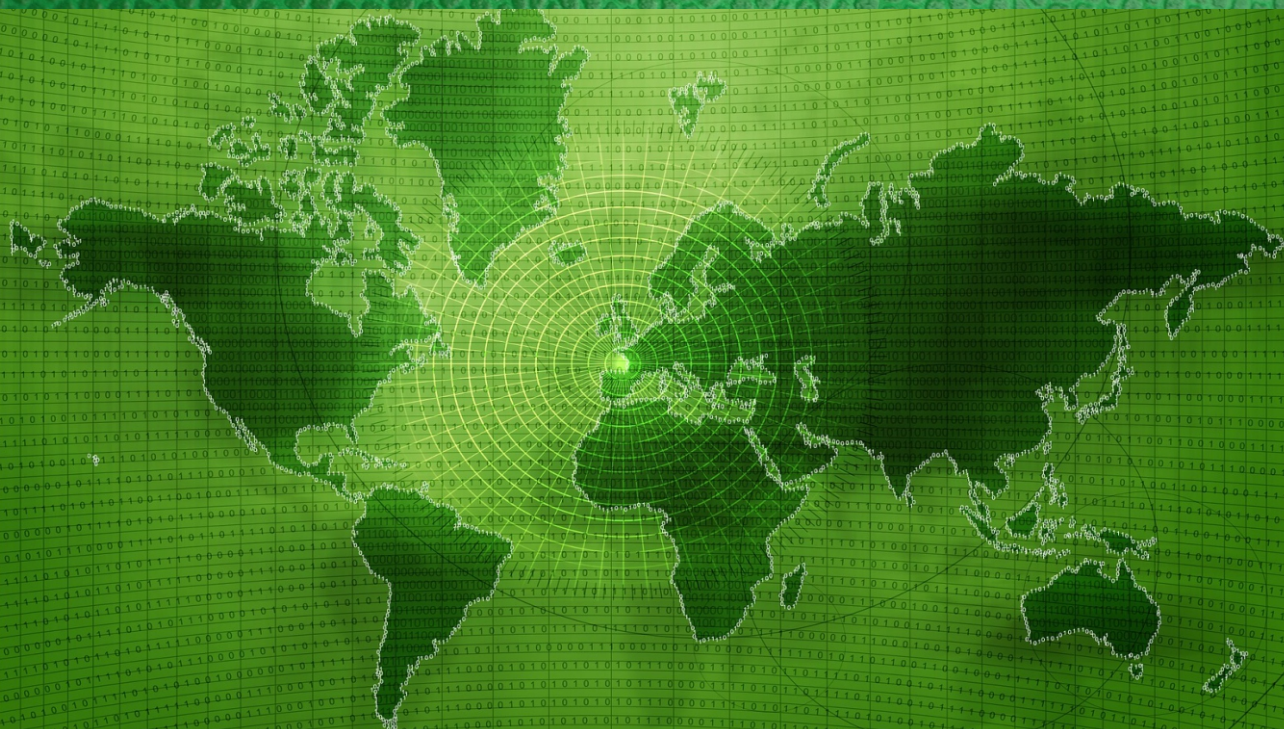


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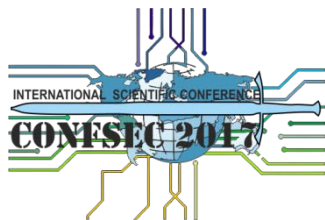
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CRISIS MANAGEMENT AS AN ACADEMIC DISCIPLINE

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Abstract: *Crisis management is rather old managerial practice, but the very term is rather new. In last decades of XX century in a number of European countries Crisis management has become recognized as an academic discipline and education and research field. Although it is included in the curriculum of number of faculties, it is not understood in the same way. There is confusion in terminology, methods, concepts and approaches. What is also confusing is the fact that the discipline of Crisis management is most developed in rich and politically stable countries like Sweden and Netherlands, while it is still in the rudimentary phase in countries that have faced serious crisis situations in recent past, like ex Yugoslav countries. However situation in this field is rapidly changing in the Western Balkans and the conditions for dynamic development of crisis management as an academic discipline emerged, which might contribute to improvement of managerial practice both in profit and public sector.*

KEY WORDS: CRISIS, CRISIS MANAGEMENT, EDUCATION, RESEARCH, ACADEMIC COMMUNITY

1. Introduction

Crises and disasters are an inevitable companion of human communities and a historical constant. In accordance with that fact, people's efforts to anticipate and avoid different kind of social crisis and natural disasters and mitigate their consequences are as old as mankind. The academic literature often refers to Noah as the first crisis manager who began to build the boat before it started to rain (Dynes, 2003). However, on the other hand, crisis management is a relatively new concept in generally, and in countries in transition particularly, both in the theoretical sense as a scientific-educational discipline and research field, and as a practical activity in private corporations, state administration, state-owned companies and organizations in the non-profit sector. Its, relative to global tendencies, belated and slow entry into the academic and practical-management sphere is accompanied by terminological confusion about basic phenomena – emergency situations, crises, conflicts and catastrophes, as well as various kinds of attempts at managing, either proactively or reactively, various kinds of hazards and uncertainties that threaten society and individual organizations and groups. Concepts are often translated literally or inadequately from the English language, and then inappropriately used, without a clear awareness of their meaning and scope. (Milašinović and Kešetović, 2008)

In the last decades, in a number of European countries, Crisis Management has become recognized academic discipline and education and research field. It is included in faculty curriculum and research plans in scientific institutes, scientific conferences and round tables are organized, books, monographs and journals are published. (Kešetović et al., 2011)

2. Crisis management as an emerging discipline

Nowadays, crisis management is rapidly developing and in the same time adjusting to ever-changing practical and academic environments. Incentives for change come from both economic and political sphere, as well as from academia. Today, we are facing the massive transformation in emergency management arena after the

September 11, 2001. These terrorist attacks on the United States have resulted in a significant reformulation of the purpose and nature of emergency management so the terrorism has become the hazard of priority among policy makers.¹ Besides these social impacts, crisis management is also affected by further urbanization and industrialization, modern infrastructure and recent technological developments such as GIS. The demands placed on emergency managers have risen, and on the other hand the training and educational opportunities now can provide a more knowledgeable cadre. Also, similar changes are occurring in disaster and emergency management research. Our views about the causes of disasters have shifted, and we now better understand the plethora of variables that contribute to their occurrence. The lessons from Sociology and Geography remain as important as ever, but other disciplines are generating vital contributions to the research literature. Revolutionary paradigms have been proposed and others have been introduced as a way to integrate them with the perspectives of the past. Although there are many understudied issues and functions, the knowledge base in emergency management is expanding at a dramatic pace. It is very interesting to see academic efforts in this area evolve, even though there are many obstacles yet to be overcome (McEntire, 2004).

However it is difficult to say if theory as an entire body of accurate scientific knowledge exists in emergency management and what that entails since the field is relatively new and because it intersects with so many other academic disciplines. Regardless, such a collection of philosophy, data and research findings is based on a number of components that help to generate theory. These building blocks include definitions, concepts, principles, classifications, typologies, models and causal relationships. (McEntire, 2004).

There is still no dominant or prevailing paradigm in crisis/emergency/disaster management.

There are a number of problems and obstacles in the constitution of this field as a scientific discipline. Prerequisite to convey and share

¹ It is obvious even on the institutional level - for example new established Department of Homeland Security (DHS) incorporated the Federal Emergency Management Agency (FEMA).

information and knowledge in any meaningful way is to clarify terms. First there is a need to provide adequate and sound academic definitions of all relevant issues and phenomena. That is the first step in clarifying the priorities and boundaries of the discipline.

Also, the central concepts and paradigms are still missing and there is probably no single overarching theory that is currently ascribed to in emergency management. For many years, Comprehensive Emergency Management has been the traditional theory of emergency management has organized emergency management functions into useful but perhaps, overly simplified, disaster phases (mitigation/prevention, preparedness, response and recovery). This single perspective can limit understanding and explanation, having trouble capturing the wider political, economic and cultural explanations of disasters (Britton, 1999). Trying to overcome these limits Anthony Oliver-Smith and Susanna Hoffman studied disasters from anthropological standpoint and proposed the social construction perspective (Oliver-Smith and Hoffman, 1999), while some authors suggested a move toward a “disaster resistant community” (Geis, 2000; Armstrong, 2000), focus on “resilience” as a guiding principle (Britton and Clarke, 2000; Burby et. al. 2000) or incorporation of “sustainability or sustainable hazards mitigation.” (Boullé et. al. 1992); Berke et. al. 1993)

The prospect of building a single overarching theory of disaster management is problematic as it might be impossible to develop a theory that would be able to capture every single variable and issue associated with disasters. For this reason, chaos or systems theory, which are frameworks that incorporate a plethora of causative variables, appear to be gaining recognition in emergency management as well as in other disciplines (Koehler et. al. 2001; Mileti 1999).

Besides mentioned there are certain barriers preventing theoretical development of disaster management theory. McEntire and Marshall (2003) have identified at least ten significant interrelated concern: how to reconcile the physical dimensions and characteristics of the event (objective / physical dimension) and its perception or social construction (subjective / social dimension), what is emergency management (academic focus is on disasters not on emergencies, not only on reaction/respond but also on prevention and social environment, and finally the term EM may imply that we have total control of disasters, which is not the case); What hazards should we focus on? Should we continue to give preference to the concept of hazards (or vulnerability)? What variables and what actors should be explored in academic research? What phases should be given priority? What disciplines should contribute to emergency management? What paradigms should guide our field?

3. Crisis/Disaster management studies - World at glance

In the USA Emergency management is a growing profession and is projected to continue growing at a rate of 20 percent or more, according to O*NET OnLine (created for the U.S. Department of Labor), which rates emergency management specialists as a “bright

outlook occupation” in the labor market. That growth is reflected in the increasing number of higher education programs offering degrees or certificates in emergency management. More than 180 emergency management programs (Associate Level; Bachelor-Level Concentrations, Minors; Bachelor Degrees; Masters Certificate, Specialization, Concentration, Track; Masters Level and Doctoral level) dot the country’s higher education landscape, and approximately 100 more colleges and universities are investigating, proposing or developing some sort of hazard, disaster and emergency management program, according to background information provided for FEMA’s 13th Annual Emergency Management Higher Education Conference held in June 2010. List of college that perform emergency management programs can be found on FEMA web page² -major of them are offering bachelor degrees, some of them even with the possibility for online studying. Just as the number of emergency management higher education programs is growing, the number of graduates from those programs is increasing, and expectations about what those degrees mean is often overstated. Students expect an emergency management degree to give them the skills and knowledge they need to walk out of school and into a good job in the field. And employers expect an emergency management degree to give those job applicants skills and knowledge to make up for their lack of experience. Neither expectation is very realistic. (Lucus-McEwen, 2011).

At seven USA universities it is possible to get PhD in crisis/emergency management: George Washington University – Ph.D. in Engineering Management with Research Focus in the Field of Crisis, Emergency and Risk Management, Georgia State University - Ph.D. Degree in Public Policy with Disaster Management Specialization, North Dakota State University - Ph.D. in Emergency Management, Oklahoma State University - PhD in Fire and Emergency Management, Saint Louis University – Doctoral Program in Biosecurity & Disaster Preparedness, University of Delaware – Ph.D. in Disaster Science and Management and University of North Texas –PhD in Public Administration and Management with a Concentration in Emergency Administration and Planning. Even working professionals can get doctorate at the Capella University and Jacksonville State University.³

On the other hand in Canada there are only two programs of this kind. One is Master of Disaster & Emergency Management (MDEM) on School of administrative Studies within York University (<http://dem.gradstudies.yorku.ca/about/>) and the other is Master of Arts in Disaster and Emergency Management at Royal Roads University, Victoria, Canada (<http://www.royalroads.ca/prospective-students/master-arts-disaster-and-emergency-management>)

² <https://training.fema.gov/hiedu/collegelist/embadegree/>

³ See more on <https://www.gradschools.com/doctorate/emergency-management/online?countries=> and <https://training.fema.gov/hiedu/collegelist/emdoctorlevel/>

In Europe the largest number of study programs in crisis/disaster management can be found in the UK. Some universities have more than one program of a kind. To number just a few: Risk, Disaster and Resilience, M.Sc. Risk and Disaster Science, M.Sc. *University College London (UCL)*, Shelter after Disaster, Postgrad.Dip. and Development and Emergency Practice (PGDip/ PGCert), M.A. *Oxford Brookes University* Oxford, Emergency Planning and Management, M.Sc. and Disaster Management, M.Sc. *Coventry University*, Security Management (Distance Learning), M.Sc. , Crisis and Disaster Management, M.Sc.and Security Management, M.Sc. *University of Portsmouth*, Safety, Risk and Reliability Engineering (distance Learning Only) MSc/Diploma, M.Sc. *Heriot-Watt University*, Risk, Crisis and Disaster Management MSc, M.Sc.*University of Leicester*, Disaster Management and Sustainable Development, M.Sc. *Northumbria University* London, Hazards and Disaster Management, M.Sc. *Kingston University* London and Disasters, Adaptation & Development, *Master King's College London*.⁴

On the other hand in France we could not find particular master programs in disaster management, while in Germany there is only one program in security management - Sicherheitsmanagement - Berufsbegleitendes Fernstudium, M.A. Berlin School of Economics and Law.

Relevant European study programs in crisis/disaster management that should be mentioned are Risk and Emergency Management, M.Sc. *Institute for Advanced Study of Pavia (IUSS)* Italy, Crisis Management and Peacebuilding, M.Sc. *Umea University* Umeå, Sweden, Security, Crisis and Emergency Management (Foundation University Research Institute José Ortega y Gasset), M.Sc.*King Juan Carlos University* Madrid, Spain, Crisis and Security Management *University of Leiden* and Disaster management *University of Copenhagen*.

When it comes to research, publishing, and sharing insights, knowledge and experiences in this field internationally, Swedish CRISMART Institute that operates within Swedish Defence University should be mentioned. CRISMART combines scientific methods and proven experience in developing and disseminating knowledge on crisis management at the local, national and international level. Through their research, analytical support and training activities, CRISMART is a valuable and driving force in helping organizations at all levels of society to deepen their understanding of crisis preparedness and strengthen their crisis management capabilities. CRISMART's core team at the Swedish Defence University consists of about twenty researchers and analysts, as well as an extensive international network.⁵

⁴ See more about this programmes on www.mastersportal.eu/search/#q=cj-30|di-297|lv-master.preparation|ldg-prebachelor.language&order=relevance&start=20

⁵ Impressive CRISMART publishing is available on <http://www.fhs.se/en/research/research-centres-and-programmes/crismart/articles/crismart-series/#content>

4. *Crisis/Disaster management studies in ex-Yugoslav countries*

In the time of socialist Yugoslavia at the academic institutions in all Yugoslav republics in the first and second academic year of studies *National defense and social self-protection* was a compulsory subject. This teaching subject had much in common with the crisis management, although, due to the political circumstances, it also had a strong ideological component. After the collapse of the socialist system and the dissolution of the SFR Yugoslavia in 1990s, each of ex-Yugoslav countries developed its own educational system, but in academic curriculum in all of them National defense and social self-protection was abandoned. Today only academic institutions in Serbia, Bosnia and Herzegovina and Croatia offer study programs in crisis management.

At the University of Belgrade – Faculty of Security Studies there is one year master multidisciplinary course Studies in Risk Management in Natural and other Disasters while the University of Sarajevo – Faculty for Criminalistics, Criminology and Security Studies offers master studies in Crisis management in security sector.

The University of Applied Sciences Velika Gorica in Croatia is a higher education institution that provides particular Study of crisis management with expert and specialist study group. Expert study programme in Crisis management lasts three years and graduate students acquire the title of professional baccalaureus/baccalaurea engineer of crisis management. Target group of this study programme are decision makers (or their support) in local and regional government, state administration, in particular army and police protection and rescue units. Competencies of graduated experts are planning and implementing of preventive measures for preventing or mitigating consequences of crisis and disasters in companies or environment and giving expert help and coordinating of expert teams and resources in the aftermath of crisis or disaster. Practical teaching is conducted in cooperation with governmental bodies and agencies and other legal entities relevant for protection and rescue (firefighter service, Red Cross, centres 112, Paramedics etc.). Specialist expert study of crisis management results in acquiring title of professional specialist engineer of crisis management, who is competent to solve problems connected with crisis management independently, to supervise the management of security and protection in public and private sector, especially in business on the national and international level. Crisis management that is intended primarily for persons who are involved in protection and security aspects of crises in the activities of legal entities, industry, bodies of local and regional administration units, and bodies of government administration. The graduate students are qualified to solve the problems of managing crises as well as managing public and corporate security and humanitarian and security operations in compliance with the valid national, EU and international relevant directives and norms.

Besides this, crisis/emergency/disaster management as a

teaching subject is present in a number of academic institutions in all ex Yugoslav countries on different level of studies.

5. Conclusion

In the modern risk society, crisis management has become an academic and research discipline in a number of European countries. Certainly, emergency management is becoming more complicated and demanding. The numbers and consequences of both natural and man-made disasters are increasing, and public- and private-sector agencies are being taken responsive for failing to mitigate or prevent the effects of those disasters. Employers are looking for emergency management professionals who understand the political and socio-economic nuances of disasters, as well as how to write a continuity of operations plan and maintain an emergency operations center.

Crisis management as the educational profile is mostly present in academic institutions of the United Kingdom, but a significant contribution to the development of the theory and the research results have provided academic institutions of the Netherlands and Sweden.

After stepping into transition, crisis management is also developing as an academic discipline in countries in transition, including ex-Yugoslav countries. Publishing in this field is still humble, but ties between researches and institutions are being restored. Crisis management as an academic discipline in Serbia is still at its very beginning. However, the fact that in only two years it became a teaching subject at five faculties gives hope that lost time will be redeemed and that scientific approach to crisis management will contribute in a way that reacting to a crisis situation in an intuitive, religious and magic-like manner will stay behind us.

References

1. Armstrong, M. "Back to the Future: Charting the Course for Project Impact." *Natural Hazards Review* Vol 1 No 3, 2000. pp. 138-144.
2. Berke, P.R., J. Kartez, and D. Wenger. "Recovery after Disaster: Achieving Sustainable Development, Mitigation and Equity." *Disasters*, Vol 17 No 2, 1993. pp 93-108.
3. Boullé, P., L. Vrolijk, and E. Palm. "Vulnerability Reduction for Sustainable Urban Development." *Journal of Contingencies and Crisis Management* Vol 5 No 3, 1992. pp. 179-99
4. Britton, N.R. "Whither the Emergency Manager?" *International Journal of Mass Emergencies and Disasters* Vol 17 No 2, 1999 pp.: 223-235.
5. Britton, N.R. and G.J. Clarke. "From Response to Resilience: Emergency Management Reform in New Zealand." *Natural Hazards Review* Vol 1 No 3, 2000, pp. 145-150.
6. Burby, R., R.E. Deyle, D.R. Godschalk, and R. B. Olshansky. "Creating Hazard Resilience Communities Through Land-Use Planning." *Natural Hazards Review* Vol 1 No 2, 2000, pp. 99-106.
7. Dynes, R., R. "Noah and Disaster Planning: The Cultural Significance of the Flood Story", *Journal of Contingencies and Crisis Management*, Vol 11, No 4, December 2003, pp. 170-177
8. Geis, D. "By Design: The Disaster Resistant and Quality of Life Community." *Natural Hazards Review* Vol 1 No 3. 2000. pp. 151-160.
9. Kešetović, Ž. Кризни менаџмент/Crisis management, Belgrade, Faculty of Security Studies, 2008.
10. Kešetović, Ž., Milašinović, S., Keković, Z. and Milošević, G., CRISIS MANAGEMENT AS ACADEMIC DISCIPLINE IN EX YUGOSLAV COUNTRIES, 16. međunarodna naučna konferencija Rješenje krizovih situacija u specifičkom prostoru, Fakultet specijalnog inženjstva ŽU, Žilina, 1. - 2. jún 2011
11. Koehler, G.A., G.G. Kress and R.L. Miller. "What Disaster Response Management Can Learn From Chaos Theory." Pp. 293-308 in Farazmand, A. (ed.) *Handbook of Crisis and Emergency Management*. New York: Marcel Dekker, Inc. 2001.
12. Lucas-McEwen, V. What You Should Know About Emergency Management Degrees, 2011, available on <http://www.govtech.com/em/training/Emergency-Management-Degrees-Careers.html>
13. Milašinović, S. and Kešetović, Ž. „Crisis and crisis management – s contribution to a conceptual & terminological delimitation“, *Megatrend review*, No 1, 2008, pp. 167-186
14. Mileti, D. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, D.C.: Joseph Henry Press. 1999
15. McEntire, D.A., "The Status of Emergency Management Theory: Issues, Barriers, and Recommendations for Improved Scholarship", Paper Presented at the FEMA Higher Education Conference, June 8, 2004, Emmitsburg, MD, 2004. available on <https://training.fema.gov/hiedu/downloads/david%20mcEntire%20-%20%20status%20of%20emergency%20management%20theory.pdf>
16. McEntire, D.A. and M. Marshall. Epistemological Problems in Emergency Management: Theoretical Dilemmas and Implications. *ASPEP Journal* No 10, 2003. pp. 119-129.
17. Oliver-Smith, A. and S.M. Hoffman. *The Angry Earth: Disaster in Anthropological Perspective*. New York: Routledge, 1999.

COMPETITIVE INTELLIGENCE AND COUNTERINTELLIGENCE – MODERN TOOLS FOR GENERATING PROACTIVE CORPORATE SECURITY

КОНКУРЕНТНО РАЗУЗНАВАНЕ И КОНТРАРАЗУЗНАВАНЕ – СЪВРЕМЕННИ СРЕДСТВА ЗА ИЗГРАЖДАНЕ НА АКТИВНА КОРПОРАТИВНА СИГУРНОСТ

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Abstract: There are a much larger number of both present and emerging threats for modern business than ever before in history. Using only classical methods and tools for protecting the enterprises' assets is no longer effective. More and more companies are implementing modern tools such as competitive intelligence and counterintelligence in order to survive in the new hypercompetitive global markets. Those companies strive to gain proactive knowledge for the environment in order to generate successful systems for corporate security and industrial counterespionage.

Keywords: COMPETITIVE INTELLIGENCE, BUSINESS INTELLIGENCE, COUNTERINTELLIGENCE, CORPORATE SECURITY, KNOWLEDGE MANAGEMENT, INDUSTRIAL COUNTERESPIONAGE

1. Introduction

Forces and factors from the business environment, characterized by perpetual change and uncertainty, are becoming more and more unpredictable and they can easily disrupt even the most comprehensive strategic plans. One group of them includes some classical external forces such as political or macroeconomic crises, social outbreaks or new technological outbursts. The second group also sums up well-known factors related to the existing or emerging competitors. In addition, there is a whole new group of risks such as possible terror attacks, especially against Western companies all over the globe and other forms of hybrid threats. In this regard, managers must learn to understand, anticipate and respond to the threats they face along with other forces likely to have an impact on their business performance (Bernhardt, 2003, p. viii). As Stephen Miller states, realizing the need of implemented competitive strategy, a growing number of the biggest world companies have established intelligence functions within their units but most of them lack fully operational toolkit. Such a toolkit serves as an early warning on future events that can have impact on company performance. On the one side, competitive (or business) intelligence and competitive analysis are implemented in order to predict what all kinds of focus groups such as competitors, suppliers, major customers, etc. will do before they do it and react accordingly to that specific knowledge. On the other side, corporate counterintelligence includes the opposite actions for protecting the company's assets from similar operations conducted by some of the focus groups mentioned above. The military doctrinal fundamentals are similar. Intelligence operations are conducted in order to achieve two objectives: 1) it provides accurate, timely and relevant knowledge about the enemy (or potential enemy) and the surrounding environment; 2) includes active and passive measures intended to deny the enemy valuable information (USMC, 2007, p. 1-1). The aim of this report is to provide readers with the concept that developing proactive corporate security capabilities can provide valuable input to corporate strategy and planning processes.

2. Definitions

2.1. What is Competitive Intelligence?

According to a research conducted by the Global Intelligence Alliance (GIA) competitive intelligence can be defined as knowledge and foreknowledge about the external operating environment which ultimate goal is to improve the decision-making processes of the companies (GIA White Paper, 2004, p. 2).

Rouach and Santi refer to competitive intelligence as 'a kind of a radar screen' – a legal and ethical process which tracks the activity of both direct and indirect competitors in a range of fields such as general business activity, business development, strategy and tactics, research and technology and so on in order to help the

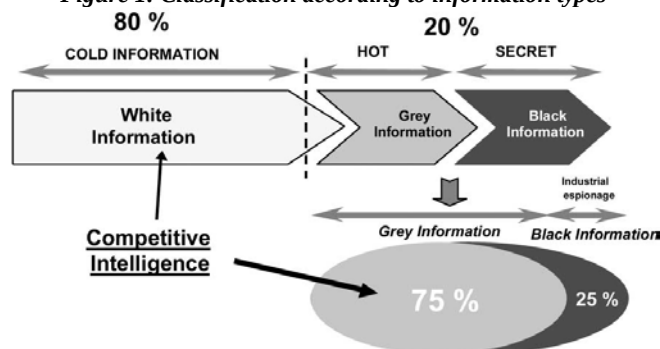
company shape its future and protect itself against current competitive threats (Rouach and Santi, 2001, p.553).

Competitive intelligence is neither market research nor industrial espionage: it involves the use of public sources to develop data on competition, competitors and the market environment (McGonagle and Vella, 2002, p.3). Sources of such information include business and trade publications, government documents, newspapers in competitor locations, advertisements and promotions, financial reports, industry reviews, market statistics and any other information that can be legally and ethically identified, located and accessed.

In addition, there is a great difference between information and intelligence. Usually, today companies possess too much information and not enough intelligence. Understanding that difference in time would help them protect their corporate secrets as well as improve their decision making. According to Kahaner (1996) *information is factual* – it consists of numbers, statistics, scattered bits of data and it is impossible to make accurate predictions based on it no matter how comprehensive it is. On the other hand, *intelligence is knowledge* – it is a collection of information pieces which have been filtered and analyzed. Authors and professionals are unanimous about distinguishing three types of data (Figure 1 illustrates how collected data are split into the three different categories):

- *White Information* which can be found in a range of data sources, many of them listed above, also called *open-source information*;
- *Grey Information* that includes private domain data such as trade shows and other publications often ignored by competitors; it can also be referred to as *restricted information*;
- *Black Information* can be collected beyond the point of ethics; it is *illegally-obtained information* by means of computer piracy, corporate espionage, telephone wire-taping and so on.

Figure 1: Classification according to information types



(The figure is excerpted from European Management Journal, Vol. 19, No. 5, p. 555, October 2001)

A logical conclusion from the above listed definitions would be that the best competitive intelligence practices are found in the most powerful companies. In relation to enterprise's size and budget, Rouach and Santi (2001) have managed to identify five types of analytical attitudes towards competitive intelligence:

Figure 2: The Five Intelligence Attitudes

Analyst type	State of mind	Methods
1. WARRIOR	War mentality; always informed; offensive position	Sophisticated tools; unlimited or significant resources
2. ASSAULT	Former law enforcement agents; hunt for strategic intelligence	Significant resources; code of ethics; a lead lookout; value put on HUMINT
3. ACTIVE	Observatory of competition	Limited resources
4. REACTIVE	Opportunists	Reacts to attacks; very limited budget
5. SLEEPERS	No particular action	Blind; passive

To sum up, the most important part of any proactive corporate security system is the competitive intelligence cycle. Logically, as stated by the GIA, companies nowadays are encouraged to implement the classical four-step intelligence cycle used by the CIA and other national security organizations around the globe (GIA White Paper, 2004, p. 9). As Kahaner (1996) describes, such a cycle within a corporation includes 1) planning and direction ('setting goals' within a national intelligence system), 2) collection (obtaining data from different sources), 3) analysis (comparing information) and 4) dissemination (estimating possible future developments). McGonagle and Vella (1996) also agree with that model. However, a number of researchers add more stages to the classical model – Miller (2000) puts a fifth stage called *feedback*; Bernhardt (1994) includes a *processing* level as a link between the collection and the analysis; Ashton and Stacey (1995) expand the original model to a sixth step called *auditing the system's performance*. As a result, GIA's experts develop an eight-step competitive intelligence cycle depicted in figure 3:

Figure 3: The Competitive Intelligence Cycle



(The figure is excerpted from Global Intelligence Alliance (2004) Introduction to Competitive Intelligence. GIA White Paper 1, p. 11)

2.2. What is Corporate Counterintelligence?

Counterintelligence within business units can be defined as the identification and neutralization of numerous threats posed by any rivals' intelligence services, and the manipulation of those services for the manipulator's benefit (Bernhardt, 2003, p. 85).

According to Strauss (1999), corporate counterintelligence is the other side of competitive intelligence because it represents the process by which companies defend their internal information.

Corporate counterintelligence possesses both active and passive characteristics (Bernhardt, 2003, p. 89). Corporate security experts are unanimous that passive counterintelligence implements defensive tactics and tools such as software solutions, countersurveillance and penetration testing. On the contrary, active counterintelligence implements offensive tactics and further investigates any illegal, unethical or threatening activities to their sources.

The classical counterintelligence process at all levels includes four steps: 1) develop a counterintelligence estimate; 2) conduct counterintelligence surveys; 3) develop the counterintelligence plan; 4) implement appropriate counterintelligence measures (USMC, 2007, p. 1-5).

John Nolan (1996), a researcher for the Phoenix Group, a world class security company, manages to distinguish the two basic dimensions of corporate security – external and internal. Logically, the Phoenix Group itself proposes a counterintelligence cycle in collaboration with the classical intelligence cycle.

Figure 4: The Counterintelligence Cycle



To sum up, the most fundamental goal of the counterintelligence unit is to ensure proactive countering of threats and to enhance corporate security in general by protecting the assets not only against criminal theft but also against entirely legal competitive intelligence efforts by business rivals.

3. Types of Threats and Industrial Espionage Tools

As mentioned earlier, businesses can easily become a target of foreign intelligence organizations, competitors or corporate spies. According to Steve Whitehead, a lifelong security expert in the field of counterespionage, methods of espionage and motivational factors behind them include (Bernhardt, 2003, p. 90):

- Trespassing;
- Covert surveillance;
- Electronic eavesdropping and bugging;
- Trash collection;
- Burglaries;
- Blackmail and bribery;
- Stealing of documents;
- Insider threat – recruitment of a staff member or infiltration of an agent.

Ira Winkler, a security consultant, adds four large categories of vulnerabilities within a company (Winkler, 1997). They include:

Operational vulnerabilities:

- Social engineering;
- Unchecked internet usage;
- Carrying work around or home.

Physical vulnerabilities:

- Easy building access;
- Open or poor storage of information;
- Lack of computer passwords.

Personnel vulnerabilities:

- No background checks;
- Susceptibility or crime;
- Personal situations causing stress or financial hardships.

Technical vulnerabilities:

- Known bugs in the system;
- Easily broken passwords.

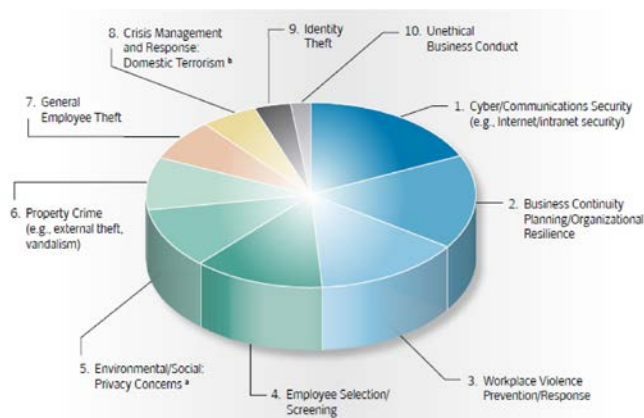
According to Stephen Fink, the most targeted groups include (Fink, 2002, pp. 266-267):

Figure 5: Groups of Targets for Industrial Espionage and Competitive Intelligence

Most targeted trade secrets	Most targeted industries	Most targeted assets
Customer lists	Pharmaceutical	Formulas
Pricing information	Chemical	Patterns
R&D information	Food	Programs
Sales information	Computer software	Devices
Manufacturing information	Aerospace	Methods
Strategic plans	Automobile	Techniques
Cost information		Proprietary processes

In a survey conducted in 2014 experts from Securitas Security Services USA Inc. have identified some trends related to security threats, management challenges and operational issues from Fortune 1000 companies. The study, which is often cited as an industry standard, revealed the issues of greatest concern to corporate security directors:

Figure 6: 2014 Top Security Threats



(The figure is excerpted from “Top Security Threats and Management Issues Facing Corporate America.” Securitas Security Services USA Inc., p. 4)

As depicted in the paragraph, the types of threats, espionage tools and management issues vary enormously. That is the reason why the need for establishing proactive corporate security through implementing modern business tools has grown as stated in the beginning of the report.

4. Results and Discussion

As former F.B.I. special agent Edwin Fraumann once said, ‘Increasing international economic competition has redefined context for espionage as nations link their national security to their

economic security. Spying conducted by intelligence services is expanding from its primary focus on military secrets to collecting economic secrets’ (Fraumann, 1997, 303). As a result, any company could become a target for economic or industrial espionage much more regularly than military or political institutions. Logically, corporate counterintelligence along with competitive intelligence must be integrated within the strategy of the organizations. Any other company’s attitude towards the issue could be devastating for its very existence.

Whether economic, industrial or corporate espionage has been engaged to harm a company, the company must counteract. To begin with, competitive intelligence and counterintelligence should be implemented within the security strategy of the companies but it should not be confused with security in general. Whether that strategy is defensive or offensive, both tools could possess passive or active components.

Passive components focus mostly on preventive measures. As explained earlier, those measures may include:

- **Security education** strengthens personnel situational awareness towards espionage threats. All security measures and practices become useless without properly trained staff members. Such trainings should be conducted on a regular basis in order to improve employees’ knowledge about both competitive intelligence tactics and illegal information gathering.

- **Defensive measures** include a number of programs which identify possible threats among personnel and the related risks that vulnerable to outside influence may bring. Security expert Steve Whitehead mentions an employee assistance program (EAP) which offers solutions for personal problems that are the main reason for recruitment by an industrial spy (Bernhardt, 2003, p. 94).

- **Technical countersurveillance (TSCM)** consists of a set of measures for identifying illegal technical devices planted for information collection purposes. TSCM’s purpose is to prevent any technical intrusions which represent the last possible tool used by industrial spies when their ways to targeted organization are cut off.

- **Penetration testing** is used for assessment of the vulnerabilities of critical for the competitive edge facilities, areas and activities. Most security systems are unable to counter professional espionage team. However, regular penetration testing could evaluate the current effectiveness of the security system and improve counterintelligence practices against most commonly hired for industrial espionage.

Active components focus mostly on active and proactive measures which include:

- **Corporate investigations** provide information about companies’ most valuable assets – their people. It is a very useful proactive tool which mitigates employee related risks through biographical facts, background checks and thorough research before an employee is even hired.

- **Competitive intelligence and counterintelligence operations** should implement effective policies and procedures for information classification. Such measures could implement a new corporate culture related to the active protection of information by employees.

- **Ethical collective process** could be implemented when the security unit in charge finds proofs for illegal proprietary information collection. Firstly, security officers should inform the law enforcement agencies. Then, they could apply their own counter measures.

Ultimately, as Bernhardt (2003) states, the finished intelligence product is the most important decision-making tool. Although it is a rather new term for companies, finished intelligence is split into five generic categories used by the U.S. Intelligence Community:

- 1) *Current intelligence* – to provide managers from different levels with arising developments likely to have an impact on corporate strategy, tactics or operations;

- 2) *Estimative intelligence* – a comprehensive analysis and long-range forecasts developed for the senior management in order to help them predict the possible opportunities and threats;

3) *Research intelligence* – classified studies that are split into two subtypes: *basic research intelligence* and *operational support intelligence*;

4) *Scientific and technology intelligence* – crucial for innovative companies operating within science or technology industries; related to competitors' research and development operations;

5) *Warning intelligence* – includes warning watchlist and alerts.

5. Conclusion

To sum up, the craft of intelligence today has evolved considerably – to the point in which even corporate board members rely on intelligence and counterintelligence units to help them better predict the external environment.

A 'perfect' corporate security system does not exist. However, if the aspects analyzed above are aligned with the organizations' architecture at all levels, a very sophisticated mechanism could be created. That new system provides proactive security to the corporations which bring some specific benefits such as:

- Enhanced knowledge management assets which will ultimately bring to increased shareholder values;
- Intelligence deliverables in the form of high value-added competitive intelligence products;
- Early warning of competitive threats thanks to the counterintelligence cycle within the organization;
- An effective human-source intelligence (HUMINT) capabilities thanks to the proactive security education;
- A trusted internal source of news and trends related to the external environment relevant to strategic and tactical decision-making;
- Improved operational communications related to security within the organization;
- Enhanced corporate security culture between the employees.

6. Literature Review

1. Ashton, W. & Stacey, G. (1995) *Technical Intelligence in Business: Understanding Technology Threats and Opportunity*. International Journal of Technology Management, Vol. 10, pp. 79-104.

2. Bernhardt, D. (2003) *Competitive Intelligence: How to acquire and use corporate intelligence and counter-intelligence*. London: Pearson Education Ltd.

3. Bernhardt, D. (1994) *I Want it Fast, Factual and Actionable – Tailoring Competitive Intelligence to Executives*. Long Range Planning, vol. 27, pp. 12-24.

4. Fink, S. (2002) *Sticky Fingers: Managing the Global Risk of Economic Espionage*. Chicago: Dearborn Trade Publishing.

5. Fraumann, E. (1997) *Economic Espionage: Security Mission Redefined*. Public Administration Review (July/August).

6. Global Intelligence Alliance (2004) *Introduction to Competitive Intelligence*. GIA White Paper 1.

7. Kahaner, L. (1996) *Competitive Intelligence*. NY, USA: Kane Associates.

8. McGonagle, J.J. & Vella, C.M. (1996) *A New Archetype for Competitive Intelligence*. Greenwood Publishing Group Inc.

9. McGonagle, J.J. & Vella, C.M. (2002) *Bottom Line Competitive Intelligence*. Westport: Quorum Books.

10. Miller, J. (2000) *Millennium Intelligence: Understanding and Conducting Competitive Intelligence in the Digital Age*. CyberAge Books.

11. Rouach, D. & Santi, P. (2001) *Competitive Intelligence Adds Value: Five Intelligence Attitudes*. European Management Journal, Vol. 19, No. 5.

12. Strauss, K. G. (1999) *Marketing Telecommunication Services*. Artech House Telecom Company.

13. *Top Security Threats and Management Issues Facing Corporate America*.” Securitas Security Services USA Inc.

14. U.S. Marine Corps (2007) *Counterintelligence*. NY: Cosimo Reports, Inc.

15. Winkler, I. (1997) *Corporate Espionage*. Rocklin, CA: Prima Publishing.

APPLICATION OF THE MODEL OF USE OF FORCE IN THE PROCESS OF DETAINING PERSONS

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Abstract: Performance of police work includes everyday contact with citizens. The majority of those contacts are peaceful, but, unfortunately there are contacts that are not peaceful and result into dissatisfaction which later is manifested in verbal, physical or armed resistance by the citizens. The fact that the police is involved in everyday contact with the citizens should reduce the possibility of inadequate behavior of the police officers, which is important for effective performance of their professional duties, in compliance with the laws. This means that the process of detaining persons should be performed in a serious manner with the application of all security measures which are in accordance with the given situation. In practice, the police mainly detain persons in cases when they collaborate, give passive or active resistance or when they perform armed or non-armed attack. In order for the police to reasonably assess the situation and react in the process of detaining persons the model of use of force is used. The theory of the application of this model is based on the principle of "control" and it offers directions for adequate and proportionate response of the police in the use of force.

KEYWORDS: POLICE OFFICERS, POLICE POWER, DETAINING, MODEL OF USE OF FORCE, TACTICAL PROCEDURES.

1. Introduction

The quality of the everyday life nowadays is result of the culture and society in which we live. To maintain these social structures, the presence of people who would be responsible for maintaining the peace and protecting our interests is necessary. Because of this, the role of the police in the everyday life is very important. The police officers are the ones who are in constant contact with the citizens and answer their urgent questions. In this regard, the main condition is to provide conditions for maintaining and improving this complex process which is very important for both of the parties.

In order to justify the trust of the citizens, the police must show high level of professionalism and integrity by keeping to the rules of law and regulations that will be applied in an appropriate, decent and unbiased manner in which the public and the interest of the citizens will be protected (Klahm & Tillyer, 2010). If the fact that the police is involved in everyday contact and different meetings with the citizens, it is expected that the possibility of inadequate behavior of the police officers will be reduced, which of course, is an important theory for effective and legal performance of the professional duties. This is especially important because the police are frequently in touch with citizens who express certain dissatisfaction that can be manifested in verbal, physical or armed resistance. For this category of citizens, the police, with good reason, can use force in order to assure that the law is obeyed. However, the level to which that force is allowed must be strictly limited, in other words, it shall not be higher than the force used by the citizens. In essence, every time when there are real conditions for that, the police should always minimize the use of force and to practice obtaining mutual accordance.

Taking into consideration the above mentioned, and contrary to the popular belief, it is important to understand that the use of force by the police is a rare case (only in approximately 0,07%), compared to the total number of contacts between the police and citizens (Paoline & Terrill, 2011). Even though only small proportion of the police work includes use of force, every situation which includes use of force, also includes the possibility of injuries as unexpected it can be. Considering the danger of excessive use of force, the police officers are obligated to provide conditions for reasonable use of force, regardless of the circumstances under which the certain operation is performed (maintenance of public order and peace, deprivation of liberty, detention of a person, police operations, ambush, etc.).

2. Description of the model of use of force

In order to withstand the temptation of abusing their authorities, the police officers must show high level of integrity during their duty by taking into consideration the directions and the code of

professional behavior. In regard to fulfilling and applying the standards, the police officers have the right to use their right of discretion in executing the law, and to use as much as force as reasonable, adequate and necessary, in performing their duties (Ivanovski & Nedev, 2013). To interpret and understand reasonably the process in which police officers use force, here follows a description of the model of use of force (Figure 1).

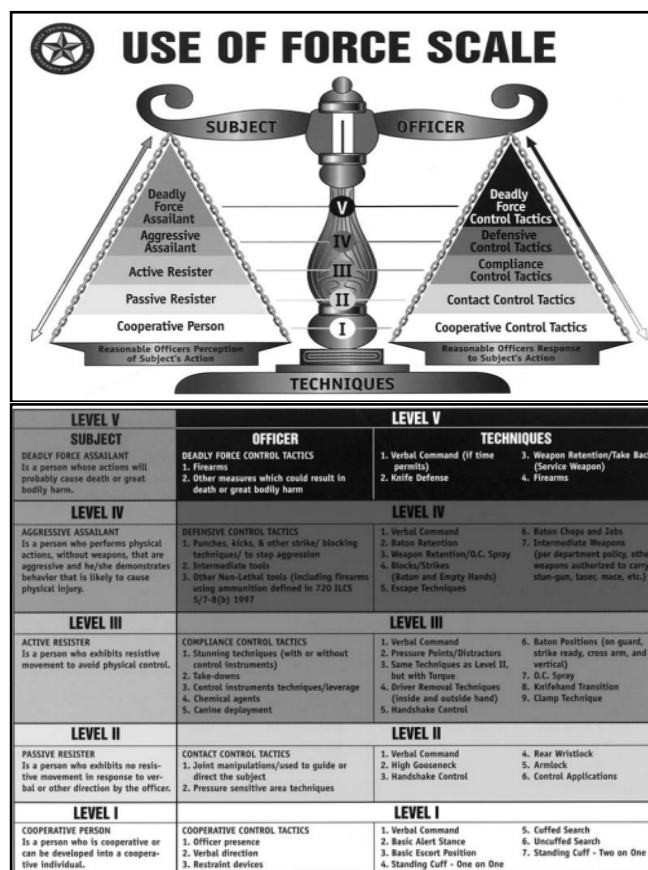


Figure 1. Use of Force Model (Source: Police Training Institute)

This model derives from the program of the University of Illinois Police Training Institute from 1999, and it directs the police officers how to evaluate the risk and to use reasonable force (Fischer, Halibozek & Green, 2008). In this regard, the Police Training Institute has developed a conceptual tool for making decisions known as the Use of Force Framework. This framework is based on the balance between the damage risk level or the resistance with which police officers face, and the use of force means which have been available and adequate in the time when the

force has been used. Theoretical application of the model is based on the principle of “control” – according to which the police officer must use force that would be proportional with the perceptive treat with which they face to an extent to which that force could be controlled and maintained.

It is important to understand that the model cannot predict all possible situations that may arise, but it helps to decide about the adequate use of force in any situation. The situational frameworks of the model provide to easily define the manner in which the police officer observes the situation, including all subjective and objective factors (all circumstances) that are present during the event. It is also well known that when the police officer makes an assessment, not always all phases of risk assessment are available, and because of that, a constant evaluation of the process is necessary, from the initial moment until the final phase. It should be mentioned that this process takes time within a second, or event parts of a second, and the police officer is always included in a continuous state of evaluation, planning and reacting. The evaluation process conducted by the police officers includes three processes that are mutually related (Butler, 2009):

- The situation itself,
- The perceived or already known behavior of the subject,
- The perception of the police officer and his tactical examination.

To integrate these processes in one, minimum six different factors of influence should be taken into consideration:

1. Environmental factors (weather conditions such as: wind, rain, daily light or darkness, physical location, for example open, closed, rural or urban areas, etc);
2. Number of police officers vis-à-vis number of persons (attackers);
3. Personal traits of the attacker (physical constitution, knowledge of skills, emotional condition, drugs or alcohol consumption, etc);
4. Previous knowledge (history) and behavior of the person;
5. Recognizing potential physical signs of attacking (aggressive communication, emotional emptiness, refusing to obey legal demands, personal space invasion, fingers and hands twisting, tension or tightening of facial muscles, pupil dilation, etc);
6. The ability of a police officer to manage time and space (risk assessment, liberation or “tactical reposition”).

If the police officers succeeds to integrate all these factors and circumstances, he will be able to react and use force reasonably (adequate force level that would be reasonable in that situation), and to explain others in which way the situation has been perceived, assessed and how he/she has reacted. In order to understand better the essence of risk assessment by the police officer, the model includes guidance for making decisions and explaining activities related to the use of force. Furthermore, this model is presented through pyramidal relation between the difficulty of the situation on one hand, and the extent of force that is used in order to efficiently, quickly and professionally solve the problem, starting from the lowest to the highest level of use of force on the other hand (Wolf, et. al, 2009). In the pyramidal presentation of the model there are five options (possibilities) for reacting to a force which is result from five different categories of behavior (Figure 1).

The first or the lowest level of hierarchy belongs to a person who collaborates and obeys police orders and does not show any resistance. Control tactics of collaboration such as physical presence of the police officer and giving clear and understandable verbal directions are being applied on this level. The level of used force is “zero”.

The second level belongs to a person who shows passive resistance and manifests resistance as a reaction of verbal or other command of the police officer. Control tactics such as physical manipulation of the wrist or pressure techniques upon sensitive body parts in order to direct the person are being applied on this level.

The third level belongs to a person who shows active resistance and manifests visible resistance in order to avoid physical contact. This level of resistance is more serious, and the police officer must

act in accordance to the force being used by the person and to apply control tactic of subduing (techniques for stunning, surmounting, support with control instruments, chemical agents and etc.).

The fourth level belongs to a person who is aggressive and manifests physical activity (manifests behavior) that would probably cause bodily harm to a police officer. The control tactic of defense that is applied on this level includes usage of techniques (physical force, baton, pepper spray) that would stop the assault and prevent temporarily the aggression.

The highest level of hierarchy belongs to a person (attacker) with a deadly force who engages in activities that would most probably cause death or serious bodily harm. The control tactic of deadly force (firearm) is being applied on this level, but only if it is absolutely necessary, while it is legitimately to use other control methods and techniques that would remove the existing danger.

Considering the circumstances under which the different levels of force are being applied, it could be established that every police officer is expected to use the level of force that is reasonable and adequate for the given situation. Increase of the stage or level of resistance of the person creates conditions for the police officer to increase the level, or change the nature of the force that is being used, in order to ensure that it would be possible to control the risk. Even though there is not a way to specify the exact method or type of reasonable use of force in a given situation, the police officers are expected to apply the guidelines of the model, in order to make professional, unbiased and reasonable decision.

3. Use of force in the process of detaining persons

During the performance of their professional duties, the police officers can often find themselves in a situation in which they would have to detain a person. Detention is a legal procedure that should be carried out in accordance with the rules of the profession. The process of detaining a person can be carried out in two ways: with an arrest warrant issued by a legal authority and without a warrant, but based on legal authorizations (Law on Police, 2006). When an arrest warrant is issued, the police can detain a person in the capacity of accused, witness and to remove their freedom of liberty. And if the situation is urgent and require so, the police can detain a person without an arrest warrant in order to establish their identity and engagement in an illegal activity or offence.

Regardless of the manner in which the process of detention is carried out, it is necessary that the person is brought in front of an organizational unit of the Ministry of Internal Affairs, or in front of some other body. To conduct this process, the police should detain a person voluntarily and avoiding the use of force every time when there are conditions for that. But taking into consideration the circumstances under which the detention is carried out, very frequently, the person that should be detained shows dissatisfaction manifested in verbal, physical or armed resistance. In such cases, the police officers have a legal duty to conduct the detention by using force or using reasonable force to prevail over the resistance of the person.

The legal duty of using force to a reasonable extent implies that the police must be prepared to use force with which they will establish control over the person, without causing further physical or corporal complications. Will the police succeed in their intentions, mostly depends on their ability to use force that would be equal or greater than the force used by the person. When the quantity (extent) of the force being used is established, it is not possible to know (estimate) in advance the quantity of the force that should be used, because there are many critical variables (factors) that influence the decision (Амановић, 2003). Among the most important factors that influence the quantity of the force that should be used during the process of detaining a person are the following: behavior and resistance of the person (passive resistance, active resistance, non-armed attack, armed attack); physical and mental conditions of the person; gender and age; place and location of the event; the skills of the police officer (ability to handle the coercive

measures); number of police officers involved in the process; professional experience; materials and equipment.

Taking into consideration the fact that the process of detaining a person depends on many objective and subjective factors, the police officers can use force only to an extent that would be absolutely necessary to achieve the legitimate and legal goal.

4. Management tactics in the process of detaining persons

In order to efficiently conduct the process of detaining persons, which is a special professional duty, it is necessary to provide all required conditions for safe and uninterrupted execution of the process. This can be achieved with the help of well-elaborated and planned tactic that would provide efficient execution of the process of detaining persons, and that process would cover all projected norms and legal restrictions (Стојановски, 1995). In conditions when the police officers apply certain tactics during the process of detaining persons, they should be prepared to choose the tactic that would provide the most rational and optimal solution of the problem. This implies finding a way to conduct the legal procedure without improvisations, including adequate and tactical performance which starts from the moment when the order is issued or from the moment when the danger is detected (criminal offence, violation) and lasts until the person is brought under control (detained). In order to avoid any omissions in the process of detaining persons, all tactical activities (verbal communication, defense mechanisms and skills) applied by the police officers, must be proportional, adequate, human and in compliance with the law.

Every case which requires detaining a person is different from the previous cases in regard to the reasons (legal base) and category (behavior) of the person being detained. However, the tactic and the manner in which the process of detaining persons is carried out, generally includes the following procedures: informing the person about the reason of detention; if possible, the identity of the person is established; the identification document is held by the police; external examination of the person is performed; the person is informed about the reasons of detention, unless in cases when the police estimates that the person will show resistance (it refers to persons for which arrest warrants are issued, because their affinities are known); the person is asked to join the patrol and they are warned not to show resistance; if there is suspicion that the person has any weapon or tool that could cause body injuries or there is suspicion that the person will hide, destroy or throw the weapon/tool that should be taken by the police and used as an evidence in the criminal or legal procedure, the person is searched without an order and presence of two witnesses; the person is handcuffed if he/she shows resistance during the process of detention, the person tries to escape or attacks the police officers or if there is suspicion that he/she will do that (Јазовић, et. al, 1988).

Taking into consideration the most important safety and tactical precautions that are applied in the process of detention, an attempt is made to elaborate in more details and more specifically the most frequent situations in which the police officers can find themselves during the performance of this legal authorization. Generally, there are five different types of situations, in which, the police officers properly and professionally apply the basic tactical procedures and techniques (Јакимов, 2011):

- Detaining a person who collaborates;
- Detaining a person who shows passive resistance;
- Detaining a person who shows active resistance ;
- Detaining a person who launches unarmed attack, and
- Detaining a person who launches armed attack.

The theoretical concept of the model of use of force is used in order to explain more efficiently the above mentioned situations, mostly the part referring to proper tactical and safety assessment of the situation and the application of certain control tactics.

Detaining a person who collaborates refers to situations in which the person acts in accordance with the orders of the police officers, without showing physical resistance. The procedure that is carried out in this type of detention is, in many aspects, different

from the one used in other types of detention, because, there is no use of physical force, only verbal communication (conversation, warning, convincing, ordering, explaining, etc.) and simple body language. In order to establish proper sequence of events in the performance of the process, the basic tactical procedure of detaining a person who collaborates includes the following activities: approaching the person and establishing verbal communication; establishing the identity of the person and explaining the reasons of the detention; establishing physical contact with the person that leads to his/her detention; transporting the person.

In cases when the official procedure of detaining a person on a voluntary basis is interrupted, there is a situation of detaining a person who shows passive resistance which is a reaction from the verbal or other order issued by the police officer. In reality, there is passive resistance when the person ignores the command or legal order of the police officer by lying down, kneeling or taking certain subject etc. Detaining a person who shows passive resistance is a specific activity, and the tactical approach and selection of control techniques that are applied must correspond with the resistance manifested by the person. This is important, because the situation can escalate and put the police officer or the person in unfavorable position (risk of injuries, exceeded use of force etc.). The tactical approach which is applied in this type of detention is more specific compared to the previous type of detention, because, despite of the verbal commands (warnings), use of force is also applied (certain techniques and pressure upon sensitive parts of the body).

Detaining a person who shows active resistance is more serious activity, because, resistance is being manifested in order to avoid physical contact (the person avoids physical contact, fights with the police officers, pushes him/her, protects him/herself with different objects etc). In situations when the person shows active resistance, he/she directly prevents the police officer of conducting the detention, and in this type of situations it is important to act in accordance with the force (resistance) manifested by the person. At the beginning of this process, and in attempt to stop the resistance of the person, it is necessary that the police officer uses force, and then, depending on the situation itself, physical force is being used (different combinations of hitting) or even a baton if the resistance level is higher. To bring the person under control, he/she is subjugated (in most of the cases the person is forced to lie down) and the procedure of handcuffing and searching the person in carried on.

In cases when a person who launches unarmed attack is being detained, it is necessary that the police officer prevents physical attack in which different body parts are engaged (punches and leg strikes, attempted strangling, pulling clothes or hair, pushing the hands of the police officer away, etc). The person who engages in this type of activity manifests destructive behavior and attempts to hurt the police officer or to stop the police officer of conducting his duty. In order to successfully detain the person, the police officer must use predicted and well-premeditated defense tactic to stop the aggression temporarily. The tactical approach that is applied in this type of detention is very similar (includes similar means of coercion) with the previous type, but with higher intensity.

Detaining a person who launches armed attack is very complex and dangerous activity because different sharp and dull objects or even firearms are being used. The person who launches armed attack also uses the highest level of deadly force which could easily cause heavy bodily injuries or even death of the police officer. In order to detain the person, the police officer must react very quickly and more severely compared to the previous cases, since this is a real life threat. It is generally known that these types of situations are among the most complex, which implies to high level of psycho-physical preparations and reasonable behavior and assessment in which the police officers must engage themselves in order to achieve their intentions (proportional and symmetrical response to the attack). In order to avoid the worst possible scenario, the tactical procedure which is applied must include conditions of damage reduction and injuries prevention of the use of force being applied. This means that, firstly, less dangerous means

of coercion shall be applied (physical force, baton), and if necessary, firearms, as a final tool of coercion shall be used.

5. Conclusion

The basic role and function of the police is to provide conditions for adequate application of the legal principles, also known as authorizations of the police. In this context, detaining a person, which is one of the many authorizations of the police, shall be carried out in accordance with all legal, ethical, human and professional (safety) standards. Regarding the application of these standards, it is very important that the police show knowledge and abilities for good assessment and analysis of every situation, regardless of reasons of the detention. Within the framework of the paper, by elaborating the most frequently applied techniques in the process of detaining a person, an attempt was made, to show the tactical and safety procedures that should serve as guidelines of the police officers, from the initial moment of the detention process until its final phase. In order to further elaborate this specific process, mostly the part referring to proper evaluation of the situation and the selection of the most suitable tactical procedure (proportional response of the police when force is being used), the theoretical concept of the model of use force is used.

From the above mentioned we can conclude that the interest of every police organization is to have well-prepared and skilled police officers, who, undoubtedly know how to react in any given situation, without neglecting the legal, ethical and human standards of behavior. Proper application of the legal authorizations is a prerequisite for earning the trust of the citizens and reducing the tensions and stress, which inevitably appear during the performance of the legal duties.

6. References

1. Амановић, Ђ. (2003). *Теоријски основ употребе силе и ватреног оружја*. Безбедност бр. 3, Београд, pp. 1-17.
2. Butler, C. *The Use of Force Model and its Application to Operational Law Enforcement - Where have we been and where are we going?* <http://www.cacole.ca/resource%20library/conferences/2009%20Conference/Chris%20Butler.pdf>
3. Fischer, R. J., Halibozek, E., Green, G. (2008). *Introduction to Security*, New York.
4. Ivanovski, J., Nedev, A. (2013). *Usage of Coercion Means for Protection of the Personal Safety of Police Officers*. International Scientific Conference, The Balkans between Past and Future: Security, conflict resolution and Euro-atlantic Integration, Vol. 1, pp. 279-290.
5. Јакимов, Ј. (2011). *Специјално физичко образование*, Факултет за безбедност, Скопје.
6. Klahm, C. F., Tillyer, R. (2010). *Understanding Police Use of Force: A Review of the Evidence*. Southwest Journal of Criminal Justice, Vol. 7(2), pp. 214-239.
7. Лазовић, М., Стојановић, В., Црнковић, М. (1998). *Војно-полицијска тактика*, Полицијска академија, Београд.
8. Paoline, E. A., Terrill, W. (2011). *Listen to me! Police officers' views of appropriate use of force*. Journal of Crime and Justice, Vol. 34, No. 3, pp. 178-189.
9. Стојановски, Т. (1995). *Полицијска тактика*. Центар за образование на кадри за безбедност, Скопје.
10. Wolf, R. Mesloh, C. M., Henych, L., Thompson, F. (2009). *Police use of force and the cumulative force factor*. Policing: An International Journal of Police Strategies & Management Vol. 32, No. 4, pp. 739-757.
11. *Law on Police*. "Government Gazette of the Republic of Macedonia", No. 114/2006.
12. *Rules of the Manner of Performing Police Work*. "Government Gazette of the Republic of Macedonia", No. 149/2007.

APPLICATION SOFTWARE PLATFORM IN TRAINING OF EXPERTS ON PROTECTION OF THE POPULATION AND INFRASTRUCTURE

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Abstract: This report presents a software platform that can be used for computer simulation of one of the most dangerous natural disasters. Offers a software product can be used for training by experts on protection of the population and infrastructure.

Keywords: TRAINING, PROTECTION, DISASTERS, COMPUTER SIMULATION

1. Introduction

In recent years, the swiftly development of computing and the widespread use of personal computers and their growing capacity, follows a new directions in the development of information-technology so we can be apply for the training of experts in various scientific fields. The computer with appropriate software becomes a virtual toolkit with broad functionality and flexibility as conventional panels, rocks, buttons, etc.

Except in the control and management of real objects, virtual tools enable to simulate the operation of these objects and performing virtual experiments with varying different parameters, which would be difficult to implement real terms. The multimedia tools can be greatly improve and facilitate to learning process and allow for greater autonomy in self-study students.

The purpose of this report is a present a software platform which has a possibility to use by civil protection experts.

Last same years humanity suffered many man-made and natural disasters, accidents and catastrophes which caused damage to the environment, many victims and devastation of settlements worldwide. In the example are Tsunami in the Indian Ocean in 2004, there were approximately 250 thousand people died and 2 million injured. Other one is Hurricane Katrina flooding in New Orleans, earthquakes in India, Iran, China, Indonesia and Chile. Do not forget earthquakes in Japan after that Tsunami and Fukushima nuclear disaster. Last year there a strong earthquake with a magnitude of 6.5 on the Richter in central Italy there were many casualties and considerable losses in the country economy. One of the most frequently occurring natural disasters causing damage is an Earthquake. Earthquakes are all suddenly occurring short-term movements of the Earth's surface caused by natural causes. On Fig. 1 there are Earthquakes for a period of two weeks.

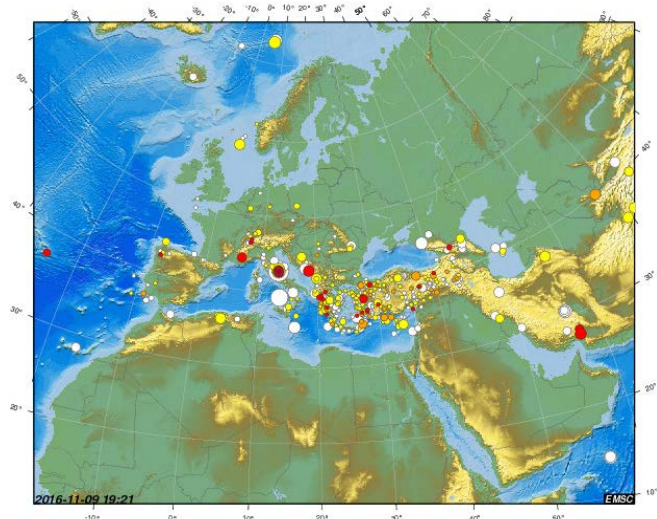


Fig. 1 Earthquakes in all over the World for two weeks.

An earthquake is a one of the most dangerous natural disaster on the last century in which had to take the most effective countermeasures. One of the countermeasures is to conduct seismic zoning of seismic risk areas in order to clarify the scope of areas under certain assumed maximum level of seismic hazard. In areas threatened by earthquakes on the Earth is introduced compulsory earthquake resistant construction. Its rules are consistent with the nature and extent of local seismic danger (presumed intensity earthquake hit, a state of rock massif, etc.) and taken into account in the design of appropriate technical facilities.

2. Measurement Methodology and Research Object

Solid Works is 3D CAD software for engineering design in mechanical engineering, industrial equipment, consumer products, automotive, aerospace, robotics, energy and many others. Solid Works offers opportunities for analysis of stress, strain, motion, tolerances, rendering, huge libraries of components, routing of pipes, tubes and wires and productivity tools. This software is suitable for parametric modeling of solids, based on building blocks. (See Fig. 2)

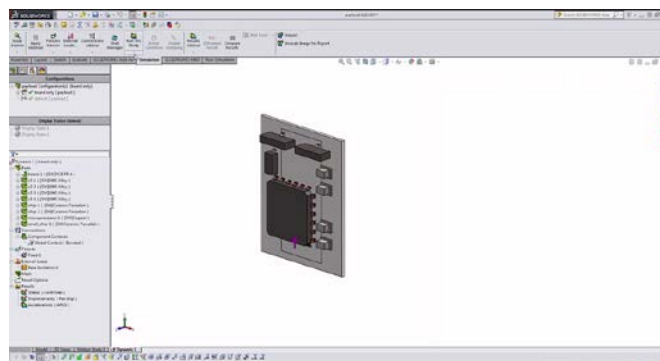


Fig. 2 Parametric modeling.

All dimensions and geometric relationships that are created in the model are stored in it. This opportunity allows subsequently making quick and easy adjustments to it. The different tools are show detail for sketching and adding geometric relationships and dimensions in sketches. The program has tools for creating, editing and reproduction of three-dimensional building blocks. The final product consists of a combination of many parts and components.

With powerful tools for validation and analysis "Solid Works Simulation" can be easily placed designed article under real operating conditions, to optimize and improve their quality without putting any means for real prototype and tests. That program has opportunity for set static and dynamic loads, different materials and conditions contact details which can be obtained their results of that evaluation. It can also create models of existing mechanisms and to check for errors in their movements, to assess all the variables of interest - forces the reactions, speed, acceleration, etc.

For dynamic analysis can include the frequency and locations of impact. A study of the effects of earthquakes is accomplished by spectral analysis (RS-analysis) as a linear dynamic method of statistical analysis. By measuring the pseudo-spectral acceleration provides insight into the dynamic behavior, velocity or displacement as a function of time and the degree of attenuation.

Spectral analysis measures the contribution of each natural mode of vibration to reflect the expected maximum seismic response of an essentially elastic structure. After creating a 3D model, we move on to the simulation by choosing the menu "Motion Study", and the menu type simulation chooses "Motion Analysis". We have an opportunity to ask different forces.

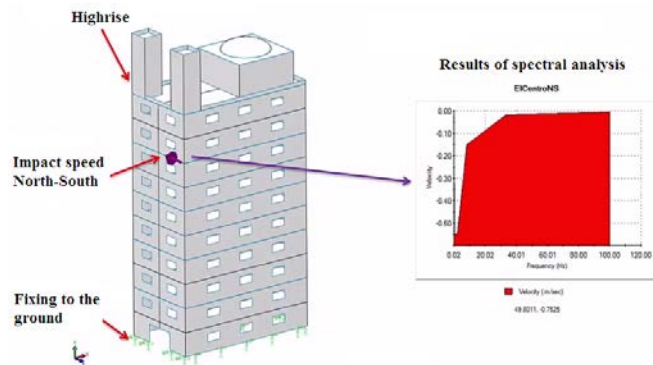


Fig. 3 Spectral analysis of an impact earthquake on the building.

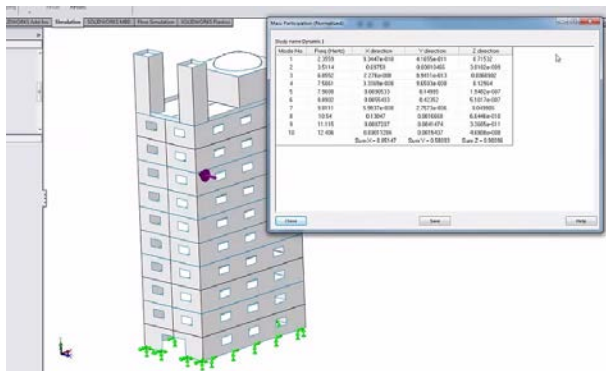


Fig. 4 Earthquake simulation.

We may choose an earthquake start by menu „Trigger”, „Condition” menu we would check a „Task End”. Solid Works Simulation is able to assign the effects of gravitational forces (Gravity). It can also be set to the contact forces acting between the components using the menu "Contact". In the same menu and note the material of the contact elements.

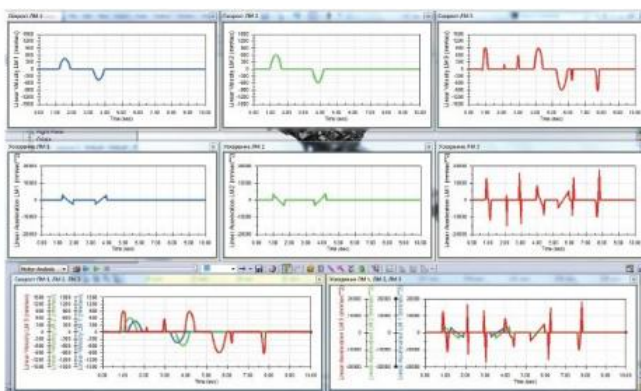


Fig. 5 Simulation results.

The results can be exported to Excel, for further analysis, which defines the maximum speeds and accelerations of linear manipulators.

3. Conclusion

Solid Works Simulation provides useful tools for every engineer that can be used for making the right decisions in the design of products. The interface is easy to use and has a rich set of tools which are undeniable advantages. Fully integrated into the operating environment of Solid Works, the simulations are available from the very beginning of the design process to final completion of the projects. The operating environment of Solid Works is a fully integrated into the simulations. They are available from the very beginning of the design process to final completion of projects.

The young audience refuses to play of passive role and prefers to play a leading role in the selection of communication channels in terms of customizing virtual content to exercise control over the design, creation of information and its dissemination. It acquired skills "digital juggling" and that the ability to perform multiple tasks at the same time must be adapted to the learning process.

4. Bibliography

1. Шопова, Татьяна. Развитие на дигиталната компетентност у студентите. Сп. „NotaBene“, бр. 26/2014.
2. Lister, Martin , Jon Dovey, Seth Giddings, Iain Grant, Kieran Kelly. New Media: a critical introduction (second edition). Routledge. 2009.
3. Selwyn, Neil. Social media in higher education. The Europa World of Learning. 2012.
4. Schumny, H. Personal Computer in Labor, Versuchs- und Prüffeld: Der PC als Hilfsmittel bei der Erfassung, Verarbeitung und Darstellung von Messdaten. Springer-Verlag, Berlin. 1990.
5. Hoffmann, J., W. Trentmann. Praxis der PC-Messtechnik. Munchen, Wien, Hanser Verlag. 2002.
6. Ненова, З.П. PC-базирани системи за събиране на данни и управление. Габрово, „Колонел“. 1997.
8. Total Solution for PC-based Industrial Automation, Advantech, Solution Guide. Vol.51. 1996.
9. Datenerfassung & Verarbeitung, Computer Boards, Inc., Ausgabe 5, 1992.
10. Dassault systèmes solidworks corp. Solidworks-tutorials. 2013.
11. <http://hisz.rsos.hu/alertmap/index2.php?area=eu#>. 2016.
12. <http://www.solidworks.com/sw/products/simulation/flow-simulation.htm>. 2016.

RADIATION BACKGROUND OF THE ATMOSPHERE, SOIL AND WATER IN BULGARIA AND ITS MONITORING IN THE CONTEMPORARY POLITICAL CONDITIONS

РАДИАЦИОНЕН ФОН НА АТМОСФЕРАТА, ПОЧВАТА И ВОДАТА В БЪЛГАРИЯ И НЕГОВОТО СЛЕДЕНЕ В СЪВРЕМЕННИТЕ ПОЛИТИЧЕСКИ УСЛОВИЯ

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Abstract: After the Second World War sharply increased testing of nuclear weapons. In making nuclear blast separate radioactive particles and rays isotopes that have an impact on man and nature. Despite the ban still the world are carried out illegal nuclear tests. Observations on the state of the radiation background in Bulgaria are carried out in parallel in two ways. In view of the uncertain international situation it is necessary to strictly observe radiation protection measures and strengthen control.

Keywords: control monitoring, radiation control, radiological risk, radionuclides, radiometric measurements, gamma background

1. Introduction

After detection of radioactivity in the early years of the century, scientists believed that the source of radioactive emissions into the atmosphere are only earth and rocks. Very soon, however, it is noted that with the increase in altitude (in experiments with balloons) the radioactive radiation has increased due to cosmic radiation. Later it was found that cosmic radiation contains two components: primary radiation - of galactic origin penetrating the atmosphere, and secondary cosmic radiation - derived from the reaction of cosmic rays with the nuclei of elements in the air, space dust, which is layered on the planet and others. This activity is mainly driven by the light radionuclides, such as: beryllium, sodium, aluminum, vanadium, etc. Cosmic rays that reach the Earth's surface can create radioisotopes decay but compared to other naturally occurring radionuclides is extremely low and not particularly important [2].

The discovery of radioactivity was one of the greatest discoveries of humankind. Just a few weeks after the discovery of X-rays (in 1896) French physicist Henri Becquerel, and studied phosphorescent properties of various substances experience began with potassium uranisulfate. The experience consisted in the fact that after exposure to daylight mineral, well wrapped in light-tight black paper was checked after a while if phosphorescent. The silhouette of the mineral are outlined under the influence of strong radiation of great penetrating power on photo emulsions. It is the existence of new called uranium by Becquerel rays, and the phenomenon is called by Marie Curie radioactivity.

This discovery quickly going into medicine and created the first X-ray machines that led to a revolution in medicine. Subsequently advanced and modernized X-ray machines of the latest generation repeatedly raising the precision of diagnostic activity and allow saving hundreds of lives [9].

At the same time found that radioactive rays are a major polluter of the environment with an extremely strong impact on the life and physiological activity of organisms ranging from incentives to killing.

It is known that everything on our planet it is subjected to constant exposure from the natural and anthropogenic, earth and space sources on ionizing radiation, ie find are in an conditions, created from the natural and technogenic radioactive background. Yonizirashite lacheniya accompany The living planet in negovite razlichni proyavleniya na all etapi from the evolyutsiyata.

Prez godinite After switching Vtorata svetovna vojna poradi razvitiето na atomnata promishlenost and osobeno usilenoto izpitvane na yadrenoto orazhie iznikva with golyama ostrata vaprosat charter radioaktivnoto zamarsyavane na planetata. Sled atomen blast in vazduha produktite na atomnoto delene zamarsyavat

atmosfera, sushata, vodite, rasteniyata, zivotnite, hranitelnye produkti and others.

The importance of the issues arising from radioactive contamination have the appearance of mnogo nauki that CE interesuvat and izsledvat razlichnite strani na essence of zamarsyavaneto with radionuklidi arise and develop Novi nauchni disciplines and napravleniya.

Environmental pollution by radioactive substances begins with the creation of the atomic bomb and the emergence of the nuclear industry. Harmful effects of radiation on living organisms and man, at first was not known. At the dawn of the nuclear age, society did not have the information needed for this activity because of the secrecy of the nuclear production and it was not possible to assess accurately the impact and extent of this pollution.

They are currently being developed biotechnologies, in which by way of specific algae is extracted and concentrated uranium in the biomass and thus the water is purified.

The first serious pollution and soil caused by human activity is in Japan and dates from August 5 to 6, 1945. Over the Japanese cities of Hiroshima and Nagasaki without special military necessity Americans throw the first atomic bombs in history. Begins the era of the nuclear race, which includes the former Soviet Union, but the number of nuclear countries today is more than 20.

Of course, environmental pollution and soil pollution by radioactive substances is enhanced and the occurrence of the nuclear industry. At first it was not known even lacked reliable information about the negative effects of radiation on the environment and man, due to insufficient theoretical and field studies and secrecy of the proceedings was not possible to estimate accurately the amount of such pollution, ecological and social damage caused by it.

For a long time it was believed that a relatively limited locally not very dangerous. Later it was found that the various stages of production of uranium fuel (open or closed mines, hydro production and concentration of uranium purification, enrichment, etc.). Possible "enrichment" of environmental radionuclide uranium, especially radon (Rn-222). Waste hydrometallurgical plants are initially discharged without adequate treatment into the nearest rivers and irrigation are polluted agricultural fields and plants on them. Later it recommended in uranium contaminated water to grow special algae that can extract and concentrate uranium and purify water, and indirectly to protect and soil from contamination [10].

Of course in the largest scale and the highest intensity radioactive contamination of the environment and soil following the accident in Chernobyl, Ukraine 26.04.1986, Trimayl aylan - USA - 1976; Fukushima, Japan - March 2011 and other nuclear accidents and catastrophes.

Local pollution and soil has been described in Spain in 1966. As a result of the mid-air collision of aircraft carrying nuclear weapons by air - tank. Radioactive substances explode a nuclear device were scattered over an area of several thousand hectares. 990 tons of soil was excavated and put in tombs for radioactive substances in South Carolina, USA. This case shows that current armament, despite the high degree of security, the risk of nuclear contamination of vast areas actually exist, even in peacetime.

Under national legislation Ministry of Environment and Water is the competent authority which carries out specialized monitoring the radiation environment status.

The radiological monitoring system of the Ministry is carried out under a program approved by the Minister of Environment and Water. The program was developed at the Executive Environment Agency (EEA) and updated annually. It includes a network of observation points, respectively frequency and range of observed indicators of environmental components: soil, air and water. The program is part of the National Automated Environmental Monitoring System (NEMS).

Radiometric measurements in real conditions, sampling and analysis are performed by EEA and radiological control laboratories in the Regional Inspectorates of Environment (Regional Inspectorate) Burgas, Varna, Vratsa, Montana, Pleven, Plovdiv and Stara. Zagora.

2. Monitoring of natural radioactivity

2.1. Gamma background

Observations on the state of the radiation background in Bulgaria are carried out in parallel in two ways:

Through the National Automated System for continuous monitoring of the radiation background by 26 local monitoring stations (LMS) covering the whole country, with greater density around NPP "Kozloduy". For operational action in the event of an accident can include mobile monitoring station. With the automated system establishes an occasional raising of the natural gamma background in the country and provides early information about neighboring countries in the event of a radiological emergency. Predictive data interpretation part of the LMS perform additional measurement of basic meteorological parameters.

A National Automated System provides real-time data the State Agency "Fire Protection and Civil Protection" at the Interior Ministry and the Committee for use of nuclear energy for peaceful purposes.

There are departmental systems for radiation monitoring to the Ministry, Ministry of Health, National Centre for Meteorology and Hydrology at the Bulgarian Academy of Sciences, including 42 laboratories for qualitative and quantitative spectrometric analysis.

By discrete measurements of gamma radiation background in the permanent observation points Burgas, Varna, Vratsa, Montana, Pleven, Plovdiv, Stara Zagora and Sofia, where he performed in triplicate daily measurements [8].

The results obtained in both ways show that the radiation background in 2015 is within the typical background values for the respective point and the particular weather conditions.

2.2. Atmospheric radioactivity

Studies of atmospheric radioactivity is carried out by stationary stations with automatic sampling system of the Ministry located in Sofia, Burgas, Vratsa, Varna and Montana.

In a signal of possible cross-border contamination conducted additional sampling point measurements with portable equipment in Plovdiv, Stara. Zagora and Pleven.

Data from the monitoring of atmospheric radioactivity in the year characterized by background concentrations of technogenic Cs-137 (<3 mBq / m³) and cosmogeneous Be-7 (from 0.7 to 15.7 mBq / m³).

2.3. Radiation status of non-arable land

Radiation status of soils is estimated gamaspektrometrichen destructive analysis of samples from pre-selected checkpoints. In

2014 it was carried out periodic monitoring of the specific activity of natural and artificial radionuclides in over 840 samples of arable land across the country.

In assessing the resulting data are not recorded values for specific activities of natural radionuclides above background typical of soils in different areas.

To maintain readiness for accurate assessments of the content of radionuclides in soil and food every two years held national calibration available in their range of spectrometers and makes interlaboratory comparisons.

Tahnogennite radionuclides within the soil layer mainly global atmospheric deposition and are the result of aboveground nuclear explosions and accidents at the sites of nuclear power, as is the case of the 1986 Chernobyl nuclear power plant.

Most affected by the Chernobyl accident is in South Bulgaria. CA Data availability of technogenic Cs-137 show spot contamination of soils in this region. They are known and are subject to annual control monitoring system for radiological control of the Ministry [6].

Compared to previous years, found overall decrease in technogenic activity of cesium-137, due to its global redistribution of natural migration processes.

Radiological characteristics of surface water from rivers and reservoirs

The radiological monitoring of rivers, lakes and dams in the country is carried out through a network of stations and includes control of total beta activity and uranium and radium values are compared with the rates fixed in GVA for "Drinking water".

Held systematic control over radiation condition of the river. River (12 points) and about 75 points along the rivers: Iskar, Timok Maritza Tsibritsa, Yantra, Topolnitsa Stryama Vacha, Tundzha, Sazliyka, Bear, Barska, Kiselchovski, Lucky Chepelarska Vit, Osam, Struma, Erma, Nishava, Black, Arda, Kamchia, Ropotamo Rezovska Veleka lakes Mandra and Vaya and dams "Iskar" and "Kamchia".

Measured in 2015. radiological indicators in samples of these points is below MAC for drinking water and this leads to the conclusion that the main rivers and reservoirs in the country were in good condition radiation.

In pursuance of Art. 144 [1] item 1 and of the Law on Environmental Protection EEA performed radiological monitoring through a network of stations established and updated with the Order № 48 / 23.01.2014g. Minister of Environment and Water.

Exercised by the EEA monitoring includes research on radiological indicators of water and sediments from the Danube River and water from the Black Sea. Background radiation was monitored by periodically sampling the stations of the network. The specific activity of natural and technogenic radionuclides examined samples of water and sediments by radiochemical and spectrometric laboratory analysis.

The location of points of radiological network characteristics tested, and cycles of study are presented in the following tables 1 and 2:

Test parameters:

- P1 - Setsifichna activity of natural and artificial radionuclides
- P2 - Total alpha activity
- P3 - General beta activity
- P4 - cesium - 137
- P5 - Tritium

Radiological monitoring is carried out in accordance with Regulation No.H-4 / 14.09.2012g. to characterize the surface water. The maximum permissible concentration of total alpha activity is 0,2 Bq / l, while for total beta activity - 0,5 Bq / l. The results of the analyzes of samples showed typical background values of radiological indicators monitored for previous periods in the relevant points.

№	water	intervals	tested indicators
1	Danube River at Kozloduy port	monthly	P2 P3
		quarterly	P4
2	Danube River at Oriahovo port	monthly	P2 P3 P5
		quarterly	P4
3	Danube River at Lom	annual	P2 P3
4	Danube River at Novo Selo	annual	P2 P3
5	Danube River at Baikal	annual	P2 P3
6	Danube River at Nikopol	annual	P2 P3
7	Danube River at at Belene	annual	P2 P3
8	Danube River at Svishtov	annual	P2 P3
		quarterly	P4
9	Danube River at Ruse	annual	P2 P3
10	Danube River at Silistra	annual	P2 P3 P4
11	Black Sea in Nessebar	annual	P4
12	Black Sea coast in Chernomorets	annual	P4
13	Black Sea in Sinemorets	annual	P4
14	Black Sea bay "Vromos"	annual	P4
15	Black Sea - Mr. Shabla bridge to the lighthouse	annual	P4 P5
16	Black Sea - town. Kavarna	annual	P4
17	Black Sea - resort "St. Konstantin and Elena" bridge against hotel "Albatros"	annual	P4
18	Black Sea - town. Varna severen beach	annual	P4
19	Black Sea - mouth of the river. Kamchiya- beach	annual	P4

Table 1: The location of points of radiological network [4]

Regarding data for marine waters, it should be noted that these points except the Black Sea - the Gulf "Vromos" become part of the permanent radiological monitoring network in early 2014. with the above-mentioned order of the Minister of Environment and Water.

№	sediments	intervals	tested indicators
1	Danube River at Kozloduy	quarterly	P1
2	Danube River at Oriahovo	quarterly	P1
3	Danube River at Novo Selo	annual	P1
4	Danube River at Baikal	annual	P1
5	Danube River at Nikopol	annual	P1
6	Danube River at at Belene	annual	P1
7	Danube River at Svishtov	annual	P1
8	Danube River at Ruse	annual	P1
9	Danube River at Silistra	annual	P1

Table 2: Sediments in the River Danube [4]

Transport and storage of radioactive materials that pose a danger to people and the environment is carried out by specialized companies and under strict rules. This is controlled by the Nuclear Regulatory Agency (NRA) and subject to the Ordinance on the transportation of hazardous materials.

State border of the Republic of Bulgaria is guarded by the Border Police, which is the structure of the Ministry. The control of incoming and outgoing passengers and cargo it was proceeded by the General Directorate "Customs" to the Treasury at certain border crossing points (BCPs) on terrestrial, aquatic and aerial borders. There all vehicles, cargo and passengers are subjected to dose monitoring in order to detect the presence of radioactive materials. At the opening of such necessary measures are taken to isolate, study and correct their further storage and also promptly notify authorities had - the NRA and the Ministry. The processing of inspected sites using modern dosimetric equipment [1].

A serious problem are persons crossing the state border checkpoint not, in random unregulated places. These are the so-called migrants, most of whom are fleeing from war, but economic migrants or potential terrorists. Millions of our flow, moving from Africa and Asia to the heart of Europe, is a serious challenge for the leaders of the united Europe. They are representatives of other nationalities, cultures and religions that are not typical for Europeans and on this basis leads to serious contradictions of religious, cultural and other bases. Very often these conflicts escalate to unmanageable collisions and interference from relevant government authorities.

The main channel of migrants surrounded Bulgaria and passing through other countries - Greece, Macedonia, Serbia, Hungary and others. After the closure of the borders of some countries flow declined, but potential migrants are located in Bulgaria's neighboring countries - Turkey and Greece, and they can once again take to Germany and other other countries of central Europe. Although we are not attractive as a destination for these settlers are not insured by the pressure as a transit corridor.

Among people fleeing war there are those who are members of the "Islamic state" other terrorist or extremist organizations. Such trained agents fell already a number of specialized organizations in European countries. They used to carry weapons, ammunition and

other ekslozivi and women and children. There is no guarantee neither Bulgaria nor other European countries, they do not have or carry radioactive materials or nuclear fuel. Omission of our national security and the European one is that it does not check for the presence of both weapons and radioactive materials. This would reduce the likelihood of organizing and carrying out terrorist actions and operations and possible casualties.

3.Conclusions:

1. A well developed and organized system for control of Gamma - background atmospheric radioactivity, radiation capable of uncultivated soils and radiological characteristics of surface water from rivers and reservoirs in the Republic of Bulgaria and to inform the population in radiation accidents;
2. Gamma radiation, atmospheric radioactivity, radiation capable of uncultivated soils and radiological characteristics of surface water from rivers and reservoirs in Bulgaria is within the typical country background values;
3. Well-functioning system of transport and storage of radioactive materials and modern control checkpoints;
4. Insufficient control over the availability and transportation of radioactive materials illegally passing and migrants in Bulgaria.

4.Literature:

1. Bulletin gamma background in Bulgaria the NRA, Sofia, 2015;
2. Dolchinkov N. T., N. B. Nichev, Characteristics of radiation, Revista academiei for țelor terestre NR. 2 (82)/2016;
3. Marinov V. Agricultural radioecology Zemizdat, Sofia, 1989;
4. National report on the status and protection of the environment in Bulgaria of the EEA in 2014;
5. National report on the status and protection of the environment in Bulgaria of the EEA in 2013;
6. Nechev Hr., Salovski P. Protection against radiation hazard, Medicine and Sports, Sofia, 1987;
7. Ordinance on basic safety standards, BSRP-2004, SG. 73, 2004;
8. Quarterly bulletin on the state of environment for the period July-September 2016;
9. Vasilev D., Radioecology, Titus Consult, Sofia 2005;
10. Yarmonenko S., Radiobiology per person and Animals, Vysshaya School, Moscow, 1988.

THE MOTIVATION OF HIGH SCHOOL TEACHERS IN THE FORMATION OF THEIR OWN COMPETENCIES IN THE FIELD OF INFORMATION SECURITY

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Abstract: *The article describes the problem of involving high school teachers in establishing the national information security by applying their own competencies in the field of information security and protection in the educational process, the demonstration of their trainees and active implementation in their own professional activities. Tasks of the personal and proprietary information protection often not resolved, which is a potential threat to the learning process, research activities of the University, and can be used cyber criminals for cyber extremist or terrorist crimes. The teaching staff motivation is a cornerstone in forming the own competencies in the field of information security process. The traditional leadership approach to formation procedure of information security in this case is insufficient, as the teacher is a leader of a new person preparation, ready to operate successfully in an information society.*

KEYWORDS: INFORMATION SECURITY, NATIONAL SECURITY, EDUCATION, PROTECTION OF INFORMATION, MOTIVATION, PROTECTION OF INFORMATION, THE TEACHER, COMPETENCE

1. Foreword

In the framework of the Russian Federation information security modern doctrine, updated in 2016, as one of the state security threats voiced the problem of "low citizens' awareness in matters of ensuring personal information security" [1]. Today the specialists categorically state that cybercrime is out of control: in 2016 more than 2 billion user accounts were destroyed or stolen. During his address to the Federal security service of Russia, President Vladimir Putin announced that the number of cyberattacks on state information resources in 2016 compared to 2015 increased in 3 times. According to German Klimenko, the adviser of the Russian Federation President, "the most important trend today in that area is cybersecurity" [2]. Analytical activity of the state structures shows that the "measures to ensure the information security of the infrastructure, <...> with using the domestic information technologies and products often have no comprehensive framework" [1]. The development process of all spheres of human activity Informatization causes emergence of the individual and society information security problems [3].

Lack of understanding that need to start information security with yourself – that's one of the major individual, society and the state threat. Often, we hear that in the data breach blame the government, paying insufficient attention to the needs of citizens and society, however, upon closer inspection act, it appears that the fault almost entirely lies either on the staff or on the management, virtually non-competent in providing both personal and organizational security. Citizens mistakenly believe that they are too "small fry" in order to motivate highly organized hacker groups or petty cyber criminals. But, let's look at an episode of malicious activity on the example of quite a common banking Trojan "Dear Wolf". He gets on the user's computer when clicking on the last link in a phishing special letter and waits a user logs into your Bank account. After that criminals have access to confidential information of the victim and opportunity to steal money. As usual, the user may be attractive in the role of pawns – computer "botnet" – a network for DDOS attacks. The examples are innumerable.

2. Prerequisites and means for solving the problems

The intensification of cybercriminals of all kinds and categories, found that the network provides endless possibilities for the implementation of any criminal plans, from simple bullying, to direct threats to the state – clearly signals the need for urgent action on education and training citizens of the state, ready at least to avoid cyberattacks of any form, and, as a maximum – to prevent criminal activity online. And the leading role in the solution of this problem must belong to the universities which train future managers and engineers, and humanities – teachers and educators. The identity of the University teacher is often crucial in the development of a student's future profession. For example, the teacher can form a stable competence in the field of personal data protection and information security, even if the subject taught is not affiliated

directly with these questions and doesn't aim to foster these competencies.

In practice, high school teachers rarely pay attention to the protection of personal information – phone numbers, home address, usernames, passwords from workstations, and more is not the information for them that needs to be closed. Storage of scientific data, information about objects, theses and dissertations, service information can be easily extracted and used for any interests. As an example, can be called a workflow element as a "draft" - reprint on already used documents. Privacy is violated more than full. We believe that a teacher should be motivated to form competencies in information security by oneself, and, especially, actively use and accentuation of these points when communicating with students.

3. The solution of the problem

It is possible to formulate the core competencies in the field of information security needed by the teacher for successful professional activity:

- protection of personal information, in the workplace, and in public access (social networks, Internet sites);
- protection of professional information;
- protecting students from inaccurate information;
- formation of critical thinking (of students and teachers) [4];
- application of standard and additional security in the workplace, mobile devices and network;

The main issue is the irresponsibility of the teacher, the unwillingness to use both in everyday and professional life the basic rules of information security and information protection. Thus, the employer raises the issue of incentives and motivation the employees on the formation of the required competencies.

4. Results and discussion

The problem of motivation and stimulation of the university faculty related to problems of implementation the management functions. The faculty is a key element of the higher school qualification of the teacher, his pedagogical competence, qualities, the General culture depends on the quality of training and the performance of all economic activity in the country. Hence, one of the most important directions of the University management is improving the system of scientific-pedagogical personnel motivation and stimulation. Studies have shown that the motivation of the teacher increases when he knows that his work is relevant to society. In his writings E. P. Ilyin said that "even a small sign of your attention to the needs of the people increases the commitment in the activity" [5].

M. H. Meskon, M. Albert, F. Hedouri, summarizing the view of many scholars say about "the existence of the four management functions, one of them is motivation, which is directly connected with the staff of the company and in the context of information security management does not lose its significance and status" [6]. In fact, the user often struggles with the problems of ensuring information security by the strengthening of control, all restrictions, prohibitions, punishments, etc. It requires a lot of

resources, inconvenience, leads to hostility. But in most cases, you can simply try to teach employees the safe work procedure (of course, you need to first make it simple, effective and straightforward), modify their behavior, to make them understand that it is in their interest. In fact, it will be a real fight with the source of the problem, not its consequences. And sometimes it is not as difficult as it seems, though unusual.

According to statistics, more than half of the losses that are suffered by the company due to incidents in the field of information security caused by the actions of the staff. And mostly they do not happen because of malice, but simply due to the low level of awareness of users. Thus, by teaching their employees basic rules in the field of information security, the company can significantly reduce the risk of security breach. Not for nothing, staff training is one of the main requirements of the international standard for information security management ISO/IEC 27001.

Statistics "studies of confidential information leaks in 2015" conducted by "InfoWatch", saying that in 54% of cases the perpetrators of the leaks were employees of the organization [7]. The same statistics research "InfoWatch" on this issue, in 2014 was 58% and in 2013 – 62% [8, 9]. Analyzing given statistics, we can say that now the amount of leakage through the fault of the employee is reduced, however, this trend is not apparent.

5. Conclusion

In our opinion, an effective solution to this problem is a close examination of the motivation theory of employees professional activity, which is essentially a way of raising attention to the issue of information security [10]. In General, it should be noted that the role of professorial-teaching staff in the formation of personality, ready to ensure their own information security is not yet sufficiently appreciated, and we believe that the work in this direction should be continued.

6. References

1. The information security doctrine of the Russian Federation: [05.12.2016 (Approved by the decree of the President of the Russian Federation 05.12.2016 No. 646)]. Available at: <https://rg.ru/2016/12/06/doktrina-infobezobasnost-site-dok.html> (Accessed: 21.02.2017) (in Russian).
2. Spiridonov Maxim Runitology: Herman Klimenko, the adviser of the Russian Federation President. Available at: <https://runetologia.podfm.ru/977> (Accessed: 17.02.2017) (in Russian).
3. Chernova E.V. Informatsionnaia bezopasnost' lichnosti i obshchestva: uchebnoe posobie [Information security of the individual and society: study guide]. Magnitogorsk, Izd-vo Magnitogorsk. gos. tekhn. un-ta im. G.I. Nosova, 2017, 275 p. (in Russian).
4. Zerkina E.V., Chusavitina G.N. ICT: innovation unsafe // Narodnoe obrazovanie [National education], 2008, no 8, pp. 273 -276 (in Russian).
5. Il'in E.P., Balashov E.P. Motivatsiia i motivy [Motivation and motives]. St. Petersburg, Piter, 2000, 512 p. (in Russian).
6. Meskon M.Kh., Al'bert M., Khedouri F. Osnovy menedzhmenta: Per. s angl. [Fundamentals of management: translated from English]. – Moscow, Vil'iams, 2007, 702 p. (in Russian).
7. Investigation of confidential information leaks in 2015 the analytical center "InfoWatch" [Site of "InfoWatch"]. Available at: <http://www.infowatch.ru/report2015> (Accessed: 15.02.2017) (in Russian).
8. Investigation of confidential information leaks in 2014 the analytical center "InfoWatch" [Site of "InfoWatch"]. Available at: <http://www.infowatch.ru/report2014> (Accessed: 12.02.2017) (in Russian).
9. Investigation of confidential information leaks in 2013 the analytical center "InfoWatch" [Site of "InfoWatch"]. Available at: <http://www.infowatch.ru/report2013> (Accessed: 10.02.2017) (in Russian).

10. Talalai M.A. Motivation as one of the ways to increase productivity. Sovremennye naukoemkie tekhnologii [modern high technologies], 2014, no 7–1, 90 p. (in Russian).

HYBRID FIBER-OPTIC/NANOFIBER DETECTION PRINCIPLE FOR SECURITY APPLICATIONS

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Abstract

In this paper, a novel patent-pending approach based on optical detection will be described. Various functionalized nanofiber materials have been used to demonstrate feasibility of realization of miniature sensors of biomedical and chemical values (enzymes reactions, metal ions content, etc.). Compactness and sensitivity of the sensors are significantly enhanced through original hybrid fiber-optic/nanofiber design. The potential of the new detection principle for security applications (forensic, seal intrusion, etc.) will be discussed.

Keywords: nanofibers, nanotechnology, fiber optics, security, forensic, seal, sensors

1. Introduction

Nanofibers are known for their exceptional surface area and wide opportunities for their functionalization. These properties have been attractive for various sensor applications, however, mostly electric sensing principles have been reported.

Fiber optic sensors (FOS) represent most significant non-communication application of optical fibers [1-3]. In comparison to the other sensor types, they excel especially in high sensitivity, geometrical variability and suitability for the use at high voltage and temperature, explosive, corrosive and flammable environment, high electromagnetic interference, etc. Their compatibility with modern fiber optic transmission systems is also a great advantage.

Functional principle of FOS is modulation of optical signal carried by an optical fiber, caused by the detected/measured physical (or another) environmental effect.

2. Principles of Fiber Optic Sensors

According to the light modulation method, the FOS can be divided into [1-3]:

- Intensity (amplitude) FOS using influence of the measured value to intensity of the light propagated in the optical fiber,
- Polarization FOS based on the effect of the measured value to the bi-refrignence of a single-mode optical fiber, resulting in a rotation of polarization plane of the transmitted optical signal,
- Phase (interferometric) FOS based on phase modulation of the electromagnetic wave propagated in the optical fiber, most often due to photo-elastic effect,
- Frequency (wavelength) FOS, often using a shift of absorption threshold of suitable detection material (e.g. semiconductor) [1-3, 7, 9],
- Propagation time of optical pulse in a fiber (methods based on Optical Time Domain Reflectometry – OTDR).

All the above mentioned modulation principles can be realized in the optical fiber itself or outside the fiber. Thus, FOS can be divided into two main groups:

- Intrinsic FOS (optical fiber is the sensing element)
- Extrinsic FOS (optical modulation occurs outside of the optical fiber)

Schemes of the intrinsic and extrinsic FOS are shown in Fig. 1.

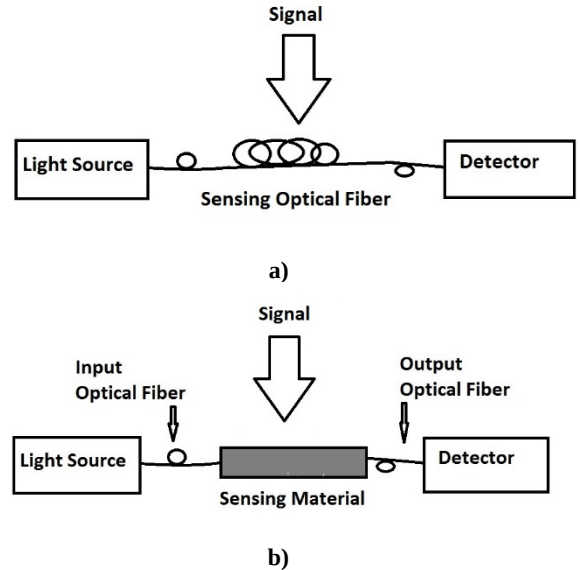


Fig. 1 Intrinsic (a) and extrinsic (b) design of fiber optic sensors

Intensity modulation method is most widely used because of its simplicity and sufficient sensitivity.

Several principles of intensity modulation FOS have been reported in both intrinsic and extrinsic categories. Large family of intensity FOS benefits from breaking the total internal reflection condition

$$\theta \geq \arcsin \frac{n_2}{n_1} \quad (1)$$

where θ is incident angle, n_2 , refractive index of fiber core. If the refractive index n_1 of the fiber cladding or incident angle is changed (e.g. due to fiber bending), intensity of transmitted light is influenced. Examples of the use of this principle are illustrated in Figures 2 to 5. FOS shown in Figure 2 is based on temperature dependence of a portion of the cladding of the sensing optical fiber [5]. Simple modulation method using microbending (figure 3) of the sensing optical fiber can be used to design various FOS of mechanical (directly) or other (indirectly) values [6].

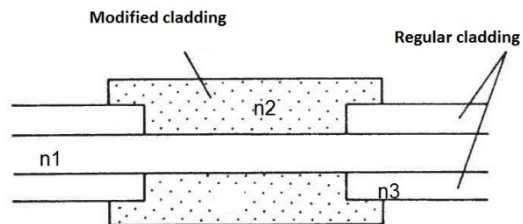


Fig. 2 Fiber optic temperature sensor using modified cladding of sensing optical fiber

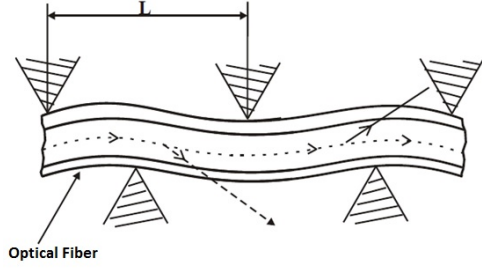


Fig. 3 Microbend intensity modulation in multimode optical fiber

An example of extrinsic FOS based on temperature dependence of light absorption in a semiconductor is shown in figure 4.

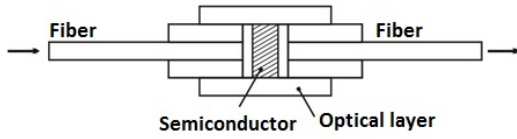


Fig. 4 Extrinsic FOS of temperature

Extensive research effort has been dedicated to development of **polarization FOS** based on Faraday's effect in a single-mode polarization-maintaining fiber. Main motivation was the opportunity to measure electric currents in high voltage power lines. A coil from the optical fiber around the line (figure 5) is an ideal tool for a safe non-galvanic device detecting magnetic component of the electromagnetic field that is proportional to the measured current. Polarization plane of the light propagated in the fiber is turned according to the equation (2), which is easily transformed to intensity change using a polarizer at the fiber output.

$$\theta_F = V \int_0^L H dl \quad (2)$$

where θ_F is angle polarization plane is turned due to the magnetic field intensity H , L is total length of the optical fiber in the coil and V is Verde constant.

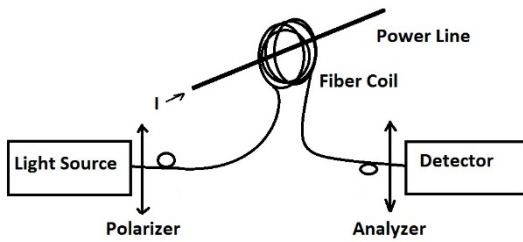


Fig. 5 Polarization intrinsic FOS of electric current

Interferometric FOS are extremely sensitive devices capable to detect phase changes of the order of 10^{-8} rad. This corresponds for example to detection threshold of interferometric fiber optic magnetometers at 10^{-13} T, or temperature changes of 10^{-8} K [1-3, 7, 9]. Phase shift $\Delta\phi$ caused by the signal Δx can be generally expressed as

$$\Delta\phi = \left(nk \frac{dL}{dx} + kL \frac{dn}{dx} \right) \Delta x \quad (3)$$

n is refractive index, k – wave number and L interaction length of the optical fiber.

Fiber optic interferometers can be very compact and robust in comparison with bulk optics constructions. Three basic types of fiber optic interferometers are illustrated in figure 6.

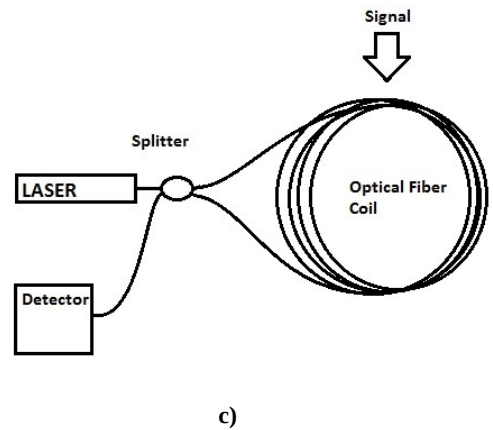
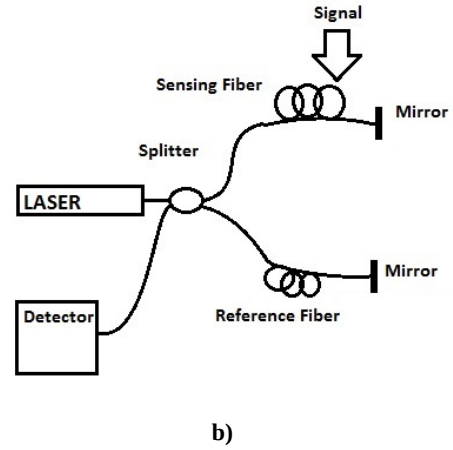
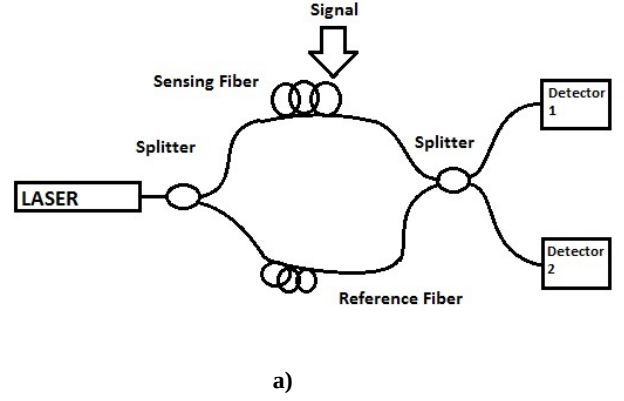


Fig. 6 Fiber optic interferometers: a) Mach-Zehnder, b) Michelson, c) Sagnac

Several types of FOS matured to commercial stage. Recently, some methods (originally developed for service purposes) have been successfully applied as a basis for FOS. For example, Optical Time Domain Reflectometry (OTDR) methods and equipment are being installed as distributed sensor systems for construction (bridges) and oil/gas pipes monitoring [10].

Interdisciplinary research is focused on the use of new materials, including nanomaterials. Nanofibers can be used as evanescent lightguides sensitive to environmental influences [11]. Functionalized nanofibers are being tested as sensing materials for biomedical and chemical FOS [12, 13].

3. Experimental

Hybrid fiber-optic/nanofiber detection principle has been verified using the opto-electronic system shown in figure 7. Plastic optical fiber components ("Y" junction with optical connectors) are attached to the proprietary electronic system consisting of red LED as light source and a photodiode as detector. Functionalized nanofiber mat has been attached at the end of the detection fiber (shown in detail in figure 8). Light emitted by the LED is carried to the sensing point and partially reflected back. The portion of the reflected light is measured by the photodetector.



Fig. 7 Opto-Electronic System

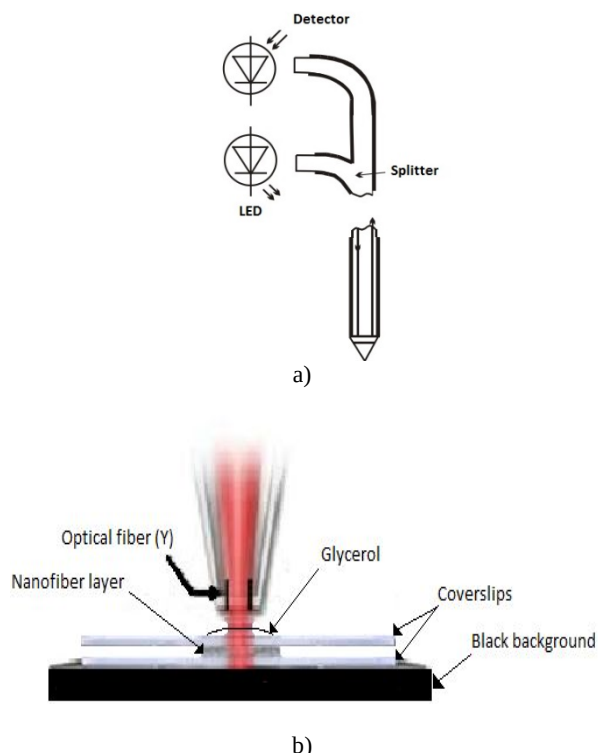


Fig. 8 Detection part of the sensor (a – optical scheme, b – realization)

As a model sensing nanofiber material, we used SiO_2 nanofibers prepared by electrospinning method on the commercial Nanospider™ NS 1S500U machine [14]. The spinning process is illustrated in figure 9.



Fig. 9 Nozzle-less electrospinning process inside Nanospider™ machine

Enzyme Esterase (Esterase from porcine liver (EC. 3.1.1.1.)) and amino acid Tyrosine have been immobilized at the surface of the nanofibers with the help of Glutaraldehyde. Deposition of the enzyme at the nanofiber surface is demonstrated in figure 10.

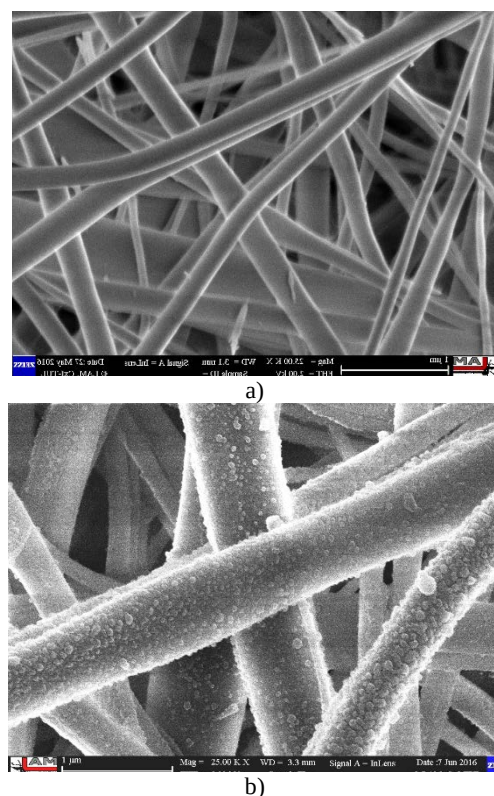


Fig. 10 SEM pictures of nanofibers without (a) and with (b) immobilized enzyme

Subsequently, the samples were immersed into a solution reacting with the enzyme. All reactions were done in Phosphate buffer of pH 7.2. For enzyme-histology proof, substrate of α -Naphthyl acetate (dissolved in 1 ml of acetone) was used; for visualization: O-DIANISIDINE (Sigma-Aldrich) and FAST BLUE RR SALT (sigma-Aldrich) were used. For amino acid proof, reaction with Ninhydrin was used and heat up to 110°C for visualization. Reflected light from the sensing nanofiber material has been recorded.

4. Results and Discussion

Initially, several construction parameters (nanofiber materials combinations, background, glass thickness, etc.) were varied to test reproducibility of the measurements and to estimate detection ability of the system. Results of these preliminary tests are shown in figure 11, which demonstrates sufficient response of the system to subtle changes of optical conditions at the tip of the sensing optical fiber. Figure 11b illustrates, that there are measurable differences between optical responses from nanofiber materials functionalized with enzymes and the reference (pure) nanofibers.

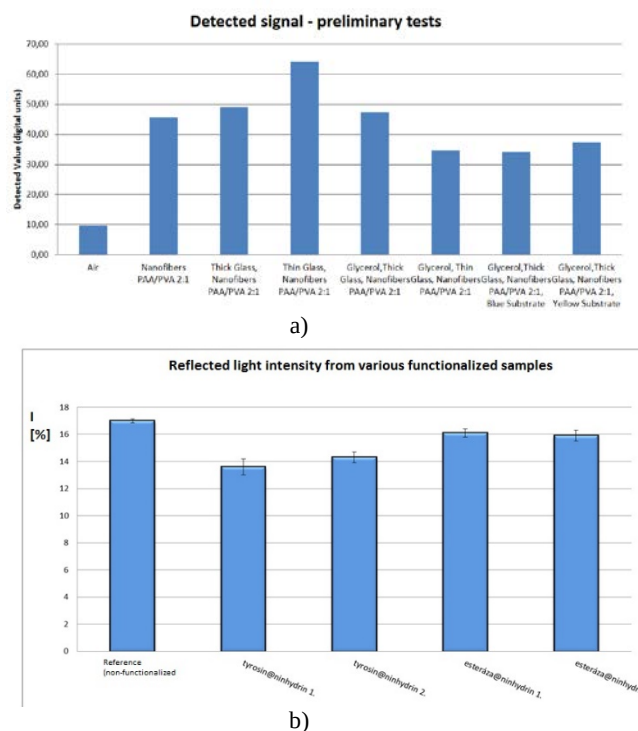


Fig. 11 Reflected light intensity: a - preliminary tests, b - from various functionalized nanofiber materials

Detected signal (reflected light intensity) as a function concentration of a model enzyme-substrate is given in figure 12. It is evident that there is a detection limit near 10 % of full initial level.

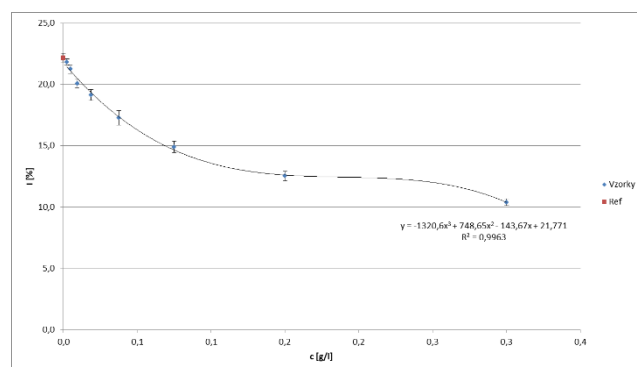


Fig. 12 Reflected intensity vs. concentration of a model enzyme-substrate

5. Conclusion

The experiments proved that the described fiber optic system with the nanofiber mesh as a detection element can be used as a basis of wide family of fiber optic sensors

sensitive to various chemical and biological substances. The proposed fiber optic sensors can be very compact and miniature which enables their intergability into security systems for fast and cost effective detection of biological and chemical traces.

Main advantages of the approach are:

- Chemically inert materials – possibility to disinfect/sterilize
- Miniature dimensions
- Sufficiently high sensitivity

Further activities of this research will be focused on

- Optical design optimization
- Electronic system stabilization and sensitivity adjustment

Acknowledgement

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References

- [1] Turán, J. - Petřík, S.: Optical Fiber Sensors (Optické vláknové senzory). Alfa, Bratislava, 1991. (ISBN 80-05-00655-1)
- [2] Eric Udd (Editor), William B. Spillman, Jr. (Editor): Fiber Optic Sensors: An Introduction for Engineers and Scientists, 2nd Edition. Wiley, 2011.
- [3] Zujie Fang, Ken Chin, Ronghui Qu, Haiwen Cai, Kai Chang (Series Editor): Fundamentals of Optical Fiber Sensors. Wiley, 2012.
- [4] Turán, J. - Petřík, S.: Chemical Optical Fiber Sensors (Chemické optické vláknové senzory). Chemické listy, Vol.83, 1989, 521-530. (ISSN 1213-7103, 0009-2770).
- [5] Kopera, P.M. – Melinger, J. – Tekippe, V.J.: Modified Cladding Wavelength Dependent Fiber Optic Temperature Sensor. In: Proc. SPIE, Vol. 412, 1983, 82-89.
- [6] Turán, J. - Petřík, S.: Sensitivity Measurement of Microbend Optical Fiber Sensor (Meranie citlivosti mikroohybového optického vláknového senzora). Elektrotechnický časopis, Vol.37, No.7, 1986, 584 – 588. (ISSN 1335-3632).
- [7] Petřík, S.: Proposal of Optimal Optical Fiber Coating for Interferometric Optical Fiber Magnetometers. Sensors & Actuators A, Vol.36, 1993, 133-137. (ISSN 0924-4247)
- [8] Naqwi, A.A. - Petřík, S.: Fiber optic dual-cylindrical wave sensor for measurement of wall velocity gradient in a fluid flow. Applied Optics 32 (30), pp. 6128-6131, 1993. (ISSN 1559-128X)
- [9] Turán, J.-Petřík, S.-Ovseník, L.: Fiber Optic Intermodal Interferometer as an Electric Current Sensor. J. Electrotechnical Eng., Vol. 43, No. 10, 1992, 317-318. (ISSN 1335-3632)
- [10] Available at http://www.ozoptics.com/products/fiber_optic_distributed.html
- [11] Zhang, L. - Lou, J. - Tong, L.: Micro/Nanofiber Optical Sensors. Photonic Sensors (2011) Vol. 1, No. 1: 31-42.
- [12] Fan, X. - White, I.M. - Shopova, S.I. - Zhu, H. - Suter, J.D. - Sun, Y.: Sensitive optical biosensors for unlabeled targets: a review. Anal Chim Acta. 2008 Jul 14;620(1-2):8-26.
- [13] Petrik, S. – Lovetinska-Slamborova, I. – Vanek, T.: Hybrid Fiber-Optic/Nanofiber Sensors for Chemical and Biomedical Applications: A Proof-of-Concept Study. In: Proceedings of Nanofibers, Applications and Related Technologies – NART, Raleigh, NC, September 13-15, 2016.
- [14] Available at <http://www.elmarco.com/nanofiber-equipment/electrospinning-machines-ns1s500u/>.
- [15] ŠLAMBOŘOVÁ, I. - ZAJÍČOVÁ, V. – EXNAR, P. - STUDNÍČKOVÁ, J.: Nanofiber structure with immobilized organic substance and the method of its preparation [online]. US20150240411 A1. [vid. 2017-03-03]. 12 Oct 2012. Available at: <http://www.google.com/patents/US20150240411>.

CAPABILITIES OF NON-LETHAL HAND GRENADES DEVELOPED AT IMSETHAC-BAS

ПОТЕНЦИАЛНИ ВЪЗМОЖНОСТИ НА НЕЛЕТАЛНИ РЪЧНИ ГРАНАТИ, РАЗРАБОТЕНИ В ИМСТЦХА-БАН

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Abstract: The capabilities of a non-lethal weapon (NLW) are its potential to successfully execute certain operational task. Non-lethal hand grenades are amongst the most used means for influence on people in any kind of missions and various operational contexts. This paper presents results of studies on the capabilities of seven types of hand grenades with different effects or combinations of effects developed and produced at the Institute of Metal Science, Equipment and Technologies (IMSETHAC-BAS). The capabilities assessment covers 14 operational tasks in which non-lethal grenades could be applied. Obtained results are compared to capabilities of highest evaluated current/programmed NLWs of leading NATO countries producers.

Keywords: NON-LETHAL WEAPON (NLW), NON-LETHAL HAND GRENADE, CAPABILITIES ASSESSMENT

Introduction

The non-lethal hand grenades are amongst the most used means in the operational tasks executed by anti-terrorist units, law and order protection forces. They are also applied by military forces during various kinds of peace-supporting missions, assuring critical infrastructure security, protection of ships against pirate and sea terrorist actions and other operations where the aim is neutralization of threat with minimum damages on people, material objects and environment.

The aim of present paper is evaluating the capabilities of 7 types of non-lethal hand grenades developed at the IMSETHAC-BAS and comparison to capabilities of highest evaluated non-lethal weapons used in NATO countries.

Evaluated Non-Lethal Weapons, Operational Tasks and Applied Methods

The following seven types of non-lethal hand grenades are evaluated:

- teargas (CS) grenade designated as (TGG);
- "sting-ball" grenade (SBG);
- "flash-bang" grenade (FBG);
- smoke grenade (SG);
- flash-bang teargas grenade (FBTGG);
- flash-bang sting-ball grenade (FBSBG);
- flash-bang smoke grenade (FBSG).

The grenades are designed, tested and produced at the IMSETHAC-BAS – Sofia, Bulgaria, under the leadership of S. Kalpakchiev and used by special units in Bulgaria and several other countries.

Data from NATO RTO Working group on NLWs capabilities assessment report [1] are used for comparing the capabilities, namely: operational scenarios, operational requirements and evaluations of highest scored current/programmed NLWs (*HS NLW*) for the correspondent operational scenario/task (such as munitions containing rubber balls, PVC elements or teargas shot by various devises, acoustic systems, electro-shock devices, etc.).

According to the aim of operation and the level of desired influence on the target, the operational scenarios/tasks described in [1] and studied here can be grouped as follows:

- 1) Move individuals (moving individuals/groups out or to certain area);
- 2) Stop individuals (prevent or impede access to certain area, stopping or changing the movement direction);
- 3) Degrade individuals (selective reducing of one or some functions/responses of the object);
- 4) Disable individuals (general reducing the most or all functions/responses of the object);
- 5) Deny access (denying the use of access/entry points).

The studied non-lethal grenades can be applied in 3 kinds of spaces – building, open area and "confined space" ("an area of varying dimensions and size that has limited or restricted avenues to enter, egress or evade engagement" [1]).

The 14 studied operational task are selected among the scenarios used in [1] with the view to cover all tasks which can be executed by non-lethal hand grenades – 5 tasks in open areas, 5 in confined areas and 4 in buildings (operational requirements for "Deny access" to buildings are not formulated in [1] due to the great variability of possible situations in this kind of space).

The capabilities assessment is made by applying the Improved methodology of assessing the NLWs capabilities [2, 3], based on general approach, scenarios, criteria and operational requirements of [1]. Data from [4-9, etc.] are used for specifying requirements for some criteria and the results analysis. The evaluation is made on 10 criteria (territory, space, targets number, targeting, mobility, physical characteristics, range, covering, onset and duration of the effect) with fixed importance according to [1]. The evaluation for a criterion represents the degree to which the NLW meets the requirement, calculated using the criterion relative weight. The overall rating for the task is the sum of rates for all the ten criteria.

Evaluation Results and Discussion

The studied NLWs evaluations are given in Table 1. The column *HS NLW(2)* presents evaluations of the highest scored NLW for each operational task published in [1] and the *HS NLW(1)* - evaluations of the same products recalculated by the Improved methodology. It can be seen that most of results for the best evaluated NLWs used or in process of development in NATO countries calculated using the Improved methodology are higher than those published in [1].

Table 1. Evaluations of NLWs capabilities

Space	Task №	TGG	SBG	FBG	SG	FBTGG	FBSBG	FBSG	HS NLW (1)	HS NLW (2)
Building	1	0.92	0.72	0.78	0.77	0.87	0.80	0.77	0.84	0.65
	2	0.86	0.67	0.75	0.70	0.81	0.76	0.71	0.65	0.59
	3	0.86	0.67	0.75	0.70	0.81	0.76	0.71	0.64	0.60
	4	0.86	0.67	0.75	0.70	0.81	0.80	0.71	0.50	0.46
Open area	1	0.68	0.62	0.62	0.57	0.68	0.63	0.64	0.86	0.79
	2	0.86	0.68	0.73	0.73	0.83	0.73	0.76	0.73	0.76
	3	0.82	0.68	0.73	0.68	0.79	0.74	0.71	0.79	0.75
	4	0.82	0.68	0.73	0.68	0.79	0.78	0.71	0.54	0.54
	5	0.65	0.62	0.61	0.56	0.65	0.67	0.63	0.73	0.68
Confined space	1	0.63	0.58	0.57	0.52	0.63	0.58	0.59	0.64	0.63
	2	0.81	0.63	0.68	0.68	0.78	0.68	0.70	0.72	0.66
	3	0.76	0.62	0.68	0.62	0.73	0.68	0.65	0.83	0.72
	4	0.80	0.62	0.67	0.67	0.77	0.72	0.69	0.50	0.46
	5	0.65	0.58	0.60	0.55	0.64	0.65	0.60	0.71	0.63
Average values		0.78	0.65	0.69	0.65	0.76	0.71	0.68	0.69	0.64

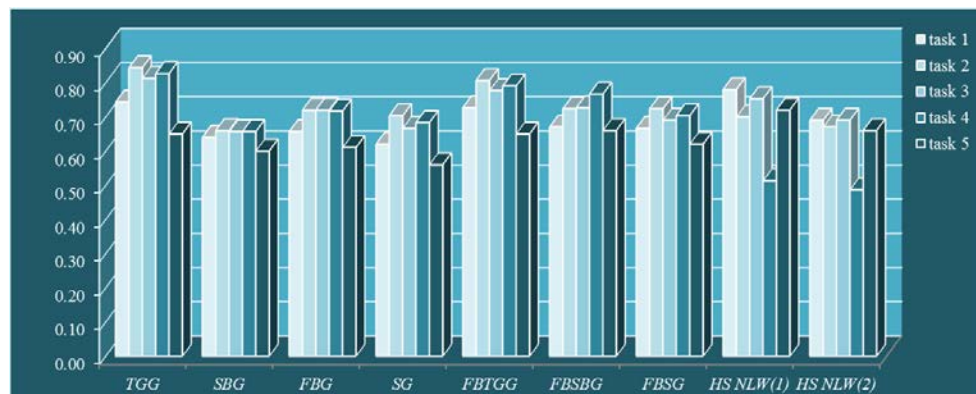
As a whole, best results demonstrates the hand grenade with chemical effect (TGG) followed by the grenade with combined chemical and flash-bang effect (FBTGG) which have the biggest coverage (radius of the effect) and duration of the effect. Lowest results show the grenades with kinetic effect (SBG) and smoke effect (SG) which have comparatively small coverage and short-time influence. Although the grenades with flash-bang (FBG) and flash-bang combined with kinetic (FBSBG) and smoke (FBSG)

effects are very appropriate for application in many operational tasks, as a whole their evaluations are lower due to the very short effect duration. Most of evaluated HS NLWs are delivered by various devices therefore they have ranges significantly higher than all hand thrown grenades - this criteria is of very high importance in the NLWs capabilities assessment.

The average values for the operational tasks are presented in Table 2 and Figure 1.

Table 2. Evaluations of capabilities by operational tasks – average values

Task №	TGG	SBG	FBG	SG	FBTGG	FBSBG	FBSG	HS NLW (1)	HS NLW (2)
1	0.74	0.64	0.66	0.62	0.73	0.67	0.67	0.78	0.69
2	0.84	0.66	0.72	0.70	0.81	0.72	0.72	0.70	0.67
3	0.81	0.66	0.72	0.67	0.78	0.73	0.69	0.75	0.69
4	0.83	0.66	0.72	0.68	0.79	0.77	0.70	0.51	0.49
5	0.65	0.60	0.61	0.56	0.65	0.66	0.62	0.72	0.66

**Fig. 1.** Evaluations of NLWs capabilities by operational tasks – average values.

Best average results for task 1 „Move individuals“ has HS NLW (1) followed by TGG and FBTGG. For tasks 2 „Stop individuals“ and 3 „Degrade individuals“ TGG and FBTGG have highest ratings, and SBG – lowest. For task № 4 „Disable individuals“ the hand grenades have evaluations similar to tasks 2 and 3, the HS NLW (electro-shock device) has lowest result due to its small range, short effect and applicability to one person. In spite of such rating this

device is the most suitable mean for immediate and full disabling in some situations. For task 5 „Deny access“ (where the requirements are high) all hand grenades have lower evaluations compared to the other tasks, and the HS NLW, which range is several times bigger, has best rating.

The average values for each kind of space are presented in Table 3 and Figure 2.

Table 3. Evaluations of NLWs capabilities by operational spaces - average values

Space	TGG	SBG	FBG	SG	FBTGG	FBSBG	FBSG	HS NLW (1)	HS NLW (2)
Building	0.88	0.68	0.76	0.72	0.83	0.78	0.73	0.66	0.58
Open area	0.77	0.66	0.68	0.64	0.75	0.71	0.69	0.73	0.70
Conf. space	0.73	0.61	0.64	0.61	0.71	0.66	0.65	0.68	0.62

All hand grenades (markedly these which contain teargas) demonstrate best capabilities for all operational tasks in buildings - they meet the requirements for covering and range to bigger degree than the requirements for open and confined areas.

The evaluated *HS NLWs* have good performance in open and confined areas due to their extended ranges, smaller average values are calculated because of the low evaluation of the *HS NLW* for some criteria in task 4.

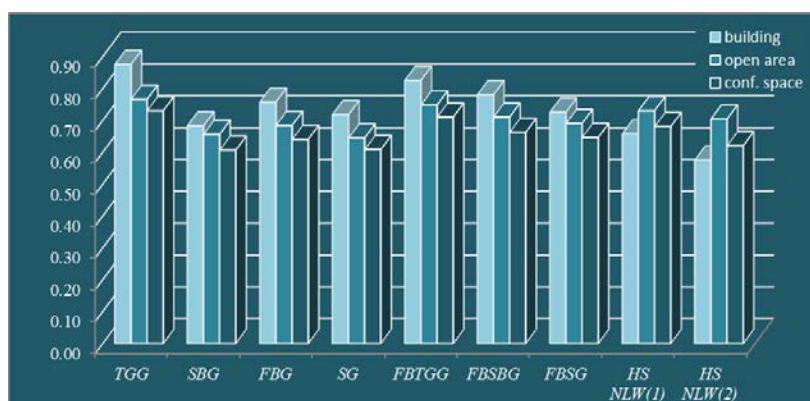


Fig. 2. Evaluations of NLWs capabilities by operational spaces – average values.

The following conclusions concerning the studied types of non-lethal hand grenades can be drawn on the base of their capabilities comparative analysis:

- The Teargas grenade (*TGG*) has highest capabilities compared to the rest grenades for the studied operational tasks and spaces. It is very appropriate for individual application in buildings as well as in most of tasks in open and some tasks in confined spaces.
- The Sting-ball grenade (*SBG*) has lowest average evaluation. It shows sufficient capabilities in buildings and some tasks in open areas. The grenade can be successfully used in situation where application of other grenades is connected with high level of risk.
- The Flash-bang grenade (*FBG*) has good evaluations for the operational tasks in buildings and some tasks in open areas, and lower for tasks with high requirements for coverage and/or effect duration. Regardless of its short-time effect this grenade is very suitable for situations where powerful disorientating effect is necessary.
- The Smoke grenade (*SG*) has lowest average evaluation due to delayed onset of the effect (3-4 s) especially in situations demanding immediate influence. The capabilities of this grenade in buildings are higher than these in open and confined areas.
- The Flash-bang teargas grenade (*FBTGG*) has the second highest capabilities. Combining the advantages and eliminating some shortcomings of chemical and flash-bang grenades, it is appropriate for application in all spaces and tasks except for some situations in open which require large range.
- The Flash-bang sting-ball grenade (*FBSBG*) has evaluations higher than these of the flash-bang and the sting-ball grenades for all operational tasks. Obviously a good balance between the components is achieved which leads to increased capabilities of this grenade with combination of light, sound and kinetic effects.
- The Flash-bang smoke grenade (*FBSG*) has capabilities slightly higher or between these of the grenades with flash-bang and smoke effects. These evaluations are result of lower coverage (area of effect) owing to decreased quantities of the active components compared to flash-bang and smoke grenades separately.

Conclusions

1. The evaluated hand grenades developed at the IMSETHAC-BAS have good capabilities for a big part of the operational tasks and spaces. They demonstrate best performance in buildings and lower in open and confined areas.
2. The non-lethal hand grenades developed at the IMSETHAC-BAS have capabilities comparable to these of best evaluated NLWs used or in process of development in NATO countries.

References

- [1] Non-Lethal Weapons Capabilities-Based Assessment, NATO Technical Report, RTO-TR-SAS-078, December 2012, 740 p.
- [2] Tumbarska, A. Investigation of the capabilities and the effectiveness of non-lethal weapons, PhD Thesis, IMSETHAC-BAS, Sofia, 2016, 175 p.
- [3] Tumbarska, A. Methodologies of Assessing the Non-Lethal Weapons Capabilities, - Engineering Sciences, LIII, No. 1, 2016, p. 75-88, ISSN 1312-5702.
- [4] DuBay, D. K. Extended Range Less Lethal Stand-Off Capabilities: A 66mm Stingball Grenade, USA, August 1998, <http://www.dtic.mil/cgi-bin/GetTRDoc%3FAD%3DADA351547>.
- [5] Davison, N. "Non-lethal" Weapons, England, 2009, ISBN 978-0-333-79483-8, 325 p., <http://nightops.net/doc/books/%27Non-Lethal%27%20Weapons%20-%20Neal%20Davison.pdf>.
- [6] Burgei, W., S.E. Foley, S.M. McKim. Developing Non-Lethal Weapons: The Human Effects Characterization Process, Defense Acq. Univ., Defense ARJ and Defense AT&L Publ. Website.
- [7] Alexander, J. Non-Lethal Weapons: No Road to Hell, NL Defense In: "VI" Symposium "Non-Lethal Weapon Options in the Global Fight Against Terrorism", Reston, VA, USA, 14-16 March 2005, <http://www.dtic.mil/ndia/2005nonlethdef/2005nonlethdef.html>.
- [8] Non-Lethal Weapons Effectiveness Assessment, NATO Technical Report RTO-TR-085, SAS-035N, October 2004, <https://www.cso.nato.int/pubs/rdp.asp?RDP=RTO-TR-085>.
- [9] Non-Lethal Weapons Effectiveness Assessment Development and Verification Study, NATO RTO TR-SAS-060, Oct. 2009, ISBN 978-92-837-0077-7, <http://www.cso.nato.int/abstracts.aspx>.

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CRITERIA FOR EVALUATING THE CAPABILITIES OF GROUPS OF SIMILAR NON-LETHAL WEAPONS

КРИТЕРИИ ЗА ОЦЕНЯВАНЕ ПОТЕНЦИАЛНИТЕ ВЪЗМОЖНОСТИ НА ГРУПИ ОТ СХОДНИ НЕЛЕТАЛНИ ОРЪЖИЯ

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Abstract: Investigation and assessment of non-lethal weapons (NLWs) require development of specific methods and tools different than those applied to conventional weapons, due to reversibility and limited duration of the NLWs' effects. The capabilities evaluation aims to establish to what extent the NLWs are able to meet the requirements of an operational task. The paper describes the criteria currently applied for assessing the NLWs capabilities and proposes an approach based on selection of criteria and variation of their relative weights depending on studied NLWs and operational tasks specific. The application of this approach is illustrated by a comparative evaluation of a group of non-lethal hand grenades with different effects.

Keywords: NON-LETHAL WEAPON (NLW), CAPABILITIES ASSESSMENT, CRITERIA

Introduction

According to the most contemporary definition the non-lethal weapons are "... explicitly designed and primarily employed to incapacitate targeted personnel or materiel immediately, while minimizing fatalities, permanent injury to personnel, and undesired damage to property in the targeted area or environment. Non-lethal weapons are intended to have reversible effects on personnel or materiel".[1] These special features require development of new methods and tools of study, since the methods applied to conventional weapons are considered inapplicable to NLWs. The most recent and comprehensive studies in this field are accomplished by the working groups on the NLWs capabilities assessment [2] and the effectiveness [3, 4] at the NATO Research & Technology Organization.

Existing Approaches for the NLWs Capabilities Assessment

In most of available publications the abilities of a NLW to achieve the desired outcome of an operation are described as "effectiveness" and its evaluations are performed using various approaches and criteria.

Differentiation between terms "capabilities" and "effectiveness" of the NLWs is introduced in the NATO working groups reports [2, 3, 4] where the capabilities of a NLW are defined as its potential to successfully execute certain operational task, while the effectiveness is the extent at which a NLW achieves the goal of the task, i.e. the ratio between performance and the desired result, along the operational phases and taking into account the effects of the weapon on all groups of subjects involved in situation.

Evaluating the NLWs capabilities and effectiveness is based on operational scenarios, which allows determination of the desired outcome and formulating requirements for assessing the suitability of a NLW depending on the degree at which it meets the requirements.

The report of the NATO Working group on the NLWs capabilities based assessment [2] is an impressive study including 160 NLWs of all types and covering the whole range of missions in which different types of forces (military, police, anti-terrorist, etc.) are engaged. Thirty seven scenarios with over 50 operational tasks are developed, requirements for each task are formulated and NLWs applicable to the tasks are discussed and evaluated. The

methodology of [2] represents "a process of analysis consisting of four steps: (1) operational requirements analysis; (2) capabilities analysis; (3) analysis of gaps (incompatibilities); (4) analysis of possible solutions". The Working group proposes 10 evaluation criteria and specifies their importance using 10-degree scale:

Context:

- Territory (air, land, water)
- Space (open, confined, building, underwater)

Target characteristics:

- Targets number (one, a few, group, crowd)
- Targeting (individual, group)
- Mobility (static, moving)
- Physical characteristics (protected, unprotected)

Characteristics of the contact with the target:

- Range (distance to the target)
- Coverage. i.e. area of the effect (point, area)

Effectiveness characteristics:

- Onset of the effect
- Duration of the effect.

These criteria with constant importance are applied in [2] to all scenarios and NLWs. The relative weight of a criterion represents the ratio between the criterion importance and the sum of importance of all criteria. The evaluation of a NLW for each criterion is the proportion between the NLW performance and the operational requirement (the rate to which the NLW meets the requirement) multiplied to the criterion relative weight. The total evaluation of the NLW for a scenario/operational task is the sum of evaluations for all criteria.

A New Approach for Evaluating the Capabilities of Groups of Similar NLWs

On the base of [2] two methodologies are developed by the author – an Improved methodology for assessing the NLWs capabilities and a Methodology for assessing the capabilities of groups of similar NLWs, which are described in [5, 6]. The first one is intended for assessing the whole range of NLWs and can be applied to compare the capabilities of different types of NLWs, the second - for evaluating groups of NLWs with similar effects and/or equal way of delivery to the target. In terms of practice the first one is suitable to select the most appropriate types of NLWs for the given scenario and the second – to choose the most appropriate NLW of the selected type.

The methodologies are based on the general approach, scenarios, criteria and operational requirements of [2]. The Improved methodology is applied to two groups of NLWs - with chemical and with kinetic effect (hand grenades developed at IMSETHAC-BAS, hand grenades and launched munitions of leading world producers) for 5 operational tasks where these types of NLWs have best capabilities to achieve the operational goal. The results of this investigation show that products using one and the same technology have identical performance for some criteria in all scenarios. For example, the rounds and hand grenades with chemical effect equally meet the requirements of criteria target number, targeting, mobility and physical characteristics, due to the inherent features of this type of products, i.e. their performance does not depend on the design and delivery system. Proceeding from the assumption that in such cases using all the 10 criteria is not necessary and the fixed importance of the criteria does not allow clear differentiation of the NLWs capabilities, an algorithm for investigating the capabilities of groups of similar NLWs is developed [5]. The main point of this approach is selection of evaluation criteria according to the type of studied NLWs and determination of criteria importance depending on the operational task. This method is applied in [5, 6] to groups of NLWs with identical effects and different delivery methods. The results analysis shows very high correlation between the evaluations obtained by this approach, the Improved methodology and the method of [2].

The relative weights of the criteria applied in [2] and the Improved methodology for assessing the NLWs capabilities are illustrated in Figure 1.

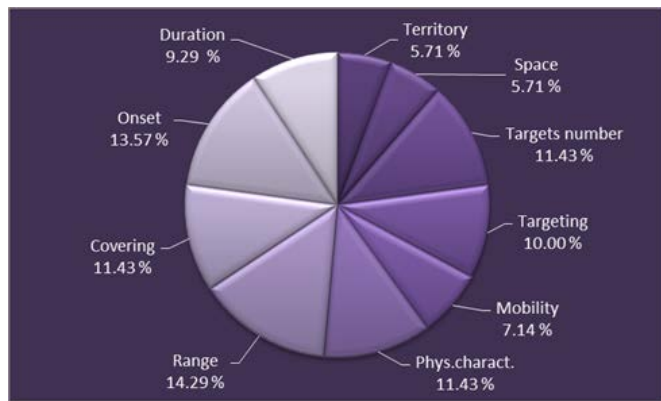


Fig. 1. Relative weights of the criteria applied in [2] and the Improved methodology for assessing the NLWs capabilities.

An example with selected criteria and varying criteria importance, applied in the Methodology for assessing the capabilities of groups of similar NLWs is given in Figure 2.

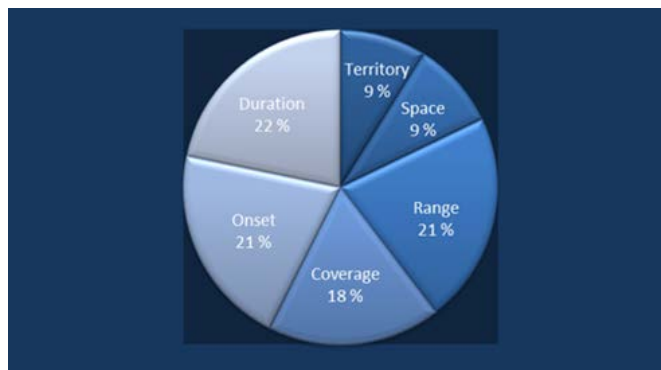


Fig. 2. An example with selected criteria and varying importance, respectively relative weights, of the criteria.

It is clearly seen that elimination of some criteria leads to increasing the relative weights of the rest criteria.

Table 2. Results from the capabilities evaluation using the approach with selected criteria and varying criteria importance

Results from Application of the New Approach to a Group of Similar NLWs and Discussion

This paper represents further efforts for verification the applicability of the proposed approach through evaluating a group of NLWs with identical way of delivery and different physical principles. For this purpose the capabilities of 7 types of hand grenades are studied: with teargas (CS), designated as TGG; "sting-ball" grenade (SBG); flash-bang grenade (FBG); smoke grenade (SG); flash-bang with tear gas (FBTGG); flash-bang sting-ball (FBSBG) and flash-bang smoke grenade (FBSG).

The products are evaluated for 4 types of operational tasks: 1) Move individuals (moving individuals/groups out or to certain area); 2) Stop individuals (prevent or impede access to certain area, stopping or changing the movement direction); 3) Degrade individuals (selective reducing of one or some functions/responses of the object); 4) Disable individuals (general reducing the most or all functions/responses of the object). Evaluation is made separately for open areas and buildings.

Three combinations of criteria importance, respectively relative weights, are used for the products capabilities evaluation (Table 1). Varying values are given in bold, the rest are equal to those used for assessing different types of NLWs (in [2] and [6]).

Table 1. Importance and relative weights of applied criteria

Criteria	Variant 1		Variant 2		Variant 3	
	importance	relative weight	importance	relative weight	importance	relative weight
Task 1						
Territory	4	0.09	4	0.09	4	0.08
Space	4	0.09	4	0.09	4	0.08
Range	10	0.22	10	0.23	10	0.21
Coverage	8	0.18	10	0.23	10	0.21
Onset	9.5	0.21	9.5	0.22	9.5	0.20
Duration	10	0.22	6.5	0.15	10	0.21
Task 2						
Territory	4	0.09	4	0.09	4	0.09
Space	4	0.09	4	0.09	4	0.09
Range	10	0.23	10	0.22	10	0.24
Coverage	10	0.23	8	0.18	8	0.19
Onset	9.5	0.22	9.5	0.21	10	0.24
Duration	6.5	0.15	10	0.22	6.5	0.15
Task 3						
Territory	4	0.08	4	0.09	4	0.10
Space	4	0.08	4	0.09	4	0.10
Range	10	0.21	10	0.24	8	0.20
Coverage	10	0.21	8	0.19	8	0.20
Onset	9.5	0.20	10	0.24	10	0.25
Duration	10	0.21	6.5	0.15	6.5	0.16
Task 4						
Territory	4	0.08	4	0.09	4	0.09
Space	4	0.08	4	0.09	4	0.09
Range	10	0.21	10	0.22	10	0.22
Coverage	10	0.21	10	0.22	8	0.18
Onset	9.5	0.20	10	0.22	9.5	0.21
Duration	10	0.21	6.5	0.15	10	0.22

The selection of criteria is made according the type of studied NLWs. The four criteria concerning target characteristics (target number, targeting, mobility, physical characteristics) are eliminated, in view of the fact that all studied products have identical performance for these criteria (typical to all hand grenades and not depending on their design), i.e. these criteria can be considered of inessential significance for comparing the products of this kind.

The calculated results are given in Table 2 and Figure 3 and compared to results obtained by the methodology using 10 criteria with fixed importance (relative weights).

Tasks, spaces and groups of criteria			Capabilities valuations						
			TGG	SBG	FBG	SG	FBTGG	FBSBG	FBSG
Task 1	in buildings	variant 1	0.91	0.56	0.66	0.65	0.84	0.70	0.65
		variant 2	0.99	0.62	0.75	0.73	0.90	0.79	0.72
		variant 3	0.95	0.57	0.70	0.68	0.87	0.73	0.67
		IM*	0.92	0.72	0.78	0.77	0.87	0.80	0.77
	in open areas	variant 1	0.54	0.41	0.40	0.34	0.53	0.42	0.44
		variant 2	0.53	0.44	0.43	0.36	0.53	0.44	0.46
		variant 3	0.53	0.40	0.40	0.33	0.52	0.41	0.43
		IM*	0.68	0.62	0.62	0.57	0.68	0.63	0.64
Task 2	in buildings	variant 1	0.89	0.55	0.71	0.63	0.80	0.72	0.62
		variant 2	0.82	0.50	0.62	0.54	0.75	0.63	0.56
		variant 3	0.84	0.54	0.67	0.58	0.77	0.68	0.61
		IM*	0.86	0.67	0.75	0.70	0.81	0.76	0.71
	in open areas	variant 1	0.88	0.56	0.65	0.65	0.82	0.67	0.68
		variant 2	0.87	0.53	0.59	0.64	0.82	0.60	0.68
		variant 3	0.86	0.57	0.64	0.64	0.81	0.65	0.69
		IM*	0.86	0.68	0.73	0.73	0.83	0.73	0.76
Task 3	in buildings	variant 1	0.86	0.51	0.66	0.58	0.78	0.66	0.58
		variant 2	0.84	0.54	0.67	0.58	0.77	0.68	0.61
		variant 3	0.85	0.51	0.64	0.56	0.77	0.65	0.58
		IM*	0.86	0.67	0.75	0.70	0.81	0.76	0.71
	in open areas	variant 1	0.78	0.51	0.60	0.54	0.73	0.61	0.56
		variant 2	0.79	0.55	0.63	0.55	0.74	0.65	0.60
		variant 3	0.81	0.57	0.66	0.57	0.76	0.67	0.62
		IM*	0.82	0.68	0.73	0.68	0.79	0.74	0.71
Task 4	in buildings	variant 1	0.82	0.50	0.62	0.54	0.75	0.74	0.56
		variant 2	0.89	0.55	0.71	0.63	0.80	0.79	0.62
		variant 3	0.82	0.50	0.62	0.54	0.75	0.74	0.56
		IM*	0.86	0.67	0.75	0.70	0.81	0.80	0.71
	in open areas	variant 1	0.76	0.52	0.59	0.51	0.72	0.71	0.56
		variant 2	0.81	0.55	0.65	0.57	0.75	0.73	0.61
		variant 3	0.76	0.51	0.58	0.51	0.71	0.70	0.56
		IM*	0.82	0.68	0.73	0.68	0.79	0.78	0.71

IM* - values calculated by the Improved methodology

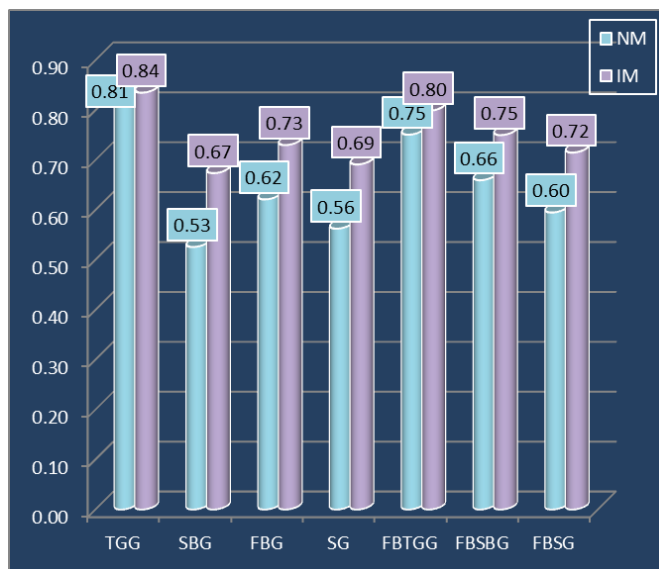


Fig. 3. Capabilities evaluations obtained by applying the approach with selected criteria and varying criteria importance (NM) and the approach with fixed criteria (IM) - average values from all operational tasks.

Additional differentiation of the products capabilities is obtained through variation of the criteria importance in accordance

From Table 3 is seen that for all operational tasks, with the exception of task 2 for TGG in buildings and open areas and task 1 in buildings for TGG and FBTGG, the results calculated by the new methodology are lower compared to these by the methodology using 10 criteria. As a result the average evaluations from all tasks by the new approach are with 9 to 14 % lower (Fig. 3). Notwithstanding, the differences between evaluations of the NLWs with best capabilities (teargas grenade and flash-bang grenade with teargas) calculated by the two methodologies are comparatively small – 3 % and 5 %. The differences between the evaluations of the highest (TGG) and lowest (SBG) scored products is 17 % by the approach with 10 criteria and 28 % by the approach using selected criteria with varying importance.

Such a differentiation, which is the purpose of the proposed methodology, is achieved mainly by reducing the criteria number. In the case with the group of hand grenades, for the criteria target number, mobility and physical characteristics, all products fully meet the requirements and have maximum evaluations of 1.00, for criterion targeting all evaluations are 0.5. When they are eliminated, the relative weights of the criteria, for which the products have worse presentation, increase and the total evaluation of products capabilities decrease. Within this group of NLWs biggest “contribution” for decreased evaluations has the criterion range (considered as most important characteristic of NLWs) – the weak point of hand thrown grenades compared to launched non-lethal munitions and other long-range NLWs.

to the specific of the concrete operational situation which leads to redistribution of the criteria relative weights. Thus the evaluations

of NLWs which have good performance for the criteria with high importance grow up while these of NLWs with inadequate performance become smaller, giving the opportunity of selecting the most appropriate NLW for the task.

Finally, eliminating the criteria which are not significant for the similar products comparison has one more positive effect – considerable reduction of the calculations number. The capabilities evaluating can be easily made using Microsoft Excel without necessity of special software.

Conclusions

The following conclusions can be drawn on the base of the comparative analysis of obtained results and taking into account observations from preceding studies:

1. The proposed approach for evaluating the capabilities of groups of similar non-lethal weapons, using selected criteria depending on the type of studied NLWs and varying criteria importance depending on the operational task specific, has the following advantages compared to existing approach using ten criteria with constant importance:
 - More rapid differentiation between the capabilities of similar products (having identical physical principle of operation and/or delivery method);
 - More realistic assessment with the view to selection of most appropriate NLWs for concrete operative situations.
 - Simplified calculation procedure which makes it easy for application without special software.
2. The proposed approach for evaluation of similar NLWs using selected criteria with varying importance can be applied for evaluation of existing NLWs, as well as in the process of development (design and testing) of new NLWs with the purpose to achieve an optimum combination of characteristics providing maximum capabilities.

References

- [1] Non-Lethal Weapons Reference Book. Joint Non-Lethal Weapons Directorate (JNLWD), DoD, Quantico, Virginia, USA, 30 June 2011, <https://publicintelligence.net/dod-non-lethal-weapons-2011/>.
- [2] Non-Lethal Weapons Capabilities-Based Assessment, NATO Technical Report, RTO-TR-SAS-078, December 2012, 740 p.
- [3] Non-Lethal Weapons Effectiveness Assessment, NATO Technical Report RTO-TR-085, SAS-035N, October 2004, <https://www.cso.nato.int/pubs/rdp.asp?RDP=RTO-TR-085>.
- [4] Non-Lethal Weapons Effectiveness Assessment Development and Verification Study, NATO RTO Technical Report TR-SAS-060, October 2009, ISBN 978-92-837-0077-7, <http://www.cso.nato.int/abstracts.aspx>
- [5] Tumbarska, A. Investigation of the capabilities and the effectiveness of non-lethal weapons, PhD Thesis, IMSETHAC-BAS, Sofia, 2016, 175 p.
- [6] Tumbarska, A. Methodologies of Assessing the Non-Lethal Weapons Capabilities, - Engineering Sciences, ISSN 1312-5702, LIII, 2016, No. 1, p. 75-88.

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ANALYSIS OF THE USE OF RADIOACTIVE SUBSTANCES FOR THE CREATION OF POLLUTION, THEIR DETECTION AND HOW THEY CAN BE SIMULATED

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Abstract: An analysis of the main radiological warfare agents and of the different types of detectors for them is performed. The basic principles of the most common detection methods are described. The aim of the study is to outline the main challenges in this field. The possibility for applications of the Surface photo-charge effect in the field of detection of radiological warfare agents is discussed. An emphasis is put on the simulation of the radioactive substances during the performing of experiments.

Keywords: RADIOLOGICAL WARFARE AGENTS, METHODS, SURFACE PHOTO CHARGE EFFECT

1. Introduction

The weapons powered by nuclear reactions (fission and/or fusion) are called nuclear weapons. They are compact and highly sophisticated - Nuclear Warheads or compact and relatively more simple Radioactive Dispersal Devices (“dirty bombs”). Although they differ in the initial impact, the consequences for the region are devastating.

Radioactive isotopes are used to fuel the nuclear weapons [1]. For example, enriched Uranium U-235 and Plutonium Pu-239 are used for Nuclear Warheads [2]. The most often used isotopes for Radioactive Dispersal Device [3] are Cobalt Co-60, Caesium Cs-137, Iridium Ir-192, Strontium Sr-90, Plutonium Pu-238, Americium Am-241, Californium Cf-252.

There are several types of radiation emitted by nuclear weapons: α , β , γ particles [4], neutrons [5] and X-rays. They are emitted at the time of detonation (initial) and for long period of time afterwards (residual). The radiation particles have different harmful effects on the human's health, which depend on their type, energy and exposure time. The most important factor is the amount of dose – the greater the energy absorbed by the cells the greater the biological damage. The α and β particles are very dangerous when are inhaled or swallowed. The γ particles, neutrons and X-rays have higher penetration and are very dangerous, if the exposure is very long. When there is a strong dose of radiation, it causes cell structure damage.

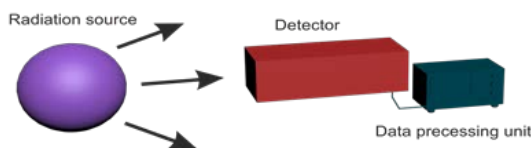


Fig. 1 General setup for radiation detection system

2. Detection methods and detector specifics

All radioactive isotopes are sources of radiation. Many of the isotopes occur in the environment and they form the radioactive background (Fig. 2). The United Nations Scientific Committee on the Effects of Atomic Radiation identifies four major source of exposure to natural radiation: cosmic radiation, consisting of fast moving particles, of which some penetrate the atmosphere and become absorbed by humans; terrestrial radiation, consisting of natural deposits of uranium, potassium and thorium which release small amounts of ionizing radiation; exposure through inhalation from radioactive gases produced by minerals found in soil and bedrock; exposure through ingestion, coming from the soul and ground water which contain radioactive materials [6]. This background has to be eliminated during the measurements or in some way accounted for or in the end results.

There are various devices that can detect materials used for nuclear weapons of mass destruction (NWMD) and determine their kind and quantity. But fundamentally the technology analyses and recognises signals and samples from the nuclear materials. The identification of natural or anthropogenic radiation is generally achieved by a detector system with a few subsystems based on physical interactions. The methods depend on the type of emitter and the intended purpose of detection. The general layout of such systems is shown in Fig. 1.

The detector is their essential unit. The signal is handled by elements that record the number of incoming pulses with pre-established features (pulse amplifiers, counters, etc.). A problem is that the energy of the emitter must be high enough to travel some distance through air. If the detectors are not sensitive in the energy range of the incident radiation, the use of absorbers between the detector and the source or of detectors with appropriate dimensions becomes necessary.

Recognizing NWMD is often rendered difficult by low count rates and different in size pulses produced by the detectors systems in accordance with the incident radiation energy. Example of such specter is shown in Fig. 2. It is derived by presenting the number of counts in each increment of the incident radiation. The obtained results are saved in the system computer where they are accessible for further processing and presentation.

All devices for detection of WMD, including those for NRWDM, implement calibration curves that associate count rates with material quantity. The relation of the count rates to the amount of material, the limits of detection for weak nearby sources or strong ones, as well as the dependence of the ambient environment, are some of the parameters described by the curves.

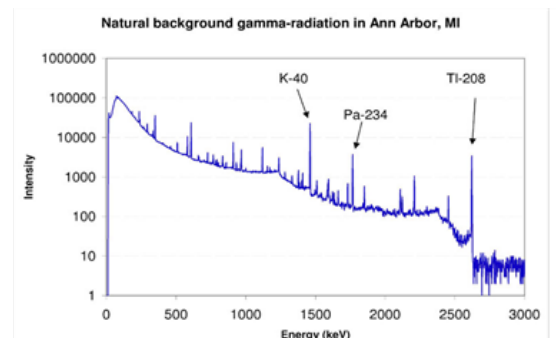


Fig. 2 Natural background gamma-radiation spectrum (<https://whatisnuclear.com/articles/radioactivity.html>)

The magnitudes of the mean free path of neutrons and gamma rays set a condition for the scale of the detectors. The typical detectors weigh several kilograms and shave volumes of tens or hundreds of cubic centimetres. The most compact detectors are restricted for strong sources at a close range.

The neutron and the gamma ray are non-charged particles. In order to detect them their energy must be transferred to a charged particle. The interaction with the detector produces electrons for the gamma rays and particle-hole pairs for the neutrons. High voltage is usually applied so that the electrical signal can be measured.

Radiation exposure monitors, such as x-ray film or personnel dosimeters, record a physical change in the material caused by the radiation. When the film is developed or the dosimeter read out, a record of the cumulative radiation exposure is obtained. Radiation detectors convert the radiation in real time to an observable effect, such as electronic pulses or scintillator light.

All neutron detectors work by detecting the charged particles produced when the neutrons interact with a suitable material. Neutron absorption is most efficient for low-energy thermal neutrons, so these detectors include a moderating material, which slows the neutron down by elastic scattering. After absorption, the excited nucleus decays, emitting a charged particle, which can be detected by a scintillator, semiconductor diode or gas-filled counter. The neutron energy information is lost in the moderation process, so the resulting display is typically count rate or is converted to dose rate.

3. Types of detectors

Nuclear radiation can only be detected by specially created detectors. Each detector has drawbacks in detecting some particular kinds of radiation and advantages for others: specific energy ranges, ionizing particles, ambient conditions.

- **Crystal Scintillation Counters** – The Crystal Scintillation Counters [7, 8] are tubes with a scintillation crystal on the one end. When a particle is absorbed in the crystal a luminous photon is generated. The photon goes through the Optical contact and a photoelectron is generated, then the photo electron hits a series of photomultipliers and in the end the cascade of photo electrons is analysed by the multichannel analyser. This way a very weak source of radiation can be accurately detected and measured.

- **Liquid Scintillation Counters** – Liquid Scintillation Counters (Fig. 3) [7, 9] are chambers containing a vial of scintillation liquid, which is surrounded by photomultiplier tubes (PMT). The sample is put in the liquid and when it emits a radiation, the radiation is absorbed by the fluid. The fluid emits a pulse of light that is detected by the PMTs. By cooling the PMTs, energy discrimination and use of shielding, and if all PMTs detect the light in coincidence, a very low background count can be achieved.

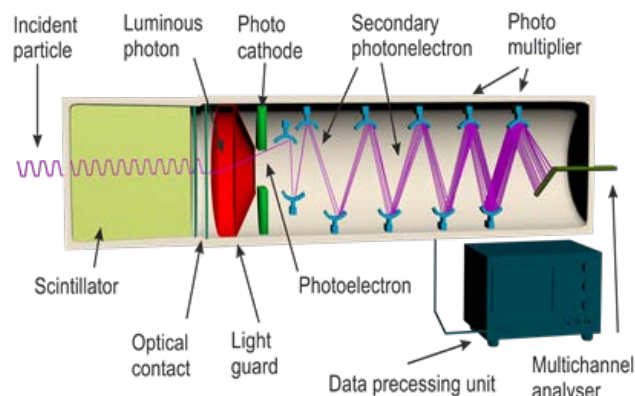


Fig. 3 Crystal Scintillation Counters

- **Proportional counter** – a chamber is filled with an inert gas and a voltage is applied, when a particle interacts with the gas, it is ionized and a pair of a positive ion and an electron begins moving towards the cathode and the anode, respectively [10]. As the particle progresses, it leaves a trail of ion pairs that is

proportional to its energy. It is efficient for the detection of alpha and beta particles and it can differentiate them.

- **Multichannel Analyser System** – it includes a sodium iodide crystal, a solid-state germanium detector (Fig. 4), or a silicon-type detector and a multichannel analyser [11, 12]. They can be used to analyse liquids or solids and, with good shielding, organic tissues of the energy spectra of gamma-ray sources. They are capable of identifying the source and determining the identity and quantity of gamma emitters present with a detailed analysis.

- **Radon Detectors** – a number of different techniques are used for radon measurements [13]. These range from long-term exposure of CR-39 plastic with subsequent chemical etching and alpha track counting, exposing a charcoal canister for several days and performing gamma spectroscopy for absorbed decay products, collection of radon decay products on an air filter and counting, and exposure of an electret ion chamber and read-out.

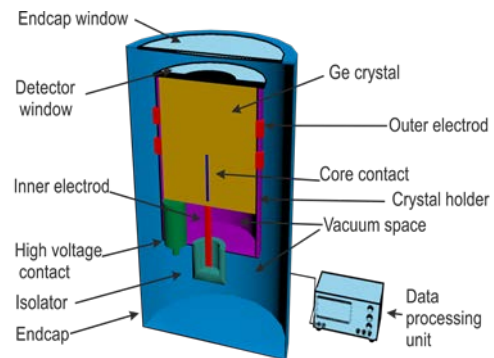


Fig. 4 Germanium detector

- **Portable Multichannel Analyser** – a compact version of the Multichannel analyser system. When gamma-ray data libraries and automatic identification procedures are used, the type of radioactive materials can be displayed.

- **Ionization (Ion) Chamber** – the chamber inner wall is coated with a conductor and there is an anode in the centre, a small voltage is applied (Fig. 5) [14]. The emission of the radioactive source forms an ion pair in the air volume when it interacts with the wall coating. The anode collects the electrons and the current is measured. The detector must be calibrated, and changes in the ambient pressure and temperature must be taken into account.

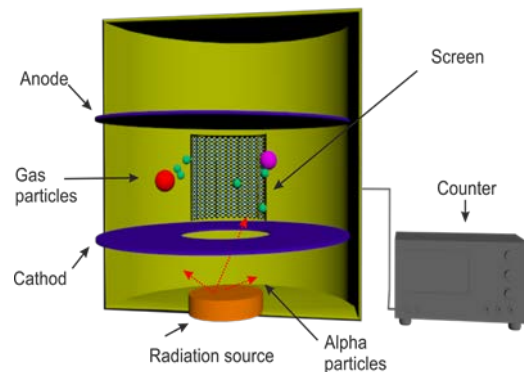


Fig.5 Ion Chamber

- **Geiger Counter** – a tube filled with inert gas, the wall is the cathode and there is an anode in the middle (Fig. 6) [15]. A high voltage is applied so when a particle interacts with the wall or the gas in the chamber, there is cascade ionization and the produced pulse is measured. It can detect alpha, beta and gamma radiation. Used for demonstrations or for radiation environments where is needed only a rough estimate of the amount of radioactivity.

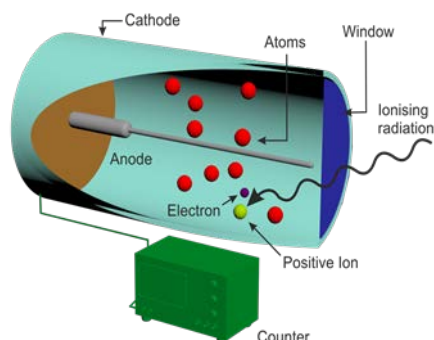


Fig. 6 Germanium detector

- **Neutron REM Meter, with Proportional Counter** – it is a tube filled with boron trifluoride or helium-3, a high voltage is applied, and when a neutron interacts with the gas, an electric pulse is created. The interactions of the neutrons with the core of the boron-10 or helium-3 cause the prompt emission of a helium-4 nucleus or proton respectively. Then a cascade of charged particles is created in the gas.

4. Surface photo charge effect (SPCE)

Some investigations carried out in the Institute of Solid State Physics, Bulgarian Academy of Sciences, resulted in revealing the so-called Surface Photo Charge Effect. The description of SPCE in its foundations is as follows: the interaction of any solid with electromagnetic field induces an electric, alternating potential difference with the same frequency as the frequency of the incident field. The SPCE is induced by electromagnetic field irradiation with frequency ranging from 1 Hz to 1 GHz, infrared, visible and the beginning of ultraviolet. Most probably this effect exists in the entire electromagnetic spectral range [16]. The measurement is contactless and does not require complicated procedures to be carried out. It is fast because the time needed depends on the technical characteristics of the used equipment.

Many parameters have importance – type of the structure, wavelength and intensity of the incident radiation, parameter of the electrical signal, which has to be measured, material of the irradiated surface, method for signal registration, measurement conditions, any additional influences.

This method can be used for developing sensors for different materials – solid, liquid, gases [17]. These sensors can be used for on-line and/or in-situ control. A great advantage is that no expensive elements for the construction are needed.

Some of the suggested possibilities of the practical applications of SPCE are: determination of impurities, defects, ion implantation regions, topology of created structures, conductivity type, semiconductor devices [18, 19].

- **Application on solid materials**

This method was studied in a large number of various conductors and semiconductors: metals Zn, Cd, Al, Pb, Mg, Au, Cu and copper alloys; semiconductors: Si, GaAs, GaP, ferrites and ceramic superconducting materials. It was observed that the amplitude of the voltage varied from sample to sample [20, 21].

It was observed in dielectric samples, too. They were exposed to amplitude-modulated non-monochromatic or, in some cases, to He-Ne laser light in the visible region. It was established that the generated SPCE voltage depends on the type of the illuminated material [22, 23].

- **Application on liquids**

This method was also studied in liquids. A characteristic feature is that the potential difference has a unique value for each liquid. The experimental results showed that under certain conditions, the signal is a function of the composition or other properties of the liquid. It was observed that any variations in the fluid characteristics induce a change in the properties of the irradiated sample [24]. Thus SPCE could be implemented as an analytical method [25].

A group of tests with mixing two liquids were also performed. Another group of experiments was performed showing that by varying the type of electrode and the illumination conditions, the SPCE signal may become dependent on the volume of the liquid.

Experiments showed that the precipitation of a substance in a solution on the surface could also be monitored. The precipitated substance affects the surface properties and changes in the SPCE signal are observed [25].

- **Chemical composition test**

Any change in the chemical composition, due to contamination with any substance, can be detected. The dependence of the SPCE signal on the chemical composition of the illuminated solid could find application in qualitative monitoring of the composition of various samples [26]. Different types of absorbing filters for gases and liquids can be monitored. The absorption of the filtered substances causes changes in the chemical composition of the filter. The SPCE could also be used for monitoring of environmental pollution. It could also find application in areas such as ecology, industry, car production, military equipment.

It can be applied for analysis of specific reactions in milk. They can be induced by adding of testing liquid to the samples. The observed changes in an experiment were specific for each testing liquid, because different testing liquids caused different reactions and processes in the milk [16].

The method was also demonstrated and studied in the case of controlling the chemical composition of bricks. The experimental results showed that samples with different compositions invoke distinctly different electronic signals [27].

The possibility of measuring any change in multiple number of materials, gives us the ability to use any convenient sample and a predesign sensing system based on SPCE, to detect possible radiation damage.

5. Conclusions

No detector capable to sense all types of radiation exists. The physical limitations of the crystal or the gas chamber are the main factors for this constraint. There should be a general idea of what is going to be measured so the most suitable detector can be selected. The variety of possible applications of the SPCE are promising enough to attract attention in sensor design and construction. The SPCE can be used for development of new techniques. It gives great possibilities, combining optical probing of the samples with electrical detection of the generated signal. Such devices will be cheap with no expenses for consumables and small enough to be used in field work.

Acknowledgement

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References:

- [1] Weapons of terror: freeing the world of nuclear, biological and chemical arms, *Weapons of Mass Destruction Commission*, 2006
- [2] Fetter S., Ballistic missiles and weapons of mass destruction: What is the threat? What should be done?, *International Security*, 1991, 16(1), 5-42
- [3] Zimmerman P. D., Loeb Ch., Dirty bombs: the threat revisited, *Defense Horizons*, 2004, 38
- [4] Wilson J. W., Overview of radiation environments and human exposures, *Health Physics*, 2000, 79(5), 470-494
- [5] Beckurts K. H., Wirtz K., *Neutron physics*, 1974
- [6] <http://nuclearsafety.gc.ca/eng/pdfs/Reading-Room/radiation/Introduction-to-Radiation-eng.pdf>
- [7] Birks J. B., *Scintillation counters*, Pergamon Press, 1960
- [8] Schotanus P., Kamermans R., Dorenbos P., Scintillation characteristics of pure and Tl-doped CsI crystals, *IEEE Trans. Nucl. Sci.*, 1990, 37
- [9] Reynolds G. T., Harrison F. B., Salvini, G., Liquid scintillation counters, *Physical Review*, 1950, 78(4), 488
- [10] Howard A. J., Gilliland G. L., Finzel B. C., Poulos T. L., Ohlendorf D. H., Salemme F. R., The use of an imaging proportional counter in macromolecular crystallography, *Journal of applied crystallography*, 1987, 20(5), 383-387
- [11] Lutz G., *Semiconductor radiation detectors*, Berlin, Springer, 1999
- [12] Owens A., Peacock A., Compound semiconductor radiation detectors, *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 2004, 531(1), 18-37
- [13] Tokonami Sh. et al., Up-to-date radon-thoron discriminative detector for a large scale survey, *Review of scientific instruments*, 2005, 76(11), 113-505
- [14] Erskine J. R., Braid T. H., Stoltzfus J. C., An ionization-chamber type of focal-plane detector for heavy ions, *Nuclear Instruments and Methods*, 1976, 135(1), 67-82
- [15] Friedman H., Geiger counter spectrometer for industrial research, *Powder Diffraction*, 1991, 6(3), 130-136
- [16] Ivanov O., Radanski S., Application of Surface Photo Charge effect for Milk Quality Control, *Journal of Food Science*, 2009, Vol. 74, No. 7, 79-83, ISSN 0022-1147 (paper); 1750-3841 (online)
- [17] Ivanov O., Kuneva M., Quality Control Methods Based on Electromagnetic Field-Matter Interactions, *InTech*, DOI: 10.5772/15857
- [18] Das P., Mihailov V., Ivanov O., Georgiev V., Andreev S., Pustovoit V. I., 235 Contactless characterization of semiconductor devices using surface photo-effect, *IEEE Electron Device Lett.*, 1992, 13, 291-293
- [19] Abbate A., Rencibia P., Ivanov O., Masini G., Palma F., Das P., 238 Contactless characterization of semiconductor, using laser-induced 239 surface photo-charge voltage measurements, *Mater. Sci. Forum*, 1995, 173/174, 221-226
- [20] Pustovoit V., Borisov M., Ivanov O., Surface photo-charge effect in conductors. *Solid State Communications*, 1989, Vol. 72, No. 6, 613-619
- [21] Pustovoit V., Ivanov O., Surface charge redistribution effect in a conductor subjected to electromagnetic radiation, *Comptes Rendus de l'Academie Bulgare des Sciences*, 1989, Vol. 42, No. 4, 39-42, ISSN 0366-8681
- [22] Ivanov O., Mihailov V., Pustovoit V., Das P., Surface photo-charge effect in dielectrics, *Comptes Rendus de l'Academie Bulgare des Sciences*, 1994, Vol. 47, No. 6, 21-24, ISSN 0366-8681
- [23] Ivanov O., Mihailov V., Pustovoit V., Abbate A., Das P., Surface photo-charge effect in solids. *Optics Communications*, 1995a, Vol. 113, No. 1, 509-12, ISSN 0030-4018
- [24] Ivanov O., Konstantinov L., Application of the photo-induced charge effect to study liquids and gases, *In Surface Review and Letters*, 2000, 7, 211-212
- [25] Ivanov O., Konstantinov L., Investigation of liquids by photo-induced charge effect at solid-liquid interfaces, *Sensors and Actuators B*, 2002, Vol. 86, 287-289, ISSN 0925-4005
- [26] Ivanov O., Vaseashta A., Stoichev L., Rapid, contactless, and non-destructive testing of chemical composition of samples. In *Proceedings of the NATO Advanced Study Institute on Functionalized Nanoscale Materials, Devices and Systems for Chem.-bio Sensors, Photonics, and Energy Generation and Storage*, Sinaia, 4-15 June 2007, Vaseashta, A. K., Mihailescu, I. N. (Eds), Springer, 2008, 331-334
- [27] Ivanov O., Vaseashta A., A method for fast and contactless control of raw materials, *Ceramics International*, 2012, 39, 2903-2907

AEROSOL GENERATION DEVICES SUITABLE FOR SIMULATING FOGS IN LABORATORY CONDITIONS

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Abstract: The current work is related to development of sensors for contamination detection, and systems, which use fog as a cleaning agent, in order to prevent disasters and accidents, and to help acting against terrorist attacks and weapons of mass destruction. Investigations in laboratory conditions of several types of mist generators are presented. For this purpose, various products, which create aerosols, were researched. The diameter distributions of the droplets, produced by them, were experimentally determined. For development purposes, several simple devices for easy fog generation are chosen. This study is related to the development of sensors for fog with different characteristics. The obtained results allow a proper selection of sprayers to be made, so that the necessary conditions for the development of sensors are ensured.

Keywords: FOG GENERATION, SENSORS, SPRAYER, AEROSOLS, DIAMETER DISTRIBUTION

1. Introduction

The sensors under development are based on the surface photo charge effect (SPCE) [1], [2]. This effect reflects the interaction of any solid with an electromagnetic field, which induces an electric, alternating potential difference with the same frequency as the frequency of the incident field [3]. An important feature of the SPCE is its significant dependence on the specific properties of the irradiated sample. This fact reveals vast opportunities for rapid and contactless analysis of solids, liquids and gasses [4-6].

A laboratory study on fog requires an apparatus, which can generate aerosols with fog-like characteristics and behavior. Consistency and repeatability of the properties of the generated experimental fog are required as well, as they are used for calibration of the sensor components.

Visualization of airflows for fluid mechanics and aerodynamics studies is of crucial importance and one of the most common solutions is to include a fine aerosol (particle tracer) in the airflow [7]. The development of a particle sizing apparatus requires monodisperse aerosols with exact size distribution and concentration to be generated, for proper calibration to be achieved (aerosol standards) [8]. Due to the practical importance, various methods for generating fine aerosols with preset size distribution have been developed [9].

Atomizing nozzles, specially designed for generation of fine aerosols are available and can be used for fog generation. The latter can be done in laboratories to simulate real-life fogs and study them in a controlled environment, such as an isolated chamber (fog chamber) [10], [11].

The property that characterizes an aerosol as a fog is the droplet diameter distribution – the typical mean droplet diameter of fog is less than 100 μm [12]. Aerosols with a mean droplet diameter of less than 10 μm are called dry fogs (dry mist) since droplets of this diameter bounce off a surface when in contact, without wetting it, while droplets with greater diameter splash and wet the surface. Typical fog is usually dry.

Another property, used for characterizing fogs, is the liquid water content (LWC), which is expressed as the mass of water in a volume of 1 cubic meter.

Three distinct stages can be observed during the life cycle of fog. The first stage, formation, involves a gradual increase in the mean droplet diameter and number concentration of the aerosol. The second stage, called maturation, is a relatively stable state of the fog, where the mean diameter and number of droplets remain seemingly unchanged. The final stage, dissipation, is a gradual decrease in the number concentration, while the mean droplet diameter increases, due to droplets merging [13].

2. Atomization methods

Different approaches to aerosolization of fluids exist. According to the methods they use, they can be classified into several categories.

- **Pneumatic atomization**

This approach uses a combination of gas and liquid; the gas is fed under high pressure through one end of a tube (Fig. 1). So, the pressurized gas creates a low-pressure region at the end of the tube, which is due to the Bernoulli effect, and this draws liquid from a reservoir and into the air stream. Due to the great pressure difference between the gas and the liquid, strong forces arise and cause shearing of the liquid. In such a way, a polydisperse spray is formed, which is ejected through a narrow orifice at the end of the tube.

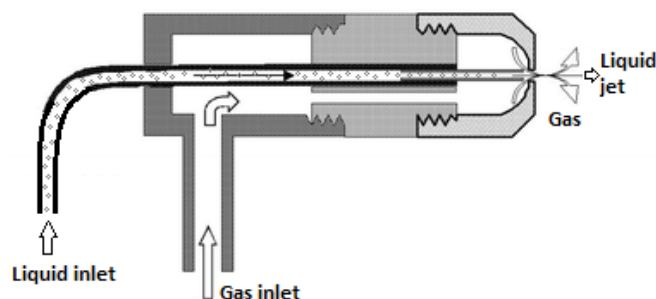


Fig. 1 A scheme of a pneumatic atomizing nozzle
(source: <http://pubs.rsc.org/>)

- **Vibrating orifice atomization**

This approach is based on Rayleigh's studies of laminar flow instabilities. An excitation electric signal is used to generate mechanical deformations in a piezoelectric material, at a frequency proportional to the signal frequency (Fig. 2). The contractions of the piezoelectric material cause an oscillating vertical movement of the orifice plate, which is constrained in the other 2 directions. By selecting the excitation frequency and orifice diameter, the desired droplet diameter with accuracy to a micron can be acquired [8]. The method can also be used to acquire solid particle aerosols by atomizing a solution and providing the conditions, necessary for the solvent to evaporate, leaving solid particles with the required diameter [14]. The aerosol, produced by this method, is a straight stream of uniform droplets, not a fog-like cloud, which renders the method useless for generating artificial fogs. Nevertheless, such precise droplet generators can be used for calibration and study of the dependence of the SPCE signal on the droplet diameter.

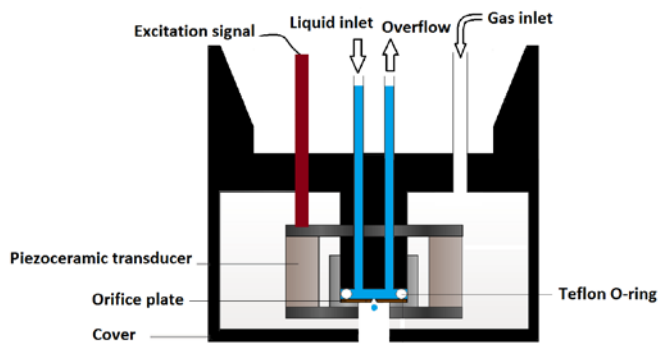


Fig. 2 A scheme of a vibrating orifice atomizer [3]

- **Spinning disc (top) atomization**

This method relies on centrifugal force for production of liquid droplets. A liquid is fed at a slow rate through a hypodermic needle on the top of a disc, or top, which is spinning at a very high speed. The liquid spreads over the disc's surface in an asymmetrical thin film, accumulating at the rim, until the centrifugal force, acting to discharge it, exceeds the capillary force, which holds the liquid together and a droplet is thrown off. The centrifugal force is equal to the product of the mass of the liquid in the drop and the centrifugal acceleration at the rim. The capillary force is proportional to the product of the surface tension of the liquid and the droplet diameter [15]. The scheme of the device is shown in Fig. 3.

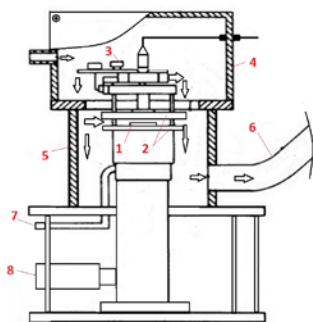


Fig. 3 Setup scheme of a spinning disc atomizer [16]

1 - spinning top; 2 - annulus extension rings; 3 - liquid feed needle adjustment mechanism; 4 - top cover and air inlet chamber; 5 - aerosol mixing cylinder; 6 - aerosol transit tube; 7 - compressed air supply; 8 - satellite particle exhaust tube

- **Ultrasonic atomization**

This technique for producing micron-sized droplets relies on ultrasonic vibration. The mechanical energy, applied from a piezoelectric crystal to the system, agitates the surface of the solution, thereby creating capillary waves, which break up into micron-sized droplets (Fig. 4).

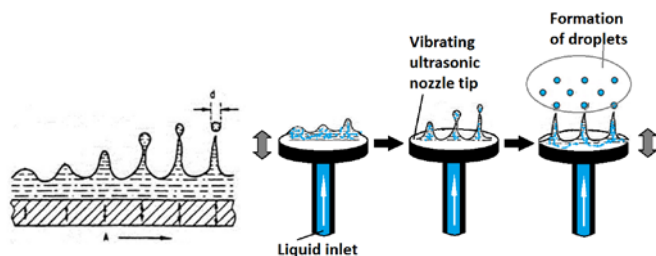


Fig. 4 – Illustration of the operating principle of a vibrating orifice atomizer

(sources: www.sono-tek.com ; www.activeultrasonic.com)

A particle-free air stream is passed over the solution to take away the generated airborne particles. The diameter of the primary droplets produced is a function of the frequency of vibration and the physical properties of the solution, i.e. surface tension and density. Compared to pneumatic atomizers, ultrasonic atomizers could produce monodisperse particles at a higher level.

Commercial nebulizers, used for medical purposes, often operate on this principle and are an economical solution. They are alternative means for aerosol generation, as they produce fine, monodisperse aerosols with high repeatability. The mean diameter of droplets, generated with these devices, is usually between 2 and 10 μm .

- **Electrohydrodynamic atomization**

This method is also called electrospraying and it could produce very fine monodisperse droplets from a liquid, under the influence of electrical forces. By controlling the liquid flow rate and the electrostatic potential between the liquid and the counter electrode, the droplets' diameters could be controlled in a narrow range – from several nanometers up to several micrometers. Different spraying modes can be obtained, depending on the strength of the electric stresses, relative to the surface tension stress on the liquid surface and on the inertia of the liquid leaving the nozzle (Fig. 5).

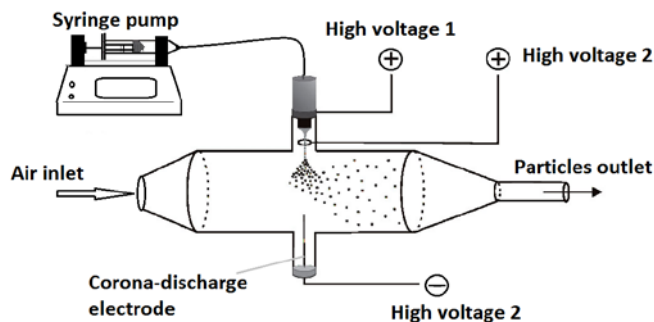


Fig. 5 Setup scheme of an electro-hydrodynamic sprayer [13]

- **Condensation**

In a volume of oversaturated vapour, droplets start to condense spontaneously. The rate of condensation, droplets concentration and size distribution strongly depend on the vapour pressure, the environmental temperature and the presence of condensation nuclei. A precise control over these is required, in order to obtain an aerosol with custom properties, which makes the practical application of this method rather difficult. Theatrical smoke and fog machines often rely on condensation, for example, by introducing vapourized oil droplets as condensation nuclei in a highly humid environment. A major drawback is that the droplets evaporate more quickly in a dry atmosphere [9]. There are two distinct types of aerosol generators, based on the condensation method [15]:

✓ **Sinclair-LaMer generator** – in this generator liquid droplets are formed in a narrow size range. It includes a nuclei source, a boiler, a reheater and a cooling chimney. The boiler, which contains a quantity of the material, which is to be aerosolized, is maintained at a constant temperature in the range 100-200°C. The reheater is maintained at a temperature exceeding that of the boiler by an amount, sufficient to ensure the complete vapourization of all aerosol material, which enters it. The nuclei are produced by an electric spark or by heating a wire coated with an inorganic salt, such as sodium chloride. A flow of clean air carries the nuclei into the boiler, where they are mixed with droplets and vapour produced by a second flow of clean air, which has bubbled through the boiler liquid. The droplets are vapourized in the reheater and finally, the vapour condenses on the nuclei in the Cooling chimney, at a relatively low rate, so the desired monodisperse aerosols are produced.

✓ **Rapaport-Weinstock generator** – This generator utilizes a nebulizer in place of a heater, as in the upper case, to generate initially polydisperse aerosols, which subsequently evaporate when passing through a heating column. The aerosol vapour condenses on the residue nuclei in the aerosol material in the cooling column and forms monodisperse aerosols. The substances used for generation of condensation aerosols are: DOP (dioctyl phthalate); esters of sebacic acid; stearic acid; menthol; rosin. These types of generators

are mainly used to produce test aerosols for instruments calibration purposes.

In practice, we tried to find the most efficient and economical aerosol generators, in regard to the purpose of our research. Various companies, that produce and sell customized nozzles for industrial applications, were contacted, in order to find a suitable option [18-36].

As mentioned above, medical nebulizers can generate monodisperse aerosols with high repeatability. Their cost is also fairly low, but due to the size distribution of the droplets they produce (mean diameter of 3-4 microns), the lifetime of the droplets in conventional lab environments is pretty short.

3. Measurements of droplet size distributions of selected sprayers

The droplet size distributions of some of these (*Gardena* and *Guala dispensing* trigger sprayers, *FERM* paint gun) have been acquired by an image analysis technique, which uses the *DepositScan* algorithm for *Image J* [37]. The results are given below.

- **“Gardena” Premium trigger sprayer**

The nozzle of this aerosol generating device can be adjusted to produce different pressures, thus generating various droplet sizes with distinctive density of the aerosols. 4 nozzle settings were tested, in the interval where the spray is a cloud of fine droplets. For each setting, 5 measurements were made, at a fixed range of 1 meter, in order to monitor the repeatability. There were no significant inconsistencies between samples exposed to aerosols, generated at identical nozzle settings.

On the first three graphs (Fig. 5), the accumulation of droplets with the minimum diameter is obvious. We have concluded, that there are many fine droplets with diameters below the minimum one, which is detectable by this technique. Information about the size distribution in this region cannot be acquired with the available equipment. Still, the curve peak is in the detectable area, and it gradually tends to move from 100 μm for the lowest settings (most tightened nozzle) to 200 μm for the lower pressure settings.

The Gardena Premium sprayer can be used to generate aerosols with relatively identical droplet diameter distributions. These are in the range 100-200 μm . A considerable amount of small droplets can also be found at higher pressure settings, but exact information of their diameter cannot be acquired by using the available equipment. By decreasing the pressure (settings 3-4), larger droplets are formed, and the spray has more polydisperse characteristics.

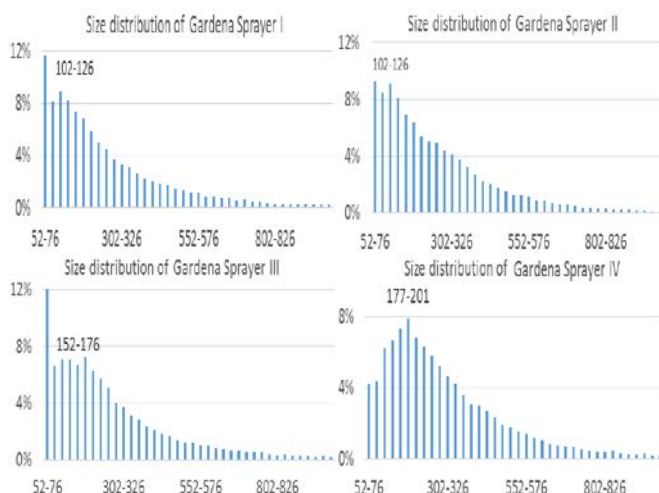


Fig. 5 Size distribution curves for 4 different nozzle settings of Gardena Premium sprayer. The droplet size in μm is depicted on the abscissa

- **“Guala Dispensing” TS1 series trigger sprayers**

We have received a free sample of 3 different types of nozzles for sprayers from *Guala Dispensing*. It is claimed, that they were able to generate aerosols with consistent and fixed size distribution. The median droplet diameter claimed was 65-70 μm for the green, 80-100 μm for the blue and 150-170 μm for the red nozzle. We have also tested them, in order to ascertain that the droplet diameter distribution is fixed and relates to the one claimed by the producer. 7 samples have been sprayed using each nozzle, from a fixed distance of 1 meter. The distribution graphs are shown in Fig. 6.

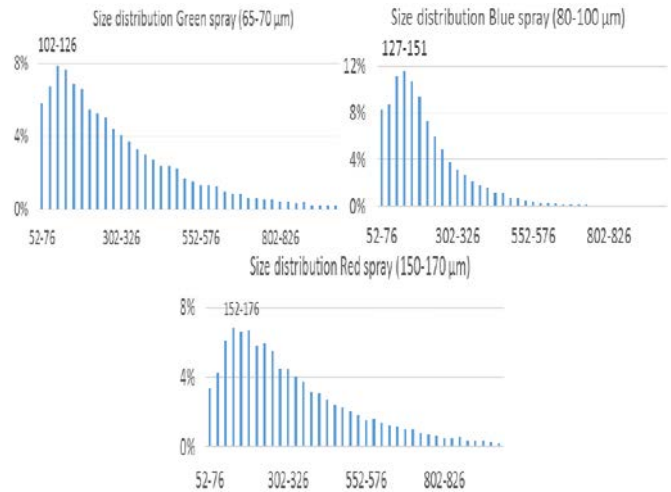


Fig. 6 Size distributions of different Guala dispensing sprayers. The sizes of droplets in μm are depicted on the abscissa

The data we acquired relates closely to the size distributions claimed by the company on their website. The curve maximum is usually greater than the given value for the nozzle. This was related to the inaccuracy of the image analysis technique, and the claimed distributions were taken into consideration, as we were informed by a company representative, that a laser diffraction analyzer was used for calibration and production control. Overall, each individual sample had almost identical distribution graph. The distribution of the blue spray nozzle had an exceptionally sharp peak, which means that the droplet diameters were concentrated heavily around the mean diameter. The size distributions of the other nozzles were less precise.

Therefore, we have concluded, that these sprayers can be used to efficiently generate fogs with predetermined and consistent size distributions, as it is claimed in their descriptions.

- **FERM SGM1008 electric paint gun**

We have also bought an electric paint gun for fog generation. As the pressure, created when pushing the trigger, varies, the droplet diameters may also vary heavily, depending on the force exerted. An automatic paint gun uses an electric pump, which ensures that the operating pressure is identical and constant for each aerosol, and respectfully the diameter distribution fluctuates less. The model, chosen by us, offers the possibility of adjusting the amount of water dispersed. Six different settings were tested, and 5 measurements were taken for each of them.

The size distributions for these aerosols are almost identical, with a sharp peak in the lower values – around 100 μm . The adjustment valve controls the amount of water dispersed, and therefore, the aerosol density is increased at higher number settings, while preserving the diameter relatively constant.

At higher number settings, the spray changes its nature almost instantaneously, which can be seen in the diameter distribution of setting VI, where 2 peaks are observed – one around 100 μm and the other around 350 μm . One possible explanation of this is that as the amount of water increases, droplets merge, thus forming larger ones, in addition to the finely dispersed. This effect is clearly visible.

Other settings have not been tested, due to the formation of even larger droplets in the stream, which are not usually found in fog. The diameter distribution data is shown in Fig. 7.

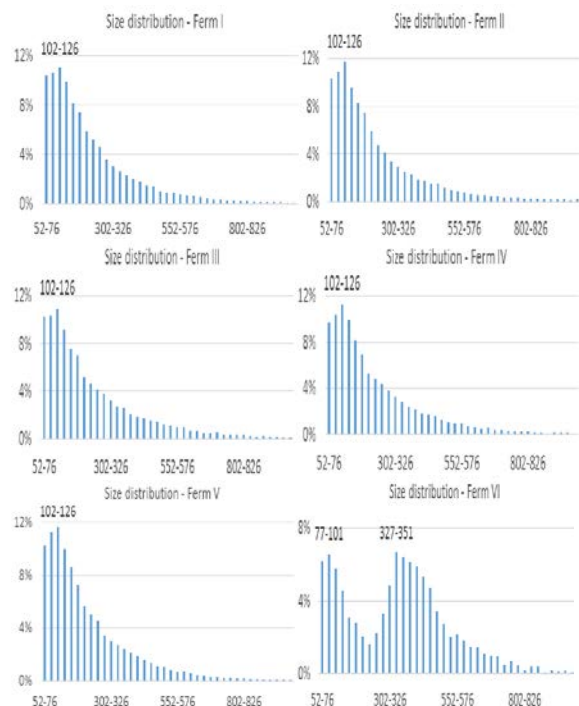


Fig. 7 Size distributions of sprays generated using the FERM Paint gun. The droplet diameter in μm is depicted on the abscissa

In summary, it could be concluded, that the FERM paint gun can be effectively used to generate identical aerosols with a dominant droplet diameter in the 100 μm region. At the same time, the number of droplets generated can be controlled via a valve at the back of the gun, which provides a method to test the SPCE signal dependence on fog density.

4. Conclusions

Methods for generating fogs with pre-set droplet diameter have been reviewed. Products of companies that produce such devices were studied. For the initial stage of our work, several simple devices for easy mist generation have been selected. The droplet diameter distributions of the fogs, generated with these devices, were investigated. It was concluded, that they generate fogs with repeatable and controlled droplet diameters.

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References

- Ivanov, O. & Konstantinov, L. (2000). Application of the photo-induced charge effect to study liquids and gases. *Surface Review and Letters*, Vol. 7, No. 3, 211-212, ISSN 0218-625X
- Abbate, A.; Rencibia, P.; Ivanov, O.; Masini, G.; Palma, F. & Das, P. (1995). Contactless characterization of semiconductor, using laser-induced surface photo-charge voltage measurements. *Materials Science Forum*, Vol. 173-174, 221- 226, ISSN 0255-5476
- V. I. Pustovoi, M. Borissov, O. Ivanov, Surface photo-charge effect in conductors, In *V. I. Pustovoi - Selected works (B. II. Пустовойт-Избранные труды)*, O. N. Krohin, (editor), Nauka, Moscow, 672-681 (2014)
- O. Ivanov, Sensor applications of field-matter interactions, In *Encyclopedia of Sensors*, Grimes C. A., Dickey E. C. & Pishko M. V. (editors), American Scientific Publishers, Stevenson Ranch, California, vol. 9, 165-197 (2006)
- O. Ivanov, Y. Mutaftchieva, and Ashok Vaseashta, Applications of an Effect Based on Electromagnetic Field-Matter Interactions for Investigations of Water, In *Advanced Sensors for Safety and Security*, A. Vaseashta, S. Khudaverdyan, (Eds.), Springer, 225 - 230 (2013)
- I. Davydov, O. Ivanov, D. Svircov, A. Odrinsky, V. Pustovoi, Contactless Spec-troscopy of deep levels in semiconducting materials: GaAs, In *V. I. Pustovoi - Selected works (B. II. Пустовойт-Избранные труды)*, O. N. Krohin, (editor), Nauka, Moscow, 711-715 (2014)
- C. J. Kahler, B. Sammler, J. Kompenhans, Generation and control of particle size distributions, 4th Int. Symp. on PIV (2001)
- B. Y. Liu, Standardization and calibration of aerosol instruments, *Fine Particles*, Elsevier, 57-110 (2012)
- C. Tropea, Springer handbook of experimental fluid mechanics: with 123 tables, Springer, Berlin (2007)
- V. P. Singh, Experimental Study of the Effects of Environmental and Fog Condensation Nuclei Parameters on the Rate of Fog Formation and Dissipation Using a New Laboratory Scale Fog Generation Facility, *Aerosol Air Qual. Res.*, 11, 140-154 (2011)
- S. N. Văjăiac, V. Filip, S. Ștefan, A. Boscornea, Assessing the size distribution of droplets in a cloud chamber from light extinction data during a transient regime, *J. Atmospheric Sol.-Terr. Phys.*, 109, 29-36 (2014)
- Clouds fog and water droplets, <http://www.atoptics.co.uk/droplets/clouds.htm>
- I. Gultepe, R. Tardif, S. C. Michaelides, J. Cermak, A. Bott, J. Bendix, et al., Fog Research: A Review of Past Achievements and Future Perspectives, *Pure Appl. Geophys.*, 164, 1121-1159 (2007)
- R. W. Vanderpool, K. L. Rubow, Generation of Large, Solid, Monodisperse Calibration Aerosols, *Aerosol Sci. Technol.*, 9, 65-69 (1988)
- P. S. Soni, B. Raghunath, Generation of aerosols: BARC nebulizer and others, Radioaerosol imaging of the lung, Benedict Press Korea, 24-39 (1994)
- H. W. Young, E. W. Larson, J. W. Dominik, Modified spinning top homogeneous spray apparatus for use in experimental respiratory disease studies, *Appl. Microbiol.*, 28(6), 929-934 (1974)
- T. Ciach, Application of electro-hydro-dynamic atomization in drug delivery, *Journal of Drug Delivery Science and Technology*, 17(6), 367-375 (2007)
- BETE Spray Nozzles, <http://www.bete.com/>
- Cerbide, <http://www.cerbide.com/>
- ANEST IWATA Corporation, <http://www.anest-iwata.co.jp/english/index.html>
- FUSO SEIKI homepage, <http://www.fusoseiki.co.jp/home-E.html>
- Air Blow Equipment Development and Sales. - GA-REW Co., Ltd., <http://www.ga-rew.com/en/index.shtml>
- Danfoss Group Global, <http://www.danfoss.com/Home/>
- 3 μm Fine Particles by Disposable Sprayer - Nozzle Network Co., Ltd., <http://www.nozzle-network.com/products/dispospray.html>
- CY spraying & purification technology limited, <http://www.cycospray.com/index.html>
- Zidecan, <http://www.zidecan.com/>
- Wilson Spray Nozzle, <http://www.wilsonspraynozzle.sg/>
- Normist, <http://www.normist-tr.com/menu.htm>
- Apel Laser, <http://www.apellaser.com/>
- The Fogmaster Corporation, <http://fogmaster.com/index.htm>
- DegreeC, <http://www.degrec.com/en/>
- FMP technology GMBH, <http://www.fmp-technology.com/>
- EXAIR Corporation, <http://www.exair.com/en-us/Pages/default.aspx>
- Hangzhou Success Ultrasonic Equipment Co., Ltd, <http://www.ultrasonic-weldingmachines.com/>
- Tracer Particles - PALAS, <http://www.palas.de/en/application/tracerparticles>
- Spraytechs, <http://www.spraytechs.com/index.php/en/>
- H. Zhu, M. Salyani, R.D. Fox, A portable scanning system for evaluation of spray deposit distribution, *Comput. Electron. Agr.*, 76, 38-43 (2011)