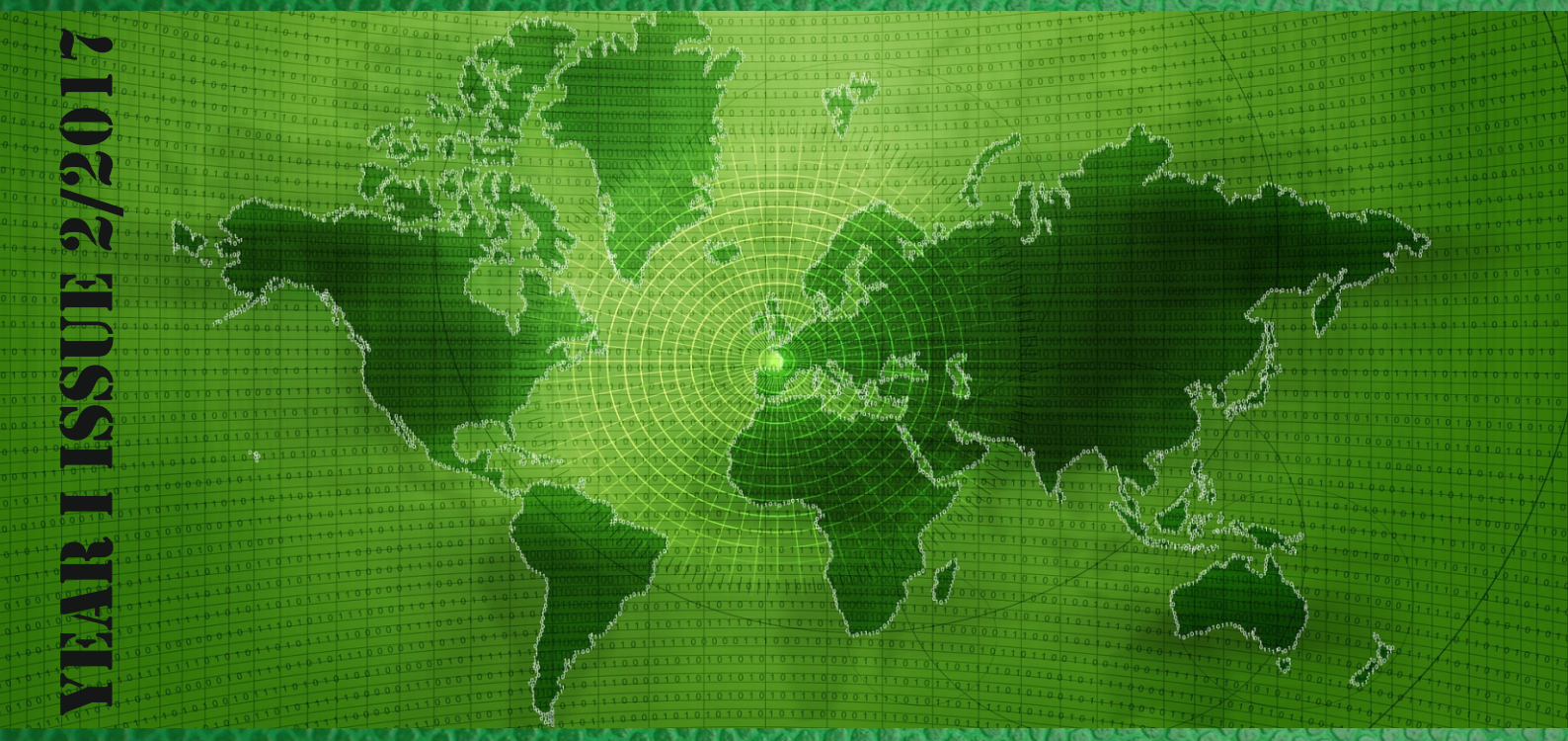
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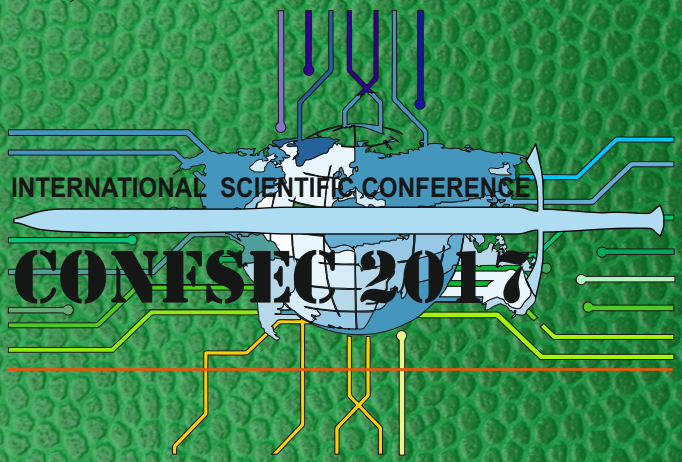


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NON-LETHAL WEAPONS AS PART OF THE REVOLUTION IN MILITARY AFFAIRS

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Abstract: *The history of war is marked by rational use of technology to increase the lethal force of weapons. In the 21st century we are observing a turning point in the dynamic development of weapon technology, strategies, policies, organizational structure, etc., known as "Revolution in Military Affairs" (RMA). One of the decisive features of this revolution is the reduction of casualties and collateral damage. The purpose of this paper is to examine the role of non-lethal weapons (NLWs) in current and future conflicts in terms of the most popular theories of RMA and the modern visions on the 21st century wars.*

Keywords: NON-LETHAL WEAPONS (NLWs), REVOLUTION IN MILITARY AFFAIRS (RMA)

"A Revolution in Military Affairs (RMA) is a major change in the nature of warfare brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and operational and organizational concepts, fundamentally alters the character and conduct of military operations." – Andrew Marshall

Introduction

The history of war is marked by the rational application of technologies aiming to increase the lethal force of weapons. However, the present-day reality and the modern technological and military organizational development during the last several decades led to rethinking the future of war.

It is well known that the nature of the war and the outcome of it are determined to the greatest extent by the level of weapon technology. These technologies have undergone significant changes in recent years - unprecedented accuracy of weapons delivery, surveillance and intelligence systems providing extremely detailed information and systems which allow for the rapid use of this information. "Such changes in the quantity and quality of weapons of war are considered by policy and academic circles as revolutionary and transformative". [1] The Revolution in Military Affairs (RMA) concept is based on the assumption that technological innovation process has the ability to form revolutions in military affairs in which technology is the main factor for transforming the basic rules of war.

Regardless of the discussions about what exactly constitutes a "revolution in military affairs", there is agreement that a technological push alone is not enough to bring about a real RMA. "It should be stressed that how warfare is conducted is not based solely on technology at the disposal of the belligerents" [1] - rather "there is a trialogue among what technology permits, what politics requires, and what society allows". [2]

Many analysts consider that revolution in warfare is taking place when the society is transformed, evoking changes at every level of its military structures and breaking the balance of military power in the world. "Change in the nature of warfare can also arise from major shifts in political-economic-societal structures, such as the rise of the nation-state or industrialization. When the resultant shifts, whatever their cause, prove fundamental, a "revolution in military affairs" (RMA) occurs". [3]

"The concept of a "RMA" has become such a pervasive topic of discussion among security experts that it has now acquired the shorthand of its initials - RMA - as representation of a wide range of loosely connected ideas and approaches in security policy. There is controversy over whether there has been, is now, or will be a RMA, or what constitutes a change in security that might deserve such a name. [4] Many analysts are convinced that a revolution generated by both technology and a dramatically altered geopolitical environment is taking place today, others support the position that changes now occurring are significant and essentially growing but still insufficient to provoke a RMA.

An inevitable consequence of both technological advances and new geopolitical, economic and social environment is the development and use of non-lethal weapons (NLWs). At present, when the avoiding civilian casualties and minimizing collateral damages in armed conflicts are being to become mandatory, NLWs are considered as part of the RMA which have the potential to dramatically reshape the nature of warfare.

Most popular theories of RMA

According the theoreticians, the revolutions in military affairs are not a new phenomenon - the history has documented several such revolutions.

The beginning of current thinking on military revolutions was set in Russia in the early 1980s by the Soviet marshal Nikolai Ogarkov who predicted a "military technical revolution" that would drastically increase the capabilities and lethality of conventional weapons.

At the end of the Cold War various scientists and military organizations (mainly in the United States) created theories of understanding and describing ongoing conflicts and those that could be expected in the future.

The PMA theories are generally based on two main approaches. The first is mainly focused on changes in states and the role of organized military in the use of force. It is based on global political, social and economic factors requiring a very different type of military and organizational structure to apply force in the future. The second approach puts emphasis on the evolution of weapons technology, information technology, military organization and military doctrine among advanced powers. "It identifies the basic combination of required force assets, namely: Command, Control, Communications, Computers, Combat Systems, Intelligence, Target Acquisition and Reconnaissance (C5ISTAR). This approach also incorporates other sophisticated technologies such as unmanned aerial vehicles, nanotechnology, robotics, and biotechnology". [5]

Based on the hypothesis that dramatic changes in society and technology over the last 50 years will inevitably lead to another military transformation, the existing literature offers different models of explaining the relationship between technology, the military, and the society, that creates transformations in military affairs.

The most popular theories of the RMA are briefly discussed below in order to highlight the role they attach to non-lethal weapons in the context of modern and forthcoming armed conflicts.

Theory of "Fourth-Generation Warfare"(4GW)

This (the most popular) theory was developed by William S. Lind and several Army and US Corps officers in 1989 and re-evaluated in 1994. According to it, the basis of any subsequent generation of war is either technological (introduction of new

technologies) or ideological. The theory assumes that generations do not replace one another but overlap and even coincide.

The beginning of the first generation war is considered to be 1648 when the Westphalian Peace Treaty was signed, which ended the European religious wars that began after the Reformation. This generation, as well as the second one (since 1815), is based on technology, while the third (since 1918) is based on ideas.

Fourth generation wars are defined as either related to ideas or technology. According to critics such a division leads to an inaccurate way of modeling wars. “In this context, military revolutions are perceived as tactical, potentially operational, innovations in combat operations that give decisive advantage to the one who first adapts to them. For this reason, the current military revolution can be regarded as comparable in scope to that which took place in the 1920s and 30s of the 20th century”. [6]

Upcoming 4GWs are supposed to be firmly based on ideas, especially non-western. "Terrorism that surrounds traditional military forces and targets directly the civilian population of a nation is perceived as a major component of this war". [7] Viewing the terrorism as a component of the 4GW, this author claims that the army requires armaments and training with NLWs and puts an example of a real anti-terrorist operation illustrating the "viability of non-lethal weapons and the requirement of introducing them as weapons for fourth-generation wars".

To clarify the understanding of his own theory, and in the spirit of the concept of non-lethality, Lind pointed out that “One of the key success factors in 4GW may be "losing to win" [sometimes to win you first have to lose]. “Part of the reason the wars in Afghanistan and Iraq are not succeeding is that our initial invasion destroyed the state, creating a happy hunting ground for Fourth Generation forces. In a world where the state is in decline, if you destroy a state, it is very difficult to recreate it”. [8]

Theory of “Third-Wave War“

This theory (1993) belongs to the famous American futurist Alvin Toffler, exploring the human progress related to society and war as a development of three waves ("super-civilizations") over the course of history. According to this theory, a military revolution arises only when a new civilization arises, challenging the old one; when the whole society is transformed, forcing its armed forces to change at every level at the same time - from technology and culture to organization, tactics, doctrine and logistics. According to this theory, when this happens, the military's relationship with the economy and society is transformed, and the balance of power on Earth is ruined.

The first wave (after 8000 BCE) was mostly agricultural, so wars are leading to conquest and retention of territories. The second wave (after 1690) was industrial - with a war focusing mainly on weakening the enemy, in order to spend its capacity to feed, dress and equip the army.

The third (current) wave is based on knowledge and reflects an information age in which the war seeks to destroy the enemy's means of gathering, processing, storing and disseminating information. According to this perception, the influence of the RMA we are now witnessing is considered as significant as that of the French Revolution of the late 18th century.

Precision-guided munitions, robots, non-lethal technologies, target-oriented weapons and computer viruses are considered as the Third Wave War attributes. [1, 6]

Theory of “Fourth-Epoch War“

The theory was published in 1994 by Robert Bunker and is based on the division of Western civilization into four eras. Each epoch is composed of one or more energy cycles, reflecting a corresponding warfare model based on the experimental and institutionalized use of a given form of energy (e.g., human, animal, machine, engine, post-engine). According to it “the current RPMA [Revolution in Political and Military Affairs] represents an inter-epochal military revolution that will place the survival of the current dominant polity form, the nation-state, in considerable doubt and, as a result, will ultimately give rise to a postmodern form of political community. This military revolution, now only in its early stages, is viewed as being equal in magnitude to that of the European Renaissance”. [6]

This theory assumes that two initial war models based on post-mechanical energy sources are being developed: western (high technology war) and non-western (a mix of terrorism and low-intensity conflicts), largely resembling the idea-based 4GW. [6] It takes into account the growing urbanization of developing countries around the world, leading to a reduction in the technological superiority of the West due to the limiting urban environment and the need to distinguish between fighters and civilians.

The theory recognizes that both tactical and operational changes, along with changes in the economic, political, social and military structure, will occur. The current RMA is perceived as equivalent to the European Renaissance. Therefore, a change in the energy base of Western civilization, along with the accompanying change in the essence of the political-military force and the deinstitutionalization of the political violence (i.e. the loss of the national state monopoly in the war), is envisaged. As a result, corresponding increase in military actors (as terrorists, guerrilla parties, local military leaders, private armies, drug cartels, and multinational corporations) are expected, questioning the political legitimacy and hence the survival of the nation state.

"Advanced technology warfare represents the rise of new military technologies such as precision guided weapons, information warfare, nonlethal weaponry, robotic war-fighting units, and directed-energy weaponry." [6] This theory sees the introduction of NLWs on the battlefield as significant as the introduction of gunpowder at the time of the European Renaissance.

***

From the way these theories (as well as other popular theories of RMA) attempt to explain the transforming nature of war, it can be seen that they all support the general view that both the present and the future war are unconventional in nature. In addition, as mentioned in [6], all theoreticians are trying to explain the new face of the war in which efforts are made to circumvent the power of the enemy.

As these theories precede the formal adoption of the non-lethal policy by the USA, it may be presumed that they may have contributed to a somewhat (and perhaps to a significant) extent to the doctrine formulation and acceptance.

Contemporary views on the role of non-lethal weapons in the RMA

The most contemporary theorist agree that while military revolutions are uncontrollable events driven by their own inertia, the revolutions in military affairs are periods of invention and progress and result from will and efforts to transform the war. They also share the view that the ultimate goal of a RMA is to develop new means to gain advantage over an enemy.

It is generally accepted that the current RMA is characterized by four types of changes: extremely precise, stand-off strikes; dramatically improved command, control, and intelligence; information warfare; and non-lethality. The most theories admit that the reduction of casualties and incidental damage associated with military operation is determining feature of the current RMA. To a certain extent this aim can be achieved by precise conventional strikes. According to [5] “even more radical change may be possible through non-lethality”. Presenting a comprehensive model of the RMA, based on previous RMA research, which considers the political, strategic and military situation and technological development at the beginning of the second decade of the 21st century, [9] claims that „nonlethal weapons have a potential to lie at the core of the next RMA“.

Some specialists consider that in the context of modern military operations the use of non-lethal weapons can have a strategic multiplier effect by avoiding incidental damages to property and

infrastructure, minimizing civilian casualties, overcoming the negative perception of the state armies, limiting the opportunities of the enemy propaganda and minimizing the cost of continuous infrastructure reconstruction.

After the attacks of 11 September 2001 new concepts describing the war characteristics in the current geopolitical environment were created using terms such as "hybrid war", "hybrid challenges", "asymmetric war", "combined warfare", "unlimited war", "low intensity conflicts", etc. Regardless of some new elements introduced by these concepts it seems that they are essentially not differ from the pioneering theories of RMA in their views that the modern war will be non-conventional in nature.

Most present-day wars have become irregular or asymmetric conflicts between states and non-state actors. The environment in which the military forces will operate in the future, and in which the adaptive "opponents will continually seek new opportunities", according to [10] will be extremely dynamic as a consequence of:

- Expansion of information systems networks (social, economic, political, military) increasing the opportunities for competition, respectively the influence of some regional forces;
- Globalization trends which will lead to rise of new forces, population changes, competition for natural resources, impact on governance, global sense of insecurity, emerging and disappearing coalitions, alliances, partnerships and new national and transnational actors, which will induce changes in the international strategic environment;
- More and more frequent military operations (which may include both resolving humanitarian crisis and conducting war operations) on urban and other complex terrains.

The wars which result of such environment "are not high-technology duels between conventional forces, but struggles that pit governments and their allies against opponents that fight along religious and cultural lines and use their own internal divisions and populations as weapons". [11]

The real RMA, according to [11], is forcing modern states to use the advances in military technology to concentrate on minimizing civilian casualties and collateral damage rather than destroying the enemy. In some cases it creates military laws designed for very different types of combat against political and propaganda arsenal owned by non-state actors and states that use asymmetric means of fighting. The abilities to selectively attack the enemy with minimal civilian casualties and incidental damage should be improved in the direction of better integration between military and civil approaches to war and should be focused more on the strategic goals than on tactical victories.

The non-lethal capabilities and the new methods of employing the force can significantly change the conduct of warfare and crisis resolving. "While the nature of war will remain a violent clash of wills between states or armed groups pursuing advantageous political ends, the conduct of future warfare will include combinations of conventional and unconventional, lethal and nonlethal, and military and nonmilitary actions and operations, all of which add to the increasing complexity of the future security environment". [10] This document recognizes the need of full spectrum force which is able to minimize noncombatant fatalities, permanent injury, and undesired damage to property and environment; maintain force protection, reinforcing deterrence; and expand the range of options available to commanders. "All of these imperatives demonstrate a clear need for nonlethal weapons, even in conjunction with lethal weapons, to achieve a decisive outcome". [10] However in fact, a small number of NLWs involving new technologies are widely deployed in military forces and the available non-lethal capabilities have limited application in the military operations.

The analyses show that initiation of a modern RMA, which includes the concept of non-lethality, depends on the presence and interaction of several key factors.

Technological progress had played a vital role in almost any RMA in the past. Although many military experts and official documents formally recognize that NLWs have a potential for successful use within the full spectrum of military operations, it seems that not everyone in the military circles is truly convinced of the NLWs effectiveness at the battlefield. Some unrealistic operational requirements of the military towards NLWs (placed in view of the own forces protection), especially concerning the range, raise the bar so high that almost none of the existing NLWs can jump over at the current stage of development and even if further significant improvement of the delivery systems is achieved. Given that non-lethal technologies reach a level of development that meets the military requirements, they still could play the role of catalyst, but could not in itself initiate a RMA.

Another stand out key factor is the way of thinking based on a framework of doctrines, concepts and strategic culture. Using the model presented in [9], the same author has analyzed the current status of NLWs within militaries in [13]. Although the common opinion that a conventional war is unlikely to happen in the future, the author has found that the military continue to prepare for such a war and "the main emphasis is on traditional lethal weapons". Despite the fact that "military industries around the globe have already clearly demonstrated the ability to integrate non-lethality with and within lethal systems" [13], "due to the erroneous perceptions of NLW's inapplicability on the traditional battlefield, militaries deny their integration with existing weapon platforms and employ very limited capabilities from the law enforcement field. As long as this situation continues, the full potential of NLW will remain unexploited and the RMA of NLWs will be delayed". [14] But there are still reasons for optimism in this respect: "Military organizations begin to understand that the achievement of a comprehensive victory demands support from the local population; and therefore, harming civilians, in most cases, will increase their involvement against the military and delay the successful end of operations". [13]

The third key factor is the political will without which no RMA can be realized. Analyzing the future of the NLWs military employment [13] notes that "Political leadership is not stressed enough (domestically or internationally) to demand fundamental changes from their military organizations. Consequently, under insignificant political pressure, military organizations choose to adopt their existing capabilities (precision strikes, selective weapon systems, strict the rules of engagement, etc.), rather than employ NLWs". The author concludes that the future of the NLWs in military operations is not entirely in the power of politicians, but without politic pressure the process of the NLWs adoption can be very long one.

In turn, the pressure that the politicians would eventually exert on the military depends on the pressure exerted by the society on the politicians. Claims that "the preservation of human life is a commonly accepted fundamental value of the 21st century, especially in the western societies", look implausible. Indeed, the efforts of the humanists have led to significant progress in this respect. Although violence is repulsive and unacceptable to any normal person, facts show that for most people, even in these societies, such aspiration in practice does not extend beyond their own and their relative (and, possibly their compatriots) lives. Obviously, the man has to go a long way until he truly adopts the idea that the lives of others are just as valuable as his. In order to trigger the processes related to the emergence of the next RMA, a revolution (or at least significant evolution) in the human way of thinking must first happen.

CONCLUSION

The theories concerning the current Revolution in Military Affairs has been the focus of academics and military analysts, trying to define the role of technology in transforming military affairs during the past three decades. [11]

Part of debates is related to the issue whether a RMA is taking place at present or a RMA is forthcoming. According to some, now this question "seems to be largely an issue of semantics, especially after the launch of an all-out war on terrorism, which is likely to remain the most salient transformation of military affairs for some years to come, if not decades into the future". [4]

In the earlier debates concerning the NLWs a number of theorists, military leaders and strategists have come to an agreement that in the next decades the political and military value of emerging non-lethal capabilities will outweigh that of lethal weapons, and that NLWs promise a real technological breakthrough for the military strategy and the war in the 21st century. However, it seems that the initial enthusiasm in this regard has cooled in recent years.

Some analysts believe that the current revolution in military affairs seems to have at least two stages. According to [5], in the drive to limit casualties, the first stage will be application of standoff platforms, stealth, precision, information dominance, and missile defense. The second may be robotics, non-lethality, pyschotechnology, and cyberdefense.

Unfortunately, it may be that the expectation that NLWs will lead to a revolution in military affairs in the foreseeable future is too optimistic and premature. Considering the factors on which the use of non-lethal weapons in current and future armed conflicts depends, it is difficult to disagree with the conclusion made in some analyzes, that at this stage NLWs have no feasible future in this respect. Humanists should not only continue to make efforts, but also have to increase repeatedly the efforts to change the nature of war through non-lethality, albeit in the second phase of the modern revolution in military affairs.

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ECOLOGICAL AND TECHNOGENIC SAFETY OF THE ECOSYSTEMS OF THE AGRARIAN SECTOR OF UKRAINE

Эколого-техногенная безопасность экосистемы аграрной сферы Украины

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Abstract: *The article substantiates the urgency of the eco-anthropogenic component of national security both of the state as a whole and of its regions. The types of interaction between society and the environment are determined. It is suggested to consider the ecosystem as a complex combination of flora, fauna and dynamics of natural systems and processes, which interacts with social institutions and power structures. The concept of environmental imbalance is formulated as a real threat to the disruption of life support mechanisms and the creation of obstacles to the economic and social development of the country, improving the quality of life of the population. The main threats to the technogenic security of the country are identified*
KEYWORDS: ECOLOGICAL, TECHNOGENIC, SAFETY, AGRICULTURE, ENVIRONMENT, ECOSYSTEM

1. Introduction

Over the last three decades all over the world gradually got used to numerous global environmental problems and threats. Environmental issues have become synonymous with a global outlook [1]. Defining globalization through social processes that interact and involve inter-regional and transcontinental measurements, it is necessary to consider four typical properties in the study of environmental problems, namely:

- not all environmental problems as not all reactions to environmental threats are global;
- ecosystems are a complex combination of flora, fauna, and dynamic natural systems and processes that interact with social institutions and power structures;
- are the main processes of environmental degradation and social impact on them;
- to understand environmental degradation and its scale means understanding the construction of human perception models of global environmental change [2].

Today the importance of environmental threats appears to be a determining and guiding factor in the development of international relations and changes in the geopolitical situation. Threats of natural and technogenic areas in the short term can become dominant. These threats are able to create and enhance a number of other threats, which are characterized by extremely high gradient enhancement factors and the defeat of the population, the environment at the time of their origin and development [3].

Excessive use of natural resources by man has led to the deterioration of the ecological situation. The main consequence of this is environmental pollution, changed environmental conditions. The growth of economic demand for natural resources creates problems of their preservation and reproduction, which today are transnational. The world community has a positive experience compliance with environmental and technological safety. International environmental organizations have carried out practical activities aimed at ecological improvement of economic relations in national and international scale.

2. Ecological and technological safety as a scientific problem

The processes of globalization, increasing disparities in economic development and resources between economically developed and underdeveloped countries, the growth of population and migration of the population increasing the threat to humanity in the long run due to the emergence of impulses disruptive of conflicts on a world scale in the form of environmental hazards [1]:

- the destruction of the ozone layer of the atmosphere and the manifestation of global climate change;
- pollution of the oceans;
- the increasing number of the world's population;
- limited access to the world's resources and disproportionate use by countries of the world;
- the civilization confrontation between the Christian and Muslim world;
- the establishment and functioning of the global terrorist network;
- the proliferation of nuclear, chemical, biological, geophysical, aerospace, psychotropic, environmental weapons and technologies of mass destruction;
- the formation of new centers of power, opposition and struggle between them for leadership;
- the emergence of a global social outbursts and protests;
- the growth in consumption and resource scarcity and energy security.

Environmental weapons include almost all types of ionizing and electromagnetic radiation, heat and light, noise, other acoustic and seismic vibrations, shock waves, thermal processes, the formation of zones of high pressure, vibration, dirt and the like. The main danger of the use of environmental weapons is the unpredictability of the magnitude of the consequences of their impact on the ecological balance of the environment. Therefore, allocate following groups of the negative consequences of military action in the context of international environmental security:

- the withdrawal from the market for a long period of land;
- direct destruction of the environment;
- the maintenance for a long time threats to the local population from bombs, mines and shells that did not explode;
- reallocation of resources from civilian production and environmental protection;
- the bomb targeted environmentally hazardous sites, which are destroyed and the destroyed industrial zone, growth of the lesion environment that leads to the fact that local military action acquire the features of a large-scale ecological warfare.

The future combat capability of the powerful military of any country will be determined not only potential weapons, but also environmentally friendly features, information modifications in the transformation of military technology, aimed at combating global threats to the peaceful existence of mankind.

Household productive human activity involves several types of interaction of society with the environment. The first is the human impact of society and its production, when in the process of economic and industrial activities on the natural environment is only used for the dispersion and distribution of industrial and domestic waste, without any purposeful action to transform nature. To the second type of human interaction with nature include the impacts associated with the effective use of natural resources, environmental conditions and possibilities of the biosphere. The third covers the processes and activities aimed at the use of natural conditions and resources through the implementation of large-scale transformations of the natural environment and ecosystems [4].

The analysis of literary sources showed a variety of definitions of the environmental component of national security. The environmental component of the national security means the protection of man and nature from adverse environmental factors. But this is only possible when the environment is a new system that combines natural, industrial and social system in which meets certain requirements: sanitary-hygienic, aesthetic and material needs of human; the conservation of the natural resource and environmental potential of natural ecosystems; maintaining the ability of the biosphere as a whole to self-regulation.

Environmental safety is usually regarded as a system of actions aimed at the protection of society from threats caused by natural disasters and man-made disasters. We believe that this approach is rather simplistic because it doesn't reveal the peculiarities of nature and the relationship of the ecological state of the environment with security companies. The greatest risk to the environment, and through feedback and for society, causing pollution of the natural environment. Often the pollution of the environment may be small, but there is a direct threat to human health or degradation of the ecosystem.

In developed countries, the nature and scope of policy the preservation of the environment due to the limits match the interests of the environment with the material interests of the economic system. The use of a certain adaptation of experience gained in Ukraine, its expansion will contribute, in our opinion, achieving a balanced relationship between economic needs and the environment.

Environmental problems have put humanity before choosing the further development, a growth-oriented agricultural production based on efficient use of natural resources, primarily land. After all, the land as national wealth is the basis for solving many socio-economic problems and food security of the country. Intensive agriculture on a global scale led to the emergence of a number of global challenges – socio-economic, demographic, climatic and the like.

National security is considering including the global problems of technogenic safety in the sphere of civil and defense purposes as one of the most important spheres of life support of man, society and the state, as well as the environment.

3. The state environmental and technological safety in Ukraine

Excessive industrialization of the cities of Ukraine and of the objective difficulties of the transition period to a market economy led to a gradual increase in the number of accidents and other emergency situations. Places of greatest concentration of population of Ukraine are the areas with the most threatening state of the natural-technogenic safety. Therefore, we believe that the definition of the basic parameters and peculiarities of natural and technogenic component of national security is one of the conditions of development of regional development plans to ensure life safety of the population.

The complexity and scale of the problem of security of the population and the environment in an emergency situation, the necessity of its solving by public authorities is due to the fact that in nature, technology and society there are many sources of risk, threats and different threat factors. In Ukraine, still lack the concept and the program environmentally sound development, in particular, the mechanism of rational use and protection of land resources [5].

In modern conditions, a special feature of the ecological state of Ukraine is that acute local ecological situation is exacerbated by the major regional crises, in particular long-term environmental, economic and social consequences, including the Chernobyl disaster. Ecological imbalances pose a real threat of infringement of life-support mechanisms and impede economic and social development hampering the improvement of the quality of life of the population of the state.

Low technical level of existing sewage treatment plants, and high degree of wear, determine low efficiency cleaning systems, which is reflected in particular in the gap reduce the flow of contaminants into the environment from the recession. As a result, in recent years in reducing gross pollution is increasing, their proportion per unit of output. A feature of the country is also a high level of pollution of some regions of toxic and radioactive substances. He remains the highest in the world.

So, in 2014-2015 technogenic load on environment somewhat softened (tab. 1), but the ecological situation in the environment, as vitally important environment for human existence, is still quite difficult.

Table 1

Indicators of emissions of polluting substances in 2010-2015 in Ukraine

Indicators	2010	2011	2012	2013	2014	2015
Emissions of polluting substances in atmosphere, thousand t	6878,0	6677,3	6821,1	6719,8	5346,2	4521,3
Discharge of polluted wastewater into surface water bodies, million m^3	1744	1612	1521	1717	923	875
Waste of I-III hazard classes, thousand t	1659,8	1434,5	1368,1	923,8	739,7	587,3
Spending on environmental protection, mln. hrn	10366,6	12039,7	13924,7	14339,0	13965,7	16915,5

The main air pollutants in the country are the enterprises of processing and extractive industries (respectively 33% and 21% of harmful emissions) and producers of electricity, gas and water (37 %). The main stakeholders in the country consumed 7.1 billion m3 of water, 2.7 billion m3 (27.6 %) less compared to 2010 and 4.2 times less than in 1990, compared with 1990 volumes of water directed to agricultural use has decreased 12 times.

The most acute problem of disposal and recycling of hazardous waste in Zhytomyr, Zaporizhia, Kharkiv, and Cherkasy regions, where the share of processed and treated waste was less than 10 % of the total number of educated.

Therefore, it is important to improve the ecological state of the natural environment with forests (the state refers to the low forest cover countries in the world – table. 2). The whole area of

Table 2

The lands of Ukraine in 2015

The structure of the land Fund	Area, thousand ha	Percent of total area
All lands	60354,9	100,0
agricultural land	42726,4	70,8
forest and forest covered area	10633,3	17,6
built-up land	2552,9	4,3
earth under water	2426,4	4,0
open wetlands	982,3	1,6
other lands	1033,8	1,7

the forest Fund of Ukraine is 10.6 million hectares. Total forest cover of the territory of Ukraine amounts to only 17.6 %, while Japan reaches 68%, Finland and Sweden – 57, Canada – 32, US – 33, Germany – 26,9, France – 24%.

4. Threats and risks of ecological safety of agricultural sphere of Ukraine

In Ukraine in the agricultural turnover is about 80% of the arable land, whereas in countries with intensive development of agriculture is much lower (Germany: 67%, France 61%, United States – 43%, UK 35%). The high proportion of tilled soil is a negative phenomenon for our country, for two reasons: first, it promotes the loss of humus (according to the Institute of soil science and agricultural chemistry of UAAS, the annual loss of humus per 1 ha of arable land amount to about 1 t); second, the evidence predominantly extensive agriculture and low level of agricultural production [6].

According to the UN, the Ukrainian soil has the opportunity to feed 100 million people. This can be achieved with effective management. The current state of use of agricultural land is a critical threat. Every year from the fields is transported to 600 million tons of fertile soil over the last 30 years the average content of humus dropped from 3,5% to 3,2%, dramatically increased the acidity and salinity, the area of land exposed to erosion, increasing annually 80-100 thousand hectares and made up one-third of the arable land. Radionuclide contaminated over 3.5 million hectares of farmland and nearly 70 thousand hectares are withdrawn from circulation. The black soil is extremely contaminated with pesticides and nitrates, the average concentration of pollution per 1 sq km is 6.4 times higher than in the US and 3.2 times higher than in the countries of the European community [7].

Thus, the modern use of land resources does not meet the requirements of environmental management. Brought ecologically valid ratio of the area of arable land, natural grassland, forest and water areas that adversely affect the sustainability of the agricultural landscape, causing the degradation of soil and is a real threat to economic security in the agricultural sector.

Evaluation of indicators of ecological safety of agriculture of Ukraine for 2010-2015 are shown in table. 3.

Ukraine is the poorest of the water resources of Europe and is one of the regions with significant anthropogenic pressures on water sources and lack of sufficient fresh water. The coefficient of purity of the water used in agriculture is very low – 0,01. The coefficient of water use efficiency is also low, at 0.1, besides, tends to decrease. Under the influence of chemicals in agricultural production, land drainage, water resources are undergoing significant changes. In river basins reduces the sustainability of natural landscapes, disturbed the balance in ecosystems and degrade surface water quality, with the result that rivers have lost their natural self-cleaning ability.

Pollution, reduced biodiversity, under irrigation with water of poor quality occurs salinization, reduced crop yields, with the watering of the cattle with contaminated water by 40-70% reduced productivity in livestock, deals heavy damages and fisheries where the commodity deteriorates the quality of the fish die young and forage organisms [10].

About the deterioration of the ecological and technological status is confirmed by the fact that the area of agricultural land, which were made of mineral fertilizers, is almost 37 times larger than the area of land fertilized with organic compounds.

Now most countries are trying to reduce the negative environmental impacts of farming, translating agricultural production on organic principles of growing of crop production. Ukraine has also introduced organic farming.

According to the Federation of organic movement of the area of certified agricultural land in Ukraine under cultivation of organic products amounts to more than a quarter of a million hectares, and the state ranked 21st among the world leaders of the organic movement [11].

Table 3

Indices of ecological safety of agriculture of Ukraine

Indicator	2010	2011	2012	2013	2014	2015
The coefficient of purity of the water used	0,01	0,01	0,01	0,01	0,01	0,01
The coefficient of water use efficiency	0,11	0,10	0,09	0,10	0,10	0,09
The coefficient of ecological stability of land use, points	0,40	0,40	0,40	0,39	0,39	0,40
Coefficient of anthropogenic load	3,53	3,52	3,52	3,53	3,53	3,53
Coefficient of atmospheric pollution	8,20	8,70	8,00	7,70	7,70	7,69
The level of tilled soil farmland	78,1	78,2	78,3	78,3	78,3	78,4
The ratio of capital expenditures on environmental protection	0,51	0,57	0,24	0,35	0,35	0,33
The ratio of current expenditures on environmental protection	0,49	0,43	0,76	0,65	0,65	0,65
The ratio of costs for air protection	0,01	0,01	0,02	0,01	0,01	0,01
Number of employees industry agriculture, working in conditions not meeting sanitary-hygienic norms, thousand people	47,7	42,5	42,5	36,9	36,9	36,8
% to the account of payroll employees in the industry	8,3	8,7	8,7	8,7	8,7	8,7

The coefficient of ecological stability is one of the criteria of efficiency of land use. During the last five years on the territory of Ukraine, environmental stability is characterized by a low level of 0.40. You must also consider that the number of objects technological security include production, storage, disposal and destruction of potentially dangerous products (radioactive, chemical, biological, explosive) used in the defense and civil systems, but the withdrawal of the operating status of compliance with the process safety requires significant resources (for nuclear materials and facilities, the cost of decommissioning may exceed 3-5 times the cost of their creation and commissioning).

There is a food and environmental threat from the use of genetic modification in domestic agricultural production. The key issues that can lead to GMOs are considered: violation of biological balance through displacement of transgenic plants of existing species, which threatens the extinction of plants, animals and insects that depend on them; the lack of long-term systematic studies of the effect of GMOs on human health and the environment; uncontrolled discharge in the food is harmful GM ingredients, which could threaten human health [12].

5. Conclusion

The global importance of environmental threats appears to be a determining and guiding factor in the development of international relations and changes in the geopolitical situation.

They operate by their own laws and interacting, able to broadcast synergistic effects in the future. Through this threats of natural and technogenic areas in the short term can become dominant.

Directions of development of ecological and technogenic safety of the state proposed to define [12]:

- controllability and predictability of the development of high-tech complex;
- scientific and technological activities and professional education;
- information and communication technology;
- environmental technology;
- industrial and agricultural production on the basis of the latest technologies and techniques;
- energy use of promising and innovative technologies and resources;
- combined transport infrastructure, diagnostics and monitoring of the technological infrastructure;
- the production and disposal of radioactive, chemical, biological and explosive products;
- military-technical cooperation;
- system protection high-tech facilities from accidents and disasters.

Analysis of the global and internal threats to ecological and technogenic safety of Ukraine has shown that there is a large number of them and the urgent need to engage in at least their neutralization. In the man-made aspect of our country added the threat of military action in the East of the country. In environmental aspect the biggest challenges – agriculture and deforestation, especially in the Carpathians. Therefore, the relevance of eco-anthropogenic component of national security as a state in whole and its regions, is undeniable, as this security is associated with the survival of the population and the future of the state as a whole.

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STRATEGIES FOR DEVELOPMENT OF MEDITERRANEAN CROSS-BORDER COOPERATION AS AN INSTRUMENT FOR INCREASING THE "WIDER" SECURITY

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Abstract: *Cross-border cooperation (CBC) in the Mediterranean region is an effective instrument of the European Neighbourhood Policy (ENP) that gives different opportunities which have a positive influence on the aspects of the "wider" security – political, economic, social, ecological and cultural security. Seven members of the European Union and ten partners from the North Africa and the Middle East take part in the Mediterranean CBC.*

The Mediterranean CBC is analysed as a system with two environments – external and internal. The report presents PESTEC-analysis and SWOT-analysis. Also, it shows the logical relation between external factors, internal characteristics and future results of cross-border projects. Applying a strategic tool of TOWS-analysis, it helps identify relevant strategic options that the Mediterranean CBC could pursue. Furthermore, the TOWS analysis enables to develop "maxi-maxi" strategies – those with the greatest potential for successful and effective CBC in regard to the aspects of the "wider" security.

Keywords: CROSS-BORDER COOPERATION, MEDITERRANEAN REGION, "WIDER" SECURITY, PESTEC-ANALYSIS, SWOT-ANALYSIS, TOWS-ANALYSIS

1. Introduction

Mediterranean cross-border cooperation (MedCBC) takes an important place in the general ENP policy context. Cross-border activities, outputs, achieved results and its effectiveness have an essential influence on the aspects of the "wider" security – political, economic, social, ecological and cultural security.

For the period 2007-2013 Med CBC was realized by seven EU members (Cyprus, France, Greece, Italy, Malta, Portugal, Spain) and six Neighbourhood partners from the North Africa and the Middle East (Egypt, Israel, Jordan, Lebanon, Palestine, and Tunisia). (Fig. 1). A total of 95 projects were awarded a total of €185,1 million (€107 million for 76 standards projects and the remaining €74,1 million for 19 strategic projects) [1].

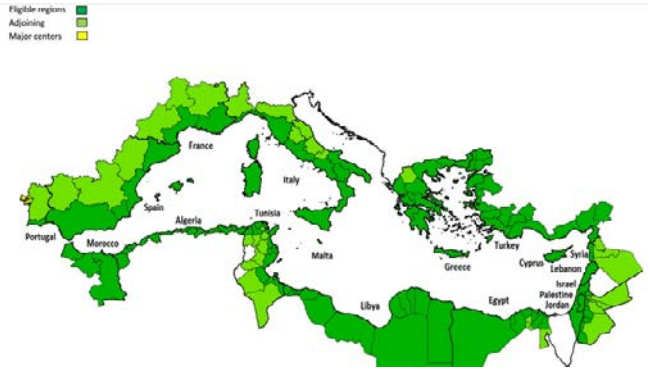


Fig. 1 *Map of the Cooperation area [1]*

In this paper, the MedCBC is analysed as a complex system that has interconnected internal elements united by common goals, priorities, and principles. At the same time, the MedCBC system is under the influence of different external factors. The subject of research is MedCBC's capacity for strategic development. Therefore, the main purpose of this work is to propose strategies for development of MedCBC by applying strategic tools as PESTEC-analysis, SWOT-analysis, and TOWS-analysis.

There are some limitations in this study by:

- territorial limitations – Mediterranean cross-border region;
- time limitations – a mid-term perspective 2018-2020;
- a number of external factors and internal elements – 12 in each group;
- a number of strategies for development – between one and three strategies.

2. PESTEC-analysis

Focusing on external factors contributes to bringing out some specific causes that have positive and/or negative effect. A suitable method is PESTEC-analysis, an expanded version of PEST-analysis, which is required to fully understand the external macro environment. The outlined acronym consists the standard political, economic, social and technological factors of influence and two other groups of factors - ecological and cultural. All the six groups of factors are logically linked to the priorities and measures set out in the Mediterranean cross-border programmes under which CBC projects are being prepared. The effect of the priorities is aimed at improving the external environment, and hence the state of the various aspects of "wider" security.

An initial list of 48 external factors was formulated on the basis of literary and documentary studies. A control survey was prepared and was sent to experts (at European, national and local level), representatives of scientific institutes, business, and non-governmental organizations, randomly selected. They evaluated significant or insignificant is each of the factors.

The experimental sample represents 16% of the general set of potential evaluators to whom the control survey was sent. An imbalance is observed in the distribution by the EU Member States and EU partner countries - 81% of the respondents are the Member States, while only 19% are from non-EU countries (Diagram 1). Diagram 2 shows the distribution by type of institutions. 56% of the respondents occupy leadership or management positions.

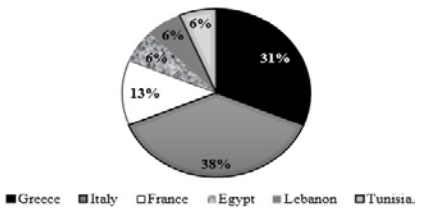


Diagram 1 PESTEC *evaluators by country*



Diagram 2 PESTEC *evaluators by type of institution*

Applying statistical tools as one sample Z-test, probability value P= 95%, significance level α = 0,05, twelve external factors (by two from each of the six groups) have been chosen like the most significant. (For more explanation about statistical methods and hypothesis testing to perform PESTEC-analysis see [2]).

The most significant components of PESTEC-analysis are:

- political factors: Cooperation agreements and financial instruments of EU/ENP (with positive effect), and Insufficient democracy and authoritarian regimes (with negative effect);
- economic factors (with positive effect): Resources availability (natural, human etc.) and Development of micro, small, medium enterprises;
- social factors (with negative effect): High rate of unemployment, especially among young people, and High levels of illiteracy, especially among girls and women;
- technological factors: Promote scientific research and facilitate the adoption of research results in commercial routes (with positive effect), and Overall technological delay of targeted regions (with negative effect);
- ecological factors (with positive effect): Awareness and understanding of environmental issues, and Effective and efficient utilization of natural resources;
- cultural factors (with positive effect): Improving the quality of education and Tourism development.

3. SWOT-analysis

The MedCBC's internal environment should be analysed and scanned too. It includes several groups of elements:

1.First group - the strategic objective of the MedCBC, sub-targets and target values to be achieved. For the period 2014-2020 there are:

- one General Objective - to foster fair, equitable and sustainable economic, social and territorial development, which may advance cross-border integration and valorize participating countries' territories and values;
- two Overarching Objectives – A. Promote economic and social development; B. Address common challenges in the environment;
- four Thematic Objectives - A.1. Business and SME development; A.2. Support to education, research, technological development, and innovation; A.3. Promotion of social inclusion and the fight against poverty; B.4. Environmental protection, climate change adaptation, and mitigation.

2.Second group – MedCBC's Content, including 14 principles, 11 priorities, budget and funding criteria, eligible costs;

3.Third group – MedCBC's Procedures: it brings together: authorities, structures and bodies that manage and administer the MedCBC (Joint Monitoring Committee, Managing Authority, National authorities, Audit Authority, Group of Auditors, Control Contact Points, Joint Technical Secretariat, Branch Office, National Contact Points, Project Selection Committee); and the procedural rules that these authorities follow in selection, approval, financing, and monitoring of projects;

4.Forth group - Participants: they can be classified to participants at European, national, regional and local level; another classification is Beneficent (EU)-Beneficiaries (eligible countries); Beneficiaries can be classified according to:

- their EU membership - eight eligible Member States and eleven eligible partner countries;
- their activity in MedCBC - active (seven Member States and six partner countries) and inactive (one Member State, United Kingdom, and five partner countries, Turkey, Algeria, Morocco, Libya, Syria);
- the level to which they belong - national, regional, local;
- the sphere of activity - state, regional and institutional, educational and research structures, business organizations, representatives of the non-governmental sector.

5. Fifth group - Results: there are several types of results, distinguished according to:

- their impact on the aspects of "wider" security - direct and indirect impact;
- the aspects of "wider" security that the results affect - political, economic, social, technological, environmental, cultural, mixed;
- the relations between results and objectives (see Fig. 2).

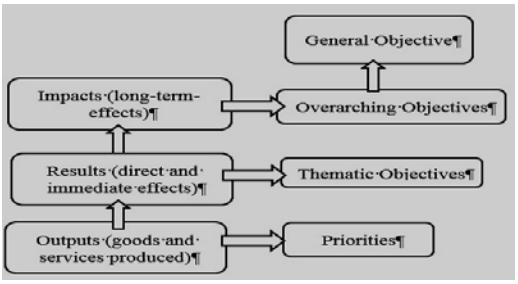


Fig. 2 *Relations between results and objectives*

The five groups of elements are not independent of each other but interact in the form of a dynamic complex. The stronger the connections between them are, the higher the effectiveness of their interaction is. The five groups of elements form the design of the MedCBC's internal environment. Its sustainability depends on:

- MedCBC capability for internal integration;
- MedCBC capability to adapt to external conditions.

In order to ensure the sustainability of its groups of elements, it is important the internal environment's strengths and weaknesses, opportunities and threats facing it, to be explored through SWOT-analysis.

For the study's benefits, experts were randomly assigned to two groups with mixed representation. The first group included ten experts who had the task of generating the maximum amount of characteristics from the four SWOT categories. For each of the internal groups and elements, strengths and weaknesses, opportunities and threats could be identified. Method of retrieving the SWOT characteristics is the so-called "unsynchronized virtual brainstorming" intuitive method.

The ten experts are representatives of eight countries of which just one is not part of the Mediterranean cross-border region. Diagram 3 shows a significant normal allocation by country. The distribution of the participants according to the institutions they represent is also fairly heterogeneous (see Diagram 4). 60% of the experts occupy leadership/management positions and the remaining 40% have executive/auxiliary positions.

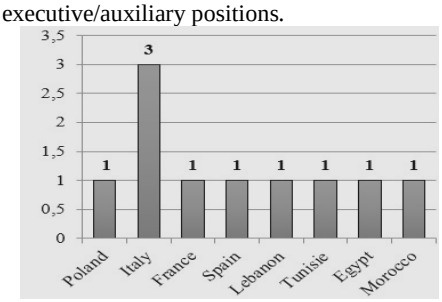


Diagram 3 *Participants in the unsynchronized virtual brainstorming by country*



Diagram 4 *Participants in the unsynchronized virtual brainstorming by type of institution*

A total of 48 strengths and weaknesses, opportunities and threats had been generated. A five-degreed questionnaire was created in which experts from the second group reflected their

agreement or disagreement for each characteristic. The experts in the second group represent 27% of the general sample of potential evaluators. The sample could be defined as large, independent and on some signs evenly distributed. 83% of the evaluators are representatives of the EU Member States (Diagram 5). The percentage of the evaluators, by institutions of which they are a part, is fairly even (Diagram 6). The job positions of 54% of the respondents are expert/technical, and 46% are leadership/management.

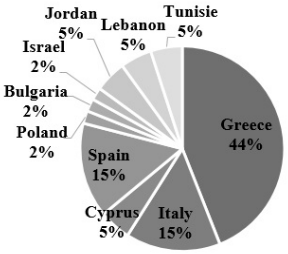


Diagram 5 SWOT *evaluators by country*



Diagram 6 SWOT *evaluators by type of institution*

Applying statistical tools as one sample Z-test, Spearman coefficient, probability value P= 95%, significance level $\alpha = 0,05$, twelve internal characteristics (by three from each of the four groups) have been chosen like the most statistically significant. (For more explanation about statistical methods and hypothesis testing to perform SWOT-analysis see [2]).

MedCBC SWOT-analysis includes:

- Strengths: Exchange of best practices; Clear priorities and measures, related to the goal; Clear and fair principles;
- Weaknesses: Complicated and bureaucratic project selection procedures and financial procedures; Difficulties in harmonizing project selection and financial procedures, caused by differences in national systems and legal basis; Limited financial resources;
- Opportunities: Creating multinational partnerships; Creating an appropriate model for measuring and evaluating the CBC's effectiveness, that would help the process of formulating future goals and priorities; Promoting strategic projects and capitalization projects;
- Threats: Strong bureaucracy and centralization; Procedures that are too complex and time-consuming; CBC budget amount is too low as a percentage of European Neighbourhood Instrument.

4. TOWS-analysis

To construct a TOWS analysis, it is important to focus on the logical relation between the external factors, the elements of the internal environment and the cross-border projects' results.

For example, the first policy factor "Cooperation agreements and financial instruments of EU/ENP" is a prerequisite for the exchange of best practices (Strength) and the Opportunity of creating multinational partnerships. The results of the cross-border projects supporting this Strength and Opportunity would help to enhance political security in the Mediterranean cross-border region (see Fig. 3).

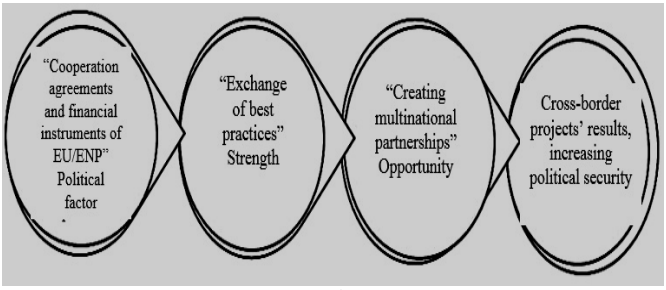


Fig. 3 *Logical relation with positive influence on political security*

There is also a logical relation between the negative political factor "Insufficient democracy and authoritarian regimes" and the difficulties in harmonizing project selection and financial procedures (Weakness), which poses the threat of too complicated and time-consuming procedures. The effectiveness of cross-border outcomes is limited by the negative influence of the external political factor and its effects on the MedCBC's internal environment (see Fig. 4).

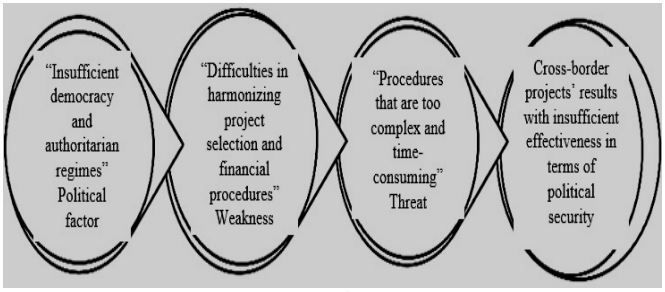


Fig. 4 *Logical relation with negative influence on political security*

Following the principle of logical relation, it is easier to understand and apply TOWS-analysis. As shown in Table 1, there are four types of strategies. These types of strategies help to identify relevant strategic options that MedCBC could pursue. Moreover, TOWS analysis can help MedCBC to see how it can take advantage of opportunities, reduce threats, overcome weaknesses and exploit any strengths. [3]

Table 1 *TOWS-matrix*

	Opportunities	**Threats**
Strengths	**SO** *"Maxi-Maxi" Strategies – strategies that use strengths to maximise opportunities and effect of posivite external factors.*	**ST** *"Maxi-Mini" Strategies – strategies that use strengths to minimise threats and effect of negative external factors.*
Weaknesses	**WO** *"Mini-Maxi" Strategies – Strategies that minimise weaknesses by taking advantage of opportunities and positive external factors.*	**WT** *"Mini-Mini" Strategies – Strategies that minimise weaknesses and avoid threats and negative external factors.*

5. Results of discussion

The main purpose of this research is to formulate between one and three strategies for MedCBC development. Therefore, the most proper type of strategies is the "Maxi-Maxi" Strategies - those with the greatest potential for success.

Using MedCBC strengths it could maximise its opportunities and effect of positive external factor "Cooperation agreements and financial instruments of EU/ENP". Three "Maxi-Maxi" Strategies are presented in Table 2 below.

Table 2 *MedCBC strategies for development*

	Opportunities (O) 1.Creating multinational partnerships; 2.Creating an appropriate model for measuring and evaluating the MedCBC's effectiveness, that would help the process of formulating future goals and priorities; 3.Promoting strategic projects and capitalization projects
Strengths (S) 1.Exchange of best practices; 2.Clear priorities and measures, related with the goal; 3.Clear and fair principles	**SO** *"Maxi-Maxi" Strategies – strategies that use strengths to maximise opportunities and effect of posivite external factors* **S1-O1** Expanding the range of partnerships (including number of cooperation agreements) and strengthening already existing partnerships by using good experience and best practice. **S2,3-O2** Creating better model for measuring and evaluating the MedCBC's effectiveness based on objectives, priorities and principles that are clear and comprehensible. **S1,2,3-O3** Encouraging partners to initiate strategic projects and capitalization projects and to use available financial instruments more effective, applying the three Strengths.

6. Conclusion

Three main tasks are implemented in this paper:

- examining MedCBC external factors of influence through PESTEC-analysis;
- exploring elements of MedCBC internal environment through SWOT-analysis;
- finding and explaining the logical relation between external factors, internal elements and cross-border projects' results with positive or negative influence on the aspects of the "wider" security.

By implementing these three tasks and the main goal is achieved - there are three MedCBC strategies for development, formulated applying TOWS-analysis. It does focus attention the areas where actions are required and given some indication of the nature of those actions.

This study provides a methodology that could be used and applied to other types of strategies, on the one hand, and to cross-border cooperations in other regions (e.g. Black Sea), on the other hand.

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IMPROVEMENT OF EARLY WARNING SYSTEMS

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ОПТИМИЗИРАНЕ НА СИСТЕМИТЕ ЗА РАННО ПРЕДУПРЕЖДЕНИЕ

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Abstract*: The aim of this article is to describe the general methodology of early warning systems. The common disaster monitoring system was analyzed, and the construction system of disaster information management system was discussed particularly. This paper addresses traditional views of early warning systems and what is needed to turn them into efficient, people-centred systems.*

Key words: EARLY WARNING SYSTEMS, DISASTER INFORMATION, NATURAL HAZARDS, GEOINFORMATION TECHNOLOGY, REMOTE SENSING SYSTEM.

1. Introduction

Natural and technological disasters and events monitoring are an important part of national security which set the task of solving some basic problems like stabilization and surroundings improvement, liquidation and prevention of regional ecologic crises. This imposes the need for developing a national system for monitoring, enabling operative solving of tasks connected with prevention and action during crises and consequences avoidance. Also, analyzing the stability of the functional structure of natural systems and making short-term prognosis.

The use of advanced tools for computation and modelling of natural hazards can be combined with a Geographic Information System (GIS) that has the capability of decision support and advanced visualization to produce models, that will represent the risks of natural hazards and man-made disasters in the form of risk maps, where the risks are categorized and quantified [Ivanov M., Yankov Y., 2016 b]. Very large amounts of data can be processed, quantified and displayed on digital maps, allowing decision makers to assess the situation rapidly and take appropriate actions. Furthermore, these processes can be automated, enabling near real time access to the risk maps. This can greatly help decision makers with the emergency measures and mitigation in most of the cases.

The role of science and research linked to early warning and crises management (EW and CM) is very specific. The roles of both are looked upon as practical activities only. For many years there have been a limit mainly for realization of inhabitants' needs for help in crises situations. Later the efforts expanded and concentrated on the readiness of population in dangerous areas for a specific type of disaster in those regions. New technologies and a dedicated scientific research have been accepted too slowly, and it took a long time before they were treated as a means to significantly change the quality of assistance provided to disaster risk reduction.

This paper aims at adding concepts and ideas about how often neglected geoinformatics and cartography can contribute to the improvement of the quality and results of disaster risk reduction.

To understand the characteristics of disasters and our potential to handle them, is one of the key topics in thinking for ways to improve EW and CM decision making process. There are five major characteristics of disasters that make them difficult to overcome:

1. *Disasters are large, rapid-onset incidents relative to the size and resources of an affected jurisdiction.*

If pre-accident data is available, geospatial analysis can provide important insight into the nature and extent of changes wrought by disasters.

2. *Disasters are uncertain with respect to both their occurence, and their outcomes.*

This uncertainty arises because hazards that present a threat of disaster are hard to identify, the causal relationship between hazards and disaster events is poorly understood and risks are hard to measure – that is, it is difficult to specify what kind of damage is possible, how much damage is possible, and how likely it is that a gven type and severity of damage will occur.

Geospatial models can help predict the locations, footprints, times and duration of events, and the damage they may
cause, so that jurisdiction can be better prepared for them.

3. *Risks and benefits are difficult to assess and compare.*

Disasters present emergency planners, emergency managers and policy makers with countervailing pressures. On the one hand, it is important to minimize the exposure of populations and infrastructure to hazards; on the other, people want to build and live in scenic, but hazard-prone areas and often oppose government regulation. What is more, various levels of government cannot keep the balance between providing reliéf to the victims of disasters and the need or desire to avoid encouraging risk accepting behaviour, etc.

Geospatial data and tools are invaluable in making the necessary assessments of the geographic distribution of risk and in estimating the quality of each assessment.

4. *Disasters are dynamic events.*

Disasters evolve as they progress, and they change in response to human actions and natural forces. This makes it imperative that response strategies be flexible and argues for the value of analysis in helping responders understand and adapt to the changing conditions they face. Managing these phenomena can thus bet the highly technical endeavor requiring specialized expertise for both policy development and policy implementation. [Ivanov M., Yankov Y., 2016 a].

In particular, geospatial data and tools can help incident managers to visualize the event over time, track the activities of responders, and predict the outcomes of various courses of action.

5. *Disasters are relatively rare.*

Most communities experience few, if any, disasters during the average time in office of a political official or the average time of residence of a citizen. More obvious and immediately pressing public service concerns displace disaster preparedness as a priority. Specialized capabilities, such as geospatial data and tools are especially vulnerable to budget cuts and resource realocation.



Fig. 1 The role of geoinformation technologies in early warning and crises management.

2. Basics of early warning systems.

The essence of early warning, as a stage of a crisis reaction, is giving timely and effective information for coming and immediate threat of disasters to a definite group of people – authorities, reaction forces and population [Nedevski D., 2010].

Warning is a process of collecting and exchanging information between command and control operatives for possible events, on the basis of which an immediate preparation of reaction forces commences [8].

The main objective of early warning is to limit the risk of threat of coming disasters, get control of the current situation and reduce the consequences.

The essence of early warning lies in revealing the earliest indications for emerging disasters on time and notifying the government and army forces in order to make a decision for protecting the citizens [Defense solution, 2016]. This makes the early warning systems (EWS) an important tool in national security conception and a real basis for crisis prevention.

In broader sense, the EWS embrace some chain processes:

- disaster monitoring;
- building a system of parameters and criteria for giving an account of the processes connected with the formation and growth of crisis situations;
- creating a system of preventive actions, which may avoid intensification of some crisis processes;
- working out a reliable and effective mechanism for population defense.

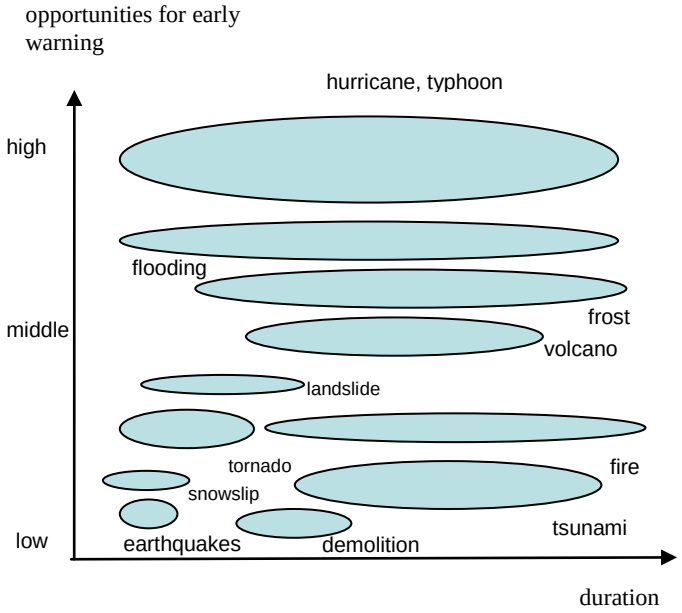


Fig. 2 Interdependence between opportunities for early warning and disaster duration.

Early Warning System tasks:

- To provide a comprehensive technological framework for practical hazards mitigation efforts.
- To consolidate the efforts of government agencies and disaster management communities involved in order to promote systematically the hazard mitigation research.
- To integrate hazard-related research results and transfer them to feasible procedures so that they can be implemented effectively.
- To develop appropriate methodologies for potential analysis, risk assessment and scenario simulation of natural hazards.

The main task of EWS is to establish a system for observation, control, analysis and prognosis, which keeps a close watch on treats, providing the incoming information on time and taking measures for prevention of potential events.

It is well known [Nedevski D., 2010; Spatial analysis, 2016], that the opportunities for early warning depend on the basic physical parameters of disasters. Meteorological events are the easiest for prognosis and the hardest (some even not possible - earthquakes) are geological threats – fig. 2.

3. Possible structure of early warning systems.

Early warning system contributes to reduction of economic loses and disaster risk for population by providing information that ensures protection to sociality, individuals, critical infrastructure and private property. The pre-emptive information gives an opportunity for fast reaction at the very beginning of a disaster. Good integration between EWS, evaluation and management of risk and action planning is a starting point for the real process of defense and prevention, reduction of human loses and economic damages.

After analyzing the objectives, principles, characteristics, main tasks and EWS requirements, a functional structure for the

EWS can be suggested. The elements which must be included in the system are:

- agencies and resources for obtaining information, monitoring and processing;
- risk identification and evaluation;
- creating a methodology for evaluation of critical infrastructure;
- zoning the territory according to risk factors;
- designing models for engagement in advance;
- modeling decisions for reaction in possible disasters;
- communication system for information in defense mode.

After integrating these specifications in the national early warning system and creating a known information picture, it is possible to:

- coordinate all activities of the special structures and businesses for preventive and remedial measures;
- interact with similar systems in other countries.

4. GIS functions in early warning systems.

Geographic Information System (GIS) is a collection of applications whose tasks include (collaborating with other systems) gathering geographic data, store and process spatio–temporal data (geo-data) and share the derived geographic knowledge with the users and other applications. Some of the most important routine applications of GIS are spatial analysis, digital elevation model (DEM) analysis such as line of sight and slope computations, watershed and viewshed analysis, etc. GIS has became quite an important tool for geospatial sciences and has gone beyond typical tasks of mapping to performing complex spatio-temporal analysis and operations. The number of users relying upon Decision and Support Systems (DSS) built upon GIS has increased as a result of the availability of a very high resolution satellite imagery and integration of spatial data and analyses with GIS packages which now satisfy the needs of many and is not only used for specialized operations.

As in many GIS applications, the geodata differs from grid and vector data. The **grid data** in the form of digital topographic maps and remote sensing data serves as a better overview of the emergency situation. Depending on the emergency site (urban or rural regions) different maps, like city or regional maps, aerial photos and satellite images are used to visualize the emergency location. For viewing this maps and images, standard-tools for clipping, panning and zooming are integrated into a combined system.

The GIS analysis in EWS is based on a **vector dataset** which includes, beside other data, geocoded addresses and the street network. Operation areas of the public safety organisations, water bodies and lines and point of interest (POI) like locations of rescue teams, SOS telephones and hydrants are used for the cartographic visualisation of the emergency area. In any case, it is important for a successful emergency aid all data to be up to date.

The main GIS functionality of PSS is a function that uses **geocoded addresses**. This function is required in order to enable localization of the emergency site. The addresses are usually organised in a dataset, which include the necessary geographic information, e.g. coordinates. In addition to this function, the emergency location can be entered via the name of the street or ordinary geographical coordinates.

The second important GIS function is the **network analysis**. In the network analysis the shortest or the fastest way between the position of the emergency forces and the emergency site is calculated. This function uses miscellaneous parameters, such as one-way-streets and turn restrictions. Applications designed for ambulances use the function of the “travelling salesman problem” for calculating the cheapest way between the location of the patients and the health care centres (hospitals, foster homes, medical specialists). The acquired routes are then shown on the cartographic visualisation tool and sent as GPS-coordinates or as a textual list of directions to the emergency vehicles.

The **cartographic visualisation** of emergency sites is another important function of EWS. It is usually presented on a digital map which can be completed with tactical symbols, simple drawings and labels. With the help of GPS transmitters, the current position of the vehicles is acquired and visualised with symbols on the map. In additional layers, buildings with high exposure like hospitals, schools, hotels, etc. can be displayed on the map or retrieved from special building databases.

Other GIS functions included in the graphic display of EWS are the measurement of routes and surfaces and the query of specific emergency data. Additionally to the described GIS functions, some applications also enable a simulation of atmospheric **dispersion of hazardous materials**. The dispersion models are standard calculation models with experience values. The result of the dispersion model (a polygon) is combined with other geodata, like geocoded addresses to warn the affected population.

Maps for disaster risk assessment combine international, regional and local data provided by various services, agencies, and organizations. The data gathered from various numerous sources as geographic database; topographic maps; thematic maps; disaster management plan; seismic hazard information; geological information; building stock information; demographic and social information; business / communications / industry information; infrastructure information; statistical data, etc. is heterogenic and its use for the disaster risk evaluation and crisis management is not easy. Therefore, the data should be integrated and presented in the most appropriate way to assist specific tasks of participants in all stages of disaster risk management. In order all the data to be integrated and presented on the maps it should be standardized and managed according to the main aspects of data harmonization following Directive recommendation [8]:

− Georeferencing the information into a uniform reference system;
− Standardizing attribute structure;
− Standardizing object classification;
− Standardizing level of detail;
− Unifying cartographic visualization.

Disaster risk evaluation encompasses rather heterogeneous information data sets. The integration of these data in a uniform data base requires a lot of multi- and inter-disciplinary efforts. Calibration and verification of the data sets and methods used is important to continue, in order to proceed further with the comparative analysis of the available maps and the consequent risk evaluation in GIS environment. It is also necessary to have compatible vector maps and/or digitized raster maps with proper spatial resolution at disposal. It would be useful and interesting to perform risk evaluations with different available maps, thereby some beneficial inferences and recommendations in terms of

sensitivity of the final risk evaluation with regard to different input data sets could be performed.

The geographic information system for EWS needs is intended for providing with geospatial information all elements of national security system in joint tasks implementation.

The main object of GIS is to create an effective spatial data infrastructure for a crisis management system, based on current and perspective information and geo-information technologies, [MC 296/1 NATO Geospatial Policy, 2006.] and satisfy world standards.

The specification of an early warning process imposes the following basic requirements on GIS:

- collecting initial digital geo-information data from different institutions and organizations;
- entry and storage of geo-information data in information bases; updating geo-data through monitoring systems and remote sensing;
- improvement of service quality and quickness, assisting government in making decisions, concerning the processes taking place in a definite territory;
- exchange of data between information bases of a particular system;
- analyses and prognoses of geo-information data and submitting the results.

5. Conclusion

Disaster reduction measures should be based on continuous assessment of vulnerability and hazards, including a vulnerability /hazard analysis and monitoring/. The geoinformation is essential for almost all disaster risk management cycle integrating all data sets in a information system. Spatial data information, as core subjects in disaster prevention and emergency management, should be reliable, timely and in digital form to be processed in a powerful GIS. The use of GIS software for data analysis and representation alongside with different techniques for data processing can reduce the uncertainty, and serve as a catalyzing agent for information acquisition and distribution. Advanced IT technologies, as base of a spatial data infrastructure, foster the process of spatial information analysis, which can be used as a valuable source in all phases of disaster risk management.

Advisable decisions for action in case of disasters depend on: preliminary preparation of a system for extraction of geospatial information; organizational structures; elements and functional relations. Spatial identification of the changes of geophysical parameters of natural events is a complex process including GIS, remote sensing and data processing.

The cartographic products, the spatial modeling of the terrain, the geographic analysis, the semantic generalization of geo-data are a base for the formation of a spatial-oriented scheme for global application in crisis management.

GIS unifies traditional operation with database, like request and statistical analysis, visualization advantages and spatial analysis which maps offer. These opportunities distinguish GIS from other information systems and give a unique opportunity for using them in a broad spectrum of tasks, connected with analyses and prognoses of events and processes.

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STUDY AND EVALUATION OF EXISTING AND FUTURE NUCLEAR POWER IN SOUTH EASTERN EUROPE

ИЗСЛЕДВАНЕ И ОЦЕНЯВАНЕ НА СЪЩЕСТВУВАЩИТЕ И БЪДЕЩИТЕ ЯДРЕНИ МОЩНОСТИ В ЮГОИЗТОЧНА ЕВРОПА

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Abstract: *With regard to the nuclear power stations located near Bulgaria, we will look at the sites that would have an impact on the change of the radiation gamma background on the territory of our country. We will also consider the possible new nuclear power plants near our border and sites where nuclear installations could be located.*

Keywords: *nuclear power, NPP, nuclear installations, radiation gamma background, accident*

1. Introduction

In view of the nuclear capacities near Bulgaria, we will look at the objects that would influence the change of the radiation gamma background on the territory of our country. We will also consider the possible new nuclear power plants near our border and sites where nuclear installations could be located.

Bulgaria borders directly with Greece and Turkey to the south, Macedonia and Serbia to the west, Romania to the north and the Black Sea to the east.

2. Location of nuclear facilities in the region

In our southern neighbor, Greece has no nuclear capacities and it is not envisaged to build such facilities in the foreseeable future. It is not known to have operating accelerators or other sources of ionizing radiation in an area 100 kilometers from our border. There are sources of radiation in medical institutions in 3 cities - Thessaloniki, Alexandroupolis and Kavala, located in northern Greece, which can not influence the radiation background in our territory due to their low power and the type of ionizing radiation used in them. In industry and mainly in the food sector, such sources are not used for different purposes. There are no vessels in the adjacent Aegean Sea where there are sources of ionizing radiation present and those in which a nuclear reaction could normally occur. The Army of Greece does not have weapons that would, after use, alter normal atmospheric parameters. In the bases of Greek territory, where troops from other countries (USA) are located, there are no nuclear-weapon based weapons.

Similarly to Greece and our Sister Macedonia, there are no nuclear power plants, other types of nuclear reactors or accelerators where significant amounts of ionizing radiation can be emitted. In the field of economy and technology, there are no enterprises and institutes that are potentially dangerous to increase the radioactive background on the territory of Bulgaria as a result of a possible accident. Sources of ionizing radiation with a small dose are located in the hospitals "Ajabadem" and two more in Skopje, which are used for medical purposes. The Macedonian Army does not have nuclear weapons or the like. There are no weapons of mass destruction on the territory of Macedonia that would increase the radioactive background after use.

Our other western neighbor, Serbia, also does not pose a threat to our safety from the point of view of radiation protection. Near the Bulgarian borders there are no industrial sites that use sources of ionizing radiation with medium and large doses of load. Due to the country's specificity and the lack of large settlements in the eastern regions of the country, there are also large medical diagnostic and health establishments in which to use equipment with significant exposure power. Industrial and medical sites that have sources of ionizing radiation with moderate and higher exposure are located in Belgrade or cities located far from the Bulgarian border and practically in case of an accident they would very hardly have an impact on the radiation situation in Bulgaria. The Serbian army does not have nuclear weapons and there are no such weapons in the territory of Serbia. There is an agreement between Serbia and Russia on mutual assistance and, if necessary, Russia can supply such a weapon on Serbian territory. In practice, this is very difficult to achieve in the current international environment because neighboring countries will not open their airspace for such supplies.

The Serbian side was interested in the Belene project, where it wanted to finance part of the construction against a corresponding shareholding in the plant. In this way, it wanted to provide electricity for itself and eventually to participate in the regional electricity market. Serbia's current process of development has not commented on its involvement in restarting the project [1].

The closest sites potentially hazardous to radioactive contamination following an accident and located west of us are Pakistani NPP in Hungary and Krusno NPP on the border between Slovenia and Croatia. Taking into account their location, their remoteness from Bulgaria, the prevailing winds and the EURDEP system, we can exclude them from the analysis and ignore their impact.

These are the countries and sites that pose a very minor threat to a possible nuclear accident and consequently change the natural radioactive background over Bulgaria. In the analysis of the state of NASCRRF and the available points in the vicinity of these countries, I believe that the system is fully in line with modern requirements and the international environment. As a result of research into sites in Greece, Macedonia and Serbia, which are sources of ionizing radiation in the development, we exclude a possible danger of radioactive contamination from these sources.

There is a significant difference in the possible threat from our other border regions and neighboring territories.

In our northern neighbor, Romania has a "Black Water" NPP, which is located on the Danube River 60 km after Silistra and about 40-50 km by air from our state border. The first reactor was built jointly by the Canadian company Atomic Energy of Canada Limited and the Italian Ansaldo and was put into operation on 2 December 1996. It is constructed using CANDU technology and has a power output of 620 MW. The second reactor was put into operation in 2007 and is of the same type. The project to build a third and fourth reactor of Romania's nuclear power plant "Cherna Voda" is part of Romania's energy strategy, as over EUR 1 billion has been invested in this project, said Energy Minister Victor Grigorescu in 2016, quoted by "Adjuster"[2]. Grigorescu pointed

out that nuclear power is one of the sources by which the country's energy security is strengthened. In his words, the project also makes sense in terms of reducing the use of coal to produce electricity, as currently 30% of Romania's electricity is generated by the thermal power plant. Romanian President Klaus Johanis also called the project for the expansion of the Chernapa NPP as a "priority investment" for the country.

The Romanian State Energy Company (SNN) and China's General Electric Nuclear Power Corp. (CGN) signed on November 9, 2015, a Memorandum of Understanding on the design, construction, operation and decommissioning of third and the fourth unit of the NPP "Cherna Voda". The agreement is the basis for a joint project company, in which no less than 51 percent will belong to CGN, SNN said.

The project envisaged the construction of five power units. In 2015 -2016 another two blocks of the same type were planned to be put into operation, which would cost investors (seven Romanian and international companies) another 4 billion euros. Romanian nuclear power company Nuclearelectrica believes that by the end of the year, it will reach agreement on the completion of the Third and Fourth Unit of the Cherna voda NPP with the Chinese group "China General Newark Power Corporation", which was announced as early as 2015 for the winner of the tender organized by the Romanian state. Fifth block is still frozen [3].

The signed Memorandum forms part of the state strategy of selecting the investor of the project and defines the "direction of the future cooperation" between the parties. "SN Nuclearelectrica SA" and "China General Nuclear Power Corp." reached the final stage of the investor selection procedure launched in August 2014 and start discussing the investment agreement and the founding agreement of the new project company, the SNN .

The CANDU 6 heavy water reactors will be installed on both 700 MW units of the second stage of the Cernavoda NPP, similar to those of the first and second power units.

Specialists are alarmed by the fact that part of the equipment is obsolete, not renewed, and the work teams are not sufficiently prepared. Part of the staff serving nodal points has left in the past 2 years and works at other nuclear sites in Europe for higher pay. The headquarters in Romania were verified by the International Agency for the Use of Atomic Energy for Peaceful Purposes under the OSART Safe Operation Program from 7 to 24 November. The mission was second for the Romanian headquarters and covered 10 areas: management and leadership, training and qualification, operation, repair, technical support, operational experience feedback, radiation protection, chemistry, emergency preparedness and severe accident management. OSART missions aim to establish the level of safety at individual nuclear power plants and are applied by the IAEA worldwide. The new element in controls - related to the management of severe accidents, was introduced after the events at Fukushima NPP in 2011. In accordance with IAEA rules, the mission has completed a report with described recommendations and good practices, which, after being endorsed by the International Agency, will be publicly available to the public.

The uncertainty in the project to complete the new 2 blocks, the outflow of a number of Western investors from the project conceals it with unpredictability and ambiguity, similar to our Belene project. The fact is that in 2014 the plant was forced to stop 6 times, and in 2015 - 4 times. The location of the "Cherna Voda" NPP and the prevailing winds in the area, according to NIMH data for the past 5 years, make it a serious potential pollutant of Northeastern Bulgaria in the event of a nuclear accident [4].

The Black Sea port of Constanta has developed very fast over the last decade. In addition to its commercial significance, it is becoming more and more of military significance, and many NATO navy ships have been moored there. The American Karneys, equipped with an Aegis Information System ("Idys"), was at the end of 2016 in the Romanian Constanta harbor. The permanent base of Carney and other American ships is the Spanish port of Rota. Carney is armed with manned missiles. Together with the rosters, Porter and Donald Cook, as well as the Ground Anti-Missile Defense (PRO) ground units in Romania and Poland, also equipped with the IGIS system, they are parts of the European segment of the American PRO. The Montreux Convention in 1936 limited to 21 days the rescue of warships of non-Black Sea countries in the Black Sea. That's why the rockets of these military craft are being made.

The presence of the Cherna Voda NPP and the increased shipping and the use of the port in Constanta are alarming as potential contributors to the increase of the natural radioactive background in the region of Northeastern Bulgaria. This necessitates possible changes and optimization of NASCRTF in this area.

In the central part of Southern Romania, about 40 km north of the Bulgarian border, in the village of Zagradzhden, Pleven district, is the former Air Force Airport of Romania to the village of Deveselo. Since mid-2016 there is a USA base, which is part of NATO's anti-missile defense strategy. NATO should thus receive 24/7 protection, integrated with radars and US missile defense systems already deployed in the Mediterranean.

In place of Romania's former Air Force Base, there are 24 SM-3 missiles and Aegis system radar. The Aegis Ashore "Land Shield" system includes powerful radar, interceptors and a communications system. It is the first of its kind in Europe. The shield will be fully integrated into NATO's wider defense system against ballistic missiles from potential enemies.

There is a serious concern and the public opinion of military scientists on the transfer of 20 atomic missile missiles from the Inzhirlik base (Turkey) to this Romanian base. Following the attempted coup in Turkey in the summer of 2016, and the recent events, talked about the security of the large American base and the weapons located there. Relations between the United States and Turkey were severely tightened, and in view of Turkey's request for extradition to 78-year-old Islamic preacher Fethullah Gullen, who lives in the United States and is accused by Turkey of organizing the failed coup on July 15, 2016. The unpredictability of Turkish President Recep Tayyip Erdogan is a prerequisite for these views of military strategy specialists.

But the presence of nuclear-powered missiles at 40 km from the Bulgarian border can not leave us indifferent to them and their storage. Despite good relations with Romania and NATO's partnership in such developments, we must take care of our radiation security and be prepared to deploy another point of the NASCRPF system to monitor the radiation background in the Zagrazhden and Gigen villages . This point would also be effective in terms of restarting the Belene project.

There are currently four active NPPs with 15 nuclear power units and a total power of 13,835 MW, according to Oleksandr Syor, PAO Radiy NPP, Ukraine [5]. For the last ten years, Ukrainian nuclear power plants produce half of the country's electricity. Ukraine's energy strategy provides for this share to be preserved by 2030. It is also foreseen to extend the lifetime of active energy units. In 2010, it was decided to extend the lifetime of Units 1 and 2 of the Roven NPP by 20 years. At the end of 2013, life was extended to 10 years and to Unit 1 of the South-Ukrainian NPP. By 2018 this will happen with another 9 blocks.

The electricity from the NPP in Slovakia is over 55% in the total energy balance. There are four units - two of Bohunice NPPs and two more of Mohovce NPP - the reactors are VVER-440, produced by the Russian company Rosatom. All of them are built on a Russian project.

Upon the entry of Slovakia into the European Union at "Bogunice" in 2006 and 2008 two blocks were stopped. They worked from 1984 and 1985. Then the country began to import electricity because a certain shortage arose. Hence, the desire to build a new block is completely logical. And the fact that Rosatom as a solid performer makes proposals on a legitimate basis is a normal business.

The Czech Republic operates 2 NPPs with 6 reactors. Temelin NPP has two power units with Sovereign WWER-1000 reactors and an electric power of 1000 MW. The second Czech Dukovany NPP was built by Soviet specialists in the period 1974-1987. There are 4 units with WWER-440 B-213 reactor units.

The Paks NPP operates in Hungary, which has 4 WWER-440 units and produces about 40% of the country's electricity. It was built in 1980 and is the only nuclear plant in Hungary.

The decision to build two new reactors was taken by the Hungarian Parliament in 2009 but the announcement of a tender for the construction was postponed several times. Rosatom, the Russian state-owned company, will finance and build two new nuclear blocks in the Hungarian Pakistani nuclear power plant, which will double the capacity of the plan Paks NPP t. In addition to Rosatom, interest in the project was claimed by Areva and Westinghouse.

Although we do not have a land border in the east, we can not be calm about the events that happen in the Black Sea. Over the last 5 years, we have an increased presence of military equipment, including one that has or could have deployed nuclear-powered missiles. The reasons for the increased presence of such a technique can be summarized in:

• The expansion of the USA and NATO missiles to the east;

• The military conflict between Ukraine and Russia, the problems in the Crimea and the military bases of Russia in the former Ukraine on the territory of the Crimea;

• The conflict in the Middle East, involving many countries in the region - Turkey, Russia, Syria, etc., as well as a large part of the Great Powers;

• The expansion of Terrorists from the Islamic State and other organizations close to it.

The presence of large vessels of Russia, the United States and NATO in the Black Sea, the continual lurking, the use of aviation and other actions continually escalate the situation near our state border. This leads to an upsurge in the situation, and a wrong move or action can cause undesirable consequences for us and the region.

In this direction we can optimize the control system by analyzing and adding, if necessary, 1-2 points, in addition to the available stations of Cape Kaliakra, Varna, Cape Emine and Ahtopol.

The last critical direction from the point of view of radiation security is our southeastern border and Turkey in particular. During the last year there have been significant political and economic changes. Turkish President Recep Tayyip Erdogan, following an unsuccessful coup attempt, made very great political changes in our southern neighbor. Relations with the United States have been greatly complicated, even in the military, where cooperation between the two countries was one of the best in the world. Even talk of ending the activities of the Inzhirlik military base - the largest US base in the Mediterranean.

After the freeze of relations between Russia and Turkey when the Su-24 bomber was shot down by Turkish fighters in the sky over Syria on November 24, 2015, there was a sharp warming in 2016 and a re-launch of many significant economic projects. The construction of the Akkuku nuclear power plant from Russia is restarted, and the construction of the Sinap NPP on the Black Sea coast from France and Japan soon begins. The Turkish president intends to start construction of a third nuclear power plant, one of the sites under consideration being located 20 kilometers south of Rezovo on the Black Sea coast. There is no decision yet to choose a site, but the Bulgarian side should carefully monitor closely the developments in the neighboring country.

Turkish Energy Minister Taner Yildiz and Rosatom Director Sergei Kiriyenko took part in the Aquarium on the Mediterranean coast in Mersin County near Syria in a ceremony for laying the first stone of the construction of the first of the four reactors, which will be with 1200 megawatts. Construction work started in mid-2015 [6]. After the cooling of Russian-Turkish relations the work was terminated, but in recent months the construction of this strategic site has begun. Electricity production is expected to start in 2020.

Besides the nuclear power plant in Akkuu, Turkey plans to build a second nuclear power plant in Synop County, on the Black Sea coast. This EUR 15 billion project was awarded in 2013 to a consortium comprising the Turkish company "UEAS", the Japanese companies Mitsubishi and Itochu and the French "Zee de Suez". "Mitsubishi Heavy Industries" and "Areva" offer their jointly developed Atmea-1 reactor with a capacity of 1100 megawatts.

Bearing in mind the unpredictability and decision-making nature of the Turkish Head of State, we should be prepared for various actions on his part and ready-made options for action to preserve the radiation safety of Bulgaria.

This is not to neglect the refugee flow from Turkey to Bulgaria and its external regulation. In these masses, composed mostly of young men, can safely be transported through the unregulated places where they cross the state border and dangerous radioactive materials. They can then be used unlawfully to infect our or other territories and increase the radioactive background.

As a result of the research conducted on sources of ionizing radiation in Romania, the Black Sea and Turkey, we exclude small sources in medical institutions, industrial plants and institutes and we focus on the "Black Water" Base in Deveselo, the Constanta port in Romania, the floating warships and the presence of large aircraft airplanes in the Black Sea and the potential new nuclear power plant in Turkey.

The idea of other nuclear fuel manufacturers to deliver to Russian-made nuclear power plants was criticized by experts in Europe. This is written by the Russian agency RIA Novosti in its analysis. International experts point out that this may cause economic risks. In addition, there is no guarantee that the second manufacturer as a "mandatory supplier" will also offer favorable terms or provide reliable fuel [7].

The mandatory availability of alternative nuclear fuel suppliers for European NPP reactors built on Russian or Soviet projects is inappropriate for a number of reasons. These include economic and nuclear safety issues. Around this, the participants took part in a round table held at the 10th European Conference on Nuclear Energy organized by Platts in Brussels [8].

Earlier, it was reported that European companies operating nuclear power plants with Russian WWER reactors must have at least two sources of nuclear fuel delivery. This scheme is backed by the US producer of nuclear fuel Westinghouse. Earlier international experts have repeatedly noted that this position does not meet free and fair market relations, says RIA Novosti.

Round table participants also criticized the idea of diversifying nuclear fuel suppliers at all costs.

"There may be economic risks," one of the founders of Trusted Sources, Christopher Grenville, [9] said. It's about consumers being interested in buying high-quality and proven fuel from a reliable supplier. And, at the same time, there is no guarantee that the second manufacturer as a "mandatory supplier" will offer such favorable terms or will deliver fuel of a reliable quality. Significant financial difficulties have been experienced by the US Westinghouse in recent years. Even in March 2017, Japanese company Toshiba, which owns the majority stake in the company, demanded bankruptcy of the company, with the exception of the European and Asian branches [10].

In addition, in the use of Russian (Soviet) fuel reactors by another manufacturer, risks may arise from the point of view of nuclear safety issues due to the technical differences of the fuel components themselves and of the fuel itself.

Ute Blom-Heber, a representative of the European Atomic Energy Community (Euratom), noted that the Agency did not insist on the necessity of two or more suppliers of fuel. "This question must be solved by the plant operators themselves," Bloom-Heber said.

Despite the pressure from the United States, the European Union must necessarily diversify sources of nuclear fuel delivery to its Russian-designed nuclear power plants to break the Kremlin's energy dependence, so far, the idea remains in the political field rather than seeing it a real economic benefit and a guarantee of technical safety.

At the end of last year, a political agreement was reached on the revised Nuclear Safety Directive. "Nuclear safety is of paramount importance to all European citizens, and we must make every effort to ensure that the highest safety standards are observed in every nuclear power plant in the EU. This directive, once it has been formally adopted, will help ensure the continuous improvement of

the safety of our nuclear installations, "said EU Commissioner Günther Oettinger.

The revised Directive will strengthen the role and independence of national regulators and will help to increase transparency on nuclear safety issues. It will introduce a system of European peer reviews to be carried out at least once every ten years. It will also ensure that European nuclear safety rules are in line with the latest international standards

By March 2016, Europe has 185 nuclear capacities with a net capacity of 162 GW (5 of which are in the Asian part of the Russian Federation), and 17 other nuclear units with a net capacity of 15 GW are being built in five countries.

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Nuclear science and experimental base is a laboratory of the Institute of Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences. It includes the only research nuclear reactor in Bulgaria located in the south-eastern part of Sofia.

The initial research reactor of the Nuclear Research and Experimental Base in Sofia is from the Soviet IRT-2000 model. Its construction began in 1956, and its launch was in 1961, when at 20:15 on September 18 the first nuclear chain reaction in Bulgaria was carried out. Initially, the thermal power of the reactor is 500 kW, but five years later it reaches 2000 kW.

IRT-2000 was temporarily suspended on July 13, 1989 on a CUAEPP prescription for security reasons following the Chernobyl accident. After the reactor shutdown, the spent fuel is stored in the territory of the Institute on Tsarigradsko shosse Blvd. - VII km in Sofia. Removal of the 70 spent fuel tanks is enshrined in the Reconstruction and Reconstruction Agreement for the Reactor for Research Purposes. At the beginning of this century, the reactor was finally shut down.

The fuel is discharged in two stages. The first stage was carried out at the end of December 2003. 16.9 kg of enriched uranium was transported with a 36% concentration of 235U (uranium-235), which equals 28 fuel elements for the IRT-2000 reactor. The fuel is transported by truck to Gorna Oryahovitsa Airport, where a Russian cargo plane An-12 supplies it to the Research Institute for Atomic Reactors (NIIAR) in Dimitrovgrad, Ulyanovsk Oblast, Russia. The transportation operation has been prepared by 35 Russian, American and Bulgarian specialists, while the $ 440,000 costs are covered by the US side.

The second stage takes place in early July 2008. 6.3 kg of enriched uranium 235U is transported. The fuel was transported by truck to a Danube port, from where a barge transported it to the Ukrainian port of Izmail. From there, a special train was delivered to Sheikh Mohammed in Chelyabinsk, Russia [11].

In our experimental reactor everything that is outside of the core zone and next to it is replaced, but in the past 2 years, any funding has been suspended and is in standby mode. A Decree of the Council of Ministers for reactor modernization is in force, but there is no real funding for the project. In fact, about 5 million levs are needed to complete the reconstruction, which the Bulgarian governments do not find.

In 2015 a cyclotron was delivered to the RNI to BAS. It is a cyclic particle accelerator, in which the particles move in a constantly homogeneous magnetic field, and their acceleration is applied to a high-frequency electric field at a constant frequency. It is still in cartons and has not been tampered with, although the media have repeatedly released messages about its commissioning [12].

Cyclotron works with unrelative heavy charged particles (protons, ions). It was first developed and built in 1931 by Ernest Lawrence, for which he was awarded the Nobel Prize for Physics in 1939. To date, cyclotrons are used to accelerate heavy particles to relatively small energies - up to 50 MeV / nuclon. In the summer of 2016, it was going to be put into operation, with which we would produce neutrons and isotopes for our medicine and technology. Currently, isotopes for PET scanners are mainly imported from Hungary and the Czech Republic. On the territory of the country there are already a few small cyclotrons specializing in the production of Fluoro-18. One in Plovdiv, one in Varna and two in Sofia. Unfortunately, they are insufficient to meet demand, and most are still not in operation but under licensing. Unfortunately, the much needed sources of neutrons and isotopes for our medicine and industry for many reasons fail to work well.

Neighboring with us experimental nuclear reactors or powerful accelerators have Romania, Hungary, the Czech Republic, Slovakia and Ukraine.

3.Conclusions:

1. A clear program has been developed and implemented to ensure nuclear safety with the participation of all levels of state and local government. A National Strategy for the Safe Management of Spent Nuclear Fuel and Radioactive Waste has been developed and the necessary control has been introduced on these activities;
2. Near Bulgaria there are nuclear facilities in Romania and planned in Turkey, which could potentially affect the radiological situation in Bulgaria in the event of a nuclear accident. There is also such a strong military presence in the Black Sea, which is not a constant magnitude. This implies the strengthening of control in these border areas, and we must not overlook the other potentially dangerous areas.

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ASSESSMENT OF COMPLIANCE OF THE BULGARIAN RADIATION PROTECTION LEGISLATION WITH THE NEW DIRECTIVE 2013/59 / EURATOM

ОЦЕНКА НА СЪОТВЕТСТВИЕТО НА БЪЛГАРСКОТО ЗАКОНОДАТЕЛСТВО ПО РАДИАЦИОННА ЗАЩИТА С НОВАТА ДИРЕКТИВА 2013/59/ЕВРАТОМ

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Abstract: *The report assessed the compliance of the Bulgarian legislation with the international legal framework in the field of radiation safety. The main Bulgarian administrative rules and short content are presented. Similarly, the basic legal instruments operating in interstate relations are similarly presented.*

Keywords: *legislation, administrative rules, nuclear power, NPP, laws, radiation gamma background, directive*

1. Introduction

In the years before Bulgaria's accession to the EU, Bulgarian legislation was transposed in line with European legislation. This does not mean that our legislation was previously at odds with the European one, but there were some differences in standards of our equipment, operational requirements, precautions and classification with European standards. Already with the commissioning of the experimental reactor first and then the reactors at the Kozloduy NPP, we have fully complied with the international requirements of the IAEA and the other nuclear regulators. Bulgaria has been guided by the requirements and requirements of leading international and global organizations in the field of nuclear technology and safety and has complied with its legislation and regulations.

Following the Chernobyl nuclear power plant accident in 1986, the global regulatory framework was renewed and the requirements for safe operation of nuclear facilities increased considerably. In the 1990s, re-writing of the entire regulatory framework in the field of nuclear technology, radiation safety and all sectors and activities related to it was started. There has been a significant increase in requirements for nuclear facility manufacturers in terms of their performance, as well as to the users of these facilities.

The member states of Euratom, an organization created together with the EU's prototype, have also taken steps to improve the safety of the work of the nuclear industry. Over the last decade, all requirements in this sector have been updated in the current Euratom Directives, with some even undergoing several changes.

The legislation in Bulgaria after our accession to the European Union has gradually been aligned with the current legislative documents in the Union and the legal committee to the Parliament, the Council of Ministers and other institutions working in the field monitor the amendments and requirements of EU, Euratom, IAEA and others. changes to the relevant competent bodies the necessary legislative and regulatory changes so that we can not go beyond the requirements. In the last years, our entire regulatory framework in the field of radiation protection has been phased and coherently aligned with the above-mentioned requirements and now it is in line with the main international requirements. At the same time, we comply not only with the European requirements but also with the requirements of the international institutions working in the field of nuclear energy and safety, besides our normative base we also strive to help our partners in this branch of the economy.

2. Laws and regulations regulating the use of nuclear energy

2.1. Legislative acts in Bulgaria

The main normative documents that provide the legal limits in the field of radiation protection are:

1.Anvironmental Protection Act

The law is a framework for other environmental laws. It regulates the basic frameworks for the protection of the environmental components - air, water, soils, landscapes, biodiversity, as well as the procedures for Environmental Analysis (EA) and Environmental Impact Assessment (EIA), permitting regimes, management and financing [1].

The law governs public relations relating to:

• establishment and operation of the National Environmental Monitoring System (NASEM);

• the conservation and use of biodiversity in accordance with the country's natural and geographical characteristics.

2.An Safe Energy Use Act

This Act regulates public relations related to the state regulation of the safe use of nuclear energy and ionizing radiation and the safe management of radioactive waste and spent fuel as well as the rights and obligations of the persons carrying out these activities for the provision of nuclear safety and radiation protection [2].

3. Regulation on Basic Norms for Radiation Protection (Promulgated SG, No. 76 / 05.10.2012)

The subject matter of this Ordinance are the basic requirements and measures for radiation protection in carrying out activities related to the use of nuclear energy and sources of ionizing radiation, as well as activities where the availability of natural sources leads to an increase in the exposure of workers and the population [3].

4. Regulation for construction, operation and development of the National Automated System for Continuous Control of the Radiation Gamma Background in the Republic of Bulgaria (Decree of the Council of Ministers № 434 / 19.11.1997)

The Regulation regulates the establishment, maintenance, operation and development of the National Automated System for Continuous Control of the Radiation Gamma Background in the Republic of Bulgaria [4].

5. Planning and Preparedness Plan for Action in Radiation Accident (Promulgated State Gazette No. 94 / 29.11.2011)

The Ordinance defines the obligations of the executive bodies, the NPP operator and legal entities operating on the territory of the Republic of Bulgaria for planning of actions in the event of a

nuclear accident in the NPP, as well as for the maintenance of emergency preparedness [5].

6. Regulation on the Norms for the Radiation Protection and Safety in the Eradication of the Effects of the Uranium Industry in the Republic of Bulgaria (Ordinance No. 1 / 15.11.1999)

This Ordinance sets out the radiation protection and safety standards applicable to sites and areas affected by the uranium mining and uranium processing industry, where action is being taken to eradicate the consequences, restore and monitor [6].

7. Regulation on ensuring the safety of nuclear power plants, adopted on September 30, 2016. The Regulation defines the basic criteria and rules for nuclear safety and radiation protection of nuclear power plants as well as the organizational measures and technical requirements for ensuring the safety of site selection, design, construction, commissioning and operation of nuclear power plants. The Ordinance regulates the requirements for technical and fire safety, emergency planning and emergency preparedness of the nuclear power plant as far as they derive from the application of the concept of in-depth protection. The Ordinance covers the physical protection of the nuclear power plant only with respect to the interconnection between physical protection measures and safety measures [7].

8. Ordinance on Basic Norms for Radiation Protection. Subject matter of the Ordinance are the basic requirements for radiation protection, criteria and levels of exemption from regulation, measures for radiation protection in carrying out activities for the use of nuclear energy and sources of ionizing radiation. The requirements of the Ordinance refer to activities where the availability of natural sources leads to an increase in the exposure of staff and the population [8].

The requirements of the Ordinance exclude the exposure of people due to:

• cosmic radiation on the Earth's surface;

• the content of potassium - 40 in the human body;

• the content of natural radionuclides in different materials that is not altered by human activity.

The Ordinance aims to:

• Determine the occurrence of deterministic effects;

• Reduce the likelihood of stochastic effects to a level that is considered acceptable under international recommendations.

Bulgarian legislation is in line with existing international law, and in particular with EU, IAEA and other regulating and controlling authorities

2.2. International regulations

1. Euratom Treaty. The European Atomic Energy Community (EAEC or Euratom) is an international organization established to create a common nuclear energy market in Europe, the development of nuclear energy and distribution among member states, and the European Atomic Energy Community. sale of non-members. It is legally distinct from the European Union, but has the same member states and is managed by the EU institutions [9]. Since 2014, Switzerland is an associate member. It was created on 25 March 1957 with the Treaty of Rome, together with the European Economic Community (EEC), and the latest amendments were introduced by the Treaty of Lisbon signed on 13 December 2007 and entered into force on 1 December 2009. The amendments to these Contracts are very rare, given the sensitivity of the participants to the essence of the content and the interpretation of matter. This Treaty defines the strategy for the development of nuclear energy and provides guidance for other normative documents that have been developed and operate in this specific area of the economy.

2. Directive 2006/117 / Euratom of the Council of Europe of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel [10]. It establishes a Community system for the supervision and control of the transboundary movement of radioactive waste and spent fuel in order to ensure adequate protection of the population and applies to the transboundary shipment of radioactive waste or spent fuel. The Directive does not apply to the transboundary shipment of waste containing only natural radioactive materials which are not the result of certain practices. It describes the procedure for the carriage of radioactive waste and spent fuel both within and outside the Community, the authorization regimes, the accompanying documents and the means of escorting and transmitting.

There is a compulsory system within the EU that uses a standard control document.

3. Directive 2011/70 / Euratom of the Council of Europe of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste. It establishes a Community framework to ensure the responsible and safe management of spent fuel and radioactive waste in order to avoid the transfer of undue burdens to future generations and to ensure that Member States take appropriate national measures to achieve a high level of the safety of spent fuel and radioactive waste management in order to protect workers and the general public from the dangers arising from ionizing radiation.

4. Council Directive 96/26 / Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation [11]

5. Directive 2009/71 / Euratom of the Council of Europe of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations. A framework is created to maintain and improve nuclear safety and its regulation in order to enhance the safe exploitation of nuclear facilities. At the same time, it is ensured that Member States will maintain their domestic legislation in line with international law [12].

6. Council Directive 2013/59 / Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation and repealing Directives 89/618 / Euratom, 90/641 / Euratom, 96/29 / Euratom, 97/43 / Euratom and 2003/122 / Euratom with effect from 6 February 2018. This Directive shall enter into force from the beginning of 2018. Under normal conditions, doses of ionizing radiation are very low and do not cause clinically detectable harmful effects [13]. However, in the long run, they can lead to health problems, especially cancer. Hence the need for a uniform threshold value of protection throughout the EU, while allowing governments to set higher safety standards if they so wish.

The directive replaces five previous legislative documents that contained contradictions, did not fully reflect scientific progress and did not fully cover natural sources of ionizing radiation or environmental protection. It defines how to ensure the safety and security of radioactive materials and the mandatory information to be provided in the event of an emergency exposure situation.

The standards it contains are based on the recommendations of the International Commission on Radiological Protection (ICRC) [14].

7. Directive 2003/122 / Euratom lays down safety standards for radiation protection. It introduces stricter rules for the handling of "closed radioactive sources". It also harmonises the EU-wide approach [15].

8. Council Decision 2007/513 / Euratom of 10 July 2007 approving the accession of the European Atomic Energy Community to the amended Convention on the Physical Protection of Nuclear Material (KFNMG) [16]. The new Convention on the Physical Protection of Nuclear Material and Nuclear Facilities aims to provide effective physical protection during the use, storage or transport of materials used for peaceful purposes and to prevent and combat crimes related to this material and these facilities. It is based on the CFSP that all EU countries are party to.

Each State Party shall introduce and enforce measures to ensure such effective protection in order to prevent, in particular, the theft or disappearance of nuclear material for which it is responsible and the sabotage of nuclear facilities on its territory . The Euratom treaty has a wider scope as it states that EU countries must prevent any misuse of nuclear material for purposes other than those for which it is intended.

In implementing the Convention, States Parties must respect a number of fundamental principles, in particular the principles of State and license holders' responsibility, a culture of security, security and confidentiality.

States Parties to the Convention must ensure that the nuclear material they import, export or transit through their territory is protected in accordance with the applicable level of safety.

9. Regulation No 236/2014 of the European Parliament and of the Council of 11 March 2014 laying down the general rules and procedures to be used for implementing Union external action funding instruments [17].

It allows for grants to non-EU countries to maintain the highest possible standards of nuclear safety.

10. European system for the registration of carriers of radioactive materials COM (2011) 518.

Carriers are required to register with the Electronic Carrier Registration System (ESCReg). This system provides limited and secure access to the competent authorities of Member States, registered carriers and applicants, subject to the relevant provisions of the Data Protection Directive. If the applicant is established in one or more Member States, the application shall be processed by the competent authority of the Member State in which the applicant's registered office is situated. If the applicant is established in a third country, the application shall be processed by the competent authority of the Member State from which the carrier intends to enter the territory of the EU.

Member States designate a competent authority and a national contact point for the transport of radioactive material [18].

11. Council Directive No 1493/93 / Euratom of 8 June 1993 on the supply of radioactive substances between Member States. It introduces a EU-wide system for declaring supplies of radioactive substances between EU countries [19].

When delivering radioactive material, the "holder" must provide a pre-declaration by the "consignee". This declaration must demonstrate compliance by the recipient with the EU legislation on mandatory reporting of activities related to natural and man-made radioactive substances. This declaration must be submitted to the competent national authority of the country of destination in the EU.

Holders also have to comply with national security regulations for the storage, use and disposal of radioactive activities.

At this stage in the development of Bulgaria it can be stated that our legal framework in the field of the safe use of nuclear energy, the storage and transportation of nuclear materials and wastes fully complies with the world requirements and in this respect we have overtaken a number of countries with more developed nuclear energetics. But this should not reassure us, because the world is developing very dynamically, and we need not to be in a state of satisfaction and just to keep track of the global trends. We need to prove that we have specialists in this field who do not just follow developments, but ask for this development and create new better regulatory documents to lead the world. So we will be a respected partner in the field of radiation protection on a global scale.

3.Conclusions:

1. Well-organized documentary and in compliance with the EU and IAEA requirements for the notification of the population in case of a radiation accident. The legislation in force in Bulgaria follows the provisions of the European legislation and the Euratom regulations.;

2. I have to emphasize that the unit of action in raising the radiation background in the system of the Ministry of Interior is not well positioned and gradually its functions are seized by non-specialists in radiation protection.

4.Literature:

1. Закон за опазване на околната среда;

2. Закон за безопасно използване на ядрената енергия;

3. Наредба за основни норми за радиационна защита (Обн. ДВ, бр.76/05.10.2012 г.);

4. Наредба за изграждане, експлоатация и развитие на Националната автоматизирана система за непрекъснат контрол на радиационния гама-фон в Р България (ПМС № 434/19.11.1997 г.);

5. Наредба за планиране и готовност за действия при радиационна авария (Обн. ДВ, бр. 94/29.11.2011 г.);

6. Наредба за норми за целите на радиационната защита и безопасност при ликвидиране на последствията от урановата промишленост в Р България (Наредба № 1/15.11.1999 г.);

7. Наредба за осигуряване безопасността на ядрените централи приета на 30.09.2016;

8. Наредба за основните норми за радиационна защита, ОНРЗ-2004, ДВ бр. 73, 2004;

9. Договор за Евратом;

10. Директива 2006/117/Евратом на съвета на Европа от 20 ноември 2006 година относно надзор и контрол на превоза на радиоактивни отпадъци и отработено гориво;

11. Директива 96/26/Евратом на Съвета на Европа от 13 май 1996 г. относно постановяване на основните норми на безопасност за защита на здравето на работниците и населението срещу опасностите, произтичащи от йонизиращото лъчение;

12. Директива 2009/71/Евратом на съвета на Европа от 25 юни 2009 година за установяване на общностна рамка за ядрената безопасност на ядрените инсталации;

13. Директива 2013/59/Евратом на съвета от 5 декември 2013 година за определяне на основни норми на безопасност за защита срещу опасностите, произтичащи от излагане на йонизиращо лъчение;

14. Communication from the commission to the council and the european parliament. Communication on nuclear non-proliferation, Brussels, 26.3.2009;

15. Директива 2003/122/Евратом определя стандарти за безопасност за защита срещу радиация;

16. Решение 2007/513/Евратом на Съвета от 10 юли 2007 година за одобряване на присъединяването на Европейската общност за атомна енергия към изменената Конвенция за физическа защита на ядрения материал;

17. Регламент № 236/2014 на Европейския парламент и на Съвета от 11 март 2014 година за определяне на общи правила и процедури за изпълнението на инструментите на Съюза за финансиране на външната дейност;

18. Европейска система за регистрация на превозвачи на радиоактивни материали COM(2011) 518;

19. Директива № 1493/93/ Евратом на Съвета от 8 юни 1993 година относно доставките на радиоактивни вещества между държавите-членки.

BIOMETRIC MULTI-FACTOR AUTHENTICATION

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Abstract: *This paper focuses on multi-factor authentication methods. It primarily addresses biometric methods, in particular authentication through written expression. It summarises the results of many years of research activities by the authors in the field of the dynamic biometric signature[1] (DBS), including new experiments. It concludes by comparing this type of signature with a signature based on cryptographic methods with a view to the current eIDAS Regulation.*

Keywords: AUTHENTICATION TECHNOLOGIES, BIOMETRICS, DYNAMIC BIOMETRIC SIGNATURE; BIOMETRIC DATA OF THE SIGNATURE; STABILITY OF THE DYNAMIC BIOMETRIC SIGNATURE

1. Introduction

Cybercrime and cyberterrorism are problems becoming increasingly urgent given the increasing dependence of civilization on information and communication technologies. Today's popular phenomena such as the Internet of Things, Industry 4.0, BYOD (Bring Your Own Device), the increasing prevalence of control systems (SCADA), and the almost precipitous rush towards robotization are increasing the potential risks arising from possible attacks on these technologies. As the numbers of connected things (thus becoming part of cyberspace) increases, we must face the fact that the risk of their abuse also increases. Yet the prevention of cybercrime is more important than the subsequent rectification of damage. A key assumption for constructing secure information systems is ensuring the proper identification and authentication of people, assets and events in the system. [1] Only after a high quality authentication we can move to the next essential step which is authorisation. For these reasons it is important to focus on the issue of multifactor authentication, in particular where biometric methods play an important role.

2. Preconditions and means for resolving the problem

The secondary research uses resources which were collected for specified purposes and its main objective is to clarify the benefits and pitfalls of authentication technologies. Based on many years of research further experiments were made which focuses on the dynamic biometric signature (further abbreviated as DBS).

The so called on-line dynamic biometric signature [2] was examined to show the possible change of the stability of the DBS of a signer depending on the scanning device. The used hardware was produced by the company Signotec GmbH. The used pads (biometric signature scanning devices) differ from each other in terms of their design, the size of the signature field, resolution, sampling rate, and even the scanning method used – a regular pen or a special pen using the ERT (Electromagnetic Resonance Technology).

The experiment was attended by 40 people in one session. As the sample represented people of both sexes aged 20 to 65, the size of the heterogeneous sample used was statistically representative enough. 8 scanning devices were used. The sampling frequency of the used devices can be set up to 150 Hz, 250 Hz or 500 Hz. The scan rate (sampling) was set up to recommended 250 points/sec. The x, y, time and pressure coordinates were scanned. The testing was carried out on the dynamic biometric signature devices with the various technical parameters produced by the company Signotec GmbH in the last five years (see listed in Table 1).

DBS were recorded on the devices using the program signoSign2 (version 10.4.5) produced by Signotec. Each participant made 10 signatures on each device to separately named *.pdf files. From the 10 times signed pdf file the biometric data were exported, so the final matrix of signatures of each participant and all devices was formed: $P_{ij} = [x_1, \dots, x_{10}]_{ij}$; where *i* is a serial number of the device, *j* is a serial number of the participant, x_k (k = 1, … , 10) are the particular signatures.

2.1 From single-factor authentication to multi-factor authentication

We will build on the classic split of authentication methods (authentication based on knowledge, ownership, and the personal characteristics of the user), which are sometimes supplemented with authentication based on physical location (geographical authentication as an additional factor). There are many examples of failure of single-factor authentication when performed based on all the above methods, and so it is superfluous to explicitly state them.

At present, two-factor authentication is dominant – this ever-increasingly uses a combination of the factor of ownership (token) and knowledge (ID, password, PIN etc.) Yet even two-factor authentication may not be sufficient, in particular in cases where the human factor fails (typically a PIN written on a credit card) or when in reality it is not genuine two-factor authentication, but actually the repeated use of a single authentication method on the same channel (the entry of two text strings of the type ID + password or several passwords), and so if the channel is compromised, all the authentication data will be compromised. [3]

Failure of the human factor is also the greatest weakness in the ever-more-popular cryptographic tools used today – see the so-called Level 4, requiring authentication based on evidence that keys are held through a cryptographic protocol and the use of tokens in the form of FIPS 140-2 level 3 or higher hardware cryptographic modules with FIPS 140-2 level 3 minimum physical security. [4] Yet from practice we know how commonly these tokens for signing are entrusted to other people, typically assistants.

Also, other proposals that have appeared – such as authentication via other people in the case of remote access – have not proven sufficiently secure or have proven complicated to apply and are thus appropriate rather for emergencies than for normal activities. [5]

The opinion that multi-factor authentication is essential to ensure sufficient security of information systems now practically dominates. [6] We can select practically any combination of authentication factors, for example according to the following diagram Fig.1 [7]:

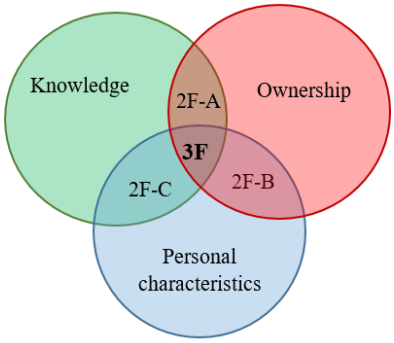


Fig. 1 *Combinations of authentication factors. [7]*

Nevertheless, without a risk analysis and a formal verification of the correctness of the authentication method, we cannot be sure that a proposal is genuinely secure. [8] The authentication methods must provide a high level of protection against their breaking or exploitation, while at the same time remaining user friendly, secure, easy to use and unobtrusive, and have reasonable implementation costs. The addition of an extra factor for authentication also brings with it an increase in the technological, organisational, and primarily financial demands of such a solution, including an impact on the user. The analysis must therefore include economic (costs for acquisition and operation of the security mechanism) and ergonomic (meaning the ease of administration and, in particular, use) assessments. For example, a system based on a secret key stored in a token, password and biometric data has a high level of protection against attack, yet its acquisition and operation costs may prove too high, in particular compared to the value of the protected assets.

The risk analysis may also be an appropriate starting point for the creation of a system for a multi-step authentication process when differing authentication scenarios are launched depending on the importance of the protected item (information, thing), or in the event of doubt as to identity.

2.2 Biometric authentication methods

Risk may arise not only from the person being authenticated and his/her behaviour, but also from an inadequately secured product. In addition, with remote access, an attack may take place anywhere along the path from the authenticated person to the authentication site. Biometric authentication methods appear to be a reasonable compromise between demands on the user and/or on the authentication tool, while not reducing the level of security. However, we must make a fundamental distinction between static and dynamic methods, where static methods are basically a continuation of the authentication principle that the user "has something", even if this means something that is part of their physiology. Here, the risk of the falsification of biometric information (faking fingerprints, an iris image, etc.) [9] or their use through coercion remains.

Hence dynamic authentication methods are increasingly of interest, where we can assume a higher level of protection from abuse, as we are moving from the variant that the user "has something" to the variant in which the user "knows something" – and, what is more, they "do not know what they know". In addition, these methods implicitly include a "test of life". This is particularly true when scanning blood flow in the palm, the back of the hand or finger [10] and in the dynamic recording of written expression. (For the sake of completeness, we must add that other dynamic methods, such as walking dynamics, typing on a keyboard, facial expressions or gestures, show relatively high instability and error rates). Hence, authentication through the recording and analysis of a person's written expression appears promising.

2.3 Authentication through written expression

The static recording of a person's writing – typically their signature – is one of the oldest authentication tools but, nevertheless, also one of the riskiest. The signature image can be imitated or forged, while comparison (e.g. of markers) is a subjective process, in particular in the case of short records such as signatures. This is especially true for experienced counterfeiters. [11]

Writing is a natural human activity and, as such, these are processes where the primary impulse arises in the central nervous system – in the human brain – with a predefined intensity and duration. The nervous system then activates the relevant muscles in a defined order so that the user can perform a certain activity – a signature, a certain gait, a gesture, and so on. [1]

Generally speaking, the dynamic recording of writing can be used to authenticate the person producing the written record. [12] The dynamic biometric signature ("DBS") is then a special variant, where by creating a signature, the person certifies a certain fact – presence at a specific location (when entering a protected space, when logging in to an IS), or a legal act, etc. In the first case, it is possible to create a comparison benchmark by entering a specific phrase or drawing which, to improve security, may be individual for each person. In the second case, the handwritten signature of the person is used.

When authenticating a person, we generally employ the 1:N model, meaning that we compare the scanned record with all the records in a database of people. Some disadvantages of this are the higher risk of mistaken identification and high demands on computing power in the system. We remove this problem by using a prior identification step (entering identification data such as name, number, ID etc.), which can be done both in the case of authentication using a general record and also for authentication using a signature. This gives us a 1:1 variant with higher accuracy and lower processing demands.

On-line verification is used in both cases, when the record is made using a special "pen" and a digitising tablet that records the data, enabling analysis of the static and, in particular, the dynamic characteristics of the record in the form of the data string (text, image or signature) connected with the typical behaviour of the person in question, which is assessed by the verification device. These include the basic features of the record: the duration, including the periods between strokes, typical points and curves in different parts of the signature, the pressure exerted by the pen on the pad during different parts of the signature, the overall size of the signature, the length and angle of lines, arcs and curves, the number of loops, the speed of individual stokes, acceleration and deceleration, etc. [13] This is all usually established by scanning the x and y coordinates (horizontal and vertical pen position), or z (the height of the pen above the writing surface). The output data must also include T (time) or DT (time difference) or uniform sampling must be indicated. The inclusion of additional parameters is optional – here, it is important to emphasise that the number of analysed channels has a significant impact on the uniqueness and reliability of the authentication of the signing person. [14]

The dynamic biometric signature contains information about how the signature was created, and thus reflects characteristics of the signing person, their habits and behaviour. These characteristics represent a biometric footprint that is unique for each individual and cannot be reproduced by a forger (unlike the actual image of the signature itself, which only makes up one of the parameters of the biometric footprint). One important attribute of a DBS is that it contains not only the element that the writer is alive, but also the fact that the signature was created by the writer consciously, and so there is no need to develop additional mechanisms to test whether the subject is present and alive or not – unlike with static biometric methods (checking the print of a finger, palm, iris etc.) It is also legally beneficial, in that we can rely on the (theoretically rebuttable) assumption that the person knew what they were signing. [15]

3. Results

As we previously showed [16] each individual has an individual set of component movements. This enables verification of the signature to be based on the stability of the set of component movements during its implementation. A decisive indicator for a DBS is that this unique set significantly eliminates the possibility of its reconstruction by a counterfeiter. Regarding alleged changes in a signature due to aging and other influences, it is important to realise that two identical signatures do not exist – or rather, if they are identical, we can be sure that they are a so-called technical forgery, produced by copying from a specimen. Hence it is crucial to know how the level of agreement between the signature and its specimen should be set for automatic evaluation to ensure that handwriting experts only receive signatures in exceptional cases.

The presented results are a summary of our original research in the field of DBS performed between 2011 and 2016, when we focused on its properties, security, resistance to counterfeiting and its stability. We addressed issues relating to an unquestionable connection between a created DBS and the text of the signed electronic document in our previous ICCST papers [15], [16].

Experiments demonstrating the uniqueness of the DBS as well as its resistance to counterfeiting have been extremely helpful [17]. These experiments examined the signatures of a sample of 102 people of varying ages, who created real and intentionally altered signatures. Subsequently they tried, using submitted specimens, to copy the signature of somebody else. It was shown that 1. the stability of the real signatures is high and the degree of conformity hovered over around 85%, with only some exceptions, 2. conformity was still found with 25% of the intentionally altered signatures, 3. not even a single forged signature was accepted. The experiments showed that the biometric data acquired during the creation of a signature provide such a set of information that enables the preparation of a clear opinion during subsequent authentication in the event of a dispute over the authenticity of a signature. It will only be appropriate to have an analysis prepared by a handwriting expert in exceptional cases for the authentication of a signature for the purpose of increasing probative value in court proceedings, while usually it is sufficient to use a validation server. In such a case, the biometric data are an ideal source of information for the handwriting expert compared to a situation in which they can only use two short texts, namely signatures on paper, for a comparison.

Another decisive aspect of DBS is its stability. Hence, in 2015, we addressed the influence of alcohol on DBS stability. [18] Before and after consuming alcohol, our test subjects 1. took the Brickemkamp-Zillmer variant of the d2 Test of Attention [19], 2. underwent an alcohol-level breath test, 3. created a set of signatures. While the results of the d2 test changed, no influence of alcohol on signature performance was proven.

It is common for the person providing a signature to be exposed to stress, one reason for this being the importance of the situation in which they are appending the signature. After all, stress, and very often negative stress, is one of the most common emotions in human life. Hence, in a different experiment, we examined whether and in what way stress influences the quality and constancy of DBS. [19] In our experiments, we used the extreme situations in which test subjects in survival courses (X-tream course) at the University of Defence of the Czech Republic found themselves, while once again we used the d2 Test of Attention and signature stability at the start, in the middle, and at the end of the course. The results of the experiments showed that irrespective of the stress levels of the participants, the stability of their DBS was high, respectively actually improved. The results are in accordance with phases I. and II. of the Selye model. [21]

These experiments also showed a high level of signature instability with so-called short signatures –initials. Hence, we performed another experiment focusing on the stability of short signatures (initials), which showed that signature recognition quality increased together with the length of the recorded information. This corresponds with the information from the manufacturer of the equipment (Signotec), namely that the method they use for evaluating signature concurrence using their own algorithm requires a specific minimum number of points (determined by the x, y and z coordinates), which leads to greater fluctuations (variability of the observed match between signatures) during comparisons of short signatures.

Based on the series of experiments we have performed [15], [16], [17], [18], [20], we consider DBS stability sufficiently demonstrated for this method to be used to identify and authenticate people or the documents they have signed with a high degree of reliability and verifiability. The use of short signatures (initials) can be something of a problem, as they show a high level of variability when evaluating conformity or non-conformity.

It was also confirmed once again that the use of the 1st signature as "practice", not included in the results reduces the variability of signatures among all test subjects [18] [20]. In accordance with these findings, the first signatures made by each person on the devices were not included in the evaluation. For the signature match rate automatic evaluation a special algorithm was created which uses the original analytical software of the device manufacturer (Signotec - eSig-Analyze). The end result was a data matrix where the signature matches were evaluated among themselves in percent for every person each. Every person (40 people) had 8 times (number of the devices) 10 signatures. From every these 10 signatures minus the first signature (so 9) which in one case (1 person and 1 device) had 36 signature alikeness comparisons. The overall 11520 signature alikeness comparison data were then used for calculations. The following values of selective means and unbiased estimates for variances of the degree of compliance of signatures were detected on the stated devices (Table 1):

Table 1: *Overview of the tested devices and the selective means and unbiased estimates for variances of the degree of compliance of signatures.*

Method of the signature capture	Scanning device of the dynamic biometric signature	**x [%]**	**S^2**
The active pen, display, and pen are mutually synchronized	Signotec Alpha Pad, ST-A4E-2-UFTE100: Color LCD Signature Pad Alpha ERT (Electromagnetic Resonance Technology)	80.342	113.019
The display is electromagnetic, the pressure is captured on the basis of the outward pressure of the passive pen on the display	Signotec Delta Pad, Touch display ST-DERT-3-U100 ERT	76.749	238.268
The display is electromagnetic, the pressure is captured on the basis of the outward pressure of the passive pen on the display	Signotec Gamma Pad, Touch display ST-GERT-3-U100: 5" Color LCD Signature Pad Gamma ERT	78.971	232.027
The display is a touch-screen, the pressure is captured on the basis of the outward pressure of the passive pen	Signotec Omega Pad revision B, Touch display ST-CE1075-2-U100 (old version)	76.02	228.052
	Signotec Omega Pad revision E, Touch display ST-CE1075-2-U100 (current version)	83.002	125.844
	Signotec Sigma Pad revision B, Touch display ST-ME105-2-U100-B (old version)	77.097	148.574
	Signotec Sigma Pad revision E, Touch display ST-ME105-2-U100-B (current version)	85.233	139.194
There is no display, only the touch area	Signotec Sigma Lite, Touch area without a display function STLT105-2-U100	77.195	120.338

The result characterizing the technology as a whole, i.e. without differentiation of types of devices and signers (i.e. for all people on all devices) is the average percentage 79.33 % with the standard deviation of σ = 13.16 %. The selective mean of the degree of compliance of signatures came under an accepted level of compliance of biometric signatures > 60% only in case of two people.

4. Conclusion

The dynamic biometric signature is in accordance with the eIDAS Regulation (Regulation (EU) No 910/2014 of the European Parliament and of the Council), which became valid on 17 September 2014 and focuses on the secure identification of people in electronic communication, respectively the provision of remote services. DBS is not a replacement for a cryptographic electronic signature, but an important alternative that can be used in cases when the use of certificates, the secure storage and "policing" of private keys, etc. would significantly impact routine and stable processes, and potentially form a barrier discouraging normal users and also bringing significant organisational and technical problems during the deployment of a guaranteed or qualified electronic signature (Advanced Electronic Signature, Qualified Electronic Signature) under the eIDAS Regulation. Its advantage over a cryptographic electronic signature is the existence of this "handwritten" quality.

There was no statistically significant difference in the means and variances of the degree of compliance of signatures of a particular person on individual devices. The different scanning technology does not affect the degree of compliance and variability of signatures (see Table 1). In the opinion of the authors, the "user-friendliness" is a key factor in creating the signature. Another factor is then the individual characteristics of the signer. The variability of the signature, and hence the low degree of compliance among individual signatures, which is exceptionally manifested among the signers, is closely related to the stability of the signature. The greater the intra-personal variability is, the less stable the signer is.

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COMPARATIVE STUDY OF VULNERABILITY SCANNING TOOLS: NESSUS vs RETINA

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Abstract: *Detecting vulnerabilities for a network is an important procedure which ensures that all the data, network-based applications and information communicated in this network, is secure. Detection of network vulnerabilities is used to determine weaknesses of the network, the risk evaluation of attacks, the diagnosis and suggestions to solve the problems. There are several types of scanning tools used to detect vulnerabilities, offering different features. In this paper, we will present a performance comparative study between two most used free, software based, network vulnerability scanning tools: Nessus and Retina. The comparison will be based on three main features: The ability to search, Scanning Time, The ability to detect vulnerabilities. In the conclusions of this paper, both scanners performed very well in vulnerability identification. In terms of speed without active Web Application feature, Nessus performed much faster than Retina; (on the other hand, with active Web Application module, Nessus performs much slower than Retina. In terms of scan depth, Nessus has a small advantage, since it includes a web mirroring tool that is very helpful in HTTP.*

Keywords: VULNERABILITY, NESSUS, RETINA, SCANNING TOOL

1. Introduction

Detecting vulnerabilities for a network is an important procedure which ensures that all the data, network-based applications and information communicated in this network, is secure. Detection of network vulnerabilities is used to determine weaknesses of the network, the risk evaluation of attacks, the diagnosis and suggestions to solve the problems. There are several types of scanning tools used to detect vulnerabilities, offering different features. With so many tools available to make penetration testing, it's hard to choose the most effective. There are not many research works on empirical comparison of vulnerability scanning tools that can help security officers to understand which tool to use, in order to have a better performance during the penetration test of a network.

Therefore, the main aim of this paper is to investigate over two most used, free, software based, vulnerability scanning tools, in terms of their performance.

Open source Nessus is defined as the world's most popular vulnerability scanner [1][2]. Additionally, Nessus scanners may be distributed throughout an entire enterprise, inside DMZs, and across physically separate networks [2]. It is free of charge for personal use in a non-enterprise environment [1]. Commercial organizations that deploy the Nessus vulnerability scanner have to purchase a Nessus ProfessionalFeed [2].

Retina CS is also software based scanning tool as Nessus [1][2][3], which is a free vulnerability scanner for up to 256 IPs gives you powerful vulnerability assessment across your entire environment [3].

There are some previous works about Vulnerability Detection by authors. In [4], Thanyada Veeraprasit et al. implemented NetClarity Auditor and Nessus on Rangsit University network in order to find vulnerability of the network and performance comparision. Then, Aniwat Hemanidhi, Sanon Chimmanee, and Prarinya [5] also deployed such vulnerability detection tools on Rangsit University network for finding vulnerability of the network. Network Risk Metric was proposed in order to evaluate a security risk level of the network based on information from such vulnerability detection tools. Consequently, Sanon Chimmanee et al. evaluated performance of such vulnerability detection tools on both Rangsit University and Royal Thai Army network [6]. Aniwat Hemanidhi, Sanon Chimmanee, and Prarinya deployed the proposed Network Risk Metric in order to evaluate security risk level on Royal Thai Army network [7]

In this paper, we will present a performance comparative study between two most used open source, software based, network vulnerability scanning tools: Nessus and Retina. The comparison will be based on three main features: The ability to search, Scanning Time, The ability to detect vulnerabilities. In the conclusions of this paper, both scanners performed very well in vulnerability identification. In terms of speed without active Web Application feature, Nessus performed much faster than Retina; on the other hand, with active Web Application module, Nessus was much slower than Retina. In this paper we have implemented the free open source version). In terms of scan depth, Nessus has a small advantage, since it includes a web mirroring tool that is very helpful in HTTP.

In section II, experiment setup is stated, also in this section, will be presented the tools configuration (Nessus and Retina scanning tools). Section III provides the experimental results and performance evaluation. In section IV are given the conclusions of this work and future work.

2. Experiment Setup and configuration

The following figure (Fig. 1) shows the network which is configured to test the tools. The client machine, which runs the network vulnerability scanning tools, is within the same subnet with other machines. IP address of the auditor must be set within the same subnet of the target network. A range of investigated IP addresses is required. In this experiment, the target network is XXX.YYY.201.0/24.

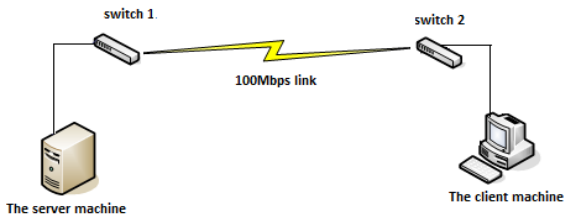


Fig. 1 *The network diagram.*

Nessus [2], by Tenable Network Security, is one of the most popular commercial vulnerability scanners. Vulnerability tests are written using NASL (the Nessus Attack Scripting Language), and

subscriptions to “feeds” of vulnerability checks are available. The “HomeFeed” (the Free version of Nessus we are using) is available for noncommercial home and educational use, while the “ProfessionalFeed” receives updates sooner and can be used in commercial settings. (Nessus Professional (NP) and Nessus Manager (NM), which offer some added features, are available to purchase.). Nessus is based on a client/server architecture, where a client (such as the web interface) connects to the server, which does the scanning. In Fig. 2 and 3 is described the establishment of a secure connection via SSL and also the administrator account setting up.

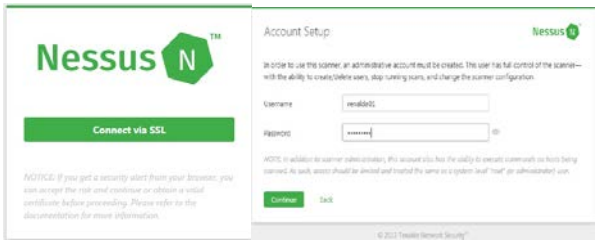


Fig.2 and 3 *The SSL connection and Nessus account setup*

In the Nessus Client side, before starting a scan, must be configured the scanning policies (Fig. 4). In this paper, we will perform a Basic Network Scan.

Results of the scanning can be imported into Metasploit. In addition to vulnerability scanning, Nessus can be used for compliance checks (such as checking the security policies on networked systems by giving Nessus credentials to manage them).

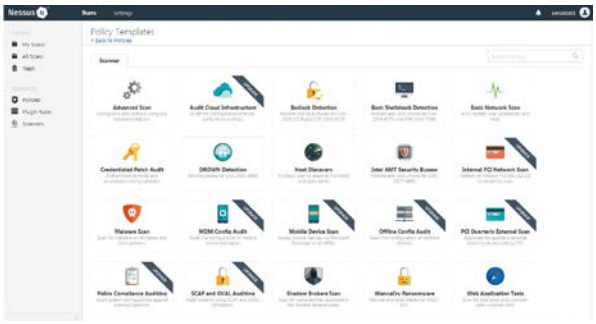


Fig. 4 *Nessus scanning policies*

Retina [3] available as a standalone application or as part of the Retina CS enterprise vulnerability management solution, Retina Network Security Scanner enables you to efficiently identify IT exposures and prioritize remediation enterprise-wide. Retina with its full features integrated is available as Enterprise Edition. For noncommercial and education use, there is Retina free or evaluation version as a Demo also as a Trial. In this paper, we are using the Demo version of Retina, which enable us to use it for 15 days.

In figure 5, is presented Retina Network Security Scanner Interface.

Retina assesses network devices, operating systems, applications, ports and services against a vast, constantly updated vulnerability database. The most innovative feature of it scans the IoT devices and safely checks them for default and hard-coded credentials used with Telnet, SSH, or Basic HTTP Authentication. Also, Retina accurately identifies vulnerabilities with a false positive rate below 1%.

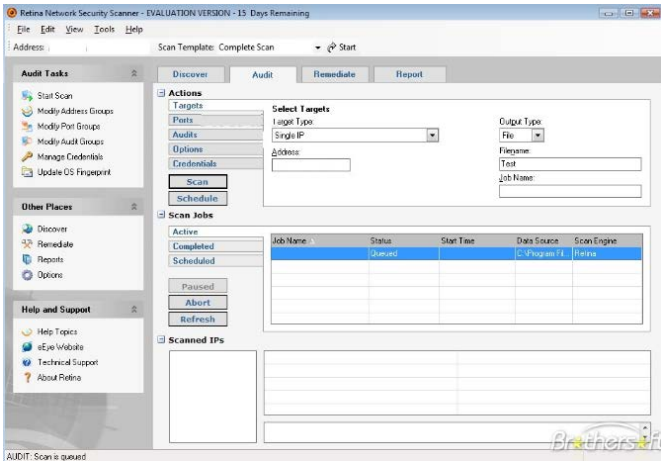


Fig.5 *Retina Network security Scanner Interface*

3. Experimental results

The experimental results will be evaluated upon these features: ability to detect vulnerabilities and the ability to search, also the scanning time.

Nessus also Retina vulnerability scanning tools performed a very good ability to search and to detect vulnerabilities. The considered subnet has five nodes connected to a switch, with the IP address range x.x.201.55-x.x.201.59 and subnet mask /24.

The vulnerabilities classification is based on [8]. The vulnerabilities classification is graded according to the level of risk that they pose to the organization, in terms of severity and exposure. A low rating can be applied to those vulnerabilities that are low in severity and low in exposure. According to this logic, the vulnerability rating 1, 2 and 3 respectively corresponds to low, medium and high risk level. (Table 1).

Table 1: *Vulnerability severity and exposure rating.*

Severity	Rating	Exposure
Minor severity: Vulnerability requires significant resources to exploit, with little potential for loss.	1	**Minor exposure:** Effects of vulnerability tightly contained. Does not increase the probability of additional vulnerabilities being exploited.
Moderate severity: Vulnerability requires significant resources to exploit, with significant potential for loss. Or, vulnerability requires little resources to exploit, moderate potential for loss.	2	**Moderate exposure:** Vulnerability can be expected to affect more than one system element or component. Exploitation increases the probability of additional vulnerabilities being exploited.
High severity: Vulnerability requires few resources to exploit, with significant potential for loss.	3	**High exposure:** Vulnerability affects a majority of system components. Exploitation significantly increases the probability of additional vulnerabilities being exploited.

Figure 6 describes the number of vulnerabilities that Nessus has detected and also the corresponsive risk level of the vulnerability.

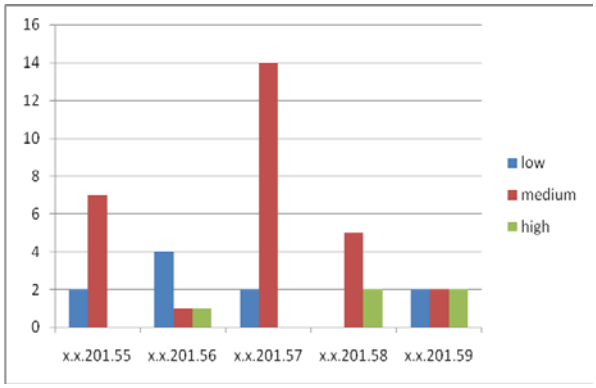


Fig. 6 *Nessus vulnerability detection*

Also figure 7 describes the number of vulnerabilities that Retina has detected and their corresponsive risk level of the vulnerability.

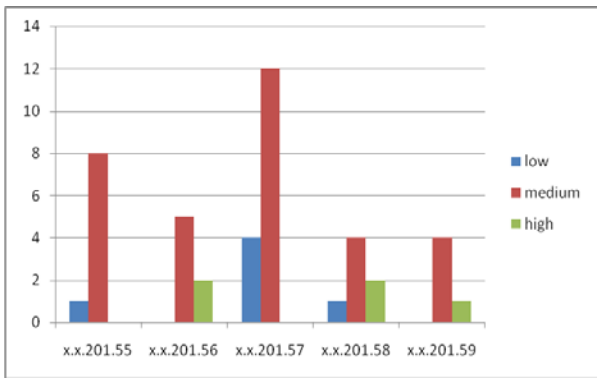


Fig. 7 *Retina vulnerability detection*

In figure 8, is shown a comparative chart according to vulnerability detection ability for these tools. As we can see, Nessus and Retina have almost the same vulnerability detection ability.

As shown on chart (Fig.8), there are much medium vulnerability detected, also some low and very little high vulnerability. The overall security level of this network may be ranked as medium.

In terms of scan depth, Nessus has a small advantage, since it includes a web mirroring tool that is very helpful in HTTP.

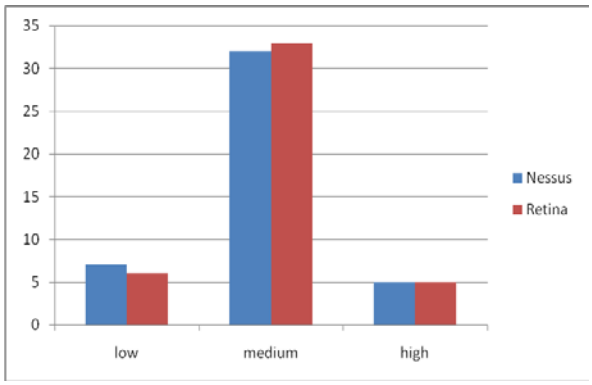


Fig. 8 *Nessus vs Retina vulnerability detection*

In terms of scanning time, (Table 2) Nessus performed much faster than Retina (approximately 6 times faster).

This result initially was a surprise to us. In fact, this result was recorded due to the deactivation of Web Application scanning module in Nessus vulnerability scanning tool.

On the other hand, with active Web application module, Nessus performs much slower than Retina.

Table 2: *Scanning Time*

Tool	Time h:m:s
Nessus	**0:06:01**
Retina	**0:35:49**

Table 2, presents the scanning time for both tools.

4. Conclusion

In this paper, we have presented a performance comparative study between two most used free, software based network vulnerability scanning tools: Nessus and Retina. The comparison is based on three main features: The ability to search, Scanning Time, The ability to detect vulnerabilities. Both scanners performed very well in vulnerability identification. In terms of speed without active Web Application feature, Nessus performed much faster than Retina; on the other hand, with active Web Application module, Nessus performs much slower than Retina In this paper we have implemented the free open source version. In terms of scan depth, Nessus has a small advantage, since it includes a web mirroring tool that is very helpful in HTTP.

The future work will be focused on performance evaluation based on other features, aside from ability to search, Scanning Time, and The ability to detect vulnerabilities. Also, we intend to evaluate other vulnerability scanning tools, not only software based but also hardware based.

Given that there are several types of scanning tools used to detect vulnerabilities, and to perform penetration testing, we aim that with this paper work and with our future work, helping security officers to choose better what tool to implement, in order to have a satisfying performance according to the purpose of use.

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PERSONAL COMMUNICATION NETWORKS WITH GLOBAL COVERAGE-ESSENTIAL FACTOR FOR THE SECURITY OF THE MODERN HUMAN SOCIETY

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***Abstract**: The Personal Communication Systems with global coverage use Integrated Satellite-Terrestrial approach with Low Earth Orbit satellite constellations. The frequency reuse problems in such systems are discussed. The advantages of the implementation here the proposed by the author Space Correlated - Code Division Multiple Access are considered too. The principles of generation and synchronization of used Unique Pseudo Noise codes are shown. The system architecture of a IST PCN, based on the proposed by the author Spatial Correlation Processing – Random Phase Spread Coding technology for LEO,s terminal and feeder lines, is given too.*

Keywords: PERSONAL COMMUNICATION SYSTEM, SATELLITE, SCP RPSC, SC-CDMA.

1. Introduction

The Personal Communication Systems (PCNs) with global coverage are of great importance not only for the government (army, police) and emergency services, but even for extreme tourists and sport practicing people in the high mountains, isolated deserts, water basins etc. Usually such kind of PCNs use Integrated Satellite-Terrestrial (IST) approach with Low Earth Orbit satellite (LEO,s) constellations. The main parameters of such IST PCNs, using LEO,s, are considered in the report from human security point of view. The conclusion of the analysis is the necessity of very high number LEO,s (in order of several hundred or even thousands) in order to achieve very high percent line of sight links even in mountain or urban areas. The frequency reuse problems in such IST PCNs are discussed. The advantages of the implementation here the proposed by the author Space Correlated - Code Division Multiple Access (SC-CDMA) are considered. The principles of generation and synchronization of used Unique Pseudo Noise (U-PN) codes are shown too. The system architecture of a IST PCN, using the proposed by the author Spatial Correlation Processing – Random Phase Spread Coding (SCP-RPSC) technology for LEO,s terminal and feeder lines, is given too.

2. Integrated Satellite-Terrestrial approach with LEO,s

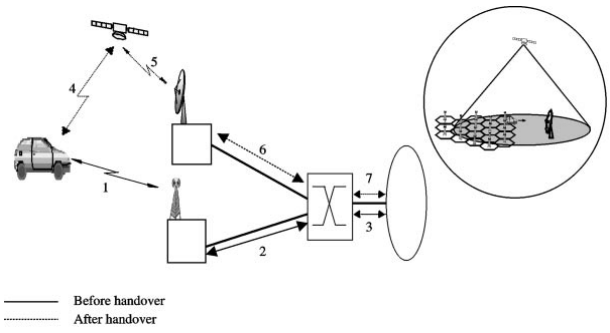


Fig.1. Terrestrial to satellite handover

One of the main objectives of the Satellite - PCNs is to complement terrestrial mobile networks by providing analogous services in areas where satellite technology is more effective and economic [1]. It can be achieved by the provision of dual-mode user equipment which communicates with both the satellite and terrestrial mobile networks so that when users roam outside of the terrestrial coverage, their requested services can still be supported via the satellite segment. Two main types of inter-segment handover are involved in an integrated satellite-terrestrial network: satellite to terrestrial handover and terrestrial to satellite handover. Fig. 1 shows the procedure of terrestrial to satellite handover [1].

The received land mobile-satellite signal consists of the combination of three components, shown in fig.2 [1]: the direct Line-Of-Sight (LOS) wave, the diffuse wave and the specular ground reflection. The direct LOS wave arrives at the receiver without reflection from the surrounding environment. The only L-/S-band propagation impairments that significantly affect the direct component are free space loss (FSL) and shadowing. FSL is related to operating frequency and transmission distance. Shadowing occurs when an obstacle, such as a tree or a building, impedes visibility to the satellite. This results in the attenuation of the received signal to such an extent that transmissions meeting a certain Quality of Service (QoS) may not be possible. The diffuse component comprises multipath reflected signals from the surrounding environment, such as buildings, trees and telegraph poles. Unlike terrestrial mobile networks, which rely on multipath propagation, multipath has only a minor effect on mobile-satellite links in most practical operating environments.

The first step towards modeling the mobile-satellite channel is to identify and categorize typical transmission environments. This is usually achieved by dividing the environment into three broad categories:

- Urban areas, characterized by almost complete obstruction of the direct wave;
- Open and rural areas, with no obstruction of the direct wave;
- Suburban and tree shadowed environments, where intermittent partial obstruction of the direct wave occurs.

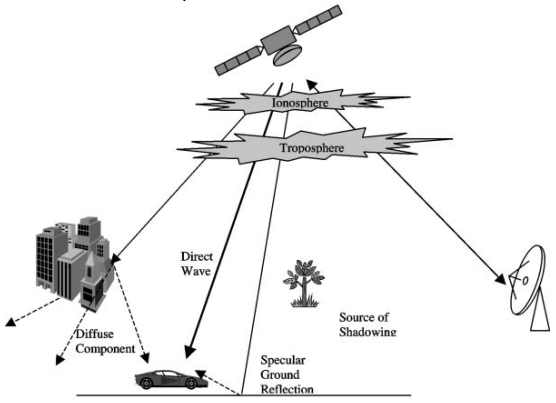


Fig. 2. Mobile S-PCN propagation environment.

As far as land mobile-satellite systems are concerned, it is the last two of the above environments that are of particular interest. In urban areas, visibility to the satellite is difficult to guarantee, resulting in the multipath component dominating reception. Thus, at the mobile, a signal of random amplitude and phase is received. This would be the case unless multi-satellite constellations are used with a high guaranteed minimum elevation angle. Here, satellite diversity techniques allowing optimum reception of one or more satellite signals could be used to counteract the effect of shadowing. For example, in order to achieve a fade margin in the region of 6–10 dB in urban and rural environments, a continuous guaranteed minimum user-to-satellite elevation angle of at least 50 deg. is required. However, to achieve such a high minimum elevation angle using a LEOs would require a constellation of upwards of 100 satellites, as shown in fig.3 [2]. On the other hand, for a guaranteed minimum elevation angle of 20 deg., a fade margin in the region of 25–35 dB, would be required for the same grade of service, which is clearly unpractical. While these figures demonstrate the impracticalities of providing coverage in urban areas, in reality, for an integrated space-terrestrial environment, in an urban environment, terrestrial cellular coverage would take priority.

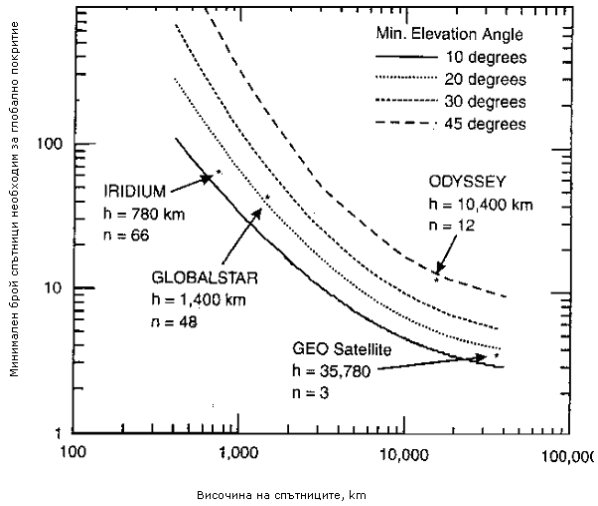


Fig.3. Number of required LEO,s for a global coverage IST PCN

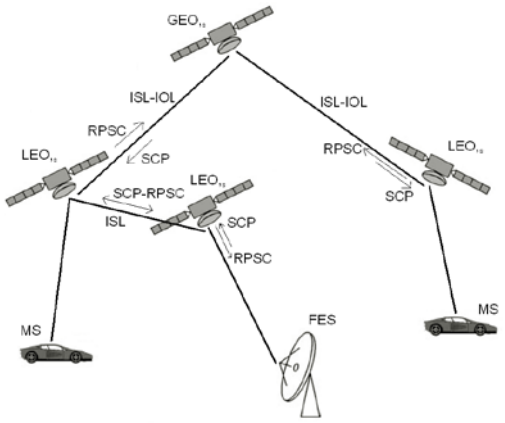


Fig.4. Architecture of a IST PCN using LEOs with different feeder lines

Bearing in mind the requirements to a IST-LEO PCN with several hundreds or even thousands satellites, two new important problems appear, as follows:

- Complicated satellite constellation architecture and corresponding Inter Satellite Lines (ISL), Inter Orbit Lines (IOL) and Satellite – Mobile Station Lines (S-MSL), shown in fig.4. The proposed by the author solution of this problem is given in paragraph 3 below.
- Frequency and code sharing among different S-MSL, using Code Division Multiple Access methods. The proposed by the author solution of this problem is considered in paragraph 4 below.

3. SCP-RPSC technology in IST-LEO PCN

In fig.4 a two-tier satellite network is formed through the use of a hybrid constellation. Interconnection between LEO satellites is established through ISL and inter-satellite inter-orbit links (IOL) (ISL-IOL) via a data relay Geo Stationary Orbit (GEO) satellite is employed. In this configuration, the GEO satellite is directly accessed by an LEO,s.

The main problems of the Fixed Earth Station (FES)-satellite feeder lines deal with the pointing of the high gain satellite antennas to the tracking FES antennas because of LEO,s continuous relative movement. For this reason low gain omni-directional antennas are used in the LEO satellites at the moment. It leads to low feeder lines link margins and poor frequency reuse capabilities.

Another way to connect LEOs is the use of ISLs to establish links with other satellites within the same orbital configuration. This option is used by the famous ***Iridium*** LEO,s system. The main problem here deals with the precise pointing of the narrow microwave antenna beams (the used frequencies are in 23 GHz band) and the need of tracking techniques to support the ISL work. It imposes very strong limitations over station keeping characteristics – about 2 km in cross-track, 5,7 km in-track and 4,7 km in radial direction. We should add the similar pointing problems of IOL narrow antenna beams of the mobile LEO satellites to the fixed GEO satellite positions.

SCP-RPSC Technology was proposed by the author [3] as cheap and effective solution of the Mobile Satellite Services (MSS) antenna problems. The unique properties of this technology could be very useful if it will be implemented in the feeder lines, ISL and IOL of the future LEO satellite communication networks [4]. In the analysis below the considered options are discussed from SCP-RPSC technology implementation point of view.

The existing satellite omn-directional antennas of the satellite-FES feeder lines can be replaced with SCP (up-link) and RPSC (down-link) with the following benefits:

SCP (up-link FES-LEO,s):

- The LEO,s receiving antenna systems will be omni-directional for the cooperative FES, but with high figure of merit G/T;
- The different FES and polarizations could be selected simply by the use of specific allocated PN-codes;
- Soft handover between different FES is feasible because of the LEO,s movement and multiple beam forming properties of the SCP technology;
- Space diversity scheme: one LEO,s – several FES with possible frequency reuse is feasible too.

RPSC (down-link LEO,s-FES):

- Providing full duplex system with one simple and cheap transmit-receive antenna;
- The transmitted random poly-phase spread signals will not cause significant harmful interference to the

conventional FES, using the same frequency channels. The interference will be similar to that, caused by the side-lobes of a phased antenna array with random inter elements spacing;

- The transmitted random poly-phase spread signals are uniformly radiated in the space below the LEO,s. Several FES, equipped with the same SCP receivers and providing space diversity, receive them. The knowledge of the receiving FES positions for the transmitting LEO,s is not necessary;
- Close situated LEO,s could communicate with FES, using the same frequency channel without interference. The isolation between the LEO,s will be provided by their specific random phase spread coding, due to their specific random design. This method was named by the author as Random Phase Spread Coding – Multiple Access (RPSC-MA).

The existing directional antennas of the ISL feeder lines can be replaced with SCP (both directions) and RPSC (both directions) with the following benefits:

- The virtual electronic scanning of the LEO,s ISL antenna patterns, typical for SCP-RPSC technology, will reduce significantly the limitations over station keeping characteristics and increase the satellite system reliability;
- LEO,s constellations with random orbits could be implemented instead the existing deterministic LEO,s orbits with their specific problems.

The LEO,s omni-directional antennas of the LEO,s – GEO,s IOL can be replaced with SCP (down-link) and RPSC (up-link) with the following benefits:

SCP (down-link GEO,s-LEO,s).

- The LEO,s receiving antenna system will be omni-directional for the cooperative GEO,s, but with high figure of merit G/T;
- The different GEO,s and polarizations could be selected simply by the use of specific allocated PN-codes;
- Soft handover between different GEO,s is feasible because of the LEO,s movement and multiple beam forming properties of the SCP technology;
- Space diversity scheme: one LEO,s – several GEO,s with possible frequency reuse is feasible too.

RPSC (up-link LEO,s-GEO,s).

- Providing full duplex system with one simple and cheap transmit-receive antenna.
- The transmitted random poly-phase spread signals will not cause significant harmful interference to the conventional GEO,s, using the same frequency channels. The interference will be similar to that, caused by the side-lobes of a phased antenna array with random inter elements spacing;
- The transmitted random poly-phase spread signals are uniformly radiated in the space above the LEO,s. Several GEO,s, equipped with the same SCP receivers and providing space diversity, receive them. The knowledge of the receiving GEO,s positions for the transmitting LEO,s is not necessary;
- The use of RPSC-MA is feasible.

4. Space Correlated - Code Division Multiple Access in IST-LEO PCN

4.1. Introduction

An important topic in IST-LEO PCN are the Connection Transference Schemes (CTS) with Soft Handover (SH) [1]. SH maintains the call connection through the old link until a new link is firmly established. SH is always associated with diversity (satellite - terrestrial or satellite – satellite). With soft handover, the service will not be interrupted since the old connection is still used for communication during the handover procedures. As a result, seamless handover can be achieved. The CDMA radio-access approach is particular suitable to realize seamless SH in the Integrated Satellite-Terrestrial Network Scenario.

CDMA Bandwidth efficiency is the main driving force in the use of CDMA since frequency re-use planning is not required. All available frequencies can be re-used in every single spot-beam. CDMA makes use of the Pseudo-Noise (PN) code concept in order to distinguish between different channels. It transmits modulated data onto wideband carriers that are distinguishable from each other by different PN sequences. Receivers retrieve their intended data by searching for their PN sequence. In order to avoid interference, the traffic carriers must be spread with synchronized and orthogonal PN sequences. Although synchronous-CDMA (S-CDMA) proves to be the most efficient to eliminate interference arising from other users sharing the same carrier and the same spot-beam, interference from other spot-beams which overlap the coverage of the intended spot is still considerable. The synchronization process to ensure orthogonality between all links requires signalling to adjust the transmission in both the time and frequency domains for every user independently. If dual satellite (or satellite – terrestrial base station) diversity is deployed, the timing advance will be addressed to only one satellite. Half of the users sharing the same frequency band will statistically be synchronized to this one particular satellite while generating intrinsic noise to the other. The system capacity is subsequently reduced. If orthogonality between PN sequences is not required, i.e. asynchronous CDMA, synchronization is not necessary. Under this situation, the number of available PN sequences will increase tremendously. However, this implies that interference levels generated by co-channel users cannot be suppressed as efficiently which may reduce the system capacity. However, since the number of PN sequences is increased, such a reduction in system capacity may still be well within the resource utilization efficiency of that offered by S-CDMA. In the case of multi-satellite diversity, longer codes may be required in order to discriminate between different links and consequently, synchronization among different satellites will be more complex. Another problem in the future IST S-CDMA systems could be the short length of the used PN-sequences, optimized for terrestrial usage, where the radiuses of the used cells are in order of several kilometers. The use of the same codes for the satellite segment will raise problems due to the ambiguity of their autocorrelation functions.

4.2. SC-CDMA basic

The proposed SC-CDMA principle [5] uses several space distributed sources of radio-signals, positioned at points O_1 and O_2 (in the case of only two sources), as it is shown in fig.5. The signals are phase modulated by appropriate PN-codes $C_1(t)$ and $C_2(t)$. The Mobile Stations (MS) receive these signals by means of the well known CDMA technology. For this purpose the same PN-codes are generated and synchronized in the MS receiver. The *sum(mod2)* of these codes creates a new code, which we named U

(Unique)-PN code. This code is used for spreading the information, transmitted by the MS. Similar approaches are used for generation of the Base Station (BS) U-PN codes.

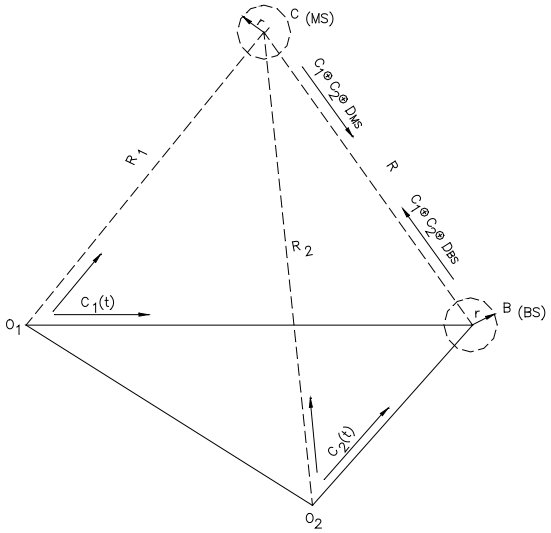


Fig.5 The basic SC-CDMA geometry

The block schemes of the MS and BS, using SC-CDMA approach, are shown in fig.6. In this particular case the recovered in MS codes $C_1(t)$ and $C_2(t)$ are used as follows:

- In MS after *sum(mod2)* for U-PN(t) code generation, spreading the transmitted information from MS to BS by means of DS-SSS method;
- In MS for dispreading (correlation) of the transmitted from BS to MS information, delayed U-PN(t+2R/C), where R is the distance between the MS and BS, and C is the speed of the light;
- In BS for dispreading (correlation) of the transmitted from MS to BS information, delayed U-PN(t+R/C);
- In BS for spreading the information transmitted from BS to MS, delayed U-PN(t+R/C).

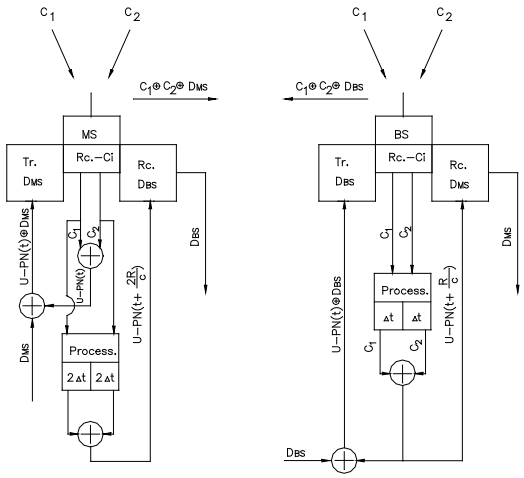


Fig. 6 The basic SC-CDMA-A architecture

A proposal for a realistic SC-CDMA system, based on the existing navigation GPS system, is given in [5] too. It was named EMI (Enhanced Mobile Information).

5. Conclusion

The practical SCP-RPSC and SC-CDMA principle implementations in the feeder lines, inter-satellite, inter-orbit and terminal lines will change the existing paradigm in the IST-LEO PCN communication business. Many of the existing problems of the proposed mobile systems with global coverage, very important for the security of the modern human society, will be solved successfully.

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SECURITY SCREENING OF EXPLOSIVES IN BODY CAVITIES

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Abstract: *Suicide bomber attackers with improvised explosive devices hidden inside their body cavities may be a new danger to air transport security. Metal detectors, passive and active millimeter or terahertz waves imaging, x-ray backscatter imaging and portals for trace particles detection are not sufficient for detection of explosives concealed under thicker layer of material with density and dielectric properties like human body. Through x-ray imaging is problematic for public health regulations and so only nuclear quadrupole resonance seems to be the solution.*

Keywords: EXPLOSIVES DETECTION; BODY SCANNER; QUADRUPOLE RESONANCE; BODY CAVITIES

1. Introduction

It wasn't so long ago when a possibility of suicide bomber attacker with improvised explosive device hidden inside his body cavity seemed to be an absolutely absurd idea for an airport security staff. Nowadays, this danger becomes a reality. Detecting explosives in body cavities of a larger number of passengers is from a health and ethical point of view very difficult, but not impossible. This possibility should be taken into account when developing a new detection technique.

2. History of development of technologies for person security screening

At the end of the last century, airport security screening of passengers was based only on walk-through metal detectors complemented by handheld metal detectors. These devices detect only metal firearms, cold weapons and munitions such as hand grenades, etc. For the era of airplane hijacking with pistols and even automatic submachine guns, screening of passengers with metal detectors and baggage screening with x-ray systems simple imaging of passing through x-rays was sufficient. An important milestone was the bomb attack on December 21, 1988, on the Pan Am 103, when the Boeing 747, after the explosion of about 300 to 400 grams of plastic explosive, probably Semtex 1H, fell on the Scottish town Lockerbie. This incident pointed out the need to develop appropriate techniques for the detection of explosives, mainly plastic explosives inside checked-in baggage of passengers. However, suitable technologies were not at sufficient level. The introduction of relatively sufficient countermeasures took many years. In the field of trace particle detection, this led to the Montreal agreement on the compulsory marking of plastic explosives for the purpose of their detection, signed in Montreal on 1 March 1991. This Montreal Agreement entered into force on 21 June 1998. However, a lot of trace particles detectors were not able to detect these markers even after its entry into force. Even the achievement of sensitivity applicable for detection of pentrite and hexogen, explosive components of plastic explosives, had taken a long time. In addition, the negative trace explosives detection during a baggage security screening is not generally sufficient to approve that there is no explosive in the luggage. In the field of volume detection of explosives, the development of technology has led to the introduction of dual-energy x-rays systems and, partly, x-rays systems with CT.

A terrorist attack on September 9, 2001 on targets in New York and Washington, using 4 hijacked aircrafts, highlighted the need to secure the doors to pilot cockpits and search more thoroughly for cool weapons on passengers. However, metal detectors were the only widespread technology for detection of cool weapons on human body at that time. Body scanners have begun to be improved significantly more, but their implementation into security practice was very slow and on a very small scale. Even though there were another warnings.

The first one was the revelation of the London plot on August 10, 2006, when terrorists had planned to take liquid explosives precursors aboard several aircrafts. This highlighted not only the need of equipment for searching for liquid and gel explosives and their precursors in handheld luggage, but also the need for body scanners to check whether the passenger had taken out all the containers and submitted them for inspection and whether the passenger had nothing hidden under his/her clothing. Detection equipment for reliable and quick analysis of liquids and gels in containers inside hand held baggage has not yet been developed so all containers with liquids must be taken out from hand held baggage and put separately into an analyzer of liquids.

Another impetus for body scanners was a failed bomb attack on NW 253 flight on Christmas Eve 2009, when young Nigerian man was smuggling 80 grams of plastic explosive of pentrite type in his slips. This terrorist attack failed only due to failure of complicated and clumsy initiation chain between TATP and other chemicals. However, body scanners may already have difficulties with this way of smuggling.

Contemporary body scanners are not able to distinguish between types of organic materials. Shoe soles can represent a relatively large volume of organic matter. This also inspired Al-Qa'ida when shoe bomber Richard Reid smuggled a plastic explosive of PETN type in the sole of his shoe on board of American Airlines 63 flight from Paris to Miami on December 22, 2001. This led to security countermeasures consisting of taking shoes off and putting them on x-ray conveyor belts, which is a rather inconvenient and delaying clearance of passengers. In addition, this security screening of shoe soles with dual-energy or CT x-ray systems relies on the attention of x-ray operators, and at the same time, on the limited technological capabilities and possibilities of the attackers, which have not yet been able to develop the soles of shoes and IED components from materials with a similar effective atomic number to each other. Such a system would be stealth to the operator of x-ray system. Drugs are also often smuggled in shoes. In technologically developed Japan, this fact has led to the development of advanced detectors of drugs in shoes working on the principle of nuclear quadrupole resonance for the needs of Japan customs at airports. Devices based on the same principle are also offered to airports for detection of explosives in shoes.

3. Possible technologies for detection of contrabands in body cavities

Currently deployed full-body scanners working on the principle of backscatter x-ray imaging or on the principle of active (or passive) millimeter wave imaging are not and will not be able to detect foreign objects in the human body cavities, let alone distinguish the type of its material.

At the same time, the so-called swallowers of smuggled contraband, especially drug packs, have been a long-established issue for customs officers around the world, especially at airports. A terrorist attack with NVS hidden in body cavities was already carried out, though not on an airplane. It was Al-Qaeda again, Abdullah Hassan al-Asiri, on August 28, 2009, attempted to commit

suicidal assassination on Saudi Arabia's interior minister, member of the royal family, Muhammad bin Nayef. It was estimated that 100g of pentrit type plastic explosive was used. The IED was hidden inside his anal cavity together with a detonating system, probably based on a mobile. The explosion was likely triggered by repeating the phrase by the attacker. The body of the suicide attacker fortunately significantly diminished the effects of the explosion and Muhammad bin Nayef was only slightly injured. This raises the question of how big of a threat to an aircraft is the explosion of IED in the body cavities of a suicide attackers. Above all, the question of the possibility of detecting explosives in the body cavities arises here. Imaging of the items smuggled in the body cavities and distinguishing types of materials is physically possible with x-ray computer tomography or x-ray diffraction systems. This is, however, impossible in security practice. It is not just about the high purchase prices of these devices and their lower speed of passenger clearance, besides these parameters may be improved in the future. A serious problem is the association with higher radiation doses per a scanned person, which are only justifiable for medical purposes. On the other hand, since no contraband should be hidden in body cavities, it is not necessary to use high doses of x-ray radiation to recognize specific types of materials.

The suppliers of x-ray systems specializing in the search for contraband in body cavities of people have existed for many years. These scanning systems are based on simple x-ray imaging. The simple image of passing through x-rays reveals all the larger foreign objects in the body cavities and at the same time under clothing. What's more, the x-ray operator is usually able to distinguish drug packages from an IED. They work on simple x-ray imaging with minimal radiation dose per person and scan. These doses are minimal but larger than doses in x-ray systems, which visualize only x-ray radiation backscattered from the surface layers of the human body. Extremely low irradiation is sufficient for x-ray backscatter systems. Despite this fact, even backscatter x-ray body scanners tend to have problems, albeit hardly justified, with their approval to operate at airport security checks in most countries.

In the near future reflected terahertz radiation spectroscopy seems to be convenient method to determine types of materials under the clothing of passengers. In the further future, the active terahertz three-dimensional imaging with the spectroscopy of the radiation reflected from each space point of the clothing of scanned person should be possible. Since human tissue contains many molecules of water, which strongly absorbs terahertz radiation, penetration of terahertz radiation through human tissue is very small.

“Neutrons in – gamma out” methods are totally inapplicable for scanning of persons for health reasons.

An excellent medical method of body organ imaging is nuclear magnetic resonance imaging. It uses a very strong magnetic field, which almost certainly destroys pacemakers and electronic devices in general. Serious problems can also be with knee joint prosthesis and similar prosthesis. Even in the hospitals, fatal accidents have been reported when nuclear magnetic resonance was accidentally applied to a patient with a pacemaker. The use of this method for passenger screening is therefore excluded.

4. Quadrupole resonance

It seems, that only the nuclear quadrupole resonance (QR - Quadrupole Resonance) method remains suitable for the detection of explosives and drugs hidden in body cavities of passengers. Quadrupole resonance is sister method of nuclear magnetic resonance but without a strong stationary magnetic field. It should be noted that this is not a nuclear reaction - a reaction during which changes in the composition of nucleus would occur. Only the electrical properties of the nucleus in the external electromagnetic field inside the radio wave range are measured.

Using this method, we can detect a presence of some atomic nuclei found in chemical bonds in the investigated space by electromagnetic fields inside radio wave range. This detection does not depend on spatial distribution of nuclei inside the investigated space. For police and security purposes, nitrogen nuclei found in chemical bonds such as pentrite, hexogen, TNT or chlorine are searched for.

The method is based on the fact, that nuclei with spin ≥ 1 generally have a non-zero electric quadrupole moment. The image of the electric quadrupole is well suited for describing the electric field of these elongated or flattened nuclei. During quadrupole resonance, a reorientation of the nucleus between its quantized orientations, relative to the electrical voltage, is observed. Simply, the moment of power acts on the non-spherical nuclear charge and causes precession.

During a nuclear quadrupole resonance measurement, transmitter sends a complex pulse of low-intensity radio waves into the luggage space. This electromagnetic impulse turns rotation axes of atomic nuclei of the investigated substances into the same angle. After the exciting impulse stops, the rotation axes turn back to the original angle, to the disarranged but balance state - state of equilibrium. During this turning back, the nuclei emits electromagnetic waves with special frequency, called resonance frequency, that is typical for the type of nuclei. This resonance frequency also slightly depends on the molecular band of these atoms. This resonance signal is captured by the receiver and immediately analyzed by the computer. The device usually searches for a stretched nucleus of nitrogen N14, located in explosives. Due to the environment of neighboring atoms, the resonance frequency is slightly shifted. As stated above, the size of this shift depends on the type of environment, from it we can deduce the type of molecule and hence the type of substance - whether it is PETN, RDX or TNT etc. QR is highly specific because the sensitivity depends on the shape of the molecules, it can detect the fabric anywhere in the controlled area, regardless of orientation and layout. QR can detects explosives formed into thin sheets and even explosives divided into separate packages or dispersed explosives, which can be abused by suicide bomb attackers. For the QR signal´s size, the total number of interest molecules in the controlled area is decisive.

QR devices were originally offered in designs convenient for luggage and consignment screening. The operator did not have to analyze any video or image output, he was directly aware of whether the inspected subject contained explosives or not. An analysis lasting a few seconds does not damage magnetic media, such as computer disks, and so on. QR detectors have very low rate of false negative and false positive detection.

Both the exciting signal and it´s response can be, of course, shielded with metallic, conductive objects. Therefore, there is an attempt to develop newer QR-based devices with metal detection capabilities to warn the operator of the possibility of shielding. In case of conveyor belt detectors of explosives in baggage, the screening of baggage with a larger metal content must be based on x-rays or other systems. This problem would not occur in the case of searching for explosives hidden under passenger´s clothing because all the larger metal objects are always detected by metal detectors and the passengers have to put them on x-ray conveyor belt. Still, the need for body scanners based on active or passive imaging of millimeter or terahertz waves or backscattered x-ray radiation imaging will exist. There can be another contraband than explosives under clothing of the passengers. It will be necessary to look for ceramic and/or plastic cold and fire weapons (fire weapons can be home made in 3D printers), as well as non-metallic containers with liquids and gels. Unlike nuclear magnetic resonance, the detection of liquid explosives by quadrupole resonance is practically impossible. Here, as mentioned above, scanning by terahertz spectroscopy will help. It is also necessary to note, that detection of vapors of liquid explosives is more effective due to higher partial pressure of their vapors. For reliable sealing of

explosives without the use of metals (due to the detection of metals), glass would be appropriate from the point of terrorist´s view. On the other hand, glass is excellently permeable for terahertz waves.

The currently offered and developed QR portals are mostly intended for detection of explosives or another contraband hidden under passenger´s clothing, not for detection of explosives hidden in body cavities. An exception is the QR portal for detection of drugs, especially methamphetamine, which is being developed by professor Hideo Itozaki of Osaka University [1] for Japanese customs officers. The human body is a problem for the exciting and excited signal of quadrupole resonance. Fortunately, even in the case of swallowers, contraband packets are hidden very close to the surface of the human body, in this case the abdomen, namely 2-4 cm. This is small enough value for the successful detection of the contraband, if we take into account the range of values of electrical conductivity of different human tissues. Detection of methamphetamine in body cavities is on the limit of current technological possibilities. However, the signal from methamphetamine is extremely small. For example, it is 8 times weaker than from TNT explosive, that is considered difficult to detect by quadrupole resonance. The QR signal from RDX, the US military explosive C-4 and the British PE-4 component, is even 500 times more powerful. It follows that explosives in body cavities can be successfully detected by quadrupole resonance.

4. Conclusion

The only way to detect explosives in body cavities of passengers in routine security inspections at airports is quadrupole resonance. Devices may take the form of walk-through portals and handheld devices, much like metal detectors. Quadrupole resonance portals and handheld detectors can also simultaneously act as metal detectors. These devices will, of course, also detect explosives and metallic objects hidden under or in passenger´s clothing. Unlike metal detection, the quadrupole resonances detection of explosives will not be accompanied by permanent pulling of harmless nonmetallic items from personal pockets and their deposition on the x-ray conveyor belt. Body scanners will be needed to search for non-metallic cold weapons, firearms and containers with liquids. Although analysis of liquids found in containers in passenger´s clothing is likely to be possible by terahertz spectroscopy even without the need for extraction.

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COMPUTATIONAL FLUID DYNAMIC MODEL FOR ESTIMATING DROPLET NUMBER FLOW RATE THROUGH A LASER BEAM

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Abstract: *The current work is related to improving security by developing a new type of fog sensors and devices. We investigate fogs and their ability to absorb and clean various pollutants from air, including chemical, biological, radiological and nuclear (CBRN) agents. Fog can be used very effectively for counteraction to terrorist attacks and weapons of mass destruction, as well as for prevention of industrial accidents and disasters. It is crucial to study the specific sizes of fog droplets, which optimally collect dangerous substances. We present a computational fluid dynamic model for estimating droplet number flow rate through a laser beam. It shows, that we can make a quantitative assessment of both the number flow rate and the droplet diameter distribution. After we have confirmed that it is possible to monitor these parameters, we proceed and investigate how they are varied, when the laser beam's distance from the nozzle is changed. Thus, by selecting the distance between the laser beam and the nozzle, it will be possible to measure the diameters and the number of fog droplets. Different nozzles can be simulated easily by entering their output parameters (mass flow rate, diameter distribution, orifice diameter) in the setup.*

Keywords: SENSORS, FOG, DROPLETS, COMPUTATIONAL FLUID DYNAMIC MODEL, LASER BEAM, NOZZLE

1. Introduction

The development of aerosol analysis apparatus relies on a solid theoretical basis, but in practice it is always necessary to calibrate the final device with a standard aerosol with known parameters [1]. Due to the number of parameters which can affect the analytical signal, the calibration process is a strenuous task. For example, the scattering of a beam of light [2], which is the basis of most modern particle analysis techniques [3], is influenced by the particle number concentration, their chemical composition, size, velocity and the optical path length among others.

It is obvious that in order to distinguish the effective influence of the parameter of interest on the signal, all other parameters and their effect on the signal must be known. When only the investigated parameter is varied and the others are kept constant, the changes in the analytical signal can be related directly to it.

This can be achieved by using precise methods for particle generation which make it possible to create streams or clouds of particles with a high degree of control over chemical composition, size and number concentration. In cases where the particles are generated as a large stream, one cannot be certain of the number concentration of droplets as their generation rate is large - in the order of 10^9 or more droplets per second.

2. Prerequisites and means for solving the problem

We have done a fluid dynamics research on the change in the number flow rate of droplets as a function of the distance from the nozzle. More specifically, when a nozzle generates droplets with different diameters consecutively. Calculations show that if we know some of the parameters of the nozzle, the distance at which the number of droplets is approximately the same for different nozzles, can be determined. Thus, if we were to move the laser beam, ensuring that the number flow rate of droplets is identical, then the measured signal will be a function only of the diameter of the droplets. In this way, the devices we have developed can be used to measure the diameter of droplets.

During our investigations for developing a fog analysis system based on light extinction measurements, we have been using various atomizing nozzles that produce sprays with different mean droplet diameter for calibration. These include nozzles which generate large conical sprays with length between 1 and 2 meters.

This investigation is focused exclusively on 5 different nozzles that generate hollow cone sprays with distinct droplet diameter distributions. The manufacturer of the nozzles provided us with information regarding the size distribution of droplets generated using the nozzles at a constant pressure of 5 bar, which we use.

The chemical composition of the droplets can be easily kept constant, thus preventing it from affecting the extinction. In the absence of external force fields except for the gravitational, the velocity of the droplets is dependent on the atomizing pressure and their mass (respectively size) which are known. Therefore, the diameter distribution and the number concentration (flow rate in our case) of droplets passing through the laser beam will affect the extinction the most [2].

Initially, two possible ways of controlling these two parameters have been outlined – sampling a portion of the spray for analysis or filtering the droplets to reduce the flow rates and shrink the size spectra. Different methodologies have been reviewed with the purpose of isolating a relatively identical number of droplets.

2.1. Filtration/separation methods

The problem can be solved by filtering the flow and separating a group of particles, usually with regard to their size. The generation of monodisperse aerosols is difficult, therefore most precision particle generators have a separator/filter stage, which controls their output to produce aerosols with uniform properties.

Passing the aerosol through a high temperature area is one of the simplest ways to remove the smallest droplets, as their evaporation rate is much higher [4].

On industrial scale, particle removal from gas flows is often of crucial importance, either from technological or ecological point of view. For this purpose, various apparatus have been developed such as settling chambers, cyclones, scrubbers, electrostatic filters [5]. For smaller particles, filtering via porous material or fibers [6] is often employed. All these methods are used on a large scale, and their purpose is to separate all particles from the flow, therefore are not useful for our needs.

An interesting case is the cascade impactor, which is used for segregating groups of droplets with regard to size for further chemical analysis. Its construction consists of a series of orifices with baffles behind them, with decreasing orifice-baffle distance at each consequent stage. The flow passes through each orifice and

around the baffle after it, but the heavier entrained particles possess more momentum and instead of following the flow, settle on the baffles. As the distance at each stage becomes shorter, lighter particles settle, until only the smallest or no particles are left in the stream [1]. This is an interesting way to separate particles, but its operation is quite complicated and it would be very difficult to apply it for our sprays, which consist of a large number of particles of high velocity.

2.2. Our approach

The research we have made on separation methods lead to the conclusion that most methodologies are either used at larger scale, or would have trouble separating droplets with higher inertia, such as ours.

Instead, we have chosen a different, simpler solution – the laser beam is placed at a specific distance from each nozzle, which ensures relatively identical droplet flow rates. This reduces the number of variable parameters to one – the droplet diameter distribution, which is determined by the nozzle. Hence, we can study the signal dependence on the droplet diameter distribution and calibrate our devices.

In this particular investigation we have created a numerical simulation model for studying the fluid dynamics of different sprays in order to predict their parameters in regions of interest.

3. Solution of the examined problem

3.1. A short overview on Computational Fluid Dynamics

Computational methods for investigation of fluid flows, regarded as Computational Fluid Dynamics (CFD), are becoming more and more popular. There are often cases where experimental studies are practically impossible due to the harsh process conditions. In other cases, computational methods are preferred to experimental methods as interrupting the process and altering its parameters would be technically challenging and result in a negative economic impact, for example in industrial-scale flows. CFD studies are also extensively used for nozzle optimization [7].

For our study, we have chosen to use the fluid analysis system CFX included in the software package ANSYS. It consists of a set of components used to define the case, solve the equations describing the process and output the solution results in a convenient form.

The stages of our investigation are:

- Creation of a geometrical model of the investigated domain.
- Discretizing the domain by generating a mesh of elementary volumes.
- Defining the boundary conditions and setting the solver parameters.
- Solving the process equations numerically.
- Exporting and analyzing the relevant data, drawing conclusions.

3.2. Presumptions

Several presumptions have been made, prior to the investigations, with the purpose of simplifying the model and reducing the computational load.

1) The model is considered to be stationary – the process parameters do not change in time and the results define the equilibrium state of the process. As the input parameters (water pressure, flow rate, environmental conditions, nozzle geometry) are either constant or vary insignificantly we conclude that the output parameters in a given point of interest (droplet flow rate, velocity, size distribution) will also be invariant of time. It should be mentioned that the size distribution in a different point will differ slightly due to evaporation.
2) The actual liquid atomization process is not modelled, even though ANSYS CFX supports primary and secondary liquid breakup models, because this would only increase the computational load tremendously. Hence, the droplets are injected from an injection point with a predefined diameter distribution, corresponding to the nozzle.
3) The flow of droplets is fully axisymmetric around the axis, normal to the nozzle orifice. As the nozzle is placed perpendicularly over the laser beam, almost all of the droplets will flow through the beam from above and only an insignificant number will flow through the sides.
4) The environmental surroundings are an infinite source of heat - the droplets receive heat and their temperature increases but the temperature of air remains constant.

3.3. Geometry

In accordance with presumption 1, the geometric model resembles a 30-degree slice of the volume of the spray (Fig. 1), as we are only interested in the flow through the laser beam and in the area close to it. The nozzle orifice is located where the central axis crosses the top face.

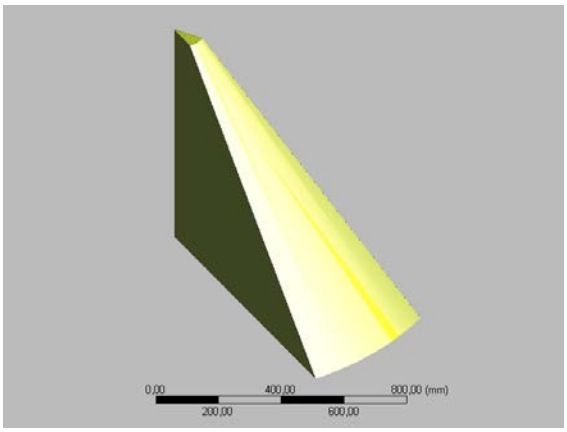


Fig. 1 *Geometry of the investigated volume*

The laser beam is directed radially from the central axis through the middle of the outer edge. It is simulated as a 2-mm wide rectangular boundary at the middle of the slice's bottom face. The beam's distance from the nozzle is varied by moving this face up or down, changing the height of the slice.

It should be noted that in this model the laser beam only passes through half of the spray until it reaches the central axis. Therefore, the resulting droplet flow rate must be doubled, again assuming that the other half is identical to the investigated one (presumption 1).

3.4. Elemental mesh

In order to obtain a relatively identical size of the elements in the mesh and consistency of the results when simulating different distances from the nozzle, the height of each element was set to be 4 mm. If the distance is not a multiple of 4, one layer of elements (usually at the top or bottom, as in Fig. 2) will have a different height.

As the shape of the spray resembles a hollow cone and most of the droplets flow closer to the edge of the volume, the element width is biased towards this area (can be seen in Fig. 2). This is done in order to increase the accuracy of the droplet trajectories.

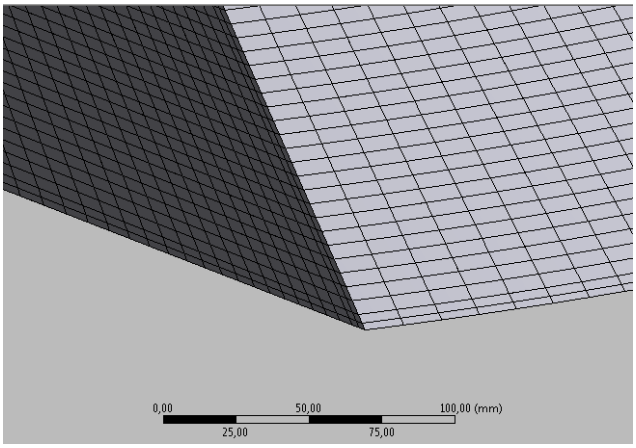


Fig. 2 *An enlarged view of the elemental mesh.*

3.5. Domain and boundary conditions

Two phases are present in the domain description – Air and Water. Water is defined as a pure substance (H_2O in liquid state) in the material description, while Air is a mixture of the materials Air Ideal Gas and H_2O (in gaseous state). The evaporation from water droplets is defined as a mass transfer of H_2O from Water to H_2O present in the Air mixture. The transfer rate is determined by the content of H_2O in Air and the heat transfer rate.

The entire volume is occupied by Air, while Water is injected from the injection region in the form of polydispersed particles. The two phases are fully coupled, meaning that any change in the velocity field of one will affect the velocity field of the other. Additional forces taken into account are drag, buoyancy and turbulent dispersion.

The injection parameters are defined using the data given by the manufacturer. The injection velocity is derived from the nozzle orifice diameter and the mass flow rate. The injection angle is 45 degrees from the central axis. Additionally, a deviation of 3 degrees from the injection angle was set. The particle diameter spectrum is defined using 4 values – minimum, maximum, mean diameters and standard deviation. The particle temperature is set to be 4°C, which is the temperature of tap water. The number of trajectories, used to represent the flow was set to 100 000.

The domain has two boundaries – the laser beam face and all other faces. They have identical conditions – openings to the environment with 0 relative pressure difference. The reason for defining them separately is to filter the droplet trajectories and isolate the ones which flow through the laser beam boundary. The number flow through the laser will be determined by these trajectories.

3.6. Solver settings

The main criterion for convergence of the solution is that the RMS (root-mean-square) value of the error in all elements is less than 10^{-6}. As convergence is too slow in some cases and the chosen RMS value may be reached after long, a secondary condition was defined – the maximum number of iterations is set to 1000. When either of these two conditions is fulfilled, the solution stops.

4. Results and discussion

The solution has converged when the main criterion was fulfilled after 225 iterations. The domain imbalances of several parameters (momentum in the 3 directions, mass fractions of the components and others) were taken as an initial numerical assessment of the accuracy, and it has been seen that the absolute value of the maximum imbalance is 0.0048%.

4.1. Particle flow trajectories

Two separate particle track objects were created – one which displays all generated tracks and one which isolates only the particle tracks which reach the laser beam boundary. The latter bears information regarding the diameter distribution and number flow rate of droplets which enter the laser beam volume.

The particle flow trajectories are shown in Fig. 3. On the left side, all trajectories are shown, and on the right side, only the trajectories that exit the domain through the laser beam boundary. The color indicates the mean diameter of the particles that travel the trajectory.

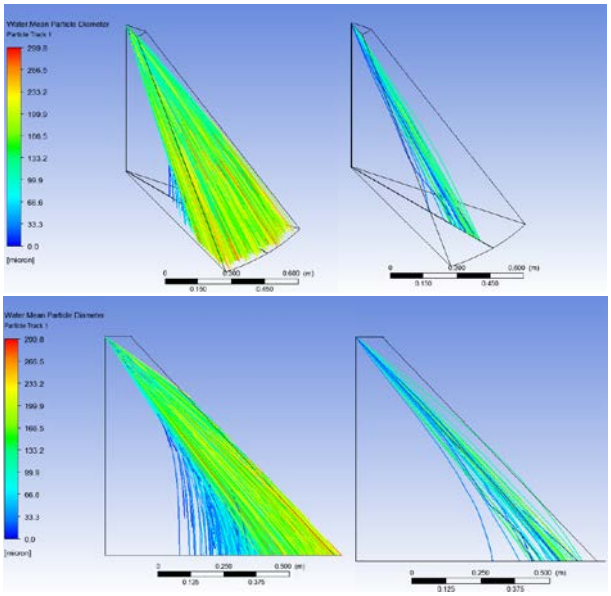


Fig. 3 *Particle trajectories, the images on the right side show only the isolated trajectories which cross the laser beam*

An interesting observation can be made – the smaller the droplets are, the closer to the central axis they settle. This phenomenon is known as droplet segregation. [6] Lighter droplets possess little momentum and lose it quickly due to drag, while heavier droplets possess more momentum and retain their velocity longer.

4.2. Flow rates

The number flow rate of droplets was calculated by taking the sum of the flow rates on each trajectory. This was done using the expression:

sum(Water.Particle Number Rate)@Particle Track

The expression was evaluated twice by changing the particle track identifier – once for the total flow rate of droplets generated by the nozzle and a second time to determine the flow rate of droplets through the laser beam. The following values were obtained:

- Total flow rate: $1.303*10^{9}$ [s^{-1}]
- Flow rate through laser: $4.665*10^{6}$ [s^{-1}]

Again, it must be noted that the value of the number flow rate through the nozzle must be doubled to obtain the expected value. In this case, the number of droplets crossing the beam per second should be $9.33*10^6$ [s^{-1}].

4.3. Diameter distribution

The diameter distribution of the spray as well as the diameter distribution of droplets which enter the laser beam were plotted in one graph for comparison (Fig. 4).

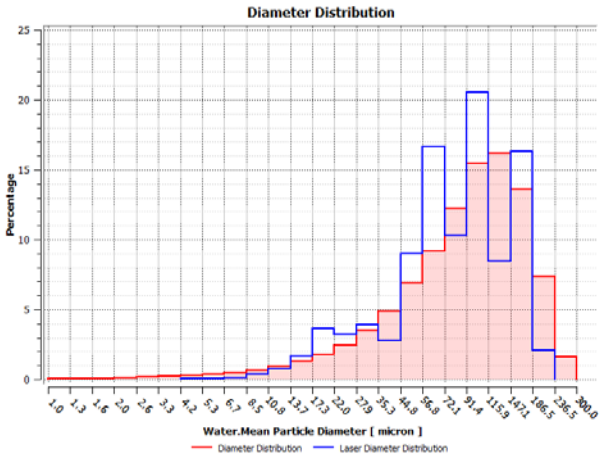


Fig. 4 *Overall droplet diameter distributions (red) and droplet diameter distribution in the volume of the laser beam (blue).*

The red plot represents the overall distribution and the blue one represents the diameter distribution of droplets that enter the laser beam. It can be seen that they are almost identical. The deviation of the blue distribution is due to the small number of trajectories that define it, compared to the overall distribution. By increasing the total number of trajectories, the plots would eventually coincide, but the increase in computational time would be great and it was decided that it is not necessary.

5. Conclusion

A spray segment model has been created and used for a computational fluid dynamics investigation of the spray's dynamics. It includes computational models that take into account the coupling of the phases, the turbulence, drag and buoyancy forces as well as evaporation of material from the disperse phase into the continuous. High accuracy was chosen for the solution (RMS < 10^{-6}) and the obtained results show very low relative domain imbalances of the main variables.

The number flow rate of droplets through a boundary, representing the laser beam has been investigated. As mentioned in the problem description, this parameter is our main concern. The results have shown that we can make a quantitative assessment of both the number flow rate and the droplet diameter distribution through the area of interest.

Acknowledgements:

The European Commission is acknowledged for supporting the work described in this paper by EU FP7 Security program under Contract 312804.

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DEVICE FOR FOG DENSITY CONTROL WITH MULTIPLE REFLECTIONS OF THE BEAM

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Abstract: *The current work is related to improving security by developing a new type of fog sensors and devices. We investigate fogs and their ability to absorb and clean various pollutants from air, including chemical, biological, radiological and nuclear (CBRN) agents. Fog can be used very effectively for counteraction to terrorist attacks and weapons of mass destruction, as well as for prevention of industrial accidents and disasters. We present a device developed by us – Fog Detector 3 (FD-3), which main purpose is to continuously monitor the atmospheric air and to produce analogue signal proportional to the density of any present aerosols, including water fog. The main components of the device, as well as their connections and way of operation are described.*

Keywords: DEVICE, FOG CONTROL, DROPLETS, AEROSOLS, DETECTION

1. Introduction

Atmospheric aerosols are a fundamental component of the air on our planet. They are represented by tiny particles of various sizes, physical and chemical properties. Aerosols play a crucial role in many climate processes [1] and affect them directly – such as formation of clouds, storms, etc. They also influence human health [2] and economy [3]. Harmful aerosol particles can be unleashed in the air in the case of industrial accidents or can be used for terrorist attacks [4, 5]. That is why it is very important to detect and identify different kinds of aerosol particles in real-time. Various techniques for aerosol detection have been developed – most of them are based on elastic scattering [6] or fluorescence detection [7]. Optical methods are also used, since they can provide information remotely. Light detection and ranging, for example, can perform 3D aerosol mapping over large distances [8]. This technique is mainly used for detection of biological aerosols by using elastic scattering [9] or ultraviolet laser induced fluorescence [10].

2. Prerequisites and means for solving the problem

Our work is related to a project with the acronym COUNTERFOG, which purpose is large-scale decontamination of facilities from chemical, biological, radiological and nuclear agents dispersed in air, which may occur in the case of terrorist attacks, industrial accidents or disasters, by using fog. For that reason, it is necessary to place devices, which continuously monitor the atmospheric air and alert the occurrence of dispersed agents, so that cleaning fog can be released. It is also required to assess if the fog has reached all areas, in order to stop releasing it, as well as to monitor its density. Such instruments are present on the market but they are quite expensive for our purposes, since we need a lot of them to be positioned at different sights. That is why we have designed and constructed several cheap versions of such devices and one of them is Fog Detector 3 (FD-3).

3. Solution of the examined problem

FD-3 is a cheap device, which allows continuous monitoring of atmospheric air and alerts when dispersed particles in the form of aerosols appear in it. It is small, inexpensive, it has a simple construction and is stable at various conditions. It has the capability to detect the presence of fog (which is also an aerosol in the form of tiny water droplets) and to assess its density. The principle of operation of the device is based on the spectrophotometric method. A beam of monochromatic light is passed through the investigated environment and its intensity is attenuated by the presence of pollutants. The device consists of three main blocks – an active block including a laser, an optical detector and a mirror; a passive block having just a mirror; and an alarm block, which alerts the presence of dispersed particles. The density of particles can be determined by attaching a voltmeter, which measures the signal from the optical detector. FD-3 operates with multiple reflections of the laser beam, so that more accurate and stronger signals can be measured.

4. Results and discussion

In this section we describe the principle of operation of FD-3, its technical implementation and main components.

4.1. Purpose and principle of operation

The main purpose of the device FD-3 is to continuously monitor the atmospheric air and to produce analogue signal proportional to the density of any aerosols, including water droplets in the form of fog. For this purpose a laser beam is used which is reflected several times on special mirrors before it falls onto the sensitive surface of an optical sensor. The density of the environment between the mirrors affects inversely the intensity of the beam. The intensity of the laser is converted in output analogue signal in the range 0÷3.9V. The general view of the three main components of our device is presented in Fig. 1.

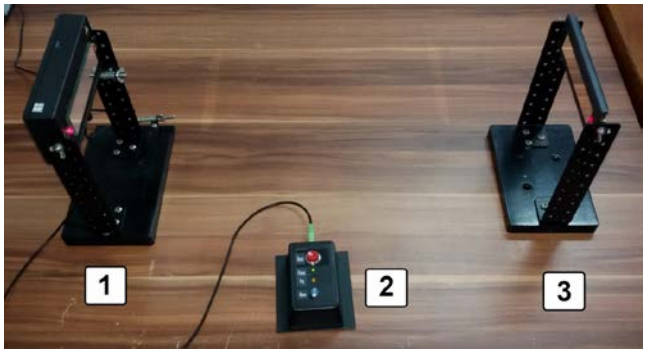


Fig.1 – General view of FD-3 and its main components

4.2. Main components

The device consists of:

- Active block with laser diode, optical sensor and mirror (position 1 in Fig.1);
- Passive block with mirror (position 3 in Fig.1);
- Alarm module with its connection cable (position 2 in Fig.1);
- Power adapter (12VDC 2A);
- Analogue voltmeter VA101A with its connection cable (used for calibration of the device and/or aerosol density assessment).

4.2.1. Active block

The active block is formed as a structure consisting of red laser diode (650 nm, < 5 mW) and optical sensor model WES103. The block is powered by a DC, 12V, 2A source. On its output the block generates analogue signal in the range 0÷3.9V, which is inversely proportional to the density of the examined aerosol. The laser beam's position is adjusted with two screw joints enabling rotation of the body of the active block on two orthogonal axes.

4.2.2. Passive block

The passive block is a mechanical assembly with one degree of freedom with respect to its base. A fixed mirror is attached to it.

4.2.3. Alarm block

The purpose of the alarm block is to detect the appearance of dispersed agents crossing the volume controlled by the device. It is triggered when there is an attenuation of the output signal under a certain threshold value ($U_{threshold}$=3.5V). Once activated, the alarm diode will blink until the "Reset" button is pressed. This threshold represents a coded constant in the program code of the microcontroller located in the active block. When a higher sensitivity is needed, this controller can be replaced with the provided spare controller. It is set to react under 3.7V.

4.2.4. Power supply block

The main purpose of the power block is to supply energy for the active block. It is powered from a standard AC network (220V 50Hz) and provides stable voltage 12V 2A on the output.

4.3. Connection of the components

The connection of the components should be done in the following order:

- The active block containing the laser diode, mirror and optical sensor, and the passive block with mirror are installed against each other at a distance in the range of 0.5÷1.5 meters. They can be placed either on a flat surface or on a rail on carriers or any other construction allowing the required positioning;
- The adjustment screws for rotation of the active block are placed at initial position (0° axial rotation);
- The mirror of the passive block is rotated in such a way that its plane is perpendicular to the base and also parallel the mirror of the active block;
- The active block and the passive block must be placed perpendicularly to the common rail (if there is such);
- The peripheral module for LED indication is connected to the coupling "Alarm LED" of the active block;
- The power adapter (12VDC/2A) is connected to the coupling "POWER" of the active block, after which is connected to the supply network;
- The voltmeter is connected to the output of the active block labelled "OUT";
- Now, the reflection of the laser beam from the mirrors must be adjusted (recommended number of reflections is 3 times):
  - The top adjustment screw of the active block is used for orienting the laser beam to the vertical center of the mirror on the passive block;
  - The bottom adjustment screw is used to acquire the needed number of reflections;
  - If needed, the above two steps should be repeated until the laser beam falls precisely onto the surface of the optical sensor. This can be judged from the shown voltage from the voltmeter. The positioning is good when the maximum value on the voltmeter is acquired;

The intensity of the laser beam can be regulated in such a way that the threshold of the output signal, in the absence of any aerosol, is 3.9V (Fig. 2). The intensity should not be increased over the point in which the sensor is saturated and the voltmeter reads 3.9V.



Fig.2 – Potentiometer for regulation of the laser intensity

4.4. Block scheme of the device

The block scheme of the device is shown in Fig. 3.

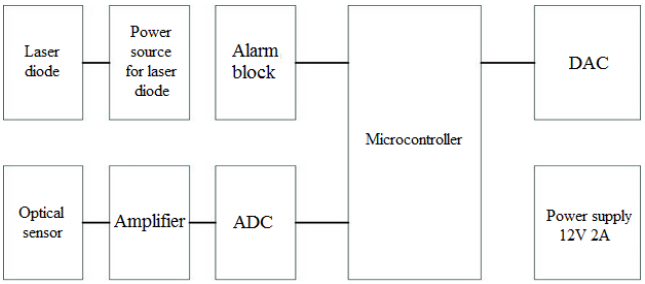


Fig.3 –Block scheme of FD-3

The power supply of the laser diode is accomplished by serially connected voltage stabilizer and current stabilizer. The laser diode is directed to the optical sensor as the beam crosses the field in which the density of water fog needs to be controlled. The incident light to the optical sensor generates analogue signal proportional to the intensity of the light. This signal is amplified and converted with ADC (analogue-digital converter) in the range 0÷4.096V before it is received from the microcontroller. The output signal, proportional to the attenuation of the light, is formed by the microcontroller via DAC (digital-analog converter) again in the range 0÷4,096V. In the cases when the output signal falls below 3.5V, the alarm block activates, in which case the blinking red LED indicates the appearance of mist. The diode can be turned off with the "Reset" button. On the alarm module there is an additional yellow diode which shows the dynamic state of the output signal –greater or smaller than 3.5V.

4.5. Working with the device

Once the laser beam is correctly directed to the optical sensor, the device is ready for work. The output signal is inversely proportional to the density of the fog. It can be monitored with the help of a voltmeter or it can be connected to additional hardware devices.

The alarm module (Fig. 4) can be used as a device for indication of fog/aerosol appearance in the controlled volume. Once activated, the alarm does not stop the signal blink LED labelled "ALARM" until it is stopped manually by pressing the "RESET" button. The LED labelled "POWER" signals for the correct operation of the alarm module when connected to the active block. The LED labelled "FOG" indicates dynamically for the current presence of

fog – it lights up at certain values of the output signal, when there is presence of aerosol/fog.



Fig.4 –Alarm module to the device FD-3

The device is sensitive to displacement of the laser beam at the receiver. This is due to the fact that the laser beam is reflected multiple times and any slight misalignment of the emitter results in much greater misalignment on the receiver. To prevent such a malfunction, stable fixation should be provided. Such a problem may occur if the base is not at rest, if there are vibrations or any forces applied to the structure, etc.

Figure 5 shows a voltmeter connected to the FD-3 device.



Fig. 5. FD-3 device connected to a voltmeter

5. Conclusion

We have presented a small, inexpensive device, which can be used to detect the presence of dispersed particles in the form of aerosols by using multiple reflections of the emitted laser beam. The density of various types of aerosols, including water fog droplets, can be evaluated by simply attaching a voltmeter to the device and observing the signal intensity.

Acknowledgements:

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SMALL-SCALE INFRARED FOG DETECTOR

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Abstract: *In the recent years, large improvement is being achieved in the area of decontamination by fog of environmental pollution caused by natural and industrial disasters or attacks with biological, chemical, nuclear weapons of mass destruction. Basic to this technique is the performance of sensors for the existence of pollution and fog in the environment. This article is going to present a small-size and relatively inexpensive instrument, developed by us, which purpose will be to alert the occurrence of visible pollution in air or mist. In that way, it can be controlled, too, whether the cleaning mist has reached all areas. It is possible, that this equipment would assess the density of fog. It works in the infrared spectral region.*

Keywords: OPTICAL SENSORS, FOG DETECTION,

1. Introduction

Environmental contaminations by biological, chemical, nuclear agents or toxic compounds due to industrial accidents, disasters, terrorist attacks, wars, etc. are usually spread by atmospheric dispersion. These harmful substances are usually dispersed as aerosols in liquid phase [1]. Recently the technique for effective decontamination of the pollution in the affected environment (indoors and/or outdoors) through spraying of fog is significantly improved in the framework of EU FP7 Security project COUNTERFOG [2]. Fog is an aggregation of microscopic water droplets spread in the air. The fog is able to sweep along different impurities – small particles, dust, different chemical compounds, etc. and to bring them to the ground thus decontaminating the area. The application of this technique requires sensors for continuous monitoring of fog. The ideal sensors should provide easy operation and the possibility for online control of both small and large areas.

Due to the presence of fog, composed of water droplets with a diameter only a few hundred microns, light scattering and reflection take place, resulting in signal degradation or complete prevention of light transmission through the environment [3]. Thus, the most widespread sensors for control of the presence of fog operate by measuring the medium permittivity. This is done in a number of ways: (a) by cameras that estimate the change in visibility as a result of the presence of fog or pollutants in the air [4], [5], [6]; (b) by light source (UV-IR) and a detector where the light intensity reaching the detector is less than the emitted intensity due to the light scattering by particles or droplets present in the optical path in the air; (c) by the use of LIDARs for surveying the environment [7]. The use of these sensors can be sometimes limited by relatively long sampling time, high price and high energy consumption.

To address these limitations, our team developed a simple and low-cost linear measuring system with high precision for quantitative assessment of disturbance effects on the quality of an optical signal transfer through optical line, called Fog Detector 1. It can be used to obtain results in relative values. Future calibration of the device can be performed.

2. Experimental setup.

The principle implemented in Fog Detector 1 is called “Transmission method”. The method measures how much light, emitted from a light source, is detected by a receiver located at a distance. In fog conditions, less light (compared to the clear optical path) will reach the receiver because of the scattering along the ray path. The reduction is used as raw data for straightforward calculation of the visibility. The attenuation of a light ray that is propagating through a homogeneous absorbing or scattering atmosphere can be described using an exponential function as:

$$I = I_0 \,.\, exp(-x.a) \quad (1)$$

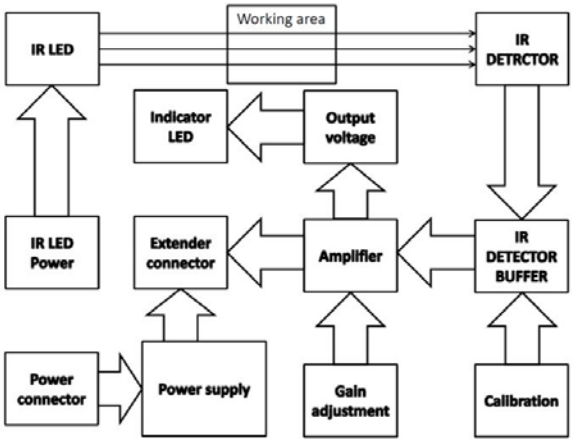


Fig. 1 *Block diagram of Fog Detector 1.*

where I_0 - is the intensity at a certain plane, x [m] - is the distance from that plane along the ray, a - is a constant [m^{-1}] that determines the attenuation.

In Fog Detector 1 we need relative results between different densities of the fog. In the laboratory experiments, the distance x is a constant. For relative results, it is enough to compare the difference between the results of the exponent part. It will not be a problem to transition from relative to real values when we have the results from Fog Detector 1.

A detailed block diagram of Fog Detector 1 is shown in Fig. 1. From the power connector, the device is supplied with stable +5V, which are used for powering the transmitter IR LED. The light from the IR LED is detected by a photo-transistor (IR detector) and the measured signal is transmitted to the buffer circuit. The buffer circuit is a high impedance operational amplifier with a gain equal to 1. The signal at the input of the buffer can be regulated through the calibration potentiometer. The purpose of that block is to reduce ambient factors such as light, temperature, humidity and etc.

After the buffer amplifier, the signal is sent to the main amplifier circuit. This circuit is a simple differential amplifier with the gain set by the switches of the 'gain adjustment' block. The reference input of the amplifier is connected to a stable reference voltage which is independent of the fog density. The output of the amplifier is connected to the extended connector and to the output for measuring. The indicator LED block contains a window comparator which is tuned for 1V to 1.1V output voltage. The LED will switch on only in that window. That guarantees that the amplifier works in its linear region. Fog Detector 1 has an analogue front end, which can be used with an external voltmeter or digital oscilloscope. The extender connector gives the ability of Fog Detector 1 to be connected to a microcontroller (MCU) module for displaying the information and/or calibrating LED transmitter. The MCU module is not a part of the current design.

Electrical schematic, which is an original design, is shown in Fig. 2.

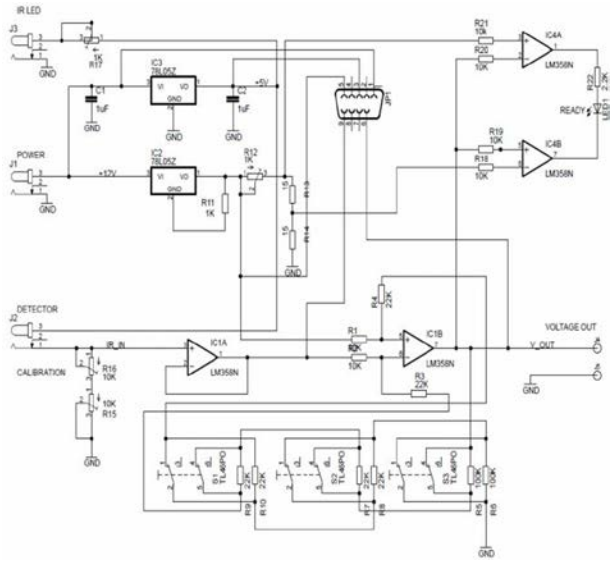


Fig. 2 *– Electrical schematic of Fog Detector 1.*

The main supply of the circuit (stable +5V) is contributed by the regulator circuit C1, C2, IC3. The operation amplifiers are powered directly from the power connector (+12V). The stable +5V is used for powering the IR LED through a current limiter resistor and also the photo-transistor (the +5V goes directly to the collector of the NPN photo-transistor, which is not shown on the schematic). The photo-transistor emitter (the second pin of the detector) is connected to the calibration circuit made by R15 and R16.

The photo-transistor emitter is connected to the buffer amplifier made by IC1A. The output of that amplifier is connected to the inverting input of the main amplifier circuit (IC1B), whose gain is adjustable through S1÷S3 and the corresponding resistors R5÷R10. The initial gain of the main amplifier is set to 2.2. When switching on the S1÷S3, we add gain to that initial gain. The non-inverting input of the main amplifier is connected to the reference voltage made by IC2, R11÷R14. That reference source is used also for reference by the window comparator consisting of IC4, R18÷R21. The window comparator is used to control the indicator LED. It turns on when the output voltage of the main amplifier is between 1V and 1.1V. Additionally, the circuit has extender connector for linking the device to a processor module. On that standard DB9 connector there are +12V, +5V, the reference voltage, the output voltage of the detector and the output voltage of the main amplifier.

3. Experimental testing and results.

Electrical simulations of the schematic itself were performed and the result can be seen in the graphs below. In Fig. 3 you can see the transfer function of the device without additional gain applied (S1÷S3 are OFF). On the ‘x’ axis you can see the input voltage from the photodetector. On the ‘y’ axis you can see the output voltage of Fog detector 1. The photodetector is powered by 5V, so the absolute maximum input voltage will be less than 5V, because of the voltage drop of the photo-transistor. The input voltage is inversely proportional to the amount of detected light. As you can see in Fig. 3, the output voltage is a linear function of the input voltage. (The input voltage is a linear function of the amount of light). This mode gives the ability to measure from 0% to 100% reduced visibility.

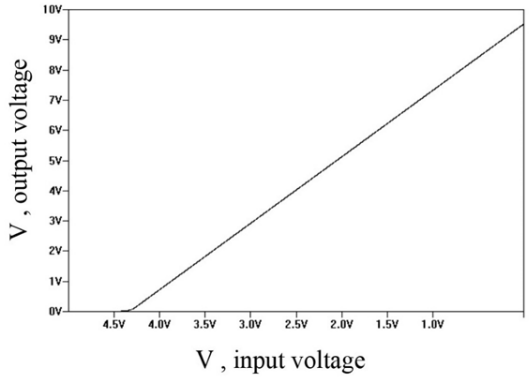


Fig. 3 *– Electrical simulation without gain*

For the purposes of the fog density measurements, additional gain should be applied to the circuit. The results are shown in Fig. 4. On the 'x' axis you can see the input voltage from the photodetector. On the ‘y’ axis you can see the output voltage of the device. A small change of the input voltage (amount of the light detected by the photodetector) results in a big linear change of the output voltage. This gain gives the ability of Fog Detector 1 to measure small differences in the optical ambiance of the working area, thus measuring the fog density.

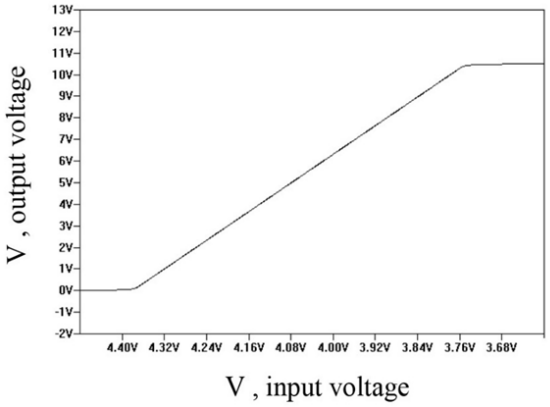


Fig. 4 *– Electrical simulation with maximum gain*

The mechanical description and connection diagram are presented in Fig. 5.

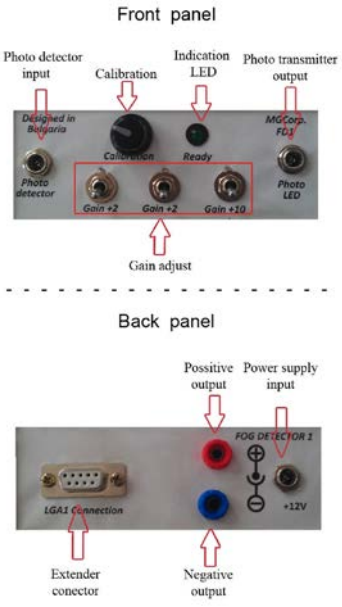


Fig. 5 *– Mechanical description and connection diagram*

4. Experimental procedure

For detection of particles in the air and qualitative evaluation of their diameter/density, Fog Detector 1 is connected to an optical system, Fig. 6. The system comprises of a rail with two optical stands and the emitter and detector placed in these stands. The distance between the emitter and the detector can be changed by sliding the moving stands.



Fig. 6 *– Measuring setup for Fog Detector 1.*

The light detector and the light emitter are both connected to the Fog Detector 1 front panel. The device has three gains to the measured signal and a calibration potentiometer. All of those are used to adjust the device in accordance with the environment under study. All possible variations of the gain switches can be used as needed. After each change in gain, calibration is needed. The optical stands are at a working distance between 35 and 100 cm. The measurement of fog can be performed in the range of 0 -100%.

The result giving the density of the fog is expressed as the difference in the output voltage (ΔU). The bigger the difference in voltage, the greater the visibility is reduced. The maximum output voltage depends on the gain. If for example, the instrument works without gains (0-100%) and after calibration the normalized voltage is 1V. Applying fog we get a reading of 3V. This means that the fog is: (((3V-1V)/(4.3-1))/1Gain)*100 = 61% (reduced visibility).

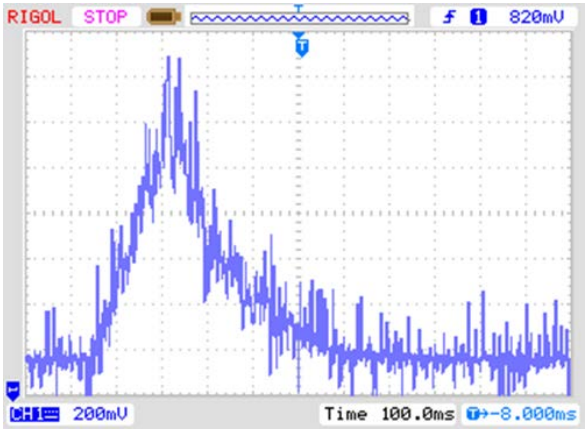
When working in mode „Fog detection“ the device lights up the alarm LED in the case that the input signal is bigger than a certain threshold for the range. After this even if the fog disappears, the LED blinks until the function is reset from the red button on the top of the module.

During measurements, the ambient illumination is of no difference to the measurements unless there are sudden changes or fluctuations. This is so because the instrument can be calibrated in accordance with the input signal, which makes such conditions correctable. It is also very important to note that under direct sunlight exposure, the receiver oversaturates and the device cannot be calibrated into a working range of values.

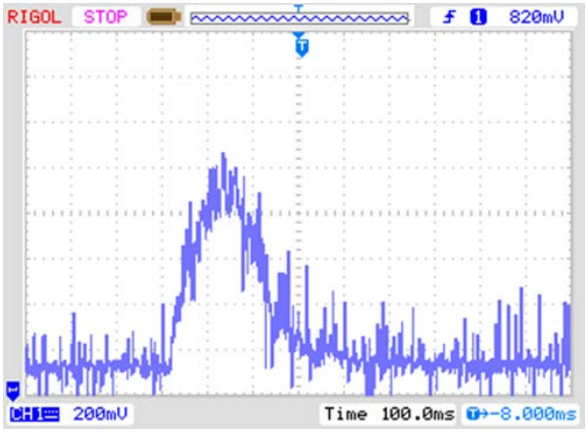
The speed of the measurement instrument is important. No matter the method of fog application, sometimes the voltmeter cannot react as fast as needed in monitoring the signal changes if the duration of presence of fog is less than 2 seconds. This can be avoided if an oscilloscope is used.

5. Experimental results

Fog Detector 1 has been applied to studying the diameter and density distributions of laboratory-made fogs. Here are presented results from the study of lab-made fogs with different average sizes of the droplets – Fig. 7. In Fig 7 the signal in the graphs is inverted, i.e. the stronger the signal, the greater the decrease in visibility. The generated signal is displayed versus time. It is seen in Fig. 7 that the fog with smaller average particle size generates a stronger reduction in visibility. This is explained by the higher number of particles present in the same control volume.



(A)



(B)

Fig. 7 *– Visibility measurement during spraying of lab-made fogs with different average size of droplets: (A) droplet size 65-70 µm; (B) droplet size 150-170 µm.*

6. Conclusions

A device capable of generating an electrical signal proportional to the fog density was developed. The mechanism of detection and the principles on which the device Fog Detector 1 is built are described in this report. It relies on light attenuation for detection of the reduced visibility. The circuit operation is based on a differential amplifier which amplifies the difference between the reference source and the measured light beam. It is an original circuit solution.

Acknowledgement

This work has been funded by EU FP7 Security program under contract COUNTERFOG 312804.

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EXPERIMENTAL DETERMINATION OF TARGET AREA LIMITS AT SHOOTING WITH SMALL ARMS WITH FITTED SILENCER

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Abstract: *Currently terrorism is one of the biggest threats for the security on national and international level. The increase of the terrorist activities led to the expansion of tasks performed by the Armed Forces. In a significant part of cases due to the specificity of the anti-terrorist activity the sound of the shots should be hidden. This can be achieved by using special devices called suppressors. That require determine of target area limits which is the purpose of that report.*

Keywords: SMALL ARMS, SILENCER, TARGET AREA LIMITS.

1. Introduction

Global acts of terrorism points out new threats to international peace and security through intentional acts of violence against the civilian population in order to achieve certain political and economic ideas.

Struggling with terrorist organizations demands an alteration in traditional perceptions of military activity and tactical usage of small arms. There by the use of special small arms equipment for anti-terrorist units is required. Parts of this special equipment are the suppressor, which allows the sound of the shot to be reduced by lowering the temperature and velocity of the effluent gases.

On the other hand, the use of special equipment for individual ballistic protection demands high efficiency for small arms. High efficiency is achieved by increased precision and shots grouping, which represents impact area at shooting with small arms.

In military units of the Republic of Bulgaria, main type of small arm is the automatic rifle AK-47. The suppressor designed for AK-47 is PBS-1, a chamber type suppressor with a rubber chopper wheel.

The survey of available literature in the Republic of Bulgaria reveals that the wear of the rubber chopper wheel has an impact on the shots grouping, but there cannot be found any results about experimental determination of target area limits at shooting with small arms with a fitted suppressor.

Based on the facts above and to determine the target area limits in semi-automatic fire mode using a fitted chamber type suppressor with rubber chopper wheel, in this report several researches have been conducted.

2. Experimental determination of the target area limits

2.1. **Purpose:** experimentally to determine the dimensions of the target area limits in semi-automatic fire mode with small arms using fitted chamber type suppressor with a rubber chopper wheel.

2.2. Objectives:

- to determine the mathematical expectation and the standard deviation of the impact points;

- to determine the vertical and horizontal target area limits where 100% of the impacts are on target.

In order to achieve the purpose of this report, data obtained from the experimental investigation will be used, described in [1]. Deviations of the hits from the control point in the horizontal and vertical plane are to be determined.

Deviations of the hits from the control point are shown horizontally in Table 1 and vertically in Table 2.

Table1: *Deviations of hits from control point horizontally*

		Series №									
		1	2	3	4	5	6	7	8	9	10
Deviation of hits from control point horizontally in centimetres	1	0,00	-8,30	-18,90	-19,70	-9,50	-16,40	2,20	-1,20	-7,00	-27,30
	2	-7,00	-8,40	-20,80	-20,60	-17,20	-18,20	2,20	-1,50	-8,30	-28,40
	3	-7,70	-9,50	-21,80	-25,00	-20,60	-19,80	6,40	-3,50	-10,00	-31,20
	4	-10,00	-10,20	-22,00	-25,80	-20,90	-20,00	7,50	-3,80	-11,30	-32,50
	5	-10,20	-11,00	-23,70	-26,50	-22,40	-20,50	-1,00	-4,00	-12,60	-35,80
	6	-12,50	-12,00	-24,90	-26,60	-22,50	-22,80	-1,20	-8,50	-12,80	-35,80
	7	-12,70	-14,00	-25,00	-26,60	-22,70	-23,50	-1,40	-10,00	-13,70	-36,00
	8	-13,20	-16,00	-26,00	-26,80	-23,50	-23,50	-2,00	-10,30	-13,80	-36,60
	9	-14,40	-17,30	-26,60	-27,20	-23,60	-23,70	-2,80	-11,40	-13,90	-36,70
	10	-15,20	-18,00	-26,80	-27,80	-27,40	-24,10	-2,80	-12,00	-14,00	-37,00
	11	-15,60	-18,20	-27,20	-28,90	-27,70	-25,00	-3,40	-12,30	-15,40	-39,50
	12	-16,30	-19,60	-27,80	-29,50	-27,60	-26,00	-4,00	-13,00	-15,70	-40,20
	13	-17,40	-20,70	-27,30	-29,80	-27,80	-26,30	-5,40	-15,00	-16,10	-40,40
	14	-18,90	-21,10	-25,80	-30,60	-28,60	-26,40	-6,00	-18,00	-17,40	-40,60
	15	-19,30	-22,10	-29,30	-31,20	-29,10	-27,80	-7,40	-18,60	-17,50	-40,70
	16	-19,40	-24,00	-29,70	-31,80	-29,60	-28,80	-9,60	-20,70	-18,00	-41,20
	17	-20,00	-24,20	-30,40	-33,90	-29,40	-29,50	-9,90	-21,50	-18,10	-41,50
	18	-22,60	-25,30	-29,50	-34,90	-32,30	-31,80	-10,00	-22,80	-19,50	-43,20
	19	-25,50	-26,30	-32,50	-35,60	-33,40	-32,00	-14,00	-23,60	-22,50	-46,40
	20	-28,50	-31,00	-34,30	-41,40	-35,80	-38,00	-19,70	-23,60	-23,00	-48,50

Table2: *Deviations of hits from control point vertically*

		Series №									
		1	2	3	4	5	6	7	8	9	10
Deviation of hits from control point vertically in centimetres	1	13,50	33,00	18,80	8,30	-8,40	-5,20	0,80	15,60	5,80	35,60
	2	6,80	32,30	9,50	1,50	-6,00	-4,50	-7,00	-3,10	6,40	29,30
	3	18,00	31,90	10,10	11,00	-8,50	-3,40	-7,20	12,90	3,80	39,00
	4	15,00	34,40	6,50	4,30	3,60	-2,60	0,80	11,90	5,50	29,00
	5	22,00	29,70	12,80	1,00	6,30	-4,20	-0,50	7,80	3,30	-4,00
	6	11,80	31,50	14,40	3,40	-5,20	-2,00	-1,70	17,80	1,80	26,80
	7	13,00	27,40	14,00	3,20	12,00	-3,70	4,40	16,50	-4,70	26,40
	8	22,90	26,80	15,10	10,70	1,90	-6,80	0,80	13,50	2,80	31,40
	9	14,20	30,90	3,80	-0,60	7,40	-2,20	-2,10	13,50	-5,60	18,80
	10	27,80	32,30	14,60	-0,80	4,20	-3,70	8,50	19,80	-14,70	28,20
	11	15,50	28,00	14,50	2,80	3,20	-8,50	0,40	18,60	5,80	33,80
	12	15,50	30,00	8,70	0,90	10,50	-7,50	3,70	6,20	4,70	30,60
	13	13,00	26,20	10,00	12,60	6,80	-6,40	-0,60	-1,70	3,60	26,20
	14	17,10	32,50	21,00	10,00	18,60	-5,00	12,20	2,00	-6,20	34,40
	15	18,80	17,90	13,50	12,10	6,50	-2,20	4,20	9,60	-2,30	24,30
	16	17,00	30,60	17,00	12,50	9,60	-5,90	-0,20	2,80	4,60	20,80
	17	15,80	32,00	17,70	9,10	11,30	-9,20	-0,60	1,80	-0,90	34,50
	18	16,10	29,20	21,80	7,20	13,30	-8,30	0,60	-7,70	0,80	17,50
	19	25,40	24,00	16,00	12,50	9,20	-3,20	0,50	-1,40	4,50	24,40
	20	17,10	5,60	5,50	10,20	7,00	-7,60	4,80	-4,50	3,60	19,20

The position of hits' deviation from control point is represented graphically on Fig. 1.

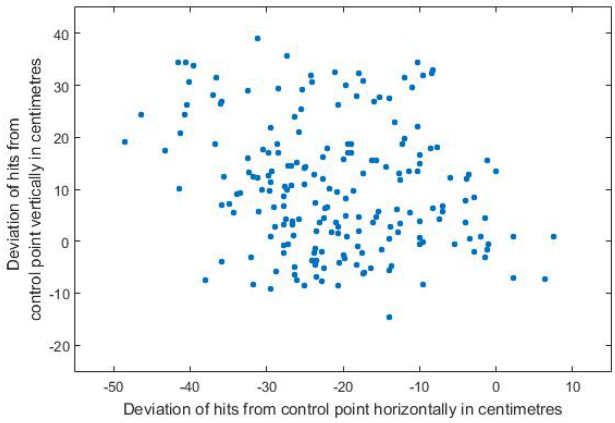


Fig. 1 *Graphics of hits' deviation from control point.*

The results are recorded in the following matrix:

$$m = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

The quantities are defined as:

n = 10 –number of series;

m = 20 –number of shots per series.

To define the mathematical expectation and the standard deviation of the hits by using mathematical software Math Lab, following equations would be used:

- for mathematical expectation:

$$\chi = \frac{1}{n}\sum_{i=1}^{n} x_i,$$

- for the standard deviation:

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \chi)^2}$$

In these equations, the quantities are defined as:

n- number of series on the basis of which the arithmetic mean value is determined;

x_i–value of ith *(i=1..n)* examined deviation.

On Fig. 2 and 3 are presented the deviations on the series and histograms for each series.

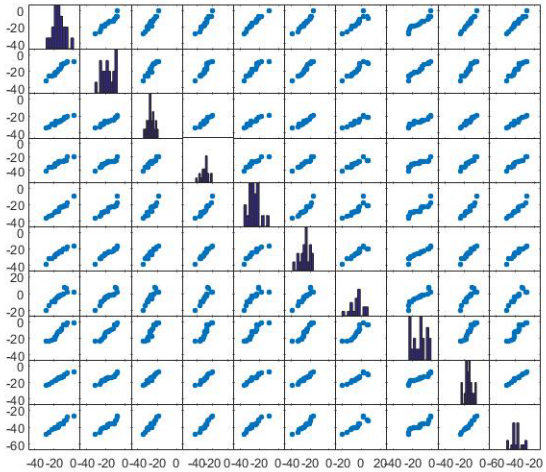


Fig. 2 *Deviations and histograms - horizontally.*

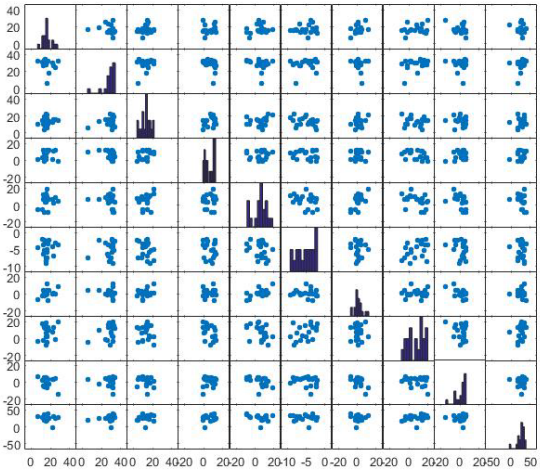


Fig. 3 *Deviations and histograms - vertically.*

In table 3 the mathematical expectation and the standard deviation of the hits in horizontal and vertical plane are presented.

Table3: *Mathematical expectation and standard deviation of series hits*

	Series №									
	1	2	3	4	5	6	7	8	9	10
χ horizontally in centimetres	-15,32	-17,86	-26,52	-29,01	-25,58	-25,21	-4,12	-12,77	-15,03	-37,98
χ vertically in centimetres	16,82	28,31	13,27	6,60	5,17	-5,11	1,09	7,60	1,13	26,31
σ horizontally in centimetres	6,48	6,43	3,79	4,91	5,88	5,07	6,38	7,35	4,10	5,29
σ vertically in centimetres	4,71	6,38	4,82	4,71	7,18	2,24	4,38	8,34	5,26	9,06

Table 4 presents the calculated mean values of the mathematical expectation and the standard deviation from the conducted experimental investigation with a chamber type suppressor with a rubber chopper wheel in semi-automatic fire mode.

Table4: *Mean values of mathematical expectation and standard deviation*

	mean value of **χ** in centimetres	mean value of **σ** in centimetres
horizontally	-20,938	5,568
vertically	10,117	5,707

Experimental data analysis shows that the deviation of hits horizontally is approximately 210 mm to the left and deviation of hits vertically is approximately 101 mm upwards, which leads to necessity to adjust sights of small arms before shooting with fitted chamber type suppressor with a rubber chopper wheel.

The analysis shows that the wear of the rubber chopper wheel has a significant impact on the deviation of the hits from the control point by constantly shifting them in different directions along the horizontal and vertical planes, but the hits grouping is influenced in a significantly lower level.

From the analysis made, using the mean values of σ and the rule of the three σ – are determined the dimensions of the target area limits on the vertical and the horizontal planes in which the 100% of the bullet hits.

The rule of the three σ sets a range in which all values of normal distributed random variable fall within, with confidence level not less than 99.7%. This range represents $\pm 3\sigma$ about mathematical expectation as shown in Figure 4.

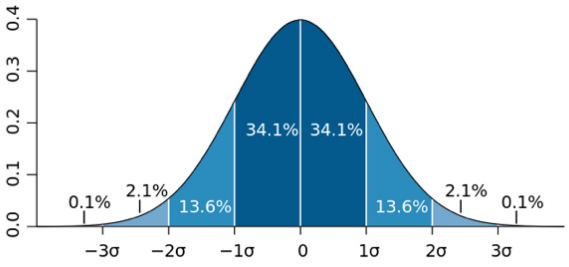


Fig. 5 *Graph of normal distribution probability of hits in standard deviation range.*

On Fig. 5 according to the rule of the three σ's with outer ellipse is graphically represented the probable dispersion and with the inner circle - the limits of the allowed deviation of the hits from the control point, which coincides with a deviation ± σ.

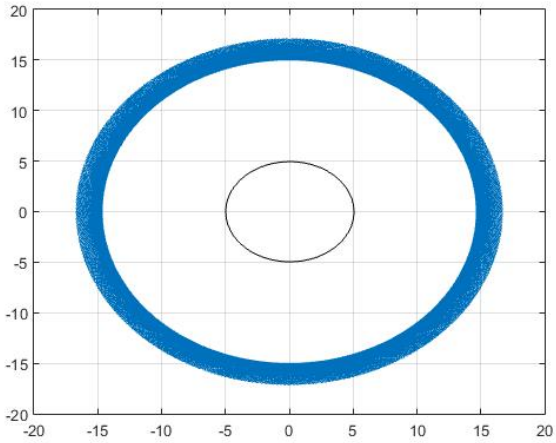


Fig. 5 *Graphic depiction of the target area limits.*

The research shows that the target area limits in which with 99.7% probability the hits fall into, within the approximate range of:

- horizontally

$$x = 3\sigma .2 = 3.55{,}68 .2 = 334{,}08 \text{ mm}$$

- vertically:

$$y = 3\sigma .2 = 3.57{,}07 .2 = 342{,}42 \text{ mm}$$

Within the permissible deviation of the hits from the control point, which almost coincides with a deviation ± σ, the probability of a hit is 68%.

3. Conclusion

From the conducted research, it is clear that in order to ensure reliable target damage, it is necessary to shoot at least two rounds on target, larger than 350 X 350 millimeters and the weapon needs to have its sight adjusted when using fitted suppressor.

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INVESTIGATION OF VARIOUS COMBINATIONS OF MATERIALS USED IN ARMORED VESTS FOR KNIFE PENETRATION PROTECTION

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Abstract: The report presents investigation of the protective characteristics against knife penetration of several combinations of materials used in armored vests. Experimental results for each combination obtained by testing with two types of knives at various energies of impact are analyzed and interpreted.

Key words: *blade, energy, penetration*

INTRODUCTION

The problem of the individual protection is of exceptional relevance in the contemporary complex international and internal situation, related to the occurrence of local conflicts, terrorism, violations of the personality, migration phenomena and others. This necessitates adequate measures of opposition from the security and defense authorities to maintaining the health and safety of soldiers, security personnel, controlling public disorders, police operations, personal protection and critical infrastructure protection.

The use of new materials and their effective combinations is important in this respect, in order to provide resistance to the wide variety of weapons - firearms and cold weapons.

EXPERIMENTAL PART

For the past two to three decades there has been remarkable progress in the experimental and theoretical study of dynamic processes in the penetration of solids bodies in different environments. The accumulated factual experimental material characterizes the physical-mechanical properties of a large number of different types of solid screens for which different model environments have been proposed to describe the movement in a multi-component environment.

Test equipment and procedure

The experimental equipment for conducting tests of the armored vests resistance against stabbing with a knife consists of a specially designed test stand and speed measuring equipment.

The stand is designed to meet the requirements of the two leading standards in the field - NIJ 0115.00 and HOSDB 2007 - Part 3, regulating the test requirements for piercing bulletproof vests and the criteria for determining the respective levels of protection.

The construction of the stand is built so that it can be used for testing all levels of protection regulated in the aforementioned standardization documents. Coverage of a given level of protection is ensured by performing a number of penetrations with a specified impact energy that must be provided by free fall of the piercing blade from a height calculated for that purpose. The integral testing system is carefully designed to allow the mass to fall under its own weight and to hit the test piece of a bulletproof vest at the specified point of impact. The guides do not allow rotation of the falling mass around its vertical axis, thus keeping the orientation of the falling body unchanged until the end of the test.

The tests were conducted under the conditions and in the order, described in the methodology developed for this purpose, for the protection levels specified in *Table 1*.

Table 1. Protection levels

Protec-tion level	Energy of impact „E1“, J	Maximum allowable penetration of the blade, mm	Energy of impact „E2“, J	Maximum allowable penetration of the blade, mm
1	24±0.50	7	36±0.60	20
2	33±0.60	7	50±0.70	20
3	43±0.60	7	65±0.80	20

Level 1 provides protection against low energy threats with impact energy ranging from 24 J ± 0.50 J to 36 J ± 0.60 J. The armor must withstand a break with energy of impact of 24 J with the maximum allowable penetration of the blade not greater than 7 mm. After that, a power impact test of 36 J was performed, where the maximum allowable penetration of the blade must not be more than 20 mm.

Level 2 provides protection from medium energy threats with impact energy ranging from 33 J ± 0.60 J to 50 J ± 0.70 J. The armor must withstand puncture impact energy of 33 J with the maximum allowable penetration of the blade not greater than 7 mm. A power impact test 50 J was performed, where the maximum allowable penetration of the blade must not more than 20 mm.

Testing was carried out with engineering knives (high-quality, factory-made knives with cutting edges). Two types of blades were used - type P1 and type S1, which are the two types of sharpened weapons most commonly used in attacks.

Blade type P1 (*Fig.1*) is representative of a simple small knife, it is smaller and thinner and has one sharpened edge, whereas a blade type S1 (*Fig.2*) is representative of a knife used

by the commandos, or a large kitchen knife - it is bigger, thicker and has two sharpened edges. Both types of test blades are hardened, with Rockwell hardness, scale C, within the range 50–140 HRC and have a pointed tip and a stable base.

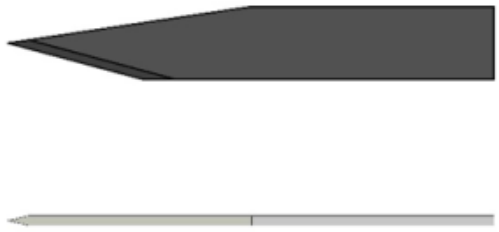


Fig.1. Test blade type P1.



Fig.2. Test blade type S1.

The tests were carried out at a meeting angle of the test blade and the test specimen 0° relative to the normal.

Before the tests, the impact energy was calibrated by calculating the fall height required for achieving the desired speeds corresponding to the impact energy, for each value of impact energy and for each type of test blade, using the equation (1).

The drop height is measured from the tip of the test blade to the surface of the bulletproof test specimen.

$$h = E/mg \qquad (1)$$

where:

h is the height of the fall, m

E is the kinetic energy of impact, J

m is the mass of the falling shuttle, with the test blade with accuracy of 1 g

g is the gravitational acceleration, m/s^2.

The places of penetrations were marked on the armor. Then the bolster material, indicator paper and the test sample of a armored vest were placed, ensuring their immobility tightening them to the base of the stand by means of elastic straps of width, fastened with Velcro® strips. After that the test blade was mounted.

An correct measurement of the impact velocity was provided by a pair of photoelectric light screens mounted at a distance of 25 mm ± 2 mm from the point of impact of the test sample of the armored vest, providing measurement with an accuracy up to ± 0.2 m/s.

When conducting the puncture resistance tests to meet the requirements at a given level, a series of tests according to *Table 2* were performed for each combination of materials composing a flexible ballistic panel of a armored vest.

Table 2. Test conditions

Number of punches	Angle of meeting	Test blade type	Energy level
6	0°	P1	E1
6	0°	P1	E2
6	0°	S1	E1
6	0°	S1	E2

The measured results were converted to the depth of penetration according to the penetration depth conversion tables. The results were recorded in a test report.

The average arithmetic values of the measured penetration depths were determined using the equation (2).

$$dcp = \frac{1}{n}\sum_{i=1}^{n} di \qquad (2)$$

where:

d is the depth of penetration, mm

n is the number of experiments conducted

i is a sequential experiment number.

Test samples

Tests have been carried out to determine the protective properties of flexible ballistic flasks of armored vests in terms of their resistance to penetration, made up of different combinations of materials.

The tested samples of flexible ballistic panels were divided into three groups, depending on the materials used and their combinations.

A packet of Dyneema® SB51 sheet with a density of 253 g/m^2 was used for the core packet of each group. The base packet weight was 4.807 kg/m^2.

The additional packages represent a certain combination of materials and are different for each specimen.

The main and additional packs were placed in an outer 100% Polyester pouch weighing 0.165 kg/m^2.

For all specimens, the face (impact) surface was on the side of the additional package.

First group of samples

To the base package is added an additional package made up of a different combination of Dyneema® SB51 based materials on which SiC, Al_2O_3 and polyvinyl chloride were strewd. For bonding between the two materials resin is used.

Second group of samples

To the base package is added an additional package made up of a different combination of Kevlar® XP based materials on which SiC, Al_2O_3 and polyvinyl chloride were strewd. For bonding between the two materials resin is used.

Third group of samples

An additional package is added to the basic package, made up of a different combination of textile-based materials on which Al_2O_3 and SiC were strewd. For bonding between the two

materials resin is used. To some combinations Kevlar® XP or Dyneema® SB51 were added.

EXPERIMENTAL RESULTS ANALYSIS

As a result of the analysis, evaluation and comparison of the results from the conducted tests for penetration resistance of the samples, it was obtained, as follows:

- For the First group of samples:

Sample 1.1 covers the penetration requirements for level 1 and for level 2 only with a test tip S1. Using a P1 test blade, the protection levels are not covered.

Sample 1.2 covers level 1 for both types of test blades (P1 and S1). Level 2 is only covered with a test blade type S1. This is the lowest weight sample of the group, which shows the best puncture resistance. The sample has been subjected to a ballistic resistance test for the protection level IIIA tested.

Sample 1.3 covers level 1 with both types of test blades (P1 and S1). Level 2 is only covered with a test blade type S1.

Sample 1.4 covers the penetration requirements for protection levels 1 and 2 only with a S1 test blade. Using a P1 test blade, the protection levels are not covered.

- For the Second group of samples:

All samples in this group (Sample 2.1, Sample 2.2, Sample 2.3 and Sample 2.4) meet the penetration requirements for Level 1 and Level 2 with a type S1 test blade only. Using the P1 type test blade, the protection levels are not covered.

Sample 2.2 has the lowest weight of this group. It also exhibits the best puncture resistance. This sample has been subjected to a ballistic resistance test for the protection level IIIA tested.

- For the Third group of samples:

Sample 3.1 and Sample 3.4 meet the penetration requirements for protection levels 1 and 2, both with the type S1 test blade and the type P1 test blade.

Sample 3.2 and Sample 3.3 meet the penetration requirements for level 1 with both types of blades (P1 and S1). Level 2 is only covered with a test blade type S1.

Sample 3.4 has the lowest weight of this group. It also exhibits the best puncture resistance. The sample has been subjected to a ballistic resistance test for the protection level IIIA tested.

CONCLUSIONS

1. It was found that from all tested samples the best protective properties with respect to puncture resistance and ballistic resistance are shown by Sample 3.4, which has the lowest overall weight of the panel.

2. In the process of improving the resistance of bulletproof vests various materials can be used such as Dyneema SB51, Al_2O_3, SiC, which, in the tested combination (Sample 3.4), show optimum results in weight of the panel and the protective properties against piercing.

3. The specimens additionally tested for ballistic resistance cover the requirements for level of protection IIIA, according to NIJ 0101.04 and NIJ 0101.06, further supporting a 7.62x25 FMJ RN cartridge.

4. An armored vest by materials of the combination used in Sample 3.4 is manufactured, which will meet the requirements of the Ministry of Defense of the Republic of Bulgaria and those of the Police of the Republic of Bulgaria in terms of weight and protective properties and will be competitive on both the national and the international market.

LITERATURE

[1] NIJ 0101.04
[2] NIJ 0101.06
[3] NIJ 0115.00
[4] HOSDB 2007