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Original Contribution

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OPTIC APPLIANCES DESIGNED FOR OBSERVATION ON THE BOARD OF SPACESHIPS

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ABSTRACT*: The criteria for the efficiency definition of visir optic appliances for observation on the boards of spaceships are related to: the eye characteristics – the pupil diameter in dependence of the background brightness, the visual sharpness and the utmost contrast; the photometric characteristics of the observed object and the background – their brightness and contrast; the optic characteristics of the visir optic appliance – magnification, vision field, entrance pupil diameter, light permeability, etc.*

Because the above mentioned class of appliances for cosmic research is used to observe distant objects, when evaluating their efficiency, it is important to render an account of the atmospheric conditions. The visual distance of the distant objects depends on the photometric characteristics, on the object size and its shape.

The presented in this research criteria for efficiency of the visir optic appliances used for observation on the boards of spaceships and also the coefficient which counts for the atmospheric influence allow evaluating the object visibility in the conditions of a natural landscape.

KEY WORDS*: appliances designed, optic.*

Taking into consideration the above mentioned conditions and to define the efficiency, it is necessary to define the possibility of observation of distant objects with a high resolution. The efficiency of the observation by means of a visir optic appliance is denoted by E and it can be defined by the correlation

$$E = \frac{\delta_0(l)}{\delta(l)}, \tag{1}$$

where $\delta_0(l)$ is the utmost resolution of an observation with the naked eye of an object which is at the distance l;
$\delta(l)$ is the utmost resolution of an observation of the same object by means of a visir optic appliance.

Such method is especially useful to evaluate visir optic appliances with a constant magnification, with a discreet variable magnification and a smooth variable magnification [1…9] because it is possible to choose optimal parameters depending on the requirements and the specific functions of the optic visirs. For example “Visir pricel 15K” (fig. 1) is designed to direct the specter-zonal appliance “Specter–15” for distant Earth research from the board of Orbital scientific stations. “Visir B 3x40” (fig. 2) is designed to direct Electrophotometric appliance “Duga” for research in the sphere of

Fig. 1. Visir pricel 15K

the cosmic physics – registration of polar lights and stable auroral red arcs and Pancratic visir (fig. 3) is designed to direct Impulse photometric appliance “Terma” for discovery of distant objects and registration of fast processes by means of a high space and time resolution.

Fig. 2. Visir B 3x40

The calculation of the utmost resolution $\delta_0(l)$ is made in the following sequience. The angle $\delta_0(l)$ can be defined by known correlations of the eyesight acuteness from the brightness and contrast of the object and background. For this purpose, it is necessary to calculate the visible contrast K

Fig. 3. Pancratic visir

of the object which is situated at a different distance l [5]:

$$K = \frac{B - B_H - \frac{B_0 - B_H}{\tau^{\Delta l}}}{B - B_H + \frac{1}{\tau^{\Delta l}} \frac{B_H}{\tau^l}}, \quad (2)$$

where B, B_0, B_H is brightness of the background, of the object and of the sky;
Δl is the distance between the object and the background;
τ is the atmospheric permeability coefficient.

In most of the cases the object is situated right in front of the background, i.e. $\Delta l = 0$. Then,

$$K = \frac{K_0}{1 + \frac{B_H}{B}\left(\frac{1}{\tau^l} - 1\right)}, \quad (3)$$

where K_0 is a real contrast between the object and the background.

The photometric characteristics of the object and the background are $\frac{B_H}{B}$, $K_0 = 1$. The atmospheric permeability coefficient τ is accepted as 0,85; 0,75 and 0,65 [ ].

To define the utmost resolution when taking into consideration the values of the visible contrast, experimental data from researched objects are used and they allow finding the dependency of the angle δ from the contrast K at different background brightness, i.e.

$$\delta = f(k), \qquad B = B_1, B_2, \ldots \quad (4)$$

By means of the correlation (4), the angle δ can be found which corresponds to the visible contrast about a different distance of the observed objects and a scale is drawn of the utmost resolution when observing with the naked eye: $\delta = f(b)$ $(B = const)$, which can be seen on fig. 4 and the background brightness is $B = 420\,\text{cd/m}^2$.

The calculation of the utmost resolution $\delta(B)$ is made in the following sequence. When observing through a visir optic appliance, the contrast and visibility decreases. The decrease of the contrast is explained by the light diffusion in the appliance and the decrease of the contrast is explained by the losses in the optic parts and the restricted outlet pupil diameter, especially if the outlet pupil diameter d' is smaller than the human pupil diameter d. At background brightness $(B > 50...100\,\text{cd/m}^2)$ and the influence of the light diffusion upon the resolution is very minor and it can be ignored in the researched problem. The visual brightness of the image B' attains special influence.

$$(5) \qquad B' = \begin{cases} B_{\tau_0} \\ B_{\tau_0}\left(\dfrac{d'}{d}\right)^2 \end{cases} \qquad d' \geq d \qquad d' < d,$$

where τ_0 is a coefficient of light diffusion of the visir.

The scales 1, 2 and 3 from fig. 4 are drawn from the gathered results and they refer to a pancreatic visir with a smooth variable magnification (fig. 3).

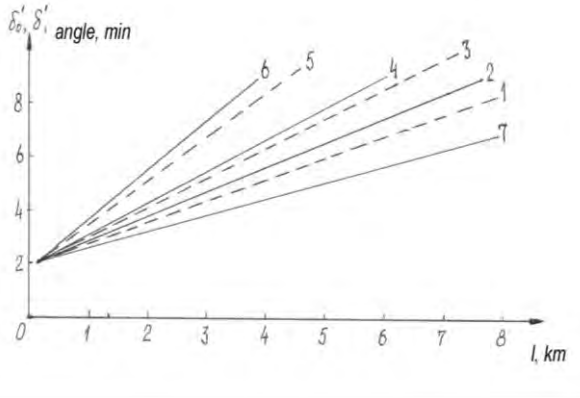

Fig. 4. Utmost Resolution δ_0 and δ' depending on the distance to the objects; $B_H = 3000\,\text{cd/m}^2$, $B = 300$ cd/m^2, $K_0 = 1$; 1,3,5 – observation with the naked eye (at angle δ_0); τ respectively equals 0,85; 0,75 and 0,65; 2,4,6 – observation through a pancreatic visir; 7 - observation with the naked eye (at angle δ_0, $\tau = 0{,}85$), calculated by formula (3)

The diameter of the human pupil $d = 3{,}00$ mm at $B' = 300\,\text{cd/m}^2$.07=210 cd/m^2, and at $B' = 300\,\text{cd/m}^2$.0,55=165 cd/m^2, d=3,1 mm.

The correlations at the lowest visible resolution of the image $B' = 110\,\text{cd/m}^2$ at visir magnification 20 times are presented by the numbers 2,4

and 6 on fig. 4. The angle δ' is made without rendering an account of a possible change of the image quality at change in the magnification. It is obvious the utmost resolution in the medium of the object $\delta = \frac{\delta'}{\Gamma}$. The efficiency E has to be presented by the formula:

(6) $$E = \frac{\delta_0(l)}{\delta'(l)},$$

where $\delta'(l)$ is the utmost resolution in the image medium of the visir telescope system when observing an object at a distance l.

It is necessary to count the atmosphere influence by means of the coefficient A and by comparison of the utmost resolution without rendering an account of the atmosphere influence and with rendering the atmosphere influence, i.e.

(7) $$A = \frac{\delta'(l)}{\delta'(l=0)}.$$

When the weather is cloudy and there is air turbulence, the coefficient which counts the atmosphere influence A (which is defined by experimental data) shows a double increase in comparison with the values in a homogeneous atmosphere.

The following conclusions can be made on the basis of theoretical and experimental results:

1. The theoretical value of the utmost resolution δ' is 7 % higher than the experimental in a comparatively homogeneous medium and when the observation is made by means of a pancreatic visir with a 20 times magnification.

2. At high heterogeneity and atmosphere turbulence which appears in sunny days during the summer, the experimental values of the utmost resolution are influenced by the magnification of the visir telescopic system.

3. The coefficient of atmospheric influence A at homogeneous atmosphere and great meteorological distance of visibility, calculated by theoretical and experimental data, basically coincide.

4. The criteria for efficiency of the visir optic appliances used for observation on the boards of spaceships and also the coefficient which counts for the atmospheric influence allow evaluating the object visibility in the conditions of a natural landscape.

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METHODS FOR DETERMINING THE AMOUNT OF MULTI-ELECTRONIC SCINTILLATIONS ON THE SCREEN OF ELECTRO – OPTIC TRANSFORMER OF IMAGES

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ABSTRACT*: One of the basic requirements when using electro – optical transformer (EOT) of images in space research [1, 2, 5, 7, 8] is the low level of bright light flashes on the screen, called multi – electronic scintillations. The existence of multi – electronic scintillations leads to significant expansion of the possibility for diminishing the utmost sensitivity of the EOT [4, 6, 9, and 10]. The definition of the amount of scintillations per definite time could be done with the help of the method for scintillations' calculation while using photo – electronic multiplier [3]. If the number of scintillations' distribution over the active surface of the screen is determined and experimentally are evaluated the distribution parameters for a certain EOT, it is a matter of simpler methods required for the scintillation evaluation without the need for development of complex scanning devices. The current research is about evaluating the law of scintillations' amount distribution over the active surface of the screen, evaluation of their amplitude spectrum and development of method for defining the amount of multi – electronic scintillations over the active surface of the EOT's screen.*

KEY WORDS*: multi-electronic scintillations*

METHOD FOR DEFINING THE DISTRIBUTION OF SCINTILLATIONS NUMBER OVER THE ACTIVE SURFACE OF THE EOT.

A certain device [3] is used in order to define the distribution of the scintillations number over the screen. The measurement of scintillations is made as in [3], from the surface o the EOT's screen, with the help of mobile diaphragm, 2 mm in diameter, and optic system for transferring the image to the photo – electronic multiplier. The light source secures monochromatic adjustable infrared radiation, hitting the photo cathode of the EOT. The method for measurement is based on evaluation of average amplitude of scintillations, invoked by single electrons, hitting the EOT's photo cathode, the amplitude distribution of scintillations and their integral number. The measurements are

taken in dark, in light, on background 10^{-7} cd/m^2, in adjustable shine of EOT's photo cathode by the light source. A consecutive account is being taken after every diaphragm's movement on every 2 mm from the center across the EOT's screen radius toward the periphery. The received experimental data serves for setting up a dependency between scintillations' amplitude spectrum and their integral number across the screen's diameter. The measurements show that the distribution is asymmetric, which allows simplification of the method and evaluation of the scintillations' distribution only in dependence with the screen's radius.

MEASUREMENT – RESULTS AND ANALYSIS

Figure 1 shows experimental data for the distribution number of dark scintillations on the EOT's screen with background brightness 10^{-7} cd/m^2.

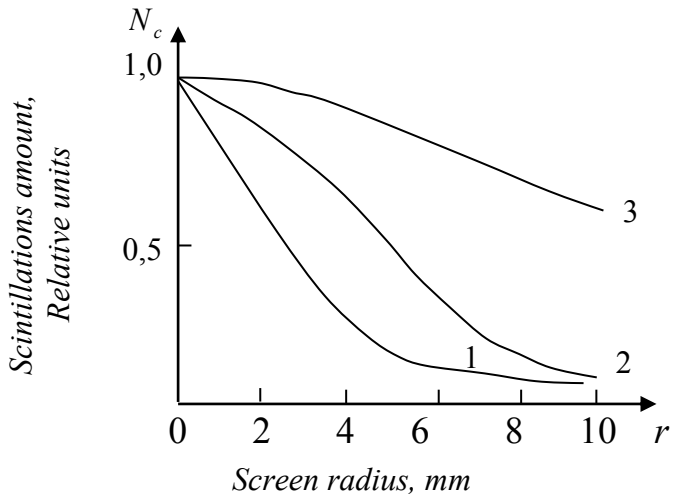

Figure 1. Distribution of dark scintillations number
across the EOT's screen radius:
1 – when $\sigma = 2{,}5$; 2 – when $\sigma = 4$ and 3 – when $\sigma = 10$.

Figure 2 shows the distribution of background scintillations across the EOT's screen radius with background brightness 10^{-4} cd/m^2.

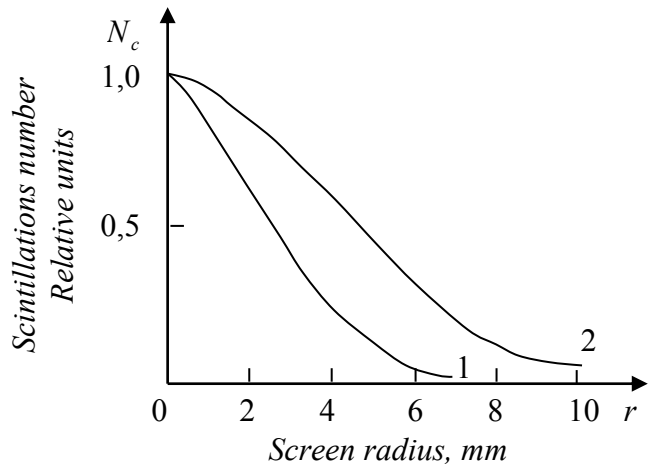

Figure 2. Distribution of background scintillations number across the EOT's screen radius: 1 – when $\sigma = 2{,}3$ and 2 – when $\sigma = 4$.

The experimental data is compared to a normal distribution law. The values of mean quadratic aberration σ are shown in the figures. The values show, that the scintillations are concentrated mainly in the center of the screen. As it is observed in the figures, the comparison of experimental data with normal distribution law shows good coordination. It could be considered that the possibility for appearance of scintillations across the EOT's screen diameter is similar to the normal distribution law (Figure 1, Figure 2), describable with the formulae:

$$y = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{r^2}{2\sigma^2}}, \tag{1}$$

where: r – EOT's screen radius.

The definition of scintillations' number over the active surface of the EOT's screen could be done in the following sequence. By following that method could be defined the scintillations' number N_c across the co-ordinate r_n. The mean quadratic aberration σ in normal distribution could be defined by the formulae:

$$\sigma = \frac{r_n}{1{,}18}. \tag{2}$$

Having in mind the values of σ and N_c, we could define the scintillations number N for the entire active surface of the screen:

$$N = N_c \frac{V}{V_c}, \tag{3}$$

where: V_c - the volume of a body, restricted by the surface in rotation of the curve $y_2 = f(r)$ across the analyzed surface of the screen *S*, definable by $V_c = S.y_2$, where $y_2 = \frac{1}{\sqrt{2\pi\sigma}}$;

V - the volume of a body, restricted by the surface in rotation of the curve $y_1 = f(r)$ across the working surface of the screen:

$$V = S + \pi \int_{y_1}^{y_2} r^2 dy, \tag{4}$$

$$y_1 = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{r_k^2}{2\sigma^2}};$$

r_k - radius of the screen working surface.

The value of r^2 could be defined by the equation (1):

$$r^2 = \left(\ln \frac{1}{\sqrt{2\pi\sigma}} - \ln y \right) 2\sigma^2. \tag{5}$$

By replacing equation (5) in equation (4), after integration we get:

$$V = 2\pi\sigma^2 \left[(y_2 - y_1)(\ln y_2 + 1) - y_2 \ln y_2 + y_1 \ln y_1 \right] + S y_1. \tag{6}$$

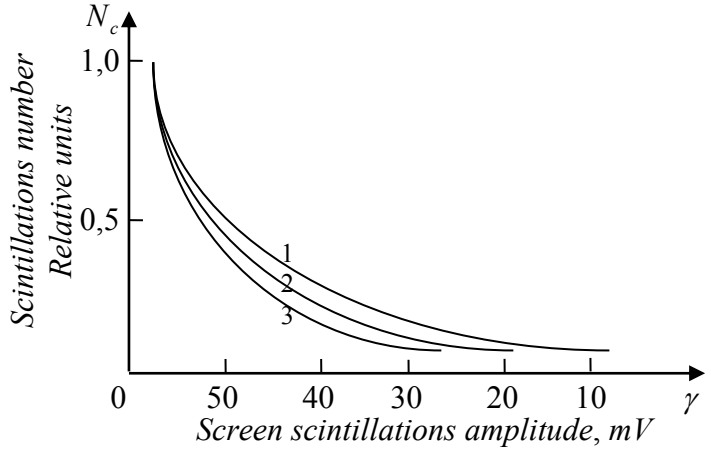

Figure 3. Amplitude distribution of dark scintillations: 1 – measured in the center of EOT's screen; 2 – measured at distance of 3 mm from the center of the screen; 3 – measured at distance of 7 mm from the center of the EOT' screen.

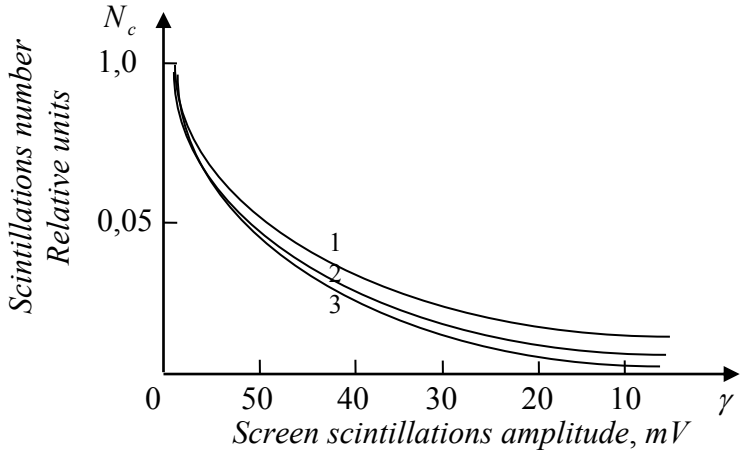

Figure 4. Amplitude distribution of background scintillations: 1 – measured in the center of EOT's screen; 2 – measured at distance of 3 mm from the center of the screen; 3 – measured at distance of 7 mm from the center of the EOT' screen.

The definition of the scintillations number across the working surface of the EOT's screen is made with the help of measurement of scintillations number in circular areas of the screen and calculation of their whole number with the suggested method for approximation of scintillations number distribution across the screen surface with a normal distribution law. Figure 3 and figure 4 show amplitude distributions of scintillations, measured in the center (scheme 1) and in distance of 3 mm (scheme 2), 7 mm (scheme 3) and 10 mm (scheme 4) from the center with background brightness – full darkness - 10^{-7} cd/m^2, created in front of the EOT's photo cathode, and at background brightness 10^{-4} cd/m^2.

Variations in amplitude distribution are observed. A significant contribution to the amplitude distribution in the screen center brings the scintillations with greater amplitude.

CONCLUSION

The experimental research of number and brightness of scintillations show that the distribution of the multi – electronic scintillations' number across the screen's diameter could be approximated by a normal law. This allows the application of the suggested method for measuring of scintillations number across the active surface of the EOT's screen.

The analysis of multi – electronic scintillations amplitude spectrum shows, that in the center of the EOT's screen, the number of scintillations with greater amplitude is significantly greater in comparison with those at the end of the active surface of the screen.

These multi – electronic scintillations could invoke the registration of non – existing signal, because of which along with the enumeration of multi –

electronic scintillations number across the active surface of the screen is necessary to be made measurement and accounting of the amplitude spectrum of scintillations across the EOT's screen.

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Original Contribution

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A SHORT SURVEY OF P-ARY PSEUDO-RANDOM SEQUENCES

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ABSTRACT: *One of the most important problems in the sequence design is to find sequences with good correlation properties. Recently, expect for the binary Pseudo-Random Sequences (PRSs), much progress has been obtained for ternary and p-ary PRSs. In this paper a short survey of p-ary PRSs and their properties is made. As a result their classification is suggested without claiming its full completeness.*

KEY WORDS: *pseudo-random sequences, pseudo-noise sequences, p-ary PRSs, binary PRSs, Security.*

1. Introduction

Nowadays, Pseudo-Random Sequences (PRSs) are widely used in many applications such as computer simulation and modeling, statistics, experimental design, digital communications, cryptography and random number generation. They are also important in areas such as signal synchronization, navigation, radar ranging, spread-spectrum commu-nications, multipath resolution and signal identification in multiple-access communication systems.

Pseudo-Random Sequences, also known as Pseudo-Noise Sequences (PNSs), are sequences that are deterministically generated, but yet possess the properties of randomly generated sequences.

PRSs have been widely used in communications and cryptography, since the creation of information theory in 1948 by Claude Shannon. The interest towards PRSs is determined by its good correlation and balance properties, and its large linear complexity.

For example, in commu-nications, good autocorrelation properties are of importance for reliable initial synchronization and components' separation in multipath environment. In Code Division Multiple Access (CDMA) systems, to suppress multiuser interference the low cross-correlation between the desired and interfering users is required.

The actuality of the security problem in communication and information networks and systems derives from the importance of the requirements for obtaining reliable and accurate information about the sent message, its sender and recipient in terms of communications with the possibility of eavesdropping and intentional noises, organized by criminal and terrorist groups.

In cryptography, the sequences with low cross-correlation can be used as key stream generators in stream ciphers to resist correlation attacks. In this case, the linear complexity is very important, in order to prevent the reconstruction of the sequence of a small part of it using Berlekamp-Massey algorithm [2], [14].

Recently, expect for the binary PRSs of period $T = 2^n - 1$, much progress has been obtained for ternary and p-ary PRSs. Increased interest in them is determined by their close relationship to trace function and difference sets. For recent work on p-ary PRSs with good correlation properties the reader can refer to [1], [3], [8-13], and [16-19].

Therefore, we try to classify the currently known p-ary PRSs in this paper. First, a brief overview of binary sequences is made. Then the currently known p-ary pseudo-random sequences and their properties are described.

2. Binary Pseudo Random Sequences

The best-known family of PRSs is binary m-sequences which satisfy balance, run-distribution and autocorrelation properties like truly random sequences. These properties make them most used in communications and cryptographic systems.

Scientific research studies of binary PRSs can be conditionally divided into three main periods.

I. Period prior to their practical application

Before 1948 the pseudo-random sequences have been studied only theoretical because of their elegant mathematical structure. They have been examined as linear repetitive sequences defined over a ring around 1930 and as a combinatorial problem in 1894, later known as sequences of De Bruijn.

II. Golden age of the sequences with maximum period

In 1945 Shannon proved the theoretical significance of the one-time pad keystream system as unbreakable. If the pseudo-random generator operates as a key stream generator in a cryptographic system and the period of the generated sequence is long enough to ensure that will be used a variety of separate segments of the generated sequence for encryption at any time. So, in the early 50s of the last century critical issue was how to generate pseudo-random sequence with a large period. The decision till 1969 were Linear Feedback Shift Registers (LFSRs), which were used as pseudo-random generators in stream ciphers because LFSR of length n can generate a sequence of maximum length

$T = 2^n - 1$. The majority of the early studies of the LFSR and Bruijn sequences are collected and aggregated in the popular book “Shift Register Sequences” of professor Golomb [5]. LFSR registers have been used in many applications such as stream ciphers, radar systems and CDMA communications.

III. Period of nonlinear pseudo-random generators

In 1969 Massey makes an extraordinary discovery that if a binary sequence has linear complexity n, then the whole sequence can be reconstructed from its $2n$ consecutive bits by the Berlekamp-Massey algorithm. Since that time, scientific researchers are looking for new methods of generating non-linear sequences. Researchers refer to basic methods to generate nonlinear sequences [6]:

1. Structures based on LFSR registers:
   - Filter generators;
   - Combinatorial generators;
   - Clock controlled generators, including cascaded cases.
2. Generators in finite fields:
   - GMW (Gordon, Mills and Welch) sequences, including cascaded cases;
   - Bent function sequences.

Good reviews of PRSs and their properties can be found in the works of Helleseth and Kumar [8], Golomb [4], and Golomb and Gong [3].

Helleseth and Kumar classify PRSs (see Fig. 1) according to the used type of correlation function between two sequences:

- *autocorrelation* function if the two sequences are the same;
- *crosscorrelation* if they are distinct;
- *periodic correlation* if the shift is a cyclic shift;
- *aperiodic correlation* if the shift is not cyclic;
- *partial-period correlation* if the inner product of correlation involves only a partial segment of the two sequences.

In the last twenty years, researchers are directed to investigate the pseudorandom sequence generators in finite fields GF(p^n), where p is an odd prime.

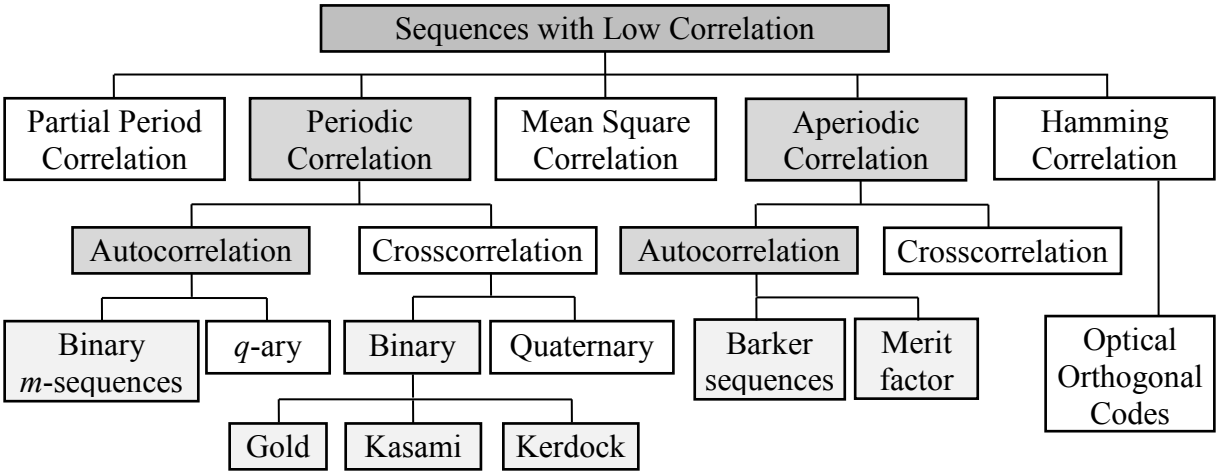

Fig. 1. Overview of PRSs [8].

This may be the beginning of a new period in the study of PRSs, which we call p-ary pseudo-random sequences.

3. p-ary Pseudo Random Sequences

The p-ary case of PRSs, where p is an odd prime, has been studied by researchers from the thirties of the last century. The p-ary m-sequences and the Gordon, Mills and Welch (GMW) sequences are two well-known families of perfect p-ary sequences of length $p^m - 1$ which have been investigated for several decades. In this section a briefly review of the known p-ary Pseudo Random Sequences and their properties is done.

In addition to them, the other types of p-ary PRSs like ternary perfect and almost perfect sequences, non-binary sequences with ideal two-level autocorrelation, non-binary Kasami sequences, p-ary pseudo-noise sequences with low correlation zone are also known.

3.1. p-ary m-sequences

Let α be a primitive element of the finite field GF(2^n). A binary sequence $s(\alpha^t)$ of period $2^n - 1$ with ideal autocorrelation is equivalent to a cyclic difference set with Singer parameters $(2^n - 1, 2^{n-1} - 1, 2^{n-2} - 1)$ [17] where a difference set is defined as

$$D = \{t : s(\alpha^i) = 0, 0 \le t < 2^n - 1\}.$$

Singer also have proved that difference set with parameters

$(p^m - 1, p^{m-1} - 1, p^{m-2} - 1)$,

where $m \ge 2$ and p is an odd prime,

forms a p-ary perfect sequence.

3.2. *p*-ary GMW Sequences

The GMW-sequences have been proposed by Gordon, Mills and Welch in their original work named Some new difference sets [7] in 1962. Sholtz and Welch have published a method for generating one class of GMW sequences in terms of trace function in his correspondence [15] after nearly twenty year of silence. In his work have been also analyzed the ideal autocorrelation properties, the linear span and balance properties of GMW sequences, and after that a pseudonoise (PN) generator design have been described.

The *p*-ary GMW sequence are based on the decomposition of the field GF(p^M). There are four types of GMW-sequences, as described by Golomb and Gong [3]:

- GMW-sequences;
- cascaded GMW-sequences;
- generalized GMW-sequences (type 3);
- generalized GMW-sequences (type 4).

The elements of a *p*-ary GMW sequence are the complex *p*-th roots of unity. The phase of a *p*-ary GMW sequence is given by

$$a(n) = \mathrm{tr}_1^J(\mathrm{tr}_J^M(\alpha^{dn})^r),$$

where α is a primitive element of the finite field GF(p^M). The trace function from GF(p^M) to GF(p^J) and from GF(p^J) to GF(p) is denoted by tr_J^M and tr_1^J, respectively. The parameters d and r must satisfy the following conditions:
$0 < d < p^M - 1$ and $\gcd(p^M - 1, d) = 1$,
$0 < r < p^J - 1$ and $\gcd(p^J - 1, r) = 1$.

The least period of the sequence is $N = p^M - 1$, i.e., $a(n + N) = a(n)$.

3.3. Ternary Perfect and Almost Perfect Sequences

Almost Perfect Ternary (APT) sequences of length $2(q^k - 1)/(q - 1)$, where $q = p^m$ and $(2k, q - 1) = 2$ have been proposed by Langevin (Langevin-sequences) in 1993 [12].

Later, APT sequences of length $2(q^k - 1)/(q - 1)$ for all $k > 1$ have been constructed by Schotten and Lüke (SL-sequences) [16].

In 1998, Lin have proposed a perfect sequence (Lin-sequences) given by the trace function

$$\{Tr(\alpha^t + \alpha^{dt} \mid t = 1, 2, \ldots, 3^{2m+1} - 1\},$$

where $d = 2.3^m + 1$ and α is a primitive element of GF(3^{2m+1}).

Later, in 2001, Helleseth, Kumar and Martinsen (HKM-sequences) have proved that the sequence

$\{Tr(\alpha^t + \alpha^{dt} \mid t = 1, 2, \ldots, 3^{3k} - 1\}$

is perfect, when $d = 3^{2k} - 3^k + 1$ and α is a primitive element of GF(3^{3k}).

New families of APT sequences of length $N = (p^n - 1)/r$, where r is an integer, and odd-perfect ternary sequences of length $N/2$, derived from the

decomposition of m-sequences of length $p^n - 1$ over GF(p), $n = km$, with p being an odd prime, into an array have been presented by Krengel (Krengel-sequences) in 2005 [11].

3.4. Non-Binary Sequences with Ideal Two-Level Autocorrelation

New families of non-binary sequences of period $p^n - 1$ with symbols from a finite field GF(p) for any prime $p \geq 3$ have been proposed by Tor Helleseth and Guang Gong (HG-sequences) in 2002 [9]. The sequences have two-level ideal autocorrelation and they are generalizations of ternary sequences with ideal autocorrelation proposed by Helleseth, Kumar, and Martinsen [10]. The authors have proved two theorems in which they have found two functions of the form

$$f(x) = \sum_{i=0}^{m} u_i x^{(q^{2i}+1)/2}$$

and

$$f(x) = \sum_{i=0}^{m} u_{m-i} x^{(q^{2i+1}+1)/(q+1)}$$

where $n/k = 2m + 1$ is odd, $q = p^n$, and α is a primitive element of Galois Field GF(p^n).

The non-binary sequence $\{s(t)\}$ over GF(p) given by

$$s(t) = Tr_n(f(\alpha^t))$$

has a two-level ideal autocorrelation function. Some of these non-binary sequences are shown in table 1.

3.5. Non-Binary Kasami Sequences

Liu and J. Komo have shown that nonbinary Kasami sequences over GF(p) can be obtained as an extension of binary Kasami sequences [13]. They have proved that the correlation values of a nonbinary Kasami set have $p + 2$ levels with maximum nontrivial correlation of $1 + p^m$. The authors have also developed the frequency of occurrence of the correlation levels for the nonbinary and binary Kasami sequences.

Table 1. Non-Binary Sequences with Ideal Two-Level Autocorrelation [10]

p	n	m	$s_0\, s_0 \ldots s_m$
3	5	2	2 1 2
3	5	2	2 2 1
3	7	3	2 1 2 2
3	7	3	2 2 1 2
3	7	3	2 2 2 1
3	9	4	2 1 1 2 2
3	9	4	2 2 1 2 1
3	9	4	2 1 2 2 1
5	5	2	3 1 4
5	5	2	3 4 1
5	7	3	3 1 4 4
5	7	3	3 4 1 4
5	7	3	3 4 4 1
7	5	2	4 1 6
7	5	2	4 6 1

The set of nonbinary Kasami sequences over GF(p), p is prime, is defined as [13]:

$$S=\{s_i(t) \mid 0 \le t \le N-1, 1 \le i \le p^m\},$$

where

$$s_i(t) = \mathrm{tr}_1^m\{\mathrm{tr}_m^n(a^t) + \gamma_i \alpha^{Tt}\},$$

$n = 2m$, $N = p^m - 1$, $T = p^m + 1$, α is a primitive element of GF(p^m), and γ_i takes on each value of GF(p^m) for $1 \le i \le p^m$.

In this set of nonbinary Kasami sequences over GF(p), similar to the binary case, one $s_i(t)$ is an m-sequence with period N and each other $s_i(t)$ is a sum of an m-sequence with period N and a different phase of an m-sequence with shorter period $M = p^m - 1$. The shorter m-sequence is a decimation T of the longer m-sequence.

3.6. *p*-ary Pseudo-Noise Sequences with Low Correlation Zone

Tang and Fan have constructed a new class of pseudo-noise sequences over GF(p) (TF-sequences) [18], based on GMW sequences in 2001. These sequences have such property that the out-of-phase autocorrelation and cross-correlation values are all equal to -1 in special low correlation zone (LCZ). Such sequences with LCZ are suitable for approximately synchronized CDMA system.

The p-ary pseudo-noise sequences with LCZ are constructed from two p-ary GMW sequences a and b. Then the p-ary sequence set is obtained

$$A = \{A, A - S^{T}b, \ldots, A - S^{(p^m - 2)T},$$
$$S^{(p^m - 1)T}\}$$

where S^i denotes left shift operator, S^ib denotes i-shift version of sequence b, and

$$T = \frac{p^n - 1}{p^m - 1},$$

where GF(p^m) is a subfield of GF(p^n) which are used to define the p-ary GMW sequences.

Some of p-ary pseudo-noise sequences with LCZ are shown in table 2 and their autocorrelation functions are presented in table 3.

As a result of short survey of p-ary PRSs described above, the following classification of p-ary sequences with low periodic correlation can be made (fig. 2).

Table 2. LCZ sequences of length $N = 80$, size $M = 3$, and LCZ $L = 9$ [18].

$x = a$	1 0 0 0 1 0 0 2 1 0 1 1 1 2 0 0 2 2 0 1 0 2 2 1 1 0 1 0 1 2 1 2 2 1 2 0 1 2 2 2 2 0 0 0 2 0 0 1 2 0 2 2 2 1 0 0 1 1 0 2 0 1 1 2 2 0 2 0 2 1 2 1 1 2 1 0 2 1 1 1
$y = a\text{-}S^{20}b$	1 1 1 2 2 0 2 2 2 1 2 0 0 0 1 0 0 1 1 0 1 2 2 1 0 0 1 2 0 2 0 1 1 2 2 0 2 0 2 1 2 2 2 1 1 0 1 1 1 2 1 0 0 0 2 0 0 2 2 0 2 1 1 2 0 0 2 1 0 1 0 2 2 1 1 0 1 0 1 2
$z = a\text{-}S^{60}b$	1 2 2 1 0 0 1 2 0 2 0 2 2 1 2 0 1 0 2 2 2 2 2 1 2 0 1 1 2 2 2 0 0 0 2 0 0 1 2 0 2 1 1 2 0 0 2 1 0 1 0 1 1 2 1 0 2 0 1 1 1 1 1 2 1 0 2 2 1 1 1 0 0 0 1 0 0 2 1 0

Table 3. Autocorrelation functions of the LCZ sequences [18].

$R_{x,\,x}$	80 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 - 1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$R_{y,\,y}$	80 -1 -1 -1 -1 -1 -1 -1 -1 -1 26 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -28 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -28 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 26 -1 -1 -1 -1 -1 -1 -1 -1 -1
$R_{z,\,z}$	80 -1 -1 -1 -1 -1 -1 -1 -1 -1 26 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -28 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -28 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 26 -1 -1 -1 -1 -1 -1 -1 -1 -1

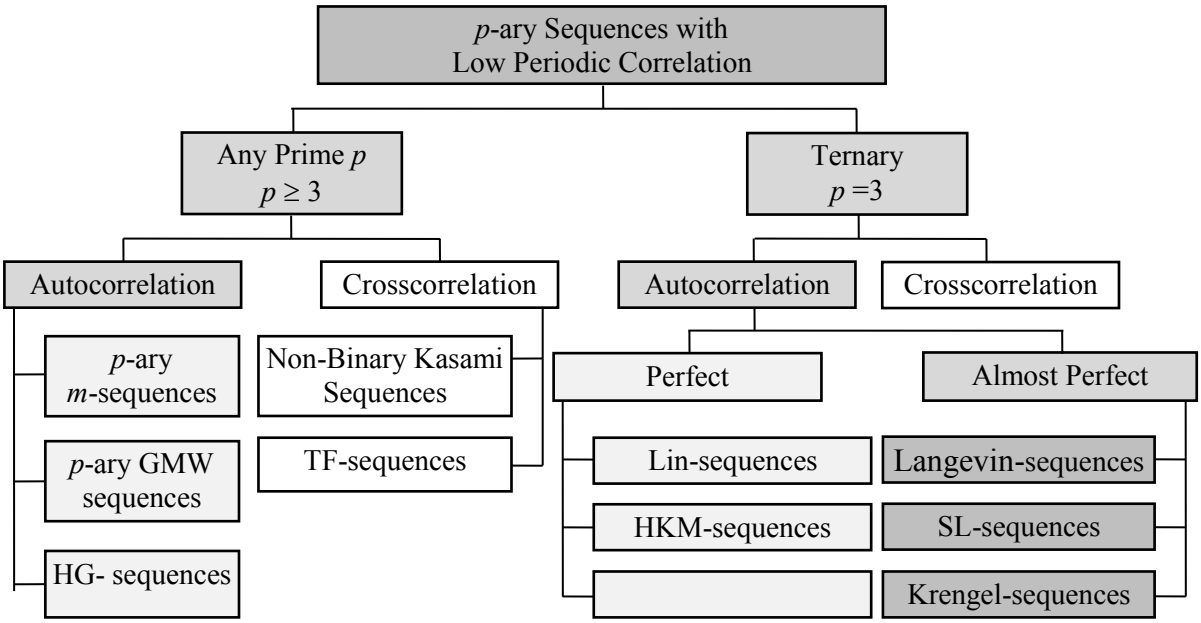

Fig. 2. Overview of *p*-ary PRSs.

4. Conclusion and Future Work

A classification of *p*-ary PRSs sequences is made without claiming its full completeness. Mainly the PRSs with low periodic correlation are divided into two branches depending on the used prime p – ternary sequences for $p = 3$ and sequences for any prime $p \geq 3$. PRSs can be divided into separate branches depending on their autocorrelation and crosscorrelation. A historical overview of the binary and *p*-ary sequences with good correlation is made. That short survey of currently known *p*-ary PRSs includes their main properties and fields of application.

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COMPARATIVE SIMULATING ANALYSIS OF TIMESTAMP ORDERING AND TWO-VERSION TWO PHASE LOCKING IN DISTRIBUTED DATABASES

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ABSTRACT: *This paper presents simulation models of two well known methods for concurrency control of transactions in distributed database systems. The paper considers an approach for modelling management of the transactions parallelism by the two-version two-phase locking (2V2PL) in its three modifications: Centralized 2V2PL, Primary copy 2V2PL and Distributed 2V2PL. The main point of research is timestamp ordering in Distributed Database Management Systems (DDBMS). The paper offers timestamp ordering (TO) service of the transactions. In order to avoid the deadlock problem we offer 2V2PL and timestamp ordering (TO) service of the transactions. The results from executing modelling algorithms by means of the simulations GPSS World environment are shown.*

KEY WORDS: *Distributed Databases, Distributed Transactions, Concurrency Control, Timestamp Ordering, Deadlocks, Two-Version Two-Phase Locking.*

The distributed database (DDB) is a distributed system, which is an aggregation of logically connected local databases, geographically distributed and unified by a computer network. Some of the most important functions of the systems for distributed database management are: synchronization of the application processes that operate in the distributed system and supply of the fault tolerance of the system. The application processes in the DDB system have to be managed in such a way so that the system remains whole even after emergency. There are several methods for concurrency control in order to provide wholeness of the information, such as two-phase locking (2PL), timestamp ordering (TO) and optimistic strategies (validation check up) [1], [2] and others. According to a number of authors the best of the three methods with respect to the response time

index in high workload in DDB system is the two-phase locking (2PL) protocol in its variants: Centralized 2PL, Primary copy 2PL and Distributed 2PL. The concurrency control by the pessimistic protocols has one main problem – the possibility of the transactions to be involved in the deadlocks. Some results of deadlock avoiding by using version of data architecture in DDB are given in [4]. The comparison analysis of algorithms for Ordering Network and Distributed 2PL in the case of full data replication is given in [6].

The using of multi-version architecture arise problems with version storage because the volume of old versions could become higher than the volume of the current database and due to this fact it could be difficult to store these old data. Multi-version protocols have been developed and a limitation of version number is implemented there due to this reason. A similar two-version 2PL (2V2PL) protocol is suggested and it is proved that deadlocks are impossible in 2V2PL client/server database systems [3]. The problems of 2V2PL application have been existed there needed to be investigated. This paper presents algorithms modelling the 2V2PL protocols in distributed databases – central protocol, primary copy 2V2PL and distributed protocol and the simulation results (summarized by throughput and frequency distribution of response time) are compared with the results from the simulation of timestamp ordering under the same initial conditions.

Basic Elements of the GPSS Simulation Models

The simulations of Centralized 2V2PL, Primary copy 2V2PL, Distributed 2V2PL and Distributed Timestamp algorithms are developed by using the GPSS World environment.

Six flows of GPSS transactions are generated in 2V2PL and TO DDBMS models. The modelling algorithms and the running schemes of distributed transaction for 2V2PL and TO protocols in DDBMS are described in details in [5] and [8]. Every GPSS transaction represents global transaction in DDB and every flow is characterized by intensity λ. The generated transactions in the models process 2 or 1 data elements. The probability for longer transaction is higher than the probability of transaction processed 1 element. Every data element has two replicas. Distribution of replicas of data elements is defined by the function DistrS1 – DistrS4.

Some parameters of GPSS model transactions in DDBMS are used:

P1 - Number of the generating transactions. The value is a sum of System Numeric Attribute MP2 and the number of the site;

P2 - Number of the site, where the transaction is generated. The value is a number from 1 to <number stream transactions>;

P$el1 / P$el2 - Number of the first / second processed data element by the transaction (El1) / (El2). The value is a random number and is uniformly distributed in the interval [1, NumEl];

P$bl1 / P$bl2 - Type of the operation over the element *El1/El2*: 1 (r) – if read; 2 (w) – if write; In 2V2PL models the value is 4 – certified lock, if second (uncommitted) version of El1/El2 has been created by the transaction;
P5 - Phase of the transactions processing. The possible values are from 0 to 3;
P$prim1/ P$prim2 - In Primary copy 2V2PL model - number of the primary site of the first/second element, which the generated transaction will be read or write;
P6 / P7 - Number of the site where the first/second copy of the first data element El1 is stored;

Transmission over the channels is simulated by delays with blocks ADVANCE which are defined by the matrix RAZST and RAZDEV.

Description of Simulation Models of Two-Version 2PL in DDBMS

Fig.1 represents a structural scheme of the simulating algorithm of execution of global (distributed) transaction T_{P2}^{P1} by Centralized 2V2PL, initiated from site S_{P2} and refreshing the data elements *El1* having copies in local databases LDB_{P6} and LDB_{P7} and element *El2* with copies in local databases LDB_{P8} and LDB_{P9} located in corresponding sites respectively S_{P6} and S_{P7}, and S_{P8} and S_{P9}. The Primary copy 2V2PL model execution is similar. In that case the requests for data elements locks are sent not only to the central lock manager LM_0, but to corresponding primary lock managers LM_{prim1} and LM_{prim2} also. The requests for locking of the data elements wait for the release of the lock manager (LM) in the queue before it QLM. They queue firstly according to a priority and secondly according to the order of getting there, thirdly according to the number of the site – generator. The Centralized 2V2PL model is described in [5].

The basic steps in the Centralized 2V2PL and Primary Copy 2V2PL algorithms are as given in fig.1 and fig.2.

Transaction coordinator TC_{P2} splits global transaction T_{P1}^{P2} in two sub-transactions. These sub-transactions are directed at lock manager LM_0 to get the proper locks for the elements *El1* and *El2*.

After given and granted locks, the transaction T_{P1}^{Pel1} splits in two sub-transaction. If the transaction T_{P1}^{Pel1} is required to read only the element *El1* then it doesn't split in two separate sub-transactions. Sub-transactions are directed to the corresponding data managers. After that they are transmitted in the network to data managers If they have to be committed in a remote node.

Many operations read/write are committed in the sites-executors, where the corresponding data managers are included.

If the sites-executors don't match to the site – initiator of T_{P1}^{P2} after the sub-transactions have finished their actions in sites S_{P6}, S_{P7} and S_{P8}, S_{P9}, they are transmitted over the communication network to the transaction manager.

Transaction manager of T_{P1}^{P2} sends messages, which consists of requests for releasing the elements *El1* and *El2* to the correspondent lock manager, when it receives messages for ends of sub-transactions.

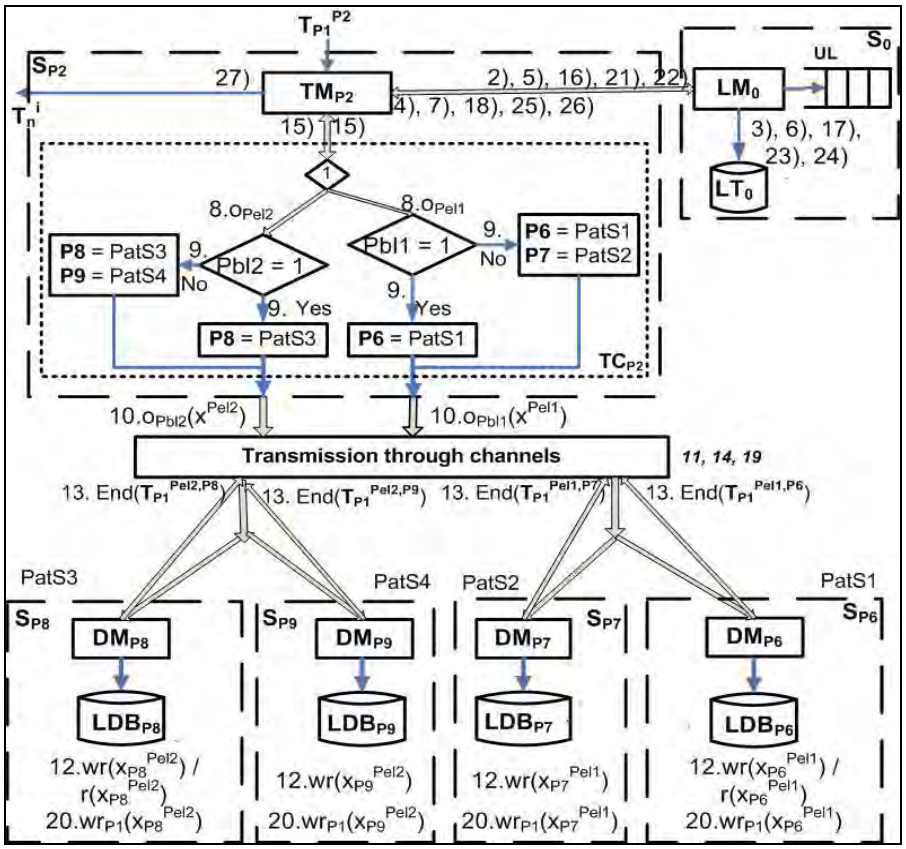

Fig. 1 Simulation model of execution of global transaction by centralized 2V2PL protocol

After fixing the results from sub-transaction processing in sites the transactions are sent through the communication network to the transaction manager.

Transaction manager of T_{P1}^{P2} sends messages to the centralized lock manager when it gets the messages for the end of the sub-transactions. These messages contain requests to request a release for locks of the elements *El1* and El2 .

Transaction T_{P1}^{P2} quits the system as soon as sub-transactions T_{P1}^{Pel1} and T_{P1}^{Pel2} finish their process.

When distributed 2V2PL is taken into consideration the requests for element locking x are sent straight to the sites-executors, in which local databases copies of x are stored. Local lock managers, which are responsible for locking the copy of element x are situated in the sites-executors.

Fig. 2 represents a structural scheme of the simulating algorithm of execution of global (distributed) transaction T_{P2}^{P1} by Distributed 2V2PL, initiated from site S_{P2}. The difference is that requests for data copy locks are sent to S_{P6} and S_{P7}, and S_{P8} and S_{P9}, because the lock managers and the lock tables are in the site – executors.

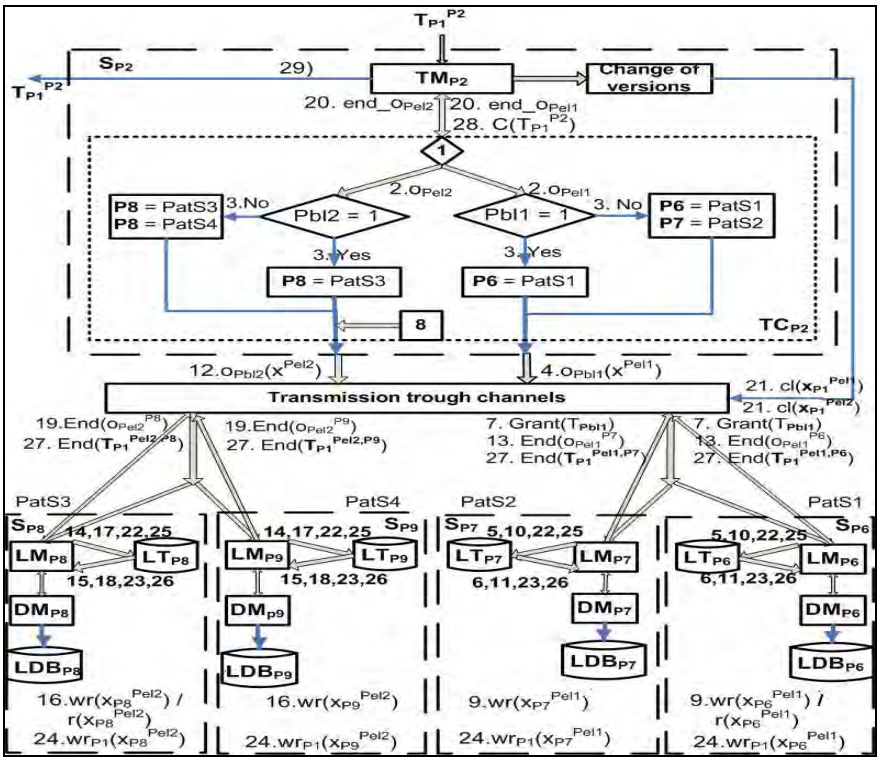

Fig. 2 Simulation model of execution of global transaction by distributed 2V2PL protocol

Simulating Timestamp Ordering Method in Distributed Databases

The Timestamp ordering protocol is described in [1] and by other authors. The algorithm uses Tomas rules. According to this algorithm:

- To each transaction *T* is assigned timestamp, denoting the time of its coming into the system and the number of the site-generator. When a transaction read/write data element, it records its timestamp (TS) in it;
- If a transaction ***T*** wants to update data element ***x***:

If TS(***T***) < readTS(***x***), then restart(***T***);
If TS(**T**) < writeTS(***x***), then ignore(***T***);
If TS(***T***) > writeTS(***x***), then execute(***T***);

- If a transaction wants to read data element ***x***:

If TS(***T***) < writeTS(***x***), then restart (***T***);
If TS(***T***) > writeTS(***x***), then execute(***T***).

The structural scheme of a modelling algorithm for distributed transactions management in timestamp ordering algorithm in DDB is shown in fig. 3.

The basic steps in the synthesized DTO modelling algorithm are given in [8].

The operations when T is not taken of consideration are not shown because they are modelled as execution without anything being recorded in the local databases.

The results are received for long period of monitoring time for about 28800 model units and summary intensity of incoming transactions flows $\lambda = 100\ tr/s$.

Comparative Analysis of Simulation Results

The frequency distribution of response time (RT) is given on fig. 4, fig. 5, fig. 6 and fig. 7.

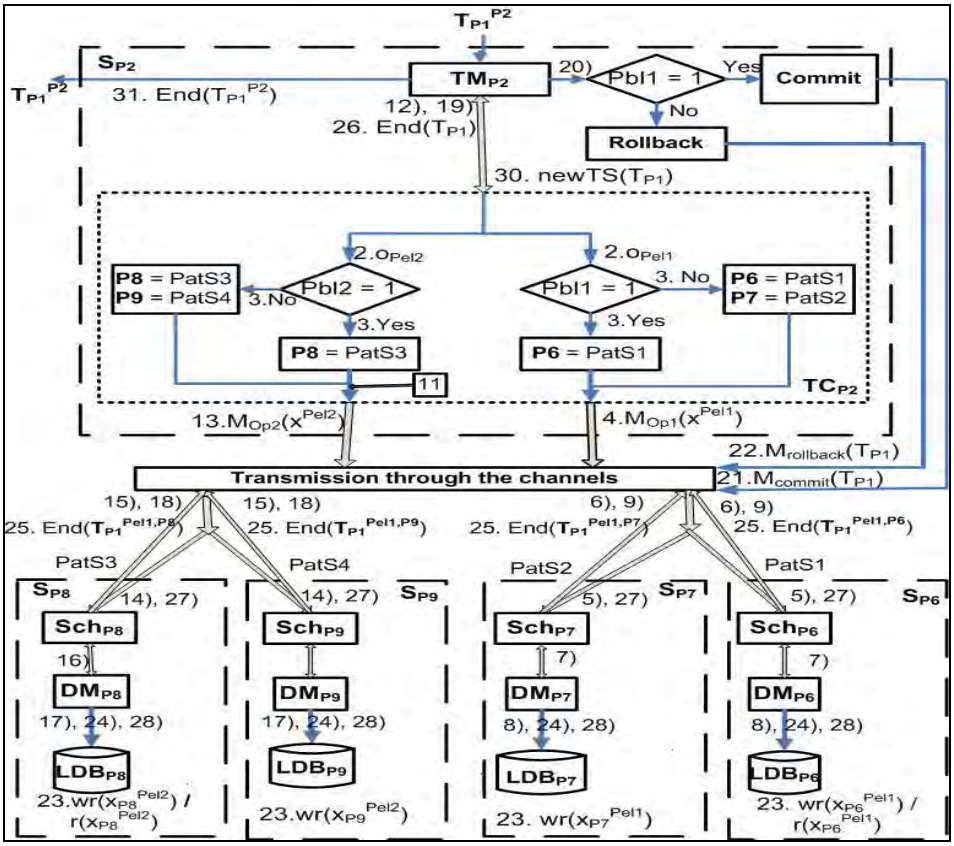

Fig. 3 Simulation model of execution of global transaction by distributed TO protocol

The graphics are generated by GPSS World according to the tables of frequency distribution, which is constructed automatically for every relevant simulation. The number of GPSS transactions is given on axis Y vs. the relevant process time for the proper interval on axis X. They are represented by four histograms. Time intervals on axis X have length 200ms.

The comparison of the graphs for frequency distribution of response time for centralized 2V2PL and Primary copy 2V2PL given in fig. 4 and fig. 5 with the template one of [7, p.74] show that the average RT (0.826 s and 0.688 s) and the

standard deviation (0.350 s and 0.308 s) are very good results. Moreover, the histograms are completely fitted in the axis X for the interval [0, 0,900]. According to the standard specification the upper limit of that interval should be 90% from the time response. So with 10% wrongness, it should be claimed the response time RT pertains to the specification considering its values for long monitoring time.

The histogram for frequency distribution of RT for distributed 2V2PL is given on fig. 6. It has almost full congruence with the standard specification. The histogram is symmetric to the line passing through the maximum and is parallel to the axis Y. Moreover the histogram is fitted in the axis X for the interval [0, 90%RT]. The diagram in fig. 7 corresponds to the stereotyped graphic of response time, shown in [7, p.74]. The trust-worthiness of the results of modeling of tree types 2V2PL algorithms is confirmed from other simulation research for simple transactions has being processed one data element. Other authors' researches made for 2PL one-version architecture of data in DDBMS [6] confirm that as well.

It is obvious that the average response time is the greatest one for centralized 2V2PL. The RT for primary copy 2V2PL is smaller and the smallest one response time is for distributed 2V2PL.

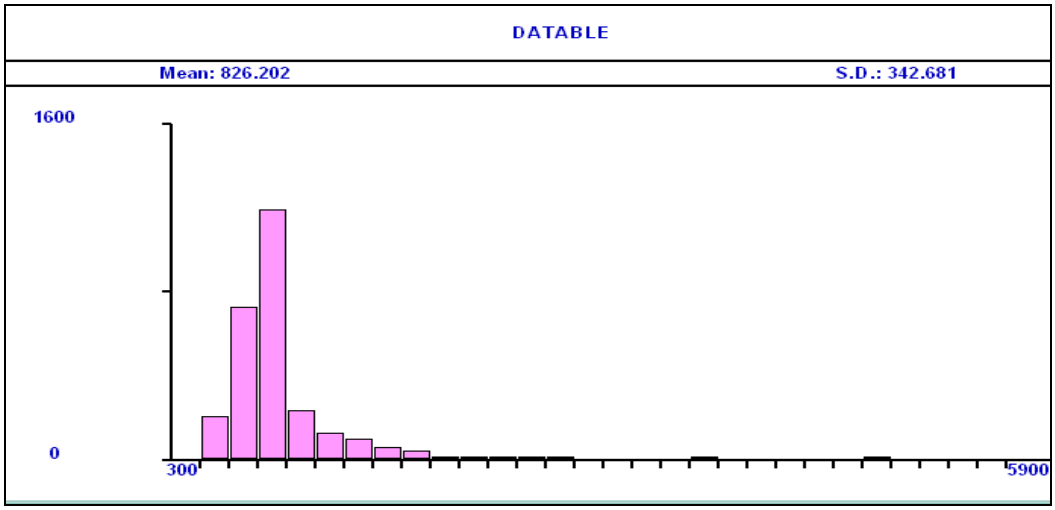

Fig. 4 Frequency distribution of transaction RT in centralized 2V2PL model.

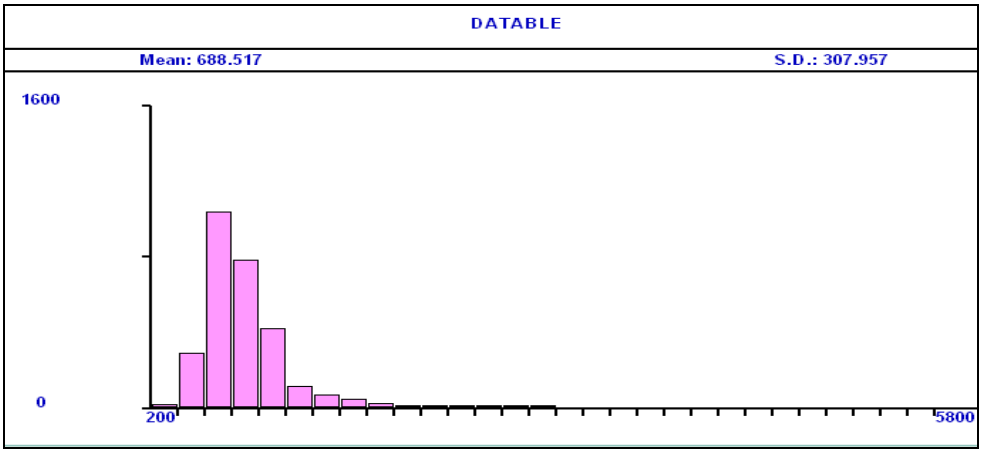

Fig. 5 Frequency distribution of transaction RT in Primary copy 2V2PL model.

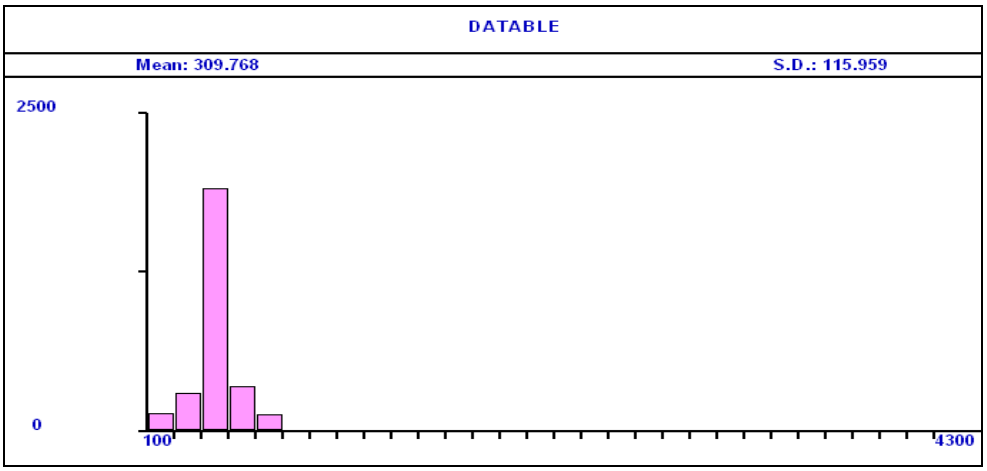

Fig. 6 Frequency distribution of transaction RT in distributed 2V2PL model.

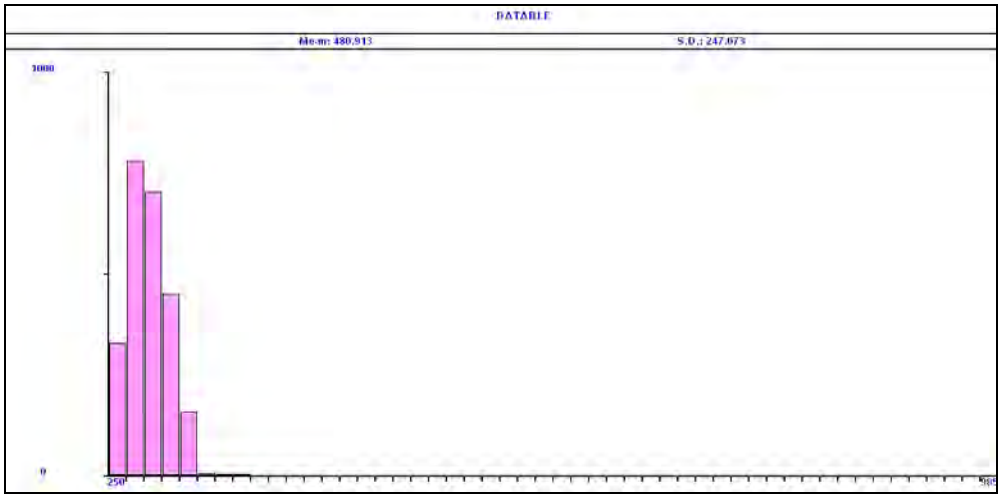

Fig. 7 Frequency distribution of transaction RT in DTO model

The summary comparative results of throughput (TP) are given on fig. 8, fig. 9 and fig. 10.

The results are obtained for different intensities of input flow and load transactions (min, average and max). The analysis of fig. 8, fig. 9 and fig. 10 shows that system's throughput is too close when the same system load is used for the two approaches – 2V2PL and Timestamp ordering in DDB.

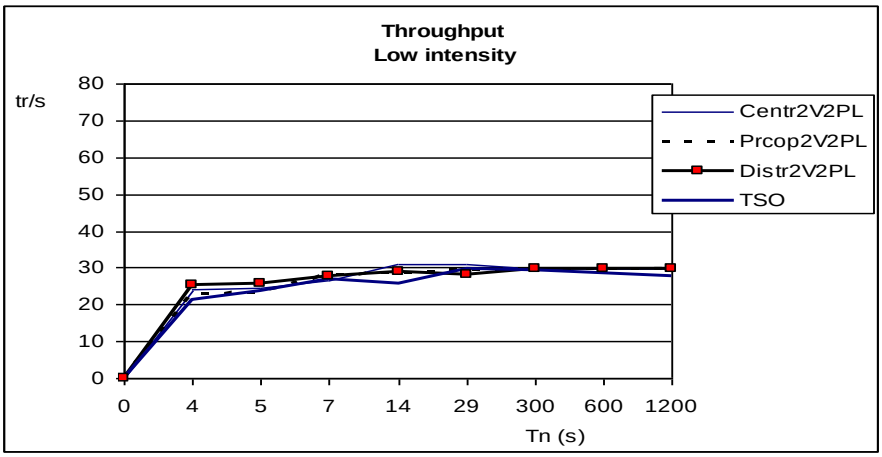

Fig. 8 TP for 2V2PL and DTO for min load

Differences can be seen for the four protocols only under maximal load of the system. The comparative analysis shows that the max load in static mode is very different. As could be seen the max load TP for distributed 2V2PL is reached before 3600 model units.

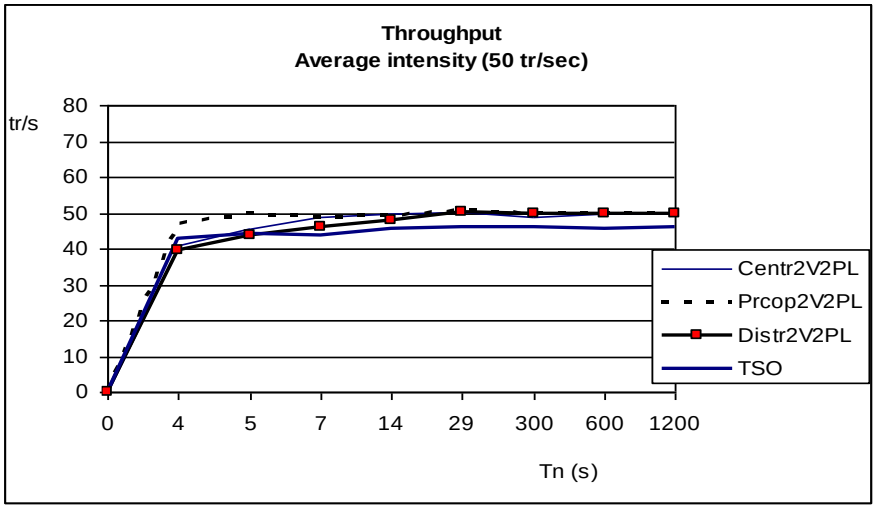

Fig. 9 TP for 2V2PL and DTO for average load

For primary copy 2V2PL it is before 14400 model units, whereas the max load TP is after 300000 model units for centralized 2V2PL. The comparative analysis of the results for two-version 2PL algorithms and DTO algorithm shows that the throughput has higher value in Distributed 2V2PL and is lower in distributed TO model. Moreover, system shows more stable growth and behavior for 2V2PL protocols then for distributed timestamp ordering.

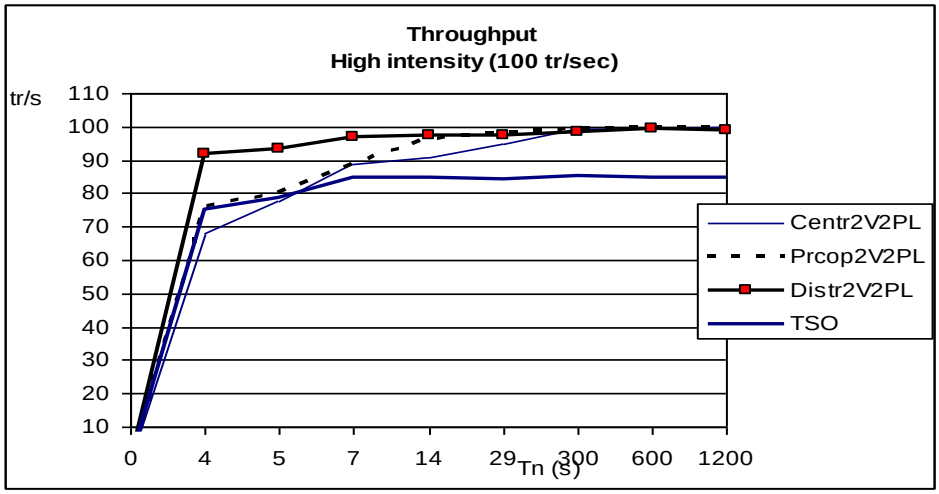

Fig. 10 TP for 2V2PL and DTO for max load

The comparative analysis of the results for two-version 2PL algorithms and DTO algorithm shows that the response time is lower for 2V2PL than similar one in distributed TO.

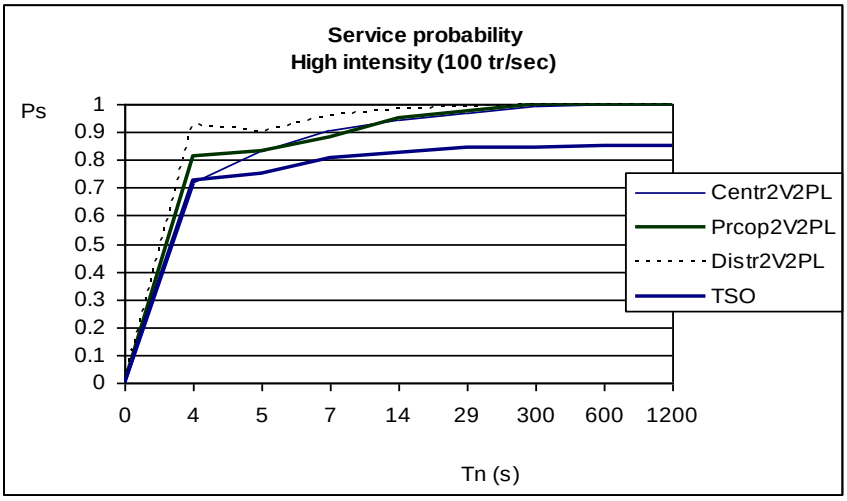

Fig. 11 Probability service of the models

The comparative analysis of the results of modeling the tree algorithms, centralized 2V2PL, primary copy 2V2PL and distributed 2V2PL, shows the fastest reaching of max values of TP for distributed 2V2PL and the smallest average RT. These facts make distributed 2V2PL protocol much effective and with the highest performance for DDBMS. This can be seen at fig.11 and it proves our analysis and researches.

Conclusions and Future Work

A program code for GPSS World is developed which can be used to model the processing of distributed transactions in time-stamping protocol and in 2V2PL protocols in DDB.

The use of the mechanisms for transactions division and submission of certain values and their parameters makes the receiving of results from the execution of transactions in systems with distributed databases possible.

The created simulation models describe the real processes with a sufficient accuracy and allow receiving a reliable estimate for the changes of the throughput capability of the system in given parameters of the incoming transaction streams. The models are limited for the number of input flows and length of processed transactions because of the limitation of other similar models compared to them.

The conducted simulations and the results confirm the functionality of the modeling algorithms.

It is necessary to develop simulation models of concurrency control algorithms with much complexity by the meaning of the number of element replicas and transaction length in number of elements.

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Original Contribution

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ANALYSIS AND ASSESSMENT THE SECURITY VULNERABILITY IN COMMUNICATION PROCESSES IN A GIVEN COMPUTER NETWORK

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ABSTRACT: *The analysis and assessment the security vulnerability communication processes is very important and obligatory on each network and computer system administrator and cyber-professionals. In this paper, a detailed listening of the UDP endpoints and TCP connections is made.*

KEY WORDS: *Computer and network security, Cyber-attacks, Databases, Port, Processes, TCP, UDP, Vulnerability, Windows 7.*

1. Introduction

The analysis and assessment the security vulnerability communication processes is very important and obligatory on each network and computer system administrator and cyber-professionals. In this paper, a detailed listening of the UDP endpoints and TCP connections is made. In the practice, some software platforms give common information about all processes and network connections and thanks to the achieved results, many computer and network professionals are able to detect and analyze the malicious vulnerabilities in the selected operating system. This paper is structured as follows. First, in section 2, a related work for the different assessments of communication and computer processes is made. After that, in section 3, an implementation of windows software program for detailed listening of TCP and UDP connection is performed [1],[2],[3],[4],[5],[6],[7],[8],[13]. The conclusions and recommendations are made in section 4.

2. Related work

In [5] analysis of TCP processing by David Clark is presented. In [4] some protocols for packet network intercommunication in the selected operating system by Vinton Cerf and Robert Icahn is made. In [7] a comprehensive and illustrated guide for TCP/IP and Internet protocols by Charles Kozierok is presented. In [1] vulnerability analysis for evaluating quality of protection of security policies by Muhammad Abedin, Syeda Nessa, Ehab Al-Shaer, and Latifur Khan is made.

3. Analysis and assessment of the running communication processes

In fact, some computer and network programs give detailed information about the communication processes in determined operating system. In this paper the Windows program TCPView is tested. This software by Mark Russinovich and Bryce Cogswell is made [13]. Thanks to this software program each plain user and system administrator is able to obtain detailed listening information about all TCP and UDP endpoints and connections, including the process id, type of transport protocol, local address, local port, remote address, the current network state, sent packets, sent Bytes and other information is shown and presented [6],[13]. A common view of the started program in shown on fig.1.

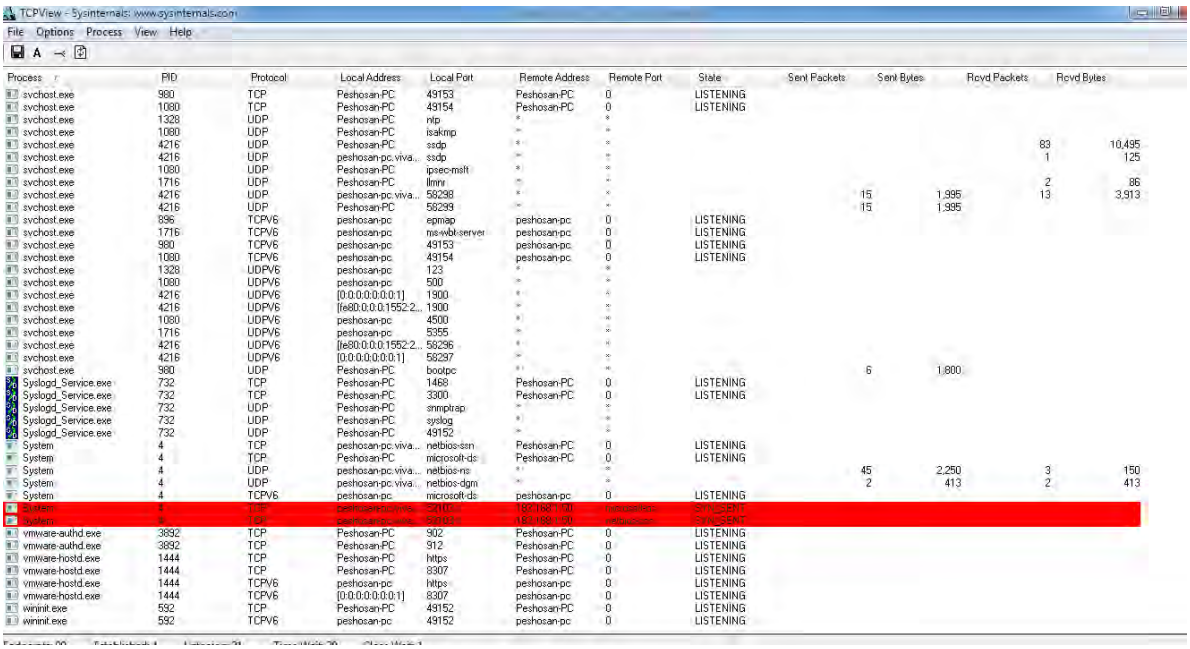

Fig.1. Common view of the started software

The process PRTG Probe.exe on fig.2 is presented.

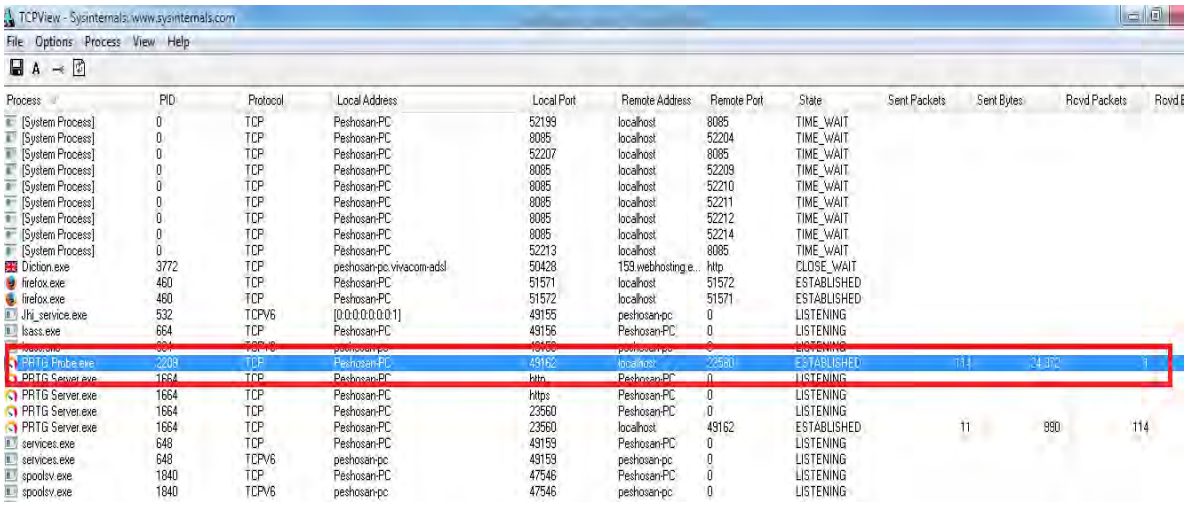

Fig.2. Common view of the started software

Each user is able to close established TCP/IP connection. This operation could be made by right clicking on the determined connection and then the user must choose “Close Connection” from the resulting context menu. This is shown on fig.3.

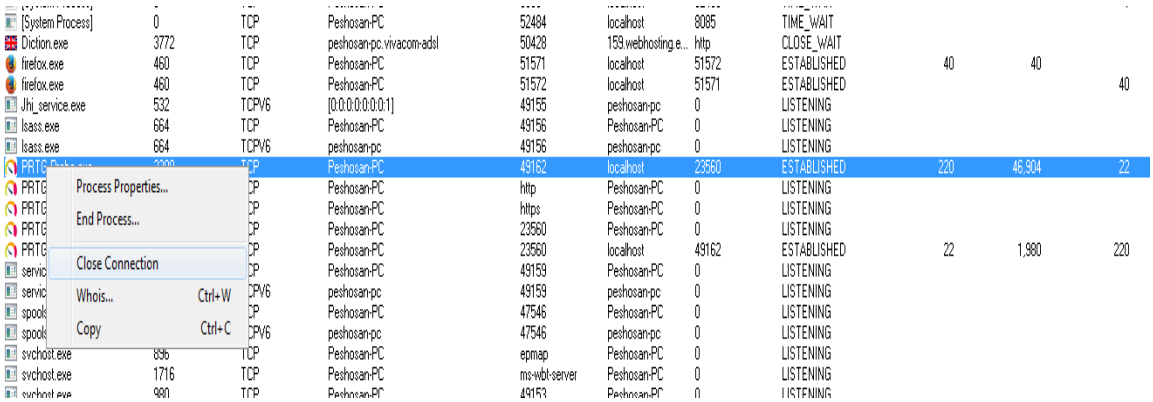

Fig.3. Closing the selected connection

Other function of this program is to obtain detailed information about registered domain. In this case, the domain “abv.bg” [8],[9],[10],[12] with http protocol is tested. This is shown on fig.4.

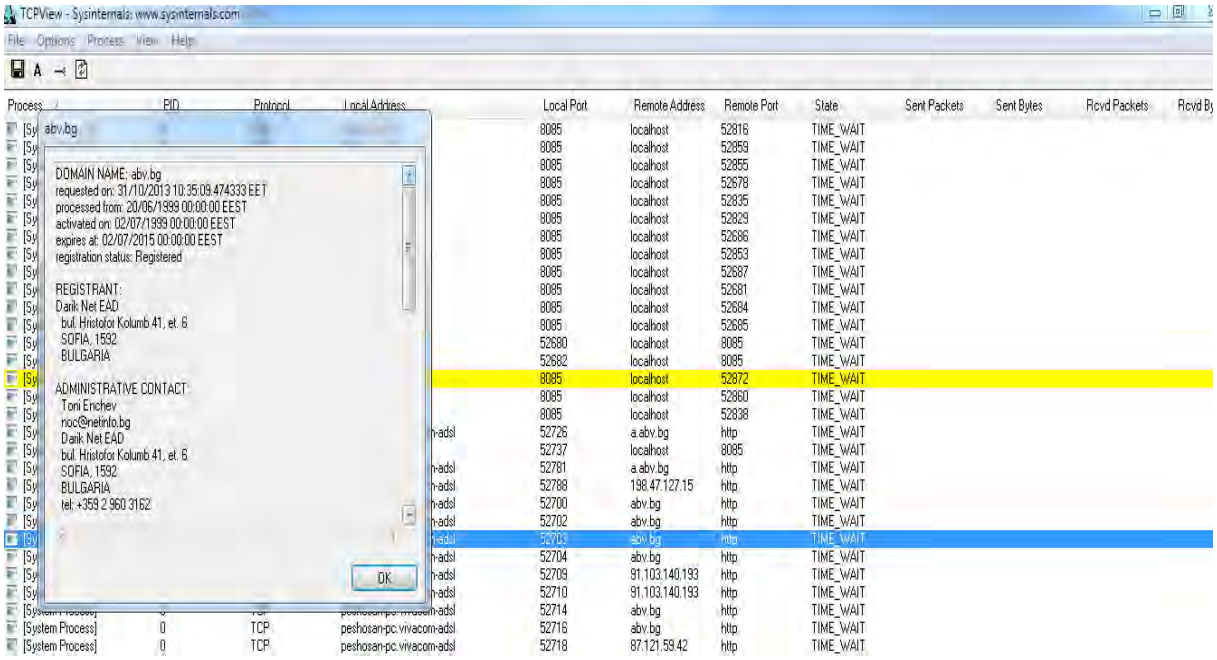

Fig.4. Obtaining information about the domain “abv.bg”

In order to analyze and assess all of the running processes, there is an option that allows the output window to be saved as a “.txt” file [13]. After that this information could be used for making detailed reference of the entire operating system [3],[5],[7],[11],[13]. This is shown on fig.5.

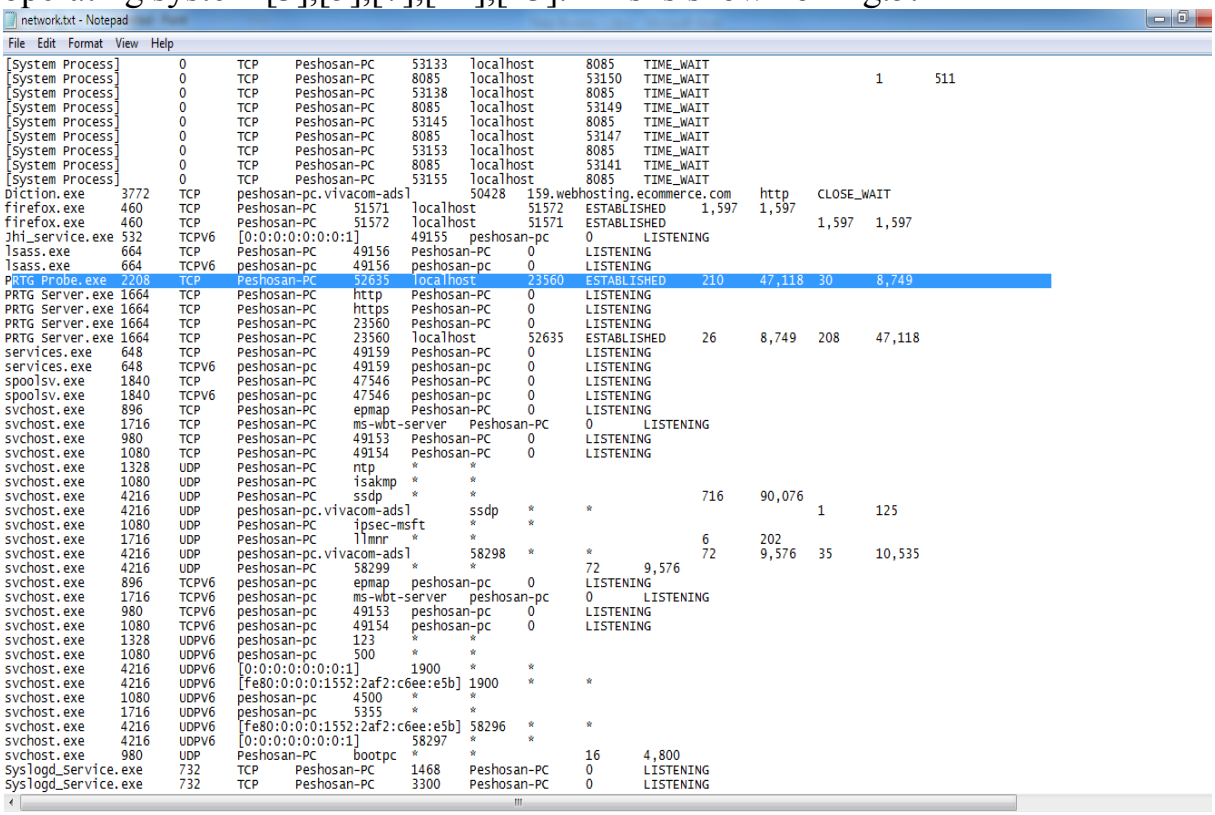

Fig.5. The saved text file “network.txt”

Thanks to this program each plain user, system administrator and cyber-professionals is able to obtain detailed information about the running processes in the determined operating system and thereby to know which of them vulnerability for the current operating system is. This research on the operating system Windows 7 Enterprise 32-bit is made [1],[2],[4],[6],[12].

4. Conclusion

Each security professional and specialist must always observe and detect the vulnerabilities, flaws, weaknesses, exploits and other specific software that can cause a total compromise of the selected operating system integrity and total shutdown of the affected confidential resources. Therefore, the attackers or cyber-criminals are able to obtain all computer and network resource completely unavailable forever. Therefore, it is important the flaws and suspicious processes terminated in host computer system and therefore the risk of cyber-attack could be reduced.

Acknowledgements

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Original Contribution

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USING HTTP FILTER TO ANALYZE AND MONITOR THE VULNERABILITY AND SECURITY STATES IN DETERMINED COMPUTER NETWORK

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ABSTRACT: *In this paper, an advanced content analyzing and monitoring using http filter is made. Most of the vulnerabilities with e-mail messages, Web content pages, downloaded and upload files, instant messages and voice conversations are connected. Therefore, it is recommended each network administrator, cyber-professionals, system administrator and plain user to analyze, monitor and capture different set of data that with the http protocol is concerned.*

KEY WORDS: *Analyzing, Computer and network security, Cyber-attacks, Http, Databases, Port, Processes, Security, Vulnerability, Web, Windows 7.*

1. Introduction

In this paper, an advanced content analyzing and monitoring using http filter is made. Most of the vulnerabilities with e-mail messages, Web content pages, downloaded and upload files, instant messages and voice conversations are connected [16]. Therefore, it is recommend each network administrator, cyber-professionals, system administrator and plain user to analyze, monitor and capture different set of data that with the http protocol is concerned [15]. The computer networks are vulnerable and weak to unauthorized access and attacks that could cause some hardware and software damages to determined host victim [1],[2],[3],[4],[5],[6],[7],[8],[9],[13]. This paper is structured as follows. First, in section 2, different special methods for measurement and analysis of http traffic are made. After that, in section 3, a http filter for analyzing and monitoring the active connections in the LAN (192.168.1.0/24 is performed [15]. The achieved results are presented in section 4, the conclusions and recommendations are made in section 5.

2. Related work

In [13] a queueing model for HTTP traffic over IEEE 802.11 WLANs by Daniele Miorandi, Arzad Kherani, Eitan Altman is performed. In [4] a special method for measurement and analysis of http traffic by Yogesh Bhole, Adrian Popescu is made. In [8] measuring normality in HTTP traffic for anomaly-based intrusion detection by Juan Estévez-Tapiador, Pedro Garcia-Teodoro, Jesús Diaz-Verdejo is achieved. In [7] analysis of TCP processing by David Clark is presented. In [6] some protocols for packet network intercommunication in the selected operating system by Vinton Cerf and Robert Icahn is made. In [10] a comprehensive and illustrated guide for TCP/IP and Internet protocols by Charles Kozierok is presented. In [1] vulnerability analysis for evaluating quality of protection of security policies by Muhammad Abedin, Syeda Nessa, Ehab Al-Shaer, and Latifur Khan is made.

3. Experiment

The experiment in specialized university computer lab is made. The network ID of this local area network (LAN) is 192.168.1.0/24. The used software program is NetResident version 2.1 (Build 592) and it is in Pro mode state. Initially was necessary to be configured the software product. This program has used TCP port #4201 in order to communicate with NetResident service [7],[8]. Other important thing is the program must get permission to communicate through windows firewall. The following experiments only with education intend and purpose is made [11],[12],[13],[14]. The Microsoft windows 7 Enterprise SP1 operating system in the scanning host has been used. On fig.1 the interface overview of NetResident is shown [1],[6],[10].

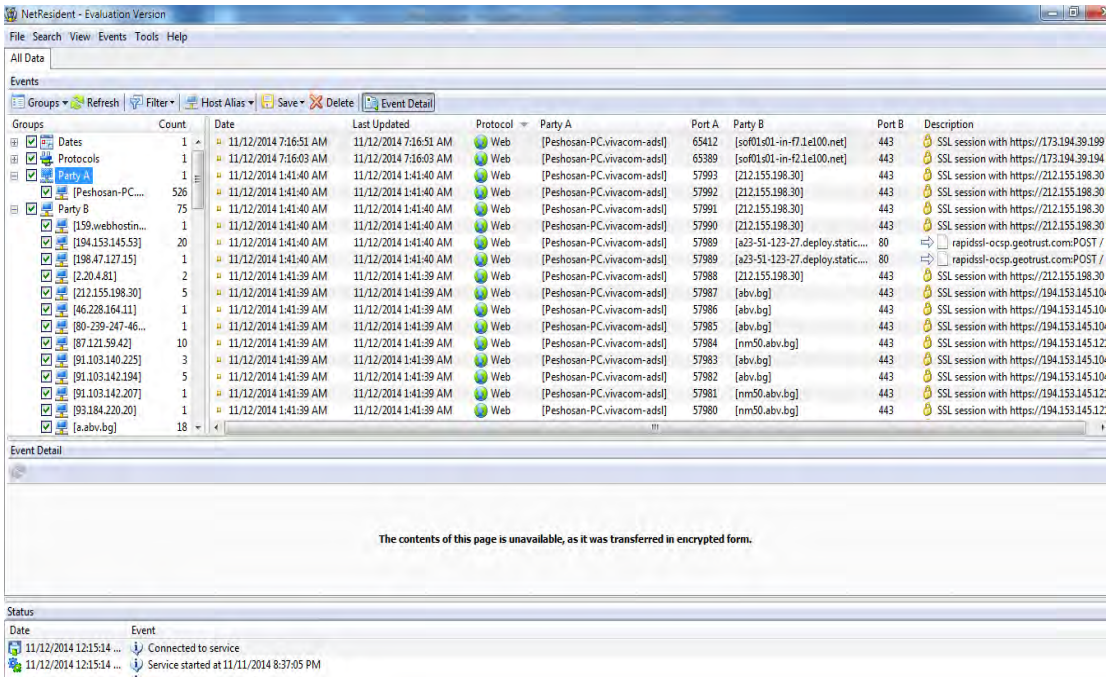


Fig. 1. The successfully started program software

The software product consists of the following special options:

- capturing the information of following social networks like Twitter, Facebook, LinkedIn, MySpace, Google+, Xing, Tumblr, Odnoklassniki, LiveJournal, VKontakte, StudiVZ, MeinVZ, SchuelerVZ, and LiveInternet;
- this program has improved ICQ, HTTP, SOCKS 4 and SOCKS proxy support;
- supporting AOL Mail, Mail.ru and Yandex.Pochta services;
- IPv6 support and implementation;
- this program has improved application performance when running on multi-core CPU computers;
- the program software has a configurable real-time traffic filtering options for HTTP and mail protocols;
- this program is able to capture, store, summarize, analyze, monitor and edit the network events such as e-mail messages, Web content pages, downloaded different type of files, instant messages and voice conversations [1],[4],[5],[6],[7],[8],[12],[13],[15].

4. Results

The captured information of the social network facebook on fig.2 is shown.

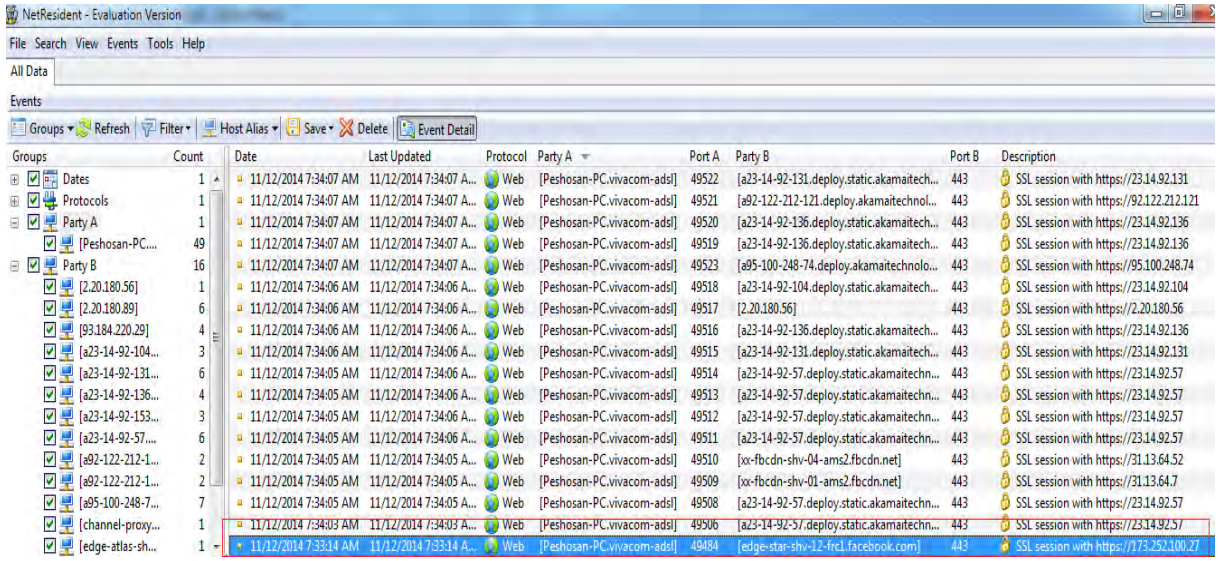


Fig. 2. The captured information between the host and facebook

On fig.3 has given the following information about [4],[8],[14],[15]:

- the name and IP address of party A and party B;
- the current date and last updated event;
- the application protocol – web;
- the port of party A;

- the port of party B;
- detailed description;

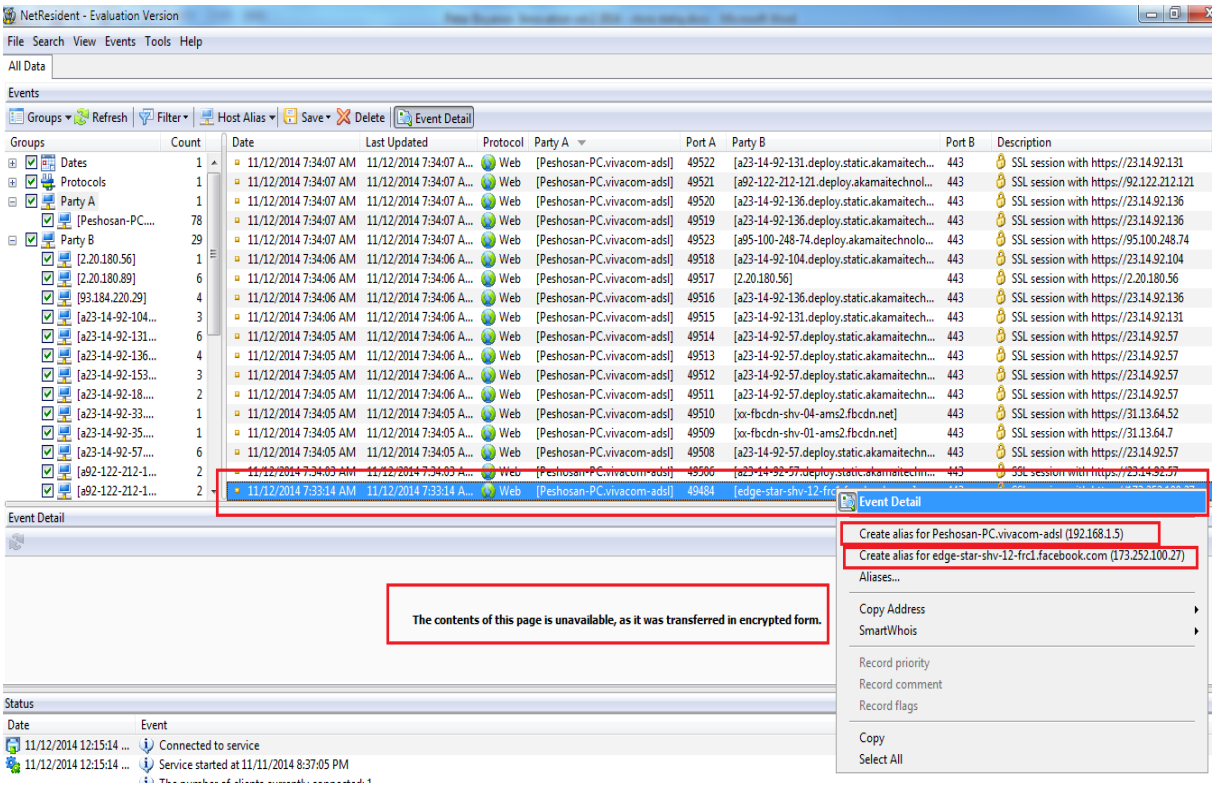


Fig. 3. Event detail between party A and party B

It is important to be marked that the contents of the selected page is unavailable, because it was transferred in encrypted form. The reason for it is the existence of SSL [16] session.

On fig.4 a captured and stored picture is shown.

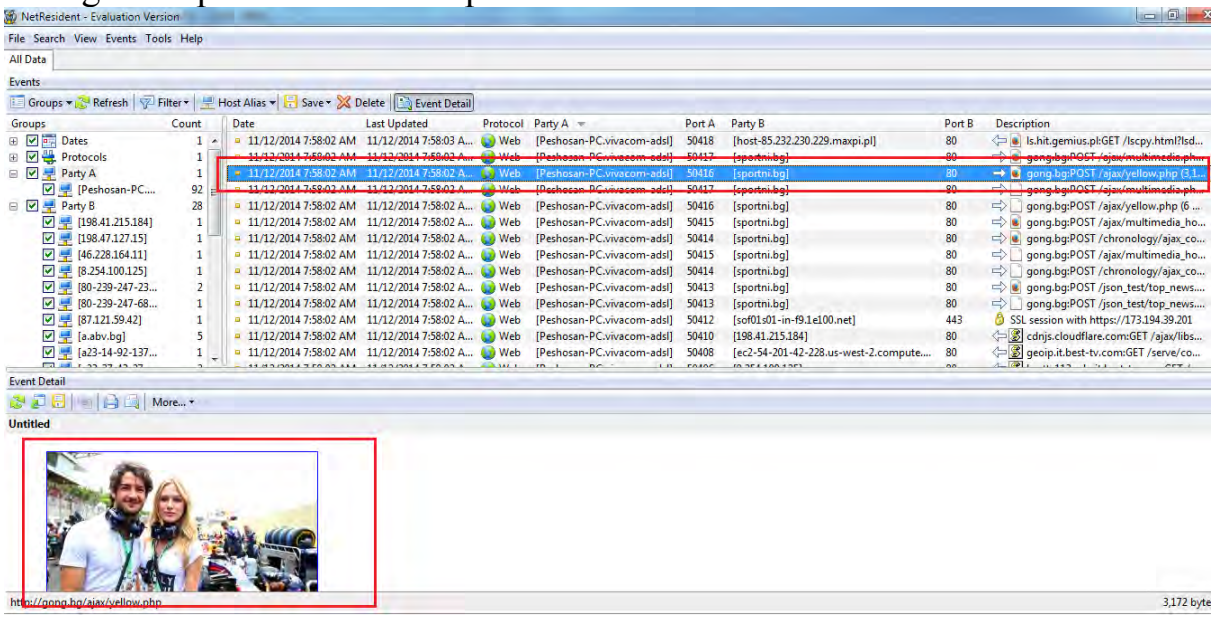
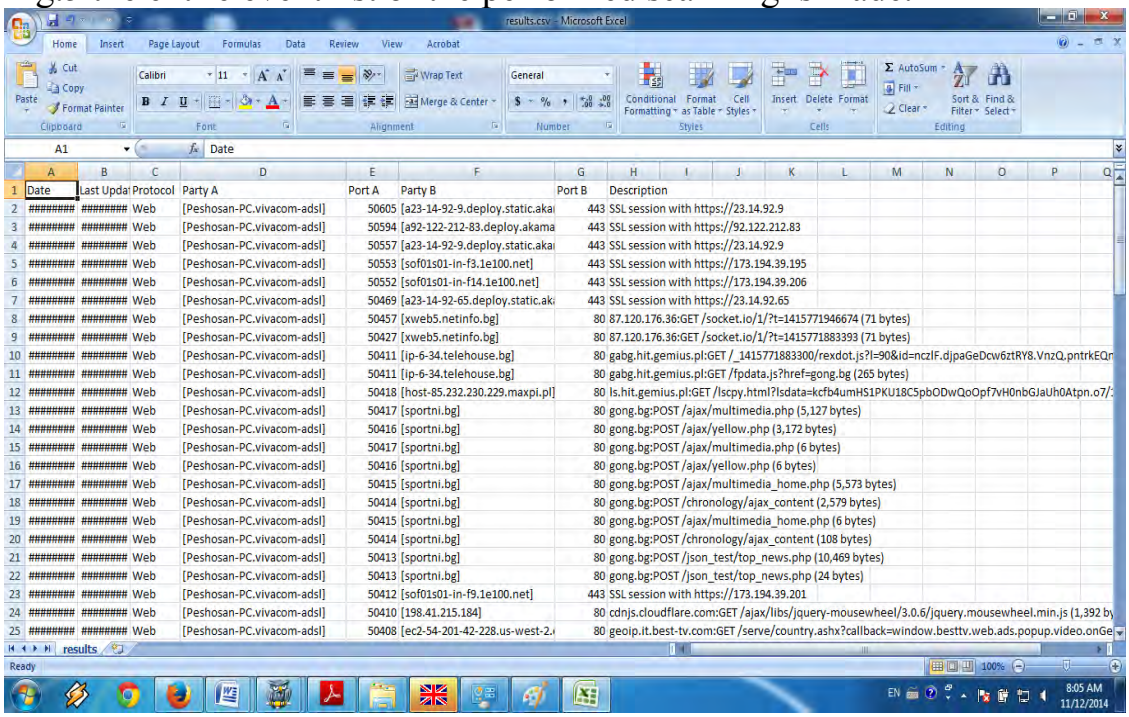


Fig. 4 Captured and stored picture

It is important to be marked that the contents of the selected page (sportni.bg) is available and thanks to the program software there could be seen the captured and stored picture.

On fig.5 the entire event list of the performed scanning is made.



Date	Last Upda	Protocol	Party A	Port A	Party B	Port B	Description
########	########	Web	[Peshosan-PC.vivacom-adsl]	50605	[a23-14-92-9.deploy.static.aka	443	SSL session with https://23.14.92.9
########	########	Web	[Peshosan-PC.vivacom-adsl]	50594	[a92-122-212-83.deploy.akama	443	SSL session with https://92.122.212.83
########	########	Web	[Peshosan-PC.vivacom-adsl]	50557	[a23-14-92-9.deploy.static.aka	443	SSL session with https://23.14.92.9
########	########	Web	[Peshosan-PC.vivacom-adsl]	50553	[sof01s01-in-f3.1e100.net]	443	SSL session with https://173.194.39.195
########	########	Web	[Peshosan-PC.vivacom-adsl]	50552	[sof01s01-in-f14.1e100.net]	443	SSL session with https://173.194.39.206
########	########	Web	[Peshosan-PC.vivacom-adsl]	50469	[a23-14-92-65.deploy.static.ak	443	SSL session with https://23.14.92.65
########	########	Web	[Peshosan-PC.vivacom-adsl]	50457	[xweb5.netinfo.bg]	80	87.120.176.36:GET /socket.io/1/?t=1415771946674 (71 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50427	[xweb5.netinfo.bg]	80	87.120.176.36:GET /socket.io/1/?t=1415771883393 (71 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50411	[ip-6-34.telehouse.bg]	80	gabg.hit.gemius.pl:GET /_1415771883300/rexdot.js?l=90&id=nczlF.djpaGeDcw6ztRY8.VnzQ.pntrkEQr
########	########	Web	[Peshosan-PC.vivacom-adsl]	50411	[ip-6-34.telehouse.bg]	80	gabg.hit.gemius.pl:GET /fpdata.js?href=gong.bg (265 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50418	[host-85.232.230.229.maxpi.pl]	80	ls.hit.gemius.pl:GET /lscpy.html?lsdata=kcfb4umHS1PKU18C5pbODwQoOpf7vH0nbGJaUh0Atpn.o7/
########	########	Web	[Peshosan-PC.vivacom-adsl]	50417	[sportni.bg]	80	gong.bg:POST /ajax/multimedia.php (5,127 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50416	[sportni.bg]	80	gong.bg:POST /ajax/yellow.php (3,172 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50417	[sportni.bg]	80	gong.bg:POST /ajax/multimedia.php (6 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50416	[sportni.bg]	80	gong.bg:POST /ajax/yellow.php (6 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50415	[sportni.bg]	80	gong.bg:POST /ajax/multimedia_home.php (5,573 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50414	[sportni.bg]	80	gong.bg:POST /chronology/ajax_content (2,579 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50415	[sportni.bg]	80	gong.bg:POST /ajax/multimedia_home.php (6 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50414	[sportni.bg]	80	gong.bg:POST /chronology/ajax_content (108 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50413	[sportni.bg]	80	gong.bg:POST /json_test/top_news.php (10,469 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50413	[sportni.bg]	80	gong.bg:POST /json_test/top_news.php (24 bytes)
########	########	Web	[Peshosan-PC.vivacom-adsl]	50412	[sof01s01-in-f9.1e100.net]	443	SSL session with https://173.194.39.201
########	########	Web	[Peshosan-PC.vivacom-adsl]	50410	[198.41.215.184]	80	cdnjs.cloudflare.com:GET /ajax/libs/jquery-mousewheel/3.0.6/jquery.mousewheel.min.js (1,392 by
########	########	Web	[Peshosan-PC.vivacom-adsl]	50408	[ec2-54-201-42-228.us-west-2.(	80	geoip.it.best-tv.com:GET /serve/country.ashx?callback=window.besttv.web.ads.popup.video.onGe

Fig. 5. The entire event list

The saved file was with extension ".csv" [3],[5],[7]. This is very useful method for saving information needed for further processing and analysis by system and network administrators of the determined computer network.

Thanks to the software program NetResident [9],[8],[10] each plain users, system and network administrators, cyber-professionals and forensic experts are able to gain detailed information [16] about the web traffic between many hosts in determined computer network and thereby they could know which web content page has vulnerability or insecure connection certificate [1],[2],[4],[6],[12],[13].

4. Conclusion

Each cyber-professional, system and network specialists, IT forensic experts have to capture, scan, observe, detect and analyze different vulnerabilities, flaws and weaknesses in the web connections that can cause a total compromise of the instant messages and voice conversations in host operating system integrity and total shutdown of the affected confidential resources. Therefore, the IT professionals and experts of the tested computer network are able to gain most of the web content completely unavailable forever. Therefore, it is important the flaws, suspicious processes and connection to be terminated in the selected host computer systems and therefore

the risk of future compromising of the computer and network resources of the target hosts could be reduced.

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SOME PROBLEMS OF OPTIMAL MANAGEMENT OF ECONOMIC SYSTEMS

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ABSTRACT: *The task of optimal management of economic system is examined. Sulution of the problem comes true through the method of the Pontryagin maximum principle. As a function of the equation of state will use the Gross Domestic Product (GDP).*
An optimal management of state of financial system United Kingdom from initial position to the set end position is offered.

KEY WORDS: *investment, optimal management, GDP.*

JEL classification codes: *C01; C53; E17; F21*

Introduction

Practically any economic-financial system changes during time. For a management of the system it is necessary to have a management function. Changing the parameters of this function, it is possible to get motion of the system on an optimal trajectory. One method of solving the management problem is the method of the Pontryagin maximum principle [1,2,3,4]. As a function of the equation of state will use the Gross Domestic Product.
In order to find out required correlations it is necessary to take into account dependences between all parameters of the system. The process of finding the optimal functional relationship between the variables can be found in [5,6].

Problem statement

As an example, consider the problem of optimal management with the initial data for United Kingdom [7] on the interval $[t_0;T]$:

Table 1: Initial data for calculation

t	Year	GDP (Current Prices, US$ Billion), *Y(t)*	Investment (% of GDP), $\alpha_1(t)$	General government total expenditure (% of GDP), $\alpha_2(t)$	General government revenue (% of GDP), $\alpha_3(t)$
1	2011	2471,88	15,584	45,861	37,301
2	2012	2602,49	16,411	44,48	37,542
3	2013	2743,35	17,358	42,793	37,776
4	2014	2890,99	18,18	41,26	37,843
5	2015	3050,52	18,913	40,072	37,779
6	2016	3220,42	19,601	38,704	37,384

Processing the data in Table 1, we find the optimal function in the form $Y = ab^t$. Applying the method of the least squares, we obtain the unknown parameters: $a = 2342{,}0198;\ b = 1{,}053276$. This optimal function corresponds to the following boundary value problem:

$$\frac{dY(t)}{dt} = \ln b\, Y(t)\ ;\ Y(t_0) = ab \tag{1}$$

Equation (1) is the equation of studied system state, with the initial condition.

Find the optimal functional dependence for $\alpha_2(t)$ - general government total expenditure (% of GDP) on the interval $t \in [t_0; T]$:

$$\alpha_2(t) = 47{,}2492 - 1{,}444057t \tag{2}$$

Thus, we obtain a mathematical formulation of the overall cost management problem for the state

Problem A

The equation of state of the system:

$$\frac{dY(t)}{dt} = \ln b\, Y(t) + U(t) \tag{3}$$

Initial conditions:

$$Y(t_0) = ab \tag{4}$$

Management function has following form:

$$U(t) = \alpha_2(t) a b^t \tag{5}$$

where $\alpha_2(t)$ has the form (2).

The condition of optimality is set in form:

$$\int_{t_0}^{T} \exp(-\delta t)(\alpha_1(t) + \alpha_3(t) - \alpha_2(t)) Y(t) dt \to \max \tag{6}$$

where δ - discount coefficient; $\alpha_1(t), \alpha_3(t) > 0$.

Taking into account data from tables 1 we will get:

$$\alpha_1(t) = 0{,}148332 + 0{,}008118t \; ; \; \alpha_3(t) = 0{,}376 \tag{7}$$

Problem statement.

It is necessary to find the optimal value of parameter $\alpha_2(t)$, on which management of state of the financial system is executed. A size reflecting financial receivabless and charges (6) is maximized.

To solve the problem we apply the Pontryagin maximum method [3].

We write the Hamiltonian function:

$$H(t) = \Psi(t)\{\alpha_2(t) a b^t + \ln b Y(t)\} + \exp(-\delta t)\{\alpha_1(t) + \alpha_3(t) - \alpha_2(t)\} Y(t) \tag{8}$$

where $\Psi(t)$ - auxiliary function that satisfy equation

$$\frac{d\Psi(t)}{dt} = -\Psi(t) \ln b - \exp(-\delta t)\{\alpha_1(t) + \alpha_3(t) - \alpha_2(t)\} \tag{9}$$

We will find the extremum of Hamiltonian function on the parameter of management :

$$\frac{dH}{d\alpha_2} = -Y(t) \exp(-\delta t) + \Psi(t) a b^t \tag{10}$$

Using the condition of extremum, we will get:

$$\Psi(t) = \frac{\exp(-\delta t) Y(t)}{a b^t} \tag{11}$$

Using (11) and taking (3) into account we will find:

$$\frac{d\Psi(t)}{dt} = \exp(-\delta t)\alpha_2(t) - \frac{\delta \exp(-\delta t) Y(t)}{a b^t} \tag{12}$$

We put (11) and (12) in (9) :

$$Y(t) = -\frac{ab^t(\alpha_1(t) + \alpha_3(t))}{\ln b - \delta} \tag{13}$$

Set:

$$\alpha_4(t) = \alpha_1(t) + \alpha_2(t) \tag{14}$$

Putting (13) in equalization of the state (3), we will get a management function in a form:

$$\alpha_2(t) = -\frac{1}{\ln b - \delta}\frac{d\alpha_4(t)}{dt} \tag{15}$$

Thus, we get a next boarding problem that corresponds to the optimal function of management :

The equation of state of the system

$$\frac{dY(t)}{dt} = \ln b\, Y(t) - \frac{\alpha_4'(t)}{\ln b - \delta} ab^t \tag{16}$$

Initial conditions:

$$Y(t_0) = ab \tag{17}$$

Assuming $\alpha_4'(t) = const$, than solution of task (16), (17) has following form :

$$Y(t) = ab^t\{1 - \alpha_4'(t) + \alpha_4'(t)t\} \tag{18}$$

Numerical examples

We will enter next basic data

For founding parameter $\alpha_4(t)$ we use correlations (7). Putting initial data in (15), we will get the value of optimal managing function $\alpha_2 = 0{,}1685$. Thus, if during investigated period a managing function will be equal to the got value, then an optimization function (6) will take on a maximal value taking into account discounting. A formula (18) allows to define the function of the system state that corresponds to the optimal function of management.

Problem B

Statement of problem A is examined. Additionally to the terms (3) - (6) we will add additional limitations:

1. condition of final system in the set eventual state

$$Y(T) = Y_T \tag{19}$$

2. limit on the function of management

$$\beta_1 \le \alpha_2(t) \le \beta_2 \tag{20}$$

We will find the solution of equalization of the state (3) with an account (20). Solution of equalization, satisfying correlation (4) has form :

$$Y(t) = ab^t \{1 - \beta_1 + \beta_1 t\} \tag{21}$$

$$Y(t) = ab^t \{1 - \beta_2 + \beta_2 t\} \tag{22}$$

Satisfying (19), we will found solution in a form:

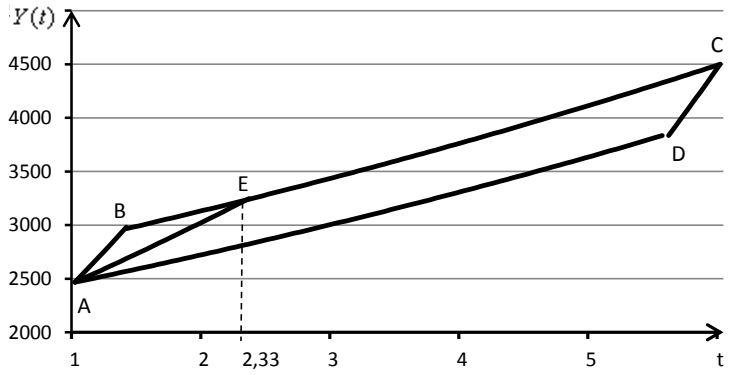
$$Y(t) = (Y_T - \beta_1 Tab^T)b^{(t-T)} + \beta_1 tab^t \tag{23}$$

$$Y(t) = (Y_T - \beta_2 Tab^T)b^{(t-T)} + \beta_2 tab^t \tag{24}$$

Building on a function plane set by correlations (18), (21) - (24), we will get an optimal management of the system state from initial position (4), in eventual (19). Thus motion has to be done on an optimal trajectory (18), but it must not go beyond the borders of possible solutions. Depending on the initial and eventual state, it is possible to make time switching from one trajectory to other. Thus an optimal function (6) will reach its maximum.

Numerical examples

As basic data we will take data from data A, and also additional data in a form $Y(6) = 4500; \beta_1 = 0{,}05; \beta_2 = 0{,}45$. On a picture 1 an optimal management of system state from the initial state in the set eventual state is presented. The area of acceptable values of state of investigated system is set as ABCD. The optimal transition of the system done firn initial state (point A) on an optimal trajectory (6) to the point E. From a transit point (point E) to the eventual state (point C) the system moves on trajectory(23). Switching time from one trajectory to other, for the set initial conditions takes place at $t_E = 2{,}33$.



Picture 1 Optimal management GDP, US$ Billion

CONCLUSION

A decision over of a few tasks of optimal management is brought through the method of the Pontryagin maximum principle. An optimal management of system state is offered from initial position to the set eventual position. It is shown that an offered algorithm works and has practical application. Numeral results of the financial indexes of United Kingdom for 2011-2016 are shown.

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RESEARCH OF THE VARIATIONS OF THE ATMOSPHERIC OZONE AND CHANGE OF THE ULTRAVIOLET SUN RADIATION OVER NORTHEASTERN BULGARIA

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ABSTRACT: *The atmospheric total ozone content variations over the North-eastern region of Bulgaria have been observed during the May-August period of 2011. The measurements are conducted above the hydro-meteorological station in the Kaliakra peninsula using a ground-based ozonometer M-124. The experimental data for the total ozone content distribution have undergone processing and the mean month values have been calculated. A distribution anomaly has been observed during the second half of July, when the trend is negative.*

KEY WORDS: *total ozone content*

1.INTRODUCTION

The problem of the periodic variations of the total ozone content is a question of present interest. The results of the interpretation of these data for the northern hemisphere show decreasing of the ozone layer with 30-50 Dobson units [1].

In 1986 a spring negative anomaly of the ozone trend has been detected in Greece [2]. In 1987 a considerable decrease of total ozone content was detected in the town of Belsk, Poland [2].

The anomalies of the ozone trend are similar (the coefficient of the correlation is +0,44) in Europe: from 1982-1983 in Moscow [6]; from 1984-1985 in Southern Europe – Vina del Vale and Lisbon [4]. From 1986-1987 in Northern Europe [4]. These data are received from ground ozonometric stations and their processing shows a negative linear trend

of the total ozone content in the Northern hemisphere – 1,4% and respectively there is a considerable variation of the average total ozone content [5,6].

2.THE RESEARCH

The goal of the research is to study the variations of the total ozone content in Northeastern Bulgaria for the period May – August 2011, which were measured by means of a ground ozonemeter in the hydro meteorological station in Kaliakra.
Kaliakra station is situated at 59,12 m altitude. Its geographic coordinates are 28°28' eastern longitude and 43°22' northern latitude. Having in mind the conservative meridional stratospheric circulation at altitude 20-22 km in northeastern Bulgaria and the comparative remoteness of Kaliakra from big industrial contaminators, it can be considered that the received experimental results are representative for a larger equable zonal structure, such as Northeastern Bulgaria.

The total ozone content is being researched by 4-month results: May, June, July and August. The data are in table 1. The days with unfavorable weather are less than 4 per month and they are not taken into consideration because they are within the limits of for the determination of the total ozone content variations.

The goal of the research is to check whether the values of the total ozone content X for the four months are commensurable and to examine for possible variations. Since the number of the days, in which the experimental value X is received, is different for the single months, the Barlet criterion is used [3].

Table 1. Average values of the total ozone content X in Dobson units, Kaliakra, 09.05. – 18.08. 2008

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
May									437			365	345	360	388
June	340	400	490	348	375				390	394	359	383	360	421	454
July	385	331	341	384	360	369	337	343	349	356	342	339	302	302	333
August	236	256	297	243	242	181	220	199	227	273	260	176	179	223	191

Month	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
May	388	304	341	335	402	384			414	437	412	414	397	380	408	384
June	383	344	428	403	389		385	389	395	324	376	364	341	330	334	
July	372	349	368	317	350	305	305	326	185	231	264	232	223	222	236	246
August	196	211	201													

The evaluations for every dispersion are calculated $S_1^2, S_2^2, S_3^2, S_4^2$

$$(1)\quad S_1^2 = \frac{1}{n_i - 1}\sum_{j=1}^{n_i}\left(X_{ij} - \overline{X}\right)^2$$

and the formula

$$(2)\quad \overline{X_i} = \frac{1}{n_i}\sum_{j=1}^{n_i} X_{ij}$$

is used to get the average values for the total ozone content for the separate months:

$\overline{X_1}$=384 Dobson units, $\overline{X_2}$=375 Dobson units, $\overline{X_3}$=313 Dobson units, $\overline{X_4}$=223 Dobson units

The dispersions are as follows:

$S_1^2 = 1245{,}94;\ S_2^2 = 1153{,}96;\ S_3^2 = 3060{,}37;\ S_4^2 = 1191{,}47.$

The zero hypothesis H_0 is checked that $S_1^2 = S_2^2 = S_3^2 = S_4^2$ as an assumption that
The number of degrees of freedom is:

$Y_1 = 19 - 1 = 18;\ Y_2 = 27 - 1 = 26;\ Y_3 = 31 - 3 = 30;\ Y_4 = 18 - 1 = 17$

In this case

$$(3)\quad Y = \sum_{i=4}^{4} Y_i = 91.$$

On the other hand,

$$(4)\quad S^2 = \frac{1}{Y}\sum_{i=4}^{4} Y_i S_i^2 = \frac{1}{91}164\ 495{,}98 = 1807{,}5$$

To calculate the value χ^2, the following values are determined:

$$(5)\quad C = 1 + \frac{1}{3(n-1)}\left(\sum_{i=1}^{n}\frac{1}{Y_i} - \frac{1}{Y}\right) = 1{,}0158,$$

$$Y_1 = \ln\frac{S_1^2}{S^2} = -0{,}3722,$$

$$Y_2 = \ln\frac{S_2^2}{S} = -0{,}4488,$$

$$Y_3 = \ln\frac{S_3^2}{S} = 0{,}5265,$$

$$Y_4 = \ln\frac{S_4^2}{S} = 0{,}4168,$$

In this case:

$$(6)\quad \chi^2 = \frac{1}{C}\sum_{i=1}^{4}\ln\frac{S_i^2}{S^2} = 9{,}659,$$

At a level of importance $\chi^2 = \frac{1}{C}\sum_{i=1}^{4}\ln\frac{S_i^2}{S^2} = 9{,}659,$ from the tables of χ^2 the distribution of the degrees of freedom 4-1=3 is given: (0,05; 3)=7,815.

4. CONCLUZION

Because χ^2=9,659>7,815= χ^2 (0,05; 3), the conclusion is that there are reasons to reject the zero hypothesis, which means that the four dispersions are different. Since they cannot be considered equal, there are distinct variations of the examined values of total ozone content for the given months. Since the dispersion S_3^2=3060,37 is maximum, the conclusion should be that the observed anomaly in the total ozone contents values is the biggest in July when the trend is negative during the second half of the month and the total ozone content reaches 185 Dobson units. Similar explanation can be given for the maximum values within the range 176-181 Dobson units in the beginning of August. A

registered sudden transition towards anomalous values of the total ozone content can be observed at the end of July.

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SATELLITE ECOLOGICAL MONITORING OF THE ATMOSPHERE

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ABSTRACT: *This overview presents an analysis of the optical and lidar methods for monitoring of the atmosphere. Emphasis is put on optical studies conducted on board of spacecraft, as they prove to be the most effective information methods for monitoring the atmosphere by studying certain atmospheric optical phenomena, variability in Earth's atmosphere, as well as geo-Heliophysical activity.*

The control on the atmosphere is crucial in weather forecasting and air pollution. This control is provided using remote sensing methods for probing the atmosphere and the crusty surface, by multi-purpose lidars providing information on environmental monitoring of the atmosphere.

KEY WORDS: *satellite, monitoring, lidar, optical, method*

INTRODUCTION

Scientific researches and experiments have been carried out with all spacecraft. An important part of the extensive programme for space experiments is the optical research of the atmosphere monitoring.

From the Earth's surface, which is part of the huge atmosphere, through relatively narrow in spectrum "windows" of atmosphere transparency, it is hard to imagine the general picture of the numerous physical phenomena and processes taking place in the Earth's atmosphere, the near and far space. The beginning of the space era opened wide vistas for the human species to enter it; the launch of measuring devices and some scientific space laboratories into the previously inaccessible space around the Earth and between the planets

and studying them in manned or unmanned spa- cecraft [1]. The space laboratories made it possible to study many sectors of the infrared, ultraviolet, X- ray and gamma emission that are absorbed in their entirety by the Earth's atmosphere.

The optical monitoring from the space with piloted aircraft is one of the most efficient and informative methods of system monitoring. With each flight, the existing preconceptions of certain optic atmospheric phenomena are getting more precise. In each flight arise particular circumstan- ces, allowing the study of particular atmospheric optical phenomena, the changeability of the Earth's atmosphere and the terrestrial and solar activity.

Visual observation is widely used by astronauts in piloted aircraft observation. They play a major part in studying the spatial and temporal distribution of a number of atmospheric optical phenomena's visible emission.

Visual observations of optical phenomena from the board of the piloted spacecraft are carried out in constant connection with instrumental research on the spatial and temporal distribution of the spectral and energy properties of certain components emitting in the ultraviolet and infrared segment of the visible spectrum. To register the spatial and temporal distribution of the sufficiently high-contrast optical phenomena, diverse television, cinema and photographic equipment is used, and to register the spectral energetic properties of the optical phenol- mena – spectrophotometric and spectroradiometric equipment.

The possibility of studying optical phenomena through the portholes, unprotected from variations in the light, in the twilight zone and in the daylight side of the Earth, depends, to a large extent, on the preliminary function of the porthole [2], which is based on the filtering of certain emissions.

Assessing the diffused emission from the por- tholes, it is accepted that they diffuse 1-5% from the emissions that fall on them. Then, in the night side of the Earth, the portholes brightness, not taking into account the light sources in the space station, the aurora and the direct glow of the Moon, does not exceed the natural background brigh- tness, the night atmosphere airglow, the clouds and the terrestrial surface. This makes possible the successful conducting of experiments in the nigh- tlight side of the Earth and the identification of such faint sources like the airglow of the upper layer of the atmosphere, the zodiacal light, the stars, the planets, the meteors, the cloud cover and the Earth's surface. The Moon glow and the powerful polar aurora significantly increase the brightness of the diffuse glow from the portholes, which, during a full moon phase can reach up to $1\text{-}2.10^{-4}$ cd/m^{-2}.
The possibility of identifying the weakest emitting sources, like the second emitting layer of the night atmosphere, the zodiacal light, etc, weakens.

In conducting space experiments, the long- duration flights are particularly effective; they allow for systematic monitoring of the atmosphere and the

atmospheric optical phenomena to be carried out. Due to this, new regularities in certain physical processes, observable in the Earth's atmosphere, can be identified. The monitoring in the course of along-duration flight also has other specifics. At the start of the flight, various emotional factors influence the astronauts' view of their surroundings. The astronauts admire the bright colourful images line intensity when λ = 5,577 *A* . In the first layer it of the twilight and daylight halo, the sunrise and the sunset. The beauty of the cloud cover, the expanses of water and the terrestrial surface, aurorae, noctilucent clouds, nightglow layers, etc. Then the astronauts slowly get accustomed to these images and start to notice more important details in the atmosphere that play substantial role in the monitoring from space: the expanse of water, the cloud cover and the Earth surface, In the course of a long flight, the astronauts start to syste- matize and analyze the phenomena observed. Following consultations with experts during the communication sessions, astronauts themselves conduct certain experiments that have a major importance for the study of the environment. Very helpful for conducting scientific experiments is the programme for visual monitoring of piloted spacecraft.

1. OPTICAL MONITORING OF THE ATMOSPHERE

The Earth's nightglow

The spectral energetic properties and the temporal and spatial distribution of the Earth's airglow depend, to a large extent, on the geophysical and heliophysical activity, and, consequently, are very sensitive indicators of the Sun-Earth relations. The monitoring from piloted spacecraft, as well as the profuse data gathered on the Earth, from aircraft, aerostats, rockets and satellites, allow us to draw the general picture of the visible nightglow of the Earth's atmosphere and to define its most significant components. [2,3 4].

In the visible spectrum, the glow of the first emitting layer occurs mainly as a result of chemical reactions leading to the appearance of excited O2, NO2 molecules and O and Na atoms. The most significant contribution to the visible glow of the first emitting layer is that of the chemiluminescent reactions. However, viewed from space, only the emission of the green line is visible, because the night vision visibility quotient for the spectrum segment λ = 6,300 A is about 0.003, and for the segment λ = 5577 A – about 1.3. In photographs of the second emitting layer, the red line could prove dominant. This depends on the spectral sensitivity of the sensor.

The second emitting layer is characterised by substantial temporal and spatial nonhomogeneity and instability. Faint vertical ray structure has been discovered in it. Under normal conditions, in the absence of geoor heliophysical disturbances, the brightness of the second layer, during observation from space, horizontally equals ~ 0.1 mcd/m^{-2} and during the midnight increase it reaches

$0.3 – 0.4$ mcd/m^{-2}.

The glow in the second emitting layer planetwide usually heralds a powerful aurora. The planetary glow of the second emitting layer can often be observed even after the end of powerful aurorae. Thus, the second emitting layer is a much more sensitive indicator of geoand heliophysical activity, as well as of the Sun-Earth relations.

Aurorae

The term "aurora" includes a complex of various and diverse phenomena related to excitement and optical emission of the upper layers of the Earth's atmosphere. The glow of the aurorae is changeable in terms of its spectral and energetic character and of spatial and temporal distribution. However, most of these phenomena have the same feature in common: they arise mainly under the influence of electron and positron currents entering the Earth's atmosphere.

The polar aurorae can often be observed in the morning auroral oval, the night part of which is situated approximately along geomagnetic latitude 67°, and the day part – about 75°. The oval is eccentric in relation to the magnetic dipole and shifts by some 4° toward the equator in the night sector. The concept of the morning auroral oval is widely popular and recognised and is a nearly universal means to represent the sectors of airglow of the aurorae, both in the Northern and the Southern hemisphere.

The orbital station observations show that from the Space the aurorae in the morning auroral oval section can be observed continuously, although from the Earth's surface they are not always visible. When observed from space, in the course of several Earth rotations, the segment of maximum auroral luminosity (in all cases in the visible spectrum) shifts along the length of the morning auroral oval at the speed of the rotation of the Earth, i.e. remains virtually static in relation to the Earth's magnetosphere. This phenomenon reminds of the midnight increase in the nightglow from the upper layers of the earth's atmosphere. It is possible this penetration into the Earth's atmosphere takes place from the same section in the magnetosphere. Of particular interest are the results from the observation of the colour image of the airglow sectors of the aurora, which provide the opportunity to make a quality assessment of the energy of the electron currents exciting the aurora glow. For more than a month and a half of flight time, systematic daily observations of auroras have been made, corroborating the suggestions made earlier on the possibility of continuous monitoring from space of polar aurora in the morning oval sector.

After the end of the polar glow after sunset until sunrise, there is general atmosphere airglow. The first emitting layer mingles with the Earth's visible horizon. Above the first emitting layer there is a faintly dim glow. There is

the feeling that the orbital complex is within mist and flies above separate areas of glowing atmosphere situated below it. After a while, the first emitting layer splits into greenish brown sublayers.

The monitoring from space superbly complete the results from the research carried out on the Earth and allows to achieve substantially more detailed picture of the development of a polar aurora. The research carried out on Earth and on the orbital station can be adequately completed with pictures and televised imaged, received from altitude 500-1000 km from unmanned spacecraft. Such complex research allows for acquiring a sufficiently detailed picture of the spatial and temporal distribution and the spectral and energetic one of the glow of the polar aurorae on a global scale.

Noctilucent clouds

Until the dawn of the space research era, the study on the noctilucent clouds was carried out mainly via ground and aircraft monitoring in the twilight horizon as well as with geophysical rockets, launched at least from altitude of 90 and more kilometers.

On the basis of a number of results from ground, aircraft and space experiments, the re has been developed the idea of the spatial and temporal distribution, the morphology, the composition, and the nature of the noctilucent clouds. It can be hypothesized, that at the same latitude, the noctilucent clouds appear with the same frequency on all longitudes. From the Earth they can be observed between several minutes and four or more hours, they have a tendency to appear for several days on end (they form clouds series). In periods of heightened solar activity, noctilucent clouds can be observed predominantly in the morning.

Noctilucent clouds can be observed mainly at altitude between 74 and 92 km, and more often 80-85 km, with average monitoring altitude 82 km, which corresponds to the mesopause altitude. The thickness of the noctilucent cloud layer is about 2 km or less. Noctilucent clouds are comprised of diffused particles, their composition is still not clear and they have a number of peculiar properties. There are three hypotheses about the origin of the noctilucent clouds: “dust”, “ice” and intermediate, according to which they are composed of dust particles of micrometeorite origin, on which water vapour condenses to form ice crystals.

According to the existing classification, a number of morphological structures of noctilucent clouds exist: gas, strips, waves and vortexes. The gas type is a homogenous aerosol form, present almost always within the noctulucent clouds and usually filling the space between other areas. Strips are quite dim cloud forms, set out against the background of other gas. Waves are clearly visible against the gas background.

2. LIDAR SENSING OF THE ATMOSPHERE

Knowledge the physical parameters of the atmosphere, which have substantial influence on atmosphere monitoring, including the processes of weather change, pollution, the solar eruption trans- formation, the distribution of optical waves, is of essential importance. In relation to this, the development of methods for sensing the atmospheric parameters, without any doubt, is a very pressing task.

Atmosphere monitoring has a decisive role in solving such large-scale problems like weather forecasting and environmental pollution.

This monitoring can occur only with via the use of remote methods for sensing the atmosphere and the underlying layer. Laser sensing occupies a particular place among the remote methods. This is due to the diversity of the phenomena, interacting with the laser emission of the atmosphere, the cross section is most important in the visible electromagnetic spectrum [3,6].

Via the use of the above phenomena makes it theoretically possible to laser sense virtually every physical parameter of the atmosphere: temperature, pressure, density, humidity, the content of gas components in the atmosphere, turbulence properties, the aerosols, in their numerous forms, with sustainable existence (clouds, fogs, mists, smoke, precipitation, etc.), optical parameters (attenuation coefficient, scatter indexes, scatter matrix components) and microphysical properties (spectra, size, concentration, complex refractive index, and particle shape).

The atmosphere laser sensing methods surpass the competition of the other remote sensing methods due to their capacity for gathering data from high spatial and temporal solutions.

The data from the laser sensing of the atom- sphere polluting components with high temporal and spatial solutions are of essential importance in obtaining information on the dynamics of polluting components distribution in the atmosphere.

Thanks to the atmosphere laser sensing methods, the simultaneous obtaining of data on the polluting component and on any other physical parameters of the atmosphere can be achieved. This is essential, as the atmospheric pollution is substantially dependent on the background presence of its various parameters.

Basics of the atmosphere laser sensing method

While travelling in the atmosphere, the laser emission undergoes numerous transformations. The emission energy can be absorbed by the atmospheric gases and aerosol particles, it scatters when it accidentally meets non-uniformities in air density or aerosol particles. Atmospheric turbulence causes accidental variation in the amplitude and the phase of the laser beam. Light scattering leads to the appearance of, besides the sensing frequency, combination frequencies, corresponding to various gases, in the diffused emission

spectrum[7].

To gather data on the atmospheric parameters and their distribution in space and time, it is necessary not only to create the respective equipment, but also to decipher the echo-signals of the interaction of sensing laser emission with the atmosphere. To decipher the echo signals, most of all it is necessary to have sufficiently correct solutions of the direct problems from the atmosphere optics, i.e. problems connected with the study of the influence of the atmosphere on the laser beam with given characteristics (spectrum, energy, power, forma of the impulse, polarization, coherence, emission angle of refraction, etc.)

An important condition for the successful deciphering of the echo signals is connected to solving the inverse problems from the atmosphere optics, ensuring, ultimately, categorical reconstruction of the atmospheric properties.

Laser sensing of aerosols

Aerosols play an important role in the process of forming a radiation field in the atmosphere, the weather forming processes, the various physical and chemical transformations, including those connected to the anthropogenic activity. Aerosols determine the atmospheric albedo, which has and important role in the processes of radiation exchange in the atmosphere-ocean-space system. There are interesting possibilities in aerosol mono- frequency laser sensing that are connected to the use of the polarization properties of the echo signals. The presence of polarized components other than zero can be caused/ determined by the polydisperse effect or the nonsphericity of monodisperse particles [4]. Thus, in measuring the polarized components of the echo signals from clouds with low optical thickness, when the polydisperse effects are disregarded, the phase cross section of the cloud is categorically determined.

Multifrequency laser sensing

Multifrequency laser sensing ensure results from the detailed digital modelling with variations in the number of lengths of the aerosol parameters.

Atmospheric humidity sensing

The water vapours field in the atmosphere plays a decisive role in the weather forming processes, the different physical and chemical transformations, including the atmospheric pollution with byproducts from the anthropogenic activity. Due to this, increased attention is paid to the development of methods for determining the level of humidity, including remote ones.

Among the known methods for remote sensing of the humidity, the first place is occupied by the differential absorption method. Its essence is the following: if two sensing impulses are directed into the atmosphere, with the length wave of one of them coinciding with the water vapour absorption

line, and the other is in a neighbouring micro window of atmospheric transparency, then, recording the two equations of lidar sensing and taking their relation, the expression for determining the humidity profile can easily be obtained.

A defining specific feature of the differential absorption application is connected to the complex approach in solving the problem.

Refractive index laser sensing

The basis of the method [3,5] is the use of the breach in the spatial coherence of the sensing beam's field that is focused in the aerosol volume, at the expense of the influence of the environment turbulence. Due to that, the image of the lit part of the aerosol volume proves wider.

In conclusion, the advantage of the methods for determining the refractive index using lidars, in comparison to the acoustic methods, is attributable to the fact that the scope of the laser locator, unlike the acoustic one, does not depend on the atmospheric turbulence. Besides, lidar methods ensure additional stabilization of the data received at the expense of the spatial averaging of the variations of the sensed properties along the whole route of the beam [5,7].

When impulse sources are used, lidars can become an effective means of operating control on the atmospheric turbulence, although only in the lower kilometer layer, making a dominant contribution to the integral meaning of the refraction index.

Assessment of the possibilities for lidar sensing of the atmosphere from space

The laser sensing of the various atmospheric parameters from space has an essential role for solving many important questions such as, above all, reliable weather forecast, and operating control on the air pollution situation and research on its dynamics. The implementation of the lidar methods ensures obtaining precise data on the monitoring of the atmosphere on a global scale with high spatial solution [8].

To estimate the possibilities for lidar sensing of the atmospheric parameters from space, making use of the aerosol and molecular dispersion, calculations of the echo signals have been made.

The analysis of the received data from the digital modelling shows the possibility of restoring the information on the sensed parameters in analogue signal processing mode, although only in the lower 30-km layer of the atmosphere, as well as for the mesospheric clouds.

The utmost contribution in the echo-signals is made by the low 5-kilometer layer. In all cases, the signal magnitude from this layer show that when the signals reach the Earth's surface, the sensing impulse still has a substantial load of energy, which can be used to determine the properties of the underlying surface: the transparency of the water in the ocean, the sea and other water

bodies, the state of the various underlying surfaces, for highly precise determining the distance of the lidar from the Earth's surface.

The results from the digital experiments allow us to draw a conclusion regarding the practicality of determining the microphysical parameters of the aerosols at various heights in the atmosphere, for multifrequency laser sensing, as well as for sensing using polarization effects. The most promising is cloud sensing; the reflection of the sensing impulses from the clouds explain the significantly bigger magnitudes of echo signals, than with the reflection from regular aerosol layers [5].

The described method of differential absorption for defining humidity profile and other gas compo- nents of atmosphere, with undoubted success can be used in sensing from space. Besides, in such a case, it will be much more efficient, insomuch as there opens up the possibility to use the strongest absorption lines; with their help, very small concentrations of water vapour and other gases in the upper layers of the atmosphere and in the near space can be measures.

The use of a set of lines with varying intensity allows for sensing the gas profile in a wide altitude interval.

The monitoring results show a relatively wide distribution of the noctilucent clouds and other diffusing layers in the mesopause. Possibly, they are connected to extremely beneficial circum- stances for monitoring the mesopause from space during flights in solar orbit. From the terrestrial surface, the monitoring of the mesopause in the equatorial zone is significantly more difficult to carry out than at latitudes 45-70°. At the low and the equatorial latitudes the timeframe when it is possible to observe noctilucent clouds in the mesopause in the twilight zone, is too narrow, it does not exceed several minutes, while in the middle latitude it is tens of minutes and hours. This is an extremely interesting and important result, substantively clarifying the concept of the mesopause structure in the low equatorial latitudes.

Perspectives for further research

The optical monitoring, carried out by orbital stations of the atmospheric airglows, polar aurorae and noctilucent clouds, make possible the gat- hering of extensive data that can be used for atmosphere monitoring, clarifying the concept of a number of physical processes and phenomena in the Earth's atmosphere. Of particular importance is the study of the atmospheric optical phenomena in the upper layers of the atmosphere, accessible for immediate observation only from an orbit at altitude 200–400 km. The most beneficial conditions arise during long-term flights, which is connected not only with the opportunity for the astronauts to conduct systematic research, as well as with the gradual improvement of the experimental methods.

The emissions in the upper layers of the atmosphere, polar aurorae and noctilucent clouds are a reliable indicator of the geomagnetic, geophysical

and heliophysical activity. To the largest extent, this is applicable to the second emitting layer, whose emission substantially depends on the density of the electronic currents and the intensity of shortwave solar emission.

In the theoretic domain, special attention should be paid to the development of the algorithms for solving the inverse equations in the irregular shape particle optics. In particular, this is especially necessary with laser sensing using polarization effects.

The development of laser equipment should be oriented towards creating unique lidars with multipurpose function, to ensure the obtaining of data on the profiles of various atmospheric physical parameters, with maximum possible spatial solution and designed for the utmost possible altitudes, accessible for sensing; lidars designed to obtain operating data, important in everyday practice, on the profiles of the separate atmosphere parameters, lidars designed to be installed in satellites and, above all, on piloted stations.

In relation with this, the programme for subsequent space flights should include systematic optical monitoring and instrumental research of the spatial and temporal distribution and the spectral energetic properties of the atmosphere.

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MODELS OF MAXIMUM CONCENTRATIONS OF NITROGEN DIOXIDE AND NITROGEN MONOXIDE IN THE AIR ALONG THE BULGARIAN BANK OF THE DANUBE RIVER

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ABSTRACT: *Statistical models are built of the regularities of nitrogen dioxide and nitrogen monoxide pollution of the air along the Bulgarian bank of the Danube river. They are theoretically significant and practically applicable in the management of the border environmental safety.The indicators chosen are the maximum hourly, daily and annual average concentrations. They present fully and authentically the pollution degree and its changes in a time function.*

KEW WORDS: *air, pollution, nitrogen dioxide, nitrogen monoxide.*

Defining the air pollution in border regions has a number of main aspects. The first aspect is the need of air quality monitoring in the country. The second aspect is defining the risk degree of cross-border transfer to the territory of the country. The third aspect is using the results in developing the system of national security, and more specifically environmental safety. The forth aspect is informing the citizens about the safety degree of the living conditions in the towns and villages.

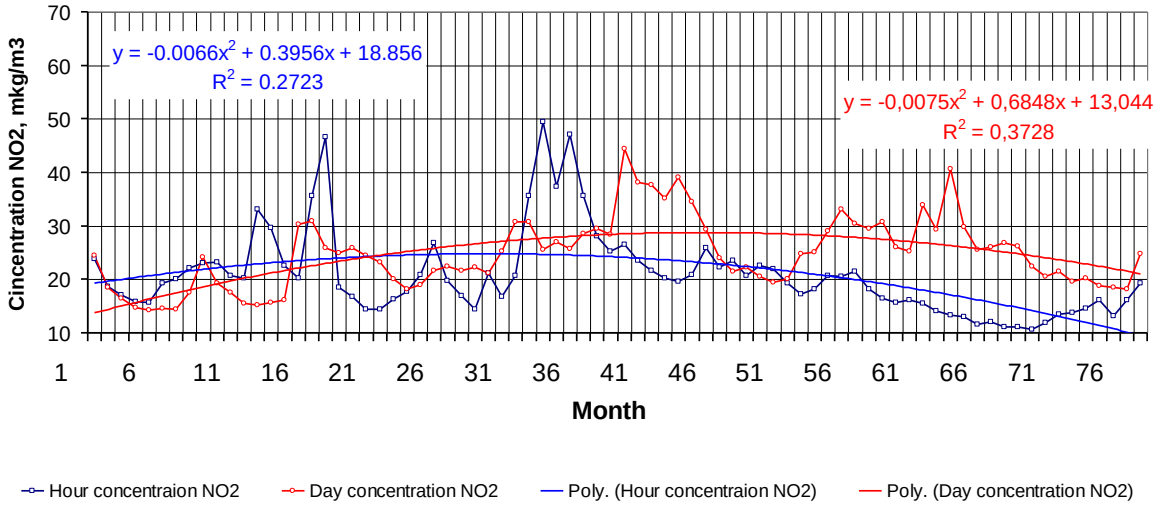
The objective of the present work is to model statistically the regularities of air pollution with nitrogen dioxide and nitrogen monoxide in the Bulgarian region of the Danube river.

To achieve the objective we solve four main tasks: 1. We choose pollution indicators; 2. We prepare representative sample data of concentrations; 3. We do computer processing of measurement results; 4. We model the concentrations of nitrogen dioxide and nitrogen monoxide.

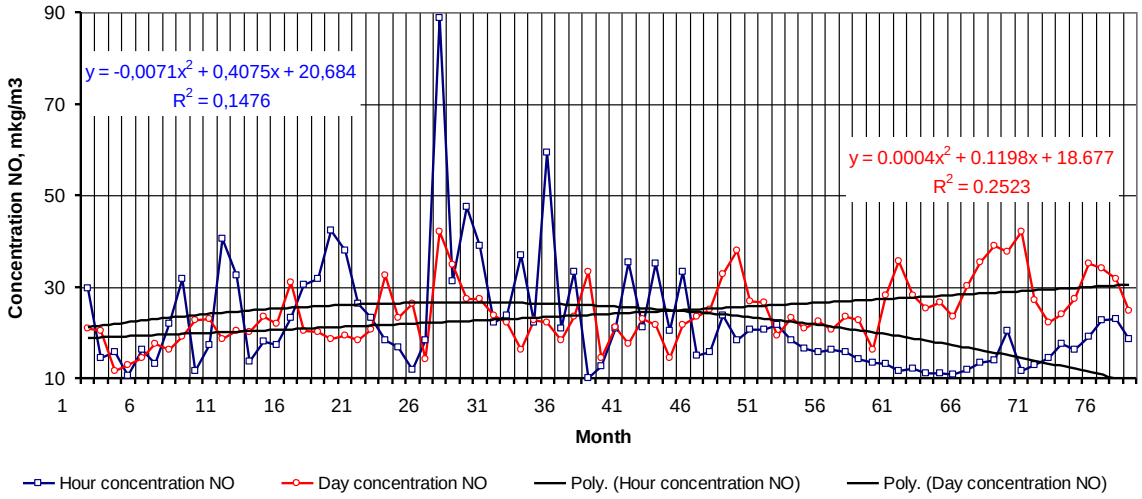
The maximum hourly average concentrations, the maximum daily average concentrations, the maximum annual average concentrations of nitrogen dioxide and nitrogen monoxide are taken as pollution indicators.

The reasons for this are that according to Regulation 12 [2] the maximum allowed values of hourly and daily average concentrations and the number of their exceeding are standardized in Bulgaria.

The hourly average limit for human health protection from nitrogen dioxide is 200 μg/m^3. It should not be surpassed more than 18 times within a calendar year.



a)



b)

Fig 1. Dinamic series and trend of maximum hour and maximum day concentration in Nikopol: a) nitrogen dioxide; b) nitrogen monoxide

The annual average limit for human health protection from nitrogen dioxide is 40 μg/m^3. There is no limit about the number of exceedings of the annual average limit for nitrogen dioxide and nitrogen monoxide.

The limit for vegetation protection is 30 μg/m^3 nitrogen dioxide and nitrogen monoxide.

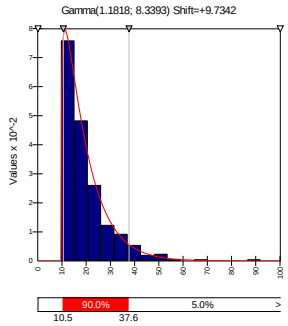
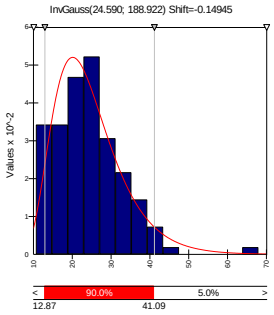
Therefore, it is necessary to analyze the hourly, daily and annual average concentrations in a time function. Hence two time indicators are used.

The first indicator is the dynamic statistical series of hourly, daily and annual average concentrations that show the fluctuation by months and years.

The second indicator of fluctuation in time is the trend. It approximates the dynamic series with regression models and illustrates the common tendencies of concentration fluctuation.

Table 1

Theoretical and empirical distribution of nitrogen dioxide in the air in Nikopol

Maximum hour concentration			Maximum day concentration		
					
Parameters	Theoretical model Gamma distribution	Empirical distribution	Parameters	Theoretical model Invariant Gauss distribution	Empirical distribution
a	1.181824		m	24.59019	
b	8.339281		l	188.922	
Left X	10.5	10.5	Left X	12.87	12.87
Left P	95.00%	96.01%	Left P	95.00%	92.65%
Right X	37.6	37.6	Right X	41.09	41.09
Right P	5.00%	5.25%	Right P	5.00%	3.68%
Diff. X	27.1054	27.1054	Diff. X	28.2107	28.2107
Diff. P	90.00%	90.76%	Diff. P	90.00%	88.97%
Minimum	9.7342	9.74	Minimum	-0.14945	10.74
Maximum	+Infinity	92.12	Maximum	+Infinity	67.98

Mean	19.5898	19.59	Mean	24.441	24.441
Mode	11.2505	16.200	Mode	20.104	29.340
Median	16.9907	16.635	Median	22.951	23.415
Std. Deviation	9.0658	9.6279	Std. Deviation	8.8716	8.8195
Variance	82.1883	92.501	Variance	78.705	77.211
Skewness	1.8397	2.2481	Skewness	1.0823	1.1282
Kurtosis	8.0769	11.5991	Kurtosis	4.9524	6.098

We created a data base of measurements made by the Executive environmental agency in Nikopol, Svishtov, Ruse and Silistra. No data were found about nitrogen oxide measurements in Vidin, consequently it is not included in the study [1,3].

The measurements are made mainly with systems for remote optical absorption spectroscopy (ROAS). At measuring station 1 in Ruse OPSIS system is used.

We study the concentrations at one measurement station (ROAS) in Nikopol and Svishtov, at three measurement stations in Ruse (OPS R1, ROAS R2, Automatic measurement station (AMS *Vazrazhdane*) and two measurement stations (ROAS S1 and ROAS S2) in Silistra.

The period of observation is from 2007 to 2013. The data from this period are analyzed as one experiment. Excerpts are taken by months and years. Each maximum concentration by hour, day and year is treated as a separate test.

The maximum concentrations are analyzed as continuous random variables. Therefore, methods of the probability theory and mathematical statistics are used [1,3,4].

We abide by Regulation 12 [2] requirements for summarizing data and statistical parameters. The required minimum valid data for hourly average values is 45 minutes. For daily values - 75 % of hourly average values or at least 18 hourly average values.

The annual average value is calculated as 90% of the hourly average values or 24-hour values per annum.

We check the hypothesis by 14 statistical laws of distribution of continuous random variables: the law of equal probability (Uniform); gamma distribution (Gamma); normal distribution (Normal); triangular distribution (Triang); logarithmic-normal (LogNormal); exponential distribution (Expon), logistic distribution (Logistic); logarithmic-logistic distribution (LogLogistic), invariant Gauss distribution of Wald (InvGauss), Weibull distribution (Weibull), Rayleigh distribution (Rayleigh); Pearson distribution (Pearson); Erlang distribution (Erlang), Gumbel distribution for extreme value (ExtValue).

We use specialized software - Risk 4.5 for the computer processing of the data.

The established laws for concentration distribution are regarded as theoretical models, which approximate experimental data. We construct their graphical interpretations illustrated in Tables 1 and 2. We represent the parameters and values of the theoretical distributions of concentrations. In parallel we give the values of empirical distribution – Table 1-13.

We use 13 values, which determine the position of the random values of maximum concentrations, concentration diffusion, the symmetry and the degree of distribution pointedness: 1) left and right absolute limit (Left X and Right X); 2) left and right relative limit (Left P and Right P в %); 3) absolute range (Diff. X); 4) relative range (Diff. P in %); 5) minimum value (Minimum); 6) maximum value (Maximum); 7) mean value (Mean); 8) mode (Mode); 9) median (Median); 10) standard deviation (Standart Deviation); 11) variance (Variance); 12) asymmetry (Skewness); 13) excess (Kurtosis).

We make one-criterion modeling of empirical data. Pearson criterion is used for checking the correspondence hypothesis.

The dynamic series of maximum concentrations in Nikopol are represented in Figure 1. They are highly variable by character. The trend is described through regression dependencies of second order.

The coefficients of correlation R^2 reflect the degree of dependence on time. With nitrogen dioxide the coefficient R^2 is 0.2723 for maximum hourly average concentrations, while for maximum daily average concentrations R^2 is 0.3725. For the nitrogen monoxide they are respectively 0.1476 and 0.2523. These values show that the correlation is small but some values are close to the mean value.

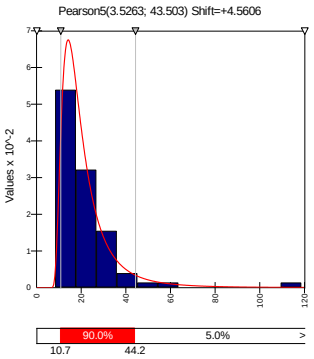
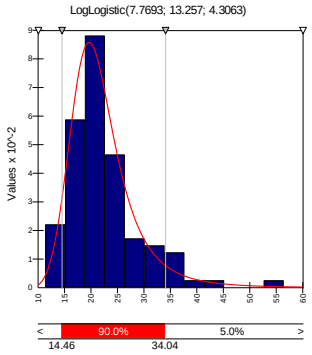
The maximum hourly average concentrations of nitrogen dioxide are distributed by gamma distribution, while the daily average concentrations by invariant Gauss distribution.

Table 1 reports that the range of maximum hourly average concentration is very broad – from 9.74 to 92.12 μg/m^3. The mean value is 19.59 μg/m^3.

The maximum value is important - 92.12 μg/m^3. It is many times lower than the limit. It should be regarded that we analyze the maximum concentrations. The maximum value of distribution is a peculiar “maximum of the maximum”.

Table 2

Theoretical and empirical distribution of nitrogen monoxide in the air in Nikopol

Maximum hour concentration			Maximum day concentration		
					
Parameters	Theoretical model Pearson distribution	Empirical distribution	Parameters	Theoretical model Loglogistic distribution	Empirical distribution
a	3.526296		g	7.76931	
			b	13.25697	
b	43.5035		a	4.306341	
Left X	10.7	10.7	Left X	14.46	14.46
Left P	95.00%	94.12%	Left P	95.00%	93.58%
Right X	44.2	44.2	Right X	34.04	34.04
Right P	5.00%	3.53%	Right P	5.00%	7.34%
Diff. X	33.4634	33.4634	Diff. X	19.5747	19.5747
Diff. P	90.00%	90.59%	Diff. P	90.00%	86.24%
Minimum	4.5606	8.54	Minimum	7.7693	11.42
Maximum	+Infinity	118.69	Maximum	+Infinity	56.45
Mean	21.781	21.828	Mean	22.28	22.319
Mode	14.172	26.080	Mode	19.647	14.490
Median	18.159	17.9	Median	21.026	20.87
Std. Deviation	13.939	14.081	Std. Deviation	6.8911	6.7156
Variance	194.286	195.96	Variance	47.487	44.685
Skewness	9.3896	4.2139	Skewness	3.4626	1.8079
Kurtosis		27.9172	Kurtosis	104.9182	8.4719

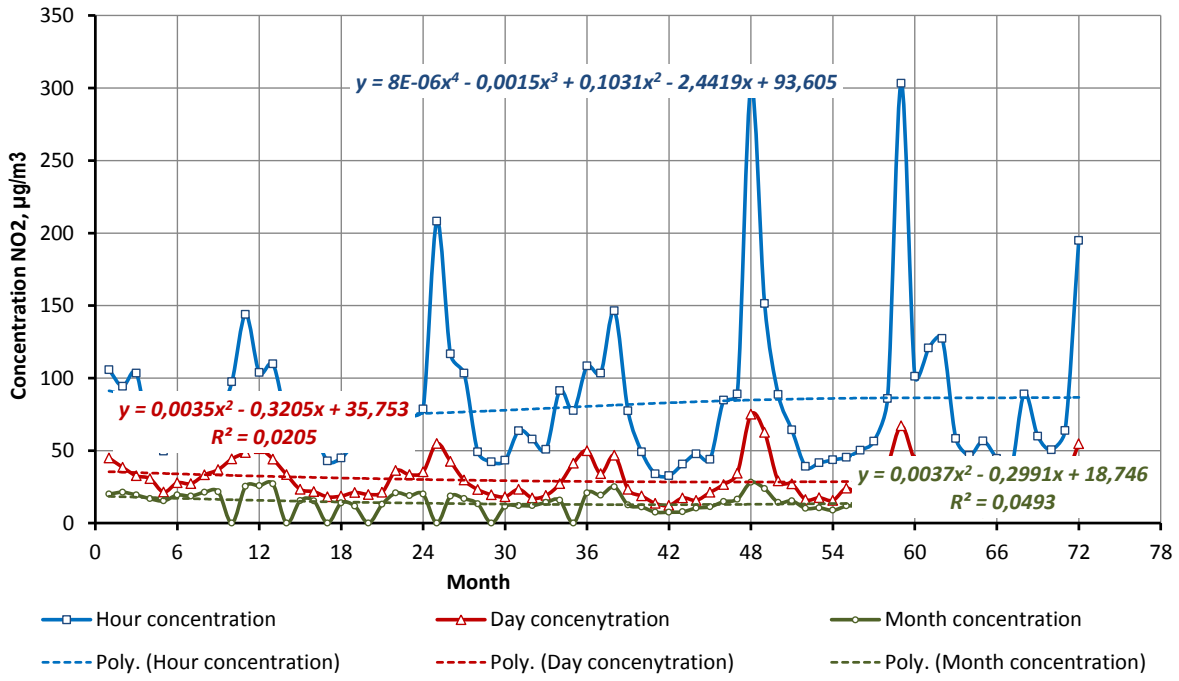
The mode reflects the maximum density of concentration distribution - 16.200 μg/m^3. The median (16.635μg/m^3) divides the concentration distribution surface of nitrogen dioxide into two equal parts.

Comparing the standard deviation and variations it can be concluded about the degree fluctuation variability of concentrations. The standard deviation or the estimated standard deviation is 9.6279 μg/m^3 and the variation - 92.501μg/m^3. Compared to the mean value of maximum hourly average concentrations the diffusion is not big and can be regarded as medium. The excess is 11.5991 μg/m^3, which proves that the distribution is more pointed compared to the normal distribution. Therefore, the concentration values are fixed in narrower range.

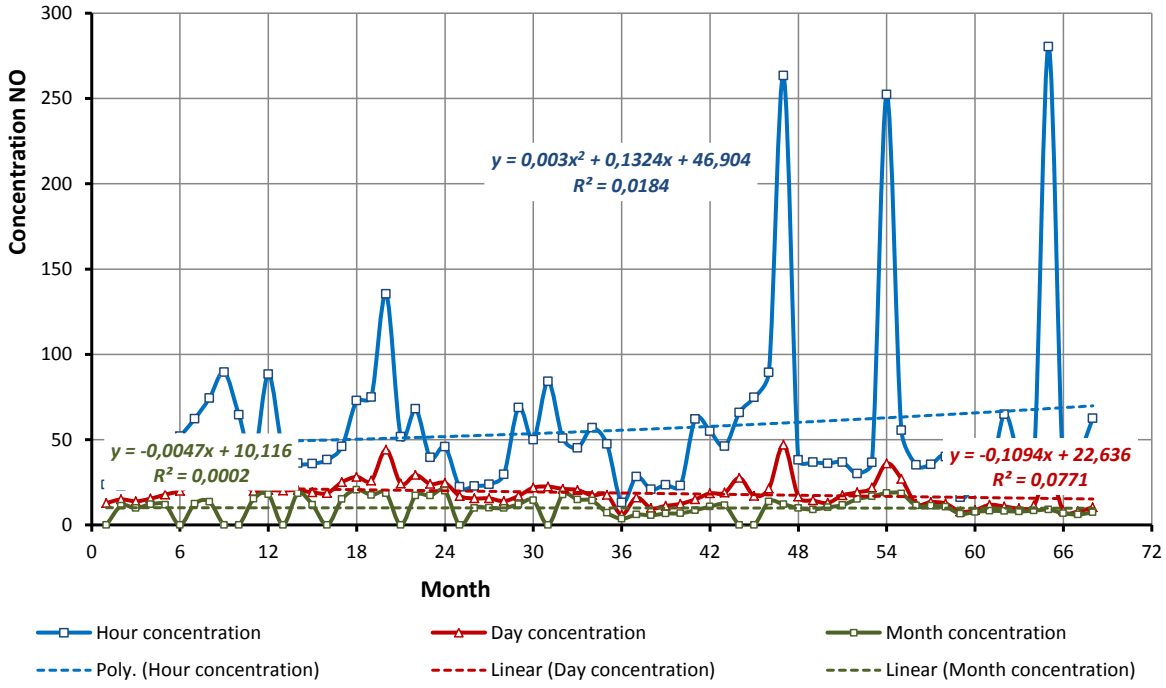
The maximum daily average concentration has different characteristics compared to the hourly average one. The range is small - 28.2107 μg/m^3. The maximum value is 67.98 μg/m^3, which is less than the limit.

Analogously, we can also make a remark about the mean value - 24.441 μg/m^3. It is higher than the mean value of the hourly average concentration.

The asymmetry (1.8397 μg/m^3) of the law of maximum hourly average concentrations is positive, which shows left orientation of the graphics. It is confirmed by the illustration in Table 1.



a)



b)

Fig 2. Dinamic series and trend of maximum hour and maximum day concentration in Svishtov: a) nitrogen dioxide; b) nitrogen monoxide

The mode (29.340 μg/m^3) and the median (23.415 μg/m^3) are higher values but they are of the same order. The same can be claimed about the standard deviation (8.8195 μg/m^3) and the variation (77.211 μg/m^3) as well.

The asymmetry and the excess are also positive – Table 1.

The theoretical and the empirical distribution of nitrogen monoxide in the air in Nikopol are shown in Table 2.

The theoretical models are Pearson distribution for maximum hourly average concentrations and respectively – logarithmic-logistic distribution for maximum daily average concentrations.

Table 3

Theoretical and empirical distribution of nitrogen monoxide in the air in Svishtov

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Pearson distribution	Empirical distribution	Parameters	Theoretical model LogLogistic distribution	Empirical distribution
a	3.4885		γ	-3.4492	
			β	22.8904	
b	140.7942		α	2.38590	

Left X	5.8	5.8	Left X	3.2	3.2
Left P	95.00%	96.30%	Left P	95.00%	94.61%
Right X	116.4	116.4	Right X	75.2	75.2
Right P	5.00%	4.63%	Right P	5.00%	3.92%
Diff. X	110.6150	110.6150	Diff. X	71.9719	71.9719
Diff. P	90.00%	91.67%	Diff. P	90.00%	90.69%
Minimum	-14.295	9.1672	Minimum	-3.4492	0.0000
Maximum	+Infinity	303.25	Maximum	+Infinity	280.32
Mean	42.281	42.151	Mean	27.691	28.346
Mode	17.072	0.0000	Mode	12.293	0.0000
Median	30.239	27.150	Median	19.441	18.555
Std. Deviation	46.371	42.332	Std. Deviation	43.201	35.624
Variance	2150.29	1783.68	Variance	1866.343	1262.85
Skewness	9.9888	3.0308	Skewness		4.6445
Kurtosis		16.2808	Kurtosis		30.2094

The nitrogen monoxide is not standardized and the level of its content in the air cannot be evaluated by statutory rules.

With the hourly average concentrations the left and right limit and the range are as follows - 10.7; 44.2; 33.4634 μg/m^3. There is a big difference between the minimum (8.54 μg/m^3) and the maximum value (118.69 μg/m^3) of hourly average concentrations. The mean value (21.828 μg/m^3) is not high. The mode 26.080 μg/m^3 and the median 17.9 μg/m^3 are close.

The standard deviation (14.081 μg/m^3) related to the maximum value and the mean value is not considerable. The variation is 195.96 μg/m^3, which is comparatively high but it is obtained by squaring the standard deviation. The distributions have left orientation and considerable pointedness, which is represented in the illustrations in Table 2.

The range of the maximum daily average concentrations of nitrogen monoxide is similar to the hourly average concentrations – 19.57 μg/m^3 – Table 2.

The minimum value (11.42μg/m^3), maximum value (56.45 μg/m^3) and mean value (22.319 μg/m^3) are similar. It can be explained with the way they are calculated. They are defined by the hourly average concentrations in twenty-four-hour period. The variation 44.685 μg/m^3 corresponds to the mean value and it is close to the variation of nitrogen dioxide.

The dynamic series and the fluctuation trend of the hourly average concentrations and the maximum daily average concentration in the air in Svishtov are enlisted in Figure 2.

The maximum hourly average concentrations of nitrogen dioxide fluctuate in the range from 30-40 to 290-300 μg/m^3. We find regularities in the dynamic

series. The concentrations increase. They coincide with the months of the autumn and winter season. The maximum values are local.

The maximum daily average concentrations coincide in their regularities with the hourly average concentrations. The reason is that they are analytically determined by the hourly average concentrations, which means that they are dependent.

The trends of the hourly average concentrations are regression models of fourth order, while those of daily average concentrations are of second order. The correlation coefficients are very small. This means that the concentrations do not depend on the weather.

The theoretical and empirical distributions of the maximum hourly average concentrations of nitrogen dioxide in the air in Svishtov are displayed in Table 3. The analysis shows the following regularities.

The theoretical distribution of maximum hourly average concentrations is Pearson distribution. There is a big difference between the left and the right absolute and relative limit. The absolute limits are respectively 5.8 and 116.4 μg/m^3. This leads to the concentrations having a big range – 110.6150 μg/m^3.

The minimum value is very low - 9.1672, at the same time the maximum value reaches up to 303.25 μg/m^3. This is due to temporary considerable increase in the concentrations. It can be said that such increases have regular character.

Table 4

Theoretical and empirical distribution of nitrogen monoxide in the air in Svishtov

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model LogLogistic distribution	Empirical distribution	Parameters	Theoretical model Invariant Gauss distribution	Empirical distribution
γ	10.9448			21.5841	
β	31.8260				
α	2.2441		$\overset{\mu}{\lambda}$	170.8918	
Left X	19.5	19.5	Лява граница X	8.82	8.82
Left P	5.00%	2.94%	Left X	5.00%	7.35%
Right X	129.1	129.1	Left P	33.24	33.24
Right P	95.00%	94.12%	Right X	95.00%	95.59%

Diff. X	109.6220	109.6220	Right P	24.4148	24.4148
Diff. P	90.00%	91.18%	Diff. X	90.00%	88.24%
Minimum	10.945	13.170	Diff. P	-2.7231	5.9900
Maximum	+Infinity	463.35	Minimum	+Infinity	46.960
Mean	56.156	60.192	Maximum	18.861	18.861
Mode	31.709	36.850	Mean	15.156	21.910
Median	42.771	41.905	Mode	17.590	17.745
Std. Deviation	80.097	69.897	Median	7.6708	7.7941
Variance	6415.551	4813.77	Std. Deviation	58.841	59.854
Skewness		4.2472	Variance	1.0662	1.2116
Kurtosis		22.1721	Skewness	4.8945	5.3779

The mean value is comparable to the concentrations in Nikopol – Figure 1 and Table 1-2. It is 42.151μg/m^3. Particularly impressive are the considerable standard deviations and variations. They are respectively 42.332 and 1783.68 μg/m^3. They can be explained with the wider fluctuations of the hourly average concentrations.

The asymmetry and the excess are positive, with left position and pointedness higher than the normal distribution.

The theoretical and empirical distributions of the maximum daily average concentrations of nitrogen dioxide in the air in Svishtov are shown in Table 3. Their distribution is logarithmic–logistic with parameters γ=-3.4492; β=22.8904; α=2.38590.

The absolute and relative limits should be pointed out because they determine the whole range of concentration fluctuation. The left limit is 3.3 μg/m^3, the right 75.2 μg/m^3. The range is 71.97 μg/m^3.

The maximum value of the daily average concentration of nitrogen dioxide is 280.32 μg/m^3. It is due to single growth. There is no repetition. The mean concentration value (28.346 μg/m^3) is lower than the annual average concentration – 40 μg/m^3. The diffusion is considerable. That is why the standard deviation is 35.624 μg/m^3, and the variation is 1265.85 μg/m^3. The asymmetry and the excess of the distributions of the maximum daily average concentrations in the air in Svishtov are positive, which can be explained with the nature of the distribution - logarithmic logistic.

The distributions of the maximum concentrations of nitrogen monoxide in Svishtov are enlisted in Table 4.

The maximum hourly average concentration is dependent on logarithmic – logistic distribution with parameters γ=10.9448; β=31.8260; α=2.2441. The maximum value is 463.35 μg/m^3. The mean value is also considerable - 60.192

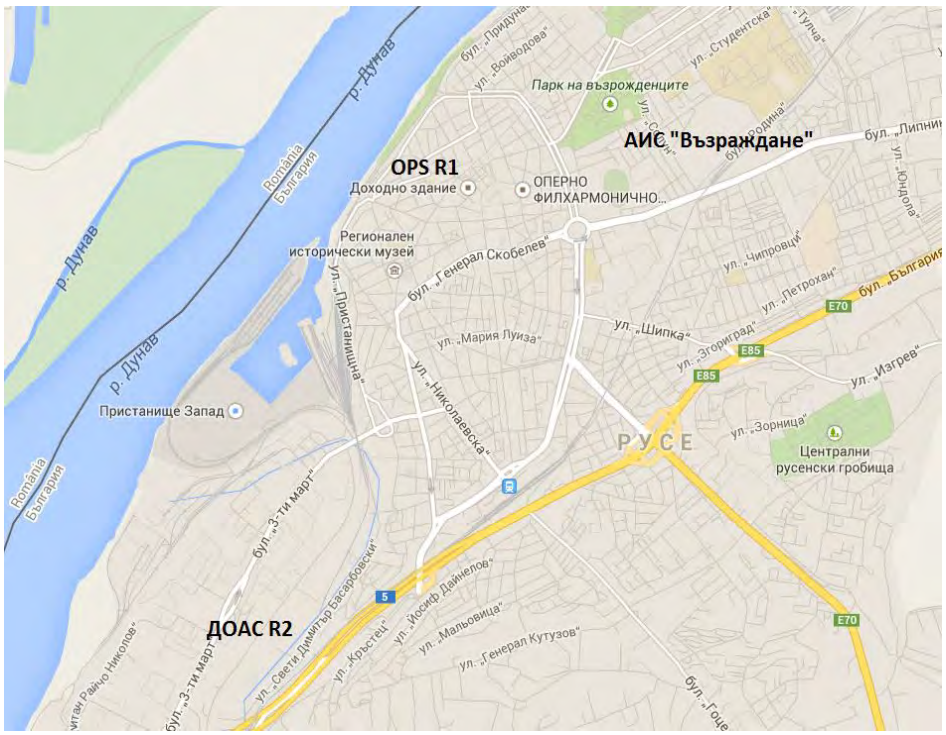


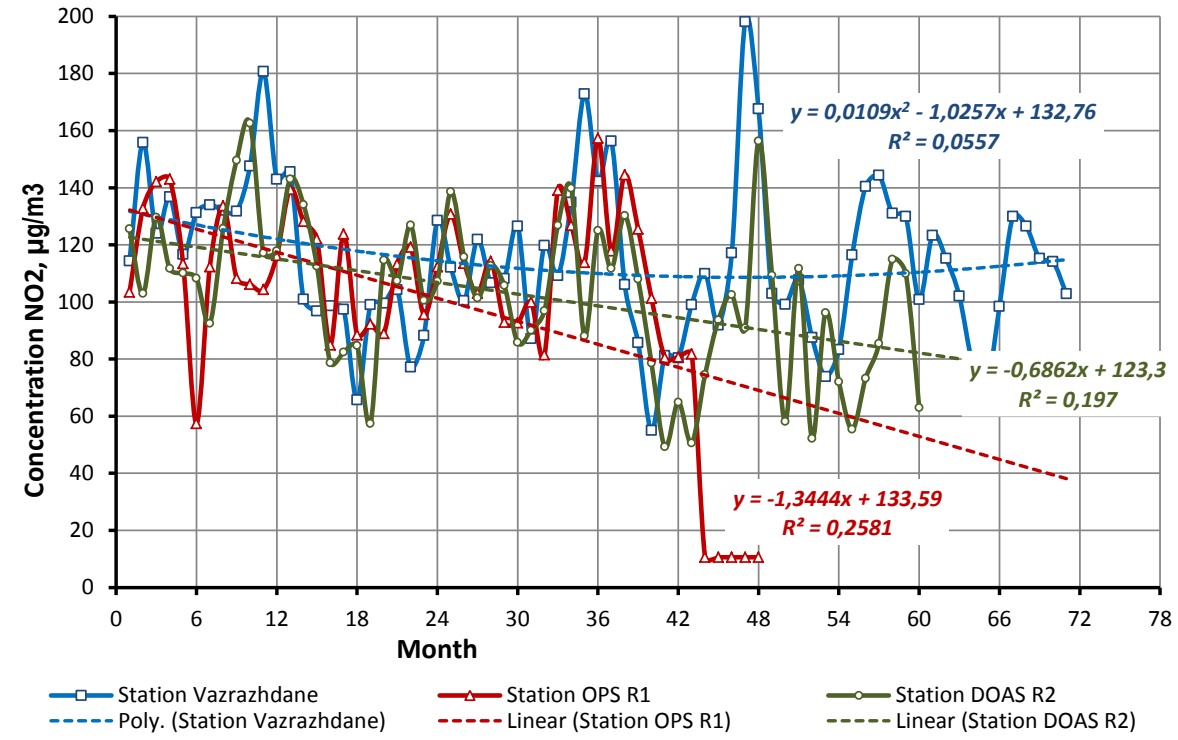
Fig.3. Location of monitoring stations in Ruse

μ

μg/m^3. The high values of the mode - 36.850 μg/m^3 and the median - 41.905 μg/m^3 correspond to it. The big range - 109.6220 μg/m^3 should be noted as well.

Unlike the hourly average concentrations we confirm invariant Gauss distribution with daily average concentrations of nitrogen monoxide in the air in Svishtov with parameters =21.5841 и =170.8918. Its left absolute limit is very low - 8.82 μg/m^3. The right limit is 33.24 μg/m^3, which is due to the small range of concentration fluctuation - 24.4148 μg/m^3.

Similar minimum and maximum values of empirical distribution correspond to this range - 5.9900 and 46.960 μg/m^3. The mean value is 18.861 μg/m^3 and the standard deviation and variation are small - 7.7941 and 59.854 μg/m^3.



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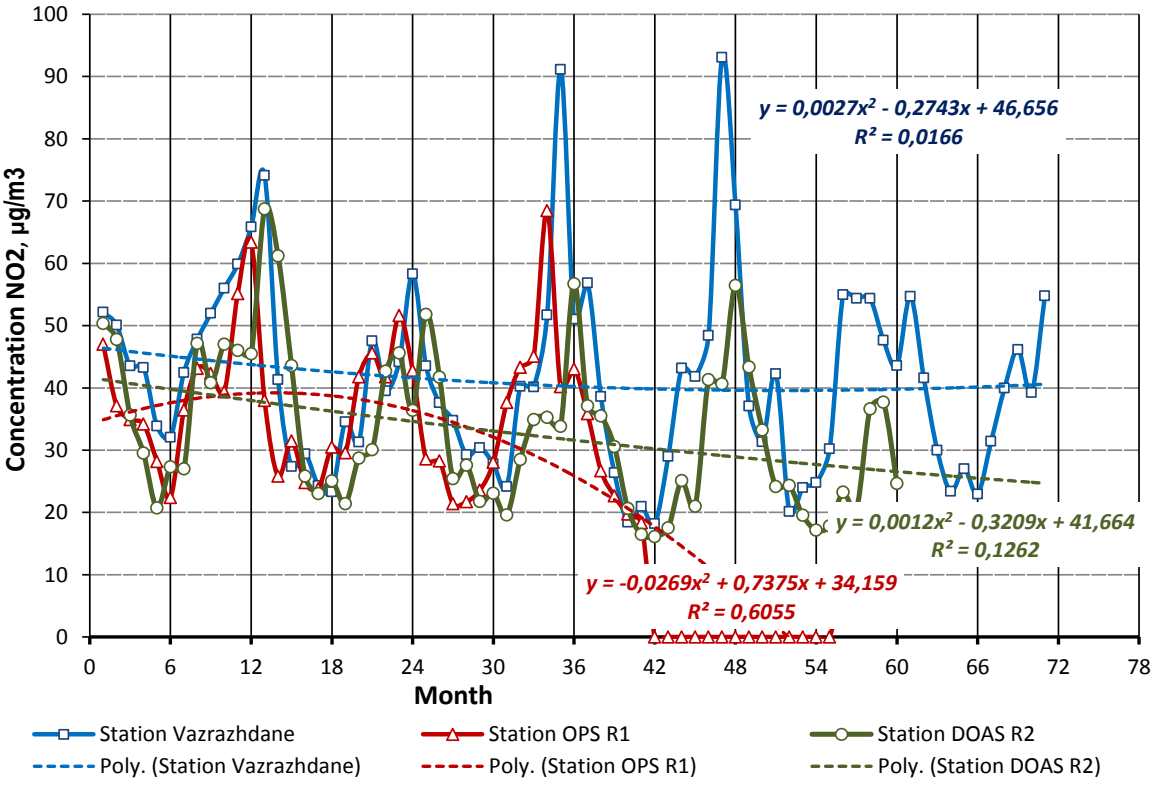


b)

Fig 4. Dinamic series and trend of nitrogen dioxide concentration in Ruse: a) maximum hour concentration; b) maximum day concentration

The measuring stations in Ruse are located as it is shown on the map in Figure 3. The measurements in OPS R1 represent the degree of pollution along the bank of the Danube river. This measuring station is the closest to the border of Bulgaria and Romania.

The dynamic series and the fluctuation trend of the maximum concentrations of nitrogen dioxide and nitrogen monoxide in the air in Ruse are illustrated in Figures 4 and 5.

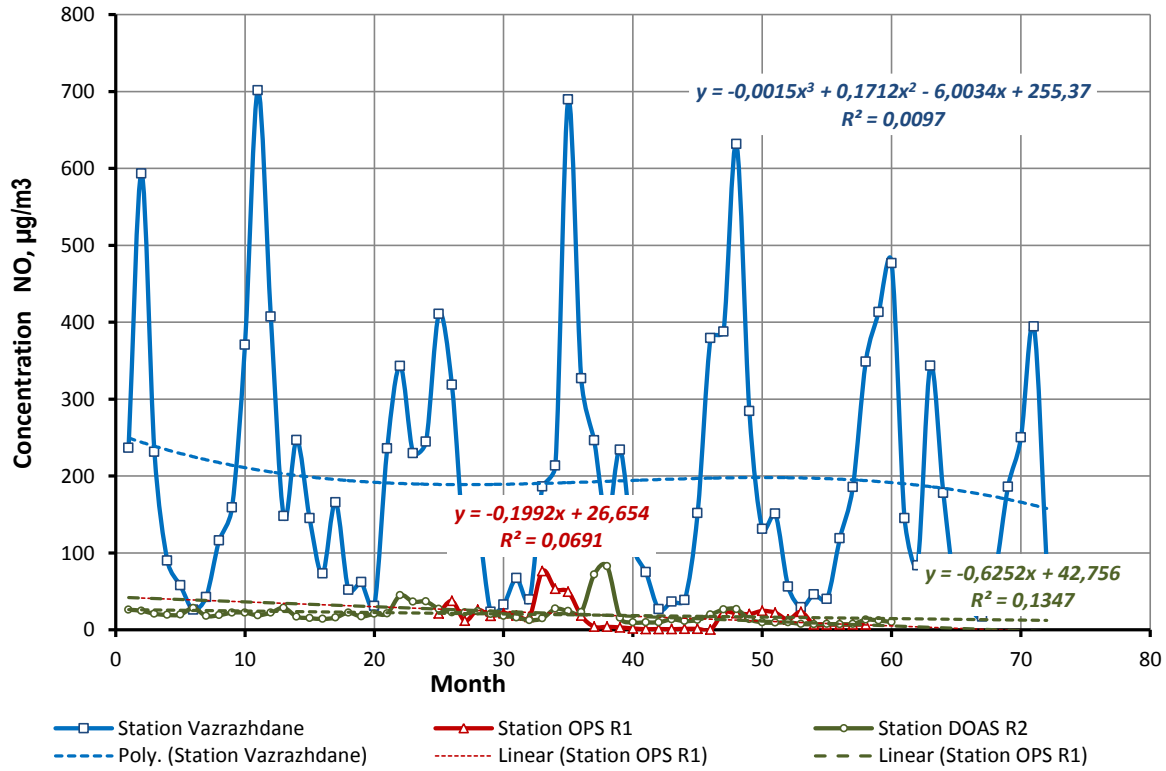
The analysis of the dynamic series shows close values of the measurements of hourly average concentrations and daily average concentrations. Clear regularities are outlined. The concentrations which are measured in AMS *Vazrazhdane* are the highest. They are followed by the concentrations measured at station ROAS R2, which is located in the west industrial zone. The lowest concentrations are found in the air at the bank of the Danube river.

Analogy we find with the regularities of the maximum daily average concentrations of nitrogen dioxide, which are represented in Figure 4b.

The fluctuation trends are interesting. With the hourly average concentrations at AMS *Vazrazhdane* the approximation follows a regression model of second order, while in OPS R1 and ROAS R2 it is linear. It turns out that the correlation coefficient R^2 is insignificant at AMS *Vazrazhdane*, which shows that the concentrations hardly depend on the weather. At the other two stations the coefficient is respectively 0.2581 at OPS R1 and 0.197 at ROAS R2. Similar tendencies are found with maximum daily average concentrations. The concentration fluctuation trends at the three stations are of second order, and the correlation coefficient is 0.6055 at OPS R1 and 0.1262 at ROAS R2.

The concentration fluctuations of nitrogen monoxide are displayed in Figure 5. When we compare them it turns out that there are seasonal cycles only with the concentrations measured in AMS *Vazrazhdane*. Their regression model is of second order and it is with insignificant correlation coefficient - R^2=0.0097, which shows that they do not depend on the weather. This opposes the graphic display of the concentrations. It could be assumed that it is due to the intensive dynamics of concentration values. The correlation is small at the other two stations - 0.0691 and 0.1347.

The dynamic series of the daily average concentrations of nitrogen monoxide in Ruse are similar to the hourly average ones. There are coincidences of maximum and minimum values as one is derived from the other. In this case and also when monitoring the air quality, the daily average concentrations may not be measured. The first reason is their dependence on the hourly average concentrations and the second – they are not standardized in accordance with the existing standards in the country. However, we should take into account the requirement for validity and the number of measurements. Similarly to the hourly average concentrations, the correlation coefficients are of the same order -0.0019 at AMS *Vazrazhdane*, 0.1117 at ROAS R2 and 0.2916 at OPS R1.



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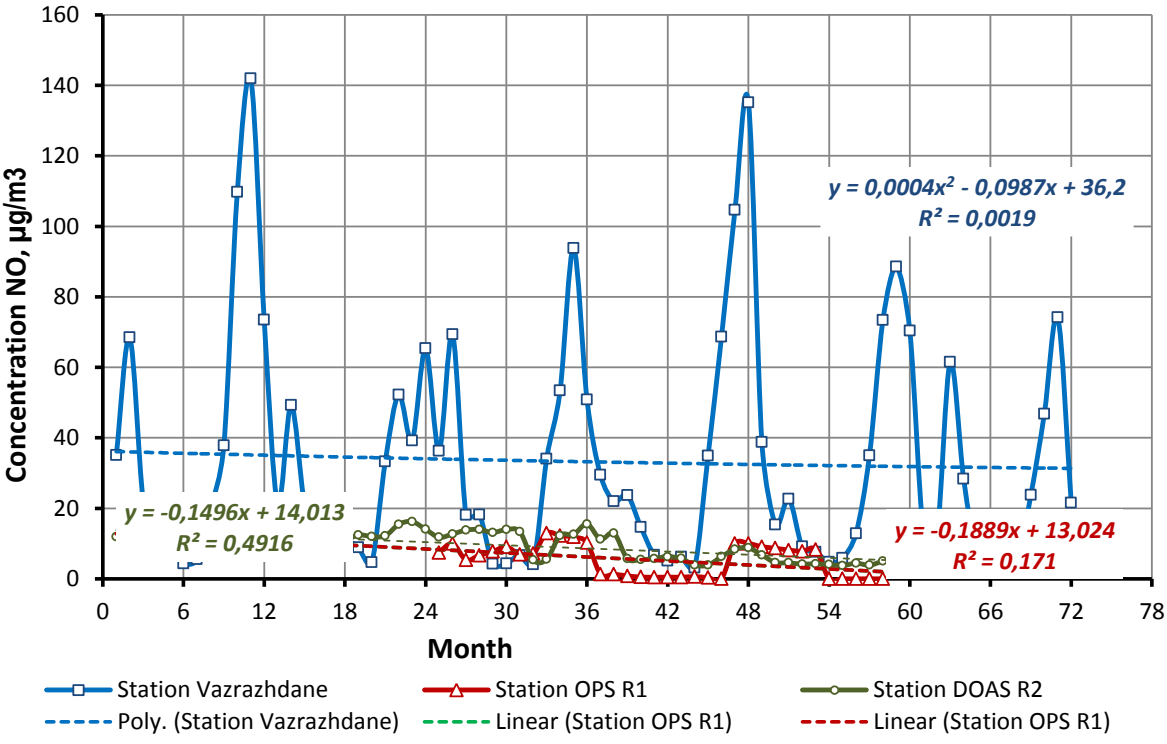


b)

Fig.5. Dinamic series and trend of nitrogen monoxide concentrations in Ruse: a) maximum hour concentration; b) maximum day concentration

The theoretical and empirical distributions are a more appropriate indicator for the concentrations of nitrogen oxides in the air. They are displayed in Tables 5 and 6. Their analysis shows a number of regularities.

Firstly, the law of the maximum hourly average concentrations of nitrogen dioxide at ROAS R2 is a triangular distribution with parameters min = 36.88328, m. likely = 109.31 and max = 167.1562, while at AMS *Vazrazhdane* the distribution is normal with parameters m = 114.7051 and s = 27.99473.

Their limits are also similar – from 58.6 to 147.7 μg/m^3 at ROAS R2 and 68.7 and 160.8 μg/m^3 at AMS *Vazrazhdane*. The mean values are 102.37 and 114.71 μg/m^3, i.e. the difference is insignificant.

The standard deviation at ROAS R2 is 27.003 μg/m^3, therefore, the deviation is high - 717.01 μg/m^3. At AMS *Vazrazhdane* they are the same - 27.995 μg/m^3 and 772.67 μg/m^3.

The maximum concentration at ROAS R2 is 162.57 μg/m^3, while at AMS *Vazrazhdane* it is 114.71 μg/m^3. Hence, they are under the limit for hourly average concentration, which is 200 μg/m^3. There is no exceeding.

It would be natural for the daily average concentrations to follow similar patterns. However, they will be strongly influenced by the validity of the measurements.

The law for hourly average concentration distribution at station ROAS R2 is beta distribution with parameters a1=0.903212; a2=2.102014; min=16.13; max=72.5177, while at AMS *Vazrazhdane* it is Weibull distribution with parameters a=1.604527 and b=26.92485. The distributions also determine the numerical values of the characteristics.

In the empirical distribution of maximum daily average concentrations of nitrogen dioxide in the air in Ruse – measuring station ROAS R2 the range is 40.9554 μg/m^3, while at AMS *Vazrazhdane* - 49.1203 μg/m^3.

The numerical values of the other characteristics are similar. At measuring station ROAS R2 the maximum value is 68.71 μg/m^3, the mean value is 33.294 μg/m^3, the mode - 24.933 μg/m^3 and the median - 30.315 μg/m^3. At AMS *Vazrazhdane* respectively the maximum value is 93.06 μg/m^3, the mean value is 41.347 μg/m^3, the mode - 43.537 μg/m^3 and the median - 40.25 μg/m^3.

The standard deviations have insignificant differences – at ROAS R2 - 12.355 μg/m^3 and at AMS *Vazrazhdane* - 15.397 μg/m^3. The differences in the variations are completely the same.

The asymmetries and the excesses of maximum daily average concentrations are positive, which determines their location and shape.

We should note here once again that irrespective of the claims for mutual dependencies between the hourly and daily average concentrations it should be borne in mind the number of valid measurements. In no case should they be considered equal to the number of days in the month or the year. If we actually

take into account that number only then it will turn unnecessary to measure the daily average concentrations.

Table 5

Theoretical and empirical distribution of nitrogen dioxide in the air in Ruse – ROAS R2

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Triang distribution	Empirical distribution	Parameters	Theoretical model Betta distribution	Empirical distribution
min	36.88328		a1	0.903212	
m. likely	109.31		a2	2.102014	
			min	16.13	
max	167.1562		max	72.5177	
Left X	58.6	58.6	Left X	17.09	17.09
Left P	95.00%	90.00%	Left P	95.00%	96.67%
Right X	147.7	147.7	Right X	58.05	58.05
Right P	5.00%	5.00%	Right P	5.00%	3.33%
Diff. X	89.1418	89.1418	Diff. X	40.9554	40.9554
Diff. P	90.00%	85.00%	Diff. P	90.00%	93.33%
Minimum	36.883	49.24	Minimum	16.13	16.13
Maximum	167.16	168.22	Maximum	72.518	68.71
Mean	104.45	102.37	Mean	33.077	33.294
Mode	109.31	111.69	Mode	16.13	24.933
Median	105.57	107.3	Median	30.384	30.315
Std. Deviation	26.647	27.003	Std. Deviation	12.918	12.355
Variance	710.08	717.01	Variance	166.883	150.105
Skewness	-0.1088	-0.117	Skewness	0.6958	0.6832
Kurtosis	2.4	2.5622	Kurtosis	2.6061	2.8356

In this case it should be taken into account only the days with 75% valid measurements in accordance with Regulation 12 [2]. That was the reason not to consider the distributions of nitrogen dioxide concentrations measured at station OPS R1 as the database is incomplete. The database of OPS R1 is complete enough with the measurements of maximum hourly and daily average concentrations of nitrogen monoxide.

The distributions of nitrogen monoxide at station OPS R1 are enlisted in Table 7 and tables 8 and 9 show the measurements at stations ROAS R2 and AMS *Vazrazhdane*.

The maximum hourly average concentrations of nitrogen monoxide are distributed according to rules with different parameters, although they have the same theoretical distributions at the two stations: 1) at OPS R1 beta distribution with parameters α_1=0.62034; α_2=3.4255; $_{min}$=0.34; $_{max}$=107.5838; 2) at ROAS R2 logarithmic normal distribution with parameters =16.6589 and =12.64921; 3) at AMS *Vazrazhdane* beta distribution with parameters α_1=0.7634; α_2=0.2281; $_{min}$=17; $_{max}$=906.6890. μ σ With maximum daily average concentrations of nitrogen monoxide the theoretical models are: 1) at OPS R1 beta distribution with parameters α_1=0.2691; α_2=0.4799; $_{min}$=0; $_{max}$=12.96, 2) at ROAS R2 Weibull distribution with parameters =3.3916 and =12.1015, 3) at AMS *Vazrazhdane* exponential distribution with a parameter =31.26

Table 6

Theoretical and empirical distribution of nitrogen dioxide in the air in Ruse – AMS *Vazrazhdane* α β β

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Normal distribution	Empirical distribution	Parameters	Theoretical model Weibul distribution	Empirical distribution
m	114.7051		a	1.604527	
s	27.99473		b	26.92485	
Left X	68.7	68.7	Left X	21.4	21.4
Left P	95.00%	97.18%	Left P	95.00%	94.37%
Right X	160.8	160.8	Right X	70.52	70.52
Right P	5.00%	5.63%	Right P	5.00%	4.23%
Diff. X	92.0945	92.0945	Diff. X	49.1203	49.1203
Diff. P	90.00%	91.55%	Diff. P	90.00%	90.14%
Minimum	-Infinity	54.96	Minimum	17.168	18.17
Maximum	+Infinity	211.11	Maximum	+Infinity	93.06
Mean	114.705	114.71	Mean	41.302	41.347
Mode	114.705	129.90	Mode	31.821	43.537
Median	114.705	112.09	Median	38.594	40.25
Std. Deviation	27.995	27.995	Std. Deviation	15.404	15.397
Variance	783.705	772.67	Variance	237.269	233.741
Skewness	0	0.673	Skewness	0.9573	1.0381
Kurtosis	3	4.0708	Kurtosis	4.0302	4.6058

The theoretical distributions make it possible to recalculate the concentration values and to simulate all possible values in the range of validity

of the laws of distribution. They account for specific regularities of concentration fluctuations and they are criteria objective enough for them.

The empirical values are the base. The theoretical distributions recreate them and are almost a copy of them. They are models which provide a number of operational possibilities for determining the concentration values. Therefore, the numerical characteristics vary in the same manner as the theoretical distribution laws.

The analysis of Tables 7, 8 and 9 shows the following regularities in the numerical values of the test characteristics.

First of all, the minimum and maximum values of hourly average concentrations in the three measuring stations in Ruse are: at OPS R1 0.34000 and 76.480 μg/m^3; at ROAS R2 7.3100 and 82.790μg/m^3; at AMS Vazrazhdane 17.000 and 701.63 μg/m^3. In other words, the highest maximum hourly average concentrations are measured at AMS *Vazrazhdane*.

Table 7

Theoretical and empirical distribution of nitrogen monoxide in the air in Ruse – OPS R1

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Betta distribution	Empirical distribution	Parameters	Theoretical model Betta distribution	Empirical distribution
α1	0.62034		*α1*	0.2691	
α2	3.4255		*α2*	0.4799	
min	0.34		*min*	0	
max	107.5838		*max*	12.96	
Left X	0.56	0.56	Left X	0.0006	0.0006
Left P	5.00%	2.94%	Left P	5.00%	17.65%
Right X	53.13	53.13	Right X	12.80	12.80
Right P	95.00%	94.12%	Right P	95.00%	97.06%
Diff. X	52.5698	52.5698	Diff. X	12.8010	12.8010
Diff. P	90.00%	91.18%	Diff. P	90.00%	79.41%
Minimum	0.34000	0.34000	Minimum	0.0000	0.0000
Maximum	107.58	76.480	Maximum	12.960	12.960
Mean	16.783	16.811	Mean	4.6563	5.1835
Mode	0.34000	6.8600	Mode		0.0000
Median	10.833	15.095	Median	2.7936	6.8150
Std. Deviation	17.202	16.967	Std. Deviation	4.7016	4.5493
Variance	295.90	279.410	Variance	22.105	20.087
Skewness	1.4300	1.6905	Skewness	0.5644	0.0706
Kurtosis	4.7803	6.1658	Kurtosis	2.6061	2.8356

There is a considerable difference in the numerical characteristics of empirical distributions at the measuring stations, namely in: 1) range: OPS R1 52.5698 μg/m^3; ROAS R2 35.8775 μg/m^3; AMS *Vazrazhdane* 510.5321 μg/m^3; 2) mean value: OPS R1 16.811 μg/m^3; ROAS R2 20.578 μg/m^3; AMS *Vazrazhdane* 196.20 μg/m^3; 3) mode: OPS R1 6.8600 μg/m^3; - ROAS R2 22.340 μg/m^3; AMS *Vazrazhdane* 39.340 μg/m^3; 4) median: - OPS R1 15.095 μg/m^3; ROAS R2 19.020 μg/m^3; AMS *Vazrazhdane* 149.42 μg/m^3; 5) standard deviation: OPS R1 16.967 μg/m^3; ROAS R2 13.233 μg/m^3; AMS *Vazrazhdane* 165.89 μg/m^3; 6) variation: OPS R1 279.410 μg/m^3; ROAS R2 172.187 μg/m^3; AMS *Vazrazhdane* 27136.74 μg/m^3.

Comparing these results we can conclude that there are no considerable differences in hourly average concentrations of nitrogen monoxide at the first two measuring stations – OPS R1 and ROAS R2. The maximum of the maximum hourly average concentrations is with the measurements at AMS *Vazrazhdane*.

Similar are the measurement results of maximum daily average concentrations of nitrogen monoxide, which are also displayed in Tables 7, 8 and 9.

The theoretical distributions of maximum daily average concentrations are: 1) at OPS R1 beta distribution with parameters α_1=0.2691; α_2=0.4799; $_{min}$=0; $_{max}$=12.96; 2) at ROAS R2 Weibull distribution with parameters =3.3916; =12.1015; 3) at AMS *Vazrazhdane* exponential distribution with a parameter =31.2634.

Table 8

Theoretical and empirical distribution of nitrogen monoxide in the air in Ruse – OPS R1

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model LogNormal distribution	Empirical distribution	Parameters	Theoretical model Weibul distribution	Empirical distribution
	16.6589			3.3916	
	12.64921			12.1015	
Left X	8.28	8.28	Left X	3.67	3.67
Left P	5.00%	8.33%	Left P	5.00%	0.00%
Right X	44.15	44.15	Right X	15.35	15.35
Right P	95.00%	95.00%	Right P	95.00%	95.00%
Diff. X	35.8775	35.8775	Diff. X	11.6827	11.6827
Diff. P	90.00%	86.67%	Diff. P	90.00%	95.00%

Minimum	3.9035	7.3100	Minimum	-1.3698	3.7500
Maximum	+Infinity	82.790	Maximum	+Infinity	16.220
Mean	20.562	20.578	Mean	9.5006	9.4513
Mode	12.319	22.340	Mode	9.5474	5.7600
Median	17.171	19.020	Median	9.4922	10.785
Std. Deviation	12.649	13.233	Std. Deviation	3.5387	3.7255
Variance	160.003	172.187	Variance	12.523	13.648
Skewness	2.7157	2.7887	Skewness	0.0531	-0.2098
Kurtosis	18.4710	12.8019	Kurtosis	2.7106	1.6663

The minimum and maximum values of daily average concentrations are: at OPS R1 0.34000 and 76.480μg/m^3; at ROAS R2 7.3100 and 82.790 μg/m^3; at AMS *Vazrazhdane* 17.000 and 701.63 μg/m^3. The other numerical values are as follows: 1) range: - OPS R1 52.5698 μg/m^3; -ROAS R2 35.8775 μg/m^3; - AMS *Vazrazhdane* 510.5321 μg/m^3; 2) mean value: - OPS R1 16.811 μg/m^3; - ROAS R2 20.578 μg/m^3; - AMS *Vazrazhdane* 196.20 μg/m^3; 3) mode: - OPS R1 6.8600 μg/m^3; -ROAS R2 22.340 μg/m^3; - AMS *Vazrazhdane* 39.3409.340 μg/m^3; 4) median: - OPS R1 15.095 μg/m^3; -ROAS R2 19.020 μg/m^3; - AMS *Vazrazhdane* 149.42 μg/m^3; 5) standard deviation: - OPS R1 16.967 μg/m^3; -ROAS R2 13.233 μg/m^3; - AMS *Vazrazhdane* 165.89 μg/m^3; 6) variation: - OPS R1 279.410 μg/m^3; -ROAS R2 172.187 μg/m^3; - AMS *Vazrazhdane* 27136.74 μg/m^3.

Table 9

Theoretical and empirical distribution of nitrogen monoxide in the air in Ruse – AMS *Vazrazhdane*

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Betta distribution	Empirical distribution	Parameters	Theoretical model Exponential distribution	Empirical distribution
$\alpha 1$	0.7634			31.2634	
$\alpha 2$	0.2281				
min	17				
max	906.6890				
Left X	22.5	22.5	Left X β	3.3	3.3
Left P	5.00%	1.39%	Left P	5.00%	4.17%
Right X	533.0	533.0	Right X	95.3	95.3
Right P	95.00%	94.44%	Right P	95.00%	94.44%

Diff. X	510.5321	510.5321	Diff. X	92.0534	92.0534
Diff. P	90.00%	93.06%	Diff. P	90.00%	90.28%
Minimum	17.000	17.000	Minimum	1.6658	2.1000
Maximum	906.69	701.63	Maximum	+Infinity	141.95
Mean	197.14	196.20	Mean	32.929	33.363
Mode	17.000	39.340	Mode	1.6658	4.3200
Median	149.43	149.42	Median	23.336	21.775
Std. Deviation	163.69	165.89	Std. Deviation	31.263	32.485
Variance	26792.84	27136.74	Variance	977.405	1040.60
Skewness	1.1210	1.2321	Skewness	2.0000	1.4234
Kurtosis	3.7204	4.1250	Kurtosis	9.0000	4.6220

We confirmed the ratios between the numerical values of empirical distributions of different measuring stations, on the one hand, and to the hourly average concentrations of nitrogen monoxide, on the other hand.

The asymmetry and the excess in all the values of distribution laws and the empirical results are positive.

The dynamic series of maximum hourly and daily average concentrations of nitrogen dioxide in the air in Silistra are presented in Figure 5. Their analysis shows high variability. We found pronounced regularities. At ROAS S1 the variability of the dynamic statistic series is higher than at ROAS S2. The values change continuously during the observation period. There are no regions with equal concentration values. The fluctuations are perennial, they do not refer to a specific season. There is no full matching of the local maximums and minimums. We find out that with daily average concentrations the fluctuation between the dynamic series of the two measuring stations is higher.

Table 9

Theoretical and empirical distribution of nitrogen dioxide in the air in Silistra - ROAS S1

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Invariant Gauss distribution	Empirical distribution	Parameters	Theoretical model Betta distribution	Empirical distribution
	305.9398		$\alpha 1$	0.8693	
			$\alpha 2$	2.5496	
$\frac{\mu}{\lambda}$	59943.8409		min	9.27	
			max	56.1668	
Left X	30.9	30.9	Left X	9.84	9.84

Left P	5.00%	5.71%	Left P	5.00%	2.86%
Right X	102.7	102.7	Right X	40.52	40.52
Right P	95.00%	97.14%	Right P	95.00%	97.14%
Diff. X	71.7969	71.7969	Diff. X	30.6742	30.6742
Diff. P	90.00%	91.43%	Diff. P	90.00%	94.29%
Minimum	-240.46	25.860	Minimum	9.2700	9.2700
Maximum	+Infinity	123.160	Maximum	56.167	51.530
Mean	65.478	65.478	Mean	21.195	21.371
Mode	63.144	71.263	Mode	9.2700	13.300
Median	64.699	66.960	Median	18.828	20.995
Std. Deviation	21.857	21.972	Std. Deviation	9.7145	9.2550
Variance	477.71	475.889	Variance	94.371	84.431
Skewness	0.2143	0.1104	Skewness	0.8756	0.7477
Kurtosis	3.0766	2.3703	Kurtosis	3.0362	3.2437

Table 10

Theoretical and empirical distribution of nitrogen dioxide in the air in Silistra - ROAS S2

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Normal distribution	Empirical distribution	Parameters	Theoretical model Invariant Gauss distribution	Empirical distribution
	46.8578			14.45624	
	16.5879		λ	73.1754	
Left X μ	19.57	19.57	Left X μ	9.13	9.13
Left P σ	5.00%	3.33%	Left P	5.00%	6.67%
Right X	74.14	74.14	Right X	29.25	29.25
Right P	95.00%	96.67%	Right P	95.00%	93.33%
Diff. X	54.5694	54.5694	Diff. X	20.1182	20.1182
Diff. P	90.00%	93.33%	Diff. P	90.00%	86.67%
Minimum	-Infinity	18.730	Minimum	2.5459	8.0800
Maximum	+Infinity	91.870	Maximum	+Infinity	31.910
Mean	46.858	46.858	Mean	17.002	17.002
Mode	46.858	58.720	Mode	13.340	18.250
Median	46.858	47.565	Median	15.718	16.045
Std.	16.588	16.588	Std.	6.4254	6.1741

Deviation			Deviation		
Variance	275.159	270.573	Variance	41.286	37.484
Skewness	0.0000	0.1933	Skewness	1.3334	0.7365
Kurtosis	3.0000	2.4924	Kurtosis	5.9633	2.8273

Table 11

Theoretical and empirical distribution of nitrogen monooxide in the air in Silistra - ROAS S1

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Normal distribution	Empirical distribution	Parameters	Theoretical model Betta distribution	Empirical distribution
μ	19.9688		a1	1.9004	
			a2	5.5346	
σ	8.0617		min	2.9044	
			max	27.3330	
Left X	6.71	6.71	Left X	4.17	4.17
Left P	5.00%	1.43%	Left P	5.00%	2.86%
Right X	33.23	33.23	Right X	16.04	16.04
Right P	95.00%	95.71%	Right P	95.00%	95.71%
Diff. X	26.5209	26.5209	Diff. X	11.8742	11.8742
Diff. P	90.00%	94.29%	Diff. P	90.00%	92.86%
Minimum	-Infinity	5.5700	Minimum	2.9044	3.0800
Maximum	+Infinity	35.350	Maximum	27.333	20.470
Mean	19.9689	19.969	Mean	9.1485	9.1291
Mode	19.9689	17.323	Mode	6.9516	7.4800
Median	19.9689	18.975	Median	8.5943	8.2650
Std. Deviation	8.0618	8.0618	Std. Deviation	3.6689	3.7359
Variance	64.9923	64.064	Variance	13.461	13.757
Skewness	0.0000	0.1380	Skewness	0.6899	0.8541
Kurtosis	3.0000	2.0234	Kurtosis	3.0705	3.1719

Table 12

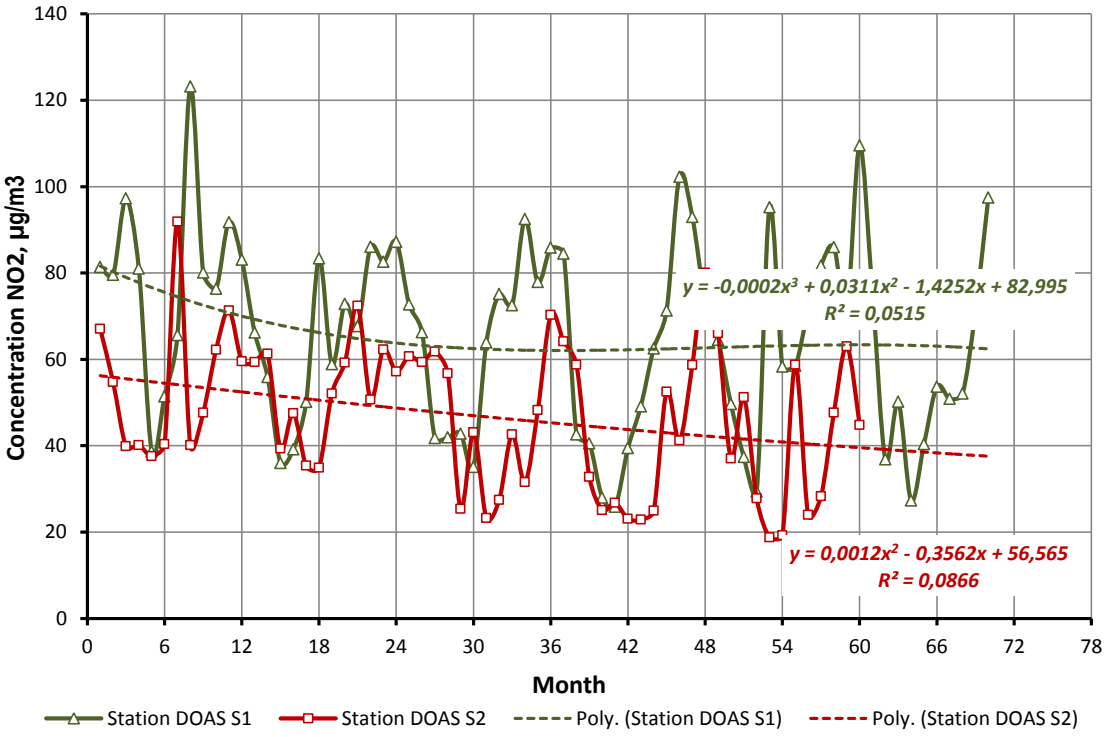
Theoretical and empirical distribution of nitrogen monoxide in the air in Silistra - ROAS S2

Maximum hour concentration			Maximum day concentration		
Parameters	Theoretical model Pearson distribution	Empirical distribution	Parameters	Theoretical model Invariant Gauss distribution	Empirical distribution
α	1.1634		γ	3.5543	
			β	6.6985	
β	16.757		α	2.5900	
Left X	10	10	Left X	5.7	5.7
Left P	5.00%	3.33%	Left P	5.00%	5.00%
Right X	203	203	Right X	24.4	24.4
Right P	95.00%	95.00%	Right P	95.00%	95.00%
Diff. X	192.9238	192.9238	Diff. X	18.7289	18.7289
Diff. P	90.00%	91.67%	Diff. P	90.00%	90.00%
Minimum	4.8122	7.3700	Minimum	3.5543	4.2900
Maximum	+Infinity	912.30	Maximum	+Infinity	265.88
Mean	107.328	67.329	Mean	12.2288	16.729
Mode	12.558	16.227	Mode	8.4457	10.070
Median	24.476	24.155	Median	10.2529	10.600
Std. Deviation	12.2451	152.53	Std. Deviation	9.5205	35.916
Variance	146.12	22876.21	Variance	90.6402	1268.48
Skewness	3.2617	4.4318	Skewness	6.1341	6.1301
Kurtosis	16.1231	22.5685	Kurtosis	23.4211	41.1992

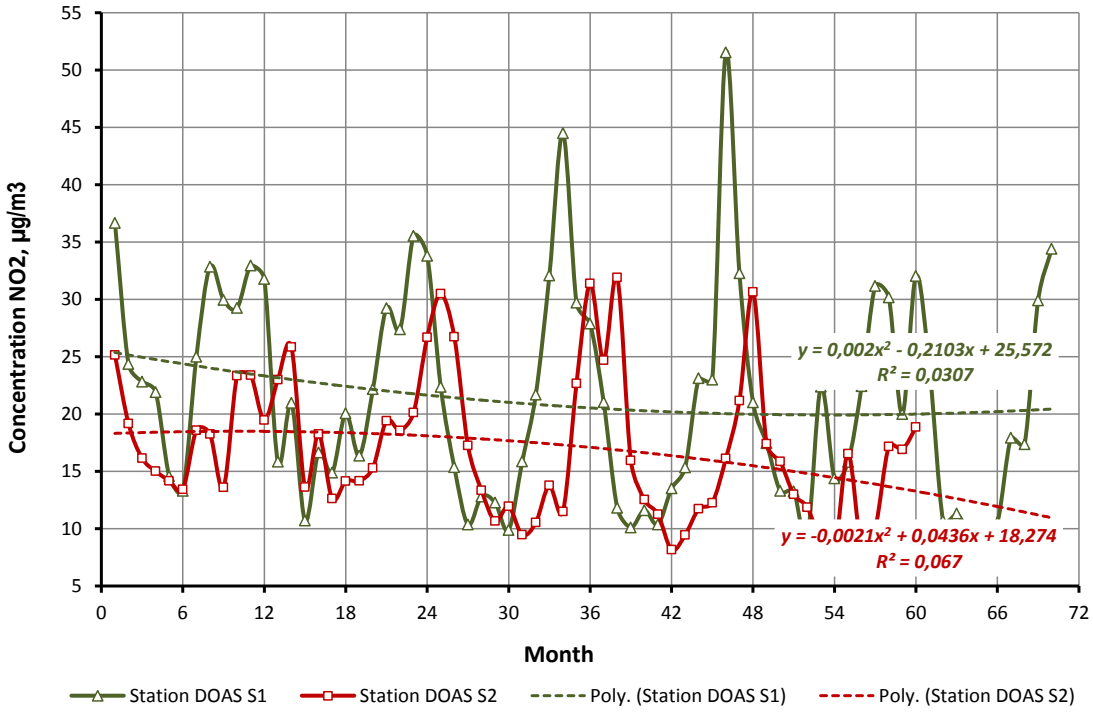
The trend of the hourly average concentrations of nitrogen dioxide is a polynomial of third degree at ROAS S1 and quadratic polynomial at ROAS S2. The correlation coefficients are insignificant, which is due to the high concentration fluctuation in time. The trend models of daily average concentrations are analogous. They are polynomials of second degree. At ROAS S2 the correlation coefficient is 0.0307 and at ROAS S1 it is 0.0670.

The trend model of hourly average concentrations of nitrogen monoxide at ROAS S1 is $y = -0.0213x + 20.726$ and at ROAS S2 it is $y = 0.0502x^2 - 1.9689x + 38.932$. The correlation coefficients are respectively 0.275 and 0.0029. We did not find any regularities of concentration values measured at ROAS S2. At ROAS S1 the fluctuations of hourly average concentrations is cyclic. Full related regularities are found with daily average concentrations of nitrogen monoxide. Regression equations of the trends are $y=-0.0598x+11.253$ at ROAS S1 and $y=0.4294x+1.1307$ at ROAS S2. The correlation coefficient R^2 at the first measuring station is 0.1062 and at the second - 0.1413.

The theoretical and empirical distributions of maximum concentrations of nitrogen dioxide in the air in Silistra – measuring station ROAS S1 are displayed in Table 10. The theoretical model of maximum hourly average concentration is an invariant Gauss distribution with parameters =305.9398 and λ=59943.8409, while of maximum daily average concentration – beta distribution with parameters α_1=0.8693; α_2=2.5496, $_{min}$=9.27, μ_{max}=56.1668.

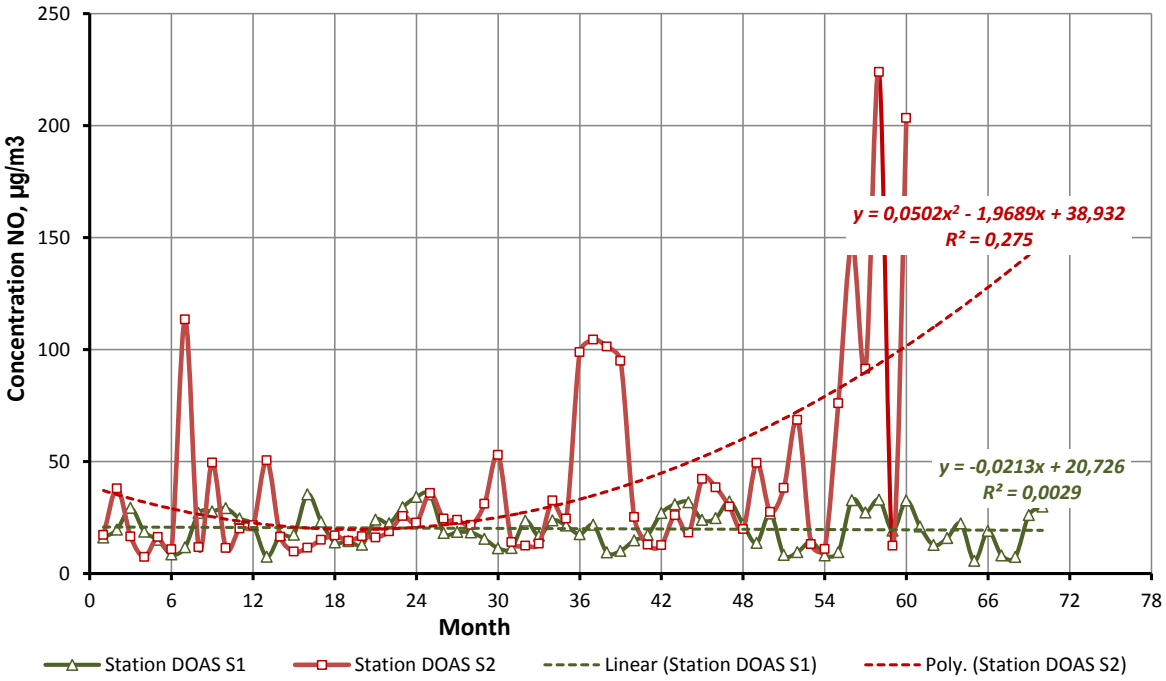


a)



b)

Fig.6. Dinamic series and trend of nitro dioxide concentrations in Silistra: a) maximum hour concentration; б) maximum day concentration



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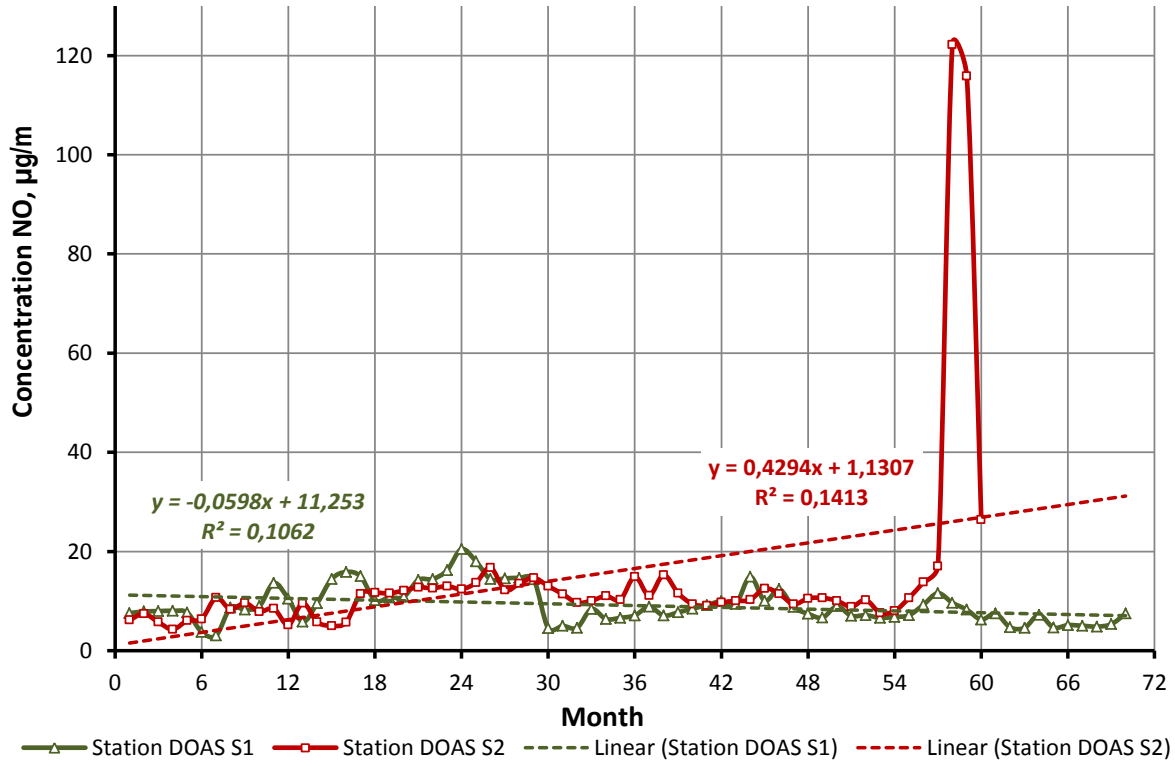

b)

Фиг.7. Dinamic series and trend of nitro monooxide concentrations in Silistra: а) maximum hour concentration; б) maximum day concentration

There is a wide range of fluctuation of the empirical values of hourly average concentration. The left limit is 30.9 µg/m^3, the right limit is 102.7 µg/m^3 and the range - 71.7969 µg/m^3. The maximum daily average concentration has significantly lower values of fluctuation – the left limit is 9.84 µg/m^3, the right limit is 40.52 µg/m^3 and the range - 30.6742 µg/m^3. The maximum value of hourly average concentrations is 123.160 µg/m^3, while of the daily average concentrations it is 51.530 µg/m^3. We observe similar ratio with the mean values of empirical distributions, respectively 65.478 µg/m^3 and 21.371 µg/m^3. This pattern remains to some extent also with the distribution mode and median, irrespective of the different theoretical laws of distribution.

With maximum hourly average concentrations the standard deviation and variation are high -21.972 µg/m^3 and 475.889 µg/m^3, which is an indicator of considerable fluctuation of their values. With daily average concentration they are 9.2550 µg/m^3 and 84.431 µg/m^3.

The indicators of asymmetry and the degree of pointedness are positive. The theoretical and the empirical distribution are with left orientation and more pointed compared to the normal distribution.

The theoretical and the empirical distributions of the maximum concentrations of nitrogen dioxide in the air in Silistra – measuring station

ROAS S2 are shown in Table 11. The theoretical model of hourly average concentrations has normal distribution with parameters =46.8578 and =16.5879, while daily average concentrations have invariant Gauss distribution with =14.4562 and λ=73.1754. The range of the hourly average concentrations is wider - 54.5694 μg/m^3 compared to the daily average concentrations - 20.1182 μg/m^3. The maximum value of the hourly average concentration is more than three times higher than the daily value. The mean value is 46.858 μg/m^3 and respectively 17.002 μg/m^3. There is a considerable difference between the standard deviations 16.588 μg/m^3 respectively 6.1741 μg/m^3 and variations 270.573 μg/m^3 and 37.484 μg/m^3. Similarly to the other distribution values the asymmetry and the excess are greater than zero.

The ratios mentioned between the concentrations of nitrogen dioxide at the two measuring stations in Silistra are preserved with the nitrogen monoxide. Naturally, their limits are different. At ROAS S1 the limits of the hourly average concentrations are 6.71 and 33.23 μg/m^3 and of the daily average concentrations - 4.17 and 16.04 μg/m^3. The maximum value respectively is 35.350 μg/m^3 and 20.470 μg/m^3. The standard deviations are very small 8.0618 μg/m^3 - 3.7359μg/m^3. Naturally, small variations correspond to them. Significant differences in the numerical values of nitrogen monoxide concentrations measured at ROAS S2 are not found. Considerably high are the standard deviation and variation of the maximum daily average concentrations - 35.916 μg/m^3 and 1268.48 μg/m^3.

The annual average concentrations are calculated. They are calculated on the base of the maximum daily average concentrations. The nitrogen dioxide concentrations per year are as follows. 1) Nikopol: 2007 year -24.12 μg/m^3, 2008 year – 18.62 μg/m^3, 2009 year – 14.88 μg/m^3, 2010 year – 16.14 μg/m^3, 2011 year – 18.89 μg/m^3, 2012 year – 14.29 μg/m^3, 2013 г. – 17.88 μg/m^3; 2) Svishtov: 2007 year – 24.71 μg/m^3, 2008 year – 13.27 μg/m^3, 2009 year – 20.03 μg/m^3, 2010 year – 16.25 μg/m^3, 2011 year – 13.82 μg/m^3, 2012 year – 19.82 μg/m^3, 2013 year – 16.27 μg/m^3; 3) Ruse OPS R1: 2007 year – 22.13 μg/m^3, 2008 year – 19.25 μg/m^3, 2009 year – 22.02 μg/m^3, 2010 year – 17.29 μg/m^3, 2011 year – 22.11 μg/m^3, 2012 year – 16.27 μg/m^3, 2013 year – 16.19 μg/m^3; 4) Ruse ROAS R2: 2007 year – 21.22 μg/m^3, 2008 year – 22.17 μg/m^3, 2009 year – 19.25 μg/m^3, 2010 year – 16.29 μg/m^3, 2011 year – 20.02 μg/m^3, 2012 year – 16.24 μg/m^3, 2013 year – 14.02 μg/m^3; 4) Ruse AIS “Vazrazhdane”: 2007 year – 18.27 μg/m^3, 2008 year – 20.02 μg/m^3, 2009 year – 22.01 μg/m^3, 2010 year – 17.25 μg/m^3, 2011 year – 13.82 μg/m^3, 2012 year – 17.03 μg/m^3, 2013 year – 14.11μg/m^3;5) Silistra ROAS S1: 2007 year - 17.22 μg/m^3, 2008 year – 20.11 μg/m^3, 2009 year – 14.82 μg/m^3, 2010 year – 16.37 μg/m^3, 2011 year – 18.42 μg/m^3, 2012 year – 15.72 μg/m^3, 2013 year – 14.25 μg/m^3; 6) Silistra ROAS S2:

2007 year – 19.55 μg/m^3, 2008 year – 14.86 μg/m^3, 2009 year – 16.28 μg/m^3, 2010 year – 17.88 μg/m^3, 2011 year – 19.03 μg/m^3, 2012 year – 14.92 μg/m^3, 2013 year – 17.33 μg/m^3.

Summarizing the abovementioned the following conclusions can be made.

Statistical models are built of the regularities of nitrogen dioxide and nitrogen monoxide pollution of the air along the Bulgarian bank of the Danube river. They are theoretically significant and practically applicable in the management of the border environmental safety.

The indicators chosen are the maximum hourly, daily and annual average concentrations. They present fully and authentically the pollution degree and its changes in a time function.

We made representative data excerpts of the air pollution in Nikopol, Svishtov, Ruse and Silistra. We considered the measurements made at seven measuring stations.

The database is computer processed with licensed software.

We obtained dynamic series and regression models of nitrogen dioxide and nitrogen monoxide concentrations.

We calculated the theoretical and empirical distributions of maximum hourly and daily average concentrations at the measuring stations.

The theoretical models allow us to simulate the concentration values in the studied ranges of change via the method of *Monte Carlo* and/or *Latin hyper club*.

The results can justify management decisions about border environmental safety.

The monitoring of air quality at border regions widens and becomes more detailed.

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INTERDISCIPLINARY LECTURES ON POLYMER MATERIAL SCIENCE IN THE EDUCATIONAL SUBJECTS

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ABSTRACT: *The specific properties of polymer materials make them widely used in various areas such as electronics, production of machine elements in aviation and space technology, automotive, textile and food industry. The polymer materials have a special place also in the medicine. In the proposed work, we express a reasoned opinion on the introduction of elements of the polymer material science in the education in some of the subjects for the students of the Faculty of natural sciences at the Konstantin Preslavsky University of Shumen.*

KEY WORDS: *polymer materials, structure, properties, polymer physics, education.*

Polymers are substances possessing specific properties which are conditioned by their molecular structure. There are high-molecular compounds which are constructed of multiple kinds of repeating structural units of the same chemical composition [1]. According to their origin polymers are divided into natural – proteins, hydrocarbons, rubber, resins, graphite, diamond etc., and synthetic – synthesized in various ways from low-molecular compounds. The polymer state of matter is characterized by certain peculiarities of its structure and properties which makes it significantly different from the low-molecular compounds.

One of the main characteristics of polymers is the flexibility of the macromolecules due to the possibility that some of their parts rotate around the chemical bonds. The internal rotation of macromolecules is determined by the flexibility of the polymer chains. Kuhn has shown [2] that from a theoretical point of view, polymer chains can exist in a huge number of conformations with virtually equal energies. Polymer molecules have two extreme forms of

existence – drawn in a chain and folded in a globule called molecular statistical globe. The size and shape of the statistical globe depend on the chemical composition and structure of the macromolecule. The properties of polymers depend not only on the flexibility and chemical composition, but also on the mutual disposition of macromolecules, i.e. the structure of the polymer matter that is determined by the flexibility of chains and the energy of intermolecular interaction. Apart from the chemical structure, the properties and structure formation in polymers depend on the external conditions that form super molecular structural formations. Single macromolecules and aggregates consisting of multiple molecules might exist depending on the ratio between the forces of intramolecular and intermolecular interactions as well as depending on the state of the polymer (solid, melt or solution).Such formations are called super molecular polymer structures. Due to the complex structure of macromolecules, the structure formation in polymers radically differs from the structure formation in low-molecular compounds. The macromolecular segment and the molecule are the basic structural elements of polymer matter. Therefore, upon characterization of the polymer structural formations it is necessary to take into consideration according to which structural element the structure is evaluated. It is possible that in polymer system to exist a long order in respect of the chain segments and to be absent such order for the macromolecules.

There are two basic types of primary structural aggregates – globular and linear. On their basis and depending on the temperature and the properties of the polymer, more complex super molecular formations might arise. One macromolecule can simultaneously participate in two or more supramolecular formations, while the parts of the same molecule, which connect these elements, remain in the unordered zones of the matter. The formation of super molecular structures in which the globule is independent structural element is a rare phenomenon and the formations are unstable and easily degradable. Unlike globules, the linear structural elements, at comparatively low temperatures, can form larger aggregate formations called fibrils.

Similar formations with high degree of orderliness can occur upon cooling of the polymer melt accompanied by orientating mechanical impact on the formation process and the subsequent fiber drawing [2, 3]. The degree of orderliness and the packing density of such fibrils strongly influence the physical properties of polymer materials. The above structures most frequently occur in amorphous polymers which are characterized by low degree of orderliness. This means that the polymers are substances having high degree of orderliness, both in the amorphous and in the crystalline state. Amorphous polymers may exist in liquid and solid physical condition. The amorphous phase state of polymers is characterized by the absence of long range order, presence of close order with fluctuation nature which stability depends on the physical condition of matter, isotropy of the physical properties and absence of precisely

determined melting temperature. Another feature of the polymers is that, unlike the low molecular compounds, they exist not only in aggregate and phase conditions but also in the so called relaxation conditions, namely glassy state, rubbery state and viscous liquid. The transition of the polymer from given relaxation state to another is associated with a change in a number of physical properties. The transitions in polymers from one relaxation state to another can be determined by means of thermo mechanical process which consists of investigation of the dependence of the polymer deformation on the temperature. The curves describing these dependencies are called thermo mechanical curves. The thermo mechanical curve can be divided into three parts which correspond to the three relaxation conditions of the amorphous polymers. The transition of the polymer matter from one state to another is realized in a certain temperature range. The temperature range of glass transition is characterized by glass transition temperature (T_g), and the fluid temperature range – by fluid temperature (T_f). The lowest temperature part of the curve describes the polymer deformation in the interval from the brittleness temperature *(T_e)* (below this temperature the object is destroyed without preliminary deformation) to the temperature of glass transition. The deformation in this area is small and it has mainly elastic nature. This is the glassy state of the polymer in which it holds behavior of solid. The minor deformations in the glassy state can be explained by the large values of the forces of intermolecular and intramolecular reaction and the limited possibilities for thermal movement of the macromolecules. The polymer deformation rapidly increases at the glass transition temperature. This is due to the increase of the energy of thermal motion which leads to defrosting of the segment mobility of macromolecules, also know as α-transition of the polymer [4, 5]. The part of the thermo mechanical curve from the vitrification temperature to the fluid temperature corresponds to the high elastic state of the polymer. The polymer deformations in this area are high, reversible and slightly depend on the temperature.

At temperatures close to the fluid temperature the deformations in the polymer increase and from elastic they turn into plastic, i.e. the polymer passes from high elastic into viscous-fluid state. By sequentially movement of the segments, the macromolecules move about one another, and in this manner the polymer flows as highly viscous fluid. Polymers like the low molecular compounds can crystallize both from melt and from solution. The crystalline polymers possess a complex structure. The possibility of crystal formation on the basis of globules is low. This is possible in terms of mono dispersity of globules which is observed in natural polymers. Crystal formations with a high level of perfection are formed on the basis of linear structural entities. The flexible macromolecules can fold and form aggregates with a proper structure from the parallel arranged parts of the molecules.

The segments fixing during the crystallization process is accompanied by the release of some heat ΔH_c and change in the entropy of the system with ΔS_c. Due to the fact that the fixing of the separate macromolecular segments occurs consecutively, the crystallization of the polymer is characterized by a set of ratios $\Delta H_c/\Delta S_c = \Delta T_c$, and thus with a range of melting temperatures of the crystalline forms. This means that the phase transitions accompanied by heat exchange in the polymers cannot run at a specified temperature, but within a temperature interval.

Due to the folding of macromolecules are formed mono- or polymolecular entities. These structural entities are arranged parallel to one another and depending on their size form needle-shaped, fibrillar or lamellar structural elements. These formations are the basis for the growth of crystals with more complex structure - spherulites and lamella crystals. Spherulites are the most common supramolecular formations. The small spherulites can group in strip-like structures, which can arrange in plates. There are two types of spherulites – radial and circular. In the radial spherulites the fibrils are joined in the center, and in the circular spherulites they are disposed along a circumference around the center.

Another important feature of the polymer units is that their structure includes both amorphous and crystalline phase and the ratio between them has a strong influence on the physical properties of the polymer products. It should be noted that a clear line between the amorphous and crystalline areas of a polymer unit cannot be drawn. Regardless of the existing models related to the phase states of the polymer matter, the intensive experimental research in this area continues [2, 6], including with the participation of the authors of this communication [7, 8].

Some important specific properties of polymers considered up to now, make them materials widely used in electronics, mechanical engineering, in the manufacture of aerospace equipment, aviation, automotive and textile industries, in everyday life, as in all other spheres of modern life. The polymer materials take a special place in medicine, where they are used as consumables, and in the production of medical equipment and implants [9, 10]. It is necessary to emphasize the application of polymers in the so called high technologies. At the same time, by means of calorimetric [8] optical [2], and other physical methods [2, 7], the interactions between the technological conditions of polymer processing, the structure and the physical properties of the end products are investigated.

The basic features and properties of polymers which have been regarded above and the spheres of their application are a reasonable prerequisite for introducing elements of polymer physics in some of the subjects for the students of the Faculty of natural sciences at the Konstantin Preslavsky University of Shumen. In relation to the polymer physics, it would be appropriate eight to ten

lectures and two laboratory exercises in condensed matter physics as well as specialized course related to the application of polymers in medicine for the master's degree of medical physics to be assigned. Within the lectures provided for studying the physical properties of polymers, the basic matters in the sphere of polymer physics should be considered.

The inclusion of elements of polymer physics in the above mentioned subjects will broaden the students' knowledge in this modern, intensively developing field of physics associated with the development of new materials and technologies, and as a result will contribute to increasing the quality of education of the students who graduate from the Physics Department at the Konstantin Preslavsky University of Shumen.

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Original Contribution

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WAXS STUDIES OF THE STRUCTURE DEVELOPMENT IN POLY (ETHYLENE TEREPHTHALATE) FIBERS CAUSED BY PROTON BEAM IRRADIATION

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ABSTRACT: *Structural changes in partially crystalline poly(ethylene terephthalate) (PET) filaments caused by proton beam irradiation has been investigated using a wide-angle X-ray scattering (WAXS). Experimental data concerning the influence of the exposure dose and the irradiation conditions in the structure changes of the studied objects have been obtained. Super molecular structural changes of the irradiated polyethylene terephthalate fibers have been analyzed. It is suggested that the basic modifying and structuring effects of the proton irradiation are ionization, radicalization, skeletal destructions and the macromolecular crosslinking.*

KEY WORDS*: poly (ethylene terephthalate), filaments, proton beam, irradiation, WAXS, structure development mechanism.*

1. Introduction

It is known that the properties of the oriented polymer systems strongly depend on their super molecular structure.

Wider application and therefore higher production of flexible chain fiber forming polymers, and especially poly (ethylene terephthalate) (PET) is due to the possibility of different ways for modification to obtain materials with improved properties. Moreover, PET can easily turn into uni- and biaxial oriented state with different qualitative properties. One of the possibility for polymer structure modification is using of ionizing radiation and it is an object of great interest in the recent years [1, 2]. It is established that the irradiated polymers possess improved tensile and yield strength, increased rigidity, higher melting temperature, etc. [3, 4].

The study of polymers using ionizing radiations is widespread in the polymer technology, operation and scientific research [1-3, 5, 6]. Due to the effect on the molecular interactions the synthetic polymers are modified by proton irradiation [3, 5, 7]. Proton radiation causes ionization along the track in the substance that passes across. Poly (ethylene terephthalate) (PET) is a crystallizable thermoplastic polymer widely used in many technological and industrial areas in the form of fibers, films, construction details, surgical polymeric textiles, composites, nanocomposites, conducting polymers, electro active polymers, etc. The applications of PET are based on its relatively high glass transition temperature, low crystallization rate, high mechanical strength and high resistance to chemical influences.

It is very important from technological and scientific point of view to investigate the role of proton irradiation on the structure and properties of undrawn amorphous uniaxially oriented PET [1-4].

The present experiment is devoted to study the effect of proton irradiation on over molecular structural organization of partially crystalline PET fibers.

2. Materials

PET partially crystalline as-spun yarns produced from industrial installation of the company "Furnet" (France) were used as precursor samples.

The initial basic characteristics of the studied PET fibers were as follows:

speed of fibrillate 2805 *m/min;*

number of single fibers in the complex filament 32;

diameter of a single fiber 13 μm;

degree of crystallinity α = 28,8 %;

birefringence $\Delta n.10^3$ = 5,35.

3. Methods

3.1. Irradiation of the PET samples with protons

Fibres of poly (ethylene terephthalate) have been attached in the form of a flat surface very close each other thus forming a layer with small thickness with respect to the range of the protons used for the irradiation. Plates with the samples were mounted on the outside wall of a circular holder (Fig. 1). Samples were irradiated with protons by the accelerator facilities AN 2000 at the National Laboratories of Legnaro, INFN, Italy.

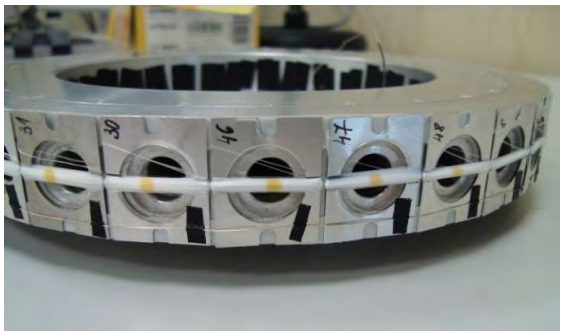

Fig. 1. The circular holder and attached to it plates with the irradiated PET filaments.

Proton beams with energy of 2*MeV* obtained using Van de Graaff accelerator have been used to irradiate the polymers' samples. The proton beam passed through a beam diffuser and was collimated to a diameter of 4 *mm*. The collimated beam passed through the samples and was collected for measuring of the total beam charge. The beam current was kept as low as 5 *nA* to prevent the samples overheating. For each sample the total beam charge was measured and the number of protons irradiated the sample was calculated.

3.2. Wide-angle X-ray scattering

In order to establish the precursor structure, the non-irradiated fibers was studied by wide- angle X-ray scattering (WAXS) using a diffractometer HZG 4 (Freiberger Präzisionsmechanik, Germany) and Ni-filtered Cu K_α radiation with a wavelength of 1,5418 *Å*. Equatorial scattering was monitored in transmission mode.

The structural changes of the irradiated PET objects were studied by wide-angle X-ray scattering Diffractometer URD - 6 (under license of SIEMES) of the company "Freiberger Präzisionsmechanik" (Freiburg im Breisgau, Baden-Württemberg, Germany). Used is β-filtered with Ni-filter Cu K_α radiation with a wavelength of λ = 1,5418 *Å*.

4. Results and Discuss

Most suitable for the packing density characterization of the structural elements on the atomic-molecular level are the X-ray diffraction methods, due to the precise geometric and structural sensitivity of the angular deviation of the diffraction reflections. Very good knowledge of the PET crystallography [8], allows establishing of adequate links between the alteration in the geometry of

the intensity distribution of the diffracted X-ray radiation and the repacking of the macromolecular chain segments in the volume of the crystal polymer phase, the transient zones of the crystallites and its mesophases. Furthermore, the changes in the intensity ratios, profile characteristics and angular deviation of the diffraction reflections provide information concerning to the crystalline phase perfection.

Chosen relatively low power proton radiation exclude the possibility of recrystallizations changes due to possibly radiation overheating and implies mainly structure determining influence of the alternative cross-linking and destructive processes that alter the molecular mass of the polymer.

The observed impact of the proton irradiation on the geometry of the intensity distribution of x-ray diffraction patterns of the object is expressed in the intensity angular deviations in the range from 10 $^{0}2\theta$ to 30 $^{0}2\theta$.

Intensity distribution of the X-ray radiation in the diffraction patterns of the non-irradiated (Fig. 2) and proton irradiated for 20 *s* fibers (Fig. 3) shows a structure similar to the PET amorphous state like its super cooled melt. Meanwhile as seen from figure 3 the diffractogram obtained at 20 *s* proton irradiation is characterized by a significant higher intensity increases in the angular interval 21 $^{0}2\theta \div 27\ ^{0}2\theta$. This is effect that upon irradiation of a similar PET sample was observed at 2040 *s* irradiation [7].

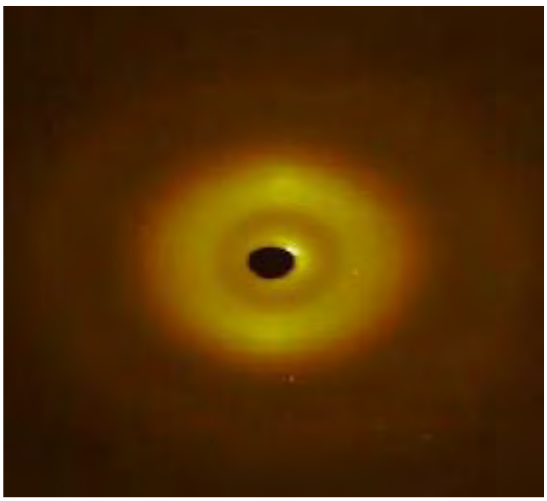

Fig.2. WAXS of non-irradiated partially crystalline PET fibers.

These are the peaks from the group -111, 1-10, 011, 1-12, 100, 1-11. The intensity increase in the positions of peaks 110 and 100 implies improving of specific mesophases with generation of advanced crystalline structure of PET. Increasing the exposure to proton irradiation up to 40 *s* (Fig. 3) indicates a total increase of the diffraction intensity of the studied PET objects in the typical angular range 16 $^{0}2\theta \div 28\ ^{0}2\theta$. Interval with increased intensity is divided into sub-areas typical for the main multiple peaks of PET.

It is observed deviation of the intensity distribution of the x-ray diffraction patterns to the left to the small diffraction angles, respectively to the large distance in the periodicity in the long range order. This may mean increasing the average statistical distance between the scattering radiation macromolecular chain segments.

In addition to this left-sided X-ray diffraction deviation of the center of gravity of the multiple X-ray halo is also observed occurrence of infrastructure as well as overall deformation of the left slope.

Probable reason for the effect is the increase and alignment of the folds width in the energetically stable folded configuration in the triclinic crystal PET cell in its crystal phase.

The largest used exposure of 2040 *s* which is two orders of magnitude different from the smallest (20 *s*) amplifies mainly the diffraction reflections 010, 1-10 and 100 and the angular intervals around them. The intensity increasing in the angular intervals around the reflections 010, 1-10 and 100 means that there is an exchange of packaging quality of macromolecular chain segments from mesophases close to the crystalline phase and from the crystalline phase of the PET. This intermediate phase between improved mesophases and highly defective low perfect mesophases is the mixture, the blank of which grows and progresses the perfect crystalline phase of PET. At 2040 *s* exposure priority of the intensity have the reflections in the multiplet situated in the angular interval from 21÷22 $^{0}2\theta$ to 24÷25 $^{0}2\theta$ which is evidence of the arrangement improvement of the macromolecular chain segments.

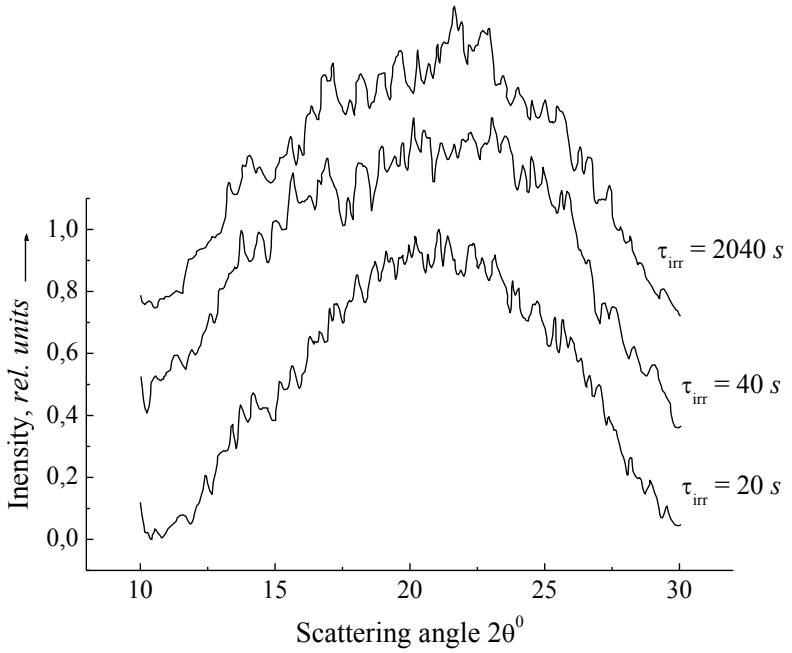

Fig. 3.WAXS curves of PET fibers irradiated with protons for 20, 40 and 2040 s.

5. Conclusions

In conclusion, it can be summarized that the proton irradiation has a major influence on the structural reorganization of partially crystalline PET in the solid phase state.

Depending on the studied objects, and the conditions of the X-ray diffraction experiments, there was observed a significant redistribution of the intensity of the diffracted X-ray radiation.

Most likely, the observed effects are the result of repackaging of the PET chain segments on atomic - molecular, crystallographic level.

It can be assumed that the basic structuring impact have the destructive and the crosslinking action of the radiation.

The most likely mechanism is associated with the folding of the released segmental ends of the broken segments on themselves or on suitable neighbors.

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SPIN-ORBIT INTERACTION IN AQUEOUS AND ALCOHOLIC SOLUTIONS OF $FeCl_3.6H_2O$

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Abstract: *The aqueous and alcoholic solutions of $FeCl_3.6H_2O$ are investigated in this work. In this connection, the absorption spectra of these solutions are measured in the spectral region 1.3 – 2.2eV. The exchange integrals for $[Fe(H_2O)_6]^{3+}$and $[Fe(OH)_4]^-$ complexes are calculated. The oscillator strength and the transition moment of the impurity band are also determined for these two complexes.*

Key words: *3d ions, spin-orbit interaction, exchange integrals, oscillator strength*

INTRODUCTION

The aqueous and alcoholic solutions of 3d ions salts manifest optical activity and interesting properties in magnetic field. This fact helped us when we decided to investigate these ionic liquids. In this work, the most important accent is on the existence and influence of aqueous and alcoholic complexes of Fe^{3+}cations. Our analyses give answer of the questions which are connected with the peculiarities of electron transitions in the complexes and with the stability in these complexes. Many authors have studied the absorption of the compounds $MCl_3.6H_2O$ (M = 3d transition metal ions, n = 2, 3), but they not give information about the exact number of d electron transitions there. This is the main aim in our work.

EXPERIMENT AND RESULTS

The experimental set up for measurement of absorption coefficient in visible spectral region has following parts: halogen lamp with stabilized rectifier 3H-7, monochromator SPM-2, system of quartz lenses, polarizer, sample holder and detector Hamamatsu S2281-01.

The concentration of the aqueous and alcoholic solutions of $FeCl_3.6H_2O$ is 1%. The thickness of the cuvette is d = 0.995 cm. The absorption spectra of iron undistorted octahedral and tetrahedral complexes are measured. These complexes are high spin complexes in weak "crystal" field. The impurity absorption structures which are manifested in the spectral region 1.3 – 2.2eV (figs. 1, 2) are compared. The calculation of first derivative of absorption coefficient determines the number of d electron transitions and the calculation of second derivative of absorption coefficient defines exact energy position of d electron transitions in $[Fe(H_2O)_6]^{3+}$ and $[Fe(OH)_4]^{2-}$ complexes (figs. 1, 2). The energy diagrams give us the real picture about spin-orbit interaction in our investigated complexes (figs. 3, 4).

DISSCUSION

The familiar colors of the transition metal ions in solutions are due to absorption bands which have their origins in electronic transitions within the 3d shell. The electric field of the nearest neigbour anions splits the energy levels of the unpaired d electrons and electronic transitions between these split energy levels give rise to the observed "crystal field" spectra [1].

The measurement of absorption spectrum of 3d metal ions solutions helps us to understand how many unpaired d electrons are in the different complex structures. In the case of $[Fe(H_2O)_6]^{3+}$, it is easy to determine the number of these unpaired d electrons. We can see that three absorption maxima manifest in the spectral region 1.6 – 2.2eV. Therefore, we have three unpaired d electrons in the iron octahedral complex. The situation with the complex $[Fe(OH)_4]^-$ is the other. Here, we observe more complicated absorption structure in the spectral region 1.3 – 2 eV (fig. 2). The Fe^{3+} structure consists of some overlap maxima. The calculation of the first derivative of absorption coefficient by the photon energy gives information about the number of d electron transitions in the complex $[Fe(OH)_4]^-$. The exact position of 3d electronic states can be precisely

determined only by calculation of the second derivative of absorption coefficient. In the end, the unpaired d electrons are three again in the iron tetrahedral complex (fig. 2).

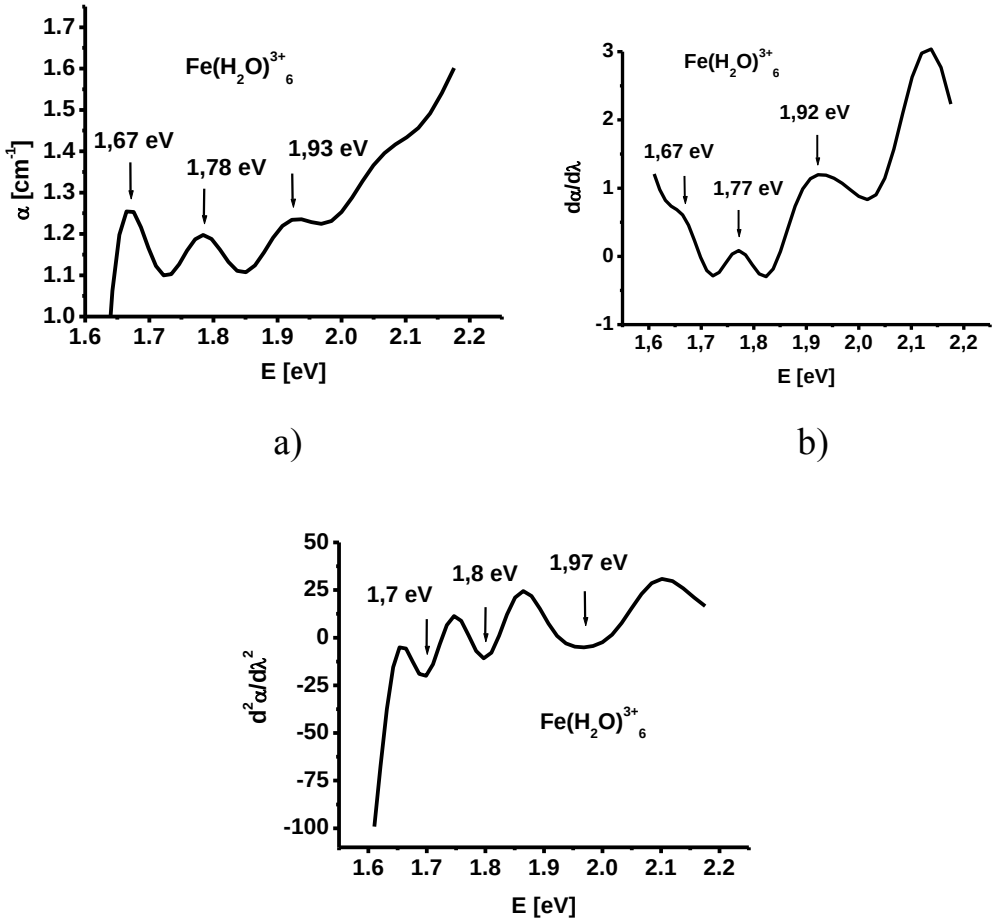
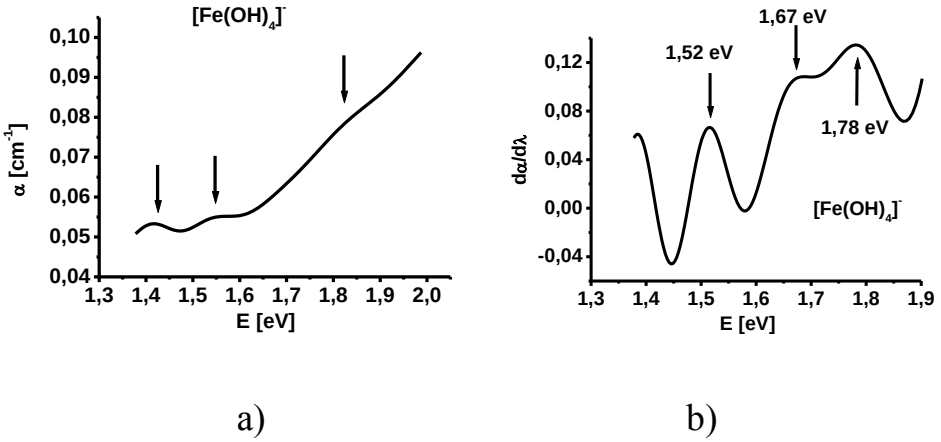
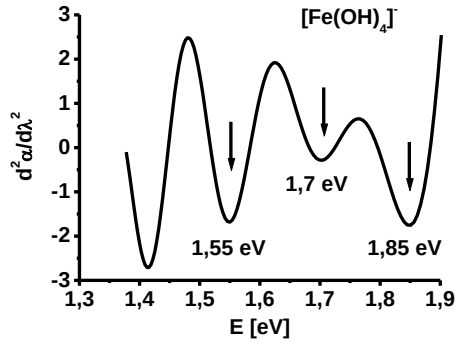


Fig. 1 a) Absorption spectrum of the complex $[Fe(H_2O)_6]^{3+}$ with: b) calculated first derivative of absorption coefficientin the spectral region 1.6 – 2.2 eV and c) second derivative of absorption coefficient in the same spectral region.





c)

Fig. 2 Absorption spectrum of the complex $[Fe(OH)_4]^-$ with: b) calculated first derivative of absorption coefficient in the spectral region 1.3 – 2eV and c) second derivative of absorption coefficient in the same spectral region.

If the electron transitions are allowed by multiplicity then we can observe wide bands in the absorption spectrum [2]. The $t_{2g} \rightarrow e_g$ transitions which are allowed by multiplicity conduct to the excited state. In this state, the distance in equilibrium between the 3d ionic nucleus and the nucleus of ligand is bigger than this distance in the basic state. If the already mentioned distance hasn't change (principle of Frank-Kondon) the electronic excited molecules are in excited vibrated states. When the molecules are excited the bond lengths correspond to these in the basic state. The excited state interacts with the molecules of solvent that aren't located in the first coordination sphere. This interaction changes because the closest molecules of solvent are located at different distances from the 3d metal ion. The solvent can't reorganize during the transition. Therefore, the excited vibrated state of different molecules interacts with the molecules of solvent which are located at different distances from this state. The change of energy of solvation influences on the energy of excited vibrated state. The result is that the wide bands manifest in the absorption spectrum. For example, the absorption spectrum of the octahedral complex $[Fe(H_2O)_6]^{3+}$ consists of three absorption maxima (fig. 1a). The absorption spectrum of the tetrahedral complex $[Fe(OH)_4]^-$ consists of wide impurity absorption band (fig. 2a). Electronic ground state of the ion Fe^{3+} is ^6S. Other sextet levels lack. In the limits of weak field octahedral configuration, the ground state is $(t_{2g})^3(e_g)^2$ with five unpaired spins. In the limits of strong field octahedral configuration, the ground state $(t_{2g})^5$ has only one unpaired spin. The

basic question is: Is the configuration $(t_{2g})^4(e_g)^1$ with three unpaired spins in ground state effective for the case of intermediate field? The answer is that such configuration cannot be examined. In our case the configuration is $(t_{2g})^3(e_g)^2$. The ground state in the limits of weak field tetrahedral configuration is $(e_g)^2(t_{2g})^3$ and the ground state in the limits of strong field tetrahedral configuration is with one unpaired spin $(e_g)^4(t_{2g})^1$. The last case is not observed heretofore. In our case, we have the manifestation of weak crystal field.

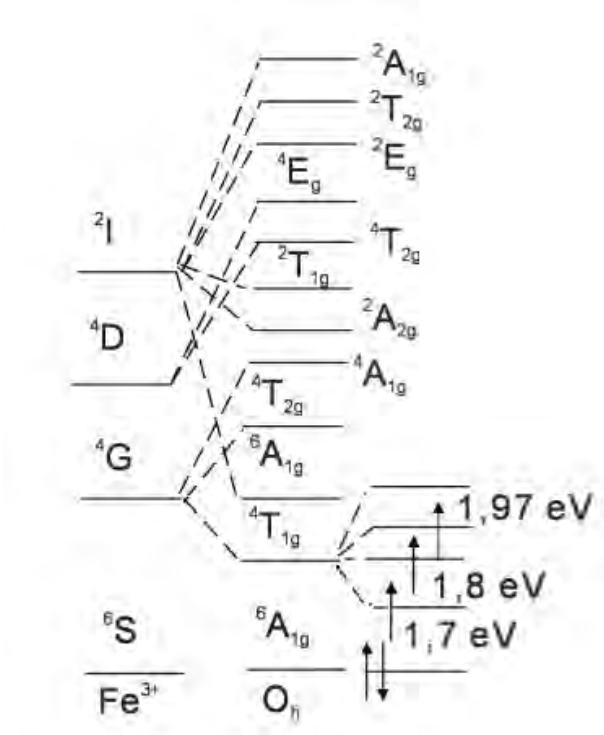


Fig. 3 Energy diagram of the iron octahedral complex.

The energy positions of electron transitions in Fe^{3+} ion for the aqueous and alcoholic solutions are compared on figures 3 and 4. The value of the crystal field parameter Dq and these of radial parameters Dt and Ds for the complex $[Fe(H_2O)_6]^{3+}$ are calculated by the next three equations: 15 898 cm^{-1} = 6Dq – 2Ds + Dt; 14 514 cm^{-1} = 6Dq + 2Ds + 6Dt and 13 717 cm^{-1} = -4Dq – 2Ds + Dt. Thus Dq = 218 cm^{-1}, Dt = 3971 cm^{-1} and Ds = -5309 cm^{-1}. The Racah parameters B and C have values respectively 614 cm^{-1} and 3332 cm^{-1} in the case of aqueous solution. F_2 = 1089 cm^{-1} and F_4 = 95 cm^{-1} are the Condon–Shortley parameters [2] which are connected with Racah parameters by these two equations B = $F_2 – 5F_4$ and C = $35F_4$. The following exchange integrals K(z^2, x^2-

y^2) = $4F_2 + 15F_4$ = 5781 cm^{-1}, K(z^2, yz) = F_2+$30F_4$ = 3939 cm^{-1} and K(x^2-y^2, yz) = $3F_2 + 20F_4$ = 5167 cm^{-1} are valid for the Fe^{3+} ion in the octahedral complex.

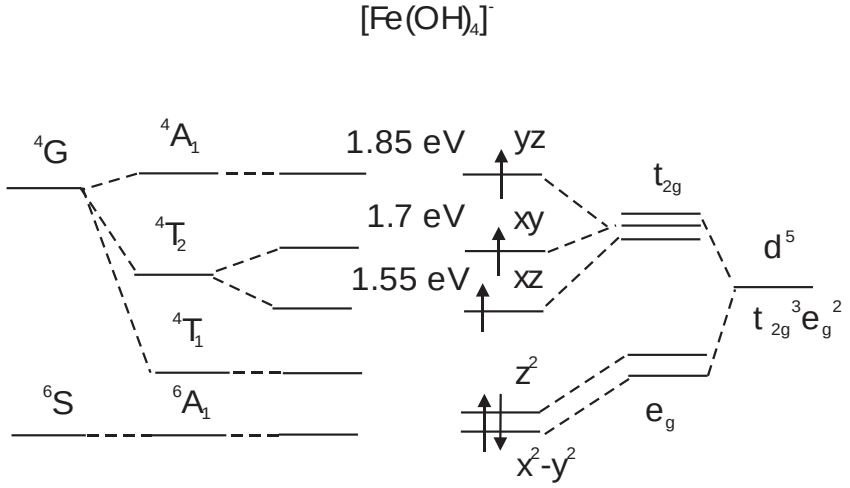


Fig. 4 Energy diagram of the iron tetrahedral complex.

The value of the crystal field parameter Dq and these of radial parameters Dt and Ds for the complex $[Fe(OH)_4]^-$ are calculated as follows: 14 925 cm^{-1} = -4Dq – 2Ds + Dt; 13 717 cm^{-1} = -4Dq + Ds - 4Dt and 12 500 cm^{-1} = 6Dq – 2Ds + Dt. Thus Dq = -243 cm^{-1}, Dt = -5635 cm^{-1} and Ds = -9795 cm^{-1}. The value of Dq indicates the dominant electrostatic interaction in the solution, because of the orbital splitting [5]. The Racah parameters B and C have values respectively 1100 cm^{-1} and 4906 cm^{-1} in the case of alcoholic solution and F_2 = 1089 cm^{-1}, F_4 = 140 cm^{-1}. The following exchange integrals K(z^2, x^2-y^2) = 6456 cm^{-1}, K(z^2, yz) = 5289 cm^{-1} and K(x^2-y^2, yz) = 6067 cm^{-1} are valid for the Fe^{3+} ion in the tetrahedral complex. The interaction between e_g and t_{2g} orbitals is connected with the exchange integrals as it is shown on figure 4. This connection is determined for the octahedral complex after the change of the position of e_g and t_{2g} orbitals for the ion Fe^{3+} (d^5).

The strength of the three-dimensional harmonic oscillator determines from the ratio of the real intensity and the intensity of the radiation of the electron. f = 1 for such “ideal electron”. The transitions of the oscillator classify by the strength f and this connects the theory with the experiment. f = 1 for the allowed transition; for single symmetric band:

$f = 4.32 * 10^{-9} \int_{\lambda_1}^{\lambda_2} \varepsilon(\lambda) d\lambda$, where ε(λ) not depends on the concentration of the solutions [4]. The next equation $Q_i = \sqrt{\frac{f_i}{\nu_i * 1{,}096 * 10^{11}}}$ explains the connection between the oscillator strength f_i and the transition moment of the impurity band Q_i, where ν_i is the frequency of the band centre. The strength of the oscillator f is 0.1061×10^{-5} for $[Fe(H_2O)_6]^{3+}$ and f = 0.0076×10^{-5} for $[Fe(OH)_4]^-$ at temperature T = 300K. This means that the transitions are spin-allowed with forbidden pairing [6]. The transition moment of the impurity band has next two values $Q_1 = 0.1457 \times 10^{-3}$ and $Q_2 = 0.013 \times 10^{-3}$ for the complexes $[Fe(H_2O)_6]^{3+}$ and $[Fe(OH)_4]^-$.

After all these analyses, we can say that we know what happens in the investigated Feoctahedral and tetrahedral complexes. Next step of our experiments is connected with the investigation of optical activity and Faraday rotation of aqueous solutions of $FeCl_3.6H_2O$.

CONCLUSIONS

The value of the crystal field parameter for the complex $[Fe(OH)_4]^-$ indicates the dominant electrostatic interaction in the alcoholic solution. Thus the spin-orbit interaction is stronger for the tetrahedral iron complex. The strength of the oscillator for $[Fe(H_2O)_6]^{3+}$ is bigger than this for $[Fe(OH)_4]^-$. The transition moment of the impurity band has again bigger value for the octahedral complex.

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QUANTUM MODEL OF COBALT COMPLEXES

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ABSTRACT: *We have investigated the absorption of the Co doped $Bi_{12}MO_{20}$ (M = Si, Ti) in the spectral region 12 092–18 149 cm^{-1}. The observed absorption band is due to the Co-impurity in the visible spectral region. Schrödinger equation is solved in the spectral region of the absorption structure of Co^{2+} and Co^{3+}.*

KEY WORDS: *3d transition metals, oxygen complexes, Schrödinger equation*

INTRODUCTION

Sillenite-type $Bi_{12}SiO_{20}$ (BSO) pure and doped single crystals are widely used in optical devices, spatial-time light modulators and as holographic media [1,2]. BSO are cubic crystals, I23 space group symmetry, built up of Si-O_4 tetrahedrons and deformed Bi-O_n polyhedrons [3], defined by some authors as Bi-O_n (n = 7) - octahedrons [4] or as Bi-O-pseudo-octahedrons [5]. The chemical bonds Bi-O and Si-O in BSO are covalent [3]. After reported literature data most of doping ions in BSO are placed at metal position in Si-O_4-tetrahedron [6]. For Ru, Cu and Mn - ions there are data for occupation of both metal positions in tetrahedron (replacing Si) and in pseudooctahedron (replacing Bi) [5,6,7]. Many studies on the optical absorption coefficient of doped with Al, P, Cr, Mn, Fe, Co, Ni, Cu, Se and Ru sillenites in the VIS spectral region have been reported so far and the effect of doping were discussed mainly in respect to possible oxidation states of doping ions, position of allowed electron transitions in the 1.5 – 2.2 eV region and the dependence of corresponding absorption coefficient on dopant concentration [5,7,8-16]. Nevertheless, until now there are no systematic complex investigations on doping effects on impurity levels in the band gap (1.5–2.2 eV). In this work, we present the quantum model of Co doped cubic, isotropic and optically active crystals without internal deformations.

MATERIALS AND SAMPLES PREPARATION

We investigated doped BSO and BTO crystals with Co. All the crystals were grown from stoichiometric melts Bi_2O_3:SiO_2 = 6:1 using the Czochralski method under conditions described in detail elsewhere [17, 18]. High purity Bi_2O_3, SiO_2 and Co_3O_4 were used for synthesis and doping. The Co^{2+} and Co^{3+} ions substitute respectively Si^{4+} and Ti^{4+} in the oxygen tetrahedra in the samples.The concentration of doping was determined by flame (Zeeman 3030) and electrical-thermal atomic (Varian 240) absorption spectrometry as well as by inductively coupled plasma atomic emission spectrometry (Jobin Yvon, ULTIMA 2).

EXPERIMENTAL RESULTS

We measured absorption spectra of $Bi_{12}SiO_{20}$:Co and $Bi_{12}TiO_{20}$:Co in the spectral region 1.5-2.25 eV (Fig. 1a, Fig. 2a). It is seen that the cobalt structure is complicated and its shape does not give information about the number of the electron transitions in Co^{2+} and Co^{3+} ion. Therefore, the calculation of the first derivative of the absorption coefficient gives information about the number of the electron transitions in the investigated Co complexes (Fig. 1b, Fig. 2b). The exact energy position of the electron transitions in the Co ion is determined by calculation of the second derivative of the absorption coefficient (Fig. 1c, Fig. 2c).

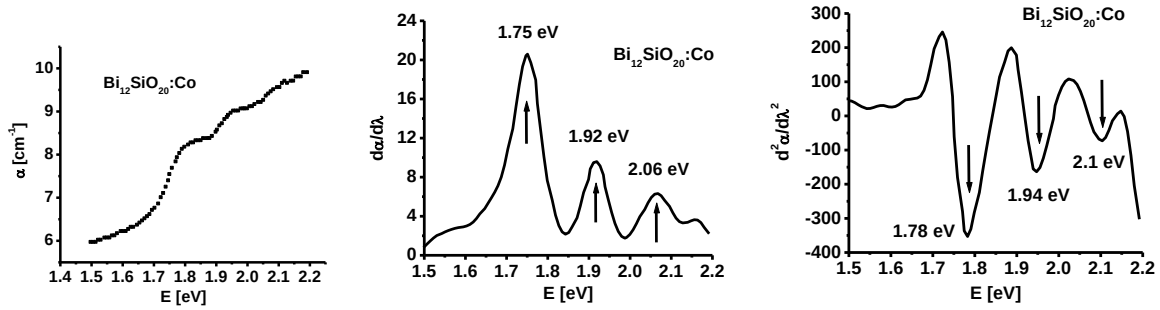

Figure 1 a) Absorption spectrum of $Bi_{12}SiO_{20}$:Co^{2+} in the spectral region 1.5-2.2 eV; b) first derivative of absorption coefficient; c) second derivative of absorption coefficient.

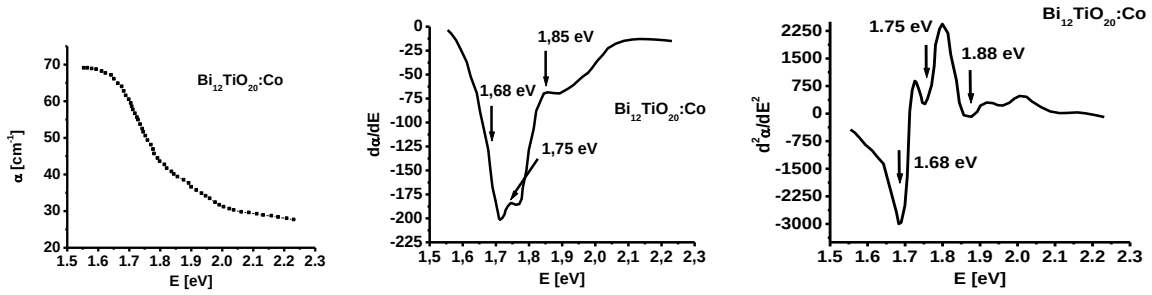

Figure 2 a) Absorption spectrum of $Bi_{12}TiO_{20}:Co^{3+}$ in the spectral region 1.55 – 2.25 eV; b) first derivative of absorption coefficient; c) second derivative of absorption coefficient.

DISSCUSION

In the process of absorption, the oscillating electric field at the time of the light in the area around the impurity center can be regarded as homogeneous. This field creates oscillating dipoles in the quantum system. These dipoles have an average dipole moments arising only when the system is in the condition which are linear superpositions of the own functions of the initial state "1" and the last excited state "n" [19].

The dipole moment of the electron transition $\hat{D}_{1,2}$ is a vector operator and it can be decomposed in three axes of the coordinate system x, y and z:

$$\hat{D}_{1,2} = \left(\hat{D}_{1,2}\right)_x + \left(\hat{D}_{1,2}\right)_y + \left(\hat{D}_{1,2}\right)_z .$$

If all three components of this vector operator are zero, the transition is forbidden by symmetry. Otherwise, the transition is allowed by symmetry. In our case, the light spreads along the z axis in the crystal. Therefore, we can calculate two components of dipole moment $(\hat{D}_{1,2})_x$ and $(\hat{D}_{1,2})_y$.

When the electric field of light is isotropic, then the potential field is independent of time and the decision of Schrödinger equation is following: $\psi(x,t) = \phi(x)\exp(-iEt/\hbar)$ [20]. The spatial part of wave function $\phi(x)$ satisfies the Schrödinger equation, which is independent of time.

If $\psi(x,t) = \phi(x)\exp(-iEt/\hbar)$ is the decision of Schrödinger equation with independent of time potential $V = V(x)$, then the spatial part of wave function $\phi(x)$ satisfies equation: $-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + V(x)\phi(x) = E\phi(x)$, where E is the energy of the particle. This equation is famous as the Schrödinger equation, which is dependent of time. The decisions which can be written as $\psi(x,t) = \phi(x)\exp(-iE\hbar t)$ are called stationary. Let's look at the ions Co^{2+} and Co^{3+} with mass m which are caught by one-dimensional hole with potential described as:

$V(x) = \{_{\infty}^{0\ 0\le x\le a}$. The potential V is zero in the hole and the Schrödinger equation takes the next form: $i\hbar\frac{\partial\psi(x,t)}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2}$. The decision, which is independent of time with potential V = 0 is: $E\psi(x) = -\frac{h^2}{2m}\frac{d^2\psi}{dx^2}$. When the last equation is divided by $-\hbar^2/2m$ and when all expressions are removed of the one side of equation, then we can see: $\frac{d^2\psi}{dx^2}+\frac{2mE}{\hbar^2}\psi = 0$, $(k^2 = 2meE/\hbar^2)$ => $\frac{d^2\psi}{dx^2}+k^2\psi = 0$ The decision of this equation is: $\psi(x) = A\sin(kx)+B\cos(kx)$. The boundary conditions are applied for determination of constants A and B. The wave function is zero outside the trap of electrons, because the potential is infinity unto $x=0$, $x=a$. The wave function must be defined and continuous everywhere. This fact shows that the decision must be applicable both inside and outside the trap borders. If $x=0$, then the decision is: $\psi(0) = A\sin 0 + B\cos 0 = B$. Thus $\psi(0)=0$ is fulfilled and $B=0 \Rightarrow \psi(x) = A\sin kx$. The wave function should also disappear abruptly at the other end of the trap-hole. This means that $\psi(a)=0$: $\psi(a) = A\sin ka = 0$. This condition is valid if $A=0$ or $\sin(ka)=0$. The first possibility is not interesting; the wave function which is zero everywhere is the same as in the case when there is no particle. So we continue to talk about the last possibility. $\sin ka = 0$, if: $ka = n\pi$, where $n = 1,2,3...$ Thus $k = (n\pi)/a$ and the wave function can be written as: $\psi(x) = A\sin(\frac{n\pi}{a}x)$. The constant A is determined by normalization of the wave function and technique we will discuss below in the text. Let us use the definition of the constant k in terms of the energy of the ions Co^{2+} and Co^{3+}, to write the expression for the energy in terms of $(n\pi)/a$:

$$k^2 = \frac{2mE}{\hbar^2} \Rightarrow E = \frac{k^2h^2}{2m} = \frac{n^2\pi^2\hbar^2}{2ma^2}$$

The wave function will disappear if $n=0$, which indicates that there is no particle in the hole. Therefore, the lowest energy of the particle can be found in $n=1$: $E_1 = \frac{\pi^2\hbar^2}{2ma^2}$ The lowest energy is called the energy of the ground state. The basic state is the state of lowest energy of the system, which may be tolerated. For infinite square area, all other energies are given as numerical multiplets of the basic energy state, i.e. $E_n = n^2E_1$.

For the energy of the photons, in which there is some peculiarity in the absorption spectrum, the constant k can be defined. Then we determine the value of a $(n=1)$, after that we calculate E_1 and finally E_n is determined. If the wavelength region is between a and b then

$$\psi(a) = A\sin(ka) + B\cos(ka)$$

$$\psi(a)=0;\psi(a)=-\frac{\hbar^2}{2mE}\quad \frac{d^2\psi}{da^2}=0$$

$$0=A\sin(ka)+B\cos(ka)(1)$$
$$x=b$$

$$\psi(b)=A\sin(kb)+B\cos(kb)$$
$$\psi(b)=0$$

$$0=A\sin(kb)+B\cos(kb)(2)$$

The constants A and B are determined by the equations (1) and (2).

$$x=b-a$$

$$\psi(b-a)=A\sin[k(b-a)]+B\cos[k(b-a)]$$
$$ka=n\pi$$
$$kb=(2n+1)\pi$$
$$n=1,2,\ldots$$

$$k(b-a)=(n+1)\pi$$

$$k=\frac{(n+1)\pi}{b-a}$$

$$\psi(x)=A\sin\left(\frac{(n+1)\pi}{b-a}x\right)+B\cos\left(\frac{(n+1)\pi}{b-a}x\right)\quad(3)$$

$$E_1=\frac{\pi^2\hbar^2}{2m(b-a)^2}\quad n=1$$

$$E_2=\frac{4\pi^2\hbar^2}{2m(b-a)^2}\quad n=2$$

$$E_3=\frac{9\pi^2\hbar^2}{2m(b-a)^2}\quad n=3$$

When the wave function which satisfies the Schrodinger equation is multiplied by undetermined constant A, we only normalize it as follows: $\frac{1}{A^2}=\int_{-\infty}^{+\infty}|\psi(x,t)|^2dx$

The function $\psi(x,t)$ is normalized, when $A\psi(x,t)$. When the particle is limited in the region $0\le x\le a$, the wave function in the basic state has the form: $\psi(x)=A\sin(\frac{\pi x}{a})$, where A is an normalization constant. The constant A is determined and the probability, when the particle is in the range of $\frac{a}{2}\le x\le\frac{3a}{4}$ is determined also.

The normalization means that $\int_{-\infty}^{+\infty} |\psi|^2 dx = 1$. The wave function is zero outside the interval $0 \le x \le a$, therefore $\int_0^a |\psi|^2 dx = \int_0^a A^2 \sin^2\left(\frac{\pi x}{a}\right) dx = A^2 \int_0^a \sin^2\left(\frac{\pi x}{a}\right) dx$. We use the trigonometric identity $\sin^2 u = \frac{1-\cos 2u}{2}$ and we rewrite the expression which is integrated: $A^2 \int_0^a \sin^2\left(\frac{\pi x}{a}\right) dx = A^2 \int_0^a \frac{1-\cos(2\pi x)}{2} dx = \frac{A^2}{2} \int_0^a dx - \frac{A^2}{2} \int_0^a \cos\left(\frac{2\pi x}{a}\right) dx$

The first part of this expression can be integrated immediately: $\frac{A^2}{2} \int_0^a dx = \frac{A^2 a}{2}$ The second part is zero. Thus only the first part gives its share in the equation, whereat $\int_0^a |\psi|^2 dx = \frac{A^2}{2} a = 1$. Finally, the normalization constant is $A = \sqrt{\frac{2}{a}}$ and the normalization wave function is $\psi(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{\pi x}{a}\right)$.

The wave functions ψ_1, ψ_2, ψ_3 of the ground state (n = 1) and of the first excited state (n = 2) of ions Co^{2+} are calculated by using the formula (3).

$\psi_1(x = 1,78) = 1,2297$, n=1; $\psi_2(x = 1,94) = 1,2504$, n=1; $\psi_3(x = 2,1) = 1,2705$, n=1.

$\psi_1(x = 1,78) = 1,336$, n=2; $\psi_2(x = 1,94) = 1,3592$, n=2; $\psi_3(x = 2,1) = 1,3813$, n=2.

The same procedure was repeated for the wave functions ψ_1, ψ_2, ψ_3 of the ground state (n = 1), of the first excited state (n = 2) and of the second excited state (n = 3) of Co^{3+} ions.

$\psi_1(x = 1,68) = 1,2015$, n=1; $\psi_2(x = 1,75) = 1,2104$, n=1; $\psi_3(x = 1,88) = 1,2272$, n=1.

$\psi_1(x = 1,68) = 1,302$, n=2; $\psi_2(x = 1,75) = 1,31$, n=2; $\psi_3(x = 1,88) = 1,33$, n=2.

$\psi_1(x = 1,68) = 1,3803$, n=3; $\psi_2(x = 1,75) = 1,3908$, n=3; $\psi_3(x = 1,88) = 1,4091$, n=3.

CONCLUSIONS

The Schrodinger equation is decided regardless of the time due to the isotropy of the light electric field for the ions Co^{2+} in the bismuth sillenite ($Bi_{12}SiO_{20}$) and the ions Co^{3+} in the bismuth titanate ($Bi_{12}TiO_{20}$). The own functions of the initial and the last excited states of Co^{2+} and Co^{3+} are calculated. All electron transitions in Co^{2+} and Co^{3+} are allowed by symmetry.

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COMPONENTS OF THE DELPHI PROCESS THEORETICAL AND RESEARCH STUDIES

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ABSTRACT: *The justification of Delphi method is not a single act but continuous process whose development is is reflected in a series of reports. They are part of research memorandum of RAND Corporation by 1948 until 1973 and represent working documents related to Delphi method. At first they were designed for the needs of the corporation and only for the period of several years exceeded its limits. Delphi methodcontains the characteristics of scientific strictly regulated process, which applies to a specific technology - each process has its components. These components are: 1.choosing a topic 2. time to conduct 3. a research group 4. an expert group 6. number of rounds 7. communication; 8. Analysis of results 9. audit of the process; 10. pilot study.*

KEYWORDS: *long-term forecasting, futurology, governed scientific process, scientific and technical progress, memorandum reports, choice of subject standards for choosing a topic, time to conduct, communication between experts, electronic communication, administration Delphi process, a research group, expert group, qualification of experts, questionnaires, iterations, number of rounds, analysis of results, audit process, a pilot study*

The U.S. **RAND Corporation** is creator of the the method for long-term forecasting - Delphi method first intended for the needs of the corporation and only for a period of several years outside its borders.

Its start Delphi method was from the Second World War - in 1944, when General H. Arnold ordered the creation of a report linked to future technological capabilities that can be used by the military. The method is described in 1964 in "Report on the study of long-term planning" Corporation. Objects of study, according to this report: scientific controversies, population growth, automation, space exploration, the emergence and prevention of wars, future weapons systems and others. For the last time the list of predictable processes using the

Delphi method has been significantly enlarged, but undoubtedly the most use it has in the field of scientific and technical progress.

The main task that started the development of the method is to answer the question: "How much can be known about the future?" When they published treir report on the long-term forecasting it became RAND - bestseller that contains forecasts for technological breakthroughs in 2000 and beyond. Contributions were also by above 82 experts participated in the Delphi.

The justification of Delphi method is not a single act but a continuous process whose development is reflected in a series of reports. They are part of a research memorandum of RAND Corporation from 1948 to 1973 and represent working documents related to the Delphi method. During the development of the method they are designed for a range of scientists and researchers. It is clear that the Delphi method contains characteristics established strictly regulated scientific process that applies to a specific technology.

Each process expresses consistent actions or events, changes, that outline specific development or achieving a defined objective. And each process has, its constituent parts - components.

The components of the Delphi method are: selection, setting of time for performing, forming of a research group, a group of experts, development of questionnaires, determining the number of rounds, choice of way of communication, analysis of results, conducting a pilot study and audit of the process.

1. **Select a theme**

According to **R. Judd, R. Taylor and J. Jacobs**, the choice of topics for study by the Delphi is the most important step in the whole process because it directly relates to the quality of the generated results [19], [36], [18].

Because Delphi technique focuses on the extraction of expertise for a short period of time, the choice of topics in general depends on the disciplinary areas of competence required by the experts on specific issues.

With respect to certain standards for the selection of topics for Delphi, in fact there are no accurate criteria mentioned in the literature. **K. Oh** argues that the selection of appropriate topics for Delphi, is usually based on the judgment of the principal researcher [26].

The choice of topic should be approached with extreme caution and need to be comply with the following:

1. Therefore appropriate is to avoid general, broad themes in the development that enables experts to meet surface only "touching" to the problem, without being able to meet full and complete. The more specific it is a topic, as it allows for a thorough and complete opinions.

2. The topic should be related to the actual problems of the science, the technological development or the social practice. In this sense, through her may

enable experts to develop a problem or make long-term forecasting associated with its development.

3. It is necessary the respect for the line between desire and intention of the researchers and their real strength and abilities to provide adequate expert team, to develop the theme and giving expert opinion. Very often it is permitted to start work on a difficult and a large volume of a topic that takes a long time and it faces insurmountable difficulties, which eventually has a negative impact on the results themselves.

4. With the choice of topic is necessary to determine baseline information from factual data, materials or existing statistics containing the necessary indicators to assist the research group. There is also a literature research in the selected direction, which has attracted initial attention and interest of the research group to orient it in a better formulation of the selected topic.

5. It is essential when choosing a topic, to answer the question how long it is possible to separate it in order to develop it.

1. Time for performing

Conducting the Delphi method can take different times. In most cases it is quite lengthy. **A. Delbecq, A. Van de Ven and D. Gustafson, B. Ludwig and F. Ulschak** recommend at least 45 days for the administration of Delphi [9] [39] [24].

With regard to the time between iterations **A.Delbecq, A. Van de Ven and D. Gustafson** advised two weeks to be able to respond calmly to the questions [9].

B. Ludwig believed that "blemish of Delphi method is that the process can be slowed down considerably, as it is possible a few days or weeks pass between the rounds." [23, pp. 54]

The research group determines the number of iterations and time required, in relation to the volume of research and also, considering the number of participants - the more they are, the longer it takes to process their opinions and there - for formulating questionnaires . Depending on whether they are using computer programs or using traditional paper-based, time may be reduced or increased. [1]

2. Research group

The research group, which plays the role of coordinator, analyzes the data and wrote the questionnaires. It plays a very important role in the whole process, as they have be careful not to reflect their views and preconceptions on issues and this may distort the results. If there are disagreements between the answers they need to be investigated, but not forgotten. Otherwise the answers to the dissidents will fall and this will lead to a false consensus. [1]

According to **W. Trochim** in front of the research group is also the primary responsibility for ensuring ethical behavior within the research. This includes the protection of human subjects participating safety and welfare, drawing on relevant protocols and adherence to the institutional and governmental regulations. It is responsible for providing an informed consent obtained from each participant and proper maintenance of records of the study. It is responsible for compliance with financial and administrative policies and conflict prevention at the realization of Delphi. [37]

All members of the research team must have appropriate education, training and qualifications to undertake the project implementation. They must have the ability to perform well under stress task and easy to acquire new skills in new situations.

Of great importance are the qualities of the leader of the research team:

- manages and coordinates overall conduct of the Delphi procedures act as the primary point of contact between the research group and the expert group;
- has the qualities of an organized person with excellent coordination and management skills, research experience and dedication to science, to be flexible, patient, good social skills, good communicator, both physically and mentally stable;
- should be involved in determining targets, responsibilities and tasks of the research team.

In the research group and the coordinator enters Data Coordinator /Analyst/. He is responsible for the overall management of the survey data, which are derived from the opinions of experts and into a specific database for the development of the questionnaires. One of his main duties is proper and timely implementation of the expert answers in the electronic database and the electronic form of communication between experts and research groups.

3. Expert group

The experts may be homogeneous or heterogeneous group. Their profile can be defined by age, nationality, knowledge, qualification, profession or professional position, etc. Of particular importance are their expertise, which affects the quality of the results [16]. **T. Gordon** wrote that "The key to a successful Delphi study lies in the selection of participants. Because the results of the Delphi depends on the knowledge and cooperation of experts is essential to include persons who could offer valuable insights. "[15, p.7]

The respondents of the questionnaire experts, should be knowledgeable in the field, but in the literature there are suggestions that high level expertise is not required. The minimum number of participants to ensure good performance of the group is to some extent depending on the project expertise.

Experiments of **K. Brockhoff** show that under ideal circumstances, and small groups composed of four expert can perform well [3].

But how can the experts be identified a priori? - Referring Dalkey, **T.Gordon** answers this question: "Can be use different rating systems, for example [15, p.13]:

1. Are you an expert in this field, you work every day?
2. Do you work in this area from time to time?
3. Was knowledge of this area received through casual professional reading?
4. Do you feel yourself informed citizen?
5. Are you uninformed about this area? "

He offers a a sample questionnaire for the selection of experts in the Delphi study [15, p. 13-14]:

„1. Which one of the terms best describes your profession?
scientific worker_____
politician_____
physicist_____
others_____
businessman ____
cleric _____
servant _____
engineer_____
actor_____
producer _____
teacher_____
publisher _____
shopkeeper _____

2. If you are a scientist, what is your research area? (Parallel issues for engineers, businessmen, teachers, etc.)

Elementary particle physics, genetics, biomedicine and others.
Organic Chemistry, Nuclear Physics, Astronomy
Materials Science, Psychology, Economics,
Social Sciences, Political Science, Agricultural Science.

3. Do you consider yourself:
Erudite
Specialist

4. Are you interested in (or have experience): Technological forecasting political developments, ideas and more. Importance of policies relating to the analysis of the issues Issues of world politics. "

If the number of respondents is large, the process of gathering information in referred matrix should be automated. The program will have access to a database of characteristics of respondents as their choice will be done automatically.

In Delphi, one of the first things facing researchers is the sample size of experts. There is a wide range for its size and it is always carefully appointed from the researcher with the topic being studied**. B. Ludwig** writes that "the greater part in the Delphi were used between 15 and 20 respondents." [23, pp. 2]

There is no consensus among researchers at Delphi regarding the number of experts involved in the process. **A. Delbecq, A. Van de Ven and D. Gustafson** believe that 10-15 people are enough [8]. **B. R. Witkin and J.W. Altschuld,** believe that the recommended amount of the expert group should generally be less than 50 people, but is likely to be employed more people [42].

H. Jones and B.C. Twiss, said the principal investigator of the Delphi study, need to identify and select the most appropriate persons through a process of nomination [18].

B. Ludwig also states that "the appointment of well-known and respected persons as members of the target group of experts is recommended". [23]

According to **M. Adler and E. Ziglio** there are four requirements for experts to conduct Delphi expertise [2]:

1. knowledge and experience to analyze issues;
2. capacity and willingness to participate;
3. have enough time to participate;
4. have communication skills.

Because seeking the expert opinion is necessary in advance sampling of experts on whether they have the necessary knowledge and willingness to answer the research questions set [11]. In the absence of full scientific knowledge, decision makers must rely on their own intuition.

A. Delbecq, A. Van de Ven and D. Gustafson explicitly identify three groups of people who are well qualified and able to participate in Delphi. According to them, these are [9]:

"(1) best management decision makers who will use the results of the Delphi study, (2) professional staff along with their team, (3) meeting the Delphi questionnaire that can provide solutions.

T. Gordon notes that in the realization of Delphi "... the first problem is how to select potential participants. Knowledgeable individuals are usually identified by the literature, which are published on the subject of the study, recommendations from institutions ... "[15, pp. 8] In his opinion the final approach suffers the most serious criticism because in the recommendations of institutions has the potential to propose people belonging to cliques, but not so good specialists. One feature that helps to ensure that the necessary skills are in place to form a matrix that lists the necessary skills [10, pp. 8-9].

In summary, about the experts participants can say the following:

- The expert in conducting the Delphi method is a participant in the team that has a lot of experience, expertise, proven practical skills in a defined

professional field, which is the purpose of discussing and contributing to the achievement of the team goal;

- Specific behavior of the expert is that he is always confident in what he say and what he does, is very knowledgeable about news and facts in whose problem / and discuss / ; convincing and suggests real confidence;
- The expert input to the target is that it provides the team with unique expertise and skills in problem discussions;
- Weaknesses of the expert are its straightforwardness and intransigence of the statements of his position, which often makes it difficult for the team.

Beyond those criteria, **B. Ludwig** specifically addresses the motivation of experts and the research group as a key to successful implementation of Delphi, which ensures a high degree of accuracy [23].

In addition cited authors a number of other researchers of the Delphi method have achieved scientific developments related to the formation and work of the expert group, such as **B. Brown and S. Cochram, P. Ashton, F. Boulder and G. Wright, L. Christian, D. Gustafson, R. Shockley, G. Uolstar, M. McKee, P. Priest, M. Dzhinzlar, N. Black, A. Klee** and others. [1]

1. Questionnaires

The start of iterations in Delphi begins with the development of the first questionnaire for the first round. It takes great care and attention to this because if respondents do not understand the issues, they can formulate the wrong answers and / or be disappointed [9]. **R. Schmidt** believes that sometimes even the purpose of the first round Delphi is to formulate these questions well [32]. Initially these are usually wide open-ended questions so that they are clear in the research network [2].

According to **G. Skalmoski** and **F. Hartman**, alternative questions can be more focused and structured to lead participants to a particular purpose, all the time in the next rounds. With a broad research questions presented to the network in the first round is likely to receive a wider range of responses than if it represented a narrow set of issues. But will they be presented to experts focused broad issues is a decision that should be taken at an early stage of the design of the Delphi procedure [35, pp. 10].

In Delphi there is a continuum representing the degree of focus openness of the questionnaire. For example, the initial questions are generally wide open-ended questions, so as to obtain open, wide responses from research network [2], [9], [23].

The alternative is that the questions are more focused and structured to lead participants in Delphi to the target set by the duration of the procedure relate to items on the next rounds. With a broad research network responses in the initial round is more likely in the next rounds to get a wider range of responses than if narrower set of questions focuses the collective intelligence of the participants

around one or more possible answers [1] . **M. Adler and E. Ziglio** added that if the experts failed to deal with issues that may lead to inappropriate application of Delphi and discredit the creative efforts [2].

Presumably responding of the questionnaire should be well informed in the field, but in the scientific literature on the Delphi method is mentioned otherwise - **G. Welty,** who takes the view that it is not necessary high level of expertise of the participants. [loc. 2]

Experts are encouraged, by answering questionnaires to draw from their experiences, and to use any historical data, studies, or other resources available to assist in response to questions.

First questionnaire is usually composed of one or two questions. They are intended to be open-ended. Experts give their opinion and return the questionnaire to the research group. It shall review the responses and use this information to develop more specific questions which will be used in the second questionnaire.

The second questionnaire has two main parts: first, results and responses from the first questionnaire are presented in an orderly format /example in the form of a list or table/. Second, include new questions formulated by the research group. Depending on the number of rounds, the procedure as for the second questionnaire multiplies.

2. Number of rounds

The number of the rounds is also variable and depends on the purpose of the study. Their number varies from two to ten, but the most common is limited to two or three rounds. **P. Gootschalk** however, identify Delphi studies with a circle [16].

A. Delbecq and D. Gustafson indicate that two or three iterations in Delphi are enough for most studies [9]. If the estimates in the group are heterogeneous, then it can be held more rounds. But, if their number is increasing, it is often a decline in the desire and effort required by participants [1].

The research group determines the number of rounds even with the setting of the Delphi and plan them in the documentation of the study.

3. Communication

In the scientific literature there are described different ways of reacting to the experts with the investigator. Originally Delphi studies were made of paper and pen by answering the questionnaires have been returned by mail to the researcher [22], [35]. But with the advent of e-mail, Delphi began to be carried out with the help of personal computers in a network as pen and paper carrier gradually lose their application. New technologies allow researchers to put Delphi on-line questionnaire, where respondents enter and reflect their answers.

These responses are in a digital format and then more easily can be processed. Some researchers use online surveys to collect data from the experts. Switchover process communication in Delphi from paper to electronic media are described by **K. Cabaniss, J. Richards, V. Schmidt** [4], [28], [34].
Email offers many advantages for both sides - researchers and experts. Perhaps the most significant contribution of e-mail for Delphi is a fast connection and hence maintain high enthusiasm among participants. Another benefit of e-mail in the fact that the data is transmitted in digital format ready which eliminates the tedious task of processing and interpretation. Through an electronic network is possible the Delphi study to be completed in a circle [1].

4. Interpretation of results

In the Delphi method, the data analysis and reporting of results are directly related to the used questions. Therefore, researchers must apply appropriate analysis techniques. Presentation of the results of the Delphi are discussed in detail in a significant number of different monographs related [7], [8], [9], [33].

Some researchers include an analysis of the results [1], sorted according to the areas of agreement and disagreement, and others, eg. **S. Kincaid and A. Watson** used purely qualitative analysis [21], [40]. Purely quantitative methods have been used by **Friend J., A. Silverman**, [13], [35] and others.

Most of them - **J. Friend, A. Prestamo, J. Rosenbaum** - starting with qualitative methods, followed by quantitative analysis of the next round, by means of questionnaires Likert [13], [27], [30]. Most of them - **Friend J., A. Prestamo J. Rosenbaum** - start with qualitative methods, followed by a quantitative analysis of the next round, using a Likert questionnaire [13], [28], [31].

Skulmoski G. and F. Hartman believe that qualitative research is an explanatory /interpretative/ in the sense that the researcher is interested in how to interpret the social world and experience as a researcher is flexible and sensitive to the social context. [35, pp. 9-10]

R. Schmidt and others., Identified as difficulty to collate the results coming from the large number of experts or that are in a different location [33].

Accelerated evolution of computers and their applications increasingly eases the process of analyzing the results and making decisions as part of Delphi. Computer models make more efficient use of data collected through traditional techniques and methods generate highly realistic predictions and results of future events. Most scientists associated with the development, implementation and analysis of the Delphi method recommended after the results achieved to undertake further study to improve and verify the results already obtained, but with a sample set of experts other geographical locations or completely different team of experts [1].

Many researchers indicate the difficulties aggregation, because of the larger sample size, their limited views, or their geographic location. Therefore it is recommended further study to test their results. To achieve this goal should be expanded set of questions and administered among experts from other geographical locations. It is possible to make a completely different study to compare the results. Verification of research would provide richer opportunities for the researchers.

While some scholars and practitioners include in Delphi the publication of the resultsthe majority do not. The results of the Delphi contain key data that are in the toolbox of futurologists, so they need to be published.

Presentation of the results of the Delphi are discussed in more detail in various monographs as the creators of Delphi and its other researchers [1].

5. Pilot study

The pilot study is sometimes performed to sampling questionnaire or all procedural issues related with the conduct of Delphi. This is especially important for inexperienced researchers who can put too ambitious tasks related to the scope of their research or underestimating the time required for realization at all stages associated with the method.

According to **P. Prescott and K. Soeken** often pilot studies are undertaken for many reasons [26]:

1. identification of problem;
2. conceptualization of the study;
3. formation /structure/ of the study;
4. development of the first questionnaire;
5. refinement of the research tools
6. developing and testing techniques for data analysis.

The pilot study can also help to establish the relevance of the research question to the relevant field of study. Usually are selected and different methods of research /qualitative and quantitative/ after considering the pros and cons of each selected the most promising of them, which have the greatest potential to answer research. And qualitative and quantitative methods can be used in the process of Delphi.

G. Skulmoski and F. Hartmann considers that the pilot Delphi is particularly important for inexperienced researchers may be too ambitious in the scope of their research or underestimate the time the research will take [35].

A. Fink and J. Kosecoff are focusing on the fact that the pilot study is needed in terms of how quality will be the searched expertise. As seeking expert opinion, targeted sample is needed when people are not elected to represent the population, and represent their personal expertise and ability to respond to research questions. [11]

6. Audit of the process

Many researchers of Delphi - **M. Adler and E. Ziglio, A. Delbecq** and others**., N. Linstone and M. Turoff** express the opinion that the permanent controls at Delphi process are crucial to improve the reliability of the results [2], [9], [22].

According **J**. **Creswell, F. Fowler, M. Sadleowski** this is related to compliance with methodological rigor, which is also crucial in Delphi [6], [12], [31].

The rigor is improved when the researchers implement "audit trail" to solve all major theoretical, methodological and analytical issues from beginning to end, says **M. Sadleowski** [31]. In this sense, **B. Rodgers and K. Cowles** write that audit trails help to justify the reliability of research [29].

G. Skulmoski and F. Hartman advised the researcher to regularly use a journal that is intended for registration of audit information. Thus, "the methodological rigor can contribute to a successful Delphi." [35, p.10] The logical rigor contributed to an extremely high level of success Delphi.

Through such composite process Delphi Method O. Helmar its creators T. Gordon and N. Dolki Rishar aim the unpredictable events and changing values /both practical life and of scientific progress/ not to be represent the discretion of the random posts and unclear predictions and to study systematically their conditions so that they become available to a strictly methodical treatment. According to them, the method is designed to build hypotheses planning in major areas of the economy, technology, science and the whole political and social reality.

The foregoing content of the pasted research problem allows to be made the following

GENERALIZATIONS AND CONCLUSIONS:

1. Purpose of the Delphi Method: (a) it is associated with the futurology - the science of predicting the future, (b) it is most appropriate for problems that require evaluation, quality responses rather than accurate quantitative results, (c) it is intended to build hypotheses on planning large areas of the economy, technology, science and the whole political and social reality.

2. Central figure in the process is the **informed expert** with its resources, basic knowledge and cultivated a sense of meaning and transfer of general in specific cases can best perform the application of quasi-laws necessary for motivated predictions in a given area, creating prototyping technology management issues of new projects to develop products, etc.

3. **The principal difference between the Delphi method and the other expert methods of the type face to face.** (a) Instead of using the traditional

approach to reaching consensus through open discussion, this technique completely eliminates the committee's work, thereby reducing the influence of some psychological factors such as specious persuasion, reluctance to express opinions publicly and disadvantages with group dynamics as manipulation or coercion is minimized. (b) The group interaction in Delphi is anonymous in the sense that the comments and forecasts do not identify their author and are presented to the group in such a way as to suppress such identification.

The difference between the Delphi method and the other expert methods of the type face to faceis visually presented in the following figures. *(Figure № 1 u Figure № 2)* They clearly show the controlled connection between experts from the research group at Delphi Method and keeping anonymity (*Figure № 1*) and operation and communication experts in all other methods face to face - they can communicate with experts in addition to the research group and each other. In their work they remain known to each other and can exchange thoughts, formulating their expertise (*Figure № 2*). The uniqueness of the Delphi method consists precisely in terms of anonymity, controlled feedback, which occurs in reaching a consensus on a particular research question.

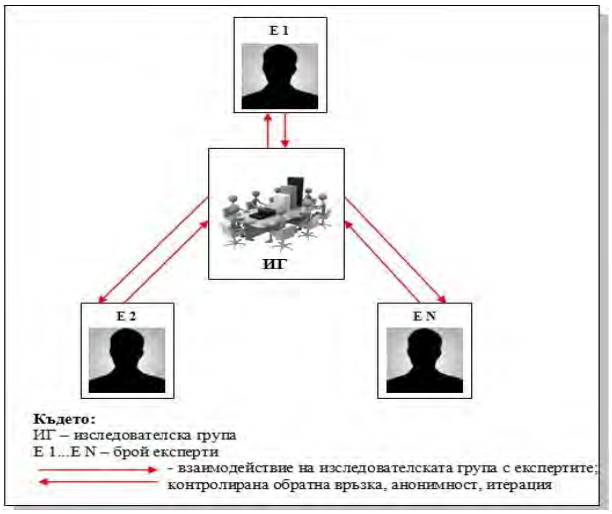

Figure № 1: Authorial model representing the controlled feedback with experts in the Delphi method

Legend:
RG – research group
E 1…E N – number of experts
→ - interaction between the research group with the experts
← - controlled feedback, anonymity, iteration

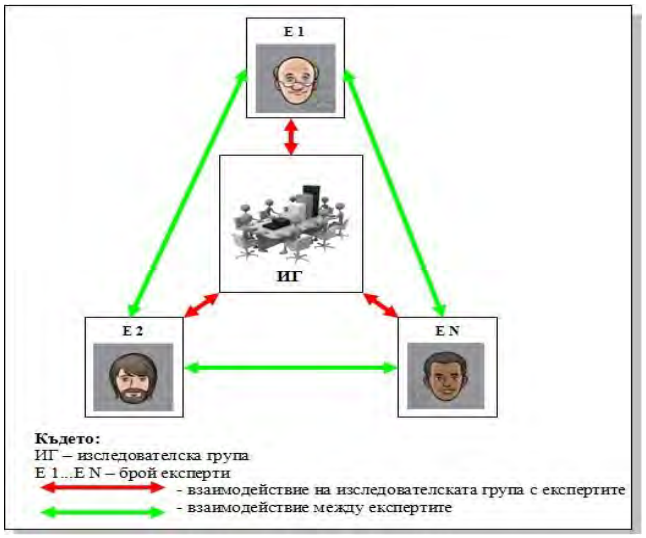

Figure № 2: Authorial model representing the uncontrolled communication between experts in the methods of the type face to faceinvolving research group

Legend:
RG – research group
E 1…E N – number of experts
- interaction between the research group with the experts
- interaction between the experts

4. **The strengths of the Delphi method are**:

- Anonymity of assessments. The principle of anonymity removes the negative psychological impact posed by stifling influence of authority or direct imposition of their own ideas. This method avoids meeting between experts and their ability to influence psychologically. Thus, each expert is not influenced by evaluations that formulate the others.
- Controlled feedback. It allows experts to take account of certain circumstances and opinions, which until then had not complied.
- The participation of highly qualified professionals as experts ensure scientific merit and reliability of the forecasts.
- Easy and quickly gets the best of the knowledge and experience of the most qualified experts.
- Impartially and objectively examine issues that require evaluation.
- Removes some very disturbing of group dynamics in other methods that arise when making decisions such as the impact of particularly charismatic or powerful actors who are able to dictate opinions.
- Allows the participants more successfully revise their opinions hidden behind anonymity.

- Advantage of Delphi is consensus in a field of uncertainty in the absence of empirical evidence of a process or phenomenon.
- The method is a quick and relatively cheap efficient way to combine the knowledge and skills of a group of experts who may be participants from several parts of the globe together to solve a problem or to predict the future.

5**. The weaknesses of Delphi are**:

- Low level of reliability of the expert decisions;
- Conditioning results related to uncertainties in the questionnaire used for data collection in each round;
- Difficulties associated with assessing the degree of expertise included in the forecast.
- The duration of the procedure is undefined because of the possibility of a more sessions;
- Defenselessness of the experts to research / analytical group that has too much power;
- The majority opinion is not always the most appropriate, creative solutions to the minority, sometimes most effective are rejected;
- The analysis requires a lot of time, the minimum of each range is at least one day;
- In an effort to fall in most constantly growing conformism of experts;
- Opportunities for manipulation by the research group.

6. **Improving the Delphi Method**. More efficient use of the expert in the context of Delphi can be achieved by further methodological studies in several areas:

- Improvements to systematic selection of experts;
- Experimenting with different schemes for respondents to give self-assessment of competence;
- The methods to achieve reliability of estimates can be improved by appropriate formulas for achieving consensus on the basis of appropriate self-ratings;
- Experiment with different methods of acquiring information to learn more about the form and content of the feedback;

7. **One of the most preferred Foresight is Delphi method** because:

- It focuses on identifying technological breakthroughs and innovation;
- through it outlines the prospects of innovative development, related to the progress of science and technology, possible technological horizons that can be achieved and the likely effects on the economy and society.

8. Detailed and consistent tracking the evolution of the Delphi Method to institutional global applicable method shows that it is a very **flexible technique suitable for studies** where there is incomplete knowledge of the various phenomena in the social world. In this context, it gives a lot of great

opportunities for different areas of knowledge that focus on problem solving and implementation of short and / or long-term forecasts. Especially suitable for project development as a tool in research.

9. The conducted Delphi studies are not identical. There are **varieties of methods ranging from qualitative to quantitative or mixed type**. But they have in common are: design considerations, a decision defining the structure of the expert group, following certain methodological orientation, a number of rounds of running, maintaining anonymity of the experts structured interaction between experts and researchers.

10. Delphi method **is applied in different situations and for a wide range of complex problems** for which there is often no other appropriate means of analysis, because it is an advantage over other expert methods:

- the iterative approach allows the experts to reconsider their decisions in the light of feedback;
- the process gives participants more time to consider their ideas before you commit to them, leading to better quality of response;
- the anonymity allows experts to express their opinions freely without showing institutional loyalty or peer pressure from the group - thus is deleted the potential impact of the individual;
- the excess "noise" - unnecessary questions and judgments that may occur during the debate can be controlled from the research /analytical group.

11. Meanwhile, Delphi can be **extremely sensitive to**:

- the level of expertise of the experts involved in the two main groups of processes - analytical and expert;
- clarity of the questions formulated in the basic questionnaire - for the first round and "daughter questionnaires" for the next iteration;
- the way in that takes into account the reasons for the large differences in the reported values for determining the consensus.

12. To **improve the effectiveness** of Delphi method is necessary to consider the following:

- it should not be regarded as a basic research tool and as a means of support, such as for the necessary studies with established and reliable research methods;
- research questions and questionnaires themselves need to be pilot tested to avoid any ambiguity or contradiction in them.

13. The theoretical study done in connection with this work showed that the application of Delphi method has the **potential for misuse**. However, it is still a valuable tool for all researchers of society as a whole and individual areas of social development and futurologists.

14. The results of Delphi method can be **very valuable to any social organization.** It can provide professionals in organizations to stimulate innovation. These results can be used as an educational tool for senior managers

who are trying to predict the future of their organizations, through long-term forecasting and planning in order to survive in an increasingly competitive global environment.

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INCREASING STUDENT COMPETENCES THROUGH PARTICIPATION IN PROJECT ACTIVITIES

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ABSTRACT: *Participation of students in project work has character on building their knowledge, skills and competencies. Project activities of students is a key factor for their personal development, as comparable to European standards professional qualification, successful social integration and continuous improvement of the qualification. It stimulates self-seeking scientific information and mastering of basic skills for the handling and application in practical situations. Helps self discovery of new scientific facts, enriches existing information focused research to critical analysis and problem solving; implementation of innovative innovations experienced research and experimentation; transfer of technology, method and procedures and study their effect optimizer.*

KEY WORDS*: project, project activity, innovation, research strategies, experimentation, scientific research, knowledge transfer, methodologies, interdisciplinary knowledge, scientific procedures, creative thinking, self development, akmeologiya*

As a member the European family, Bulgaria should bring their education in the light of **The Lisbon Strategy in 2000** [2] and **Strategy "Europe 2020"** [3] to be able to "produce" highly qualified, ready to compete at the international labor market. This task corresponds with the complex economic environment in which global world is situated. As the Bulgarian researcher of these processes **Z. Zhekov** writes: „In the terms of economic crisis and globalizing dynamic international competition very actual takes place the scientist's dedication and the active research activities. Exactly for this reason it is necessity the creation ofsupportive environment for developing of scientific researches and thetransforming the scientific results into economic advantages [10, p.15]". The author also writes that, ...Sustainable economic growth through education quality improving is realized. This is achieved in exchange for the dry theory

with pragmatically approach. It is necessity the knowledge into an innovation and into a tool for decisions taking to be changed [10, p.15]".

The project work of students in the Department of "Social Work" in Shumen University "Bishop Konstantin of Preslav" - Bulgaria is associated with basic research, applied researchs, evaluation and project management, expert consulting and other scientific and artistic activities. These activities are carried out systematically and **aim to**:

•encourage interdisciplinary research;
• creating and spreading knowledge;
•development of creative thinking and expression;
•development of studies related to the needs of the society.

All this aims at upgrading knowledge and skills among the future specialists prepared for the social sphere. As Bulgarian scientist **N. Dimitrova** wrotes**:** „Modernization in contemporary life changes are necessary in any educational system released to meet the contemporary requirements. [8, p.53] The author further adds: „Project work in the training of students helps to create a work environment that motivates self-seeking, processing and analyzing information. [8, p.54]".

The main forms of research activity are: student projects, conferences and research forums, university and in collaboration with other institutions offering social work.

From the above **target** arise tasks set by the Department with the participation of students in research projects, and in their nature they are:

1.Stimulation of the interdisciplinary research;

2.Improving the quality of education through the integration of research results in the teaching process;

3.Application of the research results and putting the skills of academic staff in the service of education, science and public practice.

Scientific research projects are developed according to the objectives, strategies and policies of the university. Priority is given to activities that create, generate or discover new knowledge and contribute to the continuous encourage of scientific work and creativity, innovate and practical applications aimed at understanding the North-East region and Shoumen region, corresponding to their needs.

Policy of the Department is dissemination of the scientific results through scientific forums at international level or published in prestigious scientific periodicals that promote its whole reputation of this university, faculty and students.

Students work on projects besides having features while upgrading ensures the unity of research and teaching as a defining characteristic of the interactions between them and the academic community. It is indispensable for

achieving the optimal balance of learning and research and quality improvement of their education - cognitive activity.

According to **D. Fried-Booth** project activities of students is a key factor for their personal development, as comparable to European standards professional qualification, successful social integration and continuous improvement of the qualification. It stimulates self-seeking scientific information and mastering of basic skills for the handling and application in practical situations. Helps self discovery of new scientific facts, enriches existing information focused research to critical analysis and problem solving; implementation of innovations experienced research and experimentation; transfer of technology, method and procedures and study their effect optimizer [9].

Further down in the article are listed research projects carried out by students studying in the major "Social activities" carried out by different methods: assisted and independent observations; fieldwork and research, conceptual and prognostic feasibility studies and models; simulation and real experiment, conducting formative and corrective work; comparative research, methodical and technological innovation; statistical processing, analysis and summary of experimental data, preparation of research reports and various publications, participation in research and creative activities, etc. /*Table № 1*/

Table № 1 Design work of the students building on their potential

№	Essence of the project	Study disciplines for acquiring basic knowledge in students	Additional knowledge and skills developed in students in project work
1.	**Project № RD-05-449/07.05.2008 – "Social inclusion of students from institutions for children through educational forms together with the Pedagogy Faculty of the Shoumen University "Bishop Konstantin of Preslav" (on the experience of orphanage "Clover " in Shoumen)**	"Social pedagogy" "Social work with groups" "Social work with individuals and families" "Social work" "Social legislation and social protection"	Upgrading the knowledge about the types of children placed in the institutions and the differentiated approach to them. Developing specific methodological approaches to work independently, according to the individual characteristics of each child. Development of unique forms of extracurricular work relating to the ability of the given institution.
2.	**Project № RD-05-245 of Shoumen University "Bishop**	"Social work" "Methods of the social work" "Social studies"	Practical realization of the knowledge in terrain, consistent with the ethno-social

	Konstantin of Preslav" "Formation of social competence of social work of the students studying in the professional Social activities through participation in planning, management and evaluation of projects for develop" /together with a team of the University - Friedensau, Germany / Shoumen, 2009	"Sociology" "Working on project" "Innovations in the social work" "Social work with ethnic and social differences"	differences in the local community. Application of specific approaches, arised in movement during the fieldwork. Innovate of a causal approaches called for by working with individuals and families. Experience of working with other institutions whose field of work is social. Processing of an effective behavior in case of extreme social conflict, requiring immediate actions of social workers. Actually managing the project for the social development of isolated communities.
3.	**Project № 5192/2011 of Shoumen University "Bishop Konstantin of Preslav" - "Futurological forecasting for the future of social services in Bulgaria"**	"Sociology" "Social studies" "Forecasting, planning and modeling in social work" "Social work"	Development of knowledge and skills for long-term forecasting. Effective participation in the development of futurological forecasts by Delphi method, Ringi method, brainstorming, Content - analysis and others. Acquiring knowledge about science futurology, which is not included in the curriculum of students.
4.	**Project № RD-08-305/15.03.2013 of Shoumen University "Bishop Konstantin of Preslav" "Socialization through art therapy in orphanage "Clover " in Shoumen**	"Sociology" "Art therapy" "Innovations in the social work" "Management of the social institutions" "Social work with individuals and families"	Exceeding the theoretical idea of socialization through direct work with children living in an institution. Awareness of their specific socialization. Application in the actual practice of various forms of art therapy provide a more accelerated, active involvement of institutional children in the society.

These and other projects end with student compilations of scientific production, where participants presented their work and significant conclusions arising therefrom [4], [5], [6], [7].

By participating in research, project work students in "Social activities" self-empowerment in the context of the writings of **N. Dimitrova**: „Project

work allows students to integrate their knowledge from different fields to apply them in practice and reach new knowledge, ideas and material values in solving a problem [Нели, 54]". Moreover, she connects the work in projects the akmeology which sets as: „Science "akmeology" is a branch of psychology and the relatively new scientific knowledge … examines the regularities and mechanisms that provide opportunities for every individual to reach its peak of development. She studied the laws and principles of human potential when reaching its highest level of development [8, p.54]". Thus in akmeological context [1] project work of the students appeared not only as a process of upgrading knowledge, but as a process of self-development. Her opinion is completely covered with that of **A. Derkach and V. Zazikin** on the discussed problem [1].

In its scientific publication **Z. Zhekov** expressed the opinion that: In the European Union a significant potential in terms of the researchunits, science and technology parks is made that serve as centers of knowledge creation and for their transformation into innovation results (radically new and/or improved processes, products and services). Nevertheless and especially in the times of crisis the European research community a number of challenges is faced. [10, p.18]". But in this connection it should be said in the final, that the Department "Social work" of the Shoumen University - Bulgaria occupies a significant place in the infrastructure of the realized design work with his students.

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CLIMATE CHANGE AS A FACTOR OF SECURITY

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ABSTRACT: *As the climate change is real and we cannot stop the anomalies in temperature, precipitation and sea level rise, a global challenge is to learn how to manage climate risks when appropriate. Climate change is a long term process. While short-term changes may be less extreme than the anticipated ones in the next 100-200 years, and risks can be significantly different from today. It is therefore necessary flexibility to adapt to the risks associated with climatic extremes and the formulation of strategies for dealing with them. Successful implementation of the policy for response to climate change can be made only if there is appropriate awareness and behavior of both individuals, businesses, and the general public and governmental decision-makers nationwide.*

KEY WORDS: *climate change, risks, appropriate, security.*

Introduction

According to the draft strategy for disaster risk reduction 2014-2020, statistics NIMH Academy of Sciences and the Third National Action Plan on Climate Change for the period 2013-2020 and others. In the coming decades, climate changes are expected to lead to increased frequency and scale of disasters. More frequent and more intense storms and floods, long-term droughts and devastating forest fires can have a significant detrimental effect on society. Therefore, it is necessary to unite the efforts of all institutions and their active involvement in the activities for the implementation of flexible mechanisms for compensation and the weakening of climate change. This policy will significantly reduce the social, economic and environmental damages and losses.

Climate change is a wide-ranging term that refers to climate change on the ground in long period of time. Often synonymous with climate change, the term global warming is used. Projections of climate change include higher temperatures, heavier rainfall and snow storms, melting snow and ice, rising sea levels, more intense cyclones, etc. Climate system is dynamic and constantly

changing. Changes do not appear linearly over time and they are not carried out evenly throughout the world.

There are different views on the causes of climate change. Imposed perception is that the main cause of global warming are greenhouse gases [3]. Their increase is largely due to the use of fossil fuels, although deforestation, land use change and agriculture also have significant influence. In an attempt to slow down the process of global warming, in 1992 at the World Summit on the problems of the Earth in Rio de Janeiro, 194 countries signed the "Framework Convention of the United Nations Climate Change" (UNFCCC). It aims to stabilize "greenhouse gas" emissions levels from 1990. In 1997 in Kyoto was signed an accompanying Protocol to the UNFCCC, which provides these emissions to be reduced by about 5% compared to 1990 levels. In 2007 at the 13th Conference on Climate Change in Bali, a decision was made to prepare a new global agreement on climate change by the end of 2009. So at the end of 2009, at the 15th Conference of Parties to the UNFCCC in Copenhagen, 130 leaders of States and Governments held a historical meeting. A political agreement was reached on certain commitments and actions of countries in the short term that they would take to meet the challenges of climate change globally.

Exposition:

What is the current global outlook?

The "Report on the State of Climate 2009" [10] issued by the U.S. National Oceanic and Atmospheric office in July 2010 and "Fourth Assessment Report" of the Intergovernmental Panel of the UN Climate Change (IPCC) [3], have published opinions and results of the joint work of 303 scientists from 48 countries, according to which our planet undoubtedly suffers warming over the last half century, and that every decade on Earth since 1980 has been hotter than the previous one [1], [4], [11]. Analyzed ten key indicators show that global warming is an undeniable fact. Indicators that have record levels [8]: the higher ground temperatures; higher temperatures over the oceans; high heat content of the oceans; higher air temperatures near the surface of the earth; higher humidity; higher sea surface temperatures; sea level rise; reduction of sea ice; reduction of snow cover; shrinking glaciers.

From the data in "Fourth Assessment Report", Space Research Institute "Goddard", National Climatic Data Center and others, it is obvious that [3], [6], [9]:

- The temperature rise of the air in the 20th century was the highest compared to previous centuries in the last 1000 years;
- The world has warmed by an average of 0.76 ° C compared to pre-industrial levels and temperatures are rising at an increasing pace;

• The rate of increase in the average global surface temperature since 1976 has almost been three times greater than the rate of increase in temperature of the air throughout the 20th century;

• The average temperature in the world in 2013 was 0.62 degrees Celsius higher than the average in the twentieth century (13.9 degrees) and amounted to 14.52 degrees. The same anomaly was observed in 2003.

• During the period 1993-2003, the sea levels have risen almost twice as fast compared to the previous three decades;

• The area of snow cover has decreased in most regions of the world, especially in the spring. In the Northern Hemisphere snow cover has decreased by 10% since the 60s of the last century;

• The average amount of sea ice in the Arctic has decreased by about 40% in recent decades;

• The maximum length of time in frozen ground has decreased by about 7% in the second half of the twentieth century.

• Spring sets earlier and earlier each year, resulting in a change in biological life cycle;

• There is a migration of plant and animal species to the pole widths;

• The average date of freezing of rivers and lakes over the last 150 years is late by about 5.8 days a century, whereas the date of thaw comes with 6.5 days a century earlier.

• Since the 1970s, the duration and intensity of droughts have increased over large areas, especially in the tropics and subtropics.

Since the beginning of the 20th century rainfall over northern Europe have increased by 10 to 40%, while rainfall in some regions of southern Europe have decreased by about 20% and droughts are more commonly seen.

Figura 1 shows the abnormality in the global average surface temperature in the period 1856 - 2005.

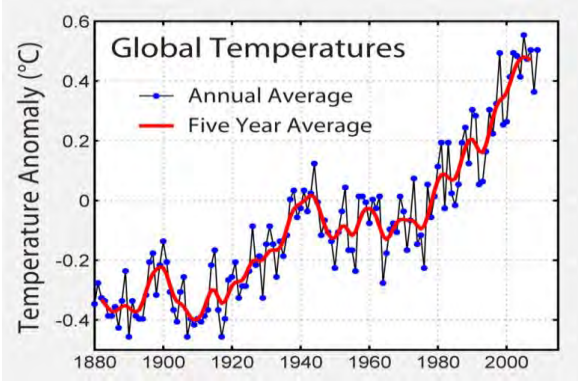

Fig. 1 Anomalies in global average surface temperature 1856 - 2005.

Facts about Bulgaria [5], [6], [9]:

• Since the end of 1970 Bulgaria has seen a trend towards warming.

• In the second half of the twentieth century winters are mild, with temperatures higher than normal.

• For the period 1971-2012, the average surface air temperature in the country has increased by 1.5 ° C.

•The average annual temperature in 2010, 2011 and 2012 is by more than 1 ° C above the climate norm. The year 2012 is the 15th one in succession with temperatures higher than usual for the country.

• 2003 and 2013 share fourth place in the ranking of the warmest years since surveys are performed. So far, the absolute record belongs to 2010, followed by 2005 and 1998.

• The longest droughts have been observed in 1940s and the last two decades of the 20th century, and the most significant droughts - in 1945 and 2000.

• There are more and longer periods of drought followed by severe storms and flooding with heavy damage and casualties.

• There is an increased frequency of extreme weather and climate events such as a significant increase in the average number of days with daily rainfall over 100 mm - about 30% between 1991 and 2007 in comparison to the base period (1961 -1990); increase of the recorded in the meteorological network cases with heavy rainfall; higher rates of spring-summer type clouds with rain, thunderstorms and hail in the winter months like January and February; increased frequency of the average number of days with thunderstorms and hail in April and September during 1991 and 2006, compared to the same base period.

• The annual amplitude between the maximum and minimum air temperature is decreasing - the minimum temperature is increasing more rapidly than the maximum.

• Snow months in the mountains reduce their length, and the thickness of the snow cover shows steady trend towards thinning.

• The upper border lines of the deciduous forests are shifting to higher altitudes.

•Data from phenological observations show advance of 7-15 days in the development in different climatic regions, unambiguous evidence of warming over the last 30 years in comparison to previous periods.

Figura 2 presents anomalies of air temperature in Bulgaria about the period 1961-1990, ° C, according to data from the NIMH-BAS. In red are marked positive anomalies of mean annual temperature for the period 1961-1990, the blue - negative anomalies of mean annual temperature for the period 1961-1990, in green - variations in the anomalies of mean annual temperature, and yellow - the linear trend in the anomalies of mean annual temperature for the period 1971-2010.

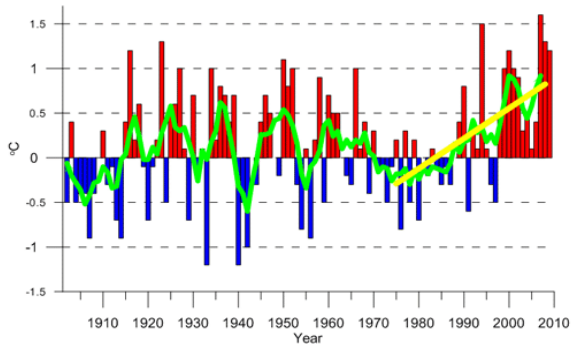

Fig.2. Anomalies of air temperature in Bulgaria for the period 1961-1990, ° C.

The next Table 1 summarizes the data for meteorological parameters in Bulgaria for the past 25 years, according to NIMH. These are values of precipitation, maximum daily precipitation and snow cover during the period 1988 - 2012.

Expected problems such as water scarcity, migration of millions of so-called "refugees because of the environment" and an increased need for disaster relief, loss of biodiversity and farmland, and financial shocks from the effects of these problems on global markets, will have a big impact on a global scale while we manage to adapt to changes.

One of the main findings of the analysis report by British economist Nicholas Stern [8], published in October 2006, has been that inaction against climate change would cost humanity 5% of global GDP per year, accumulated damage can impose costs in the amount of 20 % of global GDP.

Table 1. Meteorological parameters in Bulgaria for the past 25 years

Year	Rainfall, mm	Max. day-and-night rainfall, mm	Max. height of snow cover, cm	Temperature of air, °C
1988	579	197,5	60	11,9
1989	546	164,0	44	12,4
1990	459	135,5	38	11,8
1991	641	182,0	45	10,6
1992	456	138,0	33	11,7
1993	475	92,4	50	11,6
1994	528	263,0	31	13,0
1995	697	135,4	64	11,2
1996	599	122,2	44	11,0
1997	662	110,6	55	11,3
1998	678	157,6	61	12,1
1999	633	268,5	54	12,1
2000	377	160,0	65	12,4
2001	549	100,5	62	12,3

2002	743	158,0	55	11,9
2003	600	176,0	47	11,4
2004	604	136,0	36	11,6
2005	924	288,0	70	11,1
2006	597	300,8	43	11,5
2007	696	291,0	32	12,6
2008	496	224,0	39	12,3
2009	676	132,0	52	12,2
2010	788	200,9	49	12,1
2011	501	124,6	32	11,3
2012	660	210,0	220	11,9

Compared to this, taking action to reduce greenhouse gas emissions and mitigate the effects of global warming is estimated at 1% of global GDP. A positive effect of the transition to a low carbon is estimated at 2.5 trillion U.S. dollars, and by 2050 the markets for low carbon technologies could reach cash flow of around 500 billion dollars.

According to the National Report on the status and conservation of the environment in the Republic of Bulgaria (2012), Third National Action Plan on Climate Change, NIHM BAS and others, consequences of climate change have a significant impact on water resources, human health, ecology, ecosystems, agriculture and forestry, infrastructure, energy, industry, tourism, insurance, etc.

About one third of the world's population lives in areas where there is a shortage of water. By the year 2025 this number is expected to grow to 5 billion. The incidence of flooding on the greater part of Europe is likely to increase. The risk of continuing limitation of water resources in southern Europe will likely increase. Mountain areas are facing a reduction of snow and negative impact on winter tourism. The reduction of soil freezing in mountain areas can lead to problems of infrastructure. The majority of glaciers in the European mountains melt.

Policy of Bulgaria to mitigate climate change [6], [9].

National policy to mitigate climate change altered substantially after the accession of Bulgaria to the European Union on 1 January 2007. Policy is determined by its international commitments under the UN Framework Convention on Climate Change (ratified in 1995) and the Kyoto Protocol (2002). The commitments of the state arising from the obligations under European legislation in the field of climate and harmonization of our legislation:

Implementing the commitments of Bulgaria, as an EU member, the state has taken the following measures [5], [8]:

• Implemented are the provisions of Directive 2003/87/EC, establishing a scheme for greenhouse emission allowance trading within the Community;

• Developed and approved by the European Commission is a National Plan for allocation of greenhouse gas emissions;

• Steps have been taken to introduce the newly adopted EU legislation in the field of climate (legislative package "Climate and energy") and legislation to include aviation in the Community scheme for trading emissions (Directive 2008/101 / EC);

• In 2010 is reviewed and revised the National System for greenhouse gas inventory in order to improve accountability under the guidelines of the UNFCCC and the requirements of the law;

• Established and functioning is a Green Investment Scheme through which are financed projects that reduce greenhouse gas emissions;

• In 2012 is updated the National Action Plan on Climate Change.

Currently the Third National Action Plan on Climate Change for the period 2013 - 2020 is being implemented, adopted by the Council of Ministers № 439 on 01.06.2012.

Its main strategic objective is to outline the framework for action in the fight against climate change for the period 2013 - 2020, and to direct the country's efforts to actions that reduce the negative impact of climate change and the implementation of commitments. It sets out specific measures to reduce greenhouse gas emissions in all sectors. These are in accordance with the national policy in the field of climate change and the potential of the national economy for the reduction of emissions.

Successful implementation of a policy to limit climate change can be made only on awareness and behavior of both individuals, businesses and the general public and decision-making bodies at national and global scales. With the advent of newer technologies, greater use of satellite data and advanced mathematical models more accurate seasonal forecasts are made [7], [2]. In the world there are over 20 centers that deal with modeling of global and regional climate. These include the Max Planck Institute for Meteorology (Germany), Hadley Centre forecast and climate research (UK), Canadian Centre for Climate, the Australian CSIRO model center, Geophysical Laboratory of Fluid Dynamics (USA) and many others (IPCC, 2001).

National Institute of Meteorology and Hydrology (NIMH-BAS) is also working in this direction, taking into account the recommendations of the World Meteorological Organization (WMO) and its sister international organizations. NIMH has two main tasks - information and active protection of society. Information security means the timely transmission of the responsible government bodies and the public, early warnings of future or developing hazardous weather phenomena across the country. Active protection means the development and implementation of methods and tools for influencing atmospheric processes leading to dangerous phenomena. These two approaches

to the protection of society are practically the only real opportunity to counter alleged climate change.

Conclusion:

Climate change is a long term process. While short-term changes may be less extreme than anticipated changes in the next 100-200 years, and risks can be significantly different from today. It is therefore necessary flexibility to adapt to the risks associated with climatic extremes and the formulation of strategies for dealing with them. Adaptation is essentially a modification of existing practices to reduce negative impacts of climate change. Climate change is likely to exacerbate existing threats of flooding and water shortages and affect all sectors of the economy.

Key areas that may be affected by climate change, according to projections by the Intergovernmental Panel on UN Climate Change (IPCC), are [3]: water resources, ecosystems, agriculture, land use and forestry, coastal line, human health, infrastructure, economy, energy, insurance, tourism, industry and transport.

All countries, particularly developing ones, will feel the effects of climate change. Therefore there is a need to identify appropriate measures to adapt to the expected change. Expected impacts of climate change will reflect in more severe and more frequent natural disasters such as typhoons, floods, droughts, etc. Since the exact consequences of climate change are still uncertain, it is necessary to develop flexible strategies. These strategies should focus on improving the sustainability of society, including to natural disasters.

Strategies related to climate change must be integrated with strategies to manage the risk of disasters. By reducing the vulnerability of areas threatened by disasters, people will be better adapted to climate change and its impacts. It is important to provide timely and effective protection of infrastructure. Climate change may alter rainfall patterns significantly. It is envisaged that the extreme rainfall followed by floods to increase in many countries around the world - in cash and in intensity. Ports and other vital facilities, elements of the infrastructure will also be affected by climate change. Raise sea levels and storms will likely reduce the effectiveness of breakwaters.

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STATISTICAL MODEL OF INCIDENCE OF FIRES IN BULGARIA

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ABSTRACT: *The report justifies the thesis that the observed trend of warming and drought, and increased frequency of extreme weather and climate events in recent years is one of the causes of the fires on the territory of Bulgaria. Their effects can be crisis situations with significant material and financial damage, and sometimes casualties. Therefore, to improve the performance of state bodies involved in prevention is necessary to make scientifically based estimates of the incidence and causes of fires in the next few years. Solving this important practical task is possible by developing a statistical model of the fires.*

KEY WORDS: *statistical model, fires, crisis situations*

Introduction

A possibility of crisis and escalation of the situation in a fire can be expected as adverse weather or intentional actions of the people. As a result, fires can occur in urban areas, recreational areas, and warehouses with explosive, toxic and flammable materials to be threatened. Fires can disrupt rail and road transport, to inflict significant financial and environmental damage associated with significant destruction of forest resources and environmental pollution in the affected areas.

In this regard, the objectives of the report are:

1. To examine the trend of increasing number of fires for 1 year on the territory of Bulgaria;
2. To justify measures that improve the work of state bodies involved in preventing or eradicating the harmful consequences of emergencies.

The report justifies the thesis that the observed trend of warming and drought, and increased frequency of extreme weather and climate events in recent years is one of the causes of the fires on the territory of Bulgaria.

Exposition

Over the last decade due to climate change long droughts occurring in summer and autumn are typical, causing fires and influence. According to the General Directorate "Fire Safety and Protection of Population" (GDPBZN), their

number is constantly increasing. The distribution of fires for the period 1995 – 2013 is shown in Figure 1 and Table 1 [1], [4].

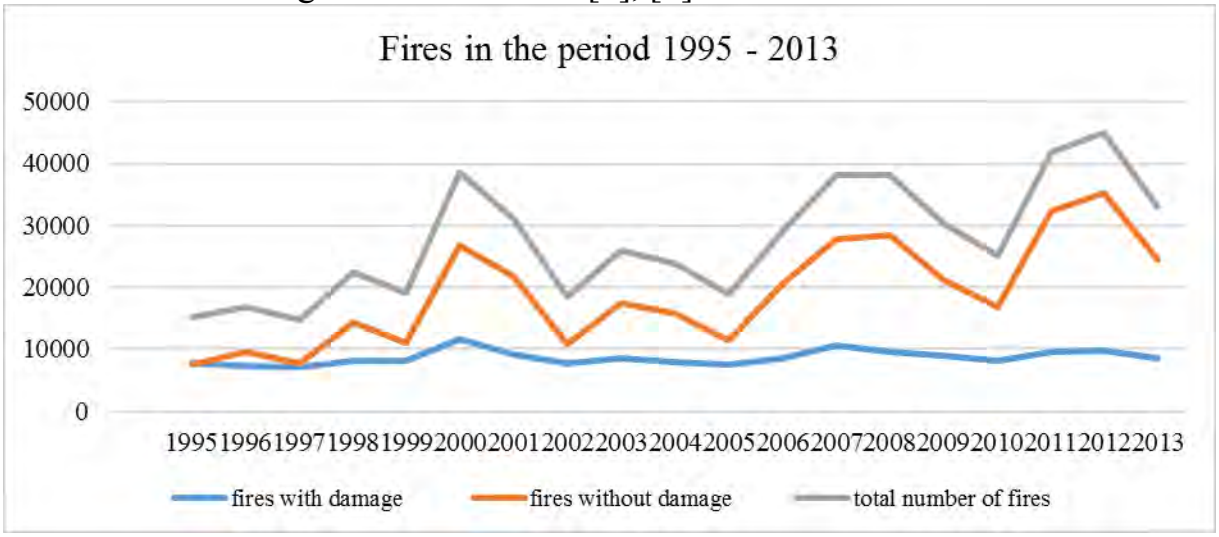

Fig.1 Statistics on fires on the territory of Bulgaria

Table 1

year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
fires with damage	7621	7357	6982	8137	8165	11670	9244	7647	8553	7980
fires without damage	7437	9486	7793	14256	10921	26802	21778	10803	17382	15846
total number of fires	15058	16843	14775	22393	19086	38472	31022	18450	25935	23826

year	2005	2006	2007	2008	2009	2010	2011	2012	2013
fires with damage	7540	8548	10501	9659	8970	8136	9487	9724	8504
fires without damage	11430	20542	27686	28439	21249	16894	32403	35209	24399
total number of fires	18970	29090	38187	38098	30219	25030	41890	44933	32903

As seen, there is a trend of increase in fires. And it is notable that the growth rate of fires without damage is greater than the fires with damage. This is due to the large number of fires occurring outside urban areas, affecting primarily forest and agricultural areas. Many of these fires destroy or threaten national parks and biodiversity within them.

Fires occur for various reasons and cannot be predicted. The most common reasons for their occurrence are two - of human activities and natural

phenomena. Most fires are caused by man, and fires from natural events are relatively rare. Average no more than 4% of fires in forest areas have occurred naturally.

The distribution of the fires according to the causes of their occurrence are shown in Table 2 [4].

Table 2

Reason of occurence	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
short circuit	2120	2115	2149	2215	2496	2288	2183	2125	2101	2373	2154
heaters	685	671	711	756	715	661	685	625	689	723	638
open fire negligence	1266	1241	1087	1468	2563	2390	1975	1755	2577	2677	1993
technical failure	914	887	836	926	1031	987	957	821	897	811	873
natural phenomena	15	87	116	189	45	48	56	65	58	79	69
intentional	292	606	585	655	848	844	866	720	770	632	621
unidentified	1030	1366	1140	1445	1748	1470	1349	1177	1484	1539	1428
child's play	243	257	230	272	243	176	164	143	177	104	119
crisis events	4002	4467	3801	3017	6245	6319	2082	1630	2185	3010	

From the table it can be concluded that the largest share of fires is caused by the burning of stubble near forests, short circuit and power lines, improper handling of electrical appliances, technical malfunction of machinery and equipment and crisis events (accidents and catastrophes).

Based on an analysis of the harmful effects and the available meteorological data in Table 3 and Figure 2 shows the annual number of fires of natural phenomena on the territory of Bulgaria in the period 2003-2013.

Table 3

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fires of natural phenomena	15	87	116	189	45	48	56	65	58	79	69

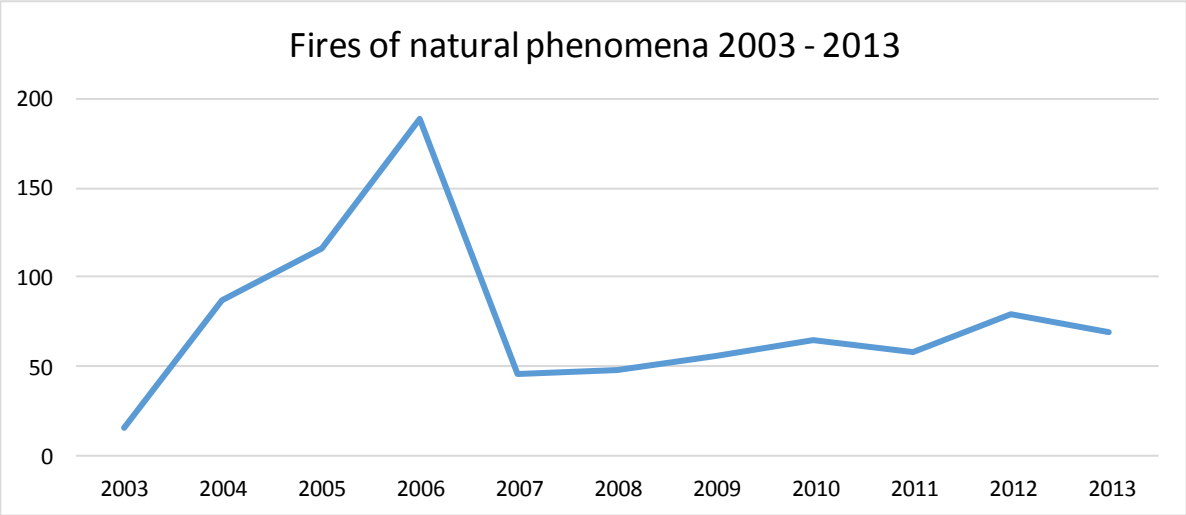

Fig.2 Distribution of fires by natural phenomena in Bulgaria for years

To improve the performance of state bodies involved in preventing or eradicating the harmful consequences of emergencies, it is necessary to make scientifically sound estimates of the frequency of fires in the next few years. Solving this important practical task is possible by developing a statistical model of the intensity of the fires in the country.

As is known [2], the main statistical method for the study of relationships in which the factor variables and resulting variables are quantitative characters is regression analysis. In its magnitude to be estimated (extrapolated) for a future period of time is represented by a mathematical function of time, called the smoothing function, whose parameters are determined by point statistical estimates based on data in previous moments of time. Very often we choose the smoothing function to be a polynomial of s-th degree. This assumption is justified by the fact that under the famous calculus theorem of Bolzano-Weierstrass, any smooth function can be represented with arbitrary precision by a polynomial.

Considering the quantity (number) $Де(t)$ of fires for t-th year, we can represent it by the following polynomial:

$$Де(t) = d_0 + d_1.t + d_2.\frac{t^2}{2!} + ... + d_s.\frac{t^s}{s!}, \quad (1)$$

as the degree **s** of the polynomial depends on the physical nature of the studied variable.

Coefficients of the polynomial $d = \{d_0, d_1, d_2, ..., d_s\}$ mean the initial value of the number of fires per year, rate of increase (decrease) in the number of fires,

acceleration of increase (decrease) in the number of fires. As noted, they are subject to statistical evaluation.

Evaluation of the coefficients of the polynomial $d = \{d_0, d_1, d_2, ..., d_s\}$ are determined by the method of maximum likelihood function, while playing the role of interference errors listing the number of fires per year that most often have a normal distribution with zero mean importance.

After logarithm of $L(\hat{d})$ and determination of partial derivatives for each of the evaluated variables $d_0, d_1, d_2, ..., d_s$, a system of equations of likelihood is compiled:

$$\begin{cases} \dfrac{\partial L(\hat{d})}{\partial d_0} = 0 \\ ..... \\ \dfrac{\partial L(\hat{d})}{\partial d_s} = 0 \end{cases} \qquad (2)$$

Solving (2) the algorithms for evaluation, we obtain the following:

$$\hat{d}_i = f(d_0, d_1, ..., d_s). \qquad (3)$$

Assume that the degree of the polynomial is **s** = 2 and from (1) for $Де(t)$ we have the following second order polynomial:

$$Де(t) = d_0 + d_1.t + d_2.\frac{t^2}{2!} \qquad (4)$$

Moreover, the coefficients of the polynomial (4) have the following physical meaning:

1) d_0 is the starting number of fires (per year);

2) d_1 is the rate of increase of fires;

3) d_2 is the acceleration, by which the number of fires changes.

In Gaussian law of distribution of errors in counting the number of fires for 1 year, the system (2) is prepared by the so-called method of least squares (MLS). In this method, the estimates of the parameters $d_0, d_1, d_2, ..., d_s$ are obtained by finding the minimum weighted sum of squared deviations of the measured values of the smoothing parameter (i.e. the number of fires for 1 year) compared with its model (1). In this particular case you need to find the minimum of the function:

$$L(d_0, d_1, d_2) = \sum_{i=0}^{n-1} w_i \left(d_0 + d_1.t_i + d_2.\frac{t_i^2}{2!} - r_i \right)^2 \qquad (5)$$

Here, the following conventions are used:

1) $L(d_0, d_1, d_2)$ is the weighted deviation of the number of fires for 1 year compared to the model (4);

2) $t_0 = 2003 - 2003 = 0, t_1 = 2004 - 2003 = 1, ..., t_i = 2003i - 2003 = i, ...$ are the discrete moments of time (years) during which the measurements were made (i.e. fires are listed);

3) r_i is the number of fires for the i-th year;

4) $w_i = \frac{1}{\sigma_{r_i}}$ is the "weight", by which is reported the number of fires in the i-th year;

5) σ_{r_i} is the average - quadratic error in determining the number of fires in the i-th year.

6) **n** is the total number of years in which fires were reported.

The minimum of (5) is determined after aligning to 0 of the partial derivatives of $L(d_0, d_1, d_2)$ in accordance with (2):

$$\begin{cases} \frac{\partial L(d_0, d_1, d_2)}{\partial d_0} = \sum_{i=0}^{n-1} w_i.2.\left(d_0 + d_1.t_i + d_2.\frac{t_i^2}{2!} - r_i \right) = 0 \\ \frac{\partial L(d_0, d_1, d_2)}{\partial d_1} = \sum_{i=0}^{n-1} w_i.2.\left(d_0 + d_1.t_i + d_2.\frac{t_i^2}{2!} - r_i \right).t_i = 0 \\ \frac{\partial L(d_0, d_1, d_2)}{\partial d_2} = \sum_{i=0}^{n-1} w_i.2.\left(d_0 + d_1.t_i + d_2.\frac{t_i^2}{2!} - r_i \right)\frac{t_i^2}{2!} = 0 \end{cases} \quad (6)$$

After detection of the brackets and the reduction of 2 in (6), the result is:

$$\begin{cases} d_0 \sum_{i=0}^{n-1} w_i + d_1 \sum_{i=0}^{n-1} w_i.t_i + d_2.\frac{1}{2!}\sum_{i=0}^{n-1} w_i.t_i^2 = \sum_{i=0}^{n-1} w_i.r_i \\ d_0 \sum_{i=0}^{n-1} w_i.t_i + d_1 \sum_{i=0}^{n-1} w_i.t_i^2 + d_2.\frac{1}{2!}\sum_{i=0}^{n-1} w_i.t_i^3 = \sum_{i=0}^{n-1} w_i.r_i.t_i \\ d_0 \sum_{i=0}^{n-1} w_i.t_i^2 + d_1 \sum_{i=0}^{n-1} w_i.t_i^3 + d_2.\frac{1}{2!}\sum_{i=0}^{n-1} w_i.t_i^4 = \sum_{i=0}^{n-1} w_i.r_i.t_i^2 \end{cases} \quad (7)$$

System of equations (7) is simplified taking into account the following circumstances:

1) Apparently the precision of the measurements in different years is the same, i.e. $\sigma_{r_i} = \sigma_0 = const$; it allows (7) to reduce the constants $w_i = \frac{1}{\sigma_{r_i}} = \frac{1}{\sigma_0}$;

2) the time of measurement can be represented with integers $t_0 = 0, t_1 = 1, ..., t_i = i, ...$

After consideration of these circumstances (7), we can obtain the following model for 11 years, including the years 2003 to 2013.

Model: After substitution in (7) with the data from Table 3 for the period 2003 – 2013, we can obtain the following system of equations:

$$\begin{cases} 11.d_0 + 55.d_1 + \frac{1}{2}385d_2 = 326 \\ 55.d_0 + 385.d_1 + \frac{1}{2}3025.d_2 = 1794 \\ 385.d_0 + 3025.d_1 + \frac{1}{2}25333d_2 = 13236 \end{cases} \quad (8)$$

From (8) for the coefficients of the polynomial (4) we can have:

$$d_0 = 163.3;\ \ d_1 = -27.86;\ d_2 = 3.77 \quad (9)$$

Therefore, the pattern of change of fires for 1 year as a function of time is as follows:

$$Де(t) = 163.3 - 27.86t + 3.77\frac{t^2}{2!} \quad (10)$$

The calculated values $Де(t)$ for each of the years studied and the trend of development for the next five years are shown in Table 5 and Figure 3, as the trend is colored green.

Table 4

Years (t)	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
N of fires	15	87	116	189	45	48	56	65	58	79	69
Де (t)	163.3	137.24	115.12	85.37	82.02	71.13	64.2	60.65	61.06	65.25	73.2
Years (t)	**2014**	**2015**	**2016**	**2017**	**2018**						
Де (t)	84.93	100.42	119.69	142.72	84.93						

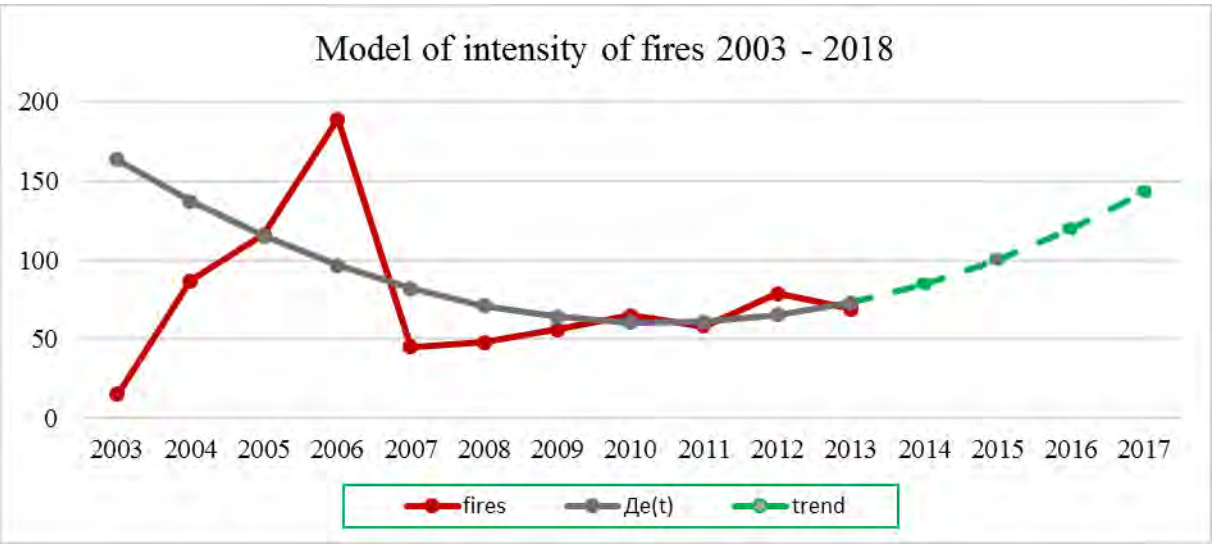

Fig.3. Model of the intensity of fires for the period 2003 - 2013 throughout the country, as has been reported, and the trend for the next five years.

From research done on the model of change in the number of fires per year in the country, shows that despite the observed warming and drought globally, in the short term there was a slight decline in fires caused by natural phenomena. Model (Fig. 3) covering the period 2003 - 20013 is optimistic. The curve of growth of fires is smooth and after calculating the trend for the next 5 years, we can see even increasing of the number of fires.

Conclusion:

Fires can be considered as a serious environmental, social, economic and business problem. They can occur in the national economy and lead to a disaster situation, endanger the life and health of many people, cause significant property damage and environmental pollution.

High risk for people have fires of technogenic character. Fires in the energy system, and especially Nuclear Power Plants, could be very dangerous, as well as in the chemical and petrochemical industry. Fires in vehicles transporting large quantities of flammable and combustible materials is another example [3].

In terms of global warming and drought, an increase of fire danger in forest ecosystems is expected. In this context, in fighting forest fires and managing forest fires should be designed and carried out with similar activities as in the Mediterranean countries, where all or the majority of the territory is designated as highly endangered.

Generally, the analysis of the statistical model of the intensity of fires in the report shows a smooth upward trend in the medium term. Therefore, to address emergencies such as fires, action is needed at all levels - national, regional and local. These actions include a wide range of preventive, legal, administrative, organizational, and other measures.

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DEVELOPMENT OF WARFARE AND COUNTER-TERRORISM

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ABSTRACT: *In the XX-th and early XXI-st century one phenomenon has more acutely occurred in social and political life and although it has been going along with human development over centuries, today it contraries to the objective needs of the time, gets alarming proportions and becomes the primary global problem. This phenomenon is terrorism. It changes its forms and it is attaining more and more dangerous character for people through spreading to more countries; it is creating new threats to national security and political stability of countries and international relations. Today terrorism is a form of undeclared war against civilization and freedom of democratic societies and countries.*

KEY WORDS: *warfare, terrorism, peace-imposing, peacekeeping operations, terrorist organization, humanitarian crisis.*

I. Introduction:

Historical changes in the international security environment and particularly the new security challenges, one of which is terrorism, have led to the development of military and associated changes in the armed forces, including the army. Terrorism is also evolving as becoming more and more comprehensive, multi-faceted and aggressive. Studying its nature, manifestations, organization, goals and objectives involves presumably an adequate response to public security system. As far as terrorism is using fighting methods and means to achieve its goals and objectives, it needs the military response to its challenges. Such a response is mainly the prerogative to the internal security authorities that in conjunction with the army forces together are putting into practice the tools of warfare. Nevertheless, the development of the military science provides the army structure with operational capabilities to successful counteraction to asymmetric threats of terrorism. This involves refinements of the combat activity through

new approaches to solve the fundamental issues that characterize the functioning of the army structures.

They involve creating:

• New structural and functional models of specialized military units with the appropriate manning, weapons and training;

• Competent command units;

• An interaction with other national departments and international military units.

Social activities on the occasion of and in connection with the war as a social phenomenon refer to warfare.

Such a definition implies a broader reflexivity for this specific activity that we can rightly define as "living totality" [1]. It is important to note that in the process of combat activity's improvement is necessary to select the correct and proper strategy, according to L. Pashov is "Each action aiming to reach the goal is a way of using the resource, as well as each way of using active agents is called strategy" [2].

II. Contents:

Terrorist activity is illegal in accordance with international and domestic law of each country. Each terrorist act is one or another kind of criminal offence. Perpetrators of terrorist activities use modern technical devices and technologies; there is an existing threat related to the usage of super-powerful weapons and extremely dangerous devices, including nuclear, chemical and biological weapons. In recent years, terrorism presents itself as one of the major threats to the security of individual countries, regions and international security as a whole. Today the threat of terrorism has many dimensions. The fear psychosis as well as the feeling of instability that terrorism creates in the society inevitably influence upon the political, social and economic decisions in national, regional and global aspect. As a part of democratic world Bulgaria is facing a common problem with terrorism too. Acceptance of the country as a full member in NATO and the future membership in the European Union as well as signing a number of international agreements related to counteracting to terrorist activity, ratified by the Republic of Bulgaria, all together define its commitment to actively participate in the fight against terrorism. This is possible only with the mutual and joint efforts of all governmental bodies.

"Terrorism is performance, incitement or assisting a criminal act which purpose is to cause fear and uncertainty among its victims and society, to force them to do things desired by the perpetrators. The act adopts nature of international terrorism when it is prepared or committed in the territory of two or more countries."

In the contemporary information society the object of terrorist cyber attacks has become the electronic control systems of life-providing economic systems of the armed forces, other governmental bodies and the private business sector.

Most of the committed in cyberspace crimes are based on gaps and weaknesses in computer and network systems. [3]

The main characteristics of terrorism occur in several ways: 1) primordially the damage of one terrorist act has great scope and the objects of its content are characterized with great variety; 2) the coverage of the harmful impact is usually wider than the range of individuals on which the perpetrators want to influence directly; 3) the instruments for committing one terrorist act are highly varied (most commonly firearms and explosives are used); 4) it does not matter how great is the damage because it isn't the very purpose of the terrorist. For the terrorist is important to cause a psychological effect - fear, dread, anxiety, insecurity, etc., which in turn to force the society adopt a desired behavior or to make public perform an action that is the actual terrorist's aim.

We will agree with George Fotev that warfare is interdisciplinary and multidisciplinary knowledge. It is that because "The army and the war are studied by different sciences" [4] and "They present these actions as multidimensional and define them as a complex reality" [5]. One deduction based on the broadest understanding of warfare is the necessity of providing more operationalized conception of it. In brief manner it is represented by Karlfon Clausewitz – "Martial art is the art of conducting the war, while you succeed to use to the best advantage the resources in the fight, which you have just before" [6]

Clausewitz himself specifies the meaning put into this concept, comparing: military science contains knowledge – martial art requires creativity [7]. But this correlation allows us to validate it exactly as a deed, but not art.

Conducting a war through the usage of available resources requires knowledge and intellectual capabilities in order to manage the war properly as well as to create and make use of these resources.

Actually, Clausewitz believed that this given definition is a statement in a broad sense. Because warfare covers "... all activities aiming war, and in particular all related to the creation of armed force, i.e. those providing sets, weapons, armor and training" [8]. Prussian military theorist tells us that even we were looking for operationalization of the concept of warfare, it implicitly contains interdisciplinary knowledge. And yet, according to Clausewitz walfare in the strict sense is represented by "...being at war (which-BA.) that includes handling of fight and its conduct" [9].

This provokes deriving of the basic structural activities of warfare - tactics and strategy. "The first one learns how to use forces in the fighting, and the second one - how to use the fighting for the purpose of the war" [10].

The sophistication of warfare (fighting in a war) caused by industrial production after The First World War is the reason about the appearance of its third structural component - operational art. It occupies an intermediate position towards tactics and strategy. In the spirit of Clausewitz it can be defined as an activity that teaches how forces are used to connect the fightings. In fact, these

three main activities construct the object of warfare as a science [11]. Because the military science as a social activity presupposes knowledges as well as capabilities in the field of creativity. These knowledges and creativity aimed at forming an ability, summarized in the classic expression of Harold Lasswell – "management of violence". For the realization of the "management of violence" is needed organization.

The primary public product of warfare is the army. It is the institution for exercising violence. Hence the role of the military as "an expert in intriducing force under certain conditions" has appeared [12]. Admittedly, these are the terms of war. But the war suggests a variety of situations and relevant ways and approaches of warfare that need to be reflected in a systematic way and then classified by tactics, operational art and strategy. Because actually "the differences between the military commanders in antiquity and (nowadays' – Bulgarian author) ... those who control the most powerful up-to-date weapons ... are in some sort rather due to current technology and resources than the methodology of their work "[13].

However, it should be noticed that namely the technology mediated methods, which are the management contrivances for combat activity conduct. [14]. This means that the subject area of warfare is inseparable from its technical system. It's about consistency between the cognitive (subject) and technical rationality in the military, which in turn requires quite possible organizational rationality [15].

The starting point here is the enemy. In this case - terrorism. What is terrorism? Researchers of this social phenomenon have not reached the formulation of one general plausible definition yet. It seems that there is a consensus on its definition related to a trinity of objectives, means and objects. Systematization imposes: "The objective pursued by the terrorists is always political.

Means used by terrorists (violence or threat with violence) depend on the specific objectives of each terrorist act.

Objects of terrorist acts are people, vehicles and/or buildings where there are huge damages and a numerous toll of human life." [16].

One important basic characteristic of terrorism is the display of "the syndrome of the consequences of violence". This means that the objects of terrorist acts are not only the physical casualties and the material destruction but the society itself in which regular activity fear will dominate. From that point of view we can conclude that terrorism is a kind of "synthesis between war and theater, a dramatization of the most rejected violence i.e. the violence that is perpetrated on innocent people, demostrated in front of public, aiming to create a mood of fear for political reasons" [17].

What is a terrorist organization? One structure–functioned approach of consideration claims that terrorist organizations are with centralized or decentralized structures.

Many researchers highlight the contemporary terrorists' organizations which are constructed on a cellular basis. Their structure includes: staff; illegal military groups; units for reconnaissance and information; psychological unit; logistics units. The presence of sympathizers should be noticed. The composition of each unit (cell) is from 5/6 to 9/10 people.

What is the tactics of terrorists? The researchers highlight three stages in one terrorist act: preparatory, organizational and technical stage as well as four types of tactical actions with a view to the method for achieving the defined aims: blasting (the threat to blow up) or using other dangerous objects; an ambush; an attack and temporary control of vehicles, buildings and places (parts of settlements) and the firing at an object from distance [18].

These general characteristics of the enemy i.e. the terrorist organization are the reason to deduce the affirmation that according to military this organization and battle modes of action don't come as a suprise. If there is some element of surprise at the current stage, it lies in the ingenious and original use of the artifacts of modern post-industrial information society. (It has already mentioned above that the differences between past times and nowadays are rather related to technologies and resources than the methodology of action!) Why? Obviously if there is a closer scrutiny at the classification of the tactical actions of terrorists, presented by researchers once as stages of one terrorist act and twice as a type of tactical maneuvers, you will notice that similar methodology is used by any resistance (partisan) movement against the current government organized power.

The similarities are obvious: each national resistance and/or guerrilla war has political objectives; the basic tactical approach is built on the „hit and run" principle expressed through the famous formula of Mao Tse-Tung: „The enemy attacks, we retreat. The enemy camps, we harrass it. The enemy shoots, we attack. The enemy retreats, we pursue it." [19]; publicity of the shares; maximum price of the consequences of power etc.

At the same time the conduct of the resistance (guerrilla) wars "in most cases includes much of the phenomenon known as ... terrorism ..." [20] with or without terrorist techniques, one resistance (guerrilla) movement as well as one terrorist organization endeavors to apply the doctrine "La politique du pire", which is nothing else but a policy of gradual deterioration of things, aimed to provoke widespread resentment and / or political crisis and at strategic level it aims to provoke a total collapse of the current "status quo". Of course, we can't miss the basic substantial difference between the actions of the terrorist organization and the classic national resistance and / or guerrilla movement expressed by Fromkin: "Unlike the soldier, the partisan or the revolutionary, the terrorist ... is always in the paradoxical position to take actions, which have the immediate physical consequences that are not particularly desired by him. An ordinary killer will kill someone because he wants that person to be dead while a terrorist will shoot someone, although he feels quite indifferent whether this person will live or die" [21].

This comparison between the resistance (guerrilla) and terrorist organizations is important. Because the used tactics is generally known. It's well-known in the military science in theory and in practice. It's not only the organizational rationality we have in mind i.e. the confrontation between military and resistance (guerrilla) formations. But first of all it's cognitive (subject) and technical rationality. What does it mean? At the stage of tactics since its nascent warfare has been developing and improving ways and means of action in symmetric and asymmetric order. Here we will focus on the asymmetry. In broad terms it means a lack of general basis to make comparison with regard to quantity, quality or actual (operational) capabilities. Obviously both resistance (guerrilla) and terrorist threats are asymmetric threats for the state and state's entities that are authorized to use violence. But since there is military science the capabilities of military units for actions under specific conditions and environments have been acquired requiring specialized purely military asymmetric and tactical actions and methods. These are enshrined in military statutes. We even recognize them in the whole types of standard combat support techniques such as reconnaissance with inbred to it ambushes and reconnaissance battle such as "hit, watch and run", engineering support and disguise. What about the tactical actions such as offensive and defense in town (village), in mountain-forested land, actions for dismantle nuclear land mine, deployment of troops outside the barracks, providing the security and defense for objectives by patrolling, etc., etc. etc. It's not necessary to mention the construction, preparation and armor of the special branch of armed forces for example landing. Under the conditions of today army forces are used in many operations distinguished from war: peace-imposing, peacekeeping, operations in humanitarian crises. They act as it is prescribed in the statutes that study the achievements of the military science. At the same time the inventive and original use of contemporary post-industrial information society's artifacts by terrorists is not ahead of the warfare development. Unfortunately it is an attempt for more adequate inserting the terrorist organizations in modern world. The development of warfare at this stage gives enough answers about possible threats because "... in the postmodern technical military systems there are intangible components which define a new paradigm that besides all explains radical disparities and incommensurability with earlier ..." [22] ones. It's worth noting the concepts of "The Future Of The Soldier", "Abilities to surf in a network" - [NEC], "Network centric warfare", the system [C4 ISTAR].

III. Conclusion:

In conclusion it must be said that „terrorists are civilians, not an army, therefore the most appropriate means for dealing with them are police forces, intelligence gathering and security measures, not tank brigades" [23]. Moreover, the police fully benefits from the achievements of the military.

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ИМЕНА НА АВТОРИТЕ се печатат през 1 празен ред под заглавието в разгърнат вид - пълно собственои пълно фамилно име; Font: Times New Roman, Size: 14, Fontstyle: **Bold**, ParagraphAlignment: Left, по средата на реда – Centered.

АНОТАЦИЯТА И КЛЮЧОВИТЕ ДУМИ НА АНГЛИЙСКИ ЕЗИК се оформят така: Анотацията (***Abstract:***) в обем до 10 реда - Font: Times New Roman, Size: 12, Fontstyle: *Italic*, ParagraphAlignment: Justified; през 1 празен ред следват ключовите думи (дескриптори - ***Keywords)*** – Font: Times New Roman, Size: 12, Fontstyle: *Italic*; ParagraphAlignment: Justified, и двата елемента с отстъп 1 cm вляво от рамката, ограничаваща основния текст.

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Литературата в текста се означават с цифра, заградена в квадратни скоби [1] Номерацията на формулите се означават вляво от тях в малки кръгли скоби ( ). Литературата, посочена в края на доклада, се изписва съгласно стандарта за библиографско описание, на английски език а цитиранията в текста се означават с цифра, заградена в квадратни скоби [1].

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