is:

$$\theta = \frac{1}{Y} = \frac{1}{\dot{T}} = \frac{b_0}{2T_P}\frac{T+C_1}{T-T_P} \tag{3.10}$$

In order to perform further calculation, we have to introduce the initial conditions. In the introduced triangle model the temperature field is assumed to be zero in intervals $[-\infty, 0]$ and $[b, +\infty]$. Based on these assumptions, at the point $t = 0$, the following is valid: $T(0) = 0$ and $\dot{T}(0) = \infty$. The second condition is the consequence of the fact that function $T(t)$ has the break-point at $t = 0$. Substituting $\dot{T}(0) = \infty$ in (3.10), we obtain that $C_1 = 0$ and equation (3.10) reduces to:

$$\frac{dT(t)}{dt} = \frac{2T_p}{b_0}\left[1 - \frac{T_p}{T(t)}\right] \tag{3.11}$$

From this formula:

$$T(t) + T_p \ln\left[T(t) - T_p\right] = \frac{2T_p}{b_0}t + C_2 \tag{3.12}$$

Using the condition $T(0) = 0$ in the latest expression, we obtain:

$$C_2 = T_P \ln(-T_P) \tag{3.13}$$

and this leads to the final result:

$$\frac{T(t)}{T_p}+\ln\left|\left[1-\frac{T(t)}{T_p}\right]\right|=\frac{2}{b_0}t \tag{3.14}$$

This formula gives the temperature field in implicit form. The field corresponds to fire risk minimum. Since $T(t)/T_p$ cannot be explicitly expressed from (3.14) as a function of time, we analyzed the function:

$$y=x+\ln|1-x| \tag{3.15}$$

where:

$$y=(2/b_0)t, x=T(t)/T_p \tag{3.16}$$

Since the fire danger exists when $T(t)>T_p$, i.e. $x>1$, we will test the curve:

$$y=x+\ln(x-1) \tag{3.17}$$

The curve (3.17) and its inverse curve are presented in Figure 4:

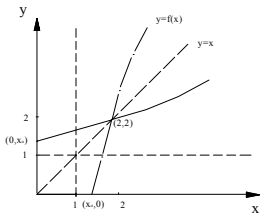


Figure 4 - Dotted line represents function $y=x+\ln(x-1)$. (Full line is inverse function. The solution of the equation $x_0=1-e^{-x_0}$ is $x_0=1,278464543$)

Based on the diagram from the Figure 4, it can be concluded that inverse function at the point $t=0$ has the value x_0. This means that minimal value of temperature field after which the risk of fire begins is $T(t)=x_0T_P=1,278464543\ T_P$. Inverse curve which defines temperature characteristics does not have an extreme value. It is concave everywhere and increases when $t\to\infty$, but slower than the line $2t/b_0$. Since according to the model we take that for $t>b$ function $T(t)=0$, it could be concluded that maximum value of the function $T(t)/T_p$ is determined from the following equation:

$$\frac{T(t)}{T_P}+\ln\left[\frac{T(t)}{T_P}-1\right]=2N \tag{3.18}$$

Now, we shall look for the value of the function $L=S_{ABC}/b$ in case when $T(t)/T_p$ fulfills the condition of minimum risk. Based on (3.2) and (3.11):

$$S = \left[T(t) - T_P\right]\left[\frac{1}{2}b - \frac{T_P}{\dot{T}(t)}\right] \quad \text{i} \quad (3.19)$$

$$\dot{T}^{-1}(t) = \frac{b}{4T_P}\frac{T(t)}{T(t) - T_P}$$

the following result is obtained:

$$L = (1/4)T_P\left[T(t)/T_p - 2\right] \quad (3.20)$$

Practical aspects of fire risk minimization based on the triangle model will be discussed in the conclusion. Based on (3.19) and (3.20), it can be concluded that fire risk is higher for those temperature fields for which the temperature descending velocity (when $t \to \infty$) is significantly less than the temperature ascending velocity. From formula (3.20) it could be concluded that in case of a minimum fire risk, the fire could appear only when temperature achieves the maximum, i.e. at the moment $t = b_0$.

4. Triangle model of explosion risk minimization

Shock waves arising due to pressure change cause the greatest destructions (Steel Construction Institute,1997; Murray J. Scearer, Vincent H.Y. Tam, Brian Corr, 2000). The most frequent type of shock waves is characterized by a relatively slow increasing to maximum pressure and sudden pressure descending to zero. Analytical form of pressure change of this standard shock wave type, in accordance with the behavior described above, can be expressed as follows:

$$P(\tau) = P_0 \sin\frac{\pi}{2}\tau(2 - \sin\frac{\pi}{2}\tau)\begin{cases}\frac{1}{2} - \frac{1}{\pi}arctgN(\Omega\tau - 1), \Omega\rangle 1\\ \frac{1}{2} + \frac{1}{\pi}arctgN(1 - \Omega\tau), \Omega\langle 1\end{cases} \quad (4.1)$$

where $\tau = t/t_0$ is relative time. Parameter $P(\tau)$ is difference between shock wave pressure and atmospheric pressure. Function (4.1) is tested for the values $N = 100$ and $\Omega = N/(N+1) = 100/101$ (Table 1) and presented in Figure 5:

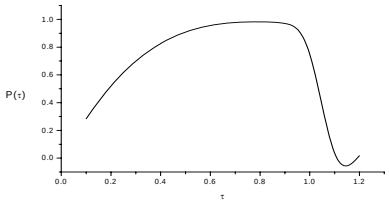


Figure 5 – Time profile of shock wave (Analytical curve reaches maximum $P(\tau) = 0,9825856P_0$ for $\tau = 0,781$)

Table 1

τ	$P(\tau)$
0,1	0.2843783
0,2	0,5204685
0,3	0,6986956
0,4	0,8257045
0,5	0,9084512
0,6	0,9559716
0,7	0,9778764
0,8	0,9823437
0,9	0,9707079
1,0	0,7484163
1,1	0,0355612
1,2	0,0168642

In order to minimize the risk coming from standard shock waves we shall use the triangle model which was used in the case of fire risk. Temperature changes are of relatively long duration, while the duration of shock wave effect lasts for a few seconds only. In order to facilitate comparison of thermal risk with the shock wave destruction risk, we shall keep notations b_0 and b from the previous section, keeping in mind that in case of pressure, time unit b_0 is two orders less than in the case of temperature field. In accordance with previously exposed issues, model shock wave pressure is presented in Figure 6:

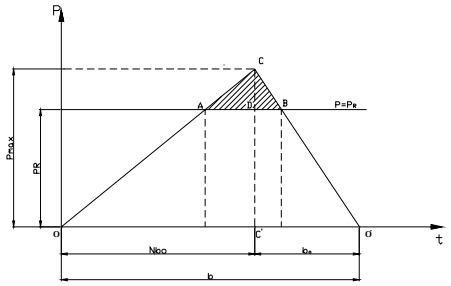


Figure 6 –The triangle model for standard shock wave with risk measure

If P_R is used to note the value of shock wave pressure for which the destruction begins, then the surface of the triangle S_{ABC} is the measure of destruction risk. By minimizing this measure, the form of shock wave leading to minimum destruction effects could be determined. Procedure is the same as for

thermal risk, so the calculations will not be repeated in detail. The area of the triangle S_{ABC} is given by:

$$S = (1/2)\left[P(t) - P_R\right]\left[b - ((N+1)/N)(P_R/\dot{P}(t))\right] \tag{4.2}$$

We shall minimize the parameter $L = S_{ABC}/b$ by equating the variation of the function $\Re = \int_{t_A}^{t_B} L dt$ with zero. Minimization condition is:

$$\frac{\partial L}{\partial P(t)} - \frac{d}{dt}\frac{\partial L}{\partial \dot{P}(t)} = 0 \tag{4.3}$$

and it leads to Bernoulli's equation, like in the case of thermal risk:

$$\frac{1}{Y^2}\frac{dY}{dP(t)} - \frac{1}{P(t)-P_R}\frac{1}{Y} = -\frac{Nb_0}{2P_R}\frac{1}{P(t)-P_R} \tag{4.4}$$

where :

$$Y = \dot{P}(t) \tag{4.5}$$

The solution of this equation is:

$$\frac{1}{Y} = \frac{1}{\dot{P}(t)} = \frac{\frac{Nb_0}{2P_R}P(t) + C_3}{P(t)-P_R} \tag{4.6}$$

In the model it is assumed that pressure is equal to zero for $t < 0$. This leads to the initial conditions:

$$P(0) = 0, \dot{P}(0) = \infty \tag{4.7}$$

By means of the second of these conditions, we find that $C_3 = 0$. So (4.6) is reduced to:

$$\frac{dP(t)}{dt} = \frac{2P_R}{Nb_0}\frac{P(t)-P_R}{P(t)} \tag{4.8}$$

The solution of this equation is:

$$P(t) + P_R \ln\left[P(t) - P_R\right] = (2P_R/Nb_0)t + C_4 \tag{4.9}$$

Particular solution is obtained from the former by means of the conditions (4.7) and has the following form:

$$P(t)/P_R + \ln\left|\left[1 - P(t)/P_R\right]\right| = (2/Nb_0)t \tag{4.10}$$

This equation can by divided into two equations. If $P(t)/P_R < 1$, the solution is given by implicit equation:

$$P(t)/P_R + \ln\left[1 - P(t)/P_R\right] = (2/Nb_0)t \tag{4.11}$$

If $P(t)/P_R > 1$, (this is the case when destruction caused by shock wave could appear), the solution is given by the implicit equation:

$$P(t)/P_R + \ln\left[P(t)/P_R - 1\right] = (2/Nb_0)t \tag{4.12}$$

We shall now analyze the latter equation further. If we introduce notations:

$$y = (1/N)(2/b_0)t, x = P(t)/P_R \tag{4.13}$$

the equation (4.12) becomes:

$$y = x + \ln(x-1) \tag{4.14}$$

This equation is the same in form as the corresponding one in the case of temperature thermal risk. Since we deal with the same form of the function as in the case of thermal risk, Figure 4 can be used. We conclude that the value of the inverse curve at the point $t = 0$ is x_0. This means that minimum pressure which can cause the destruction is $P_{\min} = 1,278464543P_R$. The pressure curve does not have the peak, it is concave everywhere and tends towards infinite value when $t \to \infty$, but more slowly than the line $(1/N)(2/b_0)t$.

We have seen that temperature field is ascending more slowly than the line $(2/b_0)t$. At the same time, the pressure field is ascending more slowly than the line $(1/N)(2/b_0)t$. It could lead to conclusion that the risk of destruction caused by shock wave is significantly less than fire risk. However, we must remind of the statement from the beginning of this analysis that in practice, time units b_0 are not the same for temperature and pressure. It is significantly less for the pressure b_0 and therefore the above conclusion may not be accepted.

According to the model, for $t = 0$ function $P(t) = 0$. It means that maximum shock wave pressure can be determined from the following equation:

$$P(t)/P_R + \ln\left[P(t)/P_R - 1\right] = 2 \tag{4.15}$$

Comparing (4.15) with (3.17), we can conclude that maximum value of $T(t)/T_p$ ratio is higher than the maximum value of $P(t)/P_R$.

Finally, we will determine the area of triangle ABC, which presents risk measure of the destruction caused by shock wave. Based on (4.2) and (4.5), we find that:

$$S_P = (1/2)P_R(N+1)b_0(x-2) \tag{4.16}$$

From the obtained expression, we can conclude that the risk of destruction starts when $x = P(t)/P_R = 2$. The same conclusion follows from the diagram in Figure 4 (we see that for $x = 2$ and $y = 2$, the destruction risk starts). The moment when the risk starts is obtained from the equation $(1/N)(2/b_0) = 2$, wherefrom it follows that $t = Nb_0$. So, we conclude that in optimal case the destruction begins at the moment when pressure achieves maximum value.

5. Risk of the soliton shock wave

Shock wave of the soliton type is characterized by a sudden pressure increase. Achieved value of pressure is constant in some time interval and then suddenly drops to zero. The analytical form of such waves would be represented by the following function:

$$R(\tau) = (1 - e^{-\Omega\tau}) \begin{cases} \frac{1}{2} - \frac{1}{\pi} arctg\Omega(\tau - 1), \tau \rangle 1 \\ \frac{1}{2} + \frac{1}{\pi} arctg\Omega(1 - \tau), \tau \langle 1 \end{cases} \tag{5.1}$$

Here $R(\tau) = P(t) / P_0$ and $\tau = t / t_0$. The diagram of the function (5.1) is based on Table 2. The values of $R(\tau)$ function are calculated for $\Omega = 1000$. The diagram is given in Figure 7:

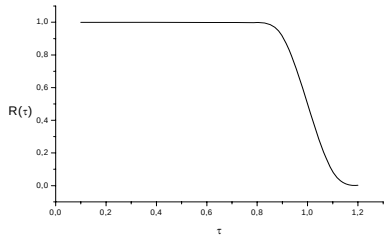


Figure 7 – Soliton shock wave . For τ = 0.018, R (τ) function has the maximum value 0.9996758**.**

For the assessment of destruction risk caused by soliton shock wave, we have formulated the trapezoid model (trapezoid is rectangular). This model is presented in Figure 8:

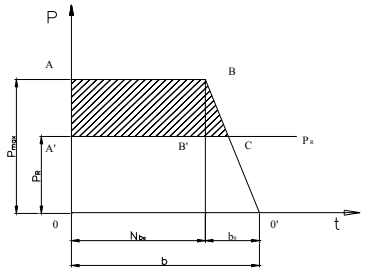


Figure 8 – Trapezoid model of soliton shock wave with risk measure (Risk measure is presented by trapezoid above the line $P(t) = P_R$ i.e. with the area $A'ABC$)

Equation of the line which goes through the points O' and B is:

$$P = \dot{P}(t - b) \tag{5.2}$$

and based on its intersection with the line $P(t) = P_R$, we can determine the area of trapezoid
$A'ABC$:

$$S = \left[(N + \frac{1}{2}) b_0 + \frac{P_R}{2\dot{P}(t)} \right] \left[P(t) - P_R \right] \tag{5.3}$$

The function of risk minimization is defined as $L = S / b$. Based on (5.3), we obtain:

$$\begin{aligned} \frac{\partial S}{\partial P(t)} &= (N + \frac{1}{2}) b_0 + \frac{P_R}{2\dot{P}(t)} \\ \frac{\partial S}{\partial \dot{P}(t)} &= -\frac{P_R}{2\dot{P}^2(t)} \left[P(t) - P_R \right] \\ \frac{d}{dt} \left[\frac{\partial S}{\partial \dot{P}(t)} \right] &= \frac{P_R}{\dot{P}^3(t)} \ddot{P}(t) \left[P(t) - P_R \right] - \frac{P_R}{2\dot{P}(t)} \end{aligned} \tag{5.4}$$

If we include these values into the minimization condition,

$$\frac{\partial S}{\partial P(t)} - \frac{d}{dt} \left[\frac{\partial S}{\partial \dot{P}(t)} \right] = 0 \tag{5.5}$$

we obtain the equation:

$$(N + \frac{1}{2}) b_0 + \frac{P_R}{\dot{P}(t)} - P_R \left[P(t) - P_R \right] \frac{\ddot{P}(t)}{\dot{P}^3(t)} = 0 \tag{5.6}$$

After the replacement $\dot{P}(t) = Y, \ddot{P}(t) = Y dP(t) / dY$, the equation (5.6) becomes Bernoulli' s equation:

$$\frac{dY}{dP(t)} - \frac{1}{P(t) - P_R} Y - \frac{(N + \frac{1}{2}) b_0}{P_R} \frac{1}{P(t) - P_R} Y^2 = 0 \tag{5.7}$$

Taking that $1 / Y = \theta$, we reduce (5.7) to non-homogenous linear equation of the first order. Its solution is:

$$\theta = \frac{1}{\dot{P}(t)} = \frac{C_1}{P(t) - P_R} - (N + \frac{1}{2}) b_0 \frac{P(t)}{P_R} \frac{1}{P(t) - P_R} \tag{5.8}$$

It is appropriate to apply initial conditions in this stage. Those are the same as in previous case: $P(0) = 0, \dot{P}(0) = \infty, 1 / \dot{P}(0) = 0$. Based on these conditions, we get $C_1 = 0$ and this leads to:

$$\frac{1}{\dot{P}(t)} = -\frac{(N + \frac{1}{2}) b_0}{P_R} \frac{P(t)}{P(t) - P_R}$$

This equation can be solved easily. Its solution is:

$$\frac{P_R}{(N+\frac{1}{2})b_0}t = P(t) + P_R \ln\left[P(t) - P_R\right] + C_2 \tag{5.9}$$

Applying the initial condition $P(0) = 0$ in (5.9), we found that

$$C_2 = -P_R \ln\left[P(t) - P_R\right] \tag{5.10}$$

After substitution of (5.10) in (5.9) we finally have:

$$\frac{P(t)}{P_R} + \ln\left|\left[1 - \frac{P(t)}{P_R}\right]\right| = \frac{1}{(N+\frac{1}{2})b_0}t \tag{5.11}$$

This equation for $P(t) < P_R$ becomes:

$$\frac{P(t)}{P_R} + \ln\left[1 - \frac{P(t)}{P_R}\right] = \frac{1}{(N+\frac{1}{2})b_0}t \tag{5.12}$$

while for the case $P(t) > P_R$, which is more important for this assessment, the solution for pressure has to be written in the form:

$$\frac{P(t)}{P_R} + \ln\left[\frac{P(t)}{P_R} - 1\right] = \frac{1}{(N+\frac{1}{2})b_0}t \tag{5.13}$$

Introducing the variables $x = P(t)/P_R$ and $y = (1/(N+0.5)b_0)t$, we can write (5.13) as $y = x + \ln(x-1)$. The function $y = x + \ln(x-1)$ has vertical asymptote for $x = 1$ where it tends towards $-\infty$, and for $x > 1$ it tends towards $+\infty$. It intersects the line $y = x$ at point $[2,2]$ and tends to infinity more rapidly than $y = x$. Inverse function, which describes the behavior of pressure, for $t \to -\infty$ tends towards 1. It passes through the point $[0, x_0]$, where $x_0 = 1,278464543$ and through the point $[2,2]$. Afterwards it tends towards infinity, but more slowly than line $y = x$. The curve $y = x + \ln(x-1)$ and the inverse one are presented in Figure 4.

Introducing prescriptions $X = t/(N+0.5)b_0$ and $Y = P(t)/P_R$, we can denote the inverse function as $Y = f(X)$. In Figure 9, the above described behavior of this function is presented:

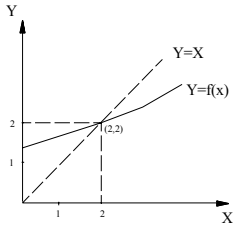


Figure 9 - The behavior of inverse function $Y = f(X)$

At the moment $t = b$, we have $X = (N+1)(N+0.5)$ and value of relative pressure at this point, which will be denoted by Y_b, can be determined from the equation:

$$(N+1)(N+0.5) == Y_b + \ln(Y_b - 1) \tag{5.14}$$

The determination of Y_b requires determination of number N. We shall do it using the Table 2 which contains the values of the analytical curve (5.1).

Table 2

τ	R (τ)
0.1	0.9996463
0.2	0.999602
0.3	0.9995452
0.4	0.9994695
0.5	0.9993633
0.6	0.9992042
0.7	0.9989389
0.8	0.9984084
0.9	0.996817
1	0.5
1.1	$3.18298 \cdot 10^{-3}$
1.2	$1.59152 \cdot 10^{-3}$

Based on the data from Table 2, it can be concluded that the pressure is approximately constant in the interval $[0-0,9]$ and it is descending in the interval $[0,9-1,2]$. Taking into account the values used in the analysis of the function (5.1), we can conclude that $b_o = 0,3$ and $b = (N+1)b_0 = 4 \times 0,3$. Consequently $N = 3$ is the value which we have been looking for. Based on this, the equation for determining $Y_b = P(b) / P_R$ reduces to:

$$Y_b + \ln(Y_b - 1) = 4 / 3.5 = 1,142857143 \tag{5.15}$$

This equation is solved numerically and it has been obtained that:

$$Y_b = 1,620342 \tag{5.16}$$

It means that maximum value of soliton shock wave pressure is $P(t) = 1,62P_R$, because after the moment $t = b$, according to the model, the overpressure of shock wave drops to zero. The risk begins at the moment $t = 0$ when $P(t) = 1,2728P_R$. It is seen that risk variation is relatively small (about $35\%P_R$.) in the period when soliton wave is capable of destruction.

This analysis has shown that the risk of soliton shock wave destruction is present all the time in the course of the shock wave duration, even in optimal case, when the risk is minimized. Comparing it to standard shock wave, where the risk begins at the moment of maximum pressure, we can conclude that this situation is significantly unfavorable. This conclusion is indirectly confirmed by the experiment: **tsunami** waves make more damage in Japan and Indonesia than standard sea waves.

6. Conclusion

The results of fire and explosion risk minimization (minimization was done analogoue to mechanical action minimization) could be summarized as follows:

- Maximum value of $T(t)/T_p$ ratio, after which fire risk ends, is higher than the maximum value of $P(t)/P_R$ ratio, after which the effect of shock waves ends (it is valid for both types of shock waves).
- Fire risk, as well as the risk of destruction caused by standard shock wave in the case of minimized risk, does not start at the moment when temperature achieves the point of ignition T_P, nor at the moment when the pressure of standard shock wave receives the value P_R, but in both cases when temperature or risk achieve the maximal value. **This conclusion is valid for minimized risk only.** These delays can be used to prevent either fire or explosion destructions.
- In case of the risk caused by soliton shock waves (trapezoid model), the situation is significantly worse. The destruction risk is present all the time that soliton wave spreads.
- General approach to fire and destruction risk assessment, when risk is caused by some external field, has shown that destruction depends both on field parameters and on environmental characteristics. It tuned out, which is completely logical, that the risk is lower when the maximum value of external field is lower, and when materials in the

room require high values of ignition temperature or of destruction pressure.

The realistic character of the resultants obtained represents the best recommendation for the application of analogy between the minimization in mechanics and in risk problems.

As far as we know, the approaches dealing with fire and explosion risk minimization systematically do not exist. The existing approaches are rather concerned with risk estimation (Maximum-Likelihood-Method and Bayes average square error method, the last is usually used in tarrifing problems).

The ways to improve the presented theory would consist of indoor measuring of time dependence on the temperature and the pressure.

7. References

1. Ahmad R. Shouman, (1998), A very simple yet accurate solution to the thermal explosion problem, *Journal of Loss Prevention in the Process Industries, 11,* pp. 383–390,.

2. Bedford T, Cooke R., (2001), Probabilitistic risk analysis: Foundations and methods*, Cambridge University Press, Cambridge United Kingdom*, pp. 4-9.

3. Fisal, I. K., Abbasi, S.A.,(1999)*,* Major accidents in process industries and an analysis of causes and consequences*, Journal of Loss Prevention in the Process Industries, 12*, pp. 361–378,.

4. Horng, J. L., Ching, C.Y., Yung F.L.,(2000), A mathematical model for predicting thermal hazard data, *Journal of Loss Prevention in the Process Industries, 13*, pp. 499–507,.

5. M. El Harbawi, et al.(2008), Rapid analysis of risk assessment using developed simulation of
chemical industrial accidents software package*, Int. J. Environ. Sci. Tech., 5 (1), pp.53-64,*

6. Model Evaluation Project, Explosion model evaluation exercise, (August 1997) – final report, *Steel Construction Institute.*

7. Murray J. Scearer, Vincent H.Y. Tam, Brian Corr, (2000) Analysis of results from large scale hydrocarbon explosion, *Journal of Loss Prevention in the Process Industries, 13*, pp.167–173,.

8. Smirnov, V.I.,(1965), *Kurs više matematike, II*, (pp. 629 – 631), Nauka, Moskva,.

9. Van Ulden, G.R.,(1990) , Quantitative risk analysis in the chemical process industries, *Reliability Engineering and System Safety, 29*, pp.55

REZIME

U radu su korišćeni forenzički metodi minimizacije rizika koji su zasnovani na analogiji sa minimizacijom mehaničkog dejsta. Određeni su parametri za minimizacije rizika od požara i eksplozija. To znači da mera rizika kod požara zavisi od temperature i njenih izvoda po vremenu, a kod eksplozija zavisi od pritiska i njegovih izvoda po vremenu. Za procenu minimizacije rizika korišćeni su : Trougaoni model za temperatursko polje i pritisak u slučaju dejstva standardnih udarnih talasa i Trapezoidni model za eksplozivna razaranja koja nastaju od solitonskih udarnih talasa. Dobijeni rezultati Trougaonog modela ukazuju da minimalni rizik od požara ili eksplozija nastaje u trenutku kada temperateure ili pritisci dostižu maksimalne vrednosti. Ovo kašnjenje se može iskoristiti za prevenciju kod svsakog požara ili eksplozije. Primena Trapezoidnog modela pokazuje da rizik od razaranja postoji za sve vreme širenja solitonskog talasa, što prevenciju čini praktično nemogućom.

SUMMARY

The forensic methods of risk minimization based on the analogy with mechanical action minimization have been used in this paper. The parameters for fire and explosion risk minimization have been determined. This means that the fire risk measure depends on the temperature and its derivations by time, and for explosions it depends on the pressure and its derivations by time. In order to assess the risk minimization, the triangle model for temperature field and pressure in case of a standard shock waves and the trapezium model for explosive destruction which are caused by soliton shock waves are used. The results obtained from using the triangle model suggest that the minimum fire or explosion risk occurs at the moment when either the temperature or the pressure reach their maximum values. This delay may be used for the prevention of any fire or explosion. The use of trapezium model shows that the risk of destruction exists during the entire period of soliton wave expansion, which makes the prevention practically impossible.

BIOMOLECULAR RECOGNITION: ON POSSIBLE QUANTUM APPROACHES

[*]Raković D.[*], Tošić B. ,Jaćimovski S.[3], Šetrajčić J.[4,5]

[1] *Faculty of Electrical Engineering, Belgrade, Serbia*
[2] *Vojvodina Academy of Sciences and Arts, Novi Sad, Serbia*
[3] *Criminal Justice and Police Academy, Belgrade, Serbia*
[4] *Faculty of Science, Novi Sad, Serbia*
[5] *Academy of Sciences and Arts of the Republic of Srpska, Banja Luka, BiH*

Abstract. Two unresolved issues of the (semi)classically addressed problems in molecular biophysics are unreasonably long time necessary for the change of biopolymer conformations and long-range directedness of selective biomolecular recognition processes – implying their essential quantum origin. In this paper several possible quantum approaches to biomolecular recognition are considered: Theory of Non-Radiative Resonant Structural Transitions, Model of Quantum Decoherence, and Resonant Recognition Model. These approaches might be of fundamental importance in understanding underlying macroscopic quantum-holographic Hopfield-like control mechanisms of morphogenesis, and their backward influence on the expression of genes, with significant potential psychosomatic implications.

Key words: Biomolecular Recognition, Conformational Transitions, Quantum Biophysics, Quantum Bioinformatics.

1. Introduction

Conformational properties of enzymes are essentially important for understanding of enzyme catalytic activity. The *conformational lability of a protein* makes its *specific interaction* with *substrates* possible. As the substrate is (most frequently) low-molecular, and the enzyme is (high-molecular) protein, then the substrate directly interacts with a particular small part of the enzyme molecule – its *active site* (group and distribution of

[*]Corresponding author: rakovicd@etf.bg.ac.yu

amino acid residues and cofactors (coenzymes, vitamins, metal-organic complexes, hormones)).

In the *enzyme-substrate complex* (ESC) the *induced structural correspondence* of the enzyme and substrate is dynamically established, thus providing the optimal value of the free energy of interaction. The *conformational transformations* involved lead to a structural fit between the enzyme and the substrate, i.e. *biomolecular recognition*. The enzyme-substrate interaction is a *weak chemical bond* (Van der Waals, hydrogen, hydrophobic, ...), which is, however, very *enhanced* due to *hydrophobic active site of the enzyme*: namely, relative dielectric permittivity ε_r of the cavity of active site of the enzyme is much less ($\varepsilon_r \sim 3 \div 4$) compared to water environment ($\varepsilon_r \sim 81$), which significantly facilitates the occurrence of electric interactions ($F \sim q_1 q_2 / 4\pi\varepsilon_0\varepsilon_r r^2$) between the substrate and the active site of the enzyme. Practically, *electrostatic* interactions within *hydrophobic cavity* (active site) *of the enzyme* provide the main contribution to bioenergetics of enzyme catalysis, i.e. *to the reduction of the activation barrier* in the enzyme-substrate complex. The energy necessary for conformational changes of the enzyme structure is liberated upon binding of the substrate to the enzyme.

During enzyme-substrate interaction and formation of the enzyme-substrate complex, the states of the electronic shells of the substrate and of the atomic groups of the active site of the enzyme are excited. In the enzyme-substrate complex the energy of electronic excitation is converted to the work of *displacement of atomic nuclei*. Among the movements of atomic nuclei the *lowest energy* is demanded by *low-frequency deformational vibrations* and *rotations around single bonds*, i.e. *conformational changes*! Hence, the interactions of electronic and conformational degrees of freedom – *Volkenshtein's electronic-conformational interactions* (ECI) are the most significant for *enzyme catalysis*, cf. Figure 1.

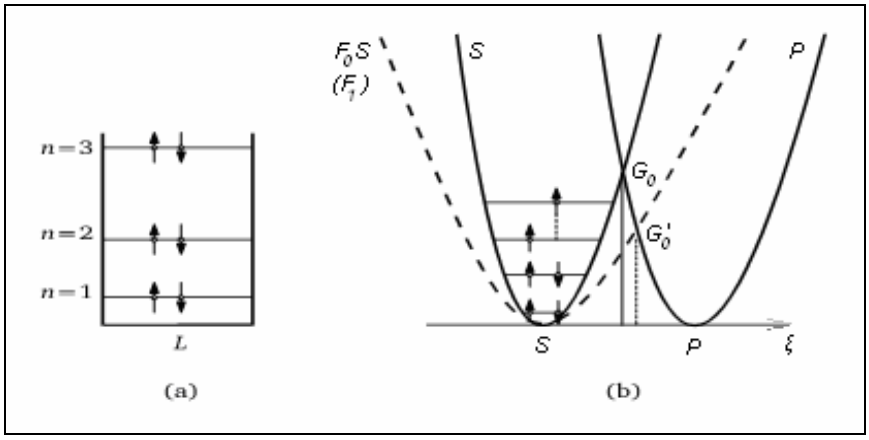


Figure 1 (a) *In order to understand the nature of ECI, it is helpful to make use of a simplified model of the interaction between electrons and atomic nuclei –*

electrons in a potential box with infinitely high mobile walls, wherefrom the electron pressure force exerted on the wall is easily obtained: $f_e = |dE/dL| = n^2h^2/4m_eL^3$. *A change in equilibrium results either from the excitation of electrons in the system (arises n) or from the addition of electrons (arises number of electrons, i.e. number of hits upon the walls of the box), when the walls of the box move and pass to a new equilibrium position, at an increased distance from each other,* $L + \Delta L$. (b) *On the other hand, if one considers a parabolic well with mobile walls, it will be easy to show how ECI lower the activation barrier (*G_a*). The expansion of the parabola of the initial reagents of the biochemical reaction, brought about by the added pressure forces of the electrons, results in the shift of the point of intersection with the second parabola of the products of the biochemical reaction, i.e. to decrease of the free energy of activation (*$G_a' < G_a$*)! Such semi-classical consideration of ECI (Volkenshtein, 1975; 1983), demonstrates that the energy of electronic excitations is converted to the work of displacement of the nuclei, i.e. to the conformational energy. As a result, the biochemical reaction is accelerated.*

2. Quantum Models of Electronic-Conformational Interactions and Biomolecular Recognition

Two *unresolved issues* of the (semi)classically addressed problems in molecular biophysics are *unreasonably long time* necessary for the *change* of biopolymer conformations (Levinthal paradox (Levinthal, 1968)) and a *long-range directedness* of selective biomolecular recognition processes – implying their essential *quantum origin* (Raković, 2008; 2009).

The quantum nature of *biomolecular recognition* might be supported by: (1) *The Theory of Non-Radiative Resonant Structural Transitions* (Gribov, 2001), through intermediate quantum-coherent superposition of the externally activated electronic-vibrational states of the participating biomolecules; (2) *Model of Quantum Decoherence* (Raković, Dugić, & Plavšić, 2004; Dugić, Raković, & Plavšić, 2005; Raković, Dugić, & Plavšić, 2005; Raković et al, 2006; Raković, 2007; Raković & Vasić, 2008), through environment-induced conformational transitions in biomolecular recognition, with possibility to consider cellular biomolecular recognition as a Hopfield-like quantum-holographic associative neural network (by treating all biomolecules of the same type within a cell as *dynamically coupled identical quantum particles,* thus implying deeper *quantum holism of the cell*); and (3) *Resonant Recognition Model* (RRM) (Cosic, 1994; 1997; Pirogova, Akay, & Cosic, 2002; Veljkovic, 1980; Veljkovic & Slavic, 1972), based on findings that *informational* biomolecules and their targets have common RRM-frequency peak but almost opposite phases – which will be elaborated in detail further on.

The Theory of Non-Radiative Resonant Structural Transitions (Gribov, 2001), within the framework of standard *quantum-chemical* Hamiltonian (including kinetic energies and Coulomb interactions of all biomolecular electrons and nuclei) and Born-Openheimer *adiabatic approximation* (of separated biomolecular electronic and vibrational degrees of freedom), replaces the (quasi)classical problem of many-electron hyper-surface $E_e(\phi_e^{(k)})$, not adiabatically well-defined when traversing between two adjacent local minima, by better defined problem of two (virtually intersecting) isomeric many-electron hyper-surfaces (hyper-paraboloids) serving as potential hyper-surfaces for two vibrational (isomeric) problems, cf. Figure 2.

In this approach, by *external perturbation* of the isomers, at this very intersection the conditions for electronic-vibrational non-radiative resonant transitions between the two isomers (*i, f*) are achieved: these resonance electronic-vibrational states of two isomers are transformed from the corresponding (non-perturbed) products of electronic and vibrational wave functions ($\phi_e^{(i)}\,\phi_v^{(i)}$, $\phi_e^{(f)}\,\phi_v^{(f)}$) into (perturbed) symmetrized superposition ($\phi_e^{(i)}\,\phi_v^{(i)} \pm \phi_e^{(f)}\,\phi_v^{(f)}$)/√2, and their (non-perturbed) energies from resonating (equal) superpositions of the ground electronic energies of corresponding minima of many-electron hypersurface and vibrational energies of higher excited states ($E_e^{(i)} + E_v^{(i)} = E_e^{(f)} + E_v^{(f)}$) into (perturbed) slightly split energy doublet ($E_e^{(i)} + E_v^{(i)} + ½\Delta E$, $E_e^{(f)} + E_v^{(f)} - ½\Delta E$), with $\Delta E = 2(E_e^{(i)} + E_v^{(i)})S_{ev}^{(i,f)}$ (where electronic-vibrational overlap integral between the two resonating isomeric states (*i, f*) is $S_{ev}^{(i,f)} = \iint \phi_e^{(f)}\,\phi_v^{(f)}\,\phi_e^{(i)*}\phi_v^{(i)*}\,dV_e\,dV_v \approx S_v^{(i,f)}\,S_e^{(i,f)}$, while $S_v^{(i,f)}$ and $S_e^{(i,f)}$ are corresponding overlap integrals of vibrational and electronic components). In the first approximation, the matrix element of *dipole transition* from *i*-th to *f*-th isomer is given by $\boldsymbol{\mu}^{(i,f)} \approx \iint \phi_e^{(f)}\,\phi_v^{(f)}(\boldsymbol{\mu}_e + \boldsymbol{\mu}_v)\,\phi_e^{(i)*}\phi_v^{(i)*}\,dV_e\,dV_v \approx \boldsymbol{\mu}_e^{(i,f)}S_v^{(i,f)} + \boldsymbol{\mu}_v^{(i,f)}S_e^{(i,f)}$, where $\boldsymbol{\mu}_e$ and $\boldsymbol{\mu}_v$ are corresponding electronic and nuclear components of the operator of total dipole moment. It is obvious that transition between two isomers will be allowed when components of corresponding dipole moments, $\boldsymbol{\mu}_e^{(i,f)}$ and $\boldsymbol{\mu}_v^{(i,f)}$**,** *and* overlap integrals, $S_v^{(i,f)}$ and $S_e^{(i,f)}$, *do not vanish*!

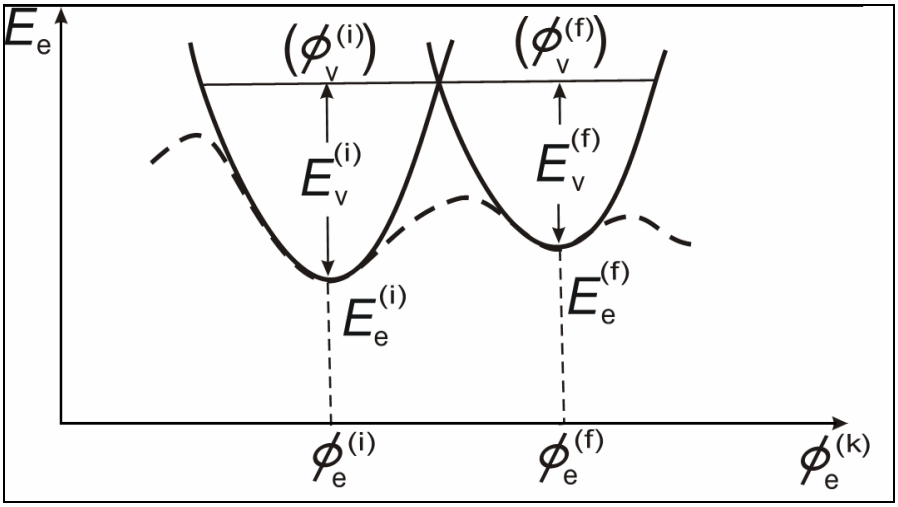


Figure 2 *The (semi)classical problem of many-electron hyper-surface* $E_e(\phi_e^{(k)})$ *as a potential energy for adiabatically decoupled Q1D vibrational and conformational system (with local minima as semi-classical 'positions', i.e. many-atomic isomer configurations on many-electron hyper-surface (broken line in the figure)) – not adiabatically well-defined when traversing between two adjacent local minima – is replaced within the framework of the theory of non-radiative resonant transitions* (Gribov, 2001) *by better defined problem of two (virtually intersecting) isomeric many-electron hyper-surfaces (hyper-paraboloids) serving as potential hyper-surfaces for two vibrational (isomeric) problems (full line in the figure). In this approach, by external perturbation of the isomers, at this very intersection the conditions for electronic-vibrational non-radiative resonant transitions between the two isomers (i, f) are achieved: in the first approximation, the matrix element of dipole transition from i-th to f-th isomer is given by* $\boldsymbol{\mu}^{(i,f)} \approx \boldsymbol{\mu}_e^{(i,f)} S_v^{(i,f)} + \boldsymbol{\mu}_v^{(i,f)} S_e^{(i,f)}$, *and it is obvious that transition between two isomers will be allowed when components of corresponding electronic and vibrational dipole moments,* $\boldsymbol{\mu}_e^{(i,f)}$ *and* $\boldsymbol{\mu}_v^{(i,f)}$**,** *and electronic and vibrational overlap integrals,* $S_v^{(i,f)}$ *and* $S_e^{(i,f)}$*, do not vanish. Also, during these resonant transitions the perturbed biomolecular system is shortly described by quantum-coherent superposition* $(\phi_e^{(i)} \phi_v^{(i)} \pm \phi_e^{(f)} \phi_v^{(f)})/\sqrt{2}$*, before its quantum decoherence into final electronic state* $\phi_e^{(f)}$ *or into initial electronic state* $\phi_e^{(i)}$ *(with subsequent de-excitations into lower vibrational states).*

From the above consideration, it can be concluded that *allowed transitions* between isomeric states (*i, f*) are possible only for close states with *non-vanishing* overlap integrals $S_v^{(i,f)}$ and $S_e^{(i,f)}$, or in *cascade* resonant transitions between *close intermediate* participating isomeric states, which might be related to non-dissipative

polaron/soliton-like transport (Raković, 2008; 2009; Keković, Raković, & Davidović, 2007).

Also, during these resonant transitions the perturbed biomolecular system is shortly described by *quantum-coherent superposition* $(\phi_e^{(i)}\phi_v^{(i)} \pm \phi_e^{(f)}\phi_v^{(f)})/\sqrt{2}$, before its *quantum decoherence* into final electronic state $\phi_e^{(f)}$ or into initial electronic state $\phi_e^{(i)}$ (with subsequent de-excitations into lower vibrational states).

Model of Quantum Decoherence (Raković, Dugić, & Plavšić, 2004; Dugić, Raković, & Plavšić, 2005; Raković, Dugić, & Plavšić, 2005; Raković et al, 2006; Raković, 2007; Raković & Vasić, 2008) fits nicely within the previously described picture of short-lasting description of *quantum-coherent superposition* of states of the two isomers before its quantum decoherence into one of the two final isomer states. It generally allows the reproduction of both *existence and stability* of the (stationary) ligand-proteins/target-receptors key/lock mismatching and matching conformations, and the *short time scales* for the quantum-mechanical processes resulting effectively in (nonstationary) mismatching-to-matching conformational transitions in selective ligand-proteins/target-receptors key/lock *biomolecular recognition processes* under external (e.g. compositional/chemical, thermal, optical ...) influences on the cell's complementary cytoplasmatic environment.

Dynamic modification of (many-electron) energy-state hyper-surface $E_e(\phi_e)$, of the *cell's quantum-ensemble* protein/substrate biomolecular macroscopic open quantum system (through changes in operator of density of states $\widehat{\rho}_e(t)$), is a natural consequence of coupled electronic-conformational processes – which implies potential possibility to consider cell's biomolecular recognition as *Hopfield's quantum-holographic associative neural network*. This approach assumes *standard cell's local treatment of quantum ensemble of non-interacting dynamically non-coupled N distinguishable* quantum biomolecular proteins of the same type (and their corresponding biomolecular classes of substrates) (Raković, Dugić, & Plavšić, 2004; Dugić, Raković, & Plavšić, 2005; Raković, Dugić, & Plavšić, 2005; Raković et al, 2006; Raković, 2008; 2009).

However, there is an alternative possibility of *holistic cell's non-local treatment of quantum system of non-interacting dynamically coupled N in-distinguishable* quantum biomolecular proteins of the same type (and their corresponding biomolecular classes of substrates) (Raković, 2007; Raković & Vasić, 2008; Raković, 2008; 2009). Then dynamical modification of many-electron energy-state hyper-surface of cell's biomolecular protein macroscopic open quantum system (and analogously their corresponding biomolecular classes of substrates), can be best represented in the formalism of *second quantization*, which treats *all biomolecules of the same atomic configuration* as *in-distinguishable quantum particles* which *occupy different isomeric-conformational states*, and considers such cell's *N-particle protein quantum state* in quantum-mechanical *occupational basis* which describes *number of proteins*

that occupy subsequently all states *of complete basis set of single-particle isomeric-conformational protein states*.

The second approach provides a *plausible quantum-holistic* picture of biological cell, and especially *phenomenologically approved quantum-holographic (fractal) coupling of various* hierarchical quantum levels – from-biological cell-to-acupuncture system/consciousness (Raković, 2008; 2009). This implies Hopfield-like quantum-holographic feedback influence of the EM field of acupuncture system on cells' conformational protein changes and genes' expression (so called macroscopic 'downward causation'), and not only reversed (microscopic 'upward causation'), with mutual quantum-informational control of ontogenesis/embryogenesis and morphogenesis, starting from the first division of the fertilized cell when differentiation of the acupuncture system begins – with significant *psychosomatic and cognitive bio-informational implications* (Raković, 2007; Raković & Vasić, 2008; Raković, 2008; 2009).

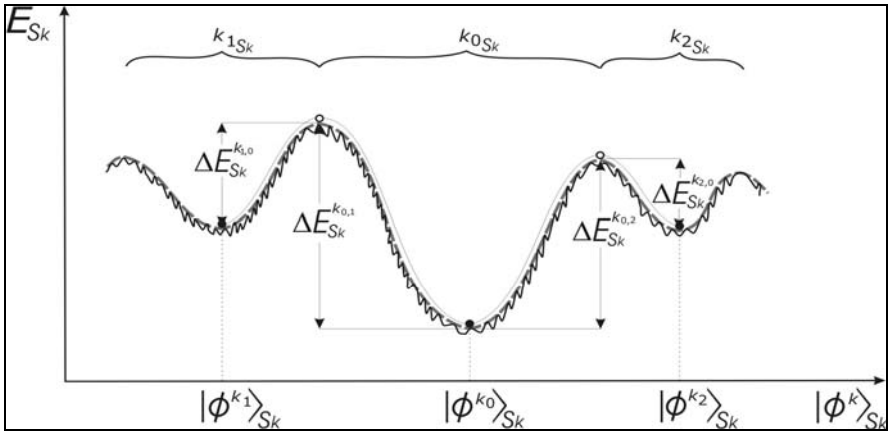


Figure 3 *Schematic presentation of the memory attractors in the energy-state* ($E_{S_k}(\phi^k)$) *hyper-surface of the quantum-holographic memory/propagator of the open macroscopic quantum system* S_k (*cell's protein/ target biomolecular one* (Raković, 2008; 2009)):

$$G(r_2,t_2;r_1,t_1)=\sum_{i=1}^{P}\phi^{k_i}(r_2,t_2)\phi^{k_i\,*}(r_1,t_1)$$

$$=\sum_{i=1}^{P}A_{k_i}(r_2,t_2)A_{k_i}{}^{*}(r_1,t_1)e^{\frac{i}{\hbar}(\alpha_{k_i}(r_2,t_2)-\alpha_{k_i}(r_1,t_1))}$$

It should be pointed out that quantum decoherence presumably plays fundamental role in biological quantum-holographic neural networks, through presented energy hyper-surface shape adaptation (in contrast to low-temperature artificial cubit quantum processors where it must be avoided until the very read-out act of

quantum computation) – which implies that Nature presumably has chosen elegant room-temperature solution for biological quantum-holographic information processing, permanently fluctuating between quantum-coherent states $\left|\phi^{k}(t)\right\rangle_{S_k} = \sum_i c_{k_i}(t)\left|\phi^{k_i}\right\rangle_{S_k}$ *and classically-reduced states* $\widehat{\rho}^{k}_{S_k}(t) = \sum_i \left|c_{k_i}(t)\right|^2 \left|\phi^{k_i}\right\rangle_{S_k S_k}\left\langle\phi^{k_i}\right|$ *of cell's biomolecular open macroscopic quantum system* S_k*, through nonstationary interactions with farther bodily environment and through decoherence by bodily closer environment. The same might be related to higher hierarchical quantum-holographic macroscopic open acupuncture system/consciousness level, thus providing natural framework for quantum-holographic coupling with lower cellular level, thus changing the expression of genes.*

To be more specific, in the formalism of second quantization – the mentioned cell's *N*-particle protein quantum state is considered in quantum-mechanical *occupational basis* (generally bosonic, because of protein-substrate integer spin due to even number of their covalent bonded electrons!), describing number of proteins which occupy complete set of *single-particle protein-substrate isomeric/conformational states*: $\left|n_0 n_1 n_2 ...\right\rangle_e$, with conditions $N = n_0 + n_1 + n_2 + ...$ and $E_{S_e} = n_0 E_e^{(0)} + n_1 E_e^{(1)} + n_2 E_e^{(2)} + ...$ (where E_{S_e} is the many-electron energy of the total cell's *N*-particle-protein quantum state, while $E_e^{(0)}$, $E_e^{(1)}$, $E_e^{(2)}$ ... are the many-electron energies of the protein single-particle quantum isomeric/conformational states 0, 1, 2, ...). An many-electron energy-state hyper-surface of such protein *N*-particle-isomeric/conformational state has a schematic representation in Figure 3, where the internal surface of every minimum is proportional to the partial energy ($n_i E_e^{(i)}$) of the *i*-th protein single-particle-isomeric/conformational state occupied by n_i isomers of the same form (i = 0, 1, 2, ...), so that total energy ($E_{S_{ke}}$) of the cell's protein *N*-particle-isomeric/conformational state is proportional to the sum of internal surfaces of the all minima of the many-electron hyper-surface.

It should be noted that inclusion of *vibrational degrees of freedom* (*phonons*) *of all possible isomeric/conformational states*, requires their consideration in quantum-mechanical *occupational basis* (also bosonic, because of phonon's integer spin!) – describing number of phonons occupying complete set of single-particle *phonon states* of the all protein-substrate isomers/conformations: $\left|n_1^{(0)} n_2^{(0)} ... n_{3N-6}^{(0)} n_1^{(1)} n_2^{(1)} ... n_{3N-6}^{(1)} n_1^{(2)} n_2^{(2)} ... n_{3N-6}^{(2)} ...\right\rangle_v$ where every isomeric protein-substrate complex composed of N_i atoms has generally $3N_i$-6 vibrational degrees of freedom (phonon types), out of which every phonon state can be occupied by an unlimited number of phonons (which is characteristic of all bosons, i.e. particles of integer spin). It should be pointed out that an energy hyper-surface of multi-dimensional

phonon quantum state has also a schematic representation in Figure 3, with potentially unlimited number of phonons in every single-phonon state. So, at the cellular level, there would exist *two* (interacting) macroscopic quantum subsystems for *every set of identical molecules* – first with *modifying many-electron hypersurface* $E_e(\phi_e)$ and second with *modifying EM multi-phonon hypersurface* $E_v(\phi_v)$ (where the second one might also include low-energy long-range coherent microwave Fröhlich excitations (Fröhlich, 1968; 1991) – created as a result of interaction of electronic and phonon isomeric subsystems, of particular significance in *microwave resonance therapy* (MRT) of a dynamic modification of the EM multi-phonon (and related many-electron) *acupuncture* macroscopic quantum subsystem).

Resonant Recognition Model (Cosic, 1994; 1997; Pirogova, Akay, & Cosic, 2002; Veljkovic, 1980; Veljkovic & Slavic, 1972) is confirmed on more than 1000 proteins from more than 30 functional groups – with numerous potential practical advantages in the fields of molecular biology, biotechnology, medicine, agriculture and nanotechnology. It is based on findings that there is significant correlation between spectra of the numerical presentation of constitutive elements of primary sequences (amino acids, nucleotides) and their biological activity or interaction in corresponding biomolecules (proteins, DNAs). The RRM model interprets this linear information by assigning the electron-ion interaction potential (EIIP) value to each constitutive element of primary sequence thus describing their average energy states of valence electrons, with subsequent using signal analysis methods in fast Fourier transform transforming this numerical series into single-electron wave number/RRM frequency domain and determining the common frequency components as peak frequencies in the multiple cross-spectral function for a group of primary sequences. The presence of peak with significant signal-to-noise ratio in a multiple cross-spectral function of a group of sequences with the same biological function means that all of the analysed sequences within the group have this single-electron RRM frequency component in common, with the following general conclusions: (1) such a peak exists only for the group of biomolecules with the same function; (2) no significant peak exists for biologically unrelated biomolecules; (3) peak frequencies are different for different biological function; (4) ligand-proteins and their biomolecular target-receptors have the same characteristic frequency in common but almost opposite phase – providing also novel theoretical possibilities for protein *de novo* design with desired functions!

In the context of the RRM-model, the same characteristic single-electron RRM frequency, and almost opposite phase, presumably characterises not only biomolecular protein and target general function, but also their *macroscopic quantum biomolecular recognition interaction* on the level of biological *cell* – possibly by externally *activated* (compositionally/chemically, by averaged intermolecular approaching of proteins and targets necessary for non-vanishing overlap integrals of the corresponding electronic and vibrational wave functions, or thermally/optically, by supplying vibrational energy necessary for making conditions for electronic-vibrational non-radiative resonant

transitions between two isomers (*i, f*), cf. Figure 2) ligand-proteins/target-receptors RRM quantum-resonantly electron-electron coupling *accompanied* by $\phi^{(i)}$-annihilation and $\phi^{(f)}$-creation of conformones' quanta in two-conformational transitions $\phi^{(i)} \rightarrow \phi^{(f)}$ (giving rise to (energy-favourable) many-electron energy-deepening of the final state $\phi^{(f)}$ and many-electron energy-shallowing of the initial state $\phi^{(i)}$ on the macroscopic quantum level of cell, i.e. to *dynamic modification of the many-electron hyper-surface* $E_e(\phi^{(k)})$ *of the cell's protein macroscopic quantum system* (cf. Figure 3 (Raković, 2007; Raković & Vasić, 2008; Raković, 2008; 2009)).

Considered within the framework of Hückel-like theory of molecular orbits (Keković et al, 2008; Raković, 2008; 2009), the quantum approach to the RRM-model shows that discrete Fourier transform in the RRM model is basically related to sequential contributions to the first order correction of energy (i.e. *primary sequence of amino-residues*, but not to (single electron) energy of the periodic part of protein's chain). So, the results of the RRM model imply that on the bio-molecular level an information processing is going on in the *inverse space* of Fourier spectra of the primary sequences of bio-molecules, bearing resemblance to quantum-holographic ideas that cognitive information processing is going on in the *inverse space* of the Fourier spectra of the perceptive stimuli (Pribram, 1971; 1991), thus supporting picture of *quantum-holographic fractal coupling* of various hierarchical levels in biological species, with significant potential psychosomatic implications (cf. Figure 3).

3. Conclusions

The two unresolved issues of the (semi)classically addressed problems in molecular biophysics are unreasonably long time necessary for the change of biopolymer conformations and long-range directedness of selective bio-molecular recognition processes – implying their essential quantum origin. In this paper several possible quantum approaches are considered: the Theory of Non-Radiative Resonant Structural Transitions, through intermediate quantum-coherent superposition of the externally activated electronic-vibrational states of the participating bio-molecules; the Model of Quantum Decoherence, through environment-induced conformational transitions in bio-molecular recognition, with possibility to consider cellular bio-molecular recognition as a Hopfield-like quantum-holographic associative neural network; and the Resonant Recognition Model (RRM), based on the findings that informational bio-molecules and their targets have common RRM-frequency peak but almost opposite phases. These approaches might be of fundamental importance in understanding the underlying macroscopic quantum-holographic Hopfield-like control mechanisms of morphogenesis, and their backward influence on the expression of genes, with significant potential psychosomatic implications.

4. References

1. Cosic, I. (1997). *The Resonant Recognition Model of Macromolecular Bioactivity: Theory and Applications*. Basel: Birkhauser Verlag.

2. Cosic, I. (1994). Macromolecular bioactivity: Is it resonant interaction between macromolecules? – Theory and applications. *IEEE Trans. Biomed. Eng., 41*(12) 1101-1114.

3. Dugić, M., Raković, D., & Plavšić, M. (2005). The polymer conformational stability and transitions: A quantum decoherence theory approach. In: A. Spasić & J-P. Hsu (Eds.), *Finely Dispersed Particles: Micro-, Nano-, and Atto-Engineering* (Ch. 9). New York: CRC Press.

4. Fröhlich, H. (1968). Long-range coherence and energy storage in biological system. *Int. J. Quantum Chem., 2* 641-649.

5. Fröhlich, H. (1991). Theoretical physics and biology. In H. Fröhlich (Ed.), *Biological Coherence and Response to External Stimuli.* New York: Springer.

6. Gribov, L. A. (2001). *From Theory of Spectra to Theory of Chemical Transformations*. Moscow: URSS, in Russian.

7. Keković, G., Raković, D., & Davidović, D. (2007). Relevance of polaron/soliton-like transport mechanisms in cascade resonant isomeric transitions of Q1D-molecular chains. *Mater. Sci. Forum, 555* 119-124.

8. Keković, G., Raković, D., Tošić, B., Davidović, D., & Cosic, I. (2008). Quantum-mechanical foundations of Resonance Recognition Model, *Preprint*.

9. Levinthal, C. (1968). Are there pathways for protein folding? *J. Chim. Phys*., *65* 44-45.

10. Pirogova, E., Akay, M., & Cosic, I. (2002). Investigation of the structural and functional relationships of oncogene proteins. *Proc. IEEE, 90*(12) 1859-1867.

11. Pribram, K. (1971). *Languages of the Brain: Experimental Paradoxes and Principles in Neuropsychology*. New York: Brandon.

12. Pribram, K. (1991). *Brain and Perception: Holonomy and Structure in Figural Processing*. Hillsdale, NJ: Lawrence Erlbaum.

13. Raković, D. (2007). Scientific bases of quantum-holographic paradigm, Invited lecture. In I. Kononeko (Ed.), *Proc. Int. Conf. Measuring Energy Fields* (pp. 64-71). Kamnik: Zavod Zdravilni gaj.

14. Raković, D. (2008). *Fundamentals of Biophysics*, 3. ed.. Belgrade: IASC & IEFPG, in Serbian; and refs therein.

15. Raković, D. (2009). *Integrative Biophysics, Quantum Medicine, and Quantum-Holographic Informatics: Psychosomatic-Cognitive Implications.* Belgrade: IASC & IEPSP.

16. Raković, D., Dugić, M., & Plavšić, M. (2004). The polymer conformational transitions: A quantum decoherence approach. *Mater. Sci. Forum, 453-454* 521-528.

17. Raković, D., Dugić, M., & Plavšić, M. (2005). Biopolymer chain folding and biomolecular recognition: A quantum decoherence theory approach. *Mater. Sci. Forum, 494* 513-518.

18. Raković, D., Dugić, M., Plavšić, M., Keković, G., Cosic, I., & Davidović, D. (2006). Quantum decoherence and quantum-holographic information processes: From biomolecules to biosystems. *Mater. Sci. Forum, 518* 485-490.

19. Raković, D., & Vasić, A. (2008). Classical-neural and quantum-holographic informatics: Psychosomatic-cognitive implications (pp. 109-114). In B. Reljin, & S. Stanković (Eds.), *Proc. NEUREL-2008*. Belgrade: IEEE Serbia & Montenegro Section.

20. Veljkovic, V. (1980). *A Theoretical Approach to Preselection of Carcenogens and Chemical Carcenogenesis.* New York: Gordon & Breach.

21. Veljkovic, I., & Slavic, M. (1972). General model of pseudopotentials. *Phys. Rev. Lett., 29* 105-108.

22. Volkenshtein, M. V. (1975). *Molecular Biophysics.* New York: Academic.

23. Volkenshtein, M. V. (1983). *Biophysics*. Moscow: Mir.

REZIME

Dva nerazrešena pitanja semi-klasično postavljnih problema u molekularnoj biofizici jesu nerazumno dugo vreme potrebno za izmenu biomolekularnih konformacija i dugo-dometna usmerenost selektivnih procesa biomolekularnog prepoznavanja.

U radu je razmotreno nekoliko mogućih kvantnih prilaza rešavanju ovih problema. Predloženi kvalitativni scenario je dovoljno opšti i čini dobru osnovu za principijelno rešenje problema biopolimernog sklupčavanja u nativnu konformaciju pri visoko selektivnim procesima protein/receptor biomolekularnog prepoznavanja, implicirajući makroskopsku kvantnu nelokalnost na biološkom ćelijskom nivou. (Bazična nelokalnost se može proširiti i na makroskopski kvantni nivo biološkog organizma na šta ukazuje makroskopska kvantna mikrotalasna rezonantna terapija akupunkturnog sistema.) Kvantna priroda ovih procesa ilustrovana je na primeru neradijativnih strukturnih prelaza, modelu kvantne dekoherencije i modelu rezonantnog prepoznavanja uz diskusiju implementirajućeg mehanizma elektronsko-konformacione sprege u ključ-brava uklapajućim konformacionim prelazima biomolekularnog prepoznavanja protein/supstrat. Na osnovu ovih prilaza u stanju smo da reprodukujemo kako egzistenciju i stabilnost (stacionarnih) polimernih konformacija tako i kratka vremena za kvantno -mehaničke procese u konformacionim prelazima u selektivnim procesima biomolekularnog prepoznavanja. Pošto ovi procesi dovode do dinamičke modifikacije više-elektronske hiperpovrši energija-stanje ćelijskog protein/receptor ansambalskog biomolekularnog makroskopskog kvantnog sistema, to otvara mogućnost razmatranja ćelijskog biomolekularnog prepoznavanja kao Hopfildove kvantno-holografske asocijativne neuronske mreže. Ovi prilazi mogu biti od fundamentalnog značaja za razumevanje bazičnih makroskopskih kvantno-holografskih Hopfildovih kontrolnih mehanizama morfogeneze i njihovog povratnog uticaja na ekspresiju genoma.

SUMMARY

Two unresolved issues of the (semi)classically addressed problems in molecular biophysics are unreasonably long time necessary for the change of biopolymer conformations and long-range directedness of selective biomolecular recognition processes.

This paper deals with several possible quantum approaches to solving these problems. The suggested qualitative scenario is sufficiently general and makes a good basis for a principled solving of the problem of biopolymer winding up into the native conformation at highly selective processes of protein/receptor biomolecural

recognition, implying macroscopic quantum non-locality at the biological cell level. (The basic non-locality can be spread to macroscopic quantum level of a biological organism also, which is suggested by macroscopic quantum microwave resonant therapy of acupuncture system). The quantum nature of these processes has been illustrated by the example of Non-Radiative Structural Transitions, the Model of Quantum Decoherence and the Resonant Recognition Model complete with the discussion on the implementing mechanism of electronic-conformational interactions in key-lock fitting conformational transitions of protein/substrate biomolecular recognition. Based on these transitions we can reproduce both the existence and stability of (stationary) polymer conformations and the short times for quantum-mechanical processes in conformational transitions in selective processes of biomolecular recognition. Since these processes lead to dynamic modification of many-electron hyper-surface energy-state of cell protein/receptor of ensemble biomolecular macroscopic quantum system, this creates possibilities to consider the cell biomolecular recognition as Hopfield-like quantum-holographic associative neuron network. These approaches can be of fundamental importance for understanding of basic macroscopic quantum-holographic Hopfield-like control meachnisms of morphogenesis and their backward influence on genome expression.

APPLICATION OF X-RAY DIFFRACTION METHOD IN DIFFERENT FORENSIC DISCIPLINES

[*]Radosavljević-Mihajlović A.[*], Matović B.[1]

[1]*Institute of Nuclear Sciences Vinca, Belgrade, Mihajla Pterovića Alasa 12-14, Belgrade, Serbia*

Abstract: Physico-chemical methods represent rather an important part of forensic science, primarily in the process of detecting and collecting of even the smallest traces of evidence from a crime scene. The X-ray diffraction is one such technique that can be used for the characterization of a wide variety of substances of forensic interest. This method has several advantages over other analytical techniques for the identification of investigation materials. It is non-destructive, requires relatively small amounts of material and can be used to semi-quantify the components of a mixture, thus determining the relative level of contamination of a sample. However, because of the form and size in which crime samples occur, the amount of material available and the evidential restrictions to preserve the samples, X-ray diffractometry is seldom used for the analysis and comparison of nonpowder samples. This paper presents the results of X-ray diffraction analysis of materials from different crime scene based on the data from literature.

Key words: X- ray, difraction method, forensic discipline

1. Introduction

The forensic science means "pertaining to the law", in other words resolves legal issues by applying natural and technical scientific principles to them. This may be related to either a crime or a civil action (Dillon, 1999). Forensic science consists of many disciplines: forensic pathology, forensic anthropology, forensic archaeology, forensic psychology, computer forensics and other disciplines.

[*]Cooresponding author at: e-mail mihajlovic@vinca.rs

Forensic engineering is the investigation of materials, products, structures or components that fail or do not operate/function as intended, causing personal injury or damage to property (Millen, 2000). In this area the main physical-chemical techniques normally used for forensic issues are: particle size distribution (Robertson et al., 1984), (Sugita et al., 2001), (Pye et al., 2007); soil color UV–vis spectrum (Thanasoulias et al., 2002); density gradient (Thorrton, 1960), microscopic examinations (Cengiz et al., 2004); Fourier Transformed Infrared Spectroscopy (FTIR) (Cox, 2000) and X-ray diffraction (Rendle, 2003), (A. Ruffell et al., 2004). Any techniques that help in crime investigation can be suitably adapted for forensic science. X-ray diffraction (XRD) is one of the most important non-destructive tools to analyse all kinds of matter-ranging from fluids, to powders and crystals. Among the various XRD techniques, X-ray powder diffraction is relatively simple and is commonly adopted for the analysis of powder samples in forensic science laboratories (Folen, 1975) (Ruffell, 2004) (Thangadurai, 2005). This method includes different techniques such as fiber diffraction, powder diffraction and small-angle X-ray scattering (SAXS) (Jenkins, et al., 1996). The importance of XRD and phase analysis in forensic science is (Rendle, 2003):

• the possibility to use small-volume samples for analysis;
• the non-destructive method (the sample can be used for further analyses even after possible powdering);
• the exact identification of phases in a mixture sample; and
• the quantitative content of substances in a mixture sample.

Successful characterization using XRD techniques requires that an amount of crystallinity be present in the substances. Each substance which consists of atomic components (atoms, ions, and molecules) has a three-dimensional periodic crystal grid (Klug, et al., 1974), in other words, the periodic arrangement of atoms in the crystals is represented by a set of crystallographic planes, and XRD occurs by the scattering of X-rays from this set of planes, Figure 1.

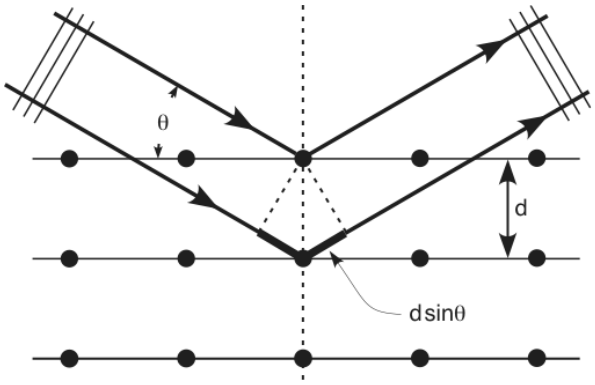


Figure 1. Bragg diffraction from a cubic crystal lattice

This phenomenon is known as elastic scattering and the electron (or lighthouse) is known as the *scatterer* (Figure 1). A regular array of scatterers produces a regular array of spherical waves. Although these waves cancel each another out in most directions through destructive interference, they add constructively in a few specific directions, determined by Bragg's law: $2d\sin\theta=n\lambda$, where d is the spacing between diffracting planes, θ is the incident angle, n is any integer, and λ is the wavelength of the beam (Karanović, et al., 1998).

The list of materials interesting for forensic science examined by XRD method is presented in Table 1 (Rendle, 2003).

building materials (cement, mortar, concrete, plaster, fillers, bricks, putty)
Soils and minerals
drugs (drugs of abuse together with their excipients and adulterants)
metals and alloys
paints, papers, pigments, cosmetics, safe ballasts
plastics and polymers
soap powders and detergents
automobile underseals, explosives and gunshot residues

Table 1. The list of materials examined by XRD method

This method can provide us with the information on the size of atoms, the lengths and types of chemical bonds, and the atomic-scale differences among various materials, especially minerals and alloys. The method also reveals the structure and functioning of many biological molecules, including vitamins, drugs, proteins and nucleic acids such as DNA (Jeruzalmi, 2006). Each crystalline substance crystallizes in a particular crystal structure characteristic of that compound, giving rise to a unique XRD pattern, Figure 2 (JCPDS, International Centre for Diffraction Data 2001).

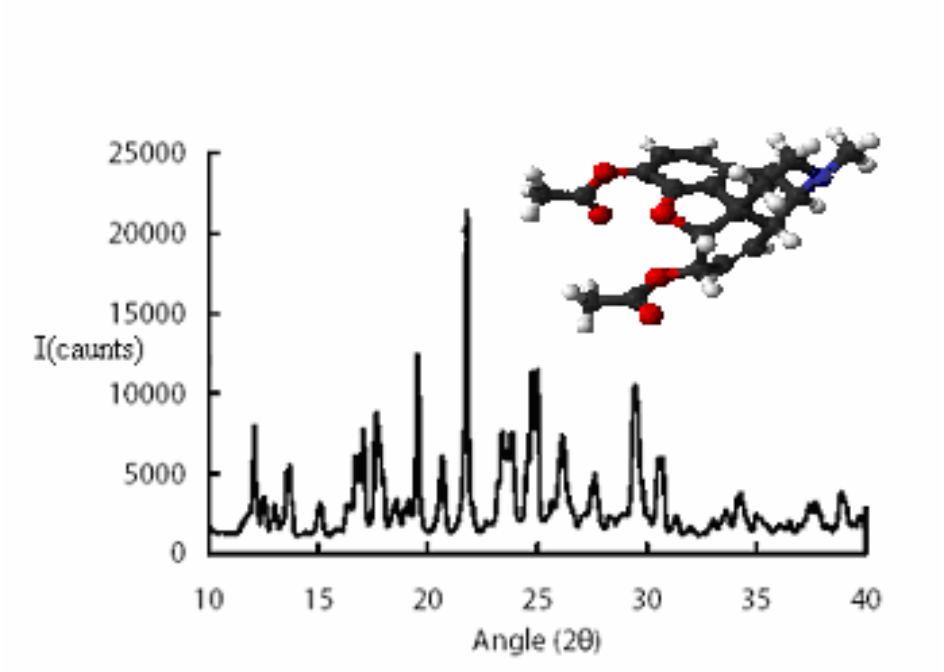


Figure 2. X-ray diffraction pattern and structure of diacetylmorphine hidrochloride drug substance

XRD method can also account for unusual electronic or elastic properties of a material, shed light on chemical interactions and processes, or serve as the basis for designing pharmaceuticals against diseases. The majority of physical evidence materials recovered from crime scenes are generally crystalline or semicrystallline in nature. This paper uses different literature case studies to illustrate the application of X-ray diffraction tehniques in forensic science. The presented results have also had an important influence on the further development of criminal case solving.

2. Results and Disscusion

2. 1. X-ray method for the investigation of soil-geoscience forensics

Forensic geoscience is emerging as an important sub-discipline within forensic science (Croft et al., 2004) (Pye et al., 2005). Forensic studies of rocks, sediments, soils and dusts have been undertaken for more than a century and these geochemical materials can provide important information in criminal investigations (Pye, 2004). However, many crimes take place under circumstances where soil is transferred by the criminal or his tools, leaving possible evidences in car tires, shoe soles, footprints, etc., that may provide connection between a criminal and a crime scene (Shorrock, 2005).

The value of geological trace evidence can be considerable, both for 'intelligence' and evidential purposes, especially where DNA and other types of direct evidence are unavailable or limited in scope (Croft et al., 2004). The analysis of soils for forensic comparison includes investigation of the sample colour (Marumo et al., 1996), mineralogical composition with XRD techniques (Ruffell et al., 2004), organic and inorganic chemistry (Cabriola et al., 1998), particle size analysis (Marumo et al., 2001) (Pye, et al., 2007), analysis by electron microscope (Pye et al., 2007) and palynology (Horrocks et al., 1999).

The geoforensics aim is that of determining the origin of investigated material and the comparison of samples taken from a crime scene with those samples recovered from a person or their belongings (Junger, 1996). From literature data (Petraco et al., 2008) in the case were the dead woman was found in the river, the crime scene investigators discovered a water-stained man`s right shoe in the suspect`s bedroom closet. A small quantity of sand was detected upon turning the shoe over. The X-ray analisis confirmed the sand from the suspect and the sand from the victim were a match, i.e. they came from the same deposite. Testimony concerning the sand specimens was used at trial to help the jury reconstruct the event. In the next case the clothing from the suspect was taken for laboratory analysis and compared with the soil sample removed from the victim’s clothing. The results of the soil sample investigations are presented in Table 2 (Petraco et al., 2008).

Sample	Location	Color	Mineral	(%)	Plant detris
S1	Crime scene	10 YR 3/1	Quartz/feldspar	75	hevy
			Muscovite	10	
			Phlogopite	trace	
			Garnet	trace	
			Chloride	trace	
			Hornblende	2	
			Hematite	2	
			Magnetite	7	
			Limonite	trace	
S2 and S2A	victm`s clothing	10 YR 4/2	●[a]	●[a]	medium
S3, S4, S5	suspect`s clothing	10 YR 3/1	●[a]	●[a]	medium

[a] identical quantitative and qualitative mineralogical composition with sample S1

Table 2. Mineralogical composition of investigated samples from literature data (Petraco et al., 2008)

The literature data presented in Table 2 show the numerous similarities between the known and investigated specimens. Based on the data on the contents and the type of soil found on the victim and the suspect, the author testified in the further process. Also, in the case where geo-forensic material taken from the suspect's boot and shovel was compared with the soil taken at the crime scene, further legal proceedings were undertaken (Morgan et al., 2006).

We can conclude that the comparasion of the geo-forensic sample from the investigated crime scene and the sample found on the suspect, we can reconstruct the criminal event, if two samples share similarities. Therefore, it is very important when interpreting the results of soil and sediment analyses that due care is given to the exclusion of samples and that the samples that show very similar characteristics are viewed in the context of the distinctiveness or rarity of their particular attributes (Morgan et al., 2006). In the course of all mineralogical investigations of geoforensic materials in these presented literature cases, the X-ray method was used.

2. 2. X-ray method for the investigation of textile fibers and polymers

It is well known that textile fibers are a mixture of crystalline and amorphous substances. The characterization and determination of the type of the textile fibre, as well as the degree of cristallinity can be made using X-ray diffractometry (Fong, 1989) (Abraham et al., 2007). The XRD patterns of various investigated forensic textile samples are presented in Figure 3 (Abraham et al., 2007).

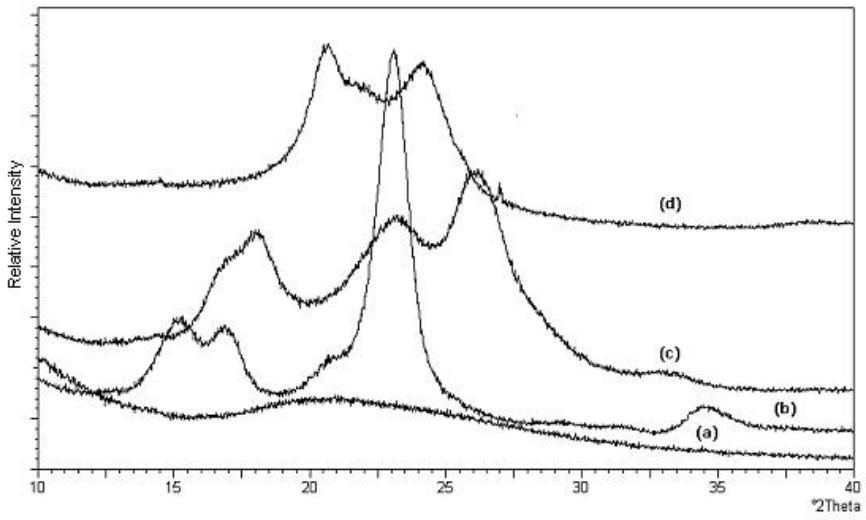


Figure 3 X-Ray Diffractograms of Textile Fabrics from literature data (a) Wool; (b) Cotton; (c) Polyester; (d) Nylon; **(Abraham et al., 2007)**

Based on these analysis, it is possible to compare materials from the crime scene and materials found at suspects, as well as to connect them to the crime scene. Two cases which will be presented illustrate the use of XRD in the analysis and determination of polymers present in forensic materials (Rendle, 2003):

1. Some pieces of unknown material were submitted for analysis and they yielded diffraction patterns similar to that of polyvinyl chloride (PVC). PyMS then confirmed the presence of a copolymer with a high PVC content.
2. A "crystalline" deposit was found on a chair. The deposit was in fact found to be largely amorphous, but a weak diffraction pattern present matched that of polymethylmethacrylate. PyMS later identified the deposit as poly-methylcyanoacrylate.

2. 3. X-ray method for the investigation of pigments and paints analyses

The XRD method of pigment and paint analysis is used in complex expert examination during determination of phases of artworks (paintings, sculptures etc.), car paints (analyses of abrasions and fragments after traffic accidents), analysis and comparison of lacquer systems of tools and instruments, lacquer systems used in building industry and some analyses of printing colors and paints (Kotrlý et al. 2006).

If paints are involved, for example in a typical break-in or road traffic accident, the first step is to compare control and suspect specimens visually—by eye and by low power visible light microscopy. If they appear identical in colour, then their chemical composition must be checked (FTIR) or XRD may be used (Rendle, 2003).

2.4. X-ray method for the investigation of drugs

The XRD analysis of drugs or narcotic mixtures (quantitative or qualitative analyses) is in many cases faster than other methods (FTIR, GC) and sample preparation is simpler (Folen, 1975) (Kugler, 2003) (Kotrlý et al. 2006). Some of the drugs most frequently encountered are cocaine, heroin, morphine and the amphetamines. These drugs occur as loose powders or tablets in which the drug is mixed or "cut" with some other substance (Rendle, 2003). The different forensic sample drugs are presented in Figure 4 (Barnes, 1954) (JCPDS-International Centre for Diffraction Data 2001).

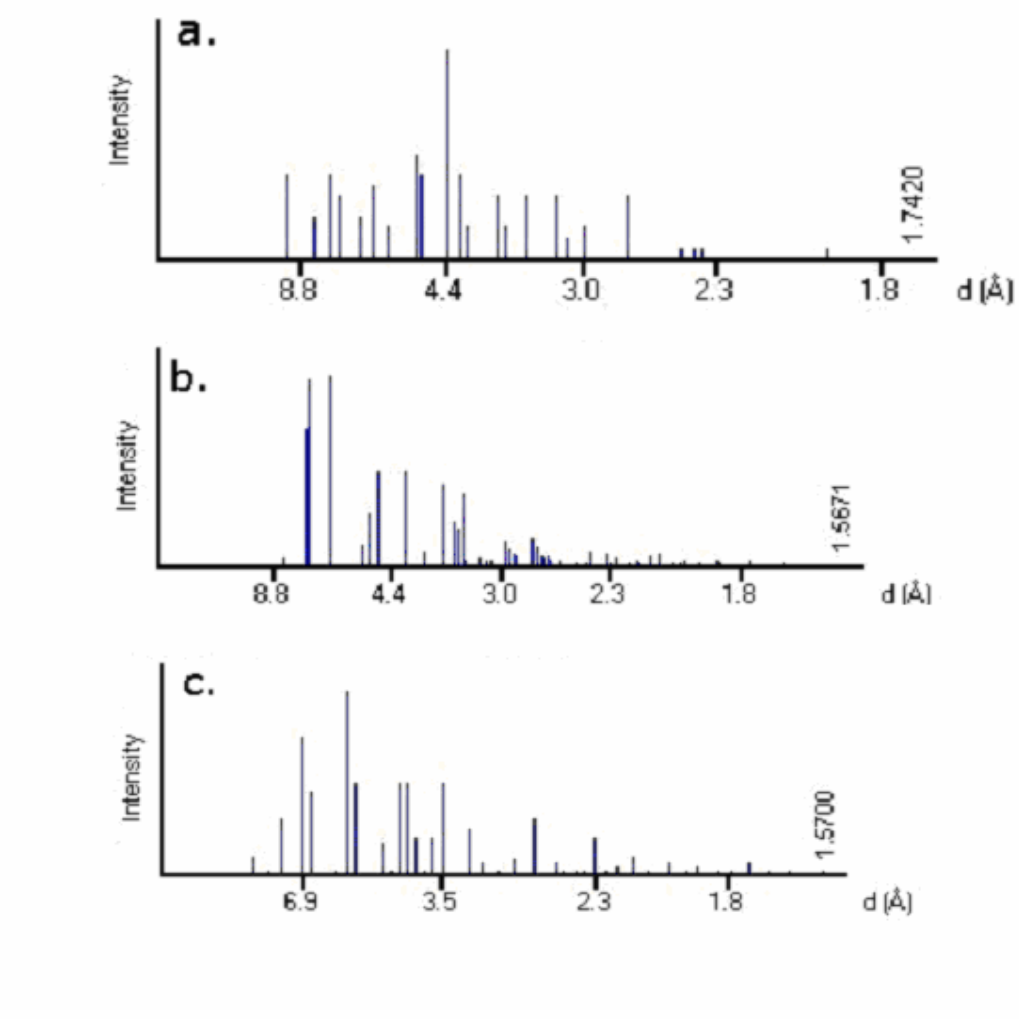


Figure 4. The XRD pattern of drugs a.) cocaine – $C_{17}H_{21}NO_4$; b.) morphine hydrochloric – $C_{17}H_{20}ClNO_3$; c.) diacetylmorphine – $C_{21}H_{23}NO_5$.

The XRD analysis of investigated drug sample usually provides the following basic data on the material:

(a) precise identification of chemical form of the present drug (salt, base, acid)
(b) presence of the type of dissolvant as well as the content of impurities
(c) quantitative analysis (for this analysis internal standard is mostly used)

(d) in some cases fast comparison with confiscated quantities and fast identification of perpetrators is possible.

2.5. X-ray method for the investigation of bones and remains

In the course of anthropological investigations it is very important to have a confirmation not only of the degree of discovered skeletons or victims of burning, but also the confirmation of the mineralogical and biochemical content of the material.

Bergslien (Bergslien et al., 2008) has demonstrated that the XRD analysis has several significant advantages over trace element analysis for the identification of human remains. Based on the presence or absence of the mineral bio-apatite the author determined the origin of the found remains. As it is well known, human bones and teeth are mineralized tissues composed of calcium phosphate compounds that are identical in composition and structure to the minerals belonging to the group of apatites and they are most frequently referred to as bio-apatites (Wopenkia, et al., 2005) (Bergslien et al., 2008). Geological appearance of iso-structural mineral bio-apatite is related to the group hydroxylapatite, which has an ideal chemical formula $Ca_{10}(PO_4)_6(OH)_2$ (Hiller, 2003). The members of apatite mineral group have a hexagonal structure (class 6/m) which provides a possibility to incorporate various chemical elements.

Bioapatite has a lower degree of structural flexibility in comparison with geological apatite. From the presented XRD patterns of investigation samples (geological samples and human remains samples) the observed reflections in range ~ 42, 53 and 63° 2θ show increase of the intensity for the geological samples (Bergslien et al., 2008). The results of this paper make it possible to use hte XRD analysis to differentiate between geological and bioapatite in the ivestigated samples.

Hiller (Hiller et al., 2003) investigated the effects of heating and burning on bone mineral using X-ray diffraction (XRD) techniques. However, the observed effects of burning on bone specimens and the determination of the techniques used are crucial in the resolution of forensic cases where cremation or other fire damage to remains is present (Murray et al., 1993) (Cattaneo et al., 1999). The bone samples were heated within the temperature range of 500, 700 and 900 °C and after that the changes in the structural and mineral composition were observed. The results obtained from material investigation can offer precise data significant for forensic or archeological investigations.

A great scientific challenge, as well as the important detail in the process of forensic investigations is to determine the time of death based on the bone remains (Knight, 1997). Prieto-Castello´(Prieto-Castello et al., 2007) used the forensic samples of bone remains (the bones were removed from cement tombs of

Murcia Cemetery) for observation of the biochemical content (potassium, sulfur, nitrogen, urea, total protein, phosphorus) and mineralogical composition (presence of bioapatite or other minerals). The authors observed the degree of crystallinity and mineral content of bone marrow of the investigated bones. They have shown that it is possible to determine the approximate time of death using the results of XRD and biological analysis (particularly the content of urea, potassium and sulphur).

3. Conclusion

Based on the presented literature data, it can be concluded that the X-ray diffraction analysis is rather suitable for forensic investigations. The XRD method of analysis is used in many forensic disciplines to determine the origin of investigated samples and most often they are as follows: the soil analyses, analyses of explosives and post blast residues, pigment and paints analyses, goods identification, analyses of unknown substances, plastics and polymers, alloys and metals, identification of degraded bones and drug analyses. This method is non destructive, fast and provides precise data on the composition of the forensic sample. The possibility to use XRD methods in forensic science will probably be connected with capillary optical analyses, micro-diffraction analyses and biochemical analyses.

4. Literature

[1]. Abraham, J., Shukla, S. K., Singh, A.K. (2007). Application of X-ray diffraction techniques in forensic science, *Forensic Science Communications* Volume 9, No. 2.
[2]. Barnes, S. (1954). *Bulletin on Narcotics*, 6, 27.
[3]. Bergslien, T.E., Bush, M., Bush J.P. (2008). Identification of cremains using X-ray diffraction spectroscopy and a comparison to trace element analysis, *Forensic Science International*, 175, 218–226.
[4]. Cabriola, N., Pommier, M.T., Gueux, M. and Payen, G. (1998). Comparison of lipid composition in two types of human peutrfactive liquid, *Forensic Science International* 94, 47–54.
[5]. Cattaneo C, DiMartino S, Scali S, Craig OE, Grandi M, Sokol RJ. (1999). Determining the human origin of fragments of burnt bone: a comparative study of histological, immunological, and DNA techniques. *Forensic Science International,* 102, 181–91.
[6]. Cengiz, S., Karaca, A.C., Akir, I.C¸ (2004). SEM_EDS analysis and discrimination of forensic soil, *Forensic Science International*. 141, 33–37.
[7]. Cox, R.J., Peterson, H.L., Yong, J., Cusik, C., Espinoza, E.O. (2000). The forensic analysis of soil organic by FTIR, *Forensic Science International* 108 107–116.

[8]. Croft, D.J., Pye, K. (2004). Multi-technique comparison of source and primary transfer soil samples: an experimental investigation, *Science& Justice* Volume 44 No.1, 21 – 28.
[9].Dillon, H. (1999). *Forensic scientists*: A career in the crime lab, from www.bls.gov/opub/ooq/1999/Fall/arto1.pdf
[10]. Folen, V.A. (1975). X-ray powder diffraction data for some drugs, excipients, and adulterants in illicit samples, *Journal of Forensic Sciences* 20, 348–372.
[11]. Fong, W. (1989). Analytical methods for developing fibers as forensic science proof: A review with comments, *Journal of Forensic Sciences* 34:295–311.
[12]. Horrocks, M., Coulson, S.A., and Walsh, K.A.J. (1999). Forensic palynology: variation in the pollen content of soil on shoes and in shoeprints in soil, *Journal of Forensic Science* 44, 119–122.
[13]. Hiller, J. C., Thompson, T.J.U., Evison, M. P., Chamberlain, A.T., Wess, T.J. (2003). Bone mineral change during experimental heating: an X-ray scattering investigation, *Biomaterials* 24, 5091–5097.
[14]. JCPDS, (2001). *Powder Difraction File, Inorganic*, International Centre for Diffraction Data, Swarthmore, USA.
[15]. Jenkins, R., Snyder, R.L. (1996). *Introduction to X-ray Powder Diffractometry*, John Wiley & Sons, New York.
[16]. Jeruzalmi D. (2006). First analysis of macromolecular crystals: biochemistry and X-ray diffraction. *Methods Mol. Biol.* 364, 43–62.
[17]. Junger, E.P., (1996). Assessing the unique characteristics of close-proximity soil samples: just how useful is soil evidence?, *Journal of forensic science* 41 27–34.
[18]. Karanović, Lj. and Poleti, D. (2003). *Rendgenska strukturna analiza*, Zavod za udžbenike i nastavna sredstva, Beograd.
[19]. Klug, H. P., and Alexander, L. E. (1974). *X-ray Diffraction Procedures for Polycristalline and amorphous materials*, John Wiley, Sons, New York.
[20]. Kotrlý, M. (2006). Application of X-ray diffraction in forensic science, *Z. Kristallogr. Suppllment* 23, 35-40.
[21]. Knight, B. (1997). *The dating of skeletal remains, in: Forensic Pathology*, 2nd eds., Edward Arnold, London.
[22]. Kugler, W. (2003). X-Ray diffraction analysis in the forensic science: The last resort in many criminal cases, *International Centre for Diffraction Data*, *Advances in X-ray Analysis*, Volume 46.
[23]. Marumo, Y. and Sugita, R. (1996). Validity of colour examination for forensic soil identification, *Forensic Science International* 83**,** 201–210.
[24]. Marumo, Y., and Sugita, R. (2001). Screening of soil evidence by a combination of simple techniques: validity of particle size distribution, *Forensic Science International* 122**,** 155–158.
[25]. Millen, P. (2000). Is crime scene investigation forensic science? Are crime scene investigators forensic scientists? *Proceedings of the 40th anniversary of the forensic science society, Science & Justice* 40(2), 125-126.
[26]. Morgan, R., Wiltshire, P., Parker, A., Bull, A. P. (2006). The role of forensic geosciences in wildlife crime detection, *Forensic Science International* 162, 152–162.

[27]. Murray K.A., Rose J.C. (1993). The analysis of cremains: a case study involving the inappropriate disposal of mortuary remains. *Jornal of Forensic Science*, 38(1):98–103.
[28]. Petraco, N., Kubic T.A., and Petraco, N.D.K. (2008). Case studies in forensic soil examinations *Forensic Science International 178*, pp. 23–27.
[29]. Prieto-Castello, M.J., Hernandez del Rincon J.P., Perez-Sirvent C., Alvarez-Jimenez P., Perez-Carceles M.D., Osuna E., Luna A., (2007). Application of biochemical and X-ray diffraction analyses to establish the postmortem interval, *Forensic Science International*, 172, 112–118.
[30]. Pye, K., (2004). *Forensic examination of rocks, sediments, soils and dusts using scanning electron microscopy and X-ray chemical microanalysis, in: Forensic Geosciences: Principles, Techniques and Applications*, Special Publications 232, Geological Society, London, 103–122.
[31]. Pye, K., and Croft, D.J., (2005). Forensic Geoscience: Principles, Techniques and Applications, *Science&Justice* Volume 45 No. 3, 168 – 170.
[32]. Pye, K., Blott, S.J., Croft, D.J., Witton, S.J., (2007). Discrimination between sediment and soil samples for forensic purpose using elemental data: an investigation of particle size effects, *Forensic Science International* 167, 30–42.
[33]. Pye, K., Croft, D.J. (2007). Forensic analysis of soil and sediment traces by scanning electron microscopy and energy-dispersive X-ray analysis: An experimental investigation, Forensic Science International 165, 52–63.
[34]. Rendle, D.F. (2003). X-ray Diffraction in Forensic Science, *Rigaku Journal*, 19 (2), 11–22.
[35]. Robertson, J., Thomas, C.J., Caddy, B., Lewis, A.J.M. (1984). Particle size analysis of soils-a comparison of dry and wet sieving techniques, *Forensic Science Internatiomal,* 24, 209–217.
[36]. Ruffell, A., Wiltshire, P. (2004). Conjunctive use of quantitative and qualitative X-ray diffraction analysis of soil and rocks for forensic analyses, *Forensic Science International*, 145, 13–23.
[37]. Sugita, R., Marumo, Y., (2001). Screening of soil evidence by combination of simple techniques: validity of particle size distribution, *Forensic Science International*, 122, 155–158.
[38]. Shorrock, G. (2005). *Wildlife Crime: A Guide to the Use of Forensic and Specialist Techniques in the Investigation of Wildlife Crime*, 88.
[39]. Thanasoulias, N.C., Piliouris, E.T., Kotti, M.S.E., Evmiridis, N.P. (2002). Application of multivariate chemometrics in forensic soil discrimination based on the UV–vis spectrum of the acid fraction of humus, *Forensic Science International*, 130 73–82.
[40]. Thangadurai, S., Abraham, J.T., Srivastava, A.K., Moorthy, M.N., Shukla, S.K., and Anjaneyelu, Y. (2005). X-ray powder diffraction patterns for certain β-lactam, tetracycline and macrolide antibiotic drugs, *Analytical Sciences* 21, 833–838.
[41]. Thorrton, J.J. (1986). Forensic soil characterization, *Forensic Science Progress*, vol. 1, Springer, Berlin, 1–35.
[42]. Wopenkia, B., Pasteris, J.D. (2005). A mineralogical perspective on the apatite in bone, *Matererial Science Engineering C 25*, 131–143.

REZIME

Forenzika u najširem smislu podrazumeva primenu znanja i tehnologija iz različitih oblasti nauka u oblasti krivičnih i građanskopravnih procesa koje u okviru krivičnog pravosuđa sprovodi policija. Oblast forenzike koja se bavi karakterizacijom, definisanjem porekla, kao i određivanjem štete na materijalu prikupljenom sa mesta kriminalnog događaja naziva se forenzički inžinjering. U ovoj oblasti koriste se različite fizičko-hemijske tehnike za karakterizaciju: analiza rasporeda veličine čestica u uzorku; UV–vis i FTIR spektroskopija; mikroskopska analiza; kao i metoda rendgenske difrakcije. Metoda rendgenske difrakcije praha koristi se u mnogim forenzičkim disciplinama za utvrđivanje porekla ispitivanih uzoraka i to najčešće u: analizi sedimentnog materijala, analizi eksploziva, pigmenta i boje; analizi tekstilnih materijala; analizi nepoznatih substanci, lekova i narkotičkih materijala; analiza plastike polimera, legura i metala; analiza posmrtnih ostataka. U radu je predstavljen pregled literaturnih podataka ispitivanja materijala rendgenskom difrakcijom u različitim kriminalnim događajima, na osnovu kojih se može zaključiti da je ova metoda veoma pogodna za ispitivanje u forenzičke svrhe.

SUMMARY

Forensics in the widest sense means the application of knowledge and technologies from various sciences in the field of criminal-investigation and civil-legal proceedings carried out by the police within the criminal justice system. The field of forensics dealing with the characterization, defining of origin, as well as determining the damage of the material collected at a crime scene is called forensic engineering. Various physical-chemical techniques of characterization are used in this field, such as: the analysis of the distribution of particle size within a sample; UV-vis and FTIR spectroscopy; microscopic analysis; as well as the method of X-ray diffraction analysis. The method of X-ray diffraction analysis of powders is used in many forensic disciplines in order to determine the origin of the investigated samples, most frequently for the analysis of sediment materials, the analysis of explosives, pigments and paints; the analysis of textiles; the analysis of unknown substances, medicines and drugs; the analysis of plastic polymers, alloys and metals; the analysis of mortal remains. This paper presents the review of literature data related to the materials investigated using X-ray diffraction analysis in various crimes, based on which it can be concluded that this method is rather suitable for forensic investigations.

COMPUTER DATA SEARCH AND COMPARISON - GENERAL REVIEWS AND APPLICATION IN CRIME INVESTIGATION

[*]Marinkovic D.[*], Brankovic A.[1], Milojkovic B.[1]

Criminal Justice and Police Academy, Belgrade, Serbia

Abstract: Collecting the most versatile kind of information about the citizens and their storing in the appropriate bases represent the reality of the contemporary society. The growth in the quantity of these pieces of information has exceeded human power to process and analyze such huge quantities of data in a traditional manner, requiring computerized techniques and means for these needs. Although widely applied for years in the work of public administration and economy, so far the computer data search and comparison have not been sufficiently used in crime investigation and forensics. Police agencies and forensic laboratories collect large quantities of various data which originate as a result of processing numerous criminal activities. The very success of their automatic search and comparison within criminal investigations depends to a large extent on the availability and characteristics of data (features, raster) which refer to persons, objects or events.

Key words: computer data search and comparison, data mining, computer matching, data surveillance, criminal-investigation aspects of data search and comparison, forensic data bases

1. Introductory remarks

Exceptional organization of human society which is present today not only in the developed countries but in other, in many ways underdeveloped parts of the world, involves collecting and managing the most various data related to their members. The efficient functioning of the government machinery and non-governmental sector requires the existence of many information registers about individuals and legal entities, their lives and work related to a specific field or problems because of which such registers and data bases are kept. On the other hand, the very development of computer technology (computerization) has largely

[*]Corresponding author: e-mail: darkoart2003@yahoo.com

increased the possibility of receiving, processing and monitoring such data, even for the purpose of surveillance of individuals and their behaviour. The essential importance of computer processing and storing of information is not only in the speed of carrying out various operations, but primarily in the possibility to access the integrated mutually linked elementary data which come from different sources. The state-of-the art information technology makes it possible to get these data in the matter of seconds or parts of a second, by networking data bases within large state and social areas, such as public administration, economy or science.

Collecting relevant information on citizens out of various (naturally legal and legitimate) motives and for the most various purposes as well as their storing into the appropriate bases represents the reality of the contemporary society, in the same way as it is the realistic (and necessary) fact that the persons these data refer to cannot have the absolute power over them. However, they have the right to feel secure from possible misuses of these data. This is why the issue of the protection of citizens' data today is highlighted even more, particularly being prominent in functioning and performing the activities of state administration institutions and judiciary, including police. Accordingly, with regards to the availability of citizen-related data, they must have certain limitations for the general interest in the same or similar way as when their other freedoms and rights are limited. The task of the legal science, law-makers and legal practice is to define standard foundations for the collection and management of the most versatile data, i.e. the conditions under which they can be used for socially justified purposes. On the other hand, the actual (primarily technical) possibilities are increasing from day to day for more comprehensive, complex and sophisticated exploiting of data on man and his activities in all fields of life and work. Among other things, the exploiting of such data can yield good results in fighting crime as well.

The explosive growth of quantity of data and bases where they are stored has exceeded human power to process and analyze such huge quantities of data by traditional means, requiring new and different techniques and means of automatic analysis in the available bases. Automatic data search and comparison, regardless of the purpose they are used for, is based, on the one hand, on the bases where certain data are stored, and on the other hand, on the application of computers (understood as hardware) and related programs (software) used for the search, comparison analysis of these data.

2. Data surveillance as a special form of personal surveillance

Surveillance may be defined as a systematic investigation or monitoring of movements or communications of one or more persons in order to collect information on them, their activities and connections. For a long time the surveillance has been implemented by direct physical observation, as well as by various devices used for the support, including telescopes, cameras, directed

microphones, telephone bugs, etc. The conventional forms of surveillance require hard work, cost much and last long (Marinkovic, 2008).

In the course of the 20th century the work of public administration has increasingly included the intensive use of personal data. The expansion of network traffic and flow of information has additionally contributed to the huge amounts of data interchanged to be widely available. Personal surveillance through personal data has become easily achievable, and at the same time much more inexpensive and simpler than the conventional techniques of physical or electronic surveillance. As a result, *data surveillance* has started developing. This is a method of surveillance of a large number of people by comparing and pairing of data referring to them which have been collected from a large number of sources. Ever since it started being applied, the data surveillance has become a topic of numerous government publications and its effects and influences have been discussed by many sociologists and some lawyers. It is usual that in Anglo-Saxon literature this phenomenon is referred to as *dataveillance* while it essentially represents the control, comparison and analysis of systemized data on persons in investigations or monitoring of their activities. There are two essential models of personal surveillance through data, and these are: 1) *personal dataveillance*, such as checking or validation of concrete, extraordinary or extra works and transaction, which are contrary to internal regulations of a certain service or organization, and 2) the surveillance of a large, usually unidentified number of persons (*mass dataveillance*), such as checking and validation of all transactions which are contrary to internal regulations of a certain organization. In addition to the two above mentioned models, there are also *facilitative and support techniques*, such as techniques for integration of data stored in various databases. In comparison to conventional forms of surveillance, dataveillance is automated, and therefore cheaper and more reliable. This is why its application during the last 30 years has flourished, in the beginning in wealthy societies with the developed and sophisticated information technologies, but recently also in the developing countries, among which there is a significant number of them having legislative problems due to the insufficiently developed mechanisms of civil rights protection.

3. Various models of computer data search and comparison

We are of the opinion that there should be a terminological difference between the concepts of (computer) data search and comparison. The search includes reviewing and analysis of data contained in certain data bases in order to find information that are not visible at first sight and refer to a certain person, action or process. Defined in such a way, the computer data search is mostly contained in *data mining* techniques. On the other hand, comparison implies to

have a certain amount of data or features in advance, which is then entered and compared with other data from a certain data base in order to find common characteristics between them which connect them and make them similar or the same (pairing). The procedure of computer comparison is almost entirely made equal with the procedure of *computer matching*.

In various fields of research (primarily statistics and artificial intelligence) the procedures of automated analysis have been developed that reveal hidden contents within large sets of data. The process used to achieve this is usually called *data mining*.[†] It marks the automated analytic process shaped for the effective and efficient exploration in large data sets in order to reveal and use valuable, "hidden" information which refer to hitherto unknown facts and relations. In other words, *data mining* can be understood as finding the previously unknown and potentially useful information or knowledge from large data sets. The basic principle is to create computer programs which scan such data sets and automatically search for certain, previously defined patterns. The potential of *data mining* technologies depends much on the nature of the available data sets and it is successfully applied in various professional fields, for instance in the remote resource management, biometrics, speech recognition or business and marketing. The *data mining* procedure uses algorithms in order to find the important hidden contents in large sets, the interpretation and understanding of which enables better diagnostics of state of affairs, better predictions and finally better decision-making.

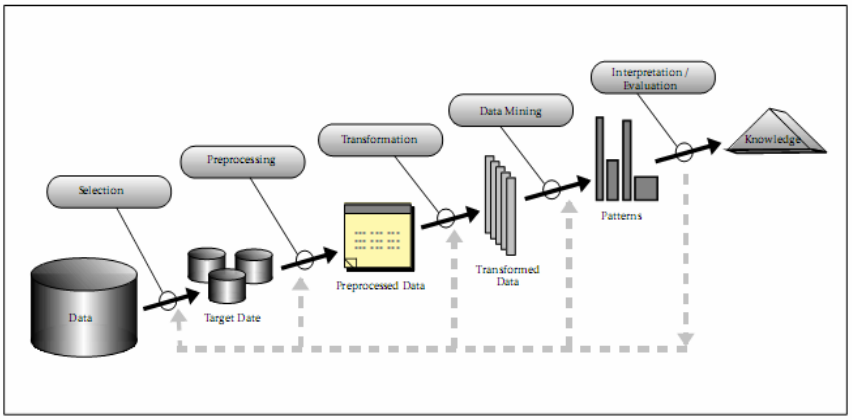


Figure 1 - Knowledge Discovery in Databases – KDD, in which Data Mining makes an integral part of the process (Fayyad et al., 1996)

[†] This is a metaphoric term used to present this process comparing it with ore mining. In the same way as ore mining is rather difficult and uncertain job, when you search for a certain precious ore in the depths of the Earth, during this procedure you dig, in other words search the vast amount of data looking for those that are useful.

The basic functions of *data mining* are: 1) classification, i.e. exploring of entity features and their sorting into previously determined classes; 2) clustering, i.e. segmenting of a heterogeneous set of entities into homogeneous sub-groups, clusters; 3) evaluation, i.e. predicting of unknown values of continuous variables; 4) detection of changes and deviations of data from previously measured or standard values; 5) detecting associations and finding items in transaction which imply the presence of other items in the same transaction, etc. Some authors (Berry, Linoff, 2000) classify *data mining* functions into two sets – the first one is directed analysis, based on supervised learning, including classification, evaluation and prediction, and the second one is undirected analysis, based on unsupervised learning, including grouping, association rules, description and visualization. The dominant view of the nature of *data mining* is that it helps reveal just the hypotheses of complex facts and their relations (Fayyad et al., 1996).

One of the *mass surveillance* techniques is computer matching, i.e. data pairing, which includes matching of (computer automated) readable records which contain personal data (generalities) of a large number of persons in order to reveal and clarify interesting cases. This technique is called *computer matching* in the USA, or *data matching* in Australia and Canada. It has become economically feasible in early 1970s, as a result of the information technologies development, and it has been developing since then so that nowadays it is widely applied, particularly in the sphere of state administration of the three mentioned countries. Some of the forerunners of *computer matching* could be found in so-called *Income Matching Programs*, which were long used by the USA IRS, or by the system for parental help, approved by the USA Congress by the amendment on the *Social Security Act* in 1974. Its original goal was to find parents who have violated the agreements related to their child support and to make them competent to honour and implement such agreements (Clarke, 1994).[‡]

[‡] It is stated in the literature that the first computer program intended for comparing and matching of data was the so-called Project Match, implemented in 1977 in the USA by the then Department of Health, Education and Welfare. Project Match compared the data of approximately 78% of the total number of families that received child support, with the data from salary lists of about 3 million federal officers. 33000 raw matches were reported, the number then being reduced to 7100, which resulted in 638 cases of internal investigations and 55 charges.
It is estimated that until 1982 about 200 programs for organizing and comparing of data were routinely carried out by the state and federal agencies in the USA. President Reagan's administration launched an action to improve government efficiency, and the President's Council on Integrity and Efficiency in Government (PCIE) has become the most ferocious advocate of computer matching method introduction into the contemporary management. Congress' Office of Technology Assessment estimated that the number of applications of computer matching method

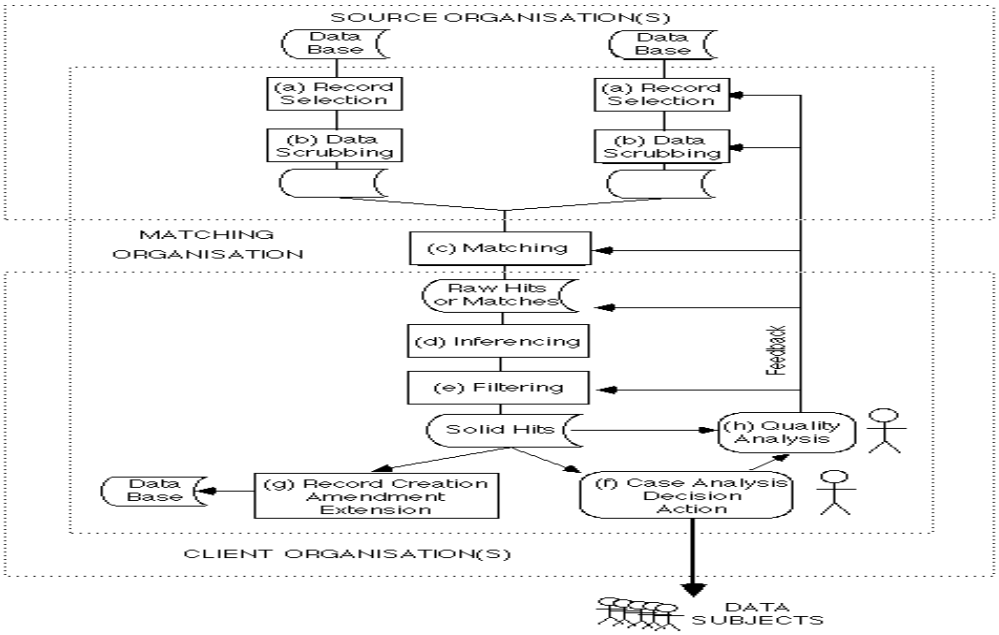


Figure 2 - Conceptual model of computer matching process (Clarke, 1994)

Computer matching technique is used for various purposes, the majority of which refer to social control and efficient work of state administration (traffic, police, health insurance, and similar), while its goals can generally be divided into primary and secondary ones. Some of primary goals would be: 1) to discover errors in programs of administration institutions (for instance, faulty estimate of certain profit, issuing bills several times, etc.); 2) to verify whether the conditions required for further use of certain benefits have been fulfilled; 3) to discover unlawful conduct of tax-payers, users of certain benefits, government officials, and similar (false or multiple claims, undeclared income or property, inappropriate conduct, conflict of interests); 4) monitoring regularity of procedure for allocation of grants or concluding agreements); 5) finding the addresses of persons that the government agencies have certain claims from; 6) identification of those who have the right to certain profit but do not exercise this right at the moment; 7) control of data validity, and 8) updating the data stored in one set of records based on the data from another database. Among the secondary goals of *computer matching* application, we would point out the following: 1) support to actions with favourable financial effects, such as ceasing cooperation with irregular payers, reduction of excessive payoffs, allowances for false payments to agencies, unpaid taxes or arrears due, collecting allowances in favour of other

in the period from 1980 to 1984 increased three times, while Laudon pointed out that the number was 500 by 1986. Quoted according to Clarke R., 1994.

government agencies, avoiding future irregular or excessive payoffs, intimidating and adverting future unlawful behaviour; and 2) establishing and maintaining the databases for the purpose of social control, research and statistics, improvement of strategic programs, and procedures and control mechanisms.

In addition to *computer matching*, there are other closely related techniques used for the support of surveillance of wide layers of population using data. One of them is *data-linkage*, the purpose of which is to store individual records into one personal file through which it is possible to identify one or more other files, which enable fast and reliable interrelation between the data in the future. The second technique, known as *data concentration* includes linking and joining of databases and creation of new ones for the requirements of support to numerous functions of state administration and economic subjects. The third technique includes the use of *common multipurpose identifiers*, which has aroused many debates on the creation of wide national programs intended for the personal identification, such as bases with social security numbers in the USA and Canada.

It is not rare that a person wants to acquire a certain profit in a fraudulent manner, for instance to receive a bigger pension cheque by giving false data about his family condition or to pay lower taxes because the tax authorities do not have true knowledge about his income; or get a loan although he does not fulfill the conditions because the creditor is not acquainted with the fact that the loaner has already the outstanding debts which are due. Under such circumstances, the organizations will probably require the confirmation of accuracy and completeness of the data enclosed by the interested persons. In order to protect their interests, they carry out the *verification* procedure, in other words they check if the presented data are true. The term *verification* is used as a common term for these purposes, but considering that it implies higher standards of proving and accuracy than it is possible to determine in these cases (without the court procedure), the term *cross-checking* is naturally more appropriate.

The large part of processing of and manipulating data is internal and is carried out for the needs of one organization. However, cross-checking in general implies the use, or discovering and disclosing of data in specific cases, which were collected earlier and processed for other functions and/or within other organizations. *Cross-checking* can be carried out in *ad hoc* situations, as required, or according to previously regulated agreements between certain organizations. They can be carried out with or without the knowledge and/or consent of the individual, as well as with or without an explicit legal authorization. Many *cross-checking* activities start on the occasions when certain individuals apply for a job, pension or loan, in which case it is usual to call them *front-end verification*. Reverse or inverse arrangement includes the agreement between organizations, which implies automatic cross-informing in case there are changes of certain data, for instance of the address. Such a procedure could be marked as *front-end*

notification. *Front-end verification* and *front-end notification* are the models of data surveillance, as a set of techniques by which one or many individuals are controlled but not directly, by physical surveillance, but using data. The previously mentioned cases, where the monitoring is actually a specific identification of persons resulting from the transactions which include the data related to these persons represent the forms of *personal dataveillance*. The person subject to such a manner of surveillance can be marked as *digital persona*.

Cross-checking can be undertaken even without the initiative by the subject who should carry out the transaction related to a certain person. The reasons for this may be contained in lifting the suspicion of the honesty of a client and the belief in their inclination to frauds, as well as validation of the data related to persons with whom the organization cooperates in order to avoid potential damaging consequences. In addition to assistance in the implementation of *personal dataveillance*, *cross-checking* may give large support to the implementation of *mass dataveillance*, which may be undertaken because it is not possible to identify in advance those persons who can be put in the category of the suspicious ones, or those inclined to embezzlement.

4. Crime-investigating aspects of computer data search and comparison

Computer search, analysis and comparison of data for crime-investigation purposes may be versatile, with various expectations and results of application. In the same manner as the large number of data stored in appropriate databases serves to the efficient performance of public administration, administration or banking, it can be very useful in crime investigation. From the point of view of the crime suppression activities, databases can be divided into primary and secondary. Primary databases are those created and maintained primarily for the requirements of crime investigations and subjects working on them, while the secondary ones are those organized and managed for the requirements of state administration, economy or health, but in certain cases they can be used for crime investigation purposes. This means that primary databases include, for instance, fingerprints data bases or criminal DNA profile databases,[§] while the secondary

[§] The Interpol's automatic fingerprint database (AFIS) contains about 90,000 fingerprints belonging to offenders, as well as fingerprints lifted from 1,600 crime scenes. DNA databases contain DNA profiles which are classified into reference profiles (the profiles of offenders, victims, the aggrieved...) and trace profiles (profiles obtained from biological traces). According to Interpol's data, in 2008 the forensic DNA analysis was carried out in the majority of Interpol member-countries, 53 countries have DNA database, while it is being created in 29 countries. There is a consensus at the level of the organization that each country should have a DNA database, and that the international exchange of DNA profiles should be carried out. There are discussions about whose DNA profiles should be stored in databases. Legal regulations in the

would include the databases of money transactions carried out by certain banks or bases of tax payers.

The factors helping in the evaluation of relevance of data mining techniques application in crime suppression range from the activities from which the databases result to their quality (the degree of insecurity, precision and completeness). Police agencies and forensic laboratories collect large quantities of various data, which result from the processing of many criminal activities. Thus the group of data is obtained within the forensic crime scene investigation which consists of the information referring to collected material of physical origin (for instance, biological traces, traces of tools, fingerprints, shoeprints, and illegal drugs seizures). This kind of data may be presented numerically and may be subject to categorization. The features extracted from these materials are often imprecise (in principle because of the instruments used for the analysis and measurements), incomplete (fragmentary) and insecure.

The discovered and processed material samples are usually categorized into three groups: 1) *useless samples* (for instance, the obvious clarity of the contents without any calculations or they are irrelevant for the problem observed), 2) *useful samples*, which provide direct important information that can be worked with, and 3) *patterns that require interpretation*, and which can be classified into two previous categories, because of which they must be studied by the experts in the given field (Terrettaz-Zufferey et al., 2006).

The researchers have developed various automated data mining techniques for the requirements of crime suppression, both in the field of local police work and at the national level. Thus the *entity extraction technique* identifies the patterns from databases such as texts, images or audio materials. It is used for the automatic identification of faces, addresses, vehicles or personal characteristics from narrative police reports. This technique provides for the basic data for crime analysis, but its achievements depend to a large extent on the availability of large quantity of pure input data. *Cluster techniques* systematize data into groups of similar characteristics, in order to maximize or minimize the similarity of data within a certain group – for instance, for the identification of suspects who commit crimes in the similar manner or to differentiate between criminal groups belonging to different gangs. *Association rule discovery* finds the groups of data that appear often in one database and the patterns of their appearance are defined as regularities. This technique is often used to trace computer network hacking so that the certain rules of association could be deduced from the history of interactions among the users. The researchers can also use this technique for

Interpol member-countries are various, ranging from Belgium where the DNA databases contain only the profiles of those convicted for major crimes, to Great Britain where the databases contain the profiles of both the suspects and convicts for all crimes and the majority of delicts, as well as the profiles of volunteers. Quoted according to INTERPOL – Forensic.

profiling of hackers so that they could help in detecting possible attacks on the network.

Sequence pattern detection (or string pattern detection) finds sequences that appear often in one set of transactions that occurred at various times. Pointing to the hidden patterns is useful for crime analysis, but in order to obtain meaningful results a rich and highly structured database is required. *Deviation detection* uses certain measures for the study of data which noticeably differ from other data. The investigators may use this technique to detect frauds, hacking into network systems and other crime analyses. However, such activities may sometimes seem usual at first sight, which makes identification of deviating data more difficult. *Classification* finds common features among various criminal entities and organizes them into previously defined classes. This technique is used for the identification of so called spam e-mail messages, based on the linguistic patterns and structural features of the sender. Often used for prediction of crime trends, the classification may reduce time required for the identification of criminal entities.

Comparative data mining techniques compare pairs of textual fields in databases and calculate similarities between records. These techniques may discover false information such as names, addresses and social security numbers. The investigators may use comparison for the analysis of textual data, but these techniques often require intensive calculations. *Social network analysis* describes the role and interactions among branching points (nods) within one conceptual network. This technique may be used in case the networks were created which would illustrate the roles of certain criminals, the flow of material and immaterial goods and information, as well as connections between these entities. Further analysis may reveal critical roles and sub-groups, as well as vulnerability, i.e. weaknesses within the network (Chen et al., 2004).[**]

One of the aspects of applying *data mining* techniques for crime-investigating purposes is the analysis of seized drugs in order to define the status of drug market as complete as possible (Ratle et al., 2006). In this case the methods of recognizing drug samples are systematically tested on the multitude of samples of seized heroine and cocaine in order to find possible regularities which could provide information related to the scope and development of illegal trafficking. Classic algorithms, such as the analysis of main components and various grouping and classifying algorithms, can successfully be applied on heroine databases. Basically, the process of diluting and cutting heroine happens at various levels of illegal trafficking, but it is most often carried out at the end of

[**] The offenders often develop criminal associations – networks within which they make groups or teams in order to commit various illegal activities. The application of data mining techniques in these cases consists of identification of sub-groups and key members in these networks, as well as of the study of patterns of interaction in order to develop efficacious strategies for neutralizing of these networks. More in Chen H. et al., 2004.

the distribution process so that the quantity of pure heroine is as small as possible, in other words the profit is as large as possible. This is why the substances for cutting heroine are of special importance for easier understanding of local trafficking network. The presence or absence of these substances is systematically detected by laboratory techniques of chemical analysis. One sample of the seized heroine can contain various substances at the same time (sugar, milk, pudding, or cocoa powder, flour, paracetamol and similar), and a certain combination of the ingredients and their ratio can be the indicator of various levels in the chain of distribution. This is why the dynamics of appearance of these combinations may be a good indicator of the condition and development of a local market, with the possibility of presenting by means of combining analysis and graph theory. Databases created for these purposes should contain the following variables (Terrettaz-Zufferey et al., 2006):

- location and time of seizure;
- presence/absence of cutting substances;
- combination of cutting substances.

When we talk about the application of computer data matching methods in crime investigation, the starting basis is made of the available features of a certain person or things or kind of events (criminal act, misdemeanor, the procedure of determining ownership, and similar) because of which the matching is carried out in the first place. It is based on these that databases are determined where it is expected to find complementary data referring to that person(s), things or events. Personal features or characteristics may be related to his personality, taken in psycho-physical (sex, age, fingerprint, DNA profile, diseases, etc.) or social sense (nationality, citizenship, political orientation, bank account, marital status, membership in some organization, etc.). Also, the features can be such as to be characteristic for only one person, so that when they are matched the identity of the person is determined beyond any doubt, or they can be common for a big or small group of people, which are then, following the search and matching, selected from the database and processed further. Therefore, there are two kinds of computer data matching:

1. comparing the data the result of which is to determine the identity of a person (for instance, by running the DNA blood samples from crime scenes through the criminal DNA profile database or by running the dead John Doe's fingerprints through the database of identity cards of the citizens);
2. searching the data the result of which is to determine the circle, or a group of people (for instance, by searching through the database containing the data on vehicles registered in a certain area in order to select vehicles of a

certain brand, type and colour, or the owners of such vehicles, because of a car accident).

Nowadays the police forces all over the world use the *Automatic Fingerprint Identification Systems* (AFIS). In these cases, we talk about the primary databases, considering the fact that such registers are made for crime-investigation purposes. However, such fingerprint bases or the bases containing other biometrical features which include the wide range of population are starting to be created, without any specific criterion except, for instance, the age or entry to the territory of a certain country.[††] In the first case the motive is to issue such identification documents to citizens (identity cards, passports) that would contain, among other things, some biometrical characteristics, most often the photograph of the person and his/her signature,[‡‡] and in the second it is the business, tourist or any other entry in the country that requires a certain procedure.

From the crime-investigation aspect, special significance is given to data matching in cases when there are material features available which are found at crime scenes or some other places and which are (or it is assumed that they are) connected to a crime, with the material features of that kind taken from the suspects for the comparing purposes. In this way, in case all features match, their connection is determined by quite a simple procedure, or in case they do not match, persons are eliminated as suspects.

It can be said that the success of computer data matching in criminal investigations depends crucially on the availability of characteristics (raster, features) of the persons and their features. Accordingly, if a small number of characteristics are available, less is the probability that the search will be successful. On the other hand, if the characteristics are too general, a large number of persons will result from the matching process and they should be processed further, which increases the costs of investigation to a large extent. This is why

[††] For instance the US-VISIT (*United States Visitor and Immigrant Status Indicator Technology*) program requires all the USA visitors to be photographed and their fingerprint taken prior to entering the country. These data are used not only for verifying the visitors when entering the USA, but they are connected with more than 20 other databases of the USA government. The goal is to prevent to a significant extent the entry of the wanted or dangerous persons who assume false identities to enter the country. Similar to US-VISIT, Japan uses J-VIS program. More in: *Homeland Security: Fact Sheet – Expansion of US-VISIT Procedures to Additional Travelers; United States Visitor and Immigrant Status Indicator Technology*.

[‡‡] This is the situation present in the Republic of Serbia also, following the passing of the Law on identity cards, according to which this basic identification document contains, among other things, the photograph of a person, signature and a fingerprint. In this way the Ministry of the Interior would in the course of issuing new identity cards create such a database where biometrical features of all Serbian citizens older than 16 (exceptionally some younger ones, too) will be stored.

some authors are questioning sincerely the very efficiency of this evidence procedure.[§§]

5. Conclusion

The great challenge all police and intelligence agencies are facing is an accurate and efficient analysis of the data on crime, the scope of which is constantly increasing. For instance, complex criminal conspiracies are often hard to reveal because the information on suspects may be geographically scattered and may include large number of people. Disclosing computer crimes can also be difficult because the extensive network traffic and frequent *online* transactions create a huge quantity of data out of which only a small portion refers to illegal actions. Police agencies and forensic laboratories collect large quantities of various data, which result from processing many criminal activities. It can be said that the automatic data searching and matching techniques have been insufficiently used so far in this field, although it could contribute significantly, particularly in discovering these crimes which are a part of dark numbers or are difficult to anticipate and prevent. Extenuating circumstance in their application is, among other things, huge versatility of data that should be processed and considered.

Those involved in criminal investigations who have years of experience can often precisely analyze crime trends, but since the frequency and complexity of criminal acts increases, human errors also appear, the time required for analysis increases as well, and the offenders have more time to destroy evidence and avoid being arrested. Automatic data searching and matching is a powerful tool which enables the crime investigators, who may not be skilled for analysts, the fast and efficient searching of large databases. Computers can process thousands of instructions in just a few seconds, saving time. In addition to this, installing and using of software often costs less than hiring or training of the staff. Computers are also less prone to errors than people, especially those investigators who work many hours both at day and night.

Special understanding of the relationship between the possibilities of the analysis and the characteristics of a certain type of crime can help investigators to apply these techniques more efficiently in order to identify trends and patterns, locate problem area, and even predict a crime.

[§§] In Germany in 2004 the fact was made public that the search of as many as 8.3 million data resulted in only one investigation, which strongly supported the arguments of critics that the search raster is actually a pure failure. Quoted according to *Rasterfahndung – Kritik*.

References:

1. Berry M., Linoff G.,(2000.), *Mastering Data Mining*, New York

2. Clarke R., (1994), Dataveillance By Governments: The Technique of Computer Matching.- In: *Information Technology & People*, p. 46-85**;** http://www.rogerclarke.com/DV/MatchIntro.html (downloaded on June 10, 2009).

3. Chen H. et al., (2004), Crime Data Mining: A General Framework and Some Examples.- In: *Computer*, Published by the IEEE Computer Society, p. 50-56.

4. Fayyad U. M. et al., (1996), From Data Mining to Knowledge Discovery: An Overview.- In: *Advances in Knowledge Discovery and Data Mining*, Cambridge, p. 1-34. http://www.daedalus.es/fileadmin/daedalus/doc/MineriaDeDatos/fayyad96.pdf (downloaded on August 18, 2009).

5. Homeland Security: Fact Sheet - Expansion of US-VISIT Procedures to Additional Travelers; http://www.dhs.gov/files/programs/gc_1231972592442.shtm (downloaded on April 24, 2009).

6. INTERPOL – Forensic; http://www.interpol.int/Public/Forensic (downloaded on June 28, 2009).

7. Marinković D., (2008), Tajni audio nadzor kao dokazna radnja – različiti modaliteti i analiza rešenja u zakonodavstvu Srbije.- In: *Sprečavanje i suzbijanje savremenih oblika kriminaliteta III*, Beograd, p. 228-256.

8. Ratle F. et al.,(2006), Learning Manifolds in Forensic Data.- U: *Lecture Notes in Computer Science*, Heidelberg, p. 894-903; http://resources.metapress.com/pdf-preview.axd?code=fkgv59020149w601&size=largest (downloaded on July 4, 2009).

9. Rasterfahndung - Kritik; http://de.wikipedia.org/wiki/Rasterfahndung (downloaded on June 18, 2009).

10. Terrettaz-Zufferey A. L. et al., (2006), Assesment of Data Mining Methods for Forensic Case Data Analysis.- U: *Varstvoslovje*, Fakulteta za varnostne vede, Ljubljana, p. 350-354.

11. United States Visitor and Immigrant Status Indicator Technology;

http://en.wikipedia.org/wiki/United_States_Visitor_and_Immigrant_Status_Indicator_Technology (downloaded on April 24, 2009).

REZIME

Prikupljanje odgovarajućih informacija o građanima iz najrazličitijih (naravno legalnih i legitimnih) motiva i u najrazličitije svrhe, te njihovo smeštanje u odgovarajuće baze, predstavlja realnost savremenog društva. Razvoj računarske tehnologije u velikoj meri je povećao mogućnosti prijema, obrade i praćenja takvih podataka, pa čak i u svrhe nadzora nad pojedincem i njegovim ponašanjem. Automatsko pretraživanje i upoređivanje podataka, nezavisno od toga u koje se svrhe primenjuje, zasniva se sa jedne strane na bazama u kojima su smešteni određeni podaci, i, sa druge strane, primeni računara (shvaćenog kao hardver) i odgovarajućih programa (softver) kojima se ti podaci pretražuju, upoređuju i analiziraju.

Kompjutersko pretraživanje, analiziranje i upoređivanje podataka u kriminalističke svrhe može biti veoma raznovrsno, sa različitim očekivanjima i rezultatima primene. Policijske agencije i forenzičke laboratorije sakupljaju velike količine različitih podatka, koji nastaju kao rezultat obrade brojnih kriminalnih aktivnosti.

Veliki izazov sa kojim se suočavaju sve policijske i obaveštajne agencije jeste tačno i efikasno analiziranje podataka o kriminalu, čiji se obim neprestano povećava. Može se reći da su tehnike automatskog pretraživanja i upoređivanja podataka do sada nedovoljno eksploatisane u ovoj oblasti, iako bi mogle dati značajan doprinos.

Automatsko pretraživanje i upoređivanje podataka je moćna alatka koja istražiteljima krivičnih dela omogućava brzo i efikasno pretraživanje velikih baza podataka. Posebno razumevanje odnosa između mogućnosti analize i karakteristika određene vrste krivičnog dela može da pomogne istražiteljima da efikasnije primene ove tehnike kako bi identifikovali trendove i obrasce, locirali problematična područja, pa čak i predvideli krivično delo.

SUMMARY

Collecting relevant information on citizens out of various (naturally legal and legitimate) motives and for the most various purposes as well as their storing into the appropriate bases represents the reality of the contemporary society. The development of computer technology) has largely increased the possibility of receiving, processing and monitoring such data, even for the purpose of surveillance of individuals and their behaviour. Automatic data search and

comparison, regardless of the purpose they are used for, is based, on the one hand, on the bases where certain data are stored, and on the other hand, on the application of computers (understood as hardware) and related programs (software) used for the search, comparison and analysis of these data.

Computer search, analysis and comparison of data for crime-investigation purposes may be versatile, with various expectations and results of application. Police agencies and forensic laboratories collect large quantities of various data, which result from the processing of many criminal activities.

The great challenge all police and intelligence agencies are facing is an accurate and efficient analysis of the data on crime, the scope of which is constantly increasing. It can be said that the automatic data searching and matching techniques have been insufficiently used so far in this field, although their contribution could be significant. Automatic data searching and matching is a powerful tool which enables the crime investigators the fast and efficient searching of large databases. Special understanding of the relationship between the possibilities of the analysis and the characteristics of a certain type of crime can help investigators to apply these techniques more efficiently in order to identify trends and patterns, locate problem area, and even predict a crime.

DETERMINING OF TRAFFIC ACCIDENT CULPRIT BY APPLICATION OF NEW THEORETICAL METHOD

♣Zoric V.[1], Sajfert V.[2], Šetrajčić J.[3], Radosavljevic-Stevanovic N.[4]

[1] *Ministry of the Interior, National Criminalistic-Technical Center, Unit in Novi Sad, Serbia*
[2] *Technical Faculty "M.Pupin" – Zrenjanin, University of Novi Sad, Serbia*
[3] *Department of Physics, Faculty of Sciences, University of Novi Sad, Serbia*
[4] *Ministry of the Interior, National Criminalistic-Technical Center, Unit in Nis, Serbia*

Abstrakt:The paper presents the analyses of the samples of paints, which were found on the place of the traffic accident in which the bicyclist was killed and the car that caused the accident disappeared. The preliminary investigation detected five cars as suspicious. The experimental analyses excluded two cars, where the low energies (the method of the infrared spectrophotometry with Fourier transformation - FT-IR) as well as high energies (the method of the scanning electron microscopy with electro dispersive x-rays spectroscopy - SEM/EDS) scientific methods were used. The experimental diagrams for the samples from the place of accident and from the two suspicious cars were visibly very similar so that no final conclusion could be made. It was the reason for the theoretical analysis of the experimental results by the application of the formula of reversible and irreversible absorption. Both types of theoretic formulas pointed to the same car as the one that caused the accident

Kay words: Traffic accident, experimental investigation of paint samples, the formulas of reversible and irreversible absorption.

1. Introduction

During the process of identification of the paints, the experimental and the theoretical methods can be applied. The example of the experiment successfully combined with theory will be shown here in order to discover the culprit of the traffic accident, which happened in the collision of a car and a bicyclist. The bicyclist remained dead on the place of the accident, while the car ran away.

♣ Corresponding author: Email-vojkan.zoric@mup.gov.rs

According to the traces of paints that were found, the experimental analyses were done both in the low energies (the method of the infrared spectrophotometry with Fourier transformation) and in the high energies (the method of the scanning electron microscopy with electro dispersive x-rays spectroscopy). The result of those analyses was the elimination of three cars. Two suspicious cars remained and it was not possible to deduce, only by applying the experimental results, which one was the culprit

These experimental results were used for the application of the theory of identification of paints which is based on the formulas of the reversible and irreversible absorption.

The application of this theoretical approach led to the final answer who is the culprit of the accident.

In Fig. 1 the delivered samples of the traces of paints are presented.

Figure 1: The samples of paints (No 1 is from the place of accident, and No 2-5 are from the suspecious cars)

2. Irreversible and reversible absorption of particles and quasi-particles

The formulas of irreversible and reversible absorption of the molecules were used in this paper in order to solve the problem which could not be solved by using the standard methods of physical-chemical analyses in forensic examination of paints.

The sequence of the analyses was the following:

According to the analyses of the paints that used physical-chemical methods (infrared spectrophotometry with Fourier transformation - FT-IR and scanning electron microscopy with electro dispersive x-rays spectroscopy - SEM/EDS), three samples of paints from three different cars were eliminated. The rest of the obtained diagrams of the analyzed samples were very similar, so that some subtle analysis method had to be found. The chosen method is of the theoretical character and is based on the application of the formulas of the reversible and irreversible absorption of the molecules. The result of this analysis gave the final answer about the most probable culprit of the accident.

The semi empirical rule of irreversible absorption of the state of the change of number of particles and quasi-particles is proportional to their number:

$$\frac{dn}{d\xi} = -an \tag{1}$$

where *a* is a coefficient of irreversible absorption and it can be a variable denoting time, configuration coordinates, wave number, wave length, etc.

Solving this differential equation for initial condition $n(0) = n_0$ we obtain exponential law of irreversible absorption (Spangenburg and Moser, 1999):

$$n(\xi) = n_0 e^{-a\xi} \tag{2}$$

The irreversible absorption is based on the fact that absorbed particles or quasi-particles do not return into the absorber. The law of irreversible absorption is expressed in Figure 2:

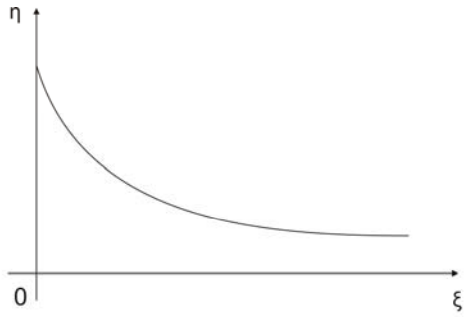


Figure 2: The general diagram of irreversible absorption

In processes of reversible absorption not all absorbed objects remain in the absorber. One part of them returns.

The experimental data have shown that the change of reversible absorbed particles is proportional to the average number of particles:

$$\frac{dn}{d\xi} = -b\frac{1}{\xi}\int_0^{\xi} d\xi\, n(\xi) \tag{3}$$

Differentiating (3) with respect to ξ we obtain the following equation:

$$\frac{d^2n}{d\xi^2} - bn + \frac{1}{\xi^2}\int_0^{\xi} d\xi\, n(\xi) \tag{4}$$

Elimination an integral from (3) and (4) leads to second order differential equation:

$$\frac{d^2n}{d\xi^2} + \frac{1}{\xi}\frac{dn}{d\xi} + \frac{b}{\xi}n = 0 \tag{5}$$

By the substitution $x = \sqrt{4b\xi}$, the equation reduces to Bessel's function with zero indexes:

$$\frac{d^2n}{dx^2} + \frac{1}{x}\frac{dn}{dx} + n = 0 \tag{6}$$

Consequently the law of reversible absorption is given by the formula (U. Timotich, 1990, U. Timotich, 1991):

$$n(\xi) = J_0\left(\sqrt{4b\xi}\right) \tag{7}$$

where J_0 is denotes zero index Bessel's function (Korn, Korn, 1961.). This law is expressed graphically in Figure 3:

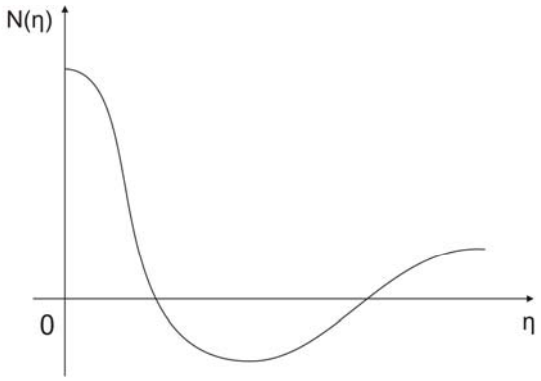


Figure 3: General diagram of reversible absorption

3. Determining the composition of irreversible absorption and the parameter of reversible absorption from the experimental data

The representative experimental data at low energies (FT-IR) as well as at high energies (SEM/EDS) are presented in Figures 4 and 5, respectively.

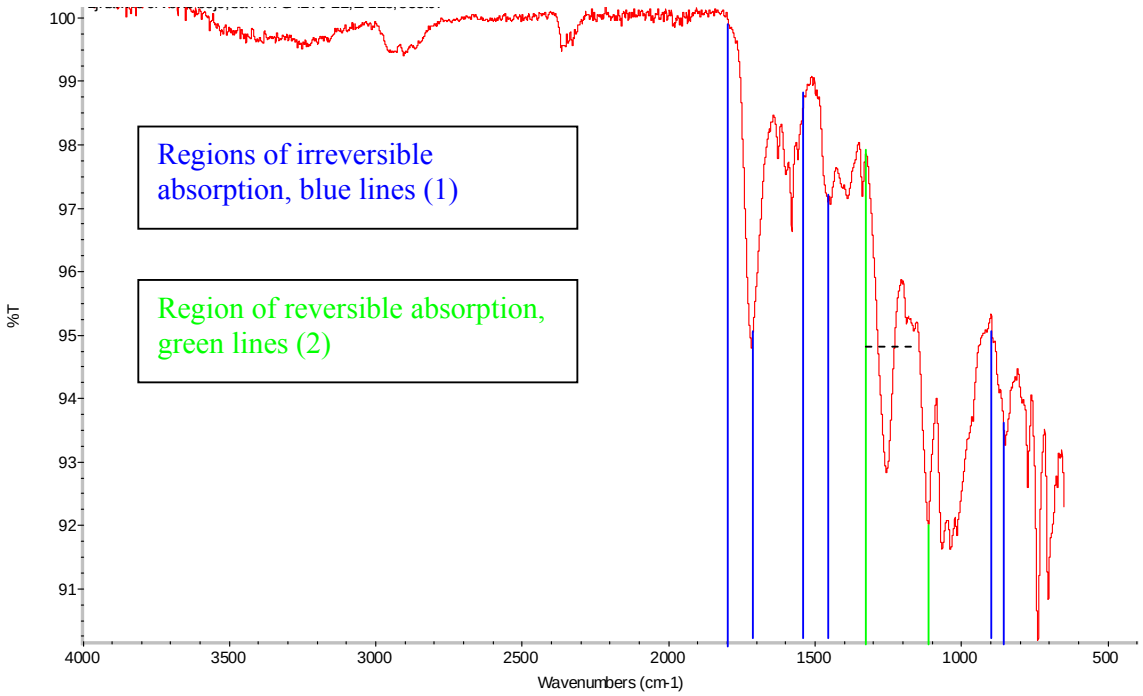


Figure 4: FT-IR spectrum of one sample of the car-paint. Blue colour marks spectral regions which were used by the application irreversible absorption formulas and green colour marks reversible absorptions

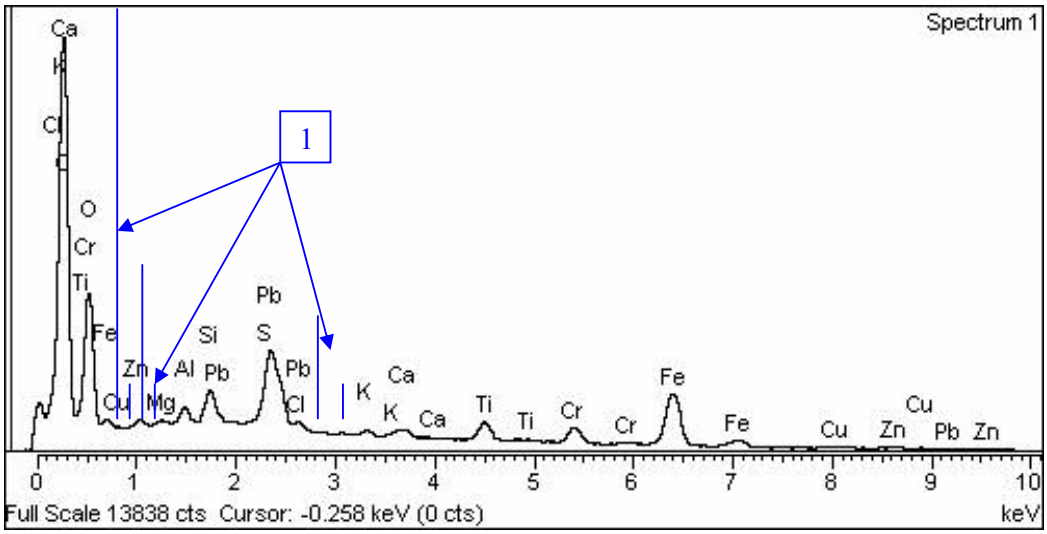


Figure 5: SEM/EDS diagram of one sample of the car-paint. Arrows denote regions which used in further analyses

The parts corresponding to irreversible and reversible absorption are taken from these diagrams and they are translated to analytical form by the method of minimal squares (Vukadinović, 1986).

Analytical formulas for irreversible absorption where used to find the resulting irreversible absorption (Bühlmann, 1970; Hipp, 1994). The convolution formulas were:

$$C_n(x) = \int_0^x dy \;\; C_{n-1}(x-y) \quad P_n(y) \tag{8}$$

where $P_n(y) = P_0 \mathrm{e}^{-ay}$.

By means of Laplace transformation the composition of a set of irreversible absorptions was determined from the formula (8), the formula of which is:

$$\begin{aligned} D_\mu(x) = \Bigg[& \frac{e^{-a_1 x}}{(a_2 - a_1)\;(a_3 - a_1)\;\cdots\;(a_n - a_1)} \;+ \\ & + \;\frac{e^{-a_2 x}}{(a_1 - a_2)\;(a_3 - a_2)\;\cdots\;(a_n - a_2)} \;+ \\ & + \;\frac{e^{-a_3 x}}{(a_1 - a_3)\;(a_2 - a_3)\;\cdots\;(a_n - a_3)} \;+\; \cdots \\ \cdots \;+ & \;\frac{e^{-a_n x}}{(a_1 - a_n)\;(a_2 - a_n)\;\cdots\;(a_{n-1} - a_n)} \Bigg] \prod_{\mu=1}^{n} \mathcal{N}_\mu \end{aligned} \tag{9}$$

Numerical analysis of this formula gives diagram presented in Figure 6:

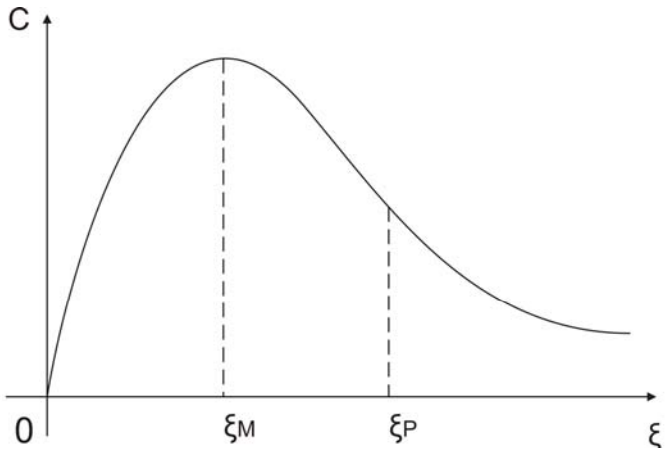


Figure 6: General diagram of composition of exponential irreversible distributions

The abscissas are the important characteristic of composition and consequently the important characteristic to determine the paint.

The experimental diagram corresponding to reversible absorption is also translated to analytical form by methods of minimal squares. Using the fact that the first two zeros of Bessel's function J_0 are $x_1 = 2.40483$ and $x_2 = 5.52008$ (Janke, Emde, Lesh, 1997), we could determine the absorption index of reversible absorption, by the following formula:

$$b = \frac{x_1 x_2}{4\sqrt{\eta_1 \eta_2}} \tag{10}$$

4. Determining more probable culprit on the basis of the presented theoretical approach

The theoretical results for the abscissa of composition distribution at low energies were (11) while for high energy range its values were (12).

Low energy range ($\xi_M \equiv \lambda_M$):

$$\begin{aligned} \lambda_1 &= 5.58378 \cdot 10^{-2}\, m \\ \lambda_2 &= 10.5518 \cdot 10^{-2}\, m \\ \lambda_3 &= 6.09032 \cdot 10^{-2}\, m \end{aligned} \tag{11}$$

High energy range ($\xi_M \equiv K_M$):

$$\begin{aligned} K_1 &= 0.86891 \cdot 10^{9}\, m^{-1} \\ K_2 &= 1{,}41639 \cdot 10^{9}\, m^{-1} \\ K_3 &= 0.613786 \cdot 10^{9}\, m^{-1} \end{aligned} \tag{12}$$

The coefficients of reversible absorption at low energies (12) were determined from the diagrams for reversible absorption which is given by the formula (10), as well as the coefficients of reversible absorption at high energies (13):

The values at low energies were:

$$\begin{aligned} b_{1L} &= 0.469336 m^{-1} \\ b_{2L} &= 0.4181 m^{-1} \\ b_{3L} &= 0.43671 m^{-1} \end{aligned} \tag{13}$$

The values at high energies were:

$$\begin{aligned} b_{1H} &= 1.3548 m^{-1} \\ b_{2H} &= 1{,}106\ m^{-1} \\ b_{3H} &= 1{,}415\ m^{-1} \end{aligned} \tag{14}$$

5. Conclusion

Comparing the results (11), (12), (13) and (14), we can conclude that characteristics of the paint traces taken from the car number 3 are closer to the paint taken from the place of accident than the results for samples taken from the car number 2.

Consequently the application of the theory of reversible and irreversible absorption has given the final answer: the more probable culprit of the accident is the car denoted with index 3.

The diagrams of the experimental results were not clear as to who the culprit of the traffic accident was. The problem was solved with the application of the reversible and irreversible absorption formulas which suggests that the application of mathematical statistics methods is the most objective instrument of forensic analysis.

6. References

1. Beam, TL; Willis, WV, (1990), Analysis Protocol for Discrimination of Automotive Paints by SEM-EDXA Using Beam Alignment by Current Centering, *JFS, Volume 35, Issue 5*
2. Bühlmann H., (1970), *Mathematical Methods in Risk Theory*, Springer-Verlag,, Berlin, Heidelberg,.
3. Hartshorn, JH, (1992), Applications of FTIR to Paint Analysis, *ASTM, Pg 21*
4. Hipp C., (1994), *Introduction to risk theory*, Lectures on Technical University Karlsruhe
5. E.Janke, F.Emde, F.Lesh, (1997), *Specialnije funkcii*, Nauka, Moscow
6. G. Korn, T. Korn, (1961), *Mathematical Handbook*, McGraw-Hill, New York-Toronto London
7. Mukai, T., (2005), Discrimination of Blue Automotive Paints by Elemental Analysis Using SEM/EDX. *Japanese Journal of Forensic Science and Technology* 10(2)
8. R.Spangenburg and D. K. Moser, (1999), *The History of Science from 1895-1945*, Universities Press (India) Ltd.
9. Suzuki, Edward M., (2006), Infrared Spectra of U.S. Automobile Original Finishes. VII. Extended Range FT-IR and XRF Analyses of Inorganic Pigments In Situ-Nickel Titanate and Chrome Titanate, Journal of Forensic Sciences 0(0)
10. U. Timotich, (1990), *First World Reneweable Energy Congress*, 3, 2137-2141, London, Reading
11. U. Timotich, (1991), *First International Conference on Combustion Technologies for a clean Environment,* 2, 89-93,Vilamoura, Portugal
12. S.V.Vukadinović, (1986), *Elementi teorije verovatnoćei i matematičke statistike*, Beograd, Ekonomska revija

REZIME

U identifikaciji boja primenjuju se i eksperimentalni i teorijski metodi. Ovde će biti naveden primer uspešno kombinovanog eksperimenta i teorije, u otkrivanju vinovnika saobraćajne nesreće koja se realno dogodila u sudaru automobila i bicikla. Analizirani su uzorci boje uzeti sa mesta akcidenta u kome je poginuo biciklista a automobil-uzročnik je napustio mesto akcidenta.

Preliminarna istraživanja izdvojila su kao sumnjiva pet automobila. Na osnovu nađenih ljuspica boje vršene su eksperimentalne analize koje su isključile dva automobila kao uzročnike nezgode, a gde su korišćeni metodi ispitivanja u nisko-energetskoj oblasti (metodom infracrvene spektrofotometrije sa Furijeovom transformacijom - FT-IR), kao i u visoko-energeteskoj oblasti (metodom skenirajuće elektronske mikroskopije sa elektrodisperzivnim spektrometrom -

SEM/EDS). Eksperimentalni dijagrami uzoraka sa mesta krivičnog događaja i sa dva osumnjičena automobila bili su vrlo slični, tako da se nije mogao izvesti definitivan zaključak.

Ovi eksperimentalni rezultati iskorišćeni su za primenu teorije identifikacije boja koja je zasnovana na formulama reverzibilne i ireverzibilne apsorpcije. Primena ovog teorijskog pristupa dovela je do konačnog odgovora o vinovniku događaja tj. oba tipa teorijskih formula izdvojila su samo jedan automobil kao vinovnika predmetnog akcidenta.

Dakle, kako iz dijagrama eksperimentalnih rezultata nije bilo jasno ko je izvršilac saobraćajne nezgode problem je bio rešen primenom formula reverzibilne i ireverzibilne apsorpcije što ukazuje da je primena metoda matematičke statistike najobjektivniji instrument forenzičke analize.

SUMMARY

During the process of identification of the paints, both the experimental and the theoretical methods are used. We shall here present the example of the experiment successfully combined with the theory in order to discover the culprit of the traffic accident, which happened in the collision of a car and a bicyclist. The samples of paints were analyzed, which were found at the place of accident in which the bicyclist remained dead on the spot while the car ran away. The preliminary investigation detected five cars as suspicious.

According to the traces of paints that were found, the experimental analyses were done both in the low energies (the method of the infrared spectrophotometry with Fourier transformation) and in the high energies (the method of the scanning electron microscopy with electro dispersive x-rays spectroscopy). The result of those analyses was the elimination of three cars. Two suspicious cars remained and it was not possible to deduce, only by applying the experimental results, which one was the culprit, since the experimental diagrams for the samples from the place of accident and from the two suspicious cars were visibly very similar so that no final conclusion could be made.

These experimental results were used for the application of the theory of identification of paints which is based on the formulas of the reversible and irreversible absorption. The application of this theoretical approach led to the final answer who is the culprit of the accident, i.e. both types of theoretic formulas pointed to the same car as the one that caused the accident.

Therefore, since the diagrams of the experimental results were not clear as to who the culprit of the traffic accident was, the problem was solved with the application of the reversible and irreversible absorption formulas, which suggests that the application of mathematical statistics methods is the most objective instrument of forensic analysis.

SECURITY PROTOCOLS

[*]Randjelović D.[*], Petrović L.[1], Radovanović R.[1], Popović

Criminal Justice and Police Academy, Belgrade, Serbia

Abstract: The Internet, as a computer network, connects millions of people all around the world and gives them a possibility to access a big quantity of data. Throughout the Internet users exchange data using certain protocols and a part of this communication is private or secret. TCP (Transmission Control Protocol) and IP (Internet Protocol) protocols are the kernel of Internet protocol. Everything that is transmitted through the Internet uses these protocols, but they cannot provide security of data transfer. For example, IP packages can be easily changed and their content can be seen by everybody in every moment, even by an unauthorized person. Today the world is already globally connected and the individuals and institutions need privacy and also the protection from identity theft that is today a very frequent aspect of misuse of the Internet. So, we need transparent and flexible tools to fulfill demands of different users and at the same time capable to achieve the assigned degree of security. Security protocols, as the most prominent SSL (Secure Sockets Layers) and TLS (Transport Layer Security), solve a good part of given problems.

Key words: Security protocols, TCP/IP kernel of protocols, SSL, TLS, computer networks, cyber criminal

1. Introduction

Users of computer systems, computers in network and independent computers, first of all want to be sure that only those who are allowed will have access to their data.

Therefore analogue to the safety of one's property, users of computer systems want the so-called computer security. The concept of computer security can be divided into four fewer parts: security made by bringing a user face to face, security from external influence, interior security mechanisms and communication security mechanisms, so that in this way it is possible to consider the four basic categories of computer security:

[*] Corresponding author: e-mail: dragan.randjelovic@kpa.edu.rs

- Authentication is the process which includes the process of identification (gives the answer to the question of the person in question) and the process of verification (only confirms the identity of person in question), that explicitly identifies the user of computer system and enables him to use data and resources in accordance with his rights;
- Cryptography is the process of data protection against unauthorized access using data coding;
- Control of the property ownership over the files (users and groups) is achievable thanks to nowdays dominant multiuser operating systems;
- Protocols of security communications.

In view of the fact of permanent threats against computer systems, in the second part - security from external influence, we can put the following category:

- Malicious programs and their two basic subcategories:
  - Intrusion detection system (IDS),
  - Systems for anti-malicious working and fire-wall for filtering of malicious programs.

1.1 Protocols

In this paper the attention is focused on the communication security mechanisms defined by security protocols, above all SSL and TLS protocols, where all other mentioned properties of computer security are considered realized: authentication as security achieved by bringing a user face to face, security from external influence, including also fire walls in addition to cryptography and already mentioned IDS, and in the end the systems for control of the ownership over the files (Stallings, 1998). A simple explantation of protocols is that they are rules and procedures based on them which enable communication. The word „protocol“ is of Greek origin and it means a seal which is put on documents as a proof of their authenticity and today this word is used in different contexts. For example, diplomatic protocol is the set of rules and customs of behaviors in inter-states relations.

In computer environment a protocol is the set of rules and conventions which define communication frame between two or more participants whereby the participants in communication can be users, processes or computer systems. If at least one part of a message is coded, the protocol can be considered cryptographic and it is used to establish the secure communication via unreliable global networks and distributed computer systems and naturally there exist also protocols for effective transfer of data which do not belong to the group of security protocols as are for example the well-known http, ftp.

1.2 Security services and threats

Security protocols should enable the implementation of security services which considers the usage of security mechanisms, i.e. mechanisms which should prevent the attacks on security or recover the system from the attacks. Security mechanisms are technologies which can be implemented in the system and they change with the development of technologies but the first three of the below listed - CIA triad (from the first letters of their English names) stay constant:

• Confidentiality, privacy – international standardization organization, ISO, defined privacy as service which provides access to information only for users who are authorized to access this information. Generally this idea is defined as capability of authors to hide all that does not have to be publicly accessible, i.e. this is the service which provides the information to be accessible only to those users it is designed for. Data must be protected when they are put into storage, during the data processing and during the transfer.

• Integrity – a service which provides totality of data, i.e. provides that the attacker cannot change the data without being observed. Consequently, integrity is security service from unauthorized, unpredicted or unintentional modification. Data must be protected when they are put into storage, during the data processing and during the transfer.

• Availability – a service that provides accessibility of data and availability of system which provides service. Examples of such service are protections against infection with the viruses which erase or damage files and avert execution of services, i.e. programs.

• Authentication – a service that demands from each user to be presented to the system before he does something and which also provides that everyone who claims to have a certain identity (for example user name), must also prove it.

• Non-repudiation – a service that provides that the user who sends a message or changes some data cannot claim later that he has not done it. For example, the user who has signed a document digitally with his private key cannot claim later that he has not made and has not signed this document because this signature can be easily checked.

• Access control – a service that prevents misuse of resources. With access control it is permitted to the user with the verified identity and suitable authorities to use some services or operations of system which are defined in the so-called matrices of access.

In order to achieve security services the following mechanisms and their combinations can be used:

- Coding;
- Digital signature;
- Mechanisms for access control;
- Mechanisms for control of data integrity (integrity of the field of information and of the flow of information) are used for time stamp, cryptographical connection;
- Mechanisms of authentication (password, smart card, biometrical devices);
- Mechanisms for traffic supplement;
- Mechanisms for direction of routing (static, dynamic), and
- Mechanisms for registering (they are usually based on digital signature).

Security protocols provide communication secure from possible threats which are manifested as active or passive and which are given in four categories:

• Interruption represents attack on availability. With one interruption the flow of information is disconnected, i.e. it is impossible to provide some service or functioning of some system. This attack belongs to the group of active attacks.

• Interception represents an attack on confidentiality. Interception in practice can be carried out as traffic eavesdropping. As a passive attack, it can hardly be discovered because it does not change data, i.e. it does not affect the functioning of the system. It is often a preliminary phase for some other type of attack.

• Modification represents an attack on the integrity. This is an active attack. If it happens on the communications path, it can be demonstrated, for example, as a man-in-the-middle attack. An attack can also happen inside some computer system and in this case there is a change of data, access rights, and the way of program or system functioning or something similar.

• Fabrication represents an attack on the authentication. This active attack is performed by an attacker generating false data, false traffic or issuing unauthorized commands. There is often a false presentation of user, service, server, web site or some other part of system.

2. Security protocols on different TCP/IP layers

OSI (Open Systems Interconnection Basic Reference Model) reference model for connection is the most used abstract description of architecture of

computer network thereby dividing it into seven logical levels from the lowest physical level, data level, network level, transport level, session level, presentation level, to application level which are grouped in two bigger groups – the first four make Transport set and they define how the information is transmitted from some location to the other and the last three make Application set and they describe the process of the application intercommunication, user's work with application and interaction user - computer.
Many protocols on the set of TCP/IP protocol can be found on the Internet, some are given in Table1.

Table 1 - OSI reference model

Level of OSI model	Unit	Protocols
Application: Network processes connected with application	Data	HTTP, FTP, Telnet, DNS, POP/SMTP
Presentation: Encryption and coding of data	Data	SSL,TLS.
Session: Establishing of session of ultimate users	Data	NetBIOS, SSH
Transport: Connection, confidence, transport	Segment Datagram	TCP, UDP
Network: Logical addressing and routing	Package	IP,IPsec, ICMP, ARP,
Connection level: Physical addressing,medium access	Frame	PPP, PPTP
Physical level: Transmission of signals	Bit	RS 232,RS422, STP

The choice of place in the stack of TCP/IP protocols where security will be implemented depends on the security and other application requirements. It is possible to provide all or only some of the stated services depending on the place in stack where the safety is implemented. It is also possible that some services are provided on one level and other services on other levels.

Application level - Protocols which provide safety and function on application level must be implemented in final points of communication, i.e. on

final computers. Advantage of this way of safety implementation is that the application can be expanded without the support of security services which the operating system provides. The second advantage is the complete access to data which user wants to protect. This advantage makes reservation of security services easier (for example non-repudiation), it also provides easy access of user authentication. Bad side is that these security mechanisms must be projected for each application and that has as consequence that existing application must be expanded. Because different applications have different needs, the consequence is in the design of many different systems the bigger probability of errors, and thus the greater possibility of security failure.

Presentation level is the sixth level of OSI model. It makes possible the work of entities of Application set, i.e. the entities of higher levels can use different syntax and semantics. Units of data are encapsulated in SPDU (Session Protocol Data Units) blocks and are sent to lower level. This level enables independence during the presentation of data thanks to the translating from application in network form and the other way round. Presentation level transforms data in the form which is accepted by the application level. Applications which work at this level form and encode data so that they can be sent through non secure networks, giving them independence from problem of coordination. Authentic structure uses the rules of coding ANS.1 (Abstract Syntax Notation One) from the set of cryptographic rules.

Session level – As the fifth level of OSI model, it controls the connection between users. It establishes, directs and defines the connection between local and distant applications. It supplies two-direction (full-duplex) and one-direction (half-duplex) operations, establishment of checkpoint and delaying and repeated start of procedures. This level is responsible for closing and repeating of session. It is usually implemented explicitly in the application environment using RPC (Remote Procedure Call) calls.

Transport level – Providing security at this level has advantages over providing security on application level because it is not necessary to expand each application. All existing applications receive equal degree of security which depends on security mechanisms implemented on transport level and it is obtained, as in the case of application level, at the end computers. And this type of security implementation characterizes dependency on protocols and, for example, TLS protocol provides security services of checking identity, integrity and confidentiality over TCP protocol. Since security services depend on transport protocol, the services such as key directing must be duplicated for each transport protocol. The fault of this level also is that applications must be changed so that they can require secure services from transport level.

Network level – The implementation of security on this level has many advantages. For example, surpassing caused by a change of keys is significantly reduced since all transport protocols and applications now divide infrastructure

key directing which is now provided by the network level. It is also important that if security is provided from lower levels, it is necessary to have lower changes of application. One of the most useful possibilities which protocols from network level offer is the capability of virtual private Network (VPN) and Intranet building. Problems in security protocols using on network level are difficult supplying of no repudiation service and difficult realization of control on user level at the multi-user computer; these problems must be solved with the introduction of additional mechanisms at the end computers. For example, IPsec obtains security on network level and is only of protocols which provides happening of all types of traffics.

Connection level – If the intended connection between two computers or routers exists and if all traffic between them must be coded, so that all attacks of types of catching or changing of data are denied, in that case it is possible to use a device for coding. An advantage of this solution is speed. The fault of such a solution is that this is useful only in intended connections, i.e. if the sites which communicate are in physical connection. This method is used, for example in bank automats.

Physical level is the lowest level of OSI model. It defines electronic and physical specifications of devices, i.e. it determines a connection between devices and physical medium. At this level voltage levels are defined, as well as the number of pins, i.e. the number of pairs in cables or coaxial cable if it is a transferable medium. For example, devices of networks card, hubs and repeaters are such. Basic functions of physical level are connection and disconnection with communication medium.

3. Secure Sockets Layer (SSL) Protocol

SSL protocol provides mechanisms for both the identification of two participants connected by computer network and secure transmission between them. SSL protocol practically provides the transmission of unsecured data over secure communication channel and fulfills the following aims:

- Cryptographical protection which implies providing of mechanisms for coding of data, i.e. for realization of the secure connection between two participants in communication.
- Independence from software and hardware which enables to programmers to write software in which SSL is implemented so that two different programs – for example, Web server and reader of the Web can exchange parameters of coding and within that do not recognize code of the other one.
- Expandability implies making of frames within which, if necessary, it is possible to embed new symmetrical algorithms and algorithms with public

key, by which the need to design new protocols is avoided.

- Efficiency influences that coding as operation uses computer processor less independent from complexity of algorithm, which is especially expressed in the case of algorithms with public keys. SSL memorizes the communication parameters of the established connections in order to reduce the number of connections which it must reestablish and in that way provides smaller load to both the processor and the network.
- The task of Secure Sockets Layer (SSL) protocol is to accomplish the secured data transfer trough the network. SSL provides mechanisms for the identification of server and client as well as the coded data exchange between them, which makes the complete system of secured communication between two network entities. The protection of communication which makes protocol SSL has three basic characteristics:

Privacy, therefore the exchanged data are coded with symmetrical algorithms for coding (DES, RCA).

- Possibility to check the identity of a client and server with public key, for this possibility SSL is using RSA and DSS algorithms.
- Reliability, therefore SSL is using SHA and MD5 hash functions to check the integrity of the received messages.
- SSL protocol forms special communication level placed over the transport level (Figure 1).

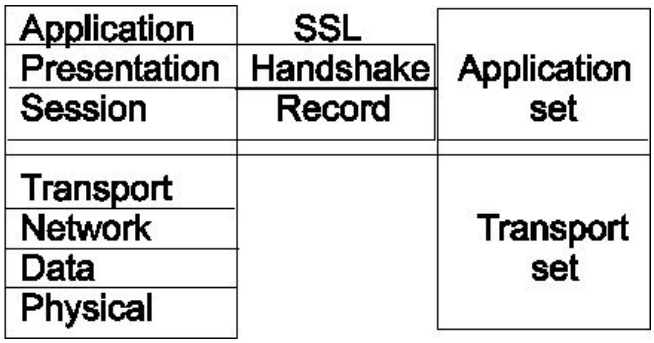


Figure 1 - SSL in the set of protocols

Application level is placed over SSL. At the side of a sender, the SSL receives message from application level which it divides into the parts suitable for coding and adds the control number to them; then it codes and possibly compresses this parts of the message. In this way the sender sends coded parts of message. The receiver receives this parts that he possibly decompresses, decodes, checks control numbers, composes the parts of messages and gives them to application level. SSL is transparent and independent from application level and

establishes security communication before application level receives or sends first byte of data. Also before the beginning of sending the coded data through network, the SSL client identifies server with which he communicates. The SSL is practically composed of two protocols (Pleskonjić, Maček, Đorđević & Carić, 2007):

- SSL Handshake provides reciprocal identification and exchange of parameters for transfer to client and server, i.e. the choice of algorithms and keys.
- SSL Record is responsible for coding and transfer of messages.

The SSL reqires at least identification of server in order to establish a secured transfer. SSL makes this during the handshake stage, sending the certificate to a client. The SSL uses public key and digital signature of server for identification. After server identification, client and server exchange mutual messages which are coded with symmetrical algorithm. The client identification is identical to server identification. After the process of identification, the exchange of data can start. The communication between the server and the client with certificate publisher is not the part of the SSL.

The SSL can establish a session between a client and a server without the identification of either the server or the client, but this means that the security level of data transfer is very low because the data are protected only with symmetrical coding with key which is in unsecured communication agreed between a server and a client.

3.1 SSL handshake protocol

The SSL handshake protocol which works over the SSL level of record makes attributes which describe a session. The handshake protocol delivers messages to the SSL record protocol, which codes and sends them, in the same way as all the others. Before the phase of session establishing, the attributes of communication are not defined and therefore the first messages are sent unsecured. When the SSL client and server start to communicate, they make the agreement about the version of protocol, choice of algorithm for symmetrical coding. Optionally, they make identification and use algorithm of public key to generate shared secret (the key for symmetrical coding). This completely described process happens in the SSL handshake protocol.

As the first client sends salutation message to server – Client hello (Figure 2) on which the server must answer with its salutation - Server hello.

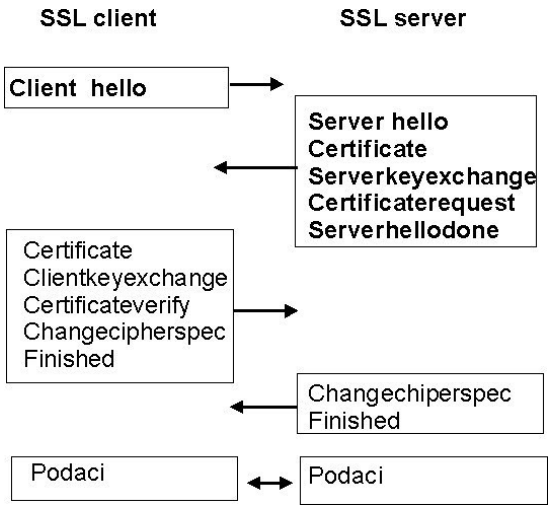


Figure 2 – The SSL handshake protocol

And if that procedure does not happen, communication is stopped. Salutation messages of client and server are used to establish the next attributes of session: version of protocols, session identification, algorithm of coding, algorithm of compression and unexpected values which set client and server. In his salutation, the client delivers the list of possible manners of coding and compression (beginning from the best for him) to server. The server chooses the best combination which it can accept from that list. After the salutation message, the server sends its certificate because the server must identify itself. If the server is positively identified, it can demand the certificate from a client if that is in harmony with the agreed algorithm of coding. After that the server sends a message to the client about the end of salutation – Server hello end. If server has demanded the certificate from the client, it expects the answer which contains certification confirmation or report that the client does not have a certificate.

Then the client sends new attributes with which it will send coded messages and this attributes set as active. After that client sends report about the end of send, coded with active attributes – End. As the answer, the server sends its attributes, and after that reports about the end of sending, coded with a new attributes.

Therefore, the phase of session establishing is ended and both the client and the server can start with the exchange of data from the application level. During the session establishing the order of messages must be strongly respected. Otherwise, the error is reported caused by an unexpected message which stops the session establishing.

3.2 Attributes of the SSL session and connection

When the SSL handshake protocol identifies the server and/or the client, and agrees on the manners of coding, then the session is established. Often, the client and the server want to establish more sessions parallely, for example, the transfer of files and reading of contents of a web-site. Therefore, it is possible to establish more connections inside one session. The session is described with attributes about which the client and the server make agreement durign the stage of handshake protocol. These attributes are basic for the establishing of each new connection. The SSL allows more connections inside one session as well as parallel executing of more sessions between the same client and server. Each SSL session is described with the following attributes:

- Secret. Before transfer of data the client and the server exchange mutual secret. This secret, i.e. sequence from 48 bits, is used to generate symmetrical keys and calculation of MAC (Message Authentication Code) values.
- Widening. Notation which shows if it is possible to establish a new connection inside the given session.
- Session identificator. The sequence of bytes which is agreed by the client and server and which unitedly identifies this session.
- Entity confirmation. The client and the server fill in this attribute during the identification process, which is otherwise empty (NULL value).
- Method of compression. Algorithm of data compression before coding (NULL value without compression).
- Coding. Two algorithms are cited: one for symmetrical coding (for example, DES), NULL value means that data are not coded and second - hash function, concrete algorithm MAC, (for example, MD5, SHA). Also other pieces of information needed for coding are defined with algorithms such as the length of control number, if both the server and the client will identify themselves, or only the server or no one.

The attributes of the SSL connection are random variables of the client and the server. The attributes are used for coding and they must be different. Server's and client's MAC secret is used for the identification of messages which server sends, i.e. client and symmetrical key of client and server (to whom server codes and client decodes and opposite), and ordinal number of messages. Both the client and the server must consider ordinal number of messages which were sent and received for each connection. If the manner of coding is changed during the connection, ordinal numbers will be set to zero. These attributes are known to the client and the server and each of them saves a copy of their values.

The task of the SSL handshake protocol is to coordinate, i.e. to equalize their values. The SSL permits the change of session attributes and the connection

while they last, and by that reaching the higher level of protection. How the process of attributes changes should not affect the communication process, both the client and the server will have to save two copies: active attributes and new attributes. The attributes for sending and for receiving of messages are saved separately. When either the client or the server receive new attributes for decoding, new attributes become active attribute which are used for decoding from that moment on. They cannot be written as active immediately because the message which contains new attributes is not coded with active attributes yet. It is same when the client or the server change a manner of coding for sending.

3.3 Resume of the SSL session

The client and the server can continue connection if they have already communicated with the SSL protocol and with this they skip the identity check and make agreement only about the necessary new attributes.

The session between the client and the server happens in the following order: first, the client sends salutation message using the session identifier which it wants to begin again.

The server looks over the list of his sessions and checks if this identifier exists. If the server finds the identifier, it answers with his salutation which contains exactly this identifier. The server and the client further exchange new attributes of coding, and then send the message for the end of the restored session. After that the data from application level can be sent over the SSL record protocol. If the server does not find the session identifier in its list, it answers with a new identifier, and the server and the client again pass trough the complete process of session establishing.

3.4 The SSL record protocol

The SSL record protocol receives the data from a higher level in the arbitrary size blocks, it does not interpret them but it separates them into parts of suitable size. The SSL record protocol then protects the data cryptographically and sends them to the conversationalist, where the reverse process takes place. At the side of the sender the following processes are happening:

- Before processing continues, the received data are separated into the blocks of fixed length without call attention on the length of client messages and by that more messages can be merged into one or one message divided into more fragments.
- All fragments of the SSL record protocol are compressed with

algorithm, which is defined by the attributes of the session. During the compression the algorithm must not lose data.

- Messages are protected by symmetrical algorithm for coding and thus enable privacy and by the MAC algorithm, which provides for the message integrity, and these are determined by the session attributes.
- After coding of compressed fragment and adding of MAC value, the result is ready for sending like the other data which are necessary for the transfer of message (for example, header), but they are not specific for the SSL protocol. The receiver decodes the accepted fragment, calculates MAC value and compares with value which the sender has generated. If both MAC values are equal, the message is accepted. Otherwise the error report is returned.

3.5 The application of the SSL

The SSL is often used for paying of goods with credit cards, when only the transfer of credit card number is protected. For that and many other cases of secured transfers, such as authenticated access to web site, distant access, exchange of electronic mail, the SSL is proper solution. It is because the SSL contains all available security methods which can be used in the case of communication channels establishing over the network. The SSL provides check of credibility with the help of certificates, using different keys for individual sessions and of the end coding and checking of integrity. If the client and the server are not active for longer period of the session, if they have equal attributes for longer period, attributes are changed.

Basic defect of the SSL protocol is the increased work of processor, which is the basic limit of its implementation. This is the consequence because the functions such as crypting and especially the operation of distribution of public keys demand the additional work of processor.

The additional work of administrator is also defect of the SSL protocol. This defect is the consequence of complicated enviroment which demands maintaince so that administrators must configure system and manage with certificates.

The size of package by the SSL protocol certainly is one of defects because the defined pieces of information are added in packages which are exchanged through network. In this way the size of package is increased and the consequence of this increasing is increasing time necessary for processing also increasing the time necessary for transfer of data and finally the late data transfer.

One of the defects of the SSL protocol is that it demands from programmer of application software a good knowledge of operating system for which he writes

this software. Namely, if the operating system directly accesses to TCP/IP protocol, it needs to be directed to work with the SSL protocol.

For the successful work of the SSL protocol the donors of certificates are important (Thawte, VeriSign, …).

4. Transport Layer Security (TLS)

Version 2.0 of the SSL developed in 1995 has contained many defects and because of that the version 3.0 was developed and published 1996. This version is used later as a basis for further development of the TLS protocol version 1.0 as IETF (Internet Engineering Task Force) standard protocol which is defined in RFC (Request for Comments) 2246 recommendation in 1999.

The TLS, like the SSL protocol, according to Table 1, works on the levels under application protocols such as HTTP, FTP, SMTP, NNTP and XMPP, but also over the reliable protocols of transport level such as TCP protocol. Therefore, the TLS protocol can supplement the security of any other protocol which uses the reliable connections and the TLS protocol is often used:

- In combination with the HTTP protocol and so receives the HTTPS protocol which is used for the security of Web sites on which the applications for electronic commerce are placed;
- In combination with the FTP protocol and so receives the FTPS protocol which is used in two modes of work: explicit – for the secure transfer of data exclusively on demand of the client and implicit – when the server without negotiation on demand of the clent enables the secure connection for the client;
- As the so-called STRATTLS, this gives the manner of annex of unsafely connection to safely connection, instead of using special connections for cryptographic communication.

The TLS protocol enables to build a tunnel through the Internet and therefore creates VPN (Virtual Private Network) network. This brings some advantages in security barrier (Fire-wall) and to NAT (network address translation) components (possibilities of coding of all data which are transferred through tunnel).

The TLS protocol is used more and more as the standard method for security of application signalization SIP (Session Initiation Protocol). It can be used for authentication and coding of SIP signalization connected for VoIP (Voice over Internet Protocol) and other applications based on the SIP protocol.

4.1 Protocols and attributes of the TLS session and connection

The TLS, like the SSL practicaly consists of the two protocols:

– The TLS Handshake - provides to client and server reciprocal

identification and exchange of parameters for transfer, i.e. choice of algorithm and keys.

– The TLS Record - is in charge for coding and transfer of messages.

For establishing the protected transfer, the TLS demands at least server identification. This is performed in the phase of session establishing (handshake) in all according to Figure 2, and by that server sends its certificate to the client. The public key and digital signature of server are used for identification. After the server identification, the client and the server mutually exchange messages coded with symmetrical algorithm using record protocol. The identification of the client is identical. After the identification of both of them, they can start exchanging data. Practically the TLS includes three basic phases:

1. Equalizing mediation for algorithm support
2. Exchange of key and authenticity
3. Symmetrical coding of encryption and establishing of messages authenticity

In first phase, the client and the server negotiate and define which coding they will use, exchange key and establishing of credibility of algorithms also authentic codes of messages MAC (Message Authentication Code). The key of exchange and establishing of credibility of algorithm are typical public keys of algorithms, or in the TLS-PSK algorithm the pre-set keys which can be used in common. The codes for authenticy of messages are composed from cryptographic collection of functions using HMAC construction. Typical algorithms can be:

–For key of exchange: RSA, Diffie-Hellman, DSA, SRP, PSK

–For symmetrical coding: RC4, Triple DES, AES or Camellia

–For criptography collection of functions: HMAC-MD5 or HMAC-SHA.

The session, which is established after the defined way of coding, is described by the attributes about which the client and the server negotiate in the stage of session establishing. These attributes are basic for the establishing of each new connection. The TLS permits more connections within one session, but also the parallel executing of more sessions between same client and the server. Each TLS session describes the following attributes which are described in detail in Section 3.2 – The Attributes of the SSL session and connection, and because of that they will only be listed here:

- Secret. (The client and the server exchange mutual secret before the transfer of data. This secret is used to generate symmetrical keys and extraction of HMAC values);

- Widening. (Notation which shows if it is possible to establish a new connection within the given session);

- Session identifier (The sequence of bytes which is agreed between the client and the server and which identifies this session);

- Entity confirmation. (The client and the server fill this attribute during the identification process, otherwise it is empty (NULL value)),
- Method of compression. (Tje algorithm of data compression before coding (NULL value without compression)),
- Coding. (Two algorithms are cited: one for symmetrical coding (for example, DES), NULL value means that data are not coded and the second - hash function, concrete algorithm HMAC (MD5 or SHA)).

4.2 The application of the TLS

The basic application of the TLS protocol is to make a safe system during the viewing of a web-site and information in HTTPS communication. The protocol can be used for many other purposes. Some examples of the TLS protocol applications are:

- The safe transfer of data for the needs of e-commerce – the protocol is applied between the client and the server. The best example is the use of credit cards for payment of products and services through the Internet. The TLS must have a possibility to be presented on web-site where circulation of data is.
- The authenticated access to web-site – in order for the authentication to be achieved, the user and the server need certificates from the CA entity. Certificates can be copied on user accounts on the two basis:
- One on one – it is used when the server has a copy of user certificate. During each registration the server checks the identity of a user. It is usually applied for handshake of private data like banking services through the Internet.
- More on one – it is used when someone wants to give access to secure materials to some group of users. Then the group is created and it is joined a defined certificate with permissions.
- Distant access – enables using of resources and services on distant computers and during that the TLS protocol can be used for the authentication and protection of data (by the user registration). Thus the users can access the e-mail messages or applications with decreasing of risk of disclosing information to other users of the Internet services.
- SQL access – Microsoft SQL Server, or a suitable operating system, makes possible for a user to ask for client authentication while connecting to the server where the SQL server is started up and it is possible to define requests for encrypting of data that are exchanged.
- Electronic mail messages – using Exchange servers. It is possible to use the TLS protocol for the security of data which are transmitted among servers or networks where it is necessary to use S/MIME (Secure/Multipurpose

Internet Mail Extensions) protocol for the ensurance of total protection of message transmission.

When the TLS protocol is enabled on the server for electronic mail message exchange of the one that sends and the one that receives, the information exchanged among them are encrypted. Those servers use the SMTP protocol for sending and receiving of messages.

There are also other uses of the TLS protocol in almost every application thanks to the possibility of the access to the protocol via the SSPI (Security Service Provider Interface) system. The primary defects and limits of the TLS protocol are the same as in the SSL:

- The programmer of the applicable software must have good knowledge of the operating system for which the software is written, therefore if the operating system directly accesses TCP protocol it should be rerouted to do it through the SSL protocol.
- The increased work of processor, which is the main limit in the implementation of the TLS protocol, because the functions as encrypting, and especially the operations connected with the distribution of the public key, demand the additional work of the processor and it is not possible to exactly define decreasing of the performance of the system which fluctuates from the frequency of the network setup and in its duration.

The greatest number of resources is spent during connecting.

- Additional work of the administrator – the TLS environment is quite complicated and it requires maintenance, so the administrators must configure the system and supervise the certificates.
- The quantity of the package – As the TLS adds certain information to the packages which are exchanged via network, the size of the package increases and the outcome of the increasing is the increasing of the time needed for the processing and the transmission of data, which results in data delay.

4.3 Similarities and differences between the TLS and the SSL

As already mentioned, the TLS derives from the SSL version 2, so it is very similar to it, and the fundamental difference is that in the TLS protocol KHMAC (keyed-Hashing for Message Authentication Code) algorithm substitutes MAC (Message Authentication Code) algorithm which is used in the SSL protocol. KHMAC provides more security than MAC algorithm. In addition to this, it creates the integrity check value, as MAC algorithm, but with using of hash functions which makes it more complex and difficult for the attacker. It is not always necessary to set up certificates from the CA root entities in TLS protocol, instead it is sufficient to use the middle CA entities.

The TLS protocol defines the values for the block increasing (padding block values) which are used in the blocks of the algorithm coding. In addition, in the specification of TLS protocol many new messages for the report warning are added.

Namely, for the insurance of the correct flow of the session, both the TLS and the SSL protocols use reports as a special kind of messages. They are also compressed and coded, and instead of the data from the higher level they consist of the type of report and description. There are two types of the report: report on the end of connection and report on the error.

Before the end of connection, both the client and the server must agree about its end, and they do it with the help of reporting the end of the connection, where the end can be initiated by any participant. That message helps the recipient to understand that the sender will not send messages inside that connection anymore. If the recipient receives messages after the report of the end, he will ignore them. Every participant is obliged to send a warning about the end of sending, so that he can continue with receiving of the messages until he receives report on the end of sending from the other participant. The obligation of the other participant is to close connection declaring its attributes invalid. After closing the connection, the client and the server must erase its attribute values. If one of the participants finds out the mistake in the communication, he informs the other participant using error report, where if it is an error about mistake which endangeres the transmission security, both participants terminate connection. The communication via other connections in the session can be continued, but it is necessary to change the identifier of the session, so that the future usage of the same identifier is prevented.

In the TLS and the SSL protocols the following errors are possible:

- An unexpected message. The error causes the end of connection (the suspicion of the data fabrication type of the attack)
- Malfunctioned MAC value. The error causes the end of connection (the suspicion of the exchange of data attack)
- The error upon an occasion of decompression. The input parameter of the decompressed algorithm does not have the expected result.
- The error in the phase of the session establishing. It shows that the sender is not capable to adjust to the sugested attributes of protection.This error makes the session end.
- Certificates errors. No certificates (It appears if there is a request for a certificate and an answer is negative), Unsuitable certificate (The protocol does not support a concrete type of certificate), Invalid certificate (The certificate validity has expired or a certificate has not become valid), Cancelled certificate (The owner has cancelled the certificate), Bad certificate (A certificate is inconsistent, the existing signature does not confirm identity, etc.) and

Unacceptable certificate (if during the certificate processing something unexpected appears, a certificate is declared unacceptable).

- Invalid parameter. Some attribute values are out of permitted parameters. This error makes the connection end.

4.4. The TLS and the SSL implementations

In this paper the three most known TLS/SSL implementations are considered: OpenSSL,

GnuTLS and NSS, furthermore JSSE (Java Secure Socket Extension) programming package is mentioned.

JSSE consists of a group of programs (API tools, algorithm implementation etc.) that enable safe communication via network implementing Java version SSL and TLS protocols.

JSSE also includes the following functionalities:

• Data encrypting
• Authenticity of the server and authenticity of a client (optionally),
• Message integrity,
• Cryptography and
• PKI (Public Key Infrastructure)

The package was an optional addition to Java program versions 1.3. (While implemented in version 1.4)

4.4.1. OpenSSL

OpenSSL is a free cryptographic tool which implements security protocols version 2 and 3 and TLS version l, and other cryptographic standards which are connected with these protocols (e.g. 3DES, AES and RSA). The program is accessible for almost all UNIX (Solaris, Linux) and Mac OS X and for BSD operating systems with open code, as for OpenVMS and Microsoft Windows operating system.

OpenSSL enables various cryptographic functions implemented in OpenSSL folders to be requested. OpenSSL enables: defining parameters for RSA and DSA keys, creating X.509 digital certificates, CRL lists and requests for signing of certificates, calculating of hash messages, coding and decoding, SSL/TLS communication support and operating with e-mail messages which are signed or coded in accordance with S - MIME (Secure Multipurpose Internet Mail Extensions) standard.

OpenSSL has a great number of instructions for managing certificate center, managing lists of taken digital certificates, calculating of hash, generating pseudo-sonic parameters and managing certificates. Package also has pseudo-

instructions list (standard–commands), 1ist of message (digest-commands) and 1ist of cipher-commands (gives all standard instructions), for hash calculation and cryptographic instructions.

4.4.2. GNU Transport Layer Security Library (GnuTLS)

GnuTLS program is free implementation of the SSL and TLS protocols, whose purpose is to enable API (Application Programming Interface) support to applications so the safe communication is enabled. It is edited under GNU LGPL (Lesser General Public License) and some parts under GNU GPL (GNU General Public License) license.

The above mentioned licenses provide free copying and distribution of tools. The main difference is that LGPL license enables connection with free programs which are not under the same license, also some additional rights of program changes.

In the beginning it is developed for GNU projects, and it is used in programs such as GNOME, CenterIM, Exim, Mutt, Slrn, Lynx and CUPS.

GnuTL is possible for majority of UNIX operating systems also for Microsoft Windows, and it could be downloaded from the site: http://www.gnu.org/software/gnutls/download.html.

Revision 1.04 CCERT-PUBDOC-2009-03-257 pages 22/29 GnuTLS includes the following characteristics:

• SSL protocol support for version 3.0 and TLS protocol version 1.0 and 1.1;

• PSK (pre-shared key) algorithm support during authenticity;

• Mechanism of TLS protocols enlarging;

• Support for strong encrypting algorithms (SHA-256/384/512 and Camellia);

• Compression, and

• Handling X.509 and OpenPGP certificates.

• It supports many algorithms for key exchange: Anon-RSA, RSA, DHE-RSA, DHE-DSS, SRP-DSS, SRP-RSA, SRP, PSK, DHE-PSK;

• It supports Cryptographic algorithms: AES-256, AES-128, 3DES, DES, RC4-128, C4-40, Camellia.

4.4.3. Network Security Services (NSS)

The NSS program is a group of libraries that serve to the SSL and S/MIME protocols. It is developed by the Netscape organization, and it is used by AOL, Red Hat, Sun Microsystems operating systems in various applications (Mozilla Firefox, Thunderbird and SeaMonkey, AOL Instant Messenger, Evolution, Pidgin, OpenOffice.org 2.0., Red Hat Directory Server etc.). It is

licensed with three licenses: „Mozilla Public License“, „GNU General Public License“ and „GNU Lesser General Public License“. The actual version wasedited in 2008, and it is the version 3.12.

The program supports various security standards:

• SSL protocol versions 2.0 i 3.0;

• TLS protocol versions 1.0;

• PKCS standards;

• PKCS #1- #12.RSA standards that define the implementation of cryptography beside RSA algorithm;

• CMS (Cryptographic Message Syntax) used in S/MIME protocol;

• X.509 certificates;

• OCSP (Online Certificate Status Protocol) certificates;

• PKIX certificates;

• Algorithms: RSA, DSA, ECDSA, Diffie-Hellman, EC Diffie-Hellman, AES, Triple DES, DES, RC2, RC4, SHA-1, SHA-256, SHA-384, SHA-512, MD2, MD5, HMAC, and

• FIPS generator pseudo –random numbers.

4.4.4 Comparing TLS and SSL implementations

In this part of the paper the three already described tools are compared:

- OpenSSL, GnuTLS and NSS from the aspect of different versions of the TLS and SSL support;

- The support of different algorithms for public key exchange;

- Cryptographic algorithms and different compression procedure support.

1. Table 2 shows the comparison of support for various versions of the SSL and TLS protocols (The Croatian Academic and Research Network (CARnet), 2009). GnuTLS tool consists of the support for every mentioned versions of protocol, and other tools support only some versions.

Table 2 - Tools support for different versions of the SSL and TLS

	SSLv2.0[1]	SSLv3.0	TLSv1.1	TLSv1.2
GnuTLS	Yes	Yes	Yes	Yes
OpenSSL	No	Yes	No	No
NSS	Yes	Yes	No	No

2. In Table 3 there is a description for key exchange. The majority of tools are supported by GnuTLS tool.

Table 3 - Tools support for various algorithms for key exchange of the SSL and TLS

	Anon-RSA	RSA	DHE-RSA	DHE-DSS	SRP-DSS	SRP-RSA	SRP	PSK	DHE-PSK
GnuTLS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OpenSSL	Yes	Yes	Yes	Yes	No	No	No	No	No
NSS	Yes	Yes	Yes	Yes	No	No	No	No	No

3. In Table 4 there is a description of cryptographic algorithms that are used in implementations. The majority of algorithms are supported by GnuTLS tool.

Table 4 - Support of tools for cryptographic algorithms for the implementation of the SSL and TLS

	AES-256	AES-128	3DES	DES	RC4-128	RC4-40[1]	Camellia
GnuTLS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OpenSSL	Yes	Yes	Yes	Yes	No	No	Yes
NSS	Yes	Yes	Yes	Yes	No	No	Yes

4. Support of the compression procedures can be found in Table 5 where there is the evidence that GnuTLS supports both of the mentioned procedures, OpenSSl only ZLIB procedure and NSS none.

Table 5 - Support of tools for various compression procedures in SSL and TLS implementations

	ZLIB	LZO[1]
GnuTLS	Yes	Yes
OpenSSL	Yes	No
NSS	No	No

From the above mentioned data given in Tables, it is clear that GnuTLS tool has the greatest possibilities.

5. Security protocols competitive to the TLS and SSL protocols

In application group of OSI model of protocols some of competitive solutions which use architecture and principles similar to those that exist in the SSL and TLS protocols are: S/MIME (Secure-MIME), SSH (Secure Shell), PCT (Private Communication Technology) and OpenPGP.

In transport group of OSI model of protocols there is a well-known IPsec (Internet Protocol Security) protocol which is competitive to the TLS and SSL.

- Protocol S-MIME is made by RSA as a supplement to existing protocol MIME. It uses a system of public keys as a base for the check of integrity and coding.
- SSH is used for connecting to distant computers by means of protected channel which is provided by SSH. The user is identified thanks to the

password that is coded before sending through the network.

- OpenPGP is a protocol for coding of electronic mail by means of cryptography with public keys, based on the original PGP distribution of Phillip Zimmermann. Protocol OpenPGP defines standard forms of coded messages, signatures and certificates for the exchange of public keys. At the moment OpenPGP is the leading standard in cryptography with public keys.
- PCT is a product of Microsoft Company that is made as a reaction to the errors made in version 2 of the SSL protocol. Although Microsoft solved this problems, PCT is practically not used after the appearance of version 3 of the SSL protocol, and that is why we will not consider it in this paper (Stinson, 1995), (Schneider, B., 1996).

5.1 S/MIME protocol

Today, one of the protocols that are probably most widely used in the applicative level is S/MIME (Secure Multipurpose Internet Mail Extension). S/MIME applications are installed in software packages that are today the most dominant on the market, for example Netscape Communicator, Microsoft Outlook, Mozila Firefox, etc.

S/MIME is based on popular internet MIME (*Multipurpose Internet Mail Extension*) standard and it enables following cryptographic services that have to do with security of applications such as electronic exchange of messages: authentication, message integrity and certainty (using digital signature), and data secrecy (digital envelope).

S/MIME can be used by traditional *Mail User Agents*, MUA, so the cryptographic security services can be added to the sent mail and to interpret cryptographic security services in the received mail.

S/MIME is not made only for electronic mail; it can be used with any transporting mechanism which transmits MIME data, as it is HTTP (*HyperText Transfer Protocol*). Beside that, S/MIME can be applied in the agents of automatic transmission of messages which use cryptographic security services and which do not need any intervention done by man (such as signing of the software generated documents and coding of fax messages that are sent via the Internet).

MIME standard supplies general structure of the Internet messages content and it allows extensions for the applications of new content.

5.2 OpenPGP protocol

OpenPGP is developed from the commercial program version 5.0 PGP and in 1998 RFC2440 document is published under the authority of the Internet Engineering Task Force which totally defines OpenPGP standard and all other

information needed for the development of the applications that are compatible with it. It exchanges data via standardized packages (key, digital signature, etc.) and in its work it uses many cryptographic algorithms. It takes the best characteristics from the world of symmetric and asymmetric cryptographic systems combining them into powerful protocol.

Encryption via OpenPGP starts with generating of the disposable key which is used in encrypting of the message with symmetric algorithm. That is usually randomly generated number. Randomly generating of symmetrical key gives the highest degree of security, because it prevents random „discovery“ of the key. After the message is encrypted with generated symmetrical key, a symmetrical key itself is encrypted with public key of the receiver for the sake of preserving the speed. The message encrypted by symmetrical algorithm and a symmetrical key encrypted with the public key of the receiver are the parts of the final message which can be safely sent via the unsecured chanell to the receiver.

The procedure of decrypting is oposite. After receiving the message encrypted with OpenPGP from the sender, the receiver first of all decodes a symmetrical key with his private key, and after that decodes messages with the received key. If the message was compressed it must be decompressed in order to get the original. The security of the message is guaranteed under the suggestion, if the private key is really private.

The encryption itself can be sufficient for the security of the message, but it cannot prove the correctness of the received message, i.e. if the message which is received is really the message which is sent. Also the legitimacy of the the sender of the message is in question. How can we be sure that the sender of a message is really the person for which he presents himself? Both of these questions are solved by the system of digital signature. What does a digital signature mean? Digital signature is the same as personal signature in the real world, it insures that the message is not falsified. Namely, the actual algorithms in digital world make it very difficult or almost impossible and certainly unprofitable to forge a digital signature. The system of digital signature is realized so that the sender of message makes abstract of message with some algorithm for abstract calculating, then codes this abstract with his private key and such abstract is sent together with or separately from message. With this all demans are effectively insured. Such a coded abstract of message corresponds to suitable received message only if the digital signature or message are not changed.

5.3 Secure Shell (SSH) protocol

SSH is the popular protocol for coding of communication channels, which is mostly used to supply security sessions of distant registration on the system. The architecture of SSH protocol is two-tier client/server architecture. SSH server is the software which accepts or rejects connections which arrive to computer.

SSH client software is installed on distant computers; clients send to SSH server demands of type „please, report me on the system ", „please, send me a file " or „please, execute this command ". In spite of this, SSH codes all data which are transferred through network and the coding of this process is transparent to the user. At this moment two incompatible versions of this protocol are used - version 1 and version 2.

SSH protocol provides security mechanisms of identity check, coding of data and also supplies integrity of data which are sent through the network. The SSH also provides for the keys to be used for registrations to distant computers instead of passwords. The SSH agent for the identity check which works on local computer is used for that purpose. This SSH functionality is especially suitable when users have distant access to many computers whose users accounts are protected with various long passwords.

5.4 Internet Protocol Security (IPsec) protocol

IPsec represents a set of protocols intended for security communication over the Internet. It belongs to Transport of OSI model of protocols which works on its network level. IPsec offers simple and effective protection for the TCP and UDP protocols of communication through computer network. IPsec ensures the realization of the following security demands:

- Confidentiality; only authorized person can access data;
- Integrity; impossible change of data by unauthorized person;
- Authentication; verification of identity of sender;
- Availability; availability of data in spite of the unexpected events.

In the base IPsec consists of two subsets of protocol:

• Cryptographic protocols – ESP protocol (Encapsulating SecurityPayload), AH protocol
(Authentication Header)

• Protocols for key exchange – IKE protocol (Internet Key Exchange)

IPsec is designed to satisfy two basic functions:

• Tunneling of packages, and

• Transport modeof work.

By tunneling few computers (or one local computer network) Ipsec hides them behind one knot and like that they are invisible to the rest of the network (so they are protected from attacks).

In the second case packages are sent between two end computers on the network, and the computer which receives package executes security checks before the delivery of packages to higher levels.

The basic idea of IPsec protocol protection is building of Virtual Private Network – VPN.

5.5 Comparison of security protocols which are competitive to TLS and SSL

The comparison of the four previously described competitive protocols, S/MIME, OpenPGP, SSH and IPsec with the TLS and SSL protocols from the viewpoint of support to different algorithms for coding of data, identification, control numbers, and also their application and implementation is given in Table 6. (Tanenbaum & Woodhull, 1997).

Table 6 - Comparison of protocols S/MIME, OpenPGP, SSH and IPsec with the TLS and SSL

	S/MIME	OpenPGP	SSH	IPsec	SSL/TLS
Coding of data	Triple DES	TripleDES	RC4,Triple DES, AES	DES, Triple DES	DES i RC4/ RC4, Triple DES, AES or Camellia
Identification algorithm	Diffie-Hellman, DSA,RSA	ElGamal, DSA,RSA	Diffie Hellman, DSA,RSA	DSA,RSA	RSA , DSS/ RSA, DSA,SRP, Diffie-Hellman
Algorithm of control numbers (hash)	SHA-1	MD5, SHA-1	MAC-SHA or MD5	SHA-1,MD5	MAC-SHA,MD5/ HMAC-MD5,SHA
Application	e-mail, web access	Data exchange	Data exchange, distant access	Data exchange	Data exchange, web access, distant access
Implementation	GpgSM,S/ MIME	GnuPGGNU PrivacyGuard	OpenSSH	FreeS/WA Npluto	OpenSSL,GnuTTL , NSS,JSSE

6. Conclusion

The TLS and SSL protocols are cryptographic protocols which provide safe communication through the Internet for the jobs of electronic banking and commerce, electronic mailing, access to distant computers and other ways of data transfer. Based on the data presented in Chapter 3, Secure Sockets Layer (SSL) Protocol, and in Chapter 4, Transport Layer Security (TLS), it is undisputable that the insignificant differences between the TLS and SSL exist, because the TLS as a derived solution uses only the safest and the most modern algorithms in the action of communication establishing but these protocols are basically the same.

1. Based on the systematized data given in Chapter 3, Secure Sockets Layer (SSL) Protocol, Chapter 4, Transport Layer Security(TLS), 4.4 TLS and SSL implementations and Chapter 5, Security protocols competitive to TLS and SSl protocols, it can be conclused that the TLS and SSL present standard and the

best solution for safe communication because in relation to competitive protocols from Application set of OSI model of protocols they have better protection, they cover wider area of applications, they have a larger number of implementations and majority of their implementations are program of open code. In the paper we note that the TLS protocol enables building of tunnel through the Internet so that the VPN can be created and which in relation to IPsec protocol, which also enables VPN, is manifested with capability for easier administration of distant access.

2. Based on comparisons given in chapter 4.4.4 Comparing TLS and SSL implementations, the best implementation is GnuTLS because it is open codeed program and also it permits to support the majority of versions of the SSL and TLS protocols, the majority of different algorithms for exchange of public key, the majority cryptographic algorithms and the majority of different actions of compression.

8. References

1.Croatian Academic and Research Network(CARnet),(2009),*TLS protocol* (CCERT-PUBDOC-2009-03-257), Retrieved July 01.2009, from http://www.cert.hr/documents/ CCERT-PUBDOC-2009-03-257.pdf
2.Pleskonjić, D., Maček, N., Đorđević, B., & Carić, M. (2007), *Sigurnost računarskih sistema i mreža*, Beograd, Srbija: Mikro knjiga.
3. Schneider, B. (1996), *Applied Cryptography*, New Jersay, USA: John Wiley & Sons.
4. Stallings, W. (1998), *Cryptography and Network Security*, New Jersay, USA: Prentice Hall.
5. Stinson, D. (1995), *Cryptography - Theory and Practice*, Florida, USA: CRC Press.
6. Tanenbaum, A. S., & Woodhull, A. S. (1997), *Operating System Design and Implementation*, New Jersay,USA: Prentice Hall.

REZIME

Internet, kao računarska mreža, povezuje milione ljudi širom sveta i obezbeduje im pristup velikoj količini informacija. Korisnici preko Interneta razmenjuju podatke na osnovu određenih protokola, a deo te komunikacije je privatnog ili službeno tajnog karaktera. Pri ovoj razmeni, korisnici resursa računarskih sistema, računara u mrežama i samostalnih računara, pre svega žele da budu sigurni da će pristup njihovim podacima i resursima uopšte imati samo oni kojima se pristup dozvoli. Dakle, analogno sigurnosti fizičke imovine korisnici računarskih sistema žele takozvanu računarsku sigurnost.

Jezgro Internet protokola predstavljaju TCP (Transmission Control Protocol) i IP (Internet Protocol) protokoli. Sve što putuje Internetom koristi ove protokole, ali oni ne obezbeđuje sigurnost prenosa podataka. IP paketi se, na primer, mogu lako izmeniti a njihov sadržaj može u bilo kom trenutku da pregleda

ma ko, pa i neovlašćena osoba. U svetu koji je danas već globalno povezan, pojedinci i razne institucije imaju potrebe za privatnošću, kao i za zaštitom od krađe identiteta, koja postaje sve češći vid zloupotrebe globalne mreže. Dakle, potrebna su sredstva koja su transparentna i dovoljno fleksibilna da zadovolje zahteve raznih korisnika, a istovremeno ostvare zadati stepen sigurnosti.

U ovom radu, pažnja je usmerena na komunikacijske zaštitne mehanizme definisane sigurnosnim protokolima, pri čemu se smatra da su ispunjene ostale kategorije računarske sigurnosti. Protokoli TLS (Transport Layer Security) i SSL (Secure Sockets Layers) su kriptografski protokoli koji omogućavaju sigurnu komunikaciju na Internetu za poslove elektronskog bankarstva i trgovine, e-mail, fax, pristup udaljenim računarima, a korisnicima rešavaju dobar deo navedenih problema.

SUMMARY

The Internet, as a computer network, connects millions of people all around the world and gives them a possibility to access a big quantity of data. Throughout the Internet users exchange data based on certain protocols and a part of this communication is of private or secret character. During this exchange, the users of computer systems, computers in network or independent computers, primarily want to be sure that only those who are allowed will have access to their data. Therefore, analogue to the safety of one's property, computer systems users want the so-called computer security.

TCP (Transmission Control Protocol) and IP (Internet Protocol) protocols are the kernel of Internet protocol. Everything that is transmitted through the Internet uses these protocols, but they cannot provide security of data transfer. For example, IP packages can be easily changed and their content can be seen by everybody at any moment, even by an unauthorized persons. Today the world is already globally connected and the individuals and various institutions need privacy, as well as the protection from identity theft, which becomes a very frequent aspect of misuse of the Internet. So, we need transparent and tools sufficiently flexible to fulfill the demands of different users and at the same time capable to achieve the assigned degree of security.

In this paper the attention is focused on the communication security mechanisms defined by security protocols, whereas all other properties of computer security should already be implemented. The TLS (Transport Layer Security) and SSL (Secure Sockets Layers) protocols are cryptographic protocols which provide safe communication over the Internet for the jobs of electronic banking and commerce, electronic mailing, access to distant computers and other ways of data transfer, while solving a good part of the mentioned problems for the users.

SOCIAL CHANGES AND MODERN CRISES – CHALLENGE FOR THEORY AND MANAGERIAL PRACTICE

[*]Milašinović S.[*] Kešetović Ž.[†]

[1] *Criminal Justice and Police Academy, Belgrad, Serbia*
[2]*Faculty of Security Studies, Belgrade, Serbia*

Abstract: The paper deals with the phenomenon of modern crises and its main features, comparing them to classic ("normal") crises, as well as the main processes that influenced this transformation. After that, the author discusses the key difficulties that coping with modern crises impose for managers. Administrative repertoire of prevention and intervention strategies is not adequate for modern crises that are much more complex and interdependent. Moreover, the conventional model of coordination is improper for dealing with proliferate number of organizations and individuals included in crisis management process. Increased politicization of crisis processes imposes new demands on crisis managers. New kinds of crises require a new way of thinking.

Key words: crisis, crisis management, prevention, leaders, managers

1. Introduction

In a certain way crises are constants of social life. Their names and dates are constants of social life, the cornerstone of historic eras. They have changed significantly the entire societies and cultures. So crises have been the integral part of human history, and they will also mark our future. Namely, with the development of the society and the progress in technology, human kind is facing frequent and more diverse crises. As a consequence, our planet has become „the world of risk"(Beck, 2002) in which the activities in one country have a dramatic influence on populations beyond its borders. This refers to the devastating natural disasters, international and domestic disturbances in vital products and services supply, industrial and nuclear accidents, fires in storehouses and hotels, accidents

[*] Corresponding author: e-mail: srdjan.milasinovic@kpa.edu.rs

of aircrafts and ships, laboratory experiments out of control, unrests and other social conflicts, terrorist attacks on political leaders and ordinary citizens, hijackings of trains, aircraft and ships, hunger and epidemics of infectious diseases. These are serious challenges for the police and other subjects of security system in each society.

Crises are actually abstract concepts for real events that can push certain community, region, nation or the whole world to the edge of chaos. These real and devastating events present a challenge for social, political and administrative elites, questioning the philosophical, social and moral nature of political leaders, society and world community, causing the changes that were inconceivable in the past. Remembrance on Brixton disorders, Challenger and Chernobyl disasters, sinking of Estonia and Akile Lauro ships, AIDS epidemic etc., are followed by fear, grief and anger, and a number of questions: Why did it happen? Was it possible to avoid the disaster? Who is responsible? The answers are often incomplete; the facts and evidence are not always transparent, while the public forgets quickly.

The European continent has always been the crisis prone place. The European history is full of text-book examples of different crises imaginable ranging from classic epidemics of infectious diseases to all forms of modern warfare, from a deep economic crisis to modern terrorism, from a serious environmental menace to a nuclear disaster, from the "mad cows' disease" to the "millennium bug". While the national governments are very slowly becoming aware of the crucial importance of establishing the appropriate institutional capacities for crisis management, new crises are emerging at the horizon.

However, it should be noted that our thought on crisis evolved. Comprehension of disasters and destruction as God's punishments have been overgrown more or less, although many Africans even today talk about the AIDS in these terms. A rational scientific explanation of causes, patterns and characteristics of crises dominate the contemporary world (Boin, Kofman-Bos, and Overdijk, 2004). Regardless of that, crises and disasters will continue to surprise us in the future. We do not expect them to happen right now, but they always choose some very bad moment. We do not expect them to happen here, but they occur here, in our country. It is high time to take these events seriously, to learn from them and to implement this knowledge in order to prevent similar events in the future, or at least, limit their harmful consequences. That is the purpose of the foundation of crisis management as a new research field and academic discipline, process that occurred in the Western countries in 1980s. Crisis management has become an academic discipline present on a number of scientific and research institutions. The fund of available knowledge that is presented in specialized journals and conferences is growing. Parallel with that, crisis management is recognized in functional and organizational sense in the state and public administration, private non-profit and NGO sector and companies that

sell products and services. The old conceptions and value systems are changing in a way that crisis management is not perceived solely as a cost, but more and more as an investment.

Methods and techniques developed within this discipline appear to be mostly efficient in coping with classic ("normal") crisis. However, modern society is very dynamic environment in which only permanent and certain thing is the change. Due to that, the nature and character of modern crisis has changed. Their behavior and pattern differ from that of "normal" crises. The consequence of this change is that the old and proven responses on classic crises are not effective and could even be counter-productive. They are not part of the solution any more and they practically become a part of the problem.

In the above-mentioned context, the modern crises, very different in their nature, phenomenology and effects, represent particular challenge for scientists and researchers and crisis managers and leaders in the state and public administration, first of all in police and other emergency services, non-profit organizations and business enterprises.

2. A phenomenon of modern crises

The classic crisis was a destructive event, which caused death, serious body harm and other damage. It was a clearly defined event, marked by a relatively clear beginning and end, cause of destruction, and victims (Rosenthal, 1998). Such events still occur and they still cause damage and despair. But the causes of these events are much better understood today. Complex organizations now deal with such crises on a routine and professional basis. The classic crisis has become the routine crisis that falls within the accepted risk boundaries of modern society.

The modern crisis is quite different from the events that used to be studied in terms of crisis. It takes on endemic quality: a modern crisis is a logic counterpart of increasingly complex systems, which, for technological, financial or political reasons, cannot keep up with safety and security requirements. The modern crisis is of a complex nature: it consists of new combinations of known crisis that suggest solutions, which only turn out to be the sources of escalation. Moreover, the modern crisis has a self-perpetuating tendency; the process turns into a vicious circle fed by uncertainty about causes and causal chains (Masuch, 1985; Ellis, 1998). There is no return to normalcy, because the future crises reappear in mutated forms. The 9/11 terrorist attacks in the U.S. exemplify the modern crisis. It clearly showed that future crisis would significantly differ from those we know today. The modern crisis is the product of the society we live in. It is the result of what we value and of the way we perceive threats. Ulrich Beck pointed out that contemporary society, rather than by the risk of destruction, is

characterized by obsessive fear of the menace to security (Beck, 2002). It is also the logical outcome of the dominant trends like trans-nationalization, media society, technological development and dissipation of the state authority that have shaped and continue to shape our society.

Trans-nationalization

Crises are increasingly defined in transnational terms. We have become accustomed to the global scale of adverse developments: two World Wars, worldwide economic regression, and ecological trends have necessitated a global outlook. The original source of the problem at hand may continue to be local or national, but immediate and long-term impact of disasters and crises spread over countries and continents. A great many major disasters and crises of the last decade have already indicated the significance of these transnational dimensions. Until the Chernobyl disaster, nuclear power plant disaster scenarios were typically nation-bound, with international implications being subordinate to national concerns. However, the radiation fallout from Chernobyl that caused substantive damage to many countries in the Northern and Western Europe indicates trans-boundary risks and consequences of modern crises. Since the dismantling of the Soviet Union, one of the most serious worries of the Western countries has been the appalling state of the nuclear plant facilities in Russia and other Eastern European states.

Crises may flow over from the local areas and domains into the international arena, but more than ever they may be a part of manifestation of problems that are global in nature. (Kennedy, 1988; Huntington, 1996). The most convincing examples are some ecological trends (ozone layer depletion, global warming, and acid rains) that spread and, according to some experts, threaten Planet Earth, requiring the international action and huge investments. At the same time the worldwide nature of the problem generates considerable uncertainty (Nijkamp, 1994). Negative consequences that have been manifested within national borders so far, like environmental endangering and economic stagnation have more influence on political and social situation in neighboring countries. In Africa, mass migrations and refugee movements reflect the artificial and conflict-ridden nature of state boundaries. Chemical accidents, air pollution, computer crimes, monetary crisis and viral diseases do not respect national borders.

Media society

The subjective notion of disaster and crisis can be summarized in a version of the Thomas theorem: “if men define a situation as a crisis, it will be a crisis in its consequences” (Thomas and Thomas, 1928). When citizens or authorities define or declare a difficult situation a disaster or a crisis, this may have a decisive

impact on subsequent course of events. To call the situation by such an evocative word may provoke hyper-vigilance and over-reaction, running from collective stress to escalatory decision on the part of the authorities; on the other hand, it may solicit the collective energy and mobilize the emergent rules and norms necessary for the effective disaster and crisis management

The modern crisis has its own version of the Thomas theorem: If CNN defines a situation as a crisis, it will indeed be a crisis with all its consequences. The media have become one of the driving forces in the world of crises. The media connect a crisis site with the rest of the world.

The media seem particularly apt to select two categories of events for intensive coverage. First, they will be keen in the ominous prospect and occurrence of mega-disasters. The category of disasters defines itself by the sheer number of potential or actual causalities and the amount of physical damage. Second, the media take a particular interest in the typically subjectivist categories of crises with the characteristics of madness, panic and collective stress. Such disasters and crises may put a heavy burden on the social fabric. They may weaken the normative structure of society.

Technological developments

The technological jumps in the area of information and communication technology have been breathtaking both in speed and scope. Our perception of time and space limitations has changed dramatically with the availability of satellite communications, the Internet and the growth of mass transportation systems.

These technological developments have consequences for both the causes and characteristics of crises. For instance, our technological systems have become so sophisticated and compressed that a minor malfunctioning is capable of causing a system breakdown (Perrow, 1984). Technology has become increasingly complex to a degree that users often do not understand how the technology works (which makes it hard to detect and correct malfunctioning elements). Yet, the efficient design of technological systems requires a tight coupling of elements (which enhances the chances of chain reactions). This explains why a malfunctioning valve and a broken warning light together may lead to a nuclear meltdown (Perrow, 1984).

The development of these immanently high-risk technologies also affects the potential scope of a crisis. This applies to mega-carriers in the transportation industry – from the forebodings of the Estonia ferry disasters with nearly 900 victims in September 1994, to the grim prospects of the new airplanes carrying 600-800 passengers, as well as to nuclear power plants disasters. The increased dependency on computer systems makes our societal and economic systems

increasingly vulnerable. This vulnerability is compounded by the threat of hackers and cyber terrorism. (Demchak, 1999).

An entirely new dimension of high-risk technologies now calls our attention in the realm of medical technology and genetic manipulation. The consequences of these developments may reveal themselves in a few generations down the line, but the impact could be irreparable. Such developments can develop partly because of the growing discrepancy between mega-science and the knowledge or understanding of the part of administrative and political decision-makers.

Dissipation of state authority

In the Western world, the role of the state has declined over the last decades. The traditional prerogative of civil authorities in times of crisis is giving way to a less pronounced and less taken-for-granted definitions of the tasks that public authorities are to perform in order to prevent, prepare for and cope with crises. The political and administrative trend has repercussions for the causes, characteristics and consequences of crises.

The declining role of public authorities is captured in the twin developments of retrenchment and managerialism. As a result of performance crises, huge budget overruns and overall decline in public legitimacy, new governments were elected in the Western democracies on the promises of a New Public Management. One of the means to "do more with less" was found in spending cuts and a re-evaluation of priorities. Another means were found in the improvement of public management.

In the atmosphere of retrenchment and reform, measures aimed at the prevention or mitigation of potential crises receive less attention than the problem at hand, which may be perceived by many as an endemic crisis of public governance. A decline in resources affects personnel numbers, maintenance activities, repairs, exercises, planning, in short: many factors that somehow may interact to cause a crisis. Since the benefits of crisis management activities are much harder to quantify than the costs, the importance of such activities is likely to be underappreciated which, in turn, may easily lead to underfunding.

A significant counter-development is found in the increasing number of participants entering the crisis arena: private companies complement the traditional but declining role of the state. In other words, crisis responsibilities have become a shared concern or a co-production between private and public actors. Public safety, for instance, is depending more and more on the role of security companies. Crisis in large-scale organizations, even in public organizations, have become the near-exclusive domain of management consultants. It is now recognized that governmental actors can be a major source

of public and private crises, an observation that relegates the public role to one amongst many others.

When crisis do occur, the public turns to public authorities for decisive action, instant relief and long-term leadership. Public authorities get caught between their limited abilities to provide effective crisis management and the increased willingness of the part of the public to scrutinize governmental actions and assign blame when deemed necessary. During crises a critical attitude towards government and its practices will rapidly translate into a decline of legitimacy. The loss of support pertains not only to what public authorities have done during the crisis but it also reduces the ambitions of the public authorities which refer to the prevention of future crises. The public role in the crisis arena then becomes part of a vicious circle.

Arien Boin and Patric Lagadec suggest a very interesting comparative description of classic (traditional), modern and future crises (Boin and Lagadec, 2000: 185-191).

Characteristics of Traditional `Faults' and Fault Management

- a known, isolated event, framed within conventional hypotheses;
- a situation perceived as manageable (technically, economically, socially);
- costs relatively easy to estimate, and recoverable within the context of tried systems;
- a limited duration;
- codified intervention procedures, well known by the specialists solicited;
- a limited number of interveners, all specialized in one aspect of the problem at hand;
- well-determined roles, responsibilities and hierarchies, known by the services in charge.

Characteristics of Modern Crises

- large impacts, large populations affected;
- very high economic costs, surpassing the classical insurance capabilities;
- unprecedented, generic and combined problems, affecting vital resources;
- snowball dynamics due to a multitude of resonance phenomena;
- emergency systems reacting on the wrong foot: obsolete, non-applicable and even counter-productive procedures;
- extreme uncertainty that will not vanish within the emergency period;
- a long duration with threats transforming over time;

- convergence, i.e. large numbers of actors and organizations bursting onto the scene;
- critical communication problems: within the responsible organizations, with the public, the media, the victims (even populations very distant in space or time);
- considerable stakes of all kinds.

Characteristics of Future Crises or `Breakdowns'

- there is a pre- and post-breakdown state, the change being irreversible;
- the breakdown is not due to a specific event: there is global and polymorph resonance;
- basic and unquestioned procedures do not apply anymore: i.e. the fundamental principles, the identities, the contexts, the actors, the rules of the game, the defense mechanisms, the knowledge, all these tools are up for re-consideration;
- breakdown brings repeated, iterative crises, with sudden crystallization, occurring and disappearing in a seemingly incomprehensible and random fashion;
- powerfully anchored in deep disequilibria of the system, the breakdowns are even more resistant to conventional treatment;
- the `decomposition' side being most perceptible, the prevailing impression is one of a generalized decoupling process, a work of disintegration almost impossible to suppress;
- The breakdown pervades the whole theatre of operations. Fundamental problems resonate with each other, preventing any sequential treatment ordered in time, space and by category. There is a feeling of loss.

3. Managing modern crises

Crisis management is stenographic phrase for all managerial practices that refer to non-routine phenomena and development. It is usually associated with hectic moments of crisis decision-making but also covers area of prevention, preparedness and crisis response, as well as sensitive area of recovery and change.

Old fashioned response to crisis was recovery through combination of flexibility, improvisation and prudence of individuals, groups and societies. Over the time both the practitioners and scientists tried to comprise the best crisis management practice into operative procedures, check lists, organizational structures and job descriptions.

Versatile nature of modern crises has direct implications on crisis management. The administrative repertoire of prevention and intervention strategies is not adequate for modern crises that are more complex and oblique. Moreover, the conventional organizational model of coordination is inappropriate for dealing with proliferous number of organizations and individuals included in crisis management process. Increased politicization of crisis process imposes new requests on crisis managers. In short, new crises require a new way of thinking.

In the future, complex disasters will be the rule, not the exception. While the stake is rising, the pitfall of traditional crisis repertoire is becoming wider. The gap between "normal" prospects of what the authorities can do to prevent the crisis and actual disturbances will be wider. Traditional strategies of crisis management – secrecy, privilege of executive power, and autarchy – are losing the ground in conditions where awaked public wants to know the details. The increased media competition will strain capacity of crisis authorities to win the support for preparedness and intervention strategy.

Future crises will necessitate preparations that will comprise recovery strategies and those based on anticipation. If there is consensus on the fact that recovery is the key in dealing with future crises, it is necessary to organize this recovery in proper manner, e.g. to facilitate fast, flexible, innovative and effective response when future crisis emerge.

As new crises by their nature are becoming more complex and transnational, the need for flexibility in prevention will be more important. Of course, chances for "routine crises" have to be reduced, based on general knowledge and specific lessons learned from the previous crises. However, an excessive reliance on prevention leaves social and political system exposed to consequences of new forms of crises. The balance between prevention and resilience is a real challenge for crisis managers.

The preparation of preventive measures and planning the activities that are to be taken in the case of crisis for a long time have been within the mandate of mezzo-level managers and operative agencies. The work in this field has characteristics of bureaucratic routine that is far from hustle and conflicts characteristic for "high" policy. The new context of risk and crisis management is quite different. An appropriate perspective of new forms of crisis management emphasizes social and psychological challenges and assumes great media attention that inevitably puts the event in the politic arena. In this context the very labeling of certain social circumstances or concrete event with the term "crisis" becomes a political act. In that context, it is not a routine bureaucratic job any more, but a challenge for political leaders and highest officials. Of course, crisis management must not remain the exclusive domain of government officials, as their agencies would not achieve results without the help of intermediary organizations.

But crises create situations that cannot be predicted and that call for responses that have not been programmed. During the crisis tactical problems are not the core of the challenge. What is at stake is the very being of activity, policy or the institution. Top managers of the organization have to take the rudder in their own hand in a very unclear environment. They have to identify key objectives, review the priorities, rethink the relations with stakeholders, clear the communication strategy; in short, they have to provide cement that keeps the organization together. Leaders often understand this as a task of the security personnel, not as their own task. As they have no knowledge of future crises pattern, they are prone to use classic model in new context. However, new crises are bringing new challenges. The facts remain unknown – you know that you will not know. Managers take the risk if they do not stop unusual activities that influence crisis. At the same time, they risk their job or company if they stop those activities without strong reasons they are not sure about. This is like piloting in the middle of tornado. They have to be trained to anticipate banishing given basic rules, to outline new vision, to recompose new coalitions of stakeholders, to avoid key errors in communication and decision-making. Imperatives that might help an organization to prepare for the unknown are the following (Boin, Lagadec, 2000):

Ensure Awareness at the Highest Levels

The first and indispensable step is to get the problem of crises and breakdowns on the agenda of top-level decision-makers ('t Hart, 1997; Preston and Cottam, 1997). Executive awareness may be raised through workshops or simulations specifically dedicated to new crises and to the decision-makers' new responsibilities (Kleiboer, 1997). The aim is to forge new attitudes: tolerate open and shared questioning about possible, yet uncertain situations; reflect on the decision-making process in the absence of clear expertise; understand the need to communicate internally and externally whilst in a situation of uncertainty, even complete ignorance, for the extended periods of time; steering complex systems by accommodating the co-existence of conflicting logics.

Develop Appropriate Operational Capabilities

In order to facilitate a resilient response, the following organizational capabilities must be developed:

- monitoring capability and capability to detect weak and non-conventional signals;
- emergency information systems, which can process relevant information to and from central authorities;

- alert and mobilization capability of crisis units, with support from all parts of the organization;
- capability to handle the technicalities of `first emergencies': actors must be prepared to deal with uncertainty and complexity and be able to relate technical matters to strategic issues;
- capability for action in situations of decentralized crises: provide for an organizational structure which allows the largest possible number of actors access to the system's response capacity (betting on centralization only leads to heaviness, closed logics, communication delays; see `t Hart, Rosenthal and Kouzmin, 1993).

Engage in continuing preparation efforts

Experience, previous research and the contributions in this field suggest a few mandatory signposts for the effective preparation. A continuous practice of feedback from experience in a constructive spirit, each crisis episode has to be subjected to a precise analysis to identify and understand the series of events that occurred in handling the case. Immediate operational learning points have to be extracted; this means that the analyses must relate to the functioning of decision support systems. International cross-fertilization has recently proven to be extremely useful.[‡]

Tests and simulation exercises - It is necessary to engage in a continuous training program; not so much to prepare for well-codified faults or failures (the `fire exercise' ritual), but for destabilizing surprises. It is irresponsible to rely on previous experience only for collective training. Simulation is a bare necessity. These simulations have to be followed by rigorous debriefings (`t Hart, 1997): this effort, often neglected, is indispensable to make progress. The tests must be both extremely short to develop the mobilization reflexes of the teams, and more complex to develop the polymorph capabilities which will be required for steering through crisis.

Training - It is of major importance to provide the various managers with the appropriate types of training. Different responsibilities require different preparatory efforts: the executives, who will play a crucial political role

[‡] After ice storms destroyed the electrical grid of southern Quebec in January 1998 (see Scanlon, 1999), the French electrical company EDF (Electricite de France) sent a team to study the problems and solutions developed by Hydro-Quebec and government agencies. Less than two years later, France was struck by two successive storms that destroyed part of the French grid. EDF reacted quickly: the nature of the problem was immediately understood, key mistakes to avoid were known, and strategic initiatives were undertaken. EDF leaders credit the learning process after the Quebec experience in explaining their successful crisis management.

throughout the crises; the crisis unit managers, who will have to steer extremely complex systems with often little known and massively perverse effects; the spokespersons; the experts - abruptly dislocated from their laboratories to the television set - are often obliged to offer judgments whilst their tools are deficient. In advanced organizations, media training is a common feature. But it is necessary to go much further: new areas of management issues are to be discovered and shared with those concerned.

Inter-actor learning - As crises are processes unfolding amidst complex networks, it is necessary to expand the learning process to the external world: meetings, feedback from experience and exercises, the exploration of unprecedented vulnerabilities - these learning mechanisms should not be internally restricted. A continuous enlargement of the circle of actors involved is necessary.

Personal involvement of elites - As crises and breakdowns typically touch upon fundamental elements of an organization's mission and structures, nothing serious is likely to happen without the durable involvement of the organizational leaders. Personal involvement in preparatory and learning processes tends to change completely when the `boss' is personally engaged in the case. This requires that high-level managers break with the pervasive attitude that a highly placed person does not need to learn about crises and crisis management, neither that he should not get involved with simulations nor engage in feedback from experience.

A general scheduling of the intervention - One has to be wary of spectacular plans and projects without follow-up, which exhaust energy, goodwill and budgets. It is necessary to introduce tests and resources progressively over time, gradually and incessantly, involving increasing numbers of actors. All aspects of learning have to be canvassed: an undertrained institution cannot support multiplied exercises or feedback from painful experiences without getting effective methodological and know-how support at the same time.

Mastery of core processes - Any effort to prepare an organization, or a network of organizations, for unknown crises that may occur sometime in the future requires an intimate knowledge of core processes and critical vulnerabilities (Wilson, 1989). The generics of crisis management must fit the specifics of the organization's core competences. In a situation of uncertainty, solutions must be anchored in a deep understanding of the organization's inner-workings. In today's world, where executives typically are generalists, not specialists, crisis preparation will thus be enhanced by project-management methodologies. The temporary nature of 'project management' must, in turn, be offset by a conscious effort to embed the developed structure in the organization.

Due to the complexity, understanding the real nature of the modern crisis is very hard managerial task. A crisis manager is restrained by the complex conditions and characteristics of undeveloped crisis and uncertainty of the results.

According to Turner, the unreliability of the response could result from the "initial lack of information, wrong initial classification, of change of the nature of the incident during its development" (Turner, 1992). Resulting dissonance between the definition of a situation and its real and actual characteristics undermine crisis response. Crisis managers believe that they are solving the crisis, while careful analysis of the situation shows that this is not the case. It usually takes some time for crisis managers to adjust their definition of the situation.

Crisis managers are undecided between immediate action and long-term effectiveness. Traditional repertoires of crisis management are marked by preoccupation "here and now" dealing with the acute threat. Consequences of initial decision are fading in the background of actual happening. However, modern crisis is not a single event, but a long term process. Long after the crisis began, crisis managers are facing problems that can become "a crisis after crisis". For example, a minor incident like oil spill or gas leak can have long-term effects that are much harder to deal with. Such crises do not fit the traditional crisis repertoire.

Consequences of contemporary crises have tendencies to be as durable and intensive as their acute phase, while leaders are under pressure of informal investigation, provocative journalism, and demands related to insurance and legal procedures against them.

Finally, in future crises it should be noted that, in the beginning, they give free hands to politicians and managers, enhancing their legitimacy. But this cannot last for a long. In the moment of serious crisis eyes of the nation are on their political leaders. While the success in solving crisis makes statesmen out of them, failure to do so eliminates them from political scene.

4. Closing remarks

A crisis response is a serious challenge. A crisis requires critical decisions that have to be made under the unsuitable circumstances. At the same time, the crisis is generating obstacles for quality decision-making. Common problems are propelling during the crisis. All of these are multiplying due to the nature and character of modern crises. Crisis managers have to solve complex dilemmas without the necessary information in unsteady organizational environment and under serious stress. If we consider dilemmas emerging during the crisis, crisis management could be labeled mission impossible. For example, crisis managers have to decide, during the initial phase of the crisis, whether it is the whole crisis or just a signal of forthcoming crisis. From the limited and fragmented pieces of information he has to conclude if it is the whole story or just the beginning. This dilemma has a consequence in resource allocation: should they all be directed to what seems to be the beginning of the crisis or it is better to wait until the

situation develops. This dilemma is even harder during the so-called conflict crises. War and terrorism are followed by disinformation campaigns, sudden attacks and multiple arenas.

In the circumstances where emotions are very intensive, it is impossible to pose impartial diagnosis. Crises are often treated as political failures. In such circumstances research following the crisis is less related to learning and more to *blame game*. Journalists and citizens consider that someone has to be responsible for faults and failures that resulted in crisis. Politicians are aware of this and they respond by improving their defense routines like seeking for acceptable negating and developing public relations skills. The more time they devote to this, the less time they have to use the crisis potential for learning. Real efforts for improving the system are often lost in post-crisis politics. If there is such a thing as post crisis learning, it is a long-term process.

All the above-mentioned indicates that modern crises are significant challenge for managers, exposing substantial and organizational insufficiency of the classic repertoire of crisis managers and their philosophy, and testing the capabilities of individuals, teams and whole organizations.

Refererences:

1. Веск, U.,(1992). *Risk Society: Towards a New Modernity.* London: Sage.1992.
2. Boin, A., Lagadec, P.,(2000) "Preparing for the Future: Critical Challenges in Crisis Management", *Journal of Contingencies and Crisis Management*, Vol 8, No 4, December
3. Boin, A., ‘t Hart, P.,(2003) "Public Leadership in Times if Crisis: Mission Impossible?", *Public Administration Review*, Vol. 63, No. 5,
4. Boin, A, Kofman-Bos, C., and Overdijk, W.,(2004) "Crisis simulations: Exploring tomorrow’ s vulnerabilities and threats", *Simulation & Gaming*, Vol 35 No.3, September 2004, 378-393
5. Ellis,P. (1998), ‘Chaos in the underground: Spontaneous collapse in tighty-coupled system‘,*Journal of Contingencies and Crisis Management* 6:137-151.
6. ‘t Hart, P., Rosenthal, U., and Kouzmin, A.,(1993) "Crisis Deceision Making: The centralisation Thesis Revisited", *Administration and Society*, 25(1):12-41
7. ’t Hart, P. (1994), *Groupthing in Government: A Study of Small Groups and Policy Failure*, Baltimore:Johns Hopkins Univarsity Press.
8. `t Hart, P. (1997), `Preparing Policy Makers for Crisis Management: The Role of Simulations', *Journal of Contingencies and Crisis Management*, Volume 5, Number 4 (Special Issue on the Use of Crisis Simulation in the Academic, Business and PolicyCommunities), pp. 207-215

9. Huntington, S.P. (1996), *THe Clash of Civiliyations and the Remaking of the World Order*, New Yoork:Simon&Shuster.
10. Jackall, R.,(1988) *Moral Mazes: The World of Corporate Managers*, Oxford,UK:Oxford University Press.
11. Kennedy,P. (1988), *The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500-2000*, New York:Random House
12. Kleiboer, M.A. (1997), `Simulation Methodology for Crisis Management Support', *Journal of Contingencies and Crisis Management*, Volume 5, Number 4, pp. 198-206.
13. Masuch, M. (1985), `Vicious circles in organiyations`, *Administrative Science Quarterly*, 30 (1):14-33.
14. Nijkamp,P. (1994), `Global environmental change: Management under longe-range uncertainty`, *Journal of Contingencies and Crisis Management*, Volume 2, Number 5, pp.1-9.
15. Preston, T. and Cottam, M. (1997), `Simulating US Foreign Policy Crises: Uses and Limits in Education and Training', *Journal of Contingencies and Crisis Management,* Volume 5, number 4 (Special Issue on the Use of Crisis Simulation in the Academic, Business and Policy Communities), pp. 195-197.
16. Turner, B.A. (1992), *Stepping into the Same River Twice: Learnig to Handle Unique Management Problems*, Middlesex University Inaugural Lectures 2.
17. Quarantelli, E., (2001)"Another Selective Look at Future Social Crises: Some Apects of Which We Can Already See in the Present", *Journal of Contingencies and Crisis Management,* Vol. 9., No.4 December
18. Rosenthal,U. (1998)`Future disasters,future definitions ` in: E.L.Quarantelli (Ed.),*What is a Disaster? Perspectives on the Question*,London:Routledge, pp. 146-159.
19. Thomas,W. and D. Thomas (1928), *The Child in America: Behaviour Problems and Programs*, New York:A.A.Knopf.
20. Turner, B.A. (1992), *Stepping into the Same River Twice: Learnig to Handle Unique Management Problems*, Middlesex University Inaugural Lectures 2
21. Wildavsky, A. (1988), *Searching for Safety*, New Brunswick:Transaction Bools.
22. Wilson, J.Q. (1989), *Bureaucracy: What Government Agencies Do and Why They Do It*, Basic Books, New York.

REZIME

Krize su stalni pratilac društvenog života. Sa napretkom društva i tehnologije koja postaje sve dostupnija i sve komplikovanija, ljudska vrsta se suočava sa sve rasnovrsnijim i brojnijim krizama.U ovom radu razmatraju se karakteristike fenomena modernih kriza i njihova razlika u odnosu na klasične krize, kao i najznačajniji procesi koji su doveli do ove transformacije. Pored toga ističu se ključne teškoće koje moderne krize postavljaju pred menadžere. Promenljiva priroda savremenih kriza ima direktne implikacije na krizni menadžment. Administrativni repertoar strategija prevencije i intervencije nije odgovarajući za savremene krize koje su sve složenije i sve više međuzavisne. Vreme je da se ovi događaji uzmu ozbiljno, da iz njih počne da se uči i da ta znanja počnu da se primenjuju kako bi se ubuduće takvi događaji izbegli, ili barem ograničile njihove štetne posledice. Upravo u tome i jeste smisao zasnivanja kriznog menadžmenta kao novog istraživačkog polja i nastavno naučne discipline. Štaviše, konvencionalni organizacioni model koordinacije je neprikladan za postupanje sa prolifelirajućim mnoštvom organizacija i pojedinaca uključenih u proces kriznog menadžmenta. Sve veća politizacija kriznog procesa stavlja nove zahteve pred krizne menadžere. Moderne krize javljaju se kao izazov za savremene menadžere pokazujući sadržinsku i organizacionu nedostatnost klasičog kriznog menadžerskog repertoara i filozofije, ozbiljno stavljajući na probu sposobnosti pojedinaca, timova i celih organizacija. Nova kriza zahteva i novi način mišljenja.

SUMMARY

Crises are the constants of social life. With the development of the society and the progress in technologies, which become increasingly available to almost everyone, human kind is faced with more diverse and more numerous crises. This paper deals with the characteristics of the modern crises phenomenon and how the modern crises are different when compared to traditional crises, as well as the main processes that influenced these transformations. In addition to this, the authors discuss the key difficulties the managers are faced with when coping with modern crises. The administrative repertoire of prevention and intervention strategies is not adequate for modern crises that are much more complex and interdependent. It is high time to take these events seriously, to learn from them and to implement this knowledge in order to prevent similar events in the future, or at least, limit their harmful consequences. That is the purpose of the establishing of crisis management as a new research field and academic discipline. Moreover, the conventional model of coordination is improper for dealing with proliferate number of organizations and individuals involved in crisis management process. Ever increasing politicization of crisis processes imposes new demands on crisis managers. Modern crises appear as significant challenges for contemporary managers, exposing substantial and organizational insufficiency of the classic repertoire of crisis managers and their philosophy, and testing the capabilities of individuals, teams and entire organizations. New kinds of crises require a new way of thinking.

THE CONCEPT OF ADMINISTRATIVE MEASURES FOCUSING ON POLICE MEASURES

Vasiljevic D.

Criminal Justice and Police Academy, Belgrade, Serbia

Abstract: The administration, a part of which is police, passes diverse legal acts. A prominent place among these belongs to material acts, which include administrative actions and administrative measures. It should be noted that the issues related to administrative measures have not been properly addressed so far in expert legal literature. This paper therefore presents an attempt to provide additional information about the very concept of administrative measures in legal theory and existing legislation, focusing on police measures taken to protect public order.

Key Words: administrative acts, legal acts, administrative act, material act, administrative actions, administrative measures, police, the principle of lawfulness, public order.

1. Introduction

Administration acts are not only legal, but also material ones. Unlike administrative acts as A form of exercising administrative authority, which present statements of will by which legal relationships are created, modified or abolished and therefore have immediate and independent legal effects, material acts are bodily acts legally relevant or irrelevant that have no immediate or independent legal effect.

It is well known that the activity of the administration does not only include the passing of administrative acts but also a range of individual acts and actions that have no immediate legal effect. These acts and activities greatly vary in character and range from simple material actions to acts provided for by the law, but the crucial fact about all of these is that they have no immediate legal effect. As some authors have pointed our, "legal effects must stem directly from the very act, or they are not immediate."[*]

[*] E. Forsthoff, Traite de droit administratif allemand, Bruxelles, 1969, p. 313.

These acts are referred to by various terms in legal theory. Thus the most commonly used terms include: material acts (Puguit), individual non-legal acts (Debbash), unilateral acts without legal effect (Vedel), and even natural acts (Eisenmann).[†]

In our legal theory the most frequently used terms include: material acts, administrative actions, concrete act of administration outside administrative act, etc., whereas the existing legislation most frequently uses expressions such as individual acts, actions and measures.[‡]

Besides, material acts of administrative organs have been given an extremely modest consideration in both national and international professional literature, especially when compared to the administrative act.

Legal theory and legislation refer to both administrative actions and administrative measures. However, the same pattern of giving a less prominent role to administrative actions as compared to administrative acts also prevails here and administrative measures are given less attention than both administrative actions and administrative acts.

2. The Notion of Administrative Measures

The term administrative measures can be encountered in literature, but without pretensions to define it clearly and make a distinction between them and administrative acts or administrative actions. S. Popovic thus points out that "coercive and restrictive measures as a rule are performed by state organs (law enforcement organs, national defense, courts by pronouncing sentences of imprisonment or other sentences)… the implementation of coercive measures and restrictions can be performed by individual acts, but also through administrative actions."[§].

P. Dimitrijevic emphasizes that performing actions of law enforcement is necessarily governed by legal rules – regardless of whether they are performed contrary to the will of the subject to which they pertain, or they do not have legal character. This author concludes that the administrative actions are such a form of law enforcement actions "which includes performing the measures of coercion or restriction based on the law in specific cases toward specific subjects."[**]

The existing law also recognizes the term administrative measures. Thus the Constitution of the Republic of Serbia (Section 202) envisages that in emergency or state of war departures from human or minority rights granted by

[†] M. Stassinopoulos, Traite des actes administratifs, Paris, 1954., p. 75. This author also calls them decisions that cannot be carried out.
[‡] D. Milkov, Pojam upravnog akta (doctoral thesis, unpublished), Novi Sad, 1983, p. 289-292.
[§] S. Popović, Upravno pravo (opšti deo), Beograd, 1995, p. 332-334.
[**] P. Dimitrijević, Osnovi upravnog prava, Beograd, 1989, p. 276.

the Constitution are allowed, but only to an extent that is necessary. These departures must not lead to discrimination based on race, sex, language, religion, nationality or social background. The measures involving departure from human and minority rights shall cease upon ending the state of public emergency or war. These measures must in no way refer to the rights provided for in Sections 23, 24, 25, 26, 28, 32, 34, 37, 38, 43, 45, 47, 49, 62, 63, 64 and 78 of the Constitution. It is to that effect that the Law on State Administration of the Republic of Serbia (Section 12) provides that state administration authorities draw bills and other regulations and general acts for the Government and propose development strategies and other measures that mould the Government policy. Section 18, paragraph 1 provides that state administration authorities supervise the enforcement of the Law and other regulations through inspection and direct insight into actions of both physical and legal persons, prescribing, within their powers, certain measures on the basis of results of such supervision. Section 19 envisages that the state administration authorities are to see to it that the work of public services is in keeping with the law. Here also the state administration authorities take measures within their legal powers.

There are numerous examples of such and similar cases in the norms of the existing legislation. However, it is generally recognized that the authors of these legal acts have used the concept of measures very broadly and inaccurately, without any intention to embark upon defining the notion.

As we can see, the concept of administrative measures is more frequently used in regulations and in practice than in theoretical literature. The practical use requires that the concept and contents of administrative measures be studied, as well as their planning for specific purposes. It is vital to explore specific activities involved in these measures, the issues of jurisdiction and responsibility for their implementation, as well as legal rules, tactical aspects and other relevant issues. From the legal point of view, it is vital to ensure legal grounds for all activities related to administrative measures including the very decision to take the said measures. Naturally, there should be a valid reason for making such a decision. However, the decision will primarily depend on the quality of available information and successful estimates of situations, that is, on converting the information into appropriate decisions. When assessing the situation, the legal aspect of the problem should be restricted to most important questions – the ones related to the scope, contents and range of available powers that the authorities are entitled to, as well as their applicability and effect in the specific situation. Problems arise on the level of principles on which successful administrative measure is based, then with respect to the method of managing used in the realization of such a measure in the given situation, and, finally, with respect to finding objective criteria for evaluating the results of the applied measures in the context of achieving the topmost aim of administrative authorities' entire activity.

An administrative measure is not something apart from an administrative act or administrative procedures. It is most frequently imposed by an administrative act and enforced by administrative procedures or stems directly from the law. Administrative measures present certain activities performed by the state administration authorities the purpose of which is to achieve the goal set for performing tasks and jobs that is within their jurisdiction, and this goal is achieved by passing an administrative act or instituting administrative procedures, or even sometimes in both of these ways. From the legal point of view, administrative measures should be seen primarily as implementation of a larger number of administrative actions with a view to achieving a specific goal in a given situation, all in keeping with the law. The implementation of a number of administrative actions within an administrative measure should lead to a concrete goal for the purpose of which it has been taken, just as the implementation of a single measure. Still, the form of an administrative measure cannot be independent from and above the legal form, and its actual effect cannot be more important than legal grounds. Measures, as a rule, involve legal activity of the administrative authority, i.e. the passing of such legal acts and implementing such material acts as may be relevant.

The administrative measures that are thus understood are characterized by a number of important elements. Firstly, the administrative measures are strictly legally envisaged and governed, based on the law. Their legality is twofold: it refers both to the contents and the form. The contents-related legal aspect of administrative measures primarily concerns legal prerequisites for their application and respect for certain legal purpose. On the contrary, if an administrative measure is aimed at achieving another purpose (which is not envisaged or is illegal) than we can speak about misuse (or abuse) of the right to take administrative measure. The formal aspect to the legality of administrative measures refers to the clear and precise legal jurisdiction for the implementation thereof, as well as to the legality of the procedure, the manner and development of the implementation.

Secondly, the purpose of administrative measures is to enforce law, which means to achieve specific public goals in legal ways. It does not have to refer to the very enforcement of the law, but also to preparing conditions for creating law.

Thirdly, administrative measures are characterized by authoritativeness typical of administration as a function of state authority. Authoritativeness of administrative measures can be more or less prominent. They may be taken for preventive purposes, but this does not imply an absence of authoritativeness.

Fourthly, administrative measures are taken only in keeping with certain principles. There are a number of these principles. The principle of lawfulness implies that the administrative measures are taken in keeping with the law. The principle of proportionality presumes that the administrative authority usually has

a number of legally possible and appropriate measures at its disposal but that it should chose the one or ones that will serve the specific purpose or goal causing at the same time as little damage to the subjects involved as possible. This principle is explicitly referred to in the General Administrative Procedure Act in the part related to execution (Section 263), to the effect that if it is possible to execute an order in more than one way and using different means, it will be executed in such a way and using such a means as to achieve the set goal and be the mildest towards the subject. This article emphasizes that on Sundays, during state holidays and at night the orders can be executed only if there is a danger in their postponing and if the authority in charge of execution has issued a written warrant. The principle of limited time duration of an administrative measure means that the duration of a measure is restricted to the period of time necessary to achieve the goal for the purpose of which the measure was taken. In keeping with the principle of independence, the state administration authority takes only necessary, most favourable and legally possible measures bearing in mind jobs and tasks assigned to it in keeping with its function performed in the system of government.

3. Administrative Measures of Police in Executing their Duty Related to Protction of Public Order

The implementation of administrative measures on the part of administrative authorities, within their powers, is inevitable. The same should be understood in the case of administrative measures enforced by police in the execution of their duties and within the powers vested in them.

It is widely known that one of police jobs is to protect public order. It implies organized and continued activity on the part of police aimed at ensuring stable public order, or the optimal state of security in this sphere[††].

We can distinguish the following activities in the process of protecting public order:

1. Monitoring and considering the state of public order;
2. Estimates and prognosis of the state of public order;
3. Decision-making related to measures for the protection of public order and planning of such measures;
4. Preparing and organizing implementation of planned measures ;
5. Supervising, coordination and control of planned measures implementation;

[††] D. Vasiljević, Osnovi prekršajnog prava sa zaštitom javnog reda i mira (*Introduction to Offence Law and Public Order Protection*), Beograd, 1998, p.102

6. Informing, analyzing and documenting phenomena and events and measures taken.

In this paper we shall focus on police activities mentioned in items 3, 4, 5, and 6 which concern measures.

3.1. Decision-making related to measures for protection of public order and planning of such measures

All measures taken by police in order to secure public order may be either preventive or repressive.

Preventive measures are aimed at preventing certain manifestations and events that jeopardize security. They are regarded to be primary measures because the basic goal in all security activities, including public order, is to prevent manifestations and events that present security threats.

Preventive police measures are manifest in constabulary and patrol activities, permanent duty activities, traffic regulation and control, operative monitoring of persons presenting security threats with respect to public order (multiple recidivists, alcoholics, mentally deranged persons, etc.), operative monitoring of facilities and places most frequently related to violations of public order (catering facilities, railway stations, bus terminals, crowded streets and squares, public transportation means, etc.), initiating independent or joint activities with other authorities and institutions (inspection organizations, institutions of culture and education, health institutions, etc.) whose activities, beside the primary function, also has preventive role with respect to maintaining stability in the sphere of public order.

Repressive measures primarily comprise efficient prosecution of perpetrators of criminal acts and offences against the public order as well as adequate policy of sanctioning by relevant authorities in proceedings instituted for both summary and indictable offences. The repressive measures include performing special operations in a specific time and a specific place (police raids, blockings, stepped-up surveillance of persons and facilities, etc.)

Decision-making related to the type and scope of measures to be taken will depend on the results of monitoring, evaluation and prognosis of further developments regarding security issues in the sphere of public order. A decision to take measures in order to protect public order specifies the types and scopes of measures to be taken. It is upon the senior officer in charge to choose which types of measures are to be taken, what their scope is to be and what intensity is to be applied. For instance, urban environments will call for 24/7 foot and patrol beats, occasionally combined with patrolling in keeping with security estimates. Certain endangered facilities may also call for a raid or stepped-up control of persons at some point in time.

On the other hand, patrolling as a rule will be planned in rural areas, but permanent or temporary beat sectors can also be defined on the basis of security estimates.

A decision principally defines the measures that will be taken, their scope and intensity, which depend on the state of security in a specified area. The decision must be subject to changes in keeping with the state of security. However, frequent changes and extensions are not good because they may indicate certain flaws in monitoring and evaluating the state.

Based on the decision on the type and scope of envisaged measures in a certain area, the plan for their implementation is drawn. The plan of measures presents the implementation of the decision and its practical implementation. The plan refers to the area, time, forces and means to be engaged in the activities of protecting public order.

Depending on the security issues and other relevant factors, long-term plans can be made for beat and patrol activities, operative surveillance of certain categories of persons and facilities, whereas certain, mostly repressive measures, are planned depending on the trends and developments of security issues for shorter periods of time, on a weekly or monthly basis.

The plan of measures is subject to changes depending on the development of security situation.

3.2. Preparing and organizing implementation of planned measures

Implementation of the planned measures calls for thorough preparation which includes both preparation of the manpower to be engaged and the technical means which are to be used.

The preparation of manpower includes providing timely information on the content of the planned measures, aims to be achieved and modalities in which the planned measures are to be carried out, specific tasks and deadlines for their performance, checking the competence of police officers for the efficient performance of the planned measures, the examination of their medical status, both physical and psychological, the preparation of senior officers.

The preparation of technical means comprises the checks of vehicles, equipment, arms and communications, as well as efforts to ensure that all of these are fully operational.

Following a high standard preparation for implementing the planned measures, the organization of their implementation is to be undertaken. This organization includes assigning specific tasks and jobs clearly stating the dynamics of their realization, the making of daily, weekly, and, where possible, monthly schedules for all police officers, as well as the organization of adequate dispatching of officers engaged to perform specific tasks.

3.3. Supervising, coordination and control of planned measures implementation

Supervising of police officers' activities in the realization of the planned measures is an important factor in the work officers in managerial positions. The supervision aims to ensure that the officer in charge is immediately and continuously informed of the quality and dynamics of the planned measures implementation. The supervision ensures the timely evaluation of the quality and scope of realization and allows possible correction in the plan and changes of the decision if necessary.

Supervision activities are diversified and include constant and immediate reading of reports and other documents created in the process (reports on offences and criminal acts, official notes, etc.), direct communication with law enforcement officers and exchange of spoken information, evaluation and conclusions on both regular and emergency meetings and debrief sessions, using the regular information system and realizing the plan of control activities.

Coordination in the process of realization of the planned measures focuses on harmonizing activities of different organization units or parts of the same organizational unit engaged in the performance of the task. The coordination achieves and ensures unified acting of all organizational parts in the engaged structure and rational use of forces and means with maximum of efficiency. In the process of coordination the required expert assistance is provided for the engaged forces and possible changes in activity plans are made if the need arises.

Control of the realization of planned measures is a planned activity aimed at ensuring direct insight into the quality and scope of performed tasks of each and every engaged police officer. It is performed in keeping with the set plan which defines the aim of control, the time and the person in charge. A special form of control is daily survey of reports, offence and crime records, official notes, and other documents produced in the course of routine procedures.

3.4. Informing, analyzing and documenting phenomena and events and measures taken

The realization of planned activities related to maintaining public order must be accompanied by an efficient system of informing. This system has its normative and practical framework on the level of all organizational units of the Ministry of the Interior and it is involved in all stages of the realization of planned measures.

Regarding the analysis, it is vital to ensure its objectivity, which means that all elements of the process must be critically evaluated. The evaluation must be based on accurate and factual reports and possible flaws that may be observed

must not be tolerated or passed by, but their causes should be established so as to use them for improving further activities.

The analysis comprises the quality of monitoring and defining the security situation, the quality of security evaluation, the correctness of the decision and quality of activity planning, preparatory activities, ways of organizing and implementing the planned measures, coordination, managing and functioning of the information system.

Documenting the phenomena and events and the measures taken concerning them is performed in keeping with the existing normative acts (books of regulations, guidelines, etc.). Namely, there are provisions for the ways of documenting every element of activity, the distribution of these documents and their storage.

4. Conclusion

We have briefly discussed the police measures related to public order protection. However, there are substantially more measures of the same complexity that the police are in charge of. In any case, administrative procedures must be based on and limited by law, i.e. they can be performed only in keeping with regulation, they are of authoritative character, their purpose is to implement law and they are performed in keeping with certain principles. However, they should be distinguished from those that have no explicit norms and frequently do not require such norms. Such measures are also included in police work. For example, the preparedness of necessary police force for major sports manifestations and public meetings, the contacts between police and the organizers of such events who are responsible for maintaining order at such conventions, informing citizens for better protection against criminal acts and the like. Since secrecy is a prerequisite of successful police activities, certain police measures cannot be observed at all. However, this does not mean that such measures do not have legal grounds. Legislation in some countries contains specific provisions regarding this matter, whereas statutes of some other countries are more or less indirect. The former group of laws refers to these secret measures by using terms such as “making photographs and sketches”, “analyzing audio recordings”, “technical means of secret surveillance”, “using reliable persons and informers”, which all point to secret intelligence gathering which provides police with necessary information. The essence of such secret intelligence gathering is that it cannot be observed as police activity. The latter group of countries, including ours, has statutes which contain provisions from which it can be more or less indirectly inferred that there are certain undercover police operations, not to be observed when practically used. These statutes

contain provisions referring to “means and methods”, “departing measures”, and the like. In fact, police cannot successfully perform its functions related to prevention or repression of crime unless parts of their activities remain secret.

5. References

1. D. Vasiljević (2005), *Osnovi prekršajnog prava sa zaštitom javnog reda i mira*, Viša škola unutrašnjih poslova, Beograd,
2. P. Dimitrijević (1989), *Osnovi upravnog prava*, Savremena administracija,Beograd
3. S. Miletić (1997-2000), *Policijsko pravo, I-II*, Policijska akademija, Beograd
4. D. Milkov (1983), *Pojam upravnog akta* (doktorska disertacija, neobjavljena), Novi Sad
5. S.Popović (1995), *Upravno pravo (opšti deo)*, Savremena administracija, Beograd,
6. M. Talijan (2001), *Rukovođenje unutrašnjim poslovima*, Viša škola unutrašnjih poslova, Beograd
7. Z. Tomić (1995), *Upravno pravo*, Draganić, Beograd.
8. *Ustav Republike Srbije*, (2006), Kancelarija za saradnju sa medijima Vlade Republike Srbije, Beograd
9. Zakon o državnoj upravi,(2005), *Službeni glasnik* br. 79.

РЕЗИМЕ

У овом раду пажња је посвећена појму управних мера са освртом на мере полиције и то на оне мере које полиција предузима у обављању послова заштите јавног реда и мира.

Управна мера не представља нешто што је одвојено од управног акта и управних радњи. Најчешће се она намеће управним актом, а принудно остварује вршењем управних радњи, или пак следи непосредно на основу закона. Управне мере представљају одређене активности органа државне управе које су усмерене ка циљу који треба постићи у вршењу послова и задатака из њихове надлежности, а тај циљ се остварује или доношењем управног акта, или вршењем управних радњи, а некада заједно и једним и другим. Управне мере са правног становишта треба посматрати пре свега као истовремену примену у некој конкретној ситуацији већег броја управних радњи ради постизања одређеног циља а све у складу са законом. Примена више управних радњи у склопу неке управне мере треба баш као и појединачна примена једне мере да доведе до стварног циља због којег је и предузета. При томе, појавни облик управне мере не може бити независан и

изнад правне форме, а фактички ефекат важнији од правног основа. Мере по правилу подразумевају правну активност органа управе, тј. доношење одговарајућих правних и предузимање одређених материјалних аката.

Познато је да је један од послова полиције и заштита јавног реда и мира. То подразумева организовану и континуирану активност полиције са циљем да се обезбеди стабилан јавни ред и мир, односно оптимално стање безбедности у овој области.

Укратко смо изложили мере полиције у вези са заштитом јавног реда и мира. Међутим, овако сложених мера које предузима полиција има знатно више. У сваком случају управне мере морају имати правни основ и оквир, тј. могу се предузимати само у складу са прописима, ауторитативног су карактера, служе примени права и предузимају се у складу са одређеним начелима.

SUMMARY

This paper focuses on the concept of administrative measures with special reference to the measures undertaken by the police while performing the jobs related to the protection of public order and peace.

The administrative measures do not represent something which is separate from the administrative acts and administrative actions. It is most often imposed by the administrative act and enforced by performing administrative actions, or it is pursued directly based on law. The administrative measures represent certain activities of the state administrative entities which are directed towards the goal to be achieved in performing jobs and tasks within their jurisdiction, and the goal is achieved either by the enactment of the administrative act or performing of administrative actions, sometimes by both. From the legal point of view, the administrative measures should be regarded primarily as a simultaneous application of a number of administrative actions in a specific situation in order to achieve a certain goal and all pursuant to the law. The application of several administrative actions within an administrative measure should lead to the real goal because of which it was taken in the first place in the same way as the application of an individual measure. The form of administrative measure at that cannot be independent and above the legal form, while the actual effect is more important than the legal basis. The measures as a rule imply the legal activities of the administrative entities, i.e. the enactment of the corresponding legal acts and undertaking of certain material acts.

It is well known that the police work includes the protection of public peace and order. This implies organized and continuous police activities aimed at providing stable public peace and order, i.e. the optimum condition of security in this area.

We have briefly presented the police measures related to the protection of public peace and order. However, there are many more complex measures undertaken by the police. In any case, the administrative measures must have legal basis and framework, i.e. they can be undertaken only in accordance with the regulations, they are of authoritative character, serve to apply the law and they are undertaken in accordance with certain principles.

THE ANTHROPOMORPHOLOGICAL PROFILE OF FEMALE POLICE OFFICER STUDENTS AND DIFFERENTLY TRAINED ATHLETES: A MULTICENTROID MODEL

[*]Dopsaj M.[*], Nešić G.[1], Koropanovski N.[2], Sikimić M.[1]

[1]*University of Beograd, Faculty of Sport and Physical Education, Beograd, Serbia*
[2]*Criminal Justice and Police Academy, SPE, Beograd, Serbia.*

Abstract: The aim of the study was to compare the anthropomorphological (AM) statuses of female students of the Academy of Criminalistic and Police Studies (ACP students) and female athletes with different training regimens. The task was to position the AM space of the ACP students in relation to female athletes with an extended systematic training experience. The study involved a total of 106 subjects, divided into four subsamples as follows: 25 water polo players, 34 volleyball players, 11 karateists, and 36 ACP students. The AM status was assessed according to eleven (11) variables, and the results underwent multivariate discriminant analysis. The results were used to define the model of AM characteristics of the ACP students located in relation to the athletes. Three characteristic functions of the studied space were discriminated and defined as: 1) general indicators of the body constitution; 2) general indicators of the subcutaneous fatty tissue; and 3) the indicator of the local distribution of the fatty tissue in the upper arm. The results obtained indicate that the AM status of the ACP students generally (75.0%) corresponds to the profiled project standards of the effects of Special Physical Education. However, it should be pointed out that as many as 9 (25.0%) of the ACP students belonged to the water polo player model, i.e. the group with most pronounced characteristics of body fat, while the total of mere 6 (4+2; 16.7%) belonged to the volleyball player and karateist model, i.e., the group with the professionally most desirable anthropomorphological characteristics.

Key words: Anthropomorphological status ACP students, female athletes, centroids

1. Introduction

In a wider context, Special Physical Education (SPE) is an academic subject which deals with the issues of general, streamed, and specific professional competence, as well as with anthropomorphological characteristics and physical ability of the employees of the Ministry of the Internal Affairs. With regard to its importance and scope, the effects of SPE are defined as: affirmative and

[*] Corresponding author e-mail milivoj@EUnet.rs

preventive influence on the health status of the police force; affirmative influence on the development of the required professional characteristics of the police force; the development and maintenance of the morphological status of the given population; and the adjustment of the level of motoric skills to individual characteristics as depending on the nature of work (Blagojević et al., 2008, pp. 1-9).

The anthropomorphological space assumes the study of bodily characteristics which define the shape and composition of the human body, as well as the study of basic dimensions which describe a given shape or composition (Wiener & Lourie, 1981; Howley & Don Franks, 1997; Blagojević et al., 2008, pp. 181-185).

There is a growing scientific evidence that people who are over- or under-weight (with a certain level of obesity or asthenia, i.e. emaciation, respectively) do not only have a reduced working capacity, but they can also show a statistically significant decrease in psychological abilities (reduced concentration, attention, stress tolerance, etc.) or a decline in their health status (problems with endocrine, metabolic, haematological, gastrointestinal or cardiovascular systems, or locomotoric and physical malfunction, etc.) (Hulens et a., 2001; Wendel-Vos et al., 2004; Rezaeian et al., 2006; Anderssen et al., 2008; Booth et al., 2008).

Every police force in economically and socially developed countries ensures high performance quality of their staff by employing precisely defined models of selection of male and female candidates, including strict criteria in the bodily characteristics, i.e. the anthropomorphological status. Additionally, there are elaborate systems of control over these characteristics throughout a police officer's working life (Lord, 1998; Sorensen et al., 2000; Australian Federal Police, 2004). This has been enabled by the development of the working technology aided by the results of scientific research (Bonneau & Brown, 1995; The Cooper Insitute, 2002; Booth et al., 2008; Boyce et al., 2008; Malavolti et al., 2008).

The aim of this study was to compare the anthropomorphological (AM) statuses of female students of the Academy of Criminalistic and Police Studies (ACP students) and female athletes at different training levels. So far such comparative analyses have been done with the male population in relation to certain motoric abilities (Blagojević, 2003; Koropanovski i Janković, 2007; Vučković i Koropanovski, 2007), while the adequate research of the female population is still lacking. The theoretical underpinnings of the study were set with relation to the fact that both female students and athletes undergo a regimen of regular physical exercise. Every training session has got a specific influence on the adaptability of the human body, while the dominant effect of a particular training will depend on what it is aimed at. The theory and practice of training has established that the level of the required physical fitness, along with adequately developed general and specific physical abilities, does not only depend on the actual morphological status but it also necessitates the optimization of the bodily status (Kostić et al., 2006; Jukić et al., 2007;

Malavolti et al., 2008; Marrin & Bampouras, 2008; Kostić et al., 2009). Within the context of the requirements of police work, this means that the professional performance of a person lacking in adequate AM (bodily) characteristics will not meet the required efficiency standards (Bonneau & Brown, 1995; Howley et al., 1997; Sorensen et al., 2001; Hulens et al., 2001; The Cooper Institute, 2002; Australian Federal Police, 2004; Anderssen et al., 2008; Booth et al., 2008; Boyce et al., 2008).

The task of this study was to identify the AM space in which female ACP students could be related to female athletes with extended systematic training of varying profiles that would have subsequent influence on the space under consideration. Thus, the ACP students' status would be defined, and an actual model showing the multivariate relations between the studied populations could be set in order to enable the utilization of the AM variable.

2. Methods

The basic method used in this study relies on laboratory measurements. The anthropomorphological variables were measured in accordance with the standard of the International Biological Program (Weiner & Lourie, 1981).

The sample

The total sample included 106 women subjects, who were divided into four subsamples as follows: 25 water polo players of the senior Serbian national team, aged 20.6±3.1 years; 34 volleyball players from the 1st Serbian League VC "Radnički-Jugopetrol", aged 19.8±3.2 years; 11 karateists of the Serbian national team, aged 21.3±3.4 years; and 36 ACP students of the 2nd and 3rd academic year 2005/2006, aged 20.8±0.8 years.

The subsample of water polo players was composed of competitors in games where mixed (aerobic-anaerobic) effort is dominant, with an emphasis on endurance in strength (Marrin & Bampouras, 2008). The subsample of volleyball players consisted of competitors in games where aerobic effort is dominant, combined with anaerobic alactate effort and pronounced speed and explosion strength in longer intervals of over 30 minutes (Nešić, 2008; Rajić et al., 2008). The karateists competed in an individual sport – in fighting, where the effort is also dominantly aerobic in combination with anaerobic alactate efforts and pronounced speed and explosion strength in short intervals of up to 3 minutes (Koropanovski et al., 2008). The athletes were chosen with regard to the level of fitness and the AM status which corresponds to the theoretical projection model of

the effects of SPE and to the physical abilities and body composition of ACP students.

Sampling the variables

The study used a set of eleven (11) variables with which the AM status of the subjects was assessed, as follows:

- Three basic variables to assess the AM status according to body composition –
  - Body weight – BW, expressed in kg,
  - Body height – BH, expressed in cm,
  - Body-Mass index – BMI, expressed in kg/m^2.
- Four variables to assess the AM status according to fatty tissue –
  - Skinfold of the upper arm, i.e. triceps skinfold – $SF_{TRICEPS}$, expressed in mm,
  - Skinfold of the hip, i.e. suprailiac skinfold – $SF_{SUPRAILIA}$, expressed in mm,
  - Skinfold of the upper leg, i.e. thigh skinfold – SF_{THIGH}, expressed in mm,
  - Total of three skinfolds – SF_{TOTAL}, expressed in mm.
- Four variables to assess the AM status according to body composition –
  - Percentage of fatty tissue – $FAT_{\%}$, expressed in %,
  - Lean body mass – LBM, expressed in kg,
  - Fatty tissue mass – FAT_{ABS}, expressed in kg,
  - Index for assessing the ratio between lean and fatty tissue mass – LBM/FAT_{ABS}, expressed in kg.

3. Method of measurement

The measurements of the ACP students were taken during the academic year of 2005/2006 in the SPE laboratory for assessing basic motoric status. The measurements of the water polo players, volleyball players and karateists were taken during the years of 2007 and 2008, using the same measuring instruments and procedures and performed by the same measurer.

Body weight was measured by the electronic scales with an anthropometer SECA – Cas (Germany) with the measurement precision MP of 0.05 kg, while that of the BH was 0.001 m (Dopsaj et al., 2006). Skinfolds were measured by The Body Caliper™ (The Caliper Co., Inc., NV, USA) with the measurement precision of 0.001 m.

The percentage of the fatty tissue ($FAT_{\%}$), the lean body mass (LBM), and the absolute value of the fatty tissue mass (FAT_{ABS}) were calculated using a standard procedure of validated mathematical models (Howley & Don Franks, 1997, pp. 121-122).

The index for assessing the ratio between lean and fatty tissue mass (LBM/FAT_{ABS}) was calculated as the value of the quotient of the lean body mass and the absolute value of the fatty tissue mass.

4. Statistical analysis

The raw data first yielded two basic statistical indicators: the central tendency measure (the mean value – MEAN), and the dispersion measure (the standard deviation – SD). Next, multivariate statistical techniques were applied: multivariate data analysis (MDA), which established the differences between the subsamples studied, at both general and partial levels; and canonical discriminant analysis, which established the structure and the set of the variables responsible for the differences in the AM space between the subsamples under study (Hair et al., 1998). All statistical analyses were done by the software packages of Microsoft Office Excel 2003 (Copyright © 1985 – 2003 Microsoft Corporation) and SPSS for Windows Release 10.0.1 (SPSS Inc., 1989-1999).

5. The results

The result of the Box's M test for homogeneity of covariance matrices showed that there was a high statistical agreement among the subsamples in the studied AM space at the levels of Box's M = 530.99, F = 3.05, p sig. = 0.000, so that the raw results can be claimed to be suitable for the application in multivariant analysis, that is, the results obtained in the study can be treated as scientifically valid.

Table 1 shows the basic descriptive statistics in the function of the subsamples with the established statistical differences between the ACP students (as the target, or criterion group) and the remaining three subsamples (as control project population).

Table 2 shows the general and partial MDA results, which can indicate to the existence of a general statistically significant difference among the groups with regard to the AM space, at the level of Wilks' Lambda of 0.258, F values = 6.019, and p = 0.000. The partial difference was established at seven variables: BW, BH, $SF_{SUPRAILIA}$, SF_{TOTAL}, $FAT_{\%}$, LBM, and LBM/FAT_{ABS}.

Table 1- Basic descriptive statistics in the function of the subsamples

	Water polo pls (N=25)	Volleyball pls (N=34)	Karateists (N=11)	ACP students (N=36)
BW	61.67±6.75	69.82±6.68***	59.73±4.31	60.82±6.95
BH	169.57±6.15	180.79±4.04***	168.59±4.25	169.14±4.50
BMI	21.48±2.41	21.34±1.70	21.02±1.43	21.25±2.22
$SF_{TRICEPS}$	13.37±2.91	13.22±3.03	12.14±4.62	14.44±3.46
$SF_{SUPRAILIA}$	12.92±5.02	9.27±3.09*	7.29±3.90♦♦	11.19±4.68
SF_{THIGH}	21.17±4.53	19.18±4.25	18.50±4.40	21.19±4.99
SF_{TOTAL}	47.46±10.20	41.67±8.09*	37.93±9.64♦♦	46.82±9.97
$FAT_{\%}$	19.26±3.43	17.22±2.85*	15.96±3.42♦♦	19.05±3.44
LBM	49.71±5.04	57.70±4.72**	50.14±3.47	49.08±4.37
FAT_{ABS}	11.96±2.93	12.12±2.74***	9.59±2.38♦♦	11.74±3.22
LBM/FAT_{ABS}	4.356±0.979	4.972±1.030*	5.575±1.661♦	4.433±1.085

ACP vs Volleyball players: $p \geq 0.05$*, $p \geq 0.01$**, $p \geq 0.001$***

ACP vs Karateists: $p \geq 0.05$♦, $p \geq 0.01$♦♦, $p \geq 0.001$♦♦♦

Table 3 shows the results of the structure matrix of discriminant functions of the defined discriminant model. Table 4 shows the results of the centroids calculated with regard to the discriminant functions, while Table 5 shows the prediction of grouping the subjects according to the defined structure matrix of the obtained discriminant model.

Table 2 - General and partial MDA results

Multivariate Tests[c]						
Effect		Value	F	Hypothesis df	Error df	Sig.
Sport	Wilks' Lambda	0.258	6.019	27.00	275.17	0.000
c. Design: Intercept + Sport						
Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sport	BW	1848.91	3	616.30	14.15	0.000
	BH	3109.04	3	1036.35	45.26	0.000
	BMI	1.79	3	0.60	0.143	0.934
	$SF_{TRICEPS}$	55.26	3	18.42	1.65	0.183
	$SF_{SUPRAILIA}$	327.65	3	109.22	6.05	0.001
	SF_{THIGH}	125.85	3	41.95	1.99	0.120
	SF_{TOTAL}	1160.21	3	386.74	4.35	0.006
	$FAT_{\%}$	141.77	3	47.26	4.46	0.006
	LBM	1579.35	3	526.45	25.16	0.000
	FAT_{ABS}	56.92	3	18.97	2.21	0.091
	LBM/FAT_{ABS}	16.43	3	5.48	4.41	0.006

Table 3 - The results of the structure matrix of discriminant functions

Summary of Canonical Discriminant Functions - Structure Matrix			
	Function		
	1	*2*	*3*
BH	**.844***	-.066	-.139
LBM	**.629***	.083	.122
BW	**.470***	-.134	-.038
$SF_{SUPRAILIA}$	-.152	**-.718***	.051
LBM/FAT_{ABS}	.121	**.594***	.373
SF_{TOTAL}	-.148	**-.551***	-.332
$FAT_{\%}$	-.153	**-.551***	-.338
FAT_{ABS}	.077	**-.431***	-.277
SF_{THIGH}	-.121	**-.319***	-.251
BMI	.010	**-.120***	.064
$SF_{TRICEPS}$	-.056	-.204	**-.655***
* Largest absolute correlation between each variable and any discriminant function			

Table 4 - Group centroid values with regard to discriminant functions

Sport	**Functions**		
	1	***2***	***3***
Water polo pls	-.820	-.571	.334
Volleyball pls	1.947	.014	-.017
Karateists	-.917	1.295	.326
ACP students	-.989	-.012	-.315

Unstandardized canonical discriminant functions evaluated at group means

Table 5 - The results of the predicted group membership model with regard to discriminant functions

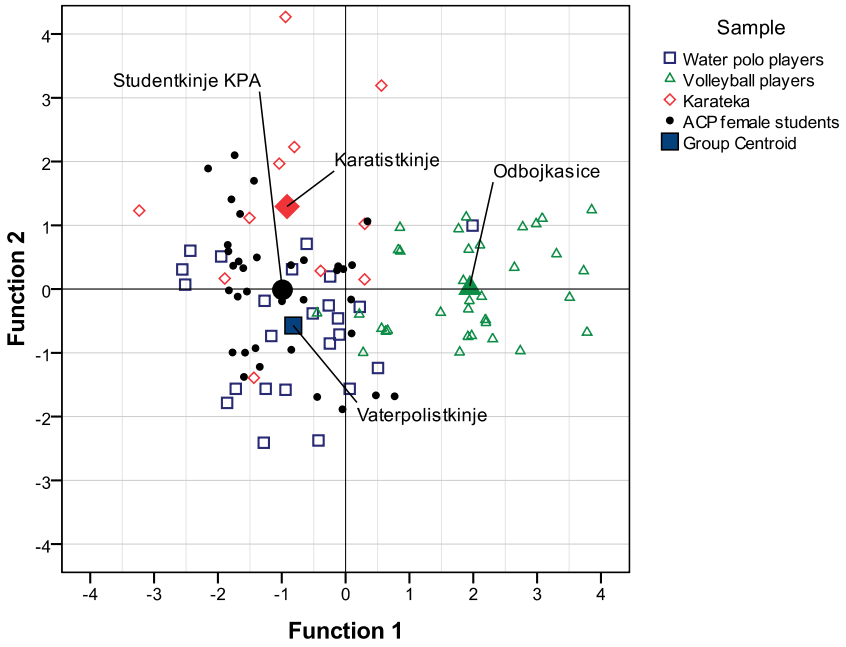
Classification Results[b]							
		Sport	Predicted Group Membership				Total
			Water polo pls	Volleyball pls	Karateists	ACP students	
Cross-validated[a]	Count	Water polo pls	11	2	0	12	25
		Volleyball pls	3	29	0	2	34
		Karateists	1	0	3	7	11
		ACP students	9	4	2	21	36
	%	Water polo pls	***44.0***	*8.0*	*.0*	*48.0*	*100*
		Volleyball pls	*8.8*	***85.3***	*.0*	*5.9*	*100*
		Karateists	*9.1*	*.0*	***27.3***	*63.6*	*100*
		ACP students	*25.0*	*11.1*	*5.6*	***58.3***	*100*

a. Cross validation was done only for those cases in the analysis. In cross validation, each case was classified by the

functions derived from all cases other than that case.
b. 60.4% of cross-validated grouped cases was correctly classified.

Graph 1 charts the two-dimensional group centroid positioning with regard to the first two defined canonical discriminant functions.

Graph 1 - Centroid positioning with regard to the first two defined canonical discriminant functions



6. Discussion

One of the educational tasks at Academy of Criminalistic and Police Studies in Beograd is to develop the AM status of the students at the level required by their subsequent professional service, which is achieved through the effects of Special Physical Education. In addition to this, methodological aspects of projecting specialized educational systems, one of which is that of ACPS, model the aims and tasks of the curriculum upon the projected professional profiles to be attained by the students (The Cooper Institute, 2002; Dopsaj et al.,

2006; Dopsaj et al., 2007; Koropanovski & Janković, 2007; Vučković & Koropanovski, 2007; Malavolti et al., 2008; Janković et al., 2008). In this study we defined the multidimensional AM status model for 2nd- and 3rd-year ACP students with regard to trained competitor female athletes from the sports whose physical ability criteria correspond to the desired professional profile of future female police officers (Bonneau & Brown, 1995; Australian Federal Police, 2004).

The results indicated that the measured spatial structure consisted of three independent factors set up by the following variables (Table 3):

1. Body height (BH=0.844), lean body mass (LBM=0.629) and body weight (BW= 0.470);
2. Suprailiac skinfold ($SF_{SUPRAILIA}$= -0.718), the index for assessing the ratio between lean and fatty tissue mass (LBW/FAT_{APS}=0.594), the total of the three skinfolds (SF_{TOTAL}= -0.551), the percentage of the fatty tissue ($FAT_{\%}$= -0.551), etc.;
3. Triceps skinfold ($SF_{TRICEPS}$= -0.655).

The first function was saturated by the indicators of body height and body weight (as total and lean), that is, by those variables that are the simplest to define the body constitution. The second function was saturated by the variables which are used to assess the quantity of subcutaneous fatty tissue of the whole body (the trunk, the thigh, the total, the ratio between fat and other, mostly muscle, tissues, etc.). The third function was saturated by only one variable, which assesses the subcutaneous fatty tissue in the upper arm, i.e. locally distributed upper arm fat.

The results of the sample showed that only the first two functions yielded a statistically significant interpretation of the overall variability of the space studied (First function: Eigenvalue = 1.846, % of the interpreted variance = 84.8%, Canonical Correlation = 0.807; Second function: Eigenvalue = 0.261, % of the interpreted variance = 11.9%, Canonical Correlation = 0.455), while the third factor had no statistical significance (Third function: Eigenvalue = 0.074, % of the interpreted variance = 3.4%, Canonical Correlation = 0.262).

Regarding the first discriminant function, the sample of the ACP students did not differ from the karateists or water polo players, but it varied from the volleyball players. In other words, with respect to the first function of body constitution, karateists, water polo players and ACP students made up a homogenous group (multiple Z score was at respective levels of -0.917, -0.820 and -0.989, while with karateists it was 1.947; Table 4, Graph 1). Such scores are quite logical, since the very nature of the volleyball game requires players of the above-average height, while its motoric structure involves very fast and explosive movements (Nešić, 2008; Rajić et al., 2008). On an average, the volleyball players

from our sample were 10 to 11 cm taller than the rest of the subjects, and also their body weight exceeded the other women's by 7 to 8 kg (LBM represents the equivalent to the muscle mass), simultaneously with a significantly lower percent of fatty tissue. Such characteristics of the studied space located the volleyball players toward the higher quality values of the first function for approximately 2.85 of the Z score in comparison with the remaining three subsamples.

The percentage levels of fatty tissue in highly fit women ranges between 12 and 22%, while the standards in developed western countries consider the percentage of fat in policewomen higher than 23% as a factor of aggravated health and professional work (Australian Federal Police, 2004; Blagojević et al., 2008, p. 185). The fatty tissue percentage in the studied sample of the ACP students was at the level of 19.05±3.44, i.e., at 95% probability ranging from 15.61 to 22.49% (Table 1). This shows that the students tested had a body fat component within the defined health, physical and professional standards. Their average BMI was 21.25 kg/m^2, which the existing standards consider as the distribution level between 47 and 48 ‰ (percentile), that is, as average (normal) values for the ACP student population (Dopsaj i sar., 2006).

The results of the second discriminant function showed that the rates of fatty tissue from the hip, the ratio between the muscle and fatty tissue, the skinfold total, and the percentage of the fatty tissue were the variables which interpreted and discriminated between the given subsamples in a statistically significant manner ($SF_{SUPRAILIA}$, LBM/FAT_{ABS}, SF_{TOTAL} and $FAT_{\%}$, respectively – Table 3). With respect to the second function, i.e. the quantity of the fatty tissue in the body generally, water polo players can be claimed to constitute a discriminant group with the highest indicators of bodily fat (multiple Z score was at the level of -0.571); volleyball players and ACP students constituted another group characterized by average indicators of body fat in comparison with the overall sample (multiple Z score was at the levels of -0.012 and 0.014, respectively); finally, the subsample of karateists belonged to a group with the least indicators of body fat (multiple Z score was at the level of 1.295) (Table 4, Graph 1).

The third discriminant function did not yield differences among the subsamples to be elaborated on; however, in this function the ACP students had the highest levels of subcutaneous fatty tissue in the triceps, i.e., of the fatty tissue locally located in the upper arm.

The results of the predicted group (subsample) membership redefined according to the obtained model discriminant functions showed that the anthropomorphological characteristics of the 36 tested ACP students were distributed as follows: 9 (25.0 %) belonged to the water polo player model (had a high % of body fat component); 4 (11.0%) belonged to the volleyball player model (pronounced BH and lean muscle mass); only 2 (5.6 %) belonged to the karateist model (below-average body fat levels with above-average lean muscle mass and average body height and weight) (Table 5).

7. The conclusion

Generally, the results obtained were used to define a characteristic AM model for ACP students with respect to three groups of athletes competing in different sports. The given model yielded three discriminant functions characteristic of the measured space, defined as: 1) general indicators of body constitution; 2) indicators of subcutaneous body fat rates at the general body level; and 3) the indicator of local distribution of the fatty tissue in the upper arm. However, statistically significant distinction was found only in the first two functions.

With respect to the first discriminant function, the ACP students did not differ from karateists or water polo players, but were different from volleyball players (regarding body constitution, karateists, water polo players, and ACP students made up a homogeneous group: multiple Z score was at respective levels of -0.917, -0.820 and -0.989, while with karateists it was 1.947; Table 4, Graph 1).

With respect to the second discriminant function, the results showed that $SF_{SUPRAILIA}$, LBM/FAT_{ABS}, SF_{TOTAL} and $FAT_{\%}$, as indicators of fatty tissue rates at the general body level water polo players were discriminated as a separate group with the highest rates of body fat (multiple Z score was at the level of -0.571); volleyball players and ACP students constituted another group characterized by average indicators of body fat in comparison with the overall sample (multiple Z score was at the levels of -0.012 and 0.014, respectively); finally, the subsample of karateists belonged to a group with the least indicators of body fat (multiple Z score was at the level of 1.295).

The results indicate that the AM status of the ACP students in the study was generally in accordance with the profiled project standards of Special Physical Education and the normative criteria for the enrollment in Academy of Criminalistic and Police Studies. However, it should be noted that as many as 9 (25.0%) of the ACP students belonged to the water polo player model, i.e., to the group characterized by the highest rates of body fat (Marrin & Bampouras, 2008), while a total of only 6 (4+2; 16.7%) belonged to the group of volleyball players and karateists, i.e., to the group with professionally most desirable anthropomorphological characteristics.

8. References

1. Anderssen, S.A., Engeland, A., Sogaard, A.J., Nystad, W., Graff-Iversen, S., Holme, I. (2008). Changes in physical avtivity behavior and the development of body mass index during the last 30 years in Norway, *Scandinavian Journal of Medicine & Science in Sports*, 18: 309-317.
2. Australian Federal Police, (2004). Minimum Standards of Physical Fitness Physical Competency Assessment, http://www.afp.gov.au/afp/page/ (23.11.2004).
3. Blagojević, M., Dopsaj, M., Vučković, G. (2008). *Specijalno fizičko obrazovanje I – za studente Policijske akademije (drugo izdanje)*, Policijska akademija, Beograd.
4. Blagojević, M. (2003). *Uticaj nastave Specijalnog fizičkog obrazovanja na promene morfoloških i motoričkih karakteristika studenata Policijske akademije*, Ministarstvo za Nauku i tehnologiju R Srbije, Beograd.
5. Bonneau, J., Brown, J. (1995). Physical ability, fitness and police work, *Journal of Clinical Forensic Medicine*, 2: 157-164.
6. Booth, F., Laye, M., Lees, S., Scott Rector, R., Thyfault, J. (2008). Reduced physical activity and risk of chronic disease: the biology behind the consequences, *European Journal of Applied Physiology*, 102: 381-390.
7. Boyce, R., Jones, G., Lloyd, C., Boone, E. (2008). A longitudinal observation of police: Body composition changes over 12 years with gender and race comparisons, *Journal of Exercise Physiology (online)*, 11(6): 1-13.
8. Dopsaj, M., Vučković, G., Blagojević, M. (2007). Normativno-selekcioni kriterijum za procenu bazično motoričkog statusa kandidata za prijem na studije Kriminalističko-policijske akademije u Beogradu, *Bezbednost*, Beograd, 49(4): 166-183.
9. Dopsaj, M., Koropanovski, N., Vučković, G., Blagojević, M., Marinković, B., Miljuš, D. (2007). Maximal isometric hand grip force in well-trained university students in Serbia: Descriptive, functional and sexual dimorphic model, *Serbian Journal of Sports Sciences*, 1(1-4): 139-148.
10. Dopsaj, M., Milošević, M., Vučković, G., Blagojević, M., Mudrić, R. (2006). Klasifikacioni kriterijumi za procenu Indeksa mase tela kod studentkinja Kriminalističko-policijske akademije, *Sportska Medicina*, 6(4): 100-110.
11. Hair J, Anderson R, Tatham R, Black W (1998). *Multivariate Data Analysis (Fifth Ed.)*, Prentice Hall, Inc., U.S.A.
12. Howley, E., Don Franks, B. (1997). *Health Fitness Instructor's Handbook (3rd Ed.)*, Champaign, IL: Human Kinetics.
13. Hulens, M., Vansant, G., Lysens, R., Classens, A.L., Muls, E. (2001). Exercise capacity in lean versus obese women, *Scandinavian Journal of Medicine & Science in Sports*, 11:305-309.

14. Janković, R., Koropanovski, N., Vučković, G., Dimitrijević, R., Atanasov, D., Miljuš, D., Marinković, B., Ivanović, J., Blagojević, M., Dopsaj, M. (2008). Trend promene osnovnih antropometrijskih karakteristika studenata kriminalističko-policijske akademije u toku studija, *Nauka-Bezbednost-Policija*, 13(2): 137–152.
15. Jukić, I., Milanović, D., Marković, G., Milanović, L., Šimek, S., Gregov, C. (2007). Scientific and practical approach to physical conditioning of athletes, *Serbian Journal of Sports Sciences*, 1(1-4): 117 – 121.
16. Koropanovski, N., Jovanovic, S., Dopsaj, M. (2008). Characteristics of pointing actions of top level female competitors in karate, O'Donoghue, P. & Hökelmann, A. (Eds.) *Book of Abstracts World Congress of Performance Analysis in Sport VIII* (p. 69). Otto-von-Guericke-Universität Magdeburg Department of Sports Science: Stielzik Druck.
17. Koropanovski, N., Janković, R. (2007). Razlike između motoričkih sposobnosti studenata kriminalističko-policijske akademije iz Beograda i dobro treniranih osoba, *Sports Mont*, 12-14: 738-743.
18. Kostić, R., Đurašković, R., Pantelić, S., Živković, D., Uzunović, S., Živković, M. (2009). The relations between anthropometric characteristics and coordination skills, *FACTA Universitatis: Series: Physical Education and Sport*, 7(1): 101 – 112.
19. Kostić, R., Đurašković, R., Miletić, Đ., Mikalački, M. (2006). Changes in the cardiovascular fitness and body composition of women under the influence of the aerobic dance, *FACTA Universitatis: Series: Physical Education and Sport*, 4(1): 59 – 71.
20. Lord, V. (1998). Swedish police selection and training: issues from a comparative perspective, *Policing: An International Journal of Police Strategies & Management*, 21(2): 280-292.
21. Malavolti, M., Battistini, N., Dugoni, M., Bagni, B., Bagni, I., Pietrobelli, A. (2008). Effect of intense military training on body composition, *Journal of Strength and Conditioning Research*, 22(2): 503-508.
22. Marrin, K., Bampouras, T. (2008). Anthropometrical and physiological changes in elite female water polo players during a training year, *Serbian Journal of Sports Sciences*, 2(1-4): 75 – 83.
23. Nešić, G. (2008). Struktura takmičarske aktivnosti odbojkašica, *Godišnjak Fakulteta za sport i fizičko vaspitanje Univerziteta u Beogradu*, 14: 89-112.
24. Rajić, B., Dopsaj, M., Pablos Abella, C. (2008). Basic and specific parameters of the explosive force of leg extensors in high trained Serbian female volleyball players: Characteristics of the isometric force-time curve model, *Serbian Journal of Sports Sciences*, 2(4): 131-139.
25. Rezaeian, Z., Torkaman, G., Nad.ali, F., Ravanbod, R., Pourfathollah, A.A., Goushen, B., Nejatian, M., Broumand, M.A. (2006). Effect of physical fitness

on the coagulant activity of healthy young men, *Pakistanian Journal of Biological Sciences*, 9(11): 2032-2039.
26. Sorensen, L., Smolander, J., Louhevaara, V., Korhonene, O., Oja, P. (2000). Physical activity, fitness and body composition of Finnish police officers: a 15-year follow-up study, *Occupational Medicine*, 50(1): 3-10.
27. The Cooper Institute (2002). Common questions regarding physical fitness tests, standards and programs for public safety, *The Cooper Institute for Aerobic Research, Physical Fitness Specialist Course and Certification*, Dallas, Texas, USA.
28. Vučković, G., Koropanovski, N. (2007). Razlike između motoričkih sposobnosti studenata kriminalističko-policijske akademije iz Beograda i kategorisanih sportista - karatista, *Sports Mont*, 12-14: 235-242.
29. Weiner, S., & Lourie, A. (1981). *Practical Human Biology*, New York: Academic Press.
30. Wendel-Vos, G.C.V., Schult, A.J., Feskens, E.J.M., Boshultzen, H.C., Verschuren, W.M.M., Sarls, W.H.M., Kromhoult, D. (2004). Physical activity and stroke. A meta-analysis of observational data, *International Journal of Epidemiology*, 33: 787-798.

REZIME

U širem kontekstu, Specijalno fizičko obrazovanje (SFO) se kao nastavna disciplina bavi i izučava problematiku opšte, usmerene i specifične profesionalno-radne pripremljenosti, antropo-morfološkim karakteristikama i fizičkim sposobnosima pripadnika Ministarstva unutrašnjih poslova. U odnosu na značaj i predmet SFO njegov uticaj je definisan i u odnosu na pozitivno i preventivno delovanje na zdravstveni status pripadnika službe, pozitivno delovanje na razvoj potrebnih profesionalnih karakteristika pripadnika službe, razvoj i održavanje morfološkog statusa date populacije, kao i usklađivanje nivoa motoričkih sposobnosti sa individualnim karakteristikama pojedinaca u funkciji zahteva posla.

U ovom radu predstavljeno je istraživanje čiji je cilj bio da uporedi antropo-morfološkog status (A-M) studentkinja KPA i populacije različito treniranih sportistkinja, a zadatak da se u A-M prostoru lociraju studentkinje KPA u odnosu na sportistkinje koje sistematski višegodišnje treniraju. Do sada je takva vrsta uporednih analiza realizovana u odnosu na populaciju muškaraca i to sa aspekta određenih motoričkih sposobnosti, ali adekvatna istraživanja kod populacije devojaka još uvek nisu rađena. U istraživanju prikazanom u ovom radu učestvovalo je ukupno 106 ispitanica, podeljenih na četiri subuzorka i to: 25 vaterpolistkinja, 34 odbojkašica, 11 karatistkinja i 36 studentkinja KPA. Upotrebljen skup od jedanaest (11) varijabli kojima je procenjen A-M status. Rezultati su analizirani

primenom multiple diskriminantne analize. Na osnovu dobijenih rezultata definisan je model antropo-morfoloških karakteristika studentkinja KPA koji je lociran u odnosu na sportistkinje. Izdvojene su tri karakteristične funkcije merenog prostora definisane kao: 1). opšti pokazatelji konstitucije tela, 2). pokazatelji količine potkožnog masnog tkiva na generalnom telesnom nivou, i 3). pokazatelj lokalne distribuiranosti masnog tkiva nadlakta – ruke. Dobijeni rezultati ukazuju da je A-M status ispitivanih studentkinja KPA, generalno u skladu sa profilisanim projektnim standardima efekata nastave SFO. Međutim, mora se naglasiti da čak 9 (25.0%) studentkinja KPA, ipak, pripadaju modelu vaterpolistkinja, odnosno grupi sa najizraženijim karakteristikama masne telesne komponente, dok ukupno samo 6 (4+2; 16.7%) pripadaju grupi odbojkašica i karatistkinja, odnosno grupi sa profesionalno najpoželjnijim antropo-morfološkim karakteristikama.

SUMMARY

In a wider context, Special Physical Education (SPE) is an academic subject which deals with the issues of general, streamed, and specific professional competence, as well as with anthropomorphological characteristics and physical ability of the employees of the Ministry of the Internal Affairs. With regard to its importance and scope, the effects of SPE are defined as: affirmative and preventive influence on the health status of the police force; affirmative influence on the development of the required professional characteristics of the police force; the development and maintenance of the morphological status of the given population; and the adjustment of the level of motoric skills to individual characteristics as depending on the nature of work.

This paper presents the study the aim of which was to compare the anthropomorphological (AM) statuses of female students of the Academy of Criminalistic and Police Studies (ACP students) and female athletes with different training regimens, while the task of the study was to position the AM space of the ACP students in relation to female athletes with an extended systematic training experience. So far such comparative analyses have been done with the male population in relation to certain motoric abilities, while the adequate research of the female population is still lacking. The study presented in this paper involved a total of 106 subjects, divided into four subsamples as follows: 25 water polo players, 34 volleyball players, 11 karateists, and 36 ACP students. The AM status was assessed according to eleven (11) variables, and the results underwent multivariate discriminant analysis. The results were used to define the model of AM characteristics of the ACP students located in relation to the athletes. Three characteristic functions of the studied space were discriminated and defined as: 1)

general indicators of the body constitution; 2) general indicators of the subcutaneous fatty tissue; and 3) the indicator of the local distribution of the fatty tissue in the upper arm. The results obtained indicate that the AM status of the ACP students generally (75.0%) corresponds to the profiled project standards of the effects of Special Physical Education. However, it should be pointed out that as many as 9 (25.0%) of the ACP students belonged to the water polo player model, i.e. the group with most pronounced characteristics of body fat, while the total of mere 6 (4+2; 16.7%) belonged to the volleyball player and karateist model, i.e., the group with the professionally most desirable anthropomorphological characteristics.

CLANDESTINE DRUG LABS: POLICE OPERATIVE PROTOCOL FOR THEIR DEACTIVATION AND INVESTIGATION

[*]Hadžić P.[1], Zorić V.[*2]

[1]*Gosa Institute, Belgrade, Milana Rakića 35, Serbia*
[2]*National criminality-technical center, Ministry of the Interior, Belgrade, Serbia*

Abstract: In recent years the Republic of Serbia is not only the territory for transportation of natural and synthetic drugs, but it has become a country where synthetic drugs are fabricated in illicit labs. Such a development must be confronted with the response of organized anti drug forces. The response is adequate action of police forces. Police action is based on the initial investigation of the type of an illicit lab, its production and drug distribution pattern and according to preplanned protocol which enables maximal efficiency of police action. Police forces that deal with illegal drug labs should be mobile and have highly trained officers.
In this paper, the suitable protocol of police forces action and some elements that provide for the efficient final result are discussed in accordance with contemporary experience in the field.

Key words: illicit labs, synthetic drugs, criminalistic investigation, drug sampling

1. Introduction

The Republic of Serbia is settled at the main crossroads of transit routes for drug smuggling. In recent years, the new smuggling roads have been developed: the cocaine from the South America, through Spain, Italy or Greece, is delivered to the Albanian or Montenegrin ports, while the synthetic drugs of the west European origin are transported in the opposite direction or exchanged for drugs of natural origin.

However, it is not a curiosity now to find that synthetic drugs (mainly amphetamines) are manufactured at the Serbian soil. The fact that synthetic drugs are being synthesized in Serbia is confirmed by few seizures in recent years; at least one of seized illegal laboratory was so called mega-laboratory.

[*] Corresponding author phadzic@yahoo.com

In this paper, some aspects of preparation and education of police and other legal forces in the fight against the illegal synthetic labs will be discussed. Practical organization of police action in connection with the termination of clandestine labs will be suggested.

2. Synthetic drugs - some possibilities for their control

Some new drugs become very popular and their misuse is widespread, while some sorts of older drugs, on the contrary, are outdated and their use is diminished. A small number of new synthetic drugs are likely to replace, to a great extent, old natural drugs. Synthetic drugs are easily prepared, there is no need for much human work for their preparation compared to the preparation of natural drugs; synthetic drugs are independent of weather and climate conditions, which are important factors in growing plants for natural drugs. The facts are as follows: in Europe and in the Republic of Serbia spreading of synthetic drugs as amphetamine, methamphetamine and methylenedioxy methamphetamine (Ecstasy) is irrepressible process.

Moreover, the drugs from which users expect to help in sexual contacts (gamma hydroxy butyric acid GHB, gamma butyrolactone GBL and like) and substances for fake-medical uses, as anabolic steroids for sportsmen and builders, are gaining much popularity.

The problem of spreading of synthetic drugs abuse opened the new questions for Serbian police; the best way to find some answers is to follow the experience of the developed countries where the abuse of synthetic drugs is a more prominent phenomenon. The general directions of crime-investigating and legislative measures (Marinković, 2003) and the comparison of the European Union to Serbia in the field of drug abuse are already discussed in domestic literature (Marinković, 2004).

Finding and seizing clandestine drug labs is not the common experience for police. The small labs are easy to set up or move from one place to another. It is almost impossible to develop any universal and efficient strategy for dealing with the problem. However, some operative police procedures for clandestine labs finding and seizing do exist - operative forces should be familiar with them and educated in the course of their training.

Dealing with clandestine labs requires high level of technical experience, the understanding of illicit drug chemistry at first.

A method for the control of illicit drug labs is a detailed tracking of chemicals necessary for drug synthesis. This way of clandestine labs control was adopted by the United Nations, the United States of America and many other countries confronted with serious problem of synthetic drugs. For this purpose the Tables are formed of the chemicals necessary for the synthesis of most

widespread drugs, the so-called Table 1 and Table 2. According to the US Tables (popularly, Red List1 and Red List 2), which are the regular part of the US federal legislative system (the US Department of Justice, 2005), chemicals are divided into two parts.

Table 1	**Table 2**
N-acetyl anthranilic acid	Acetic anhydride
Ephedrine	Acetone
Ergometrine	Anthranilic acid
Ergotamine	Diethyl ether
Isosaphrole	Hydrochloric acid
Lysergic acid	Ethyl methyl ketone
3,4-methylenedioxy-2-phenyl propanone	Phenylacetic acid
1-phenyl-2-propanone	Piperidine
Piperonal	Sodium permanganate
Pseudoephedrine	Sulfuric acid
Safrole	Toluene

Table 1 contains the names of chemicals used for the illicit drugs synthesis. The use of chemicals listed in Table 1 is extremely rare for other purposes than the drug synthesis. As for the Table 2, the chemicals listed there could be used either for the drug synthesis or they have many other legal uses and are raw materials for the preparation of many other products for everyday use.

Chemicals listed in Table 1 are most frequently diverted from official laboratories or from chemical markets in the Arab world, or the Far East (China), where trade legislative is more liberal. Epherdrine and pseudo-epherdrine are mostly imported from Turkey, where their trade has not been regulated so far.

In the Western Europe (the European Union), it is impossible for a single person to buy the chemicals from Table 1. However, as for other goods (cigarettes, textiles etc.), illegal trade of chemicals is not insignificant.

If a person collects or transfers the chemicals listed in Table 1, it is almost certain that this person is involved in drug preparation. If a person collects or transfers the chemicals listed in Table 2, it is possible that he/she is involved in drug synthesis, but there are other possibilities (some other legal or illegal business, but not drug business), since the use of chemicals listed in Table 2 for legal purposes is many times more frequent than their use for the illicit drug preparation.

Chemicals listed in Table 2 are frequently used for legal purposes. Based on this ground, those chemicals are over the counter goods; one can find it in chemical stores and they may be sold according to the regulations designed to thwart the underground use. However, for their illicit use, those chemicals could be obtained from an authorized dealer company with false declaration of their end use.

In the Republic of Serbia today there is not good enough evidence about the use of chemicals at the time when they are delivered to the end user. Foreign chemical exporting companies ask for customer declaration of the purpose or intended use of chemicals from Table 2 before they deliver chemicals. When a company receives the declaration, it delivers goods to the end user. The declaration of end use should reasonably state the legal use of chemicals, i.e. the process that is already known in chemistry and technology. Chemical companies do not insist much on the inspection of chemicals for the end use; their business is to provide chemicals for any interested customer.

A written declaration of the intended use of chemicals from Table 2 is obligatory in many countries. When the declaration is received by a dealer company, there is no more responsibility on the side of chemicals dealer, even if the declaration is false.

Chemicals from Table 2 are frequently removed (stealed, diverted) from industrial companies or laboratories.

The police officers working in drug departments are provided with a list (names) of chemicals frequently used in illicit drug manufacture. The list contains chemical names in English, German and Spanish. On the spot the officer compare the chemicals that were found with those in the list and see if the particular chemical substance has any use in drug production and for which drug it is used in particular. (the UN International Narcotics Control Board, 2005).

2.1 Illegal (clandestine) labs – their organization, detection, and termination of drug production

Synthetic drugs are manufactured in illegal, out-of-sight synthetic labs. A clandestine lab can be very elaborate or very simple. Places where clandestine labs are organized are most frequently residential areas, industrial areas, hotel rooms, open fields, abandoned structures (cars, buses) or different kinds of vehicles for example (Mayo, 2005).

It is hard to detect an ilegal laboratory. Some of the characteristic signs of illegal laboratories are:

- Extraordinary security precautions being taken by the people to protect their privacy, such as security cameras, added locks, bars over windows, etc.;
- Finding chemical containers, particularly without the labels;
- Unusual traffic, containers moved in and out;
- Persons who come outside only to smoke and/or eat and drink;
- Unusual odors coming from a structure or location, such as the odor of ether or acetone (odor of fingernail polish remover);
- Dead foliage in run-off areas.

The production of drugs in a clandestine laboratory should be stopped (terminated) by police action. This task is accomplished by incursion of police forces and other procedures after the incursion. To ensure efficient subsequent court proceedings, it is necessary to develop reasonable protocols for police action in such situations. Clandestine labs are dangerous places. An attack on the laboratory is for police forces always difficult and dangerous tasks (Donell, 2004). Difficulties in police operations originate from the fact that the police forces have little experience regarding the problem specificity in their previous professional experience. Threats for police forces originate both from the persons in labs and from the different nature of an action (Walton, 2000). This specific nature of threats consists mainly of the possibility of injuries caused by chemicals.

The police actions for disruption of drug production in clandestine labs consist of few necessary steps which should be considered in advance, carefully planned and executed in the following order:

1. Gathering of initial information;
2. Incursion planning;
3. Incursion execution;
4. Actions that directly follows incursionl
5. Collecting of drug and chemicals specimens for the analysis and completion of court evidence from inside and outside the laboratory;
6. Securing the place after the attacking police forces leave.

If the laboratory is discovered in the course of police action not connected with drugs and the advance planning of action is therefore not possible, points 4, 5 and 6 in the above list should be executed in uniform mode. Some hints for reasonable and effective execution of the tasks from the list are as follows:

2.1.1 Gathering previous information

Information on the general activity and capacity (magnitude, type of production) of a clandestine lab are significant. Sometimes, previous information are of crucial importance for the success of the whole action. The necessary piece

of information is *which drug is synthesized in the lab*. The issue of the final product from the laboratory is significant in the sense that on the ground of these information police forces could predict the technology, chemical equipment and internal laboratory organization significant for the attack planning. When there is no doubt that clandestine drug laboratory is discovered, police have no need to act in a hurry. It is wise to monitor the laboratory at least some time and locate the whole transportation system of chemicals into and out of the laboratory, communication systems of the employed people, ways of obtaining necessary chemicals etc.

Drug synthesis under illegitimate conditions is a hard, complicated and dangerous task. It is a hard task because chemical processes have to be organized under totally inappropriate and secret conditions: one should gather and stock plenty of chemicals and chemical equipment and the whole "business" should remain totally sheltered. The job is dangerous because of high penalties for the people involved. Among drug producers a number of rules are worth to be mentioned:

1. Serious and large illegal drug producers work in as little groups as possible. Only highly trusted and really necessary people are engaged. Cooks are frequently not chemists – they are instructed from a chemist or a person experienced in the field to execute just a few steps in the synthesis.
2. Never (by no means!) communicate by phone about the business! Do not use a phone to arrange a business meeting. Never make any written evidence or note about quantity or type of drug synthesized.
3. Do not sell your product in your laboratory or at any other place while laboratory is working. The imperative is to finish the planned quantity of drug, disassemble the laboratory and then sell your product. This rule is especially illustrative for LSD producing labs. To the best of our knowledge, there is no example that a working LSD laboratory has ever been discovered. This situation is easy to understand: a laboratory manufacture 5-6 grams of pure LSD and this amount is quite enough for many doses of drug (6 grams equals to 80000 doses; one dose 75 micrograms!). When the drug is in the streets, the laboratory is disassembled and it does not work any more at the same place. However, at the same time, there is another effective laboratory and production of this laboratory will be on the market in the future.
4. If a person is organizing illegal drug production, they do it frequently in rented facilities. This procedure is good protection from courts to confiscate the possession of the defendant.

Drug producers are prone to organize long chains of drug transportation to the market in exchange for the lower income. Missing of a laboratory is the indispensable loss for drug producers, while small drug dealers could be easily compensated for.

The supply of chemicals necessary for the synthesis is an especially difficult task. It seems that this step is most dangerous for illegal drug manufacturer. This phase in drug synthesis is the most open stage for police to gather information and to attract attention. In the Republic of Serbia, the legislative rules of chemical trade are not at the level appropriate to enable the adequate control.

Useful pieces of information are frequently gathered from the persons close to the main drug production organizers. The information gathered from phone communications between the suspected persons (if available) is the most useful: based on the collected pieces of information, the police chemists acquainted with the methods of illegal drug synthesis could definitely discover the main data on drug production in the laboratory. Conversation records, even if conversation was conducted in slang or jargon, is of indispensable value to a police specialist. Based on the type of used chemicals and their quantity, police experts could identify the type of drug produced and even the lab production capacity. Frequently, the lab and chemicals stockpiles are at different places. As a rule, well organized drug producers always organize production and stockpiles at diverse locations. Separate stockpiles and labs make difficult the further evaluation of drug quantities, the fact important for the Court processing.

As to the places where the drug production is organized, it is hard to predict which place is more likely to be used. Ironically, the general phenomenon is that drug production is organized in densely populated areas (cities, densely populated living facilities, etc). In addition to the living facilities, the cottages and garages are frequently used. Rural regions are inappropriate for drug production because any new face in the village attracts interest of country people.

The technology of illegal drug production of all main illegal drug types is well known to the police specialists. Illegal drug production requires neither much space nor complicated tools. Information on recipes for the production, on technology instructions, on processing apparatuses are numerous and easily accessible both to the illegal producers and police forces. Much of the chemical equipment used for drug production are used in everyday chemical processes and do not attract attention by themselves. However, it is important to gather information on the type of chemical equipment installed and used in laboratory, if possible. If available, the construction plan of the entire facility is valuable in action planning, as well as the plans of plumbing, drainage and gas installations.

2.1.2 Incursion planning

Termination of production of clandestine laboratory consists in immediate armed police action with intention to rule over the laboratory space and later crime scene investigation to collect material significant for court prosecution.

Crime scene investigation which follows the police action should be performed in accordance with Criminal Law system. It should be systematic and composed of both preliminary and detailed investigation, securing of the scene and all relevant details.

Within the scope of this analysis, the police action on termination of a clandestine lab is discussed in some details, including the discussion of the risk for police forces engaged in the action. Some suggestions on collecting the evidence material connected with the technology of laboratory production are also given. However, from the standpoint of legally regulated procedures, some new tools of evidence in Serbian Code of Criminal procedure (Fejes, 2007) and general discussion of Criminal Law regulations of crime scene investigation are discussed elsewhere (Žarković, 2005).

The team assigned for the termination of laboratory production includes experienced police operative leadership and chemical experts (chemists) with profound knowledge of chemical processes used in illegal underground drug production. If an illegal lab was followed for some time, then good planning of action is possible. Planning should include the following elements:

1. Based on the information gathered, the operative team and a chemical expert have to determine the type of laboratory, which drug is the main product and the production capacity of the laboratory. Health risk for police forces and general population, which is possible at different stages of the action, should be carefully investigated.
2. The strategy of police action is planned in advance. For each phase of the planned action, every participant should have his clearly defined individual role and responsibilities. The minimal risk for the entry team is an imperative in planning. Based on the information on production processes executed in laboratory, the members of police team are informed about possible risks from chemicals and chemical equipment. Information on risk issues should be passed to the team members shortly before start of the action in order to prevent information leakage. Police forces should be protected against chemical risks with protecting masks and protective gloves at least. The planned action should engage the number of police forces expected to be sufficient for all circumstances that could be reasonably predicted.
3. The headquarters of the action should provide information about the time and place of action to other services (fire service, health service) to ensure the cooperation and eventually the success of the whole action. At the same time, one should have in mind that the powerful drug clans probably have a considerable number of informers in the public services. It leaves a positive impression on the general public if the information is also passed to the agencies for the environment protection. Of course, the secrecy of action is the request which must be taken into account above all.

2. 1. 3 Incursion execution

Incursion in the laboratory and ending of its production is best performed at the time when the suspicious persons are in the laboratory and at the time when it is known that some production takes place. The entrance in empty laboratory, in some cases, could be counterproductive. If at the time of the action the laboratory was out of business, proving what was actually produced in the laboratory could be a complex task.

Police attacks should be rapid and last for a short time. When a laboratory is a large one, the authorities should be in control of all the facilities, premises and chemical equipment in the shortest possible time to prevent panic among the people in the laboratory, to prevent their escape or damaging and destruction of evidence.

In the American police routine (Smith, 2003), ending of illegal labs production is performed with more than one team. Teams enter the building one after another and perform the planned work when the previous team finished its part. According to their practice, the first team is the entry team. The principal task of the entry team is to empty the lab of all people independent of their actual function in the lab. At the course of the action, the lab is not a place to resolve mutual relations of the captured people. The people taken away from the laboratory cannot leave the place or communicate with each other.

The Americans expect to complete fully the function of the entry team in less than two minutes from the beginning of the action. The entry team secures the building later and then the lab processing team, which enters afterwards.

In the practice of the American police it is thought that keeping the suspects in the laboratory is counterproductive giving them a potential opportunity to destroy some evidence or, being surprised and scared, to intentionally cause some other incident situation.

As to the protective equipment for the entry team, there are different views. The entry team should have protection for dermal contact with aggressive chemicals, but there are different opinions in regard whether the members of the entry team should always have a complete respiratory and eye protection. Those who advocate wearing a complete respiratory protection (mask), support their opinion by the fact that during the action, the concentration of toxic substances in air could increase. The other side, however, believes that because of the short time expected for the entry team to be in the laboratory, there should not be any respiratory effect. Moreover, wearing a mask reduces mobility, visibility and orientation in space at critical moments and almost completely prevents the issuance of verbal commands to those who are overtaken in the laboratory.

The police attack on the laboratory is a particularly sensitive moment during the whole operation. The possibility for something to go wrong is

increased at the moment of attack and a few minutes after the attack. First of all, one should take into account the possibility of fire or explosion. If at the time of the attack the laboratory was working, the work should be discontinued by stopping chemical processes that are in progress. Therefore, according to other authors, it is possible to leave the suspects at the places where they where captured with a guard. They could give information on stopping processes because of their interest for their own personal safety. When there is no risk of fire or explosion, the people found in the laboratory may be taken away (Street, 2000).

General operations to be performed immediately after the attack on larger laboratories are:

1. Turn off all heating sources for working chemical equipment. Never stop heating by disconnecting the electricity in the whole building.
2. Leave the chemical equipment to cool if it was switched on at the time of attack. Cooling is most frequently performed by cold tap water circulation through metal, plastic or glass pipes. Do not close the water taps until determining their function.
3. If electric mixers for mixing of chemicals in reaction flasks are working, do not stop them. Excluding of mixers could provoke local overheating of chemicals with damaging effect. Water taps and mixers could be stopped later when chemicals cooled down and apparently there is no more risk of fire or overheating.
4. Air in the laboratory should be tested and adequate ventilation provided. Immediately after attack, all the windows should be left open for adequate period of time.

General rule for laboratory handling is not to do anything if consequences could not be predicted. As a rule: if unwanted events in connection with chemicals and chemical equipment do not occur in the first 5-10 minutes after the attack ended, nothing will go wrong.

2. 1. 4 Actions after incursion

After overpowering an illegal laboratory the police forces have to:

- Secure a video record of the general appearance of the laboratory, the photographs of the laboratory and take fingerprints and DNK traces, if available, from the chemical equipment. The fingerprints taken could sometimes be evidence in court to connect particular defendants with their work on individual parts of the process in the laboratory.

- Commanding officer should immediately examine the arrested person about what risks exist in the laboratory in terms of possible fire or explosion. The help of attending chemist is significant at this stage. One should bear in mind that those who directly work on the production of drugs sometimes do not have

accurate knowledge about the essence of chemical processes in which they are involved. It is important for a chemist to know that illegal cooks frequently use slang instead of the official naming of chemicals and processes. Chemist should be familiar with the slang.

- Specimens are collected by competent people (chemists, technicians or other specialists). Specimens taken should be representative ones and in sufficient quantity. Court should order chemical equipment to be disassembled after the specimens are secured. If suspects are interrogated at the site, the attending chemist should provide necessary explanations and information. The chemist could suggest necessary questions, but should not interrogate the defendants himself.

2. 1. 5 Collecting of specimens and analysis

During the interruption of the drug-laboratory, it is necessary to collect samples of material for the analysis. The analysis should prove whether the drugs were actually produced. For the chemical analysis, only specimens of material should be collected because, in some cases, chemicals can be found in big packaging (drums, etc.).

The collected samples are sent for the analysis in the laboratory which is equipped for this type of work, or the analytical laboratory selected by the court.

A person, who takes samples for the analysis, does it in the following way: by arbitrarily selected sequence, one takes samples of solid and liquid substances. Solid compounds are packed in plastic bags, while liquids are collected in glass bottles that can be closed so that the liquid cannot spill over. While collecting the solid samples, the officers make description or number on a peace of paper and put the paper inside the plastic bag with the sample. The bag is then closed and sealed with sticky tape. The officer marks the bag identically as the one that is put inside the bag and the same designation is written down in the List of samples. It is advisable to provide video record and photograph of the original place of each sample. Solid samples are taken by an appropriate spoon (plastic or metal) or by a peace of paper, as they do this in pharmacies, for example. For each consecutive sample one has to do this with a new spoon, or a thoroughly cleaned one. Liquid samples are taken from barrels or bottles either by direct transfusion in a bottle for the sample, or by plastic syringe. The syringes could be equipped with additional long plastic tubule in place of the needle, to provide for collecting samples from the bottom of barrels, or other inaccessible places. When liquid is transferred to the sample bottle, the bottle is marked and the same mark is written down on the List of samples with a short comment on where the specimen was collected. For the next sample, new or cleaned syringe is used.

200-500 mg samples of substances or 1-2 ml of liquid are sufficient for chemical analysis. In simple cases, the identity of drug could be confirmed if only a few milligrams of substance are available. However, it is advisable that a person collecting specimens for the analysis takes 20-50 g of a solid sample and 20-50 ml of a liquid, if possible. Modern instrumental methods of chemical analysis in Serbian police analytical labs are fast and not exhausting for the person performing the analysis. If for example 40-50 chemicals were found in the laboratory, the sample of all existing chemicals should be collected. If there is a vast amount of different chemicals, the acting officer should proceed according to his previous experience or some specific circumstances on the spot.

Especially suspicious are the chemicals without a label or with a label in some rare languages (Chinese, Indian, etc.) and not in English. When the original (previously unopened) packaging of chemical substance was found with an original label in English, this substance, as a rule, needs not be collected for the analysis.

The list of samples formed during the sampling process should be clear. Sampling procedure should be done in such a manner that a person who collected specimens should even after several months, at Court, clearly determine where the actual sample was taken. For example: "Specimen AB1, white powder taken from the red plastic mortar in room 2." It is a very unpleasant situation when the court expert, or a person who collected the samples, do not remember where the sample was exactly taken from.

If a substance to be collected is not a homogenous one, a collecting person should try to homogenize it. However, in such a situation, it seems better to take a few samples from a non-homogenous substance at different places of specimen, so that all performances of the unknown are contained in collected specimens. Collecting substance for chemical analysis for drugs does not correspond to the analytical sampling in chemistry. If the presence of drugs was proven in a collected sample, it is not important whether the sample represents the average of the whole substance.

2.1.6 Leaving and securing objects

Police teams engaged in the action leave objects after the planned results are achieved. Before leaving, the commanding officer should ensure that the perimeter of the lab site after the police action is secured, all the necessary samples collected, and that the left objects are not dangerous to general public (Hargreaves, 2000). It is necessary to prevent access of unauthorized persons.

3. Conclusion

Drug production in detected clandestine labs should be stopped by police action. Police action has to be carefully planned and effective one, including follow-up of chemicals for drug production (precursors), seats for chemicals stocking, high-quality processing after liquidation (collecting of fingerprints, broad and detailed list of confiscated chemicals, chemical equipment and collected samples for analysis) and securing of terminated laboratory facilities after leaving of police forces. Effective police action should be performed with specially trained police forces for this purpose and according to the details discussed above.

4. References

1. Donell, R. C. (2004). *Forensic Investigation of Clandestine Laboratories*. Boca Raton, USA: CRC Press.
2. Fejes, I. (2007). New tools of evidence in Serbian Code of Criminal Procedure, in: *Publication in the honour of Cséka Ervin, Nagy Ferenc e*d., Szeged, Hungary, pp. 32-48.
3. Hargreaves, G. (2000). Clandestine Drug Labs: Chemical Time Bombs. *FBI Law Enforcement Bulletin, 69*(4), 1-9.
4. Marinković, D. (2003). Osnovni pravci kriminalističkog postupanja u suzbijanju narko kriminaliteta, *Nauka-Bezbednost-Policija*, *2*, 129-145.
5. Marinković, D. (2004). Uporedni prikaz sankcionisanja zloupotrebe opojnih droga u zemljama Evropske Unije i našem zakonodavstvu. *Revija za kriminologiju i krivično pravo, 42*(1), 161-175.
6. Mayo, C. (2005). Processing Clandestine Laboratories. *Evidence Technology Magazine*, *3*, 10-13.
7. Smith, J. (2003). Developing a Clandestine Laboratory Entry Team. *The Police Marksman*, *38* (2), 24-30.
8. Street, D. (2000). An Investigation Guide to the Methamphetamine Lab. *Police: The Law Officer's Magazine, 24*(12), 20-28.
9. UN International Narcotics Control Board. (2005). *Precursors and Chemicals Frequently Used in the Illicit Manufacture of Narcotic Drugs and Psychotropic Substances* [Electronic version]. Retrieved June, 10, 2009, from http://www.oregondec.org/legislation/UN-INCB-PrecursorsReport.pdf
10. US Department of Justice, (2005). *US code of federal regulations* [21 CFR 1310.02]., in effect from 22. 06. 2005.
11. Walton, S. (2000). Clandestine Laboratory Investigation Safety Techniques. *Blue Line Magazine, 12*(7), 42-45.

12. Žarković, M. (2005). *Krivično procesni i kriminalistički aspekti uvidjaja na mestu dogadjaja*, Beograd, published by the author.

REZIME

U poslednje vreme Republika Srbija nije samo teritorija preko koje se transportuju prirodne i sintetičke droge, već postaje i teritorija na kojoj se proizvode sintetičke droge u ilegalnim laboratorijama. Činjenicu da se sintetičke droge proizvode u Srbiji potvrdjuje i nekolicina zaplena koje su izvedene proteklih godina, pri čemu je bar jedna od ilegalnih laboratorija bila takozvana mega-laboratorija.

Ovakvom razvoju mora biti suprotstavljen odgovor organizovanih snaga za borbu protiv droge. Neposredan odgovor se sastoji u odgovarajućoj akciji policije. Policijska akcija se zasniva na polaznom ispitivanju tipa ilegalne laboratorije, ispitivanju tehnologije proizvodnje droge, načina distribucije sirovina za proizvodnju i gotovih proizvoda, a u skladu sa unapred planiranim postupcima koji treba da obezbede maksimalnu efikasnost akcije. Policijske snage koje rade na suzbijanju proizvodnje sintetičkih droga treba da budu mobilne i sastavljene od posebno obučenih pripadnika.

U ovom radu biće reči o nekim vidovima pripreme i obučavanja policije i ostalih organa u borbi protiv ilegalnih laboratorija. Biće reči i o praktičnoj organizaciji policijske akcije koja je usmerena na zatvaranje tajnih laboratorija. Policijska akcija mora da bude pažljivo planirana i efikasna, što uključuje i praćenje sirovina za proizvodnju droge (prekursori), mesta gde se sirovine skladište, kvalitetnu obradu nakon prekida rada laboratorije (prikupljanje otisaka prstiju, sveobuhvatnu i detaljnu listu zaplenjenih sirovina, hemijske opreme i prikupljenih uzoraka za analizu) i obezbedjivanje zatvorene laboratorije nakon što policija ode. Efikasnu policijsku akciju treba da izvedu policijske snage posebno obučene za ovu namenu, a u skladu sa odredjenim uputstvima.

Ovaj rad govori i o elementima postupka policije pri prekidu rada otkrivenih ilegalnih laboratorija u skladu sa savremenim iskustvima u svetu u ovoj oblasti.

SUMARRY

In recent years the Republic of Serbia is not only the territory for transportation of natural and synthetic drugs, but it has become a country where synthetic drugs are fabricated in illicit labs. The fact that synthetic drugs are being synthesized in Serbia has been confirmed by several seizures in recent years; at least one of seized illegal laboratory was the so-called mega-laboratory.

Such a development must be confronted with the response of organized anti drug forces. The response is adequate action of police forces. Police action is based on the initial investigation of the type of an illicit lab, its production and drug distribution pattern and according to preplanned protocol which enables maximal efficiency of police action. Police forces that deal with illegal drug labs should be mobile and have highly trained officers.

In this paper, some aspects of preparation and education of police and other legal forces in the fight against the illegal synthetic labs will be discussed. Practical organization of police action in connection with the termination of clandestine labs will be suggested. Police action has to be carefully planned and effective one, including follow-up of chemicals for drug production (precursors), seats for chemicals stocking, high-quality processing after liquidation (collecting of fingerprints, broad and detailed list of confiscated chemicals, chemical equipment and collected samples for analysis) and securing of terminated laboratory facilities after leaving of police forces. Effective police action should be performed with specially trained police forces for this purpose and according to the specified details.

This paper also deals with the suitable protocols of police forces action and some elements that provide for the efficient final results and they are discussed in accordance with contemporary experience in the field.

Uputstvo autorima

Opšte napomene	*NBP - Journal of Criminalistics and Law / НБП - Журнал за криминалистику и право* objavljuje originalne naučne radove na engleskom jeziku.	
Naslov rada	Naslov rada: veličina fonta 14 pt, **bold,** Times New Roman	
Autori	Navodi se prezime i početno slovo imena autora (veličina fonta 12 pt).	
Naziv i adresa institucije	Naziv i puna adresa institucije u kojoj autor radi, a u fusnoti corresponding author sa e-mail adresom	
Apstrakt	Apstrakt sadrži 100-250 reči (veličina fonta 10 pt)	
Ključne reči	Ne više od 10 ključnih reči (Key words)	
Tekst **Struktura teksta**	Radovi se šalju u štampanoj formi (dve kopije na engleskom, i jedna na srpskom jeziku), kao i u elektronskoj formi, samo na engleskom jeziku. Obim rada je do 16 strana A4 formata. Rad se priprema y *MS Word* formatu, font *Times New Roman,* jednostruki prored (single), sa marginama: Top – 2,5 cm, Bottom 2,5 cm Left – 3 cm, Right – 2,5 cm Nazivi podnaslova u radu pišu se fontom veličine 13 pt, **bold.** **1. Uvod** **2. Podnaslov 1** **2.1 Podnaslov 2** **2.1.1 Podnaslov 3** **3. Zaključak** **4. Reference**	
Gde poslati rad	Radovi se dostavljaju na CD-u ili elektronskom poštom na adresu: casopis@kpa.edu.rs, ili poštom na adresu: Kriminalističko-policijska akademija 11080 Beograd – Zemun Cara Dušana 196 Republika Srbija Criminal Justice and Police Academy 11080 Belgrade-Zemun Cara Dušana 196 The Republic of Serbia	
Tabele, grafikoni i slike	Tabele uraditi u *Wordu ili u Excel-u.* Fotografije, grafikoni i slike se dostavljaju u formatu jpg ili pdf. Širina slika, grafikona i crteža treba da bude do 16 cm. Debljina linija na grafikonu i crtežu treba da bude od 0.3 mm i više.	
Autorska prava	Autori radova potpisuju saglasnost za prenos autorskih prava.	
Referentna literatura	Referentni izvori se navode prema abecednom redu, u skladu sa APA Citation Style.	
Citiranje literature	Reference navoditi u originalu	
Vrsta rada	**Reference**	**Citiranje u tekstu**
Knjiga 1 autor	Nation, I. S. P. (2001). *Learning vocabulary in another language.* Cambridge, UK: Cambridge University Press.	(Nation, 2001)
Knjiga	Cohen, L. G., & Spencer, L. J. (1994).	(Cohen & Spencer,

2 autora	*Assessment of language proficiency.* New York: Longman.	1994)
Knjiga 3 autora	Pratkins, A. R., Breker, S., & Green, A. (1989). *Attitude structure and function.* Hillsdale, NJ: Erlbaum.	First citation: (Pratkins, Breker, & Green, 1989) Subsequent citations: (Pratkins et al., 1989)
Kolektivno autorstvo	*Oxford essential world atlas* (3rd ed.). (1996). Oxford, UK: Oxford University Press.	(*Oxford*, 1996)
Poglavlje u knjizi	Richardson, J., & Riethmuller, P. (1999). Women in the Japanese workplace. In H. C. Roy, C. A. Tisdell, & H. C. Blomqvist (Eds.), *Economic development and women in the world community* (pp. 79-96). Westport, CT: Praeger Publishers.	(Richardson & Riethmuller, 1999)
Članak u časopisu (samo volumen)	Jenkins, R. (1984). Learning vocabulary through reading. *American Educational Research Journal, 21,* 767-787.	(Jenkins, 1984)
Članak u časopisu (volumen i broj)	Anderson, J. E. (1977). A component analysis of recent fertility decline in Singapore. *Studies in Family Planning, 8*(11), 45-70.	(Anderson, 1977)
Članak u časopisu 3 do 6 autora	Kneip, R. C., Lee, A., & Ismond, T. (1993). Self-ratings of anger as a predictor of heart disease. *Health Psychology, 12,* 301-307.	First citation: (Kneip, Lee, & Ismond, 1993) Subsequent: (Kneip et al., 1993)
Enciklopedija	Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.	(Pittau, 1983)
Novinski članak	Stewart, I. (2000, December 18). Book fuels mistrust of meritocracy. South China Morning Post, p. A12.	(Stewart, 2000)

Elektronski izvori	**Knjiga:** Wallace, A. R. (2001). *The Malay archipelago* (vol. 1). [Electronic version]. Retrieved November 15, 2005, from http://www.gutenberg.org/etext/2530 **Članak u elektronskom časopisu:** Rickson, B. L. (2001, March 7). Cultivating positive emotions to optimize health and well-being. *Prevention & Treatment, 3,* Article 0001a. Retrieved November 15, 2005, from http://journals.apa.org/prevention/volume3/pre00300001a.html **Dokumenti i izveštaji:** Organization for Economic Co-operation and Development. (2001). *Trends in international migration: Continuous reporting system on migration* (Annual Report, 2001 edition). Retrieved October 24, 2005, from http://www.oecd.org/dataoecd/23/41/2508596.pdf	(Wallace, 2001) (Rickson, 2001) (Organization for Economic Co-operation and Development [OECD], 2001) Subsequent: (OECD, 2001)

- Molimo Vas da prilikom dostavljanja rada prema ovom uputstvu, dostavite rezime Vašeg rada na engleskom i srpskom jeziku do 15 redova.