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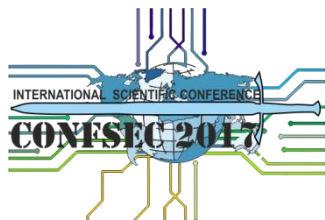
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Airport vulnerability model in civil aviation

Nikolayi I.Ovchenkov, Ruslan S. Fadeev
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Abstract: The work presents the author's view on one of the most important problems of civil aviation in modern conditions – the problem of ensuring the aviation security of civil aviation facilities. Problems of security and problems of aviation security management are investigated and addressed in the assessment approach through the creation of integrated systems for aviation security and the concept of vulnerability. The concept of vulnerability is determined by the degree of protection of transport infrastructure objects from unauthorized interference in their activities. The work proposes the airport vulnerability model as an object of transport infrastructure. The proposed methodology includes a system of views of the authors on the problem of aviation security based on the concept of vulnerability.

KEYWORDS: CIVIL AVIATION, TRANSPORT SECURITY, VULNERABILITY MODEL, VULNERABILITY ASSESSMENT METHODOLOGY.

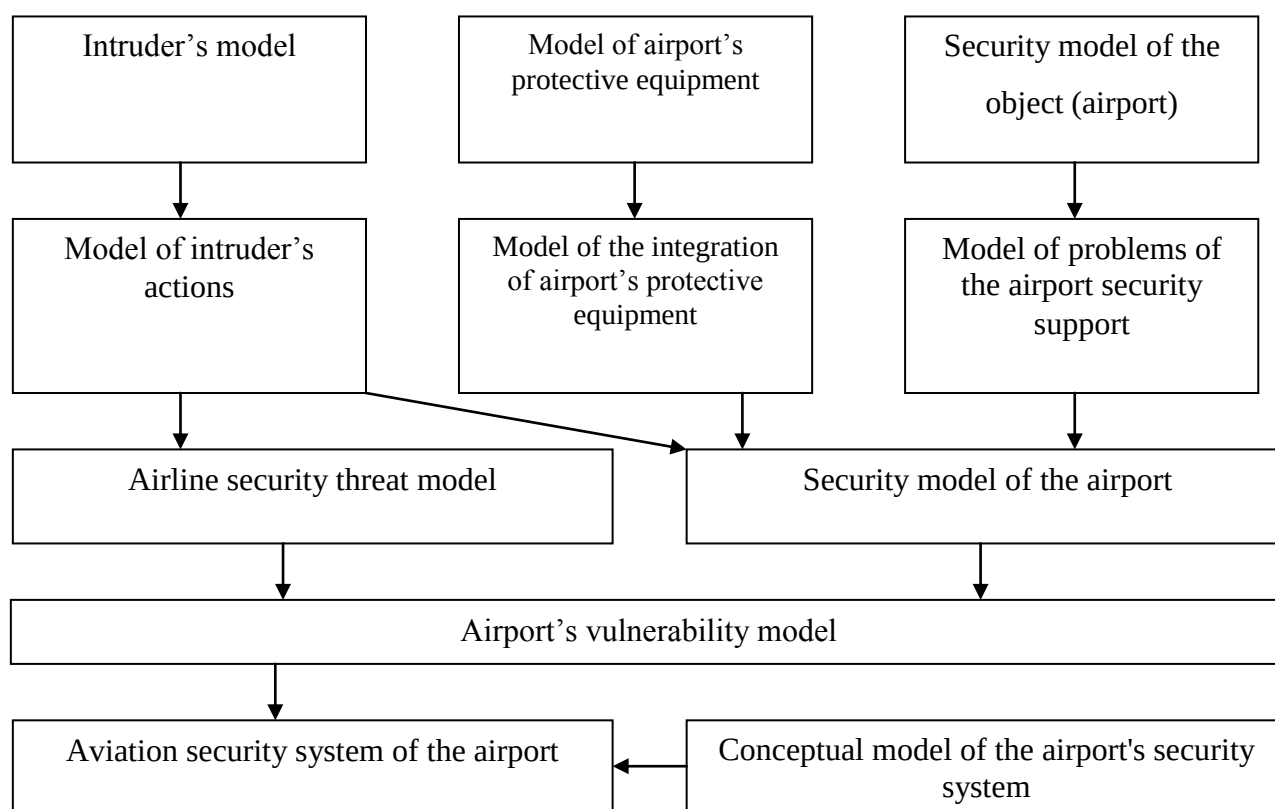
INTRODUCTION

The issues of aviation security (AS) support and the level of aviation security management are under investigation, they are solved within the framework of the validation approach and through the creation of the integrated aviation security systems. The concept of vulnerability is defined by the degree of security of transport infrastructure and transport facilities (TF) from tampering into their sphere of action. Vulnerability assessment process is supposed to have specified assessment techniques, procedures and parameters of the object. They can be implemented and obtained unless and until the object identification to which they were applied. In other words, the object needs to be investigated and structured. For this purpose, the object's technical, technological, operational characteristics, critical components, potential threats and the ways to implement

them should be specified. On this basis the protection system management is developed.

VULNERABILITY MODEL AND ITS ASSESSMENT METHODS

The structural and logical basis of the airport's aviation security system is the vulnerability model (Pic.1). It is based on two models: the airline security threat models and the security model of the airport. These two models define the processes of confrontation in the aviation security system, where vulnerability is the main parameter. On the other hand, the threat model includes the intruder's model and the model of his actions, and the protection model consists of the security model of the object, protective equipment, a model of integration of the object's protective equipment and a model of problems.



Picture.1 The question of airport vulnerability model's generation.

There is no generally accepted methodology for assessing the vulnerability of TF today. At the same time, serious work is being done to investigate this problem.

The Markov process and chain apparatus can be used for this purpose [1,2]. Despite the seeming attraction of using Markov processes and chains to study the vulnerability of transport infrastructure and vehicles, it should be borne in

mind that the process can be attributed to Markov only if it is an ordinary flow of events without aftereffect, the characteristics of which do not depend on the background, and the number of states is finite. In this case, it is very difficult to identify events in the airport's aviation security system that meet the listed requirements, which request the use of other approaches and methods of solution.

In some works [3,4,5], the concept of "vulnerability" is associated with some "weakness" of the object, allowing for the possibility of destructive effects. In relation to the civil aviation (CA) object, this "weakness" is a consequence of the presence of a certain set of factors of different physical content that contribute to the implementation of the j -th act of unlawful interference (AUI) in the activity of the i -th CA object.

The concept of "vulnerability" of an object is understood as the state of the CA object and the system for ensuring its AVSEC, allowing the possibility of committing AUI in its activities and implementing the threat of the CA object.

In symbolic form, this vulnerability definition can be written as follows:

$$f_{ij} \in F \quad (1)$$

$$I=1,2,\dots,I; j=1,2,\dots,J; \lambda=1,2,\dots,\Lambda; l=1,2,\dots,L,$$

where F - multiple vulnerabilities of CA objects;

u_{ijl} - the potential amount of damage of the l -th type for the i -th CA object due to the implementation of the j -th AUI in its activities;

U - the set of all damage values that are characteristic of this CA object.

It follows that the vulnerability is characterized by a multiparametric dependency

$$f(t) = f(\Phi(t), B(t)) \quad (2)$$

where t is the lifetime of the CA object.

In relation to the fixed characteristics of the aviation security system of the i -th CA object as a basic quantitative indicator of vulnerability, we can consider the probability of $W_i(b_j)$ implementation of the j -th AUI in the activity of the i -th CA object in certain conditions and the vulnerability indicator

$$f_{ij} = W_i(b_j) \quad (3)$$

The vulnerability assessment is based on a set of indicators that are likely in nature. Quantitative evaluation of these indicators is assumed in the framework of some simulation model. The simulation model, depending on the specific object of the CA and the system for ensuring its AS, may include a set of interrelated elements of various mathematical content: algebraic, transcendental and differential equations, models of the dynamics of averages, probabilistic models in continuous and discrete form, and models of statistical tests. The work suggests a general procedure for developing a simulation model, and this is the end of the study, which does not allow us to draw any conclusions about the possibility of practical use of this model.

Thus, the analysis of the proposed methods shows significant difficulties in their practical use for solving the problem of assessing the level of security of TF objects.

It is proposed to assess the vulnerability of TF objects using a qualimetric approach, i.e. to base the assessment on the quality category [6,7].

The airport vulnerability model, based on the principles of qualimetry, is shown in Pic. 2. The principal difference between the model and the known ones is the use of the "quality" and "risk" categories as vulnerability assessment

criteria. Quality is understood as the degree to which inherent characteristics meet requirements. The concept of risk is used in the conventional sense as an assessment of the probability of event's occurrence and an assessment of the magnitude of the expected damage. There are determined the two sides of the confrontation:

1. the subject of illegal activity, which should be understood as a set of negative factors, including people, equipment, weapons, ammunition, etc., aimed at the implementation of unauthorized interference in the activities of civil aviation, including the implementation of acts of illegal interference and terrorist acts;

2. an object protection system that includes people, machinery, equipment, methods and procedures combined within an integrated aviation security system. Based on the study of these two sides, the vulnerability assessment is determined as the level of security of the object.

It is important to note two circumstances: the assessment must be obtained in a quantitative form, the vulnerability assessment is not a constant value and changes when the parameters of the parties to the counteraction change.

Therefore, it is necessary to identify not only the object of protection, but also the subject of illegal activity, i.e. it is necessary to determine the threat parameters and protection parameters. Taking into account the dynamics of threat parameters, we can talk about the corresponding dynamics of security parameters.

Hence, taking into account the dynamics of threat parameters and protection parameters, we can talk about dynamic integration, that is, such integration of aviation security tools that ensures the formation of the structure of the aviation security system that is adequate to the currently operating threat at the object.

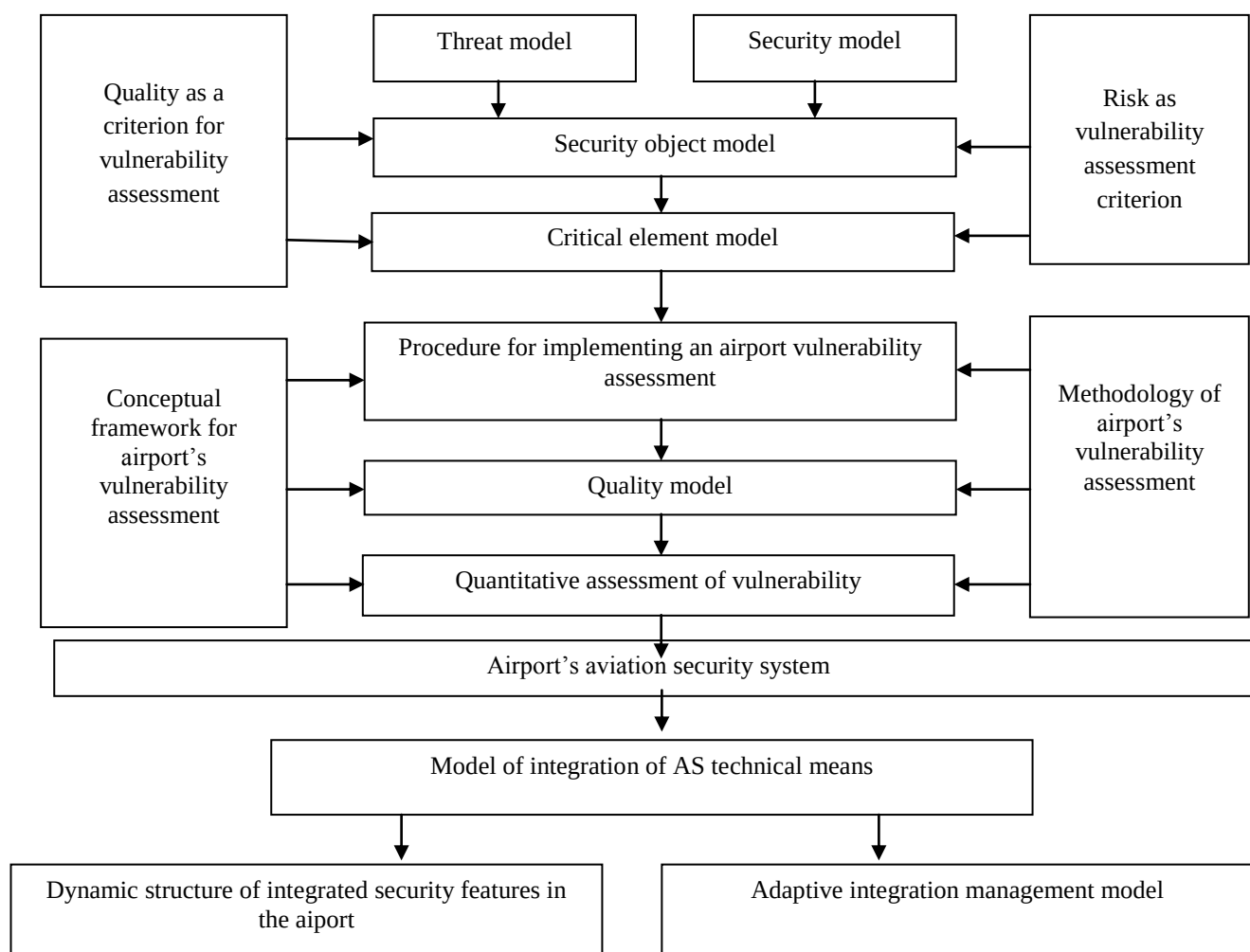
CONCLUSION

The concept of vulnerability of TF objects is based on the concept of dynamic integration of the aviation security system using the concept of vulnerability as a parameter for adaptive management of dynamic integration procedures.

Implementation of the concept involves identification of the security object in the form of a security object model and security tools in the form of a security model. On the other side of the confrontation, the subject of illegal activity is identified as the corresponding models of the intruder, the intruder's actions and threats. Based on the protection model and the threat model, the vulnerability model of the TF and the vehicles is formed.

The next aim is to select a vulnerability assessment method. The authors suggest using qualimetry methods for these purposes, since, based on the physical meaning of the concepts of vulnerability and quality and their definitions, we can talk about a sufficient degree of their coincidence.

Quantitative vulnerability assessments in the form of quality indicators can be used as integration management parameters. Using these parameters, there are implemented adaptive integration security's management system, what means there is implemented dynamic integration, correcting the structure and parameters of the AS system, which adjusts the parameters of the model of vulnerability, providing the parameters of the confrontation, adequate to the parameters of the current threats. Adaptability here should be understood as management that meets current requirements.



Picture. 2 Airport vulnerability model.

REFERENCES

1. Elisov L.N., Ovchenkov N.I., Fadeev R.S. Introduction to the theory of aviation security, Yaroslavl, Filigran` Publ., 2016, 320 p. (In Russian).
2. Elisov L.N. To the question of the accuracy of heuristic algorithms for solving optimization problems in operation. Nauchnyj Vestnik MGTUGA=Scientific Bulletin of MSTU CA, 2012, no. 179, pp. 123-126. (In Russian).
3. Filippov V. L., Ovchenkov N. I. Some problems of automation of aviation security management procedures at the airport // Scientific Bulletin of the State Research Institute of Civil Aviation. 2019. No. 24. P. 66-74.
4. Elisov L.N., Ovchenkov N.I. To the question of structural modeling of transport security subjects. Scientific Bulletin of MGTUGA=Scientific Bulletin of MSTU CA, 2013, no. 197, pp. 58-61. (In Russian).
5. Elisov L. N., Ovchenkov N. So. Integrated air transport security. Scientific Bulletin of MGTUGA, volume 20.-M.: MGTUGA, 2017, № 6-p. 36-44
6. Ovchenkov N., Elisov L. N. Assessment of vulnerability of objects of transport infrastructure and vehicles in civil aircraft // Scientific Bulletin of MGTUGA. 2014. No. 204. P. 65-68.
7. Elisov L. N., Gorbachenko V. I., Zhukov M. V. Learning Radial Basis Function Networks with the Trust Region Method for Boundary Problems // Automation and Remote Control. - 2018, Vol. 79. - No. 9. - P. 1621-1629.

Opportunities for determining factors affecting the development of intelligent security systems models

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Abstract: Contemporary security challenges require the creation of a continuous and manageable process that guarantees the survival and sustainability of the organization's core activities before, during and after a devastating event. This means that it is necessary to manage the organization's activities, resources, personnel, impact on its functioning and countless risks. Significant contribution in this direction provides intelligent security systems.

Thanks to rapid technological progress it is possible to be developed sophisticated security systems able to integrate heterogeneous sources that can monitor, control and manage the security environment of the organization, which is potentially at risk. But the combination of different technologies is not sufficient to significantly increase the level of security and the approach to the integrity of system elements, and compatibility with other systems management organization are basic factors for success in this direction.

Key words: ORGANIZATION MANAGEMENT, INTELLIGENT SECURITY SYSTEMS

1. Introduction

National agencies and business organizations are increasingly exposed to risks that threaten productivity or the ability to provide their services to their customers, in a timely and continuous manner. Different trends in society and the economy contribute to these risks, such as increasing globalization, networking, centralization, automation, outsourcing or offshoring. Significant influence on the development of these risks have and the increasing complexity of business processes and increased dependence on IT and external service providers by events such as fires, floods or loss of information technologies, suppliers or staff. In addition, the risk of a pandemic, extreme climatic conditions and terrorism is also increasing.

Business Continuity Management (BCM) is a way that can address the challenges faced by organizations associated with the impact of probable risks. BCM is a management process in order to detect serious risks that threaten the survival of the organization and applying precautionary measures against these risks at an earlier stage. The essential part of BCM is the correct identification of critical organization risks associated management strategies to be planned and ways to implement the response to the possible risk events.

The essential part of BCM is the correct identification of critical organization risks associated management strategies to be planned and ways to implement the response to the possible risk events.

In order the whole range of activities to be completed, good practice requires the establishment of models of the organization's Business Continuity Management System (BCMS). This system integrates interrelated methods, procedures and rules to preserve the duration of critical processes and can be integrated into or based on existing management systems.

Physical security is one of the main factors influencing the development of the organization's intelligent security systems and providing the BCM. This activity relates to the use of physical means to protect premises, sites, facilities, buildings or other physical assets belonging to critical assets. The application of physical security is the process of using layers of physical security measures to prevent unauthorized access or damage.

2. Impact of the physical protection system on the critical infrastructure continuity management model

Current rates of technological advancement make it possible to develop sophisticated physical protection systems (PPS) that integrate heterogeneous sources [1÷5] that create ability to monitor the environment of the organization potentially at risk. In this way, PPS sustainability can be achieved by adding new technological solutions. But the integration of various technologies is not sufficient to significantly increase the level of protection and the approach to the integrity of the elements of the PPS, and compatibility with other systems management system of the organization is essential.

PPS development

In the following text I will present approaches for design, development and implementation of PPS [1÷5] in terms of building a new nuclear facility designated as critical infrastructure (CI) (for short in the following text will be presented as a “facility”), construction of new installations within existing facilities, modernization and reviewing the effectiveness of existing PPS.

The PPS development is best achieved through a systematic approach consisting of three phases, namely:

1. Defining the goals and requirements for the PPS;
2. Designing the PPS to meet the objectives and requirements, set out in Phase 1;
3. Analyze and evaluate the PPS effectiveness, designed in Phase 2, the objectives and requirements established during Phase 1 to be achieved.

The implementation of these three phases will ensure the development of a PPS design for protection against threats of unauthorized removal or sabotage, and will also meet other facilities for specific purposes that may be applied.

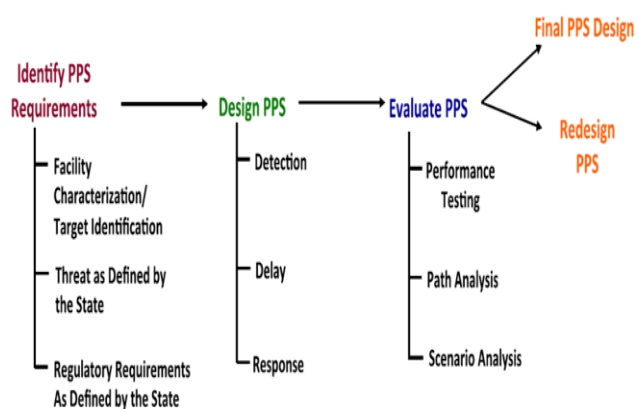


Figure 2-1: PPS model process development [1]

The sequence of these three phases and the summary of activities for each phase are illustrated in Figure 2-1 (activities need not be performed in the order shown).

PPS Requirements identification

The purpose of Phase 1 activities of developing and evaluating a PPS project is to determine how the State's physical protection requirements apply to the specific facility and PPS.

There are several steps to identifying these requirements, namely:

- *Characterization of the operations of the facility and its condition.* This includes: a description of the processes and operations within the facility; detailed description of the facility development, including the location of the facility boundary, site locations, floor plans, construction height and access points, and features of the facility or systems identification that can be used as PPS elements
- *Interpretation of threat information submitted by the State of the operator or applicant to provide the basis for the project.* This step is either performance-specific or a combined approach. In the recommended approach, the state does not usually provide information to the operator about the threat.
- *Identification of the targets to be protected from the threat and their location within facility.* It is carried out according to the identification by the state regulator, based on the categorization of the facility or the levels of consequences of a risk event (sabotage).

PPS Development

During Phase 2, it is determined how best to combine in the PPS physical protection measures (such as fences, arches and sensors), procedures, communication devices and response personnel that can meet the required level of security. The overall objective is to ensure that, regardless of the physical protection strategy chosen by the organization, the PPS fulfills the security requirements by appropriately balancing detection, delay and response functions.

Good practice in the PPS development is the application of the principle of "defence in depth" that provides deception of the likely opponent on the location of risky assets and forcing him to overcome (eliminate) several protection measures in order to achieve success.

This is usually achieved through a multi-layered defence, where a series of protective layers built around the goals may include a combination of physical measures such as access control areas (Physical Security) and administrative measures, such as protection of sensitive information and reliability (Information Security). Thus it is achieved using the strengths of each component of physical and

information security in combinations that complement the strengths or compensate for the limitations of each.

The effect produced by this system on the probable intruder will be:

- Increasing the insecurity of the infringer on the configuration and operation of the system;
- Requirement for additional tools and more extensive preparation before affecting the system;
- Creating additional steps in which the infringer can fail or decide to abandon the attack.

The design of the PPS must be compatible with the systems of operation of the equipment important for safety and allow personnel to carry out their duties in a safe and secure manner. If there are physical security measures that are too difficult for personnel to comply with, they may find ways to accomplish their tasks more easily by circumventing security measures. Building a thorough understanding of the operation of the facility and applying this knowledge during the design of the PPS will help balance the needs between physical protection with the safety of exploitation.

PPS evaluation

During the Phase 3, the draft PPS in Phase 2, whether it concerns a new or existing system, is evaluated to determine whether it meets the requirements as identified in Phase 1.

The grounds for the evaluation of the PPS include:

- Confirmation that the PPS, as designed (for an new system) or characterized (for an existing system), meets the requirements for physical protection;
- Identification of any system deficiencies in the design or implementation that need to be removed in order to meet the system requirements;
- Analyzing possible improvements that may be needed to address the identified deficiencies and improve system performance;
- Repeat evaluation of the effectiveness of PPS on an annual or other regular basis to take into account any changes in the objectives, the operation of the system or requirements to it.

The PPS provides detection, delay and response functions through structural, technical elements and personnel. The interaction of these elements with the hardware and procedures makes the evaluation of the PPS performance challenging.

Methods for evaluation of the system:

- *Path analysis.* This involves setting deadlines for different paths of the intruder to determine with sufficient certainty that the attack will be detected as long as there is sufficient response time to interrupt the task of the intruder. Usually, times of tasks and response times are measured or evaluated quantitatively.
- *Simulation.* This includes computer-based simulations of the PPS and cabinet exercises that allow consideration of security plans and emergencies, as well as intruder decision-making and response forces of the facility.
- *Exercises.* They vary from limited exercises aimed at responding to an alarm to force exercises that address the effectiveness of the entire SPS against the simulated impact of the intruder.

3. PPS lifecycle

Once the PPS is designed and evaluated using the development process presented, the next steps in the PPS life cycle are: use of the system; maintaining the PPS in place and planning for an appropriate design of the PPS based on threat changes, changes in

facility configuration or operations or potential targets, or based on performance monitoring [1].

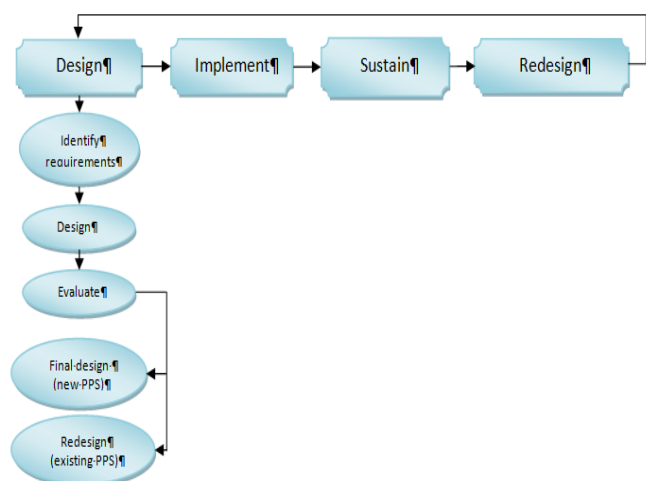


Figure 3-1: The process of developing an PPS model

For the purposes of the development I will look in more detail only the PPS “Sustain” step.

Taking into account the State's approach to maintaining the nuclear security regime, operators must ensure that the necessary resources - trained and knowledgeable personnel, reliable equipment, related infrastructure, quality assurance and financing - are available to maintain their PPSs as part of the sustainability programme. Additional information about the program sustainability of the organization includes the allocation of resources to effectively design, operation and maintenance of systems and security measures [6÷10].

Senior managers set priorities and identify the long-term financial resources needed to continue operating costs associated with staffing; training, training and testing of results; purchase, maintenance and replacement of equipment and configuration management. They also define roles, responsibilities and accountability.

The plans provide a means of documenting these management decisions. They enable operational organizations to both demonstrate to the relevant competent authorities their compliance with applicable requirements and provide guidance to their own personnel on the operation, maintenance and continuous improvement of nuclear safety systems and measures.

In this regard, the organization has to:

- Document the decisions outlined in the appropriate plans;
- Prepare and use a security plan, transportation security plan, contingency plans, deployment plan, response plans or other plans appropriate for its operations.

These plans have to:

- review relevant threat information and implement informed approach to risk;
 - include appropriate agreements and the identification of relevant external organizations that may need to be contacted or informed about a nuclear security event;
 - be regularly reviewed and revised based on operational feedback and changes in requirements.
- Establish appropriate measures for measurement, evaluation and continuous improvement.

Organizations should establish a process to ensure that threat information provided by competent authorities, as well as local threat information is systematically and timely reported through

nuclear security systems and measures. They also need to put in place mechanisms to deal with the temporary increase in threat that may arise due to economic, political, environmental or other factors. It is important to point out that the process of identifying and analyzing current information on possible threats is documented to the corresponding security plans or other similar documents.

Under the leadership of management in the organization should:

- Creates and documents a systematic process for maintaining and updating current threat information, including:
 - exchange with the competent authorities of up-to-date external and internal threats information;
 - establish and liaise with competent authorities, including law enforcement authorities, to facilitate the exchange of information.
- Performs activity review to mitigate potential internal threats by means such as a security program, information security program and security training.
- Adapt security systems and measures, if necessary, to counter the current threat.
- Applies compensatory measures in response to a specific, emerging or increasing threat.
- Has a developed reporting mechanism for the occurrence of an up-to-date threat or an effective information system with the responsible competent authorities.

Key functions of the SPS

The PPS meets the requirements and achieves the objectives of physical protection through *deterrence* and a combination of *detection, delay and response*.

Deterrence

Deterrence is achieved when potential offenders consider the facility as an unattractive target and decide not to attack it or abandon their plans of attack. To encourage deterrence, an operator may apply surveillance security measures such as the visible presence of security guards patrolling the facility, bright night lighting, window grilles and vehicle barriers. Deterrence may be useful, but its effectiveness is difficult or impossible to be measured.

Detection

Detection is a process in the PPS that begins with the establishment of a potentially malicious or otherwise unauthorized act and ends when the cause of the alarm is identified [11÷12]. The effectiveness of the PPS in securing detection depends on the capabilities of the sensors, the alarm reporting and evaluation systems, as well as the work of the alarm system operators and any security guards or members of the response forces who have a role in the detection.

Delay

Delay is the function of the PPS, which seeks to slow the intruder's progress toward a target, thus providing more time for an effective response. Delay can be accomplished through distances and areas that need to be crossed, and barriers that need to be overcome, including fences, gates, doors, locks, cells, and delay systems activated.

Response

The response is the function of the PPS, which seeks to interrupt and neutralize the intruder when performing malicious action [13÷14]. Guards assigned responsibility for access control, escorting persons, monitoring and assessment of alarms in the system, patrols and / or performing the initial response. Response forces consist of persons inside or outside the field, who are armed

and appropriately equipped and trained to interrupt and neutralize an intruder attempting to remove or sabotage the wrongdoing.

4. Conclusion

The implementation of measures to improve the protection of CIs depends mainly on the status and actions of the various bodies and organizations involved in the process, belonging to both the public and private sectors. It is clear that to meet this challenge requires a multidisciplinary approach for the development and implementation of new technological solutions capable of providing a proper response against the main threats to the security of citizens while respecting their fundamental rights. Therefore, the area of interest in this direction is focusing on the physical protection of CIs.

The physical protection of CIs requires the development of innovative approaches to identify, detect and mitigate threats, vulnerabilities and risks. It is therefore an area where practical needs, technological resources and research and development converge. At the same time, the integration of physical and information security is a key element in the management and planning of physical security resources. Integration helps to provide important security benefits to the organization as it guarantees the synergy of the two mechanisms.

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Bibliography:

- [1] Kiril Stoichev, Dimitar Dimitrov, Valeri Panevski. „Critical infrastructure integrated security and protection“, section one, p.p. 16-49, section three, p.p. 130-142., IMSETHC-BAS, 2018, ISBN:978-619-90310-8-7;
- [2] Associate Professor Dr. Eng. Dimitar Dimitrov, Monograph "Development of Standardized Criteria for Security Assessment and Modeling and Enhancement of Critical Infrastructure Protection", First Edition, 2019, ISBN 978-619-188-285-4;
- [3] Associate Professor Dimitrov D. L. Ph.D., „Standardized Approaches for the Integration of Management Systems of the Critical Infrastructure Objects“, 2019, VII International scientific technical conference, Proceedings - volume 3., Publisher: Scientific technical union of mechanical engineering, ISSN: 2535-0315 (print), 2535-0323 (online), p.p. 239-241, <https://techtos.net/sbornik/2019/3-2019.pdf>;
- [4] Dimitrov D., Nikolova V., Asenov M., Vasileva P. Project "Integrated employment interventions in the border cooperation region Giurgiu - Ruse", "MOBGIRU", project code 16.4.2.036 interreg V-A Romania-Bulgaria Program. Proceedings of the Sixth National Conference with International Participation in Metal Science, Hydro and Aerodynamics, National Security 2017, IMSETHC-BAS, 2017, ISSN:1313-8308, p.p. 179-183;
- [5] Dimitar Dimitrov, "Comparative evaluation of modeling and simulation techniques for interdependent critical infrastructure", International Scientific Journal „Security & Future“, Issue 4/2019, Scientific Technical Union of Mechanical

Engineering, 2019, ISSN:ISSN: 2535-0668 (print), 2535-082X (online), p.p. 128-132;

- [6] Georgiev, N.L. "Analysis of one class of specialized sensors for protection of objects from critical infrastructures", 2015, ISBN:978-619-90310-4-9, 170, monograph;
- [7] Georgiev, N.L. "Summary description of the state of sensors by object protection systems", Collection of scientific papers - Days of non-destructive control' 2015, 2, 2015, ISSN:1310-3946, p.p. 118-120;
- [8] Yavor Boichev, "Pneumatic-jet engine for propulsion of special purpose submarines", Sixth National Conference with International Participation "Metal Science, Hydro and Aerodynamics, National Security" 2017. 2017, ISSN:1313-8308, p.p. 293-295;
- [9] Yavor Boichev, Stanislav Asenov, "Pyrotechnic compositions for non-lethal light-sounding means", 2018, ISBN: 978-619-7246-20-9, ISSN:2367-7481, p.p. 614-620;
- [10] Yavor Boichev, "Water-soluble principle safety devices for special purpose underwater products", Sixth National Conference with International Participation "Metal Science, Hydro and Aerodynamics, National Security" 2017. 2017, ISSN:1313-8308, p.p. 296-298;
- [11] Nachev A.I., "Techniques and Systems for Information Protection", Sofia, For Letters, O'pismeneh, 2014, ISBN:978-619-185-126-3;
- [12] Nachev A.I., "Approach for modeling the process of scanning sensors management system" Scientific Session 2003, Collection of scientific reports, National Military University "Vasil Levski", Faculty "Artillery, Air Defense and Communications", Part II, Communication Equipment and, , ISBN: 954-9681-02-5, p.p. 116-121;
- [13] Genov B.G., Nikolov N.V., Genov G.B. "Development of ballistic methods for ballistic protection testing", Hemus International Scientific Conference 2006, Proceedings, 2006, ISSN: 1312-2916 (print), p.p. 329-337;
- [14] Borislav G. Genov, "Trends in the Development of Ballistic Testing Methods for Bulletproof Vests - Bullet Resistance", Scientific Conference "Military Technology and Defense Systems MT & S-2011", Proceedings, DI, 2012, ISBN 978-619-90024-1-4, p.p. 381-391.

Analysis of motivation theories of Locke, Galbraith, Bandura and Lancaster and their applicability in the military

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Abstract: *The article discusses some of the process motivational theories, examining their applicability in military organisation. The purpose of the report is to analyse the theories of Locke, Galbraith, Bandura and Lancaster rather than indicate the best approach for motivation. The results of the analysis will contribute to a clearer understanding of military motivation and provide guidance that commanders and chiefs could use to enhance their own motivational style.*

Keywords: MOTIVATION, THEORIES, MILITARY.

1. Introduction

Today, many organisations face the problem of a lack of motivated and skilled labour. According to one of Manpower's latest studies [1], Bulgaria ranks 5th in terms of staff shortages, especially in the fields of economy, business, education, security. The author of the article shares, 'If some time ago the competitiveness of companies was measured by their technological innovation, today the focus is on a new problem – the human factor.' [1]. This requires a study of theories and approaches to motivation in order to use the most effective of them to attract and retain personnel in the armed forces.

Due to the great variety of procedural theories of motivation, we have considered some of them in view of their relevance to the army. This report analyses the procedural theories of motivation of Locke, Galbraith, Bandura and Lancaster, assesses their applicability in military conditions and derives the characteristics of each theory.

In procedural theories, the emphasis is primarily on the mental processes that take place in relation to motivation. Unlike content ones, procedural theories focus on the nature of motivation as a process, that is how behaviour is initiated, directed, maintained, and stopped. From a practical point of view, these theories are often defined as more useful in human resource management because they provide guidance for the use of a wide range of motivational techniques.

According to procedural theories, a person's behaviour is a function of his perceptions and expectations related to a given situation, as well as the possible consequences of the chosen type of behaviour. [2]

2. Procedural theories of motivation of Locke, Galbraith, Bandura and Lancaster

2.1. Locke's goal-setting theory

Published in 1968, Edwin Locke's theory [3] gives us the basis for modern motivation in the workplace. Through it, he links employees' goals, productivity and commitment, showing that they are motivated by clear, well-defined goals and that the challenge of the workplace in reasonable quantities is not superfluous.

The author focuses mainly on setting specific and measurable goals rather than on the results as a whole. With his theory, he demonstrates how a clear goal such as 'increasing sales by 20%' is much more effective than a vague guidance of the type 'improve your performance.' In this way, Locke laid the foundation for modern goal-setting, which is essential for management.

Goals also have a direct impact on work intensity and work behaviour. According to Locke, the strength of motivation is linearly related to the level of difficulty of the goals and the individual commitment to them. The more difficult the goals, the more motivated the employees are. Locke says managers can also use 'impossible' goals to encourage creativity, but employees need

to be reassured that there will be no penalty for not achieving such ambitious goals. If this cannot be achieved, the goals need to be difficult but achievable at the same time. However, the importance of clarity and specificity of objectives must not be forgotten. In addition, it is very important for employees to recognise goals as their own so that they can have a stronger impact on their motivation. For this reason, employees need to participate in the process of formulating goals or to be as close as possible to it. This way they will feel much more empathetic.

Another important issue in the process of achieving goals is feedback. Obtaining accurate, constant and timely feedback on the achieved individual results allows simultaneous control of their implementation and increases the motivation to work.

The goal-setting theory plays an important role in modern management. Today, we increasingly see individualisation at the expense of collectivisation. The individual, the individual personality, comes to the fore at the expense of the team. This leads many organisations to apply the principles of goal management (goal-based management) and to welcome the initiative in individual goal setting and self-determination.

Under the influence of society, this theory is gaining popularity in the military. In the past, the initiative in the army was not very useful, and this trend continues today. But in modern conditions, the classical military approach to management by giving clear and specific orders is beginning to be displaced by management by setting goals and objectives. When defining goals and setting tasks, creative thinking and initiative in subordinates are stimulated. They are motivated to perform their duties, while feeling satisfaction with the achieved collective goals, recognising them as their own.

The use of management through goal setting in the army, of course, does not override the classical approach of giving orders and following instructions exactly. In the absence of time, it is vital to execute the order quickly and accurately, instead of wasting valuable time thinking about how to achieve the goal. In the military, the use of one of these two management approaches is largely determined by the specific level in the hierarchical structure and the time available. The higher the management level (operational and strategic), the command is displaced from the management, and the approach used is by setting goals and objectives. The lower the level (tactical) the management is replaced by the command, and the management approach is by giving clear and specific orders. The dependence between the management levels and approaches is determined by the specifics of the activities performed at the particular levels. At the low levels, they are much more detailed, concrete and specific, while at the high levels they are much more general and integrated.

Given the specifics of targeted motivation, an important aspect is the knowledge of the personal characteristics of subordinates and the ability to set individual goals. In the absence of these abilities, it is appropriate for the commanders and superiors to support this process through personal example, mentoring and implementation of lessons learned in management practice.

2.1. Galbraith's theory of the four motives

A relatively more modern but also more private pragmatic approach to dealing with motivation is that of John Galbraith. [4] He brings out the motivational needs by looking at the individual as workforce. In this sense, at the level of organisation, according to him, there are the following four motives: coercion; financial recompense; identification; adjustment. They can be used individually or in combination as motives for a person's activity. The author calls their joint impact on the individual influence of the system of motives.

Coercion is a negative motive, expressed in the form of a certain punishment for non-compliance with established rules and obligations. Financial recompense leads to compliance with organisational goals by using positive rewards in the form of cash. Identification, on the other hand, is seen as the recognition of organisational goals as one's own, as a result of which they displace personal ones and become more important than them. In adapting, one can serve the organisation not because he identifies its goals as his own interests, but because he hopes to bring them to the service of his own goals. This motive is closely related to the desire for power, but it is given very little recognition in the theory of organisation.

Looking at economic development in historical terms, Galbraith believes that there is a relationship between the economic factor that dominates in the period and the various motives. For example, when it is land, the motive for participation in the economy is coercion, in the domination of capital – financial recompense, and in modern conditions, in the domination of technostucture – identification and adaptation.

The strength of each motive or system of motives needs to be measured according to the degree of connection of the individual with the organisation. In turn, the systems of motives differ significantly depending on what motives are included in them and in what interrelations they are. Some motives collide with each other and neutralise each other, some motives combine poorly, but others significantly reinforce each other, making the organisation effective, achieving its goals in the best way.

According to the author of the theory, the connection between the different motives is important. He considers that coercion is to varying degrees compatible with financial recompense, but is incompatible with identification and adjustment. The following statement is also of great importance for the functioning of modern economy: 'If the element of coercion is significant, then the financial motive is incompatible neither with identification nor with adaptation. If it is insignificant, then the other motives are fully compatible.' [4] This in turn means that the system of motives will be different in poor and rich countries, as well as among poor and rich people. And the quantitative difference eventually turns into a qualitative difference. In a poor country and among low-paid people, the attitude towards work in general is characterised by intolerance and resentment, which in combination with coercion alienates the worker from the employer. In rich countries and among wealthier people, relationships are based on more benevolence, pushing coercion into the background. As a result, alienation is small or absent, and the employee perceives the goals of the organisation.

In his research, Galbraith found that a paradox related to the financial motives arose: 'The higher the level of wages, the lower its value compared to other motives.' [4] He finds the explanation for this not in the diminishing and insignificant value of money, but in the fact that the increase of income in most cases decreases the dependence on the specific job. At the same time, the element of coercion will also decrease, which will lead to identification and adjustment with goals and devaluation of money as a motive.

According to Galbraith, the structure of a modern corporation can be represented as concentric circles depending on the influence that different motives have on the different categories working in

the organisation and its shareholders. In the peripheral circles are the ordinary shareholders, who are influenced only by the financial motive and the maximum dividends and are not in solidarity with the organisational goals. The next circle is the production workers. According to their position in the organisation and the degree of their participation in the management, their motives represent a kind of combination between the financial motive and the identification with the organisational goals. As you approach the center, the next circle is gradually filled by fewer and fewer employees directly involved in production/work (foremen, supervisors, technicians, engineers, workshop/department heads, specialists, etc.) until you reach the center of the circle where the leaders are. As we move from the periphery to the center, the role of identification and adjustment to goals increases, pushing out coercion.

The considered theory is characterised by flexibility and applicability in modern conditions. In the context of military environment, it corresponds to some extent to the military organisational structure. Just as Galbraith suggests using different motives from the periphery to the center, so in the military they could be used from the base to the top of the pyramid at different levels in the military organisation. However, the question arises as to the appropriateness of using coercion as an adequate motive, even at the lowest army levels. In today's professional army, this motive would not be applicable except in emergencies. Rather, the combination of the other three, depending on the position held, can turn them into an effective incentive system that would help increase the overall motivation of servicemen and interest in the military profession.

2.3. Socio-cognitive theory of Albert Bandura

In his social cognitive theory, the psychologist Albert Bandura emphasises that human behaviour is formed and controlled on the basis of environmental influences or internal motives. Socio-cognitive theory explains the functioning of the human psyche as a result of the 'Triad reciprocal determinism.' In this determinism, cognitive, behavioural, personal factors, as well as those related to the environment act as interrelated determinants that interact with each other and in both directions forming motivation and behaviour. [5] The triad is determined by three interrelated determinants – behaviour, personal characteristics and environmental influence (see Fig. 1). Reciprocity neither means that different sources of influence are equally powerful, nor that reciprocal influences occur simultaneously. It takes time for the stimulus to get activated and then for it to activate reciprocal influences. Due to the bilateral impact, people are both products of their environment and its producers.

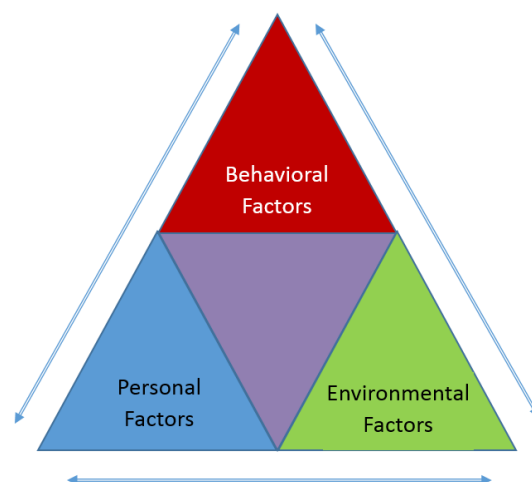


Fig. 1 Bandura's Triad Reciprocal Determinism

In socio-cognitive theory, the self-regulation of motivation and achievement in performance is managed by several mechanisms that act together. One of the mechanisms playing a central role in this regulatory process works through people's beliefs in their own

self-efficacy. [6] Self-efficacy refers to people's beliefs in their abilities that they can mobilise the motivation, cognitive resources, and ways of acting needed to control events in their lives. There is a difference between having skills and using skills well in difficult circumstances. To be successful, one must not only have the necessary skills, but also be confident in their ability to exercise control over events in order to achieve the desired goals. Therefore, capable people may perform poorly, moderately, or exceptionally, depending on their beliefs in self-efficacy, which may increase or worsen their motivation to solve problems. The author believes that 'Whatever other factors serve as motivators, they are rooted in the basic belief that one has the power to produce change through his actions.'

According to Badnura, one can strengthen faith in self-efficacy in four main ways: positive experience, observation, persuasion, and physical strength. [5]

The best way to develop a strong sense of effectiveness is through positive experience. Success at work strengthens confidence in one's abilities, while failures raise doubts about self-confidence. However, when people have only easy successes, they expect quick results and in case of failure, they are easily discouraged. In order to gain a lasting sense of efficacy, one needs to constantly gain experience in overcoming difficulties.

Modeling through observation is the second way to strengthen self-confidence. This way influences the human belief in self-efficacy through a model of social comparison. People often judge their abilities by comparing them to others. Observing success based on hard work increases faith in one's own abilities, while observing failures, despite great efforts, reduces self-confidence.

Social persuasion is a third way to increase a person's confidence. If he is encouraged, he will probably put more effort into success than if he doubts himself. However, if his idea of self-efficacy rises unrealistically, he risks failing, which will lower his perception of his own effectiveness. In order to increase a person's faith in his abilities, it is appropriate to initially set him such tasks and goals that will lead to success. Setting more difficult tasks should be done only after gaining enough experience through self-perfection.

The fourth way to change a person's self-confidence is by improving his physical condition. One often evaluates one's abilities by relying on someone's judgment of his physical condition. In cases when he is tense, agitated or exhausted, he loses confidence in his own abilities. For this reason, it is necessary to improve the person's general physical condition, which in turn will reduce stress levels, feelings of incapacity and increase self-confidence.

Refracted through the prism of military environment, the social-cognitive theory is a serious challenge not only to commanders but also to subordinates. Despite the growing popularity of this theory in the scientific community, there is still insufficient data on the results of its practical applicability. This requires its careful use in practice compared to the theories discussed so far. The options proposed by the theory for increasing self-efficacy are largely applicable to the military. Some of them, such as mentoring, persuasion and physical training, are still used today. The most effective way to increase self-confidence – gaining positive experience – is also an interesting approach, but given the importance of tasks and the cost of failure, it is difficult to apply in a real environment. However, it can be successfully implemented in training and preparation while using the experience already gained in the system 'Lessons learned'.

2.4. A theory based on generational differences

The theory was developed by Lynn Lancaster in collaboration with David Stillman. The author of the theory conducted a number of studies examining generational differences and became popular with her book 'The Clash of Generations' [8]. The concept described in her work is based on the understanding that each

generation has its own characteristics that, used properly, can increase the efficiency of the organisation. Used improperly, these differences would lead to reduced income, staff turnover, career failures, customer rejection, wasted human resources, and health problems caused by stress.

Lancaster examines four main generational groups:

- Traditionalists (builders) – born in the period 1920-1945;
- Baby-boomers – 1946-1964;
- Generation 'X' – 1965-1980;
- Generation 'Y' (new millennium) – 1980-1995.

The author's research draws attention to the growing importance for proper management and motivation of employees from different generations working in one place. The analysed results of the research of the generations show that '... the differences between the generations can strengthen and not harm the organisations' and '... that the companies that learn to take advantage of the weaknesses of the generations, and not just manage or support them, are likely to be the desired employers in the future, able to attract and retain skilled workers.' [8] In other words, successful organisations will be those that are able to realise, understand and use the strengths of all generations, as well as their perceptions of immediate and future needs. For this reason, it is vital for managers to understand the value system of each generation and to discover their individual differences if they want to create and maintain work atmosphere that encourages and motivates.

Other proponents of the theory of generational differences also offer similar approaches to the study and application of generational determinism. Mark McCrindle believes that 'The key to business success is to understand human traits, change in attitudes, social trends and the thinking of ever-changing customers and employees.' Although McCrindle generally accepted Lancaster's ideas, in contrast he developed the theory by adding two more generations:

- Generation 'Z' – those born in the period 1995-2009;
- Generation 'Alpha' – those born after 2010.

He draws attention to the younger generations (especially the 'Y' and 'Z'), arguing that in order to attract and retain younger workers in their busy lives, companies and enterprises need to be aware and adapt to the changing needs of the workforce. [9] Employers need to use creative approaches to attract young workers, to advertise and interview to show how they will meet their needs.

McCrindle's example with the Australian Armed Forces is indicative of the strength of a quality advertising campaign. Following the onset of one of the largest recruitment crises, the Australian Army launches a new advertising campaign aimed at Generation Y. Instead of the old approaches, the campaign uses various new technologies and social media such as Facebook, videos uploaded to YouTube and online gaming sites simulating military action to recruit potential candidates. They attract young people by promising them opportunities beyond pay, with the motto 'you get paid to stay in shape', 'sports entertainment', 'great food – eat like you've never eaten before' and 'see Australia and the world' [9]. In contrast, the Generation X campaign in the early 1980s read, 'You'll be wet, you'll be nostalgic and scared – but you'll be the pride of the Navy.'

This example aptly embodies the skillful use of different approaches, according to the needs of different generations. To attract and retain new generations, employers and managers must keep their promises and respond to their changing needs. Research on different generations reflects that people's needs in the workplace are changing. Increasingly, when looking for a job, the balance between work and life, workplace culture, various work activities, management style and training come to the fore.

The application of the theory of generational differences has invariably become increasingly important not only in civilian life but also in military circles. Given the growing shortage of troops in recent years, Lancaster's theory is quite adequate in the military. It corresponds to the growing age difference between the military, due to the increasing length of military service and the retirement age in the army. Therefore, it is necessary to research, analyse and know the needs of servicemen of different generations. This will, on the one hand, improve the working climate in the organisation with a large age range, and on the other hand, it will help increase the interest in the military profession and attract and retain personnel.

3. Conclusion

Locke's theory provides the basis for modern work motivation, emphasising the challenges of the workplace by setting clear and measurable goals. This makes it applicable in an army environment, stimulating creative thinking and initiative, which lead to the satisfaction of subordinates with the achieved goals.

Galbraith presents a relatively more modern, but also more private pragmatic approach to the consideration of work motivation. He examines the system of four motives in the work environment and deduces the relationship between them, differentiating the motivating impact of each depending on the position. This makes the theory applicable to some extent in military conditions, giving guidelines for building an effective system of incentives that helps to increase the overall motivation of servicemen.

Bandura's social-cognitive theory considers human behaviour, personal characteristics and the environment as interrelated determinants that form motivation. A key point in the theory is the self-regulation of motivation, carried out mainly through the perception of self-efficacy. Bandura's tools for increasing self-efficacy are still being used in the military, making his theory applicable in a military environment.

In today's age-inhomogeneous work environment, the theory of generational differences is becoming extremely relevant. The challenges faced by modern managers in any environment impose on them the need to know the characteristics and needs of employees of different generations. Knowing and applying this knowledge will help to attract and retain a skilled workforce and create a work atmosphere that is encouraging and motivating.

4. References

1. България е на 5-то място по недостиг на работна ръка в света, Редактор: Николай Киров, [economic.bg https://www.pariteni.bg/novini/osigurjavane/bylgarija-e-na-5-to-mjasto-po-nedostig-na-rabotna-ryka-v-sveta--217363](https://www.pariteni.bg/novini/osigurjavane/bylgarija-e-na-5-to-mjasto-po-nedostig-na-rabotna-ryka-v-sveta--217363) (Последно посетен на 16.12.2019 - 16.40)// България е на 5-то място по недостиг на работна ръка в света, Редактор: Nikolaj Kirilov, [economic.bg https://www.pariteni.bg/novini/osigurjavane/bylgarija-e-na-5-to-mjasto-po-nedostig-na-rabotna-ryka-v-sveta--217363](https://www.pariteni.bg/novini/osigurjavane/bylgarija-e-na-5-to-mjasto-po-nedostig-na-rabotna-ryka-v-sveta--217363) (Last visited 16.12.2019 - 16.40)//
2. Василев, В., Ефремовски, И., 'Организационна култура и мотивация на персонала – теоретични основи и добри практики', Пропелер, 2017, С., с. 216 – 222//Vasilev, V., Efremovski, I., Organizatsionna kultura I motivatsiq na personala – teoretichni osnovi I dobri praktiki, Propeler, 2017, S, p. 216 – 222.
3. Locke, E., 'Toward a theory of task motivation and incentives', Organisational Behaviour and Human Performance, 1968
4. Galbraith, J., 'The new Industrial State', Princeton university Press, First Princeton Edition with a new foreword by J. Galbraith, USA, 2007, pp. 162-199
5. Wood, R., Bandura. A., 'Social Cognitive Theory of Organisational Management', The Academy of Management Review, Vol. 14, No. 3 (Jul., 1989), pp. 361-384.
6. Bandura, A. 'Social cognitive theory of personality. In L. A. Pervin & O. P. John (Eds.)', Handbook of personality: Theory and research (2nd ed., pp. 154-196). New York: The Guilford Press, 1999
7. Bandura, A., 'Social cognitive theory: An agentic perspective', Asian journal of Social Psychology, Blackwell Publishers Ltd. 1999, p; 28
8. Lancaster, L., Stillman, D. 'When generations collide: Who they are. Why they clash. How to solve the generational puzzle at work'. New York, NY: Harper Collins. 2002.
9. McCrindle, M. 'The ABC of X, Y, Z – Understanding the Global Generations', UNSW PRESS, 2009, pp. 143 – 176.

Stress symptoms under extreme circumstances in latvian national guard personnel with different personality supertraits

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Abstract. In European countries, existing security issues are highly connected to the current global situation. Along with the professional military personnel ensuring national security, in Latvia this task is also performed by the Latvian National Guard (LNG) personnel, a part of the National Armed Forces. A number of documents of the Ministry of Defence of the Republic of Latvia indicate that national security depends on the combat effectiveness of the armed forces directly related to the level of professional training of personnel, including LNG. Previous studies demonstrate that professional competence of military staff is associated, inter alia, to stress resilience shaped by a certain combinations of personality traits. Stress resilience makes it possible to successfully carry out combat missions with less damage to psychological and physical wellbeing of a member of armed forces. Current paper focuses on the empirical study investigating possible differences in stress symptoms in groups of LNG personnel with different personality supertraits under extreme circumstances involving military exercises. The obtained results revealed differences in stress symptoms, thus, allowing to identify predispositions to pathological stress reactions under extreme situations and to develop new psychological training methods.

KEYWORDS: EXTREME SITUATION, BATTLE STRESS, STRESS RESILIENCE, STRESS SYMPTOMS, SUPERTRAITS, LATVIAN NATIONAL GUARD.

1.Introduction

The COVID-19 pandemic in the EU countries lead to a significant strengthening of security measures, which is guaranteed by certain actions of military personnel, including the Latvian National Guard (LNG), a part of the Latvian National Armed Forces. The LNG is a voluntary paramilitary public formation, in which volunteers (national guards) serve, performing their duties in their free from main work time. Along with the permanent military personnel, the national guards ensure the state territory protection, safeguard security and public order, and participate in NATO exercises as part of battle groups. National guards systematically improve skills and knowledge necessary for military operations, can be involved in operations both during immediate emergency situations as well as in processes eliminating the emergency consequences. These tasks require a strong ability to withstand increased physical and psychological stress. Currently, the LNG personnel is involved in the COVID-19 spread elimination in Latvia: as a part of the declared emergency situation response the national guard helps to strengthen the board control and participate in city patrols.

2. Theoretical Foundation

A number of authors note that military service is always stressful [1,2] and require such abilities as prompt response to changing conditions during a military conflict, quick mobilization and adjusting one's mental state while counteracting stress [3,4], as well as certain personality factors. The authors [5] indicate that during combat missions a high level of stress resilience is significantly more important than other personality traits. Nevertheless, in peacetime, military service is also connected to severe stress: previous data confirm that even during military exercises military personnel are subject to significant stress [6]. These data are of considerable importance due to the specific conditions of the LNG personnel military service. During military exercises national guards are away from their families and regular lives and have to function in accordance with the strict principles and disciplines. Despite the fact that stressful situations faced by the LNG personnel are mostly short-term, the impact can be more intense compared to regular military.

The military personnel, including the LNG, are exposed to such military-related stressful factors as strict subordination within a highly hierarchical system, obedience to orders without discussion, high physical demands, lack of time for decision-making, uncertainty of the situation, difficult environments, long lasting compelled contact with same-sex colleagues, lack of confidentiality, conflicts [7]. There are three types of response forms to stressful situations, which also serve as an indicator of a military personnel stress resilience, affecting the success of the missions [8]:

- Impulsive type of maladaptive behaviour (rapid loss of control over organized behaviour and desired actions, loss of acquired skills, repeated motor reactions);
- Inhibitory type of maladaptive behaviour (deceleration of action and movement up to a stupor, violation of information reception and handling processes, disturbances in signal perception, impeded decision making);
- Adaptive behaviour (clear perception, full situation awareness, self-control, appropriate actions).

These types of stress responses can be associated with personality traits combination [9, 10]. As indicated [11], the intensity, duration and strength of the reaction is subjective by nature and depends on personality traits, being also a stress resilience indicator. Literature suggest that intensive stress combined with low stress resilience can cause disappointment in military service as such. Among the LNG personnel, in our opinion, it can lead to reluctance to extend the service contract, especially among recruits. Studies [11] revealed that due to low stress resilience a significant number of recruits develop psychosomatic and emotional disorders already during the first year of military service.

It should be noted that stress resilience can be described in frameworks of various theoretical approaches and there is no single universally accepted concept. As indicated in [12], current research pay little attention to the role of biological factors in the functioning of stress resilience, there is also a lack of studies on individual typological characteristics affecting stress reactions. The authors indicate that the concept is considered either as a result of an integral influence of psychological characteristics on behaviour in the context of stressful situations, or as a response to adverse conditions. An integrative approach describes stress resilience as an emotional and mental response of a various intensity shaped by perception of a stressful situation [11]. A number of authors describe stress resilience among military personnel as an ability to successfully adapt to a situation of combat missions with the least possible losses to their psychological and physical condition [5].

According to a modern transactional analysis model [13], stress resilience among military personnel is strengthened by cognitive assessment of a stressful situation and an understanding of one's ability to overcome stress. Positive psychology [14, 15] also contributed to understanding of stress resilience highlighting positive emotions, positive individual traits and positive organizational environment as stress resilience strengthening sources. Theoretical principles of transactional model and positive psychology, as well as stress resilience factors identified in empirical studies contributed to military personnel stress resilience training program development [14].

In general, the literature analysis demonstrate that the largest number of studies is focused on understanding factors affecting the stress resilience among military personnel, as well as long- and short-lasting effects of stress on their health and psychological

wellbeing in order to create training programs. In Latvia, to the authors knowledge, no such studies have been carried out among LNG personnel.

The typological personality model [9] allows to explain the behaviour in stressful situations and associated tendencies to pathological reactions based on the neurophysiological analysis. Within the framework of the existing approach, it is possible to predict soldiers' agitation level in extreme situations, as well as strength and duration of their reactions to a stimulus in combat conditions, during training and after the stressful situation is over. The author [9] noted that individual differences in autonomic nervous system response and the speed and stability of conditioned reactions are correlated with indicators of neuroticism/emotional stability and extraversion/introversion. It was revealed that the sensory threshold in extroverts is higher than in introverts, therefore the latter are less sensitive to sensory stimulations. Neuroticism is associated with the lability of autonomic nervous system, the imbalance of neuropsychic processes, emotional instability, anxiety and slowness. Under stress, high neuroticism results in psychosomatic symptoms and slow recovery after the danger disappears. Neurotic symptoms are described as a conditioned reflex [9, 16]; whilst, the associated behaviour as the avoidance of a conditioned reflex stimulus (danger signal) arising under certain conditions. According to the transactional stress model [17], individuals with a high level of neuroticism demonstrate a distorted assessment of their own resources, which leads to an underestimation of the threat, while emotionally stable individuals perceive these situations as a challenge and seek to overcome them. This has been confirmed by a revealed negative correlation between stress resilience and the level of neuroticism [18]. Studies [19] revealed that in situations of stress, military personnel demonstrate an increase in such neuroticism components as hypochondria, depression, hysteria, as well as increased anxiety along with decreased emotional stability. The study [20] also revealed that soldiers with pronounced neuroticism are poorly engaged in the military environment.

Thus, based on the analysis of available theoretical and empirical studies, it can be concluded that, besides programs for selecting candidates for service in individual units, there are only few studies on typological features of military personnel. It can be assumed that this is due to the opinion of most researchers that orientation toward individual differences will interfere with the development of training programs for military personnel. However, it can also be assumed that stress resilience is a result of combining biologically determined and acquired personal qualities. Therefore, to ensure military personnel optimal functioning under stressful conditions it is important to consider individual differences shaping stress response and resilience.

The study is based on the theoretical principles of the integrative approach to stress resilience research [11] and the typological personality theory [9, 16].

The study aims to identify differences in stress resilience among the LNG personnel with different personality traits. It was hypothesised that there are differences in stress resilience among extroverted and introverted personnel and there are differences in stress resilience among national guards with emotional stability and neuroticism.

Research questions:

- Whether there is a difference in the levels of stress resilience indicators among national guards with emotional stability and neuroticism?
- Whether there is a difference in the levels of stress resilience indicators among extraverted and introverted national guards?

3. Method

The study involved 104 male the LNG soldiers aged 19 to 39 ($M = 25.7$, $SD = 5.36$, $Mdn = 24$) with a length of service between 1 and 16 years ($M = 4.48$, $SD = 3.74$, $Mdn = 3$). Participation in this research was voluntary. The study was conducted immediately after the end of military exercises. The age distribution of participants does not correspond to the normal distribution: skewness .88 ($SES = .24$). The distribution of the length of service does not correspond

to the normal distribution: skewness 1.40 ($SES = .24$) and kurtosis 1.54 ($SEK = .47$). The research sample is non-probability, purposive. The sample size is sufficient to obtain reliable results. The study was conducted in Latvian language.

Study methods:

- Volkov and Vodopyanova *Well-being in Extreme Conditions* symptomatic questionnaire [11]. The questionnaire aims to determine the level of stress resilience, as well as a predisposition to pathological stress reactions and neurotic disorders under military service conditions, by evaluating the following symptoms: Depletion of psycho-energetic resources (decreased mental and physical activity) - DR; Violation of volitional regulation - VVR; Emotional instability - EI; Vegetative instability - VI; Sleep disturbances - SD; Anxieties and fears - AF; Deadaptation - DA. The reliability analysis ($\alpha = .85$) demonstrated a high internal consistency of the questionnaire and its suitability for implementing in the study.
- *Eysenck Personality Inventory* (EPI; Eysenck, 1963), in Reņģe's adaptation [21]. The inventory aims to identify such personality supertraits as extraversion-introversion and neuroticism-emotional stability. A sincerity scale allows to reveal the attitude to the examination and the reliability of the results. Only reliable results were included in the sample.

4. Results and Discussion

The obtained data processing was carried out using SPSS 22 software. The choice of statistical procedures corresponds to the study objective. The distribution of the obtained quantitative data did not correspond to the normal distribution, thus, the non-parametric Mann-Whitney *U*-test was implemented to compare differences between groups. The Mann-Whitney *U*-test assumes that the variables are measured at least in an ordinal scale (ranked). The assumption has been met in the current study.

The study revealed statistically significant differences in the level of stress resilience and stress symptoms in groups of extroverts and introverts (Table 1). According to the obtained data, extroverts demonstrate higher scores across all stress reaction components: Depletion of psycho-energetic resources, ($U = 824.5$, $p = .012$); Violations of volitional regulation ($U = 783$, $p = .006$); Emotional instability ($U = 753$, $p = .003$); Vegetative instability ($U = 700$, $p < .001$); Sleep disturbances ($U = 642$, $p < .001$); Anxiety and fears ($U = 753$, $p = .003$); Deadaptation ($U = 855$, $p = .023$); overall stress resistance score (SR: $U = 735$, $p = .002$). The results suggest that the level of stress resilience in extroverts is lower compared to introverts in the studied sample (the higher the score, the lower the stress resilience).

Table 1. Differences between groups of extraverted and introverted the LNG soldiers^a

	DR	VVR	EI	VI	SD	FA	DA	SR
Mann-Whitney U	824.5	783	753.5	700	642	753	855	735
Wilcoxon W	3380	3339	3309	3256	3198	3309	3411	3291
Z	-2.50	-2.76	-3.02	-3.74	-3.89	-3.00	-2.27	-3.05
Asymp. Sig. (2-tailed)	.012	.006	.003	.000	.000	.003	.023	.002

a. Grouping Variable: Extraverts/Introverts

The study also revealed statistically significant differences in the level of stress resilience and stress symptoms across all stress reaction components in groups of emotionally stable individuals and individuals with revealed neuroticism (Table 2): Depletion of psychoenergetic resources ($U = 190$, $p < .001$); Violations of volitional regulation ($U = 110$, $p < .001$); Emotional instability ($U = 149$, $p < .001$); Vegetative instability ($U = 204$, $p < .001$); Sleep disturbances ($U = 119$, $p < .001$); Anxiety and fears ($U = 137$, $p < .001$); Deadaptation ($U = 147$, $p < .001$); overall stress resistance score (SR: $U = 80$, $p < .001$). Thus, the demonstrated level of stress resilience among individuals with revealed neuroticism is lower compared to emotionally stable personnel of the studied sample (the higher the score, the lower the stress resilience).

Table 2. Differences between groups of emotionally stable individuals and individuals with revealed neuroticism^a

	DR	VVR	EI	VI	SD	FA	DA	SR
Mann-Whitney U	190	110	149	204	119	137	147	80
Wilcoxon W	3511	3431	3470	3525	3440	3458	3468	3401
Z	-5.99	-6.55	-6.33	-6.46	-6.70	-6.40	-6.32	-6.70
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000

a. Grouping Variable: Emotionally stable/Neuroticism

Thus, the results of the study have confirmed the hypothesis that there are differences in stress resilience between extroverted and introverted the LNG soldiers. Extroverts demonstrated a lower stress resilience level compared to introverts, which is consistent with the descriptions of their behaviour [9, 16]. In a stressful situation, extraverts will actively perform, bring themselves to a state of alert without delay, however, in absence of certain skills can take unreasonably risks, promptly run out of energy. It is essential for extraverts to be able to relax and learn how to restore own resources. Introverts, on the opposite, can experience stress when it is necessary to actively act under a shortage of time for thinking. However, with appropriate skills, they are able to quickly relieve this sense of tension, distribute the load, activate the stamina and tenacity, while quickly concentrating on the task.

The hypothesis that there are differences in stress resilience between emotionally stable and neurotic the LNG soldiers has also been confirmed. The obtained results are consistent with the previous research [17, 18, 19]. The level of stress resilience in the emotionally stable soldiers is higher than in those with neuroticism. Neuroticism in stressful situations can be expressed as extreme nervousness, emotional instability, poor adaptation, a proneness to quick mood change (lability), anxiety, depressive reactions, distracted attention, instability, which limits the effectiveness of military activities. Emotionally stable individuals are more self-confident, believe they have sufficient internal resources.

The quantitative data analysis allows to confirm positive answers to the research questions, which is consistent with previous research results [11]. Introverted and emotionally stable the LNG soldiers demonstrate lower levels of psychoenergetic resources depletion, violation of volitional regulation, sleep disturbance, deadadaptation, they are also less anxious, demonstrate better emotional and vegetative stability compared to the extraverted LNG personnel with revealed neuroticism. Individuals demonstrating low levels of these components are able to control emotions, can mobilize for active service, regulate own behaviour, overcome stress, cope with prolonged and significant pressure [22]. Previous studies indicate that military personnel with a high anxiety level have limited options for adequate response under pressure, not able to analyse own mistakes and look for options and ways to eliminate errors, which can result in a loss of interest in military service [23]. Moreover, violation of volitional regulation can lead to a decrease in volitional activity, for instance, decrease in willingness to continue military exercises or respect the disciplinary regulations [24].

4. Conclusions

- The study hypotheses have been confirmed and positive answers to research questions received.
- The obtained data revealed that the level of stress resilience among extroverted the LNG soldiers is lower compared to introverts.
- The level of stress resilience among the LNG soldiers with neurotic traits is lower compared to emotionally stable individuals.
- The obtained results suggest that to increase the military service training effectiveness it is important to consider the typological characteristics of personnel.
- Further research involving a larger sample size is needed to further explore the stress resilience among military personnel with different personality supertraits.

5. References

- [1] Sinclair, R.R.& Tucker J.S. (2006). Stress-CARE: An Integrated Model of Individual Differences in Soldier Performance Under Stress. In: Military Life, C.A. Castro, T. Britt & A.B. Adler, Editors. Greenwood Publishing Group: Santa Barbara, CA.
- [2] Pflanz, S., & Sonnek, S. (2006). Work stress in the military prevalence, causes and relationship to emotional health. In: Military Medicine. 167 (11), 877-882.
- [3] Naglic, M. (2008). Effectiveness of psychological selection methods of candidates to the officer school of the Slovenian Armed Forces, Paper presented at the 44th International Applied Military Psychology symposium, Saint Petersburg, September.
- [4] NBS Psihologu dienesta Militārā psihologa rokasgrāmata. Retrieved from http://www.mil.lv/~media/NBS/Vienibas/MVP/psihologi/Militara_psihologa_ROKASGRAMATA/
- [5] Meredith L., Sherbourne S., Gaillot, S., Hansell, M., Parker A., Wrenn, L. & Ritchad, H. (2011).. Promoting psychological resilience in the U.S, Military. Santa Monica, CA: RAND Corporation
- [6] Корчемный, П. А. (2008). Военная психология: методология, теория, практика М.: Воениздат, 280.
- [7] Козлова И. Н. (2012). Стрессогенность срочной службы в современной российской армии для военнослужащих по призыву. В: Психология: традиции и инновации: материалы междунар. науч. конф. Уфа, 92-102.
- [8] Сидоров П., Мосягин И., Марунык С. (2008). Психология катастроф. М.: «Аспект Пресс», 77.
- [9] Eysenck, H. (1982). Personality, genetics, and behavior. N.Y.: Praeger, 330.
- [10] Гуренкова Т.Н., Елисеева И.Н. и Кузнецова Т.Ю. (2009). Психология экстремальных ситуаций. М.: «Смысл», «Академия». 42-49.
- [11] Водопьянова, Н. Е. (2009). Психодиагностика стресса. СПб.: «Питер», 27-33.
- [12] Luthar, S., Cicchetti, D. & Becker, B. (2017). The Construct of Resilience: A Critical Evaluation and Guidelines for Future Work. In: Journal "Child Development", May/June 2017, Volume 71, Number 3, 543– 562.
- [13] Lazarus, R. (1993). Psychological Stress and Coping Process. New York: Free Press.
- [14] Meredith, L., Sherbourne, C., Gaillot, S., Hansell, L., Ritschard, H., Parker, A. & Wrenn, G. (2011). Promoting Psychological Resilience in the U.S. Military. In: Center for Military Health Policy Research, 186. Retrieved from https://www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG996.pdf
- [15] Seligman, M. & Csikszentmihalyi, M. (2000). Positive psychology: An introduction. In: American Psychologist, Vol 55(1), 5-14.
- [16] Eysenck, H. J., & Eysenck, S. B. (1969). Personality structure and measurement. London: Routledge & Kegan Paul.
- [17] Лазарус, Р.С.(1989). Индивидуальная чувствительность и устойчивость к психологическому стрессу. Психологические факторы на работе и охрана здоровья. М.-Женева, 121–126.
- [18] Боковиков, А. М. (1994). Определение модуля контроля за деятельностью и его роль в формировании и преодолении напряженности. Методики диагностики психических состояний и анализа деятельности человека. М.: Изд-во «Институт психологии РАН», 49-61.
- [19] Анцупов, А. Я., Белов, В. Г., Васильков, А. М., Благинин, А. А., Жильцов, В. А. и Маклаков А. Г. (2004). Психология и педагогика. Военная психология. Учебник для вузов. СПб.: «Питер». 463.
- [20] Mount, M. & Barrick, M. (1995). Rediscovering Personality at Work. Tippie College of Business University of Iowa.
- [21] Renģe, V. (2003). Organizāciju psiholoģija. Rīga: «Kamienes».
- [22] Куликов Л. В. (2000). Стресс и стрессоустойчивость личности. В: Теоретические и прикладные вопросы психологии. Вып. 1. СПб., 174.
- [23] Станкин М. (2008). Эффект бумеранга или как укреплять психологическую устойчивость в экстремальных ситуациях. Журнал Служба кадров и персонал. № 12, 49 - 53.
- [24] Шкуренок Д.А. (2002). Общая и медицинская психология. Учебное пособие. Ростов-на-Дону: «Феникс», 352.

Application of restraint devices as a method of protecting the personal safety of the police officers

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Abstract: *The existence of special police authorizations justifies the legal goal of applying restraint devices. Considering its function, the application of restraint devices must be an exception, not a rule and that's the reason why it should be applied only when there are no other methods of solving a conflict between the police and citizens. When applying restraint devices, special attention should be put on the safety of the police officers. Taking into consideration all potential and unseen threats that may arise, it is crucial to provide high quality preconditions for the legal proceedings. As a result of that, this paper analyses and elaborates in detail the tactical model during the direct application of the restraint devices - "handcuffs". The application of this model includes performing several tactical and security activities that would minimize the security risks among the police but in the meantime will not put into danger the dignity of the person being handcuffed.*

Keywords: POLICE AUTHORIZATIONS, RESTRAINT DEVICES, TACTICAL PROCEDURES, SECURITY ASSESSMENT, SECURITY TRIANGLE

1. Introduction

Handcuffing, as a coercion method used by the police to restrict the movement of a person is applied by the use of two types of devices: formative and manual [1]. Formative devices include handcuffs and plastic straps, while manual devices can include different items such as a strap, adhesive tape, scarf, rope, clothing, chain, etc. In all cases, where the conditions for handcuffing a person are met, the formative devices (metal handcuffs have an advantage) must be used, and while the manual devices are used only in those situations when a sufficient amount of metal or plastic handcuffs is not available.

Determining the conditions under which the police use coercion methods usually happens when a person is detained, deprived of liberty, or executed. This means that the police have a legitimate right to use methods of coercion in the following cases: to prevent a resistance by a person or to prevent an attack to a police officer, to prevent a person from escaping and to prevent self-harm or injury [2]. Knowledge of the legal grounds regarding the use of restraint devices is a good prerequisite for high quality and effective implementation of the legal duties, but this condition alone is not sufficient if other conditions are not provided for safe and smooth implementation of the entire restraining procedure.

2. Tactical model of policing during the implementation of restraint devices

The legal obligation to use restraint devices requires that the police implements suitable tactical manners of conducting the procedure that is in full compliance with the prescribed safety procedures [3]. If the use of restraint devices is known to be a very dynamic and complex process, then the police must not allow the consequences of inadequate and inappropriate actions to occur. The main goal, during the application of restraint devices, is ensuring personal and the safety of other individuals, because in this way it directly reduces or avoids the danger of unwanted bodily injuries among both parties [4].

When the handcuffing is carried out, it must be performed in a fast and energetic manner and not to allow any reactions from the persons being detained (attempt to escape, attack on police officers or other personal, self-harm). If it happens that the persons manifest any of these illegal actions, then it is necessary to use other methods of coercion to prevent such behavior and not to allow further escalation of the situation [5]. In the process of finding a solution for the proper use of the restraint devices, the tactical procedure through which the essential requirements of the police will be met implies the consistent fulfillment of a number of tactical-security activities that will enable the normal course of the legal procedure [6, 7].

When initiating the handcuffing procedure, the first step is to make a personal safety assessment. The initial security assessment of the situation is an important part of the tactical procedure, as it includes all relevant data on individuals and influences the decision-making process of police officers in the process of restraining. When assessing the safety of the individuals, specific information about body constitution and appearance, physical abilities, skills, emotional and mental state, mood, age, etc. are collected. The quality perception of police officers for the different characteristics of a person is an important prerequisite for further police action, because it largely determines the order of use of appropriate tactical methods. When it comes to making a security assessment of people, there are three different categories of behaviors [8]: people who cooperate completely, people who do not potentially cooperate, and people who do not cooperate at all.

The first category includes persons who actively and voluntarily cooperate and do not oppose the given orders and requests from the police officers for handcuffing. If resistance occurs among these individuals, it is usually verbal and is expressed through various voice complaints, repetition of questions, and so on. People who do not potentially cooperate in the initial part of the procedure, there is not manifest visible verbal or physical resistance, but they manifest number of physical signs such as rubbing the hands, spreading the pupils, tightening the facial muscles, stiff posture, through which signals are intentionally or unintentionally sent for their further conduct. In such circumstances, the police officers are involved in a continuous monitoring and preparation for an appropriate response depending on the resistance that may arise at any point in the restraining or handcuffing procedure. The category of people who do not cooperate completely are people who show behavior that aims to physically impede the attempt of police officers to use restraining devices. In such complex communication circumstances, the police officers are forced to use additional means of coercion (physical force, rubber truncheon) to overcome resistance and establish physical control over those who are to be detained.

After conducting the security assessment of the individuals that should be detained, the next step is to bring the persons to an appropriate handcuffing position. The choice of the position in which the handcuffing will take place should be in accordance with the behavior of the persons, in order to timely prevent an attempt to escape, to overcome resistance, to repel an attack and to prevent self-harm. Depending on the behavior of the individuals, the handcuffing is performed in a standing, kneeling or lying position [9]. Among cooperative individuals, the handcuffing procedure is usually performed in a standing position, while among less cooperative individuals, the handcuffing is always carried out in kneeling or lying position.

The tactical procedure of bringing individuals into a handcuffing position begins with indicating the reasons and the legal obligation to use of the restraint devices. During the official

address of the police officers, voluntary consent is required for placing handcuffs, which especially emphasizes the need for full cooperation during the procedure. If successful, the police officers, by giving simple verbal guidance and instructions, bring the persons to the desired position (Fig. 1).



Fig. 1 Taking position for handcuffing.

After bringing the persons in a handcuffing position, the next step in carrying out the tactical procedure and to bind the persons. In order to gain an advantage and control over those who are being arrested, police officers need to take the following tactical actions into consideration [4, 6]:

- to perform adequate tactical and secure spatial positioning;
- to take a preparatory position for taking out the handcuffs;
- to hold the handcuffs in a proper manner;
- to choose the appropriate way of approaching the individual being detained;
- to establish strong physical contact with the individual;
- to maintain the correct position of the handcuffs when using them.

Proper tactical and security positioning in space means that police officers should always stay at a safe distance, i.e. at a minimum distance of three to five steps from the person to be detained. This distance is a "remote security zone" because police officers can protect themselves or avoid possible counter-attack by the individual. Once the preparation position is established, they proceed with removing the handcuffs from the holster. The handcuffs are usually held with the dominant hand in the area that connects the two steel rings in the direction of the rings in order to allow a quick reaction in case of a sudden attack. The position of the forearms and elbows should be close to the body, because in a case of an attack they will be able to more easily protect the head and upper body. Before approaching and making physical contact with the person that should be arrested, the police officers are placed at an angle of 45 degrees and thus form a "security triangle" (Fig. 2).



Fig. 2 Forming a "security triangle" during handcuffing.

At the moment when physical contact with the person that should be detained is established, the positioning of the police officers depends on the position of the person and on the manner in which they behave. Control over those who cooperate, regardless of their position, is achieved by taking a stable position and by covering (fixing) the hand in the part of the wrist around the palm. This tactical way of proceeding, implemented by the police officers, provides an advantage and additional protection if there is a reaction from those who are arrested.

Once the necessary conditions for establishing physical control over the person have been provided, police officers proceed with putting the handcuffs around the wrists of the person. The handcuffs are placed in such a way that the moving part of the bracelet approaches to the wrist of the nearest and then the farthest hand,

and is pressed until it closes and enters the grooves of the fixed part of the bracelet. When placing the handcuffs, police officers should be careful not to over-tighten the handcuffs, as normal blood circulation and damage to the skin and soft tissues of the wrists may occur. To prevent this from happening, an additional check is always made of the tightness of the handcuffs and, if necessary, they are loosened. In addition, double locking of the handcuffs is performed with the help of a locking fuse in order to prevent abuse by persons who may intentionally cause the handcuffs to tighten (Fig. 3).



Fig. 3 Putting, checking and handcuffs double locking.

After the handcuffing procedure is completed, prevention search is continued. The manner of the search largely depends on the situation and the circumstances under which the connection is made, as well as on the very situation in which the persons find themselves. It is common practice to conduct the search in the same position in which the handcuffing took place, but if necessary (visible verbal or physical resistance is manifested) the individuals can be brought to another less risky position (from standing to lying down, and from kneeling to lying position).

At the moment when the search begins, it is necessary to provide all the conditions for safe and uninterrupted conduct of the entire search procedure and not to allow any possibility of any reaction by the person being searched. To achieve this, certain rules must be observed when searching [10]:

- never step in front of people during the search;
- systematically divide the body parts vertically and horizontally;
- not to proceed to the other side of the body of the person, until one half of the body has been searched in detail;
- to practice a search by touching with the back of the palm;
- always maintain physical control over the person by holding the handcuffs or using a lever on the palm;
- when performing the search, pay special attention to all the natural indentations of the body, groin, armpits, hair, shoulders, front and back waist;
- whenever there are conditions to practice the search, it should be performed by two police officers.

Adhering to the basic safety rules, the search of a person in a standing and kneeling position is performed by pulling the upper part of the body backwards or pressing it forward in order to further disturb the stability, and then all parts of the body on the right and left. Unlike the previous two positions, the search in a supine position due to the specific placement of the faces and the minimum possibility of moving is performed with the help of police officers who twist the person on the right and left side so that they can more easily conduct the search (Fig. 4)

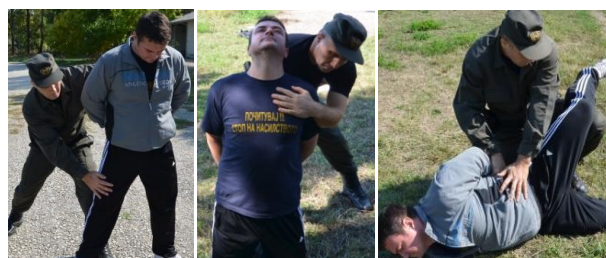


Fig. 4 Searching a person in standing, kneeling and lying position.

The search is followed by a tactical procedure of guide the detainees. In order to initiate this procedure, it is necessary to bring the searched person to an appropriate position. Among people who are in a standing and kneeling position, this is achieved only by issuing short verbal orders, while in persons who are in a supine position, a complete procedure for lifting the faces is performed. Once the people have been brought into the wanted position, it is very important to maintain total control over them and eliminate any possibility of reaction and an attempt to escape. Depending on the category of people and their behavior, an appropriate tactical approach to is used. Among people who cooperate, control is provided by soft (preventive) physical contact, which is achieved by holding the handcuffs and the hand in the area of the elbow, while among people who partially, or not fully cooperate, control is achieved by inflicting an appropriate degree of pain in the area of the hand (Fig. 5).



Fig. 5 Leading a handcuffed person who shows resistance.

In the last part of the tactical procedure, the handcuffs are removed and the person is released. This procedure is usually carried out at the moment when the person is brought to the police station or handed over to other state institutions and services. In order to enable the safe removal of handcuffs from the detainees, it is very important that the approach of the police officers is fully official and that they do not relax at any time. When starting the final procedure, first of all, the person is required to place themselves in a standing position, and after fulfilling this request, they move on to removing the handcuffs, first on the more distant and then on the closer hand. During the whole unlocking process, control is maintained on the person by holding the connective parts of the handcuffs. In exceptional situations when a person who have previously manifested visible physical or armed resistance is released, the removal of the handcuffs is performed in a supine position [11]. In this position, the persons must be brought in with the help of two police officers who help him to occupy and maintain the required position with the body for the whole time while the handcuffs are being removed from their hands (Fig. 6).



Fig. 6 Releasing a handcuffed person in lying position.

3. Conclusion

The police profession, due to its specific nature and exceptional social significance, always carries a high risk and danger for the police officers, especially in those cases when the legal requirements for the use of coercion methods are met. Given that any presumed situation in which coercion methods are used, including handcuffing, poses a serious problem for the protection and the personal safety of members of the police, then, it is necessary to develop solutions in order to reduce or avoid negative consequences. Therefore, within the frames of this paper, through elaboration and detailed analysis of the tactical model for police action and the immediate use of the methods of coercion - "handcuffs", an attempt was made to single out and emphasize the most important tactical-security activities that would allow uninterrupted procedure without violating the dignity and reputation of the person being detained. Moreover, of special importance for solving the complex problems between the police and the citizens, is to work continuously on raising the quality of education and training in order to improve mutual communication and personal security.

4. References

1. Д. Арлов, Употреба средства принуде - средства за везивање, Без. 4, 633-645 (2006)
2. Уредба за употреба на средства за присила и огнено оружје, Сл.Вес. на РМ, 23/1998
3. Ј. Ивановски, *Тактика на полициско постапување при употреба на средства за присила* (Скопје, 2019)
4. ABC Baton Manual 2010_5.qxd - ASP Instructor Portal <https://asptraining.wikispaces.com/file/view/ABC+Baton+Manual+2010.pdf> [12.3.2020]
5. J. Ivanovski, A. Nedev, Model of tactical police action when using physical force, Sec. Fut, 2, 22-25 (2018)
6. J. G. Petters Jr., *Tactical Handcuffing* (New Mexico 1988)
7. Defensive Tactics Training Manual-GitHub <https://www.whatdotheyknow.com/request/.../Full%202011%20UDT%20Manual.pdf> [10.4.2020]
8. *Тактички пристап кон современата полициска обука*, ОБСЕ (Скопје, 2006)
9. Г. Вучковић, М. Допсај, Поузданост тестова за процену основне оспособлености за употребу средства за везивање код полицајца. Збо. Рад., 325-342 (2003)
10. G. Ribičić, M. Svitlica, Taktika policijskog postupanja pri savladavanju fizičkog napada. Zbo. Povz. (2008)
11. Defensive and Arrest Tactics, A Training Guide For Law Enforcement Officers: Wisconsin Department of Justice, Law Enforcement Standards Board, 2007. <http://naminc.org/nn/blat/wisc-training-guide.pdf> [17.4.2020]

Options of Healthcare Facilities Protection Against Terrorist Attacks in the Czech Republic

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Abstract: Medical facilities are distinctive types of premises accessible by a wide range of visitors seven days a week. They are places characterized by a high concentration of civilians and low-level security against the occurrence of various types of emergencies. Undoubtedly, terrorism is one of them. From a security point of view, hospitals are soft terrorist targets. Given the topicality of terrorism, we must address the question whether sufficient security is ensured for medical facilities. The aim of this paper is to point out the key role of security management in the overall management of hospitals. It will also outline some shortcomings in technical and operational security applications for their premises. The paper further discusses the effectiveness of crisis plans and emergency management exercises, as those are the primary conditions of successful emergency management.

KEYWORDS: MEDICAL FACILITIES, SECURITY, TERRORISM, EMERGENCIES

1 Introduction

The current stage of development of civilization, besides many indisputable positives, also carries with it some great security risks, such as illegal human migration, organized crime, the proliferation of weapons of mass destruction and terrorism. In recent years, terrorism has become a topical issue mostly because of its globalization and wide media coverage. In June 2013, 14 female university students were killed during a bus explosion and another 19 were injured. After bringing the victims to a hospital, a suicide bomber detonated a bomb in the door to the emergency room, followed up by terrorists storming the facility with firearms. Another 11 people were killed before this attack was brought under control by the security forces. The Lashkar i Jhangvi terrorist group claimed responsibility for the attack. In September and November 2012, suicide bombers of the Jabhat al-Nusra group attacked hospitals in Syria. In November 2005 London police arrested two suspected terrorists who were later accused of plotting a bomb attack. One of them had a piece of paper with the words in Arabic, Hospital = Target.[1]

It might seem that as no terrorist attack has so far taken place on a medical facility in the Czech Republic, the security solutions used by hospitals against such attacks are exaggerated or even unnecessary. The above examples from abroad, however, prove the opposite. Terrorism can be defined as the politically, ideologically or religiously motivated blind, indiscriminate killing of defenceless, innocent civilians.[2] A hospital can thus definitely become a target of a terrorist attack. At the same time, medical facilities are what are called soft terrorist targets. Currently, security measures are being significantly increased around government buildings, military facilities, airports, etc., but we have yet to see any noticeable changes in the protection of soft targets (hospitals, shopping malls, school facilities, etc.). It is of course very difficult for the government to ensure the overall security of all soft targets, and with the commitment of considerable financial resources. It is therefore necessary for medical facilities (or any other institution facing the risk of a terrorist attack) to take primary responsibility themselves, and ideally for each of us personally as well. We also must take into account the issue of the adequacy of every anti-terrorist measure, thus preventing, for instance, excessive restrictions on the free movement of people and so on.

2 Results and discussion

The following are the findings of a research project called "Protection of medical facilities against terrorist attacks", conducted by the Central Bohemian Region of the Czech Republic in the hospitals in the region in 2017. Furthermore, the results are

also based on the conclusions of conferences focusing on the security of medical facilities, organized by the Faculty of Biomedical Engineering of the Czech Technical University in Prague and the Society for Radiobiology and Crisis Planning of the Czech Medical Association of J. E. Purkyně under the auspices of the Health Committee of the Chamber of Deputies of the Parliament of the Czech Republic. The contributions by representatives of several Czech hospitals and experts on the security of medical facilities in the Czech Republic have shown that the crisis managers of these facilities do carry out risk analyses, are aware of the threats related to operating hospital facilities and often develop crisis plans aimed at preventing and addressing a variety of crises and emergencies. It remains to be seen, however, to what extent these findings and plans are accepted in the practical application of hospital security.

2.1 Terrorist attacks

The aim of a terrorist attack is to provoke a severe psychological effect, a sense of threat, fear and manipulation of public opinion. To achieve this goal, many types of terrorist attacks can be used when targeting inpatient medical facilities. Acts of a brutal nature with numerous innocent victims will ensure sufficient media coverage and thus extend the psychological impact beyond the territory or society that is attacked. This creates an environment suitable for achieving terrorist goals.

2.2 Vulnerability of medical facilities

Medical facilities housing inpatients, especially those obliged to provide mandatory emergency admission, provide constant access to the general public. At the same time, numerous members of staff are on duty and there are the inpatients, people often vitally dependent on the facility's operation. These are spaces in which we assume that our health will be restored and therefore protected. At the same time we encounter a low level of security of hospital premises against potential crimes. From the point of view of terrorist attacks, medical facilities are classified as soft targets, i.e. the most common targets of violent terrorist acts [3]. The analogy of terrorist attacks on soft targets demonstrates well the vulnerability of hospitals to any emergency situation. Being part of this group of terrorist targets proves that medical facilities are easy targets for committing a violent or other crime with a great social and psychological impact. This is mainly due to the high concentration of defenceless people, the low level of security and a certain degree of feeling untouchable while failing to acknowledge potential security risks. These risks are associated

with both a hospital's operation and also external factors which can jeopardize the safety of their premises.

2.3 Importance of security management

The management of medical facilities includes departments dealing with the issues of security and crisis management. The staff of these departments are security managers ensuring the tasks necessary for making their hospital a safe environment for all employees, patients and visitors to the premises. This means, on the one hand, providing high-quality and safe patient care and on the other securing all areas of the hospital, protecting against emergencies and preparing for solutions to them. In this paper, we will mostly focus on crisis situations on our own premises.

Being aware of the threats and risks, preventing the occurrence of emergencies and preparing for any potentially needed solutions contributes to building an adequate response to crisis situations. First of all, therefore, security management requires a risk analysis to be performed. It will also serve, besides allowing reflection on the medical facility's current security situation, as a basis for the subsequent creation of crisis plans. These plans are then ideally used as guides for addressing specific emergencies and their feasibility and effectiveness is tested through training in each crisis situation. In addition to creating crisis plans and verifying their functionality, providing preventive security measures is an equally important part of hospital crisis management. This mostly means the technical and operational management of the medical facility.

Our own experience tells us that healthcare professionals are usually not aware of the threats which they may face at work. They are not familiar with potential emergency situations in their workplace and with how to react at such moments or whom to notify, let alone having any opportunity to practise those reactions. For many security managers, ensuring security only means organizing training in safety and health at work (OSH) and providing information about the existence of crisis documentation. From the point of view of protecting the population and that of crisis management, such an intervention is insufficient and fails to ensure adequate preparedness for dealing with emergency situations. They explain this shortcoming by a lack of time and financial resources, which will, however, be negligible if an emergency occurs and is dealt with inadequately and inefficiently as a result of unpreparedness, thus causing substantial health and material losses.

It is therefore necessary to improve the awareness of medical facility staff of the potential risks of emergency situations, streamline the interpretation of instructions found in crisis plans to deal with them and allow the members of staff to try out these procedures in practice. It is equally important to ensure the technical security of hospital premises as an essential step in their protection from emergencies.

2.4 Indispensability of technical security

A safe environment and, in many cases, the prevention of various emergencies in hospitals can be ensured by using appropriate technical security resources. Our investigation shows that it is often the technical security solution which is significantly underestimated by medical facilities.

By way of example, gates and entrances are used ineffectively. These points of entrance usually only serve to pay for entry or parking. It would, however, be appropriate to equip these places

with barriers and licence plate readers and chip card readers allowing entry to authorized persons only, and thus reduce the risk of unwanted objects or persons being brought onto the hospital premises.

In relation to the above-mentioned individuals representing a risk, it is also clear that the free unmonitored movement of persons in the hospital does not contribute to its security. Currently, it is hardly difficult to gain access to virtually any clinic. Certain wards are even freely accessible, although, for instance, immobile patients who cannot defend themselves against a potential attacker in any way are hospitalized there. Other departments are accessible through a remote doorbell, but even that most often happens without the visitor's identity and the purpose of their visit being verified. Here it would be worth considering establishing one central reception or several separate ones, through which it would be possible to enter individual departments only after the identity and the purpose of the visit had been checked.

It is also worth mentioning that there is zero or insufficient use of CCTV monitoring systems. An appropriate assessment of security camera information can prevent an emergency situation or ensure a timely reaction to it. We can then use the cameras to monitor the development of the situation and collect information which can be beneficial to the rescue services when deciding about further action. This definitely also requires well-informed staff assessing the information provided by the cameras. These members of staff need to be trained in, for instance, identifying a suspicious person (untypically shaped, noticeably thick clothing to cover a firearm, a large piece of luggage, aggressive behaviour) and what steps to take and whom to notify.

The efficiency of a security camera system is significantly reduced if this service is not managed from one control room, together with other technical security installations, thus allowing a rapid reaction to emergencies. By this we mean an audio communication exchange, an electronic fire alarm system, an electronic security alarm or a mass distribution device for sending urgent text messages. It is also advisable to equip the control room with software to control the buildings' technical equipment (heating, cooling, air conditioning, tube mail, etc.).

As regards the employees monitoring what is happening in the hospital through security cameras, we would like to draw attention to the unsatisfactory condition of the hospitals' physical security systems. The main shortcomings are the composition of the group of employees, the wide range of tasks assigned to them and their minimal preparedness for dealing with emergency situations. In many cases, physical security is ensured by security agencies, but the hospitals do not assist in the selection of the people charged with guarding their facility. There are cases where physical security is ensured by women of pensionable age. The duties of these employees include monitoring the hospital through security cameras and patrols around the area; in some cases they are located in gatehouses. These people also serve as so-called security guards and are used to solve conflicts with aggressive patients. That can represent a threat to themselves, given their age, as mentioned, or insufficient physical and technical training to deal with such events.

The above-mentioned examples of weak technical security provision in medical facilities show their insufficient security against emergencies, especially violent crimes. At present,

the threat of terrorist attacks is leading to increasing security measures in government buildings, at airports, and so on. Since medical facilities are soft targets, steps need to be taken to improve their security.

2.5 Usability of crisis plans

The risk analysis of inpatient medical facilities shows that crisis managers are aware of the threats and the related emergency situations. In many cases, specific plans are in place for addressing critical situations (emergencies, evacuations, pandemics and traumatological issues). It is, however, necessary to verify whether these plans are functional, whether they are indeed usable in real time at the moment of an emergency and whether everybody among the medical facility's staff is familiar with their content.

Our survey showed that these plans are usually extensive yet fail to provide specific procedures for dealing with situations. Hospital employees often express objections, and rightly so, that it is not possible to browse through files with crisis plans under stress and time pressure, searching for the steps to take. It is thus necessary to reconsider the form of the presentation of these plans and create a brief and clear document about the most important instructions which will clearly indicate what to do in a specific situation. Some hospitals already have such brief instructions in the form of what are called "crisis cards" in A4 format, or an "emergency calendar" with procedures to follow for each type of situation. Besides finding a suitable form for communicating this information, it is also very important to select an appropriate location for it. As already mentioned above, filing it among other documentation (nursing standards, medical equipment manuals, medical facility directives and other documents and regulations) is not a good solution, as it is not possible to spend valuable time searching for instructions on how to act and whom to notify immediately. It is therefore desirable to place the emergency guidelines in a visible place known to every member of the department staff (ideally near a telephone line).

2.6 Irreplaceability of training

The crisis plans themselves are, however, not a sufficient guarantee of preparedness for emergencies. Even a well-designed, understandable and user-friendly crisis plan needs to be put into practice and its usability has to be practised. Here we come across another problem, because, as we have found out, hospitals mainly carry out trauma plan exercises in emergency rooms, while neglecting exercises in managing other crisis situations in other hospital departments. Hospital management often explains this failure to carry out evacuation training and training in dealing with attacks by aggressive or armed patients and other threats by referring to an excessive economic burden limiting the medical facility's operation. Here it should be pointed out that any potential complications (material losses, harm to patients or members of staff) which can occur in a real emergency as a result of a lack of staff preparedness are many times more costly than ensuring preventive measures and training. Last but not least, these drills bring the undeniable benefit of retrospective evaluation.

We can thus check the real and practical usability of preventive measures and crisis plans. The aim is to identify shortcomings and problems in communication among the crisis managers, the medical staff, the patients who are hospitalized and the visitors, as well as the weaknesses in the staff members' ability to respond

to the situation. Lessons must be learned from these shortcomings and the necessary steps need to be taken to mitigate or eliminate them, thus ensuring a safer environment for the patients, for visitors and for the members of the medical facility's staff.

3 Conclusion

The quality and the credibility of a medical facility depend, in addition to professional medical and nursing care and modern equipment, on its security. Ensuring a safe environment contributes to the level of satisfaction among a hospital's employees, clients and visitors. Appropriate preventive measures can substantially mitigate the potential impacts of emergencies, therefore also including terrorist attacks. Hence the need for medical facilities' security management to take steps towards increasing hospitals' preparedness for addressing emergencies and eliminating the shortcomings in the security of their premises. The area of crisis planning and preparedness in hospitals is now being heavily tested by the COVID-19 pandemic, which will ideally give an impetus to emphasizing the increased need to address medical facilities' security and preparedness for emergencies in general, with more effort and resources.

4 References

- 1) ERNST, Matthew. Are U.S. Hospitals in the Crosshairs? [online]. *AmericanThinker*. 2013. [quot.24 May 2020]. Available online: http://www.americanthinker.com/articles/2013/07/are_us_hospitals_in_the_crosshairs.html
- 2) EICHLER, Jan. *Terorismus a války v době globalizace* (Terrorism and wars during globalization). Prague: Nakladatelství Karolinum, 2011. ISBN 978-80-246-1790-9
- 3) KALVACH, Z. 2016. Introduction to protecting soft targets - methodology. The Ministry of the Interior of the Czech Republic. [quot. 24 May 2020]. Available online: <https://www.mvcr.cz/clanek/ochrana-mekkych-cilu.aspx>

Nuclear Deterrence. Is It Back?

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Abstract: During the Cold War, the concept of deterrence was often used as a term for nuclear deterrence with the use of nuclear weapons, but the term fell into relative obscurity, in broad strokes, after the collapse of the Soviet Union. Thereafter, nuclear forces tended to play a marginal and diminishing role for many policymakers in the 1990s and 2000s. The topic of nuclear weapons has not been included in political debates of the countries for more than twenty years. Therefore, the threat of nuclear weapons appeared remote and debates often centred on a nuclear-free world's possibility of proliferation and expectations. However, over the past few years though, this has changed significantly. The primary and regional powers are increasingly modernising their nuclear forces and are starting to give them a central role in their large strategic positions. Nuclear deterrence has come up again in such a setting.

KEYWORDS: NUCLEAR DETERRENCE, NUCLEAR WEAPONS, COLD WAR, ARMS RACE

1. Introduction

Deterrence theory, in international relations, is a strategy based on discouraging potential competitors from continuing a certain behaviour by threatening intolerable outcomes. Deterrence can, therefore, be defined as a distinguishable and clear demonstration of a behaviour or attitude that would prevent a country from harmfully opposing a group or country. As William Kaufmann describes, the logic of deterrence can be explained: "Essentially, deterrence means preventing certain types of contingencies from arising"[1]. To enable deterrence to function successfully, a potential attacker would have to find their opponent's threat, convinced enough that they would retaliate. The success of deterrence depends on the conviction of threats towards potential aggressors. To put it simply, the potential attacker needs to be persuaded that if the attack happens, the deterrence can and will be executed through its intimidation [2].

Concept of deterrence is quite old in practice, as in, "the study of deterrence might be as old as politics" [3]. As an example, to this statement, we see that Chinese strategist Sun Tzu wrote about the importance of directing the opponent's tendencies to the threat: "To fight and conquer in all your battles is not supreme excellence; supreme excellence consists in breaking the enemy's resistance without fighting" [4]. Correspondingly, one of the biggest military strategists, Carl von Clausewitz, repeatedly stressed the importance of the threat posed by a powerful army among military strategies, in his book, on War [5].

However, the systematic study of deterrence as a theory could be possible because "only after the onset of the Cold War did it grow into the relatively complex set of ideas" [3], that we see today. Because the destiny of deterrence theory changed and shifted to nuclear deterrence theory with the use of nuclear weapons after the Second World War. Since then, theory gained increasing importance as a military strategy which was theoretically most advanced and most effective in practice during the Cold War years. Hereby, as Maria Sperandei emphasis, "the awesome increase in destructive power brought about by nuclear and thermonuclear weapons soon after the rise of the 'iron curtain', marked the 'golden age' of deterrence" [3]. On the other hand, nuclear deterrence theory has become one of the most important foreign policy instruments to which states are directed at the strategic level. As Todd S. Sechser and Matthew Fuhrmann simplifies, because nuclear states have the capacity to impose extraordinary levels of punishment, they can more easily intimidate crisis opponents by submitting to their compellent demands. In addition, this advantage is thought to persist even when coercers do not explicitly threaten nuclear attacks [6].

There hasn't been a global war since World War II and this reality has strengthened nuclear deterrence's power in establishing an unusually strong and stable relationship in the world. According to William J. Broad and David E. Sanger, the arms race of the Cold War period and the destructive power balance between nations that

have preserved by nuclear peace for more than half a century [7]. Along with, Sam Marullo also expresses that nuclear weapons are thought to be a "major component of this simplified image of international order; its critical function believed to be to prevent overt conflict between the superpowers and their allies" [8] and "many argued that this was best done through deterrence and accordingly, much attention was devoted to exploring the dynamics of deterrence, particularly from about 1960-1990" [9].

The paper argues that nuclear weapons have been effectively used as a war-preventive tool. Herein, the author seeks answers to the main question, "Has nuclear deterrence come back to play a role in the contemporary political area once again"? The study compiles analytical research based on discourse, along with comparative and analytical content focusing on Nuclear Deterrence. The methodology of this paper used analytical existing data and secondary literature by using various sources. Books, book chapters, journal articles and internet sources, as well as the findings from empirical research, have been widely used.

2. Back and Forth

The Cold War period was a time when the ideological two blocks were led by two superpowers. In this period, "the United States and the Soviet Union, as the world's two superpowers and leaders of powerful alliances, competed against each other in order to prevent the other from becoming dominant in a bipolar system" [8]. The era had started with the division of Germany and the spread of Soviet-type governments in Eastern Europe, which was effective in the political, economic and military aspects of the Soviet Union until the 1991 collapse of the Berlin Wall.

During the Cold War, two superpowers saw the use of nuclear weapon technology as an element of difficulty and entered the nuclear arms race. Within the era, "every time one state develops nuclear weapons to balance against its main rival, it also creates a nuclear threat to another state" [10]. In fact, this race was triggered by the United States developing nuclear weapons used, for the first and last time, in 1945 with the USSR's nuclear tests in 1949 following on from then; afterwards, the U.S. obtained a hydrogen bomb in 1952 and the USSR had a hydrogen bomb in 1953 [11]. A balance was reached between the two superpowers in terms of nuclear power, but the US had short and medium-range missiles that could hit the USSR; however, it changed the game. Afterwards, these two superpowers created large nuclear arsenals with previously unimagined destructive power [12]. In addition to all these, United Kingdom's first nuclear test was carried out in 1952, France in 1960, China in 1964 and India in 1974 [13]. Because of the 'do not deny or decline' strategy Israel thought to have nuclear explosive device, most likely, they obtained its first nuclear explosive device during the Cold War [14]. The main factor that distinguished the US and the USSR as superpowers from other states was their possession of nuclear weapons. Furthermore, "the United States and the Soviet Union were engaging in the largest and most costly arms race in world history (costing more than both world wars combined)" [12].

In the late 1950s, 1960s and at the latter of 1970s, the proliferation of nuclear weapons became a growing concern. Because, having a nuclear arsenal was one of the defining elements of the era and the most crucial feature of this period was the strength of the development of nuclear weapon technology to create great devastation from a distance. The theory behind this was the practice of deterrence based on the hegemonic supremacy of the bipolar system. Between 1945 and 1991, “55,260” nuclear warheads had been tested by the aforementioned countries [15]. Continuous improvement of existing arsenals and testing of these weapons were seen as the vital element of the qualitative nuclear arms race. However, in this period, there was a balance in understanding created by the danger of ‘terror’ or ‘mutual annihilation’ due to mutual nuclear deterrence rather than war [16]. As a consequence of these, as a possible threat might have been a result of nuclear destruction, states agreed to prevent a possible nuclear war and in contrast have weapons of mass destruction that neither of them knows the number of, resulting in them having to counteract against each other. This reality “demonstrated the critical importance of effective dialogue” [17] and this was the beginning of a period of ‘softening’, in which dialogue between the US and the USSR increased, rather than creating a confrontational environment. “Multilateral arms control efforts led to a number of treaties, including the 1968 Treaty on the Non-proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT)” [18]. Additionally, namely, the Interim Agreement on Offensive Arms (SALT I) in 1972, the Anti-Ballistic Missile Treaty (ABM) in 1972, the Strategic Arms Limitation Treaty (SALT II) in 1979, the Intermediate-Range Nuclear Forces Treaty (INF) in 1987 and the Strategic Arms Reduction Treaty (START I), signed in 1991 and ratified 1994.

Even though, despite all the efforts, “when the duel was over and the Berlin Wall came down, 40 years of arms racing had produced 70,000 nuclear weapons and the world’s arsenals contained about 60,000 warheads, 98 per cent of them Soviet and American” [19].

3. Nuclear Weapons in Relation to Deterrence

The end of the Cold War offered a unique opportunity to attain the goal of creating a non-nuclear world. The nuclear arms race, which was a significant feature of the Cold War, was over and France, Russia, the United Kingdom and the United States significantly reduced their arsenals [19]. In an environment where the Cold War ended and the possibility of interstate conflict in world politics decreased considerably, a new meaning was applied to nuclear weapons and it was not reasonable to use weapons of mass destruction; hence, “nuclear arsenals have been cut by more than 60 per cent” [19].

However, there are still huge arsenals, especially in Russia and the USA. China, India, North Korea, Pakistan and probably Israel are growing their stocks, though far below Russia’s and the United States’ levels [20]. Today, The United States and Russia control 92 percent of all nuclear warheads in the world. Every year, many countries continue to expand their nuclear arsenal. According to information compiled by Kelsey Davenport and Kingston Reif, there are about 14,000 nuclear warheads; more than 90 percentage of them are held only by Russia and the United States. Russia has 6,490 nuclear warheads, followed by the US with 6,185. It is also estimated that France has 300 nuclear warheads, 290 in China, 200 in Britain, 160 in Pakistan, 140 in India, 30 in North Korea and 90 in Israel [21]. Dr Bruce Blair, former Minuteman ICBM Launch Control Officer and Former President of the World Security Institute, underlines the situation with these words and lift the lids on regarding proliferation of nuclear weapons: “both the United States and Russia today keep about one-third of their total strategic arsenals on launch-ready alert. Hundreds of missiles armed with thousands of nuclear warheads - the equivalent of about 100,000 Hiroshima bombs - can be launched within a few minutes. The end

of the Cold War did not lead the United States and Russia to significantly change their nuclear strategies or the way they operate their nuclear forces” [22]. To this day, nuclear-armed states are talking about nuclear weapons as a permanent and irreversible part of national and international security [20]. Far worse than, recently, 5 out of 9 countries with nuclear weapons (USA, China, Russia, France, UK) are pledged under the nuclear Non-proliferation Treaty (NPT) to “pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament” [20]. Furthermore, other countries who, well-known, possess nuclear weapons such as India, Pakistan and Israel not even a party to this agreement. Further, North Korea withdrew from the agreement in 2003 and has developed nuclear weapons. This situation brings to mind the possibility that they will be able to use nuclear power when they perceive a threat to the security of the state.

Nuclear deterrence is assumed to be an important result of nuclear weapons’ coercive power, the fact is that, nuclear weapons are now a card that strengthens the hand in political negotiations rather than military and strategic superiority and functionality; moreover, they have become a tool of psychological and ideological superiority and oppression. It is seen that nuclear weapons have the power of oppression and sanction in diplomacy. States with nuclear weapons try to determine the optimal nuclear military strategy in order to create a credible and effective nuclear deterrence consistent with their physical capacities and positions in international politics. Because of this reason, almost all nuclear-armed states rather than taking advantage of this power in the military field, make the weapon a material of diplomatic methods, which can be an element of conflict-fighting strategies with the advantages of power. Although nuclear weapons were never used throughout the Cold War, they were widely spoken about and led to a relatively stable order based on fear among superpowers. The reason why nuclear weapons effective in international politics and coercive diplomacy is the ‘deterrence’ element created by this destructive force and countries with nuclear weapons consider weapons of mass destruction an element of existential deterrence [23]. However, it causes, naturally, security dilemma because nuclear weapons are much more effective than conventional weapons and “enormous destructive power of nuclear weapons, any state that seeks to maintain its national security must balance against any rival state that develops nuclear weapons by gaining access to a nuclear deterrent itself” [10]. Nevertheless, most statesmen and scholars consider nuclear weapons the ultimate source of coercive power in international politics like TV Paul expresses here; nuclear weapons are also said to provide the possessor with diplomatic power [24]. Correspondingly, as Scott Sagan impressively states here, “Nuclear weapons, like other weapons, are more than tools of national security; they are political objects of considerable importance in domestic debates and internal bureaucratic struggles and can also serve as international normative symbols of modernity and identity” [10]. In this regard, the most essential effect of nuclear weapons in terms of international politics is still deterrence. Regardless of the purpose of the states, because the destructive power of nuclear weapons makes it possible to cause irreparable damage to the enemy, this reduced the likelihood that states could achieve their interests by using force or threatening to use force [24].

4. Withdrawal of Agreements and Modernisation of Weapons

The remarkable era of nuclear arms control which started on December 26, 1991, when the Soviet Union was dissolved and ended formally on February 1, 2019, following withdrawal from the Intermediate-Range Nuclear Forces treaty by the USA. U.S. Foreign Minister Mike Pompeo announced that his country had suspended its INF [25] and that the period that began with the fall of the Berlin Wall in 1989 and the dissolution of the USSR in 1991 was now ended. The INF treaty between the United States and the Soviet Union entered into force in 1988 and was the product of a set of circumstances unique to the era of Cold War superpower

confrontation[26].The agreement banned all nuclear and conventional missiles and launchers fired on the surface in the US and Soviet countries ranging from 500 to 5,500 km worldwide.

However, the treaty prevented any new INF systems or different stages of INF missiles or launchers from being developed or tested on flight. Thus 1,846 missiles were destroyed by the Soviet Union, 846 were destroyed by the United States. The treaty created the Special Verification Commission (SVC) to resolve possible enforcement issues and monitor implementation. A total of 2,692 intermediate-range missiles had been completely removed by 1 June 1991[27].

The end of the INF treaty might trigger the start of a new arms race. In recent years, it has been seen that the US' decision to withdraw from the treaty is not the cause of the already started and accelerating arms race. Washington and Moscow have accelerated competition in the field of new nuclear weapons technologies and both sides have been stepping up their military exercises in recent years. In a more general sense, multi-polarity and tension in the international system are strengthened. Therefore, this decision by the USA shows that we, might, are on the verge of a new Cold War. "The withdrawal from the INF treaty has fired the starting pistol on a new Cold War", warned Beatrice Fihn [28]. Agreements must be maintainable; however, Russia and the United States have more than 90% of the nuclear weapons in the world, nuclear weapons limitation agreements still do not prevent them from having more nuclear arsenals than other countries.

The negotiations on the nuclear weapons plan, which started in 1971, have been eliminated one by one and the addition of a space dimension shows that humanity will be in a new arms race. "Consequently, in the area of arms control, the world is about to be left without any structure, any functioning arrangement at all" [29]. INF is not the only matter here; the new START will expire in 2021. There are currently no talks on whether to prolong the New START or sign a follow-up agreement. Shannon Kile, Director of SIPRI's Nuclear Disarmament, Arms Control and Non-proliferation Programme, says, "the prospects for a continuing negotiated reduction of Russian and US nuclear forces appears increasingly unlikely given the political and military differences between the two countries" [30].

Both Russia and the US have comprehensive and costly projects underway to upgrade and modernise their nuclear warheads, delivery systems for missiles and aircraft and production facilities for nuclear weapons. The United States is engaged in a systematic overhaul of its entire nuclear arsenal – from processing to delivery systems and warheads. The plan is scheduled to be completed by 2046 and will cost an estimated \$1.2 trillion-\$ 494 billion between 2017 and 2026 to be allocated [31]. Here again, according to Kingston Reif, Director for Disarmament and Threat Reduction Policy, the overall nuclear modernization program includes: Modernized Strategic Delivery Systems, Refurbished Nuclear Warheads, Modernized Production Complex, Command and Control Systems and Nuclear Force Improvement Program [31].

Russia is modernizing its nuclear forces, replacing new missiles, warships and aircraft in the Soviet era while developing new delivery systems. The current cycle of Russia's modernization of its nuclear forces started in the early 2000s and is likely to end in the 2020s. However, Russian President Vladimir Putin announced in March 2018 that Russia is developing new forms of nuclear systems. While some interpret these weapons as an effort by Russia to gain a measure of dominance over the United States, others note that they are likely to be a Russian response to concerns regarding evolving U.S. missile defense capabilities. Such new Russian technologies include, among others, a powerful intercontinental ballistic missile(ICBM) with the ability to carry multiple warheads, an autonomous underwater vehicle, a hypersonic glide vehicle [32].

The other nuclear-armed states' nuclear arsenals are much smaller but they either build or deploy new weapons systems or have announced their intention to do so [33]. China holds, as

illustrated earlier, a relatively small nuclear arsenal, albeit slowly increasing. China is continuing the nuclear weapons modernization program it initiated in the 1980s, with more nuclear weapons forms and more numbers than ever before. China continued to launch a new variant of an existing medium-range nuclear mobile ballistic missile, a new dual-capable intermediate-range mobile ballistic missile, and an improved road-mobile launcher. A road-mobile multiple independently targetable re-entry vehicles (MIRV) capable of ICBM and an air-launched dual-capable ballistic missile have also continued to be produced [34]. China was not party of INF agreement. Therefore, in recent years, China has always had the chance to develop its armed forces, nuclear weapons and missiles freely. When U.S. President Trump considers the security of America, he now considers China rather than Russia. His concerns are more related to China. As Tselichtchev stated, "Washington's major strategic goal in this region is to contain China and to achieve this goal, it is seeking a level playing field to develop all kinds of weapons, ground-based intermediate-range missiles included" [29]. However, this decision liberates both Russia and China's hands.

On the other hand, India and Pakistan are increasing their capacity to produce military fissile materials on a scale that could lead to significant increases in the size of their inventories of nuclear weapons over the next decade. North Korea continues to view its military nuclear program as a key component of its national security policy, even though it signed a moratorium on nuclear weapons testing as well as medium and long-range ballistic missile delivery systems in 2018[33].The cornerstone of India's current nuclear modernization program is the production and induction of portable, solid-fueled intermediate-range ballistic missiles, the deployment of submarine ballistic missiles, the implementation of a ballistic missile defense system, the construction of weapons storage and integration sites, and the completion of its command and control network[35].Today, Pakistan's arsenal includes up to medium-range gravity rockets and ballistic missiles as well as cruise missiles, glide bombs, and a host of new and complex nuclear tactical weapons. Most credible scholars believe that Pakistan's nuclear arsenal consists of some 90-110 warheads, although the military could easily increase to more than three times that number within a decade at the current rate of growth[35].

Despite significant reductions in the overall number of nuclear weapons relative to the Cold War era, all the nine nuclear-armed states around the world are busy modernising their remaining long-haul nuclear forces[20].Furthermore, "although the numerical nuclear arms race between East and West is over, a dynamic technological nuclear arms race is in full swing and may increase over the next decade"[20]. Humanity has a bad habit: it hasn't given up on the idea that security can be armed in more places. "They believe nuclear weapons are essential and 'core capabilities' for the military that must be maintained and never parted with" [36].

5. Conclusion

Almost three decades have passed since the Cold War but nuclear weapons and nuclear deterrence are once again on the agenda. Countries are now modernising their nuclear systems launched from the air, land and sea and making changes to their nuclear weaponry. Weapon controls are now in the secondary plan. This means a new dimension of nuclear arming and deterrence. The motivation for the repeal of agreements to have nuclear weapons and propulsion systems, which is a prerequisite for nuclear war, is that it can quickly realise itself. Nevertheless, there is no doubt that it has regained its influence and its popularity has returned due to factors such as the suspension of arms control agreements one by one, as well as a new wave of nuclear weaponries modernisation because of the military competition between world superpowers. Countries still regard nuclear weapons as an unassailable power and place this factor at the base of their nation's interests.

The world is once again in the shadow of a nuclear conflict; a "Go" game of the deterrence of nuclear-armed forces. Furthermore, decisions to withdraw agreements mean that all the world, not only

European territories, will be under threat. The fight for nuclear deterrence appears with the new generation of nuclear weapons of the US and Russia; moreover, those who will experience fear during this new period of nuclear dominance will not only be inhabitants of Europe, the US and Russia. The Middle East, Southeast Asia and Southern Asia shall also be involved in this complex game. Nuclear armament and deterrence are about to gain a new dimension. Peacetime took a little longer than 30 years. In light of these developments, we see that the theory of deterrence has returned to its glory days.

References

- [1] Kaufmann, W. W. (1989). The requirements of deterrence. In P. Bobbitt (Ed.), *American Nuclear Strategy: A Reader* (p. 525). London: Macmillan. Retrieved from <https://babel.hathitrust.org/cgi/pt?id=mdp.39015034327646;view=1up;seq=3>
- [2] Danilovic, V. (2002). *When the stakes are high: Deterrence and conflict among major powers*. Ann Arbor: University of Michigan Press.
- [3] Sperandei, M. (2006). Bridging Deterrence and Compellence: An Alternative Approach to the Study of Coercive Diplomacy. *International Studies Review*, 8(2), 253-280.
- [4] Tzu, S. (1994). *The Art of War*. (L. Giles, Trans.) Project Gutenberg. Retrieved October 7, 2019, from <http://classics.mit.edu/Tzu/artwar.html>
- [5] Clausewitz, C. V. (1989). *On war*. Princeton, New Jersey, United States of America: Princeton University Press.
- [6] Fuhrmann, M., & Sechser, T. S. (2013). Crisis Bargaining and Nuclear Blackmail. *International Organization*, 67(1), 173-195.
- [7] Broad, W. J., & Sanger, D. E. (2016, April 16). Race for Latest Class of Nuclear Arms Threatens to Revive Cold War. *The New York Times*.
- [8] Marullo, S. (1985). The Ideological Nature of Nuclear Deterrence: Some Causes and Consequences. *The Sociological Quarterly*, 26(3), 311-30. Retrieved from www.jstor.org/stable/4106218
- [9] Quackenbush, S. L. (2011). Deterrence Theory: Where Do We Stand? *Review of International Studies*, 37(2), 741-62. Retrieved from www.jstor.org/stable/23024618
- [10] Sagan, S. D. (1996). Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb. *International Security*, 21(3), 54-86. Retrieved from https://www.jstor.org/stable/2539273?seq=1#metadata_info_tab_contents
- [11] Friedman, U. (2016). When Truman Announced the H-Bomb. Retrieved 2019, from <https://www.theatlantic.com/international/archive/2016/01/north-korea-truman-hydrogen-bomb/423060/>
- [12] McLauchlan, G., & Hooks, G. (1995). Last of the Dinosaurs? Big Weapons, Big Science, and the American State from Hiroshima to the End of the Cold War. *The Sociological Quarterly*, 36(4), 749-76. Retrieved from www.jstor.org/stable/4121350
- [13] Gull, I. (2000). History of Nuclear Non-Proliferation. *Pakistan Horizon*, 53(2/3), 89-96.
- [14] Wenger, M. (1986). Recipe for an Israeli Nuclear Arsenal. *MERIP Middle East Report* (143), 9-11.
- [15] Norris, R. S., & Kristensen, H. M. (2010). Global nuclear weapons inventories, 1945–2010. *Bulletin of the Atomic Scientists*, 66(4), 77-83.
- [16] Delpech, T. (2012). *Nuclear Deterrence in the 21st Century: Lessons from the Cold War for a New Era of Strategic Piracy*. RAND Corporation.
- [17] Countryman, T., & Zagorski, A. (2018, June). *ARMS CONTROL TODAY*. Retrieved May 2, 2019, from *Urgent Steps to Avoid a New Nuclear Arms Race*: <https://www.armscontrol.org/act/2018-06/features/urgent-steps-avoid-new-nuclear-arms-race#endnotebio>
- [18] Anthony, I. (2006). Reflections on continuity and change in arms control. In *SIPRI Yearbook 2006: Armaments, Disarmament and International Security* (p. 928). Oxford: Oxford University Press.
- [19] Lodgaard, S. (2011). *Nuclear Disarmament and Non-Proliferation Towards a nuclear-weapon-free world?* New York: Routledge.
- [20] Kristensen, H. M. (2015). *Nuclear Weapons Modernization: A Threat to the NPT?* Retrieved 2019, from <https://www.armscontrol.org/act/2014-05/nuclear-weapons-modernization-threat-npt>
- [21] Davenport, K., & Reif, K. (2019). *Nuclear Weapons: Who Has What at a Glance*. Retrieved 2019, from *Arms Control Association*: <https://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhats>
- [22] Blair, B. G. (2007, October 13). *A Rebuttal of the U.S. Statement on the Alert Status of U.S. Nuclear Forces*. Retrieved from <https://www.globalzero.org/http://lcn.org/disarmament/opstatus-blair.htm>
- [23] Kissinger, H. (1956). *Force and Diplomacy in the Nuclear Age*. Retrieved May 1, 2019, from <https://www.foreignaffairs.com/articles/1956-04-01/force-and-diplomacy-nuclear-age>
- [24] Paul, T. V. (1995). *The Paradox of Power: Nuclear Weapons in a Changed World*. *Alternatives: Global, Local, Political*, 20(4), 479-500.
- [25] URL1. (2019, February 2). *INF nuclear treaty: Russia follows US in suspending pact*. Retrieved from *BBC News*: <https://www.bbc.com/news/world-europe-47101429>
- [26] Anderson, J. V., & Nelson, A. J. (2019). *The INF Treaty: A Spectacular, Inflexible, Time-Bound Success*. *Strategic Studies Quarterly*, 13(2), 90-122.
- [27] Kühn, U., & Péczeli, A. (2011). *Russia, NATO, and the INF Treaty*. *Strategic Studies Quarterly*, 11(1), 66-99.
- [28] URL2. (2019, May 2). *The starting pistol on a new cold war: US signs more than US\$1 billion in missile contracts in just three months*. Retrieved May 10, 2019, from *U.S. missile contracts have surged since decision to exit arms treaty, study shows*: <https://www.scmp.com/news/world/united-states-canada/article/3008589/starting-pistol-new-cold-war-us-signs-more-us1>
- [29] Tselichtchev, I. (2019, Feb 2). *The cold war INF nuclear treaty is dead, killed by rise of China and Trump. A global arms race is next*. Retrieved May 2, 2019, from *This Week in Asia*: <https://www.scmp.com/week-asia/opinion/article/2184742/cold-war-inf-nuclear-treaty-dead-killed-rise-china-and-trump>
- [30] URL3. (2019). *Global Nuclear Arsenal Declines, But Future Cuts Uncertain Amid U.S.-Russia Tensions*. Retrieved September 10, 2019, from <https://www.rferl.org/a/nuclear-weapons-russia-start-inf-warheads/30003088.html>
- [31] Reif, K. (2018). *U.S. Nuclear Modernization Programs*. Retrieved 2019, from *NATO Parliamentary Assembly*: <https://www.armscontrol.org/factsheets/USNuclearModernization>
- [32] Woolf, A. F. (2019). *Russia's Nuclear Weapons: Doctrine, Forces, and Modernization*. Congressional Research Service.
- [33] Stockholm International Peace Research Institute. (2019). *Summary of SIPRI Yearbook 2019: Armaments, Disarmament and International Security*. OUP Oxford.
- [34] Kristensen, H. M., & Korda, M. (2019). *Chinese nuclear forces, 2019*. *Bulletin of the Atomic Scientists*, 75(4), 171-178.
- [35] Tellis, A. J. (2015). *China, India, And Pakistan—Growing Nuclear Capabilities with No End in Sight*. Retrieved 2019, from <https://carnegieendowment.org/2015/02/25/china-india-and-pakistan-growing-nuclear-capabilities-with-no-end-in-sight-pub-59184>
- [36] Simpson, E. (2019, April 29). *Blind devotion to nuclear deterrence*. Retrieved May 1, 2019, from *The London Free Press*: <https://lfpres.com/opinion/columnists/simpson-blind-devotion-to-nuclear-deterrence>

Models and approaches for motivation, recruitment and retention of military personnel in the british armed forces

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Abstract: *The report examines different models and approaches for motivating and attracting personnel to the British Armed Forces. Positive and negative approaches for motivating service members are theoretically analysed and the most attractive among them are specified. The results obtained could be used in the development of an integrated strategy to motivate service members in the Bulgarian Armed Forces.*

Keywords: MOTIVATION, MODELS, RECRUITMENT, RETENTION, MILITARY, PERSONNEL

1. Introduction

Great Britain has a centuries-old tradition of building and maintaining its armed forces. As a result of many years of experience, the country's understanding of building a combat-ready military is built on the ability to attract, motivate and retain sufficiently qualified personnel with the appropriate skills. Awareness of this idea, however, is not a sufficient condition for its realisation. For this reason, the United Kingdom's armed forces are still experiencing great difficulty in recruiting and retaining personnel.

The structure of the British Armed Forces includes three types of armed forces: Land Forces, Royal Air Force and Royal Navy. The total number of the three types of armed forces of the United Kingdom by 2020 should be 144,200 regular army and 35,060 reserve, distributed as follows: Land Forces – 82,000, reserve – 30,100; Air Force – 31,750, reserve – 1,860; Navy – 30,450, reserve – 3,100. [1]

Each of the three types of armed forces consists of officers and servicemen with other ranks, and each category has certain specifics for enlisting and concluding service contracts.

2. Models and approaches to motivation in the British Army

In the United Kingdom, the principle is that each type of armed force should be responsible for recruiting and selecting the personnel it needs. To achieve this, each armed force develops its own recruitment and retention strategies. However, the Strategic Defence Review encourages the harmonisation of these processes between the armed forces of the United Kingdom.

In the British Army, staffing with the necessary personnel is conditionally divided into elements: recruitment, selection and retention. Each of these elements is a separate process, regulated by separate documents and strategies, and sometimes different structures and agencies are responsible for its implementation. For example, the policy in the Land Forces states that 'Recruitment can best be described as: '... steps taken to attract enough men and women of appropriate quality to meet the personal requirements of the army. Selection is the process that takes place to ensure that those admitted to the Land Forces have the potential to be good soldiers and are able to be trained and carry out their chosen activity'[2].

The British leadership has been following the global trend of declining strength since the end of the Cold War. Therefore, we will look at the development of motivation strategies for recruiting and retaining personnel that have arisen as a result of difficulties in manning the army.

In the United Kingdom, people tend to be attracted to individual types of armed forces rather than the military as a whole. Each type of armed force has its own identity, ethos, core values and standards. People tend to join the army, navy or air force. This is

reflected in the way each type of armed force conducts its recruitment and marketing campaigns. Each of them has its own motto (for example, for the land forces it is 'Be the best' and for the air force it is 'Be above the others').

The overall calculation of the personnel required to complete the armed forces staffing is performed by the Ministry of Defence. This is done taking into account the organisational and staffing changes of the military units and the leaving servicemen after the expiration of their contracts or ahead of schedule. After the analysis, the required number of servicemen by specialties (military type) in the respective armed force is assessed, after which competitions are announced to fill the vacancies.

One of the points of intersection of the types of armed forces are career centres providing information to the candidates. These are joint information centres where people can ask for information about their careers in the different armed forces. There are over 120 centres located throughout Great Britain. In addition, recruitment activities will be carried out by school counsellors, career officers, youth teams of the types of armed forces and regimental teams (for the land forces) for recruitment. Potential recruits are attracted to the types of armed forces in many ways, including advertisements on television, on the Internet and in the press.

In 2008, the House of Commons in the parliament drafted its 14th report to the Defence Committee, stating that the three types of armed forces were relatively successful in motivating but did not meet their recruitment targets. The report's findings show that recruitment is hampered by the following factors:

- Recruitment is influenced by economic growth and is facilitated in times of higher unemployment;
- The aging of the population reduces the number of people of working age in the long run;
- The share of ethnic minorities will increase in military service, as the number of ethnic minorities is growing faster than the population of the United Kingdom as a whole;
- The share of women as a workforce in the United Kingdom is expected to reach 50% by 2030;
- The increasing level of obesity and the resulting health problems will reduce the number of young people who can join the military;
- Young people are less interested in a lifelong career. [3]

The findings set out in the report can be considered valid for most developed countries and those in Europe. This makes it necessary to take them into account when preparing the concepts and activities for motivation in the army.

The trend shows that the armed forces are unable to meet their personnel needs, and this problem is deepening. The Land Forces, as the largest armed force, have the largest shortage of personnel, but it also exists in the specialties of the Navy and Air Force. This requires the UK Ministry of Defence (MoD) to develop a

comprehensive strategy for staffing and improving recruitment and retention. [2] This includes improving the accommodation and housing of the military and their families, comprehensive measures to support families and the working conditions of the military and civilians.

The general policy of the Ministry of Defence does not deprive the types of armed forces of the opportunity for their own initiatives and strategies for recruitment. For example, the Land Forces use the approach 'to-recruit-a-soldier-you-need-a-soldier'. Guided by the understanding that word of mouth is the most effective advertising, the Land Forces send young, trained soldiers to their hometowns and schools to talk to friends about life in the military. In addition, the Land Forces introduce a bonus scheme when entering in an attempt to attract more troops to the artillery and infantry, which gives good results at least initially.

Periodically, the types of armed forces conduct labour market surveys, which reveal a number of difficulties in entering the military. An Air Force Survey [2] finds, as an obstacle to entering the military, misconceptions about the required qualifications, lack of awareness of career opportunities and training provided, fears of military discipline, family problems, and detachment from civilian life. The main reasons that point to young people as an obstacle to joining the military are: distance from home, danger of injury or death, and obligation to carry out orders. This study shows that the focus for recruitment should be on providing accurate information to potential recruits about working in the armed forces.

The approach to the new recruitment strategy seeks to raise public awareness of the armed forces. As there are not enough people who join the military, the aim is to raise awareness of the opportunities that are offered. The idea is evolving that the armed forces should be separated from other private sector employers by defining the necessary target group and achieving its attraction.

The selection for each type of armed forces is again conducted separately, but the selection processes are similar in nature. All three types of armed forces have different procedures for selecting officers, sergeants and soldiers.

These include interviews, aptitude tests and some specific activities. There is a filtering system that selects people at the initial stage of application, after which those admitted are invited to an assessment centre for up to three days. Their general suitability for servicemen and abilities for the chosen specialty are assessed. In addition, medical examinations are performed to check weight, vision and hearing and to make a general assessment of physical fitness.

A 2004 study conducted by the Royal Air Force concerning leaving the military indicated a number of reasons for that. These include low job satisfaction and motivation for future work, problems and alienation from family, better job opportunities outside the Air Force [2]. The results of the study show that the demand for personnel is growing globally, which makes retention in the military difficult to achieve. Wages and lifestyles are in many cases more attractive in civilian life, and security is greater. In some specialties, such as pilots, the transfer of skills from military to civilian life further creates major problems with retention. Therefore, the Strategic Defence Review decided on a pilot education programme. It makes it possible to reimburse pilots for the costs of obtaining a civil air transport license for pilots in exchange for an obligation to serve up to 38 years of age or 16 years of service. The programme has not yet been evaluated, but much deeper motivational problems with quality of life, flying opportunities, pay, job satisfaction and job security have been identified.

In an attempt to solve the identified problems, the Ministry of Defence took steps to improve the work-life balance, provide opportunities to improve training and increase pay. An incentive for financial retention of pilots was introduced, but only as a short-term measure.

Years later, staff motivation problems were not resolved. A 2018 MoD survey showed shocking results that only two out of five servicemen were satisfied with the service, 35% were completely dissatisfied, and the fighting spirit in the formations had dropped significantly. [4]

In the same year 2018, the Court of Auditors of the United Kingdom prepared an audit report examining the approaches of the Ministry of Defence to develop the capabilities of the armed forces and their adaptation to the new challenges of the security environment. The report shows a critical shortage of personnel in the British Army. The figures show that as of January 2018, the armed forces number 137,300 people, which is 8,200 (5.7%) below the set number of 145,500, and there is a significant shortage of specialists in 102 specialties. Estimates show that by the end of 2020, the military will not be able to meet the intermediate target of recruiting 144,200 trained and qualified personnel. [5] For this reason, the Court of Auditors recommends that the Ministry of Defence reconsider its strategy for motivating, recruiting and retaining troops.

The audit report also states that the Ministry of Defence experiences an acute shortage of engineers, pilots, IT specialists and intelligence analysts. Furthermore, the lack of sufficient staff is likely to place an additional burden on other servicemen, leading to an extra outflow of personnel from the armed forces.

The Strategic Defence and Security Review in 2015 determined the maintenance of the number of Land Forces – 82,000 people, Navy – 30,450 people and the Air Force – 31,750 people, pending new equipment and future operations. [6] Then the Ministry of Defence set quite ambitious goals and plans by 2027 to increase investment costs for equipment and reduce those for property maintenance, which led to the need to hire qualified staff for their implementation.

The audit report finds that the goals set by the Ministry of Defence in 2015 are not based on a detailed assessment of the capabilities needed to perform Defence tasks. It is doubtful that the department will be staffed with 144,200 trained military personnel by 2020, achieving a diversity of 15% women and 10% black, Asian and other ethnic communities. [5]

The current problems with staff shortages in the United Kingdom are a reflection of a number of structural reforms over the years and ill-considered redundancies. Based on the 2010 Strategic Defence and Security Review, the MoD decided to release 17,000 servicemen by 2015. [7] Fortunately, a smaller number were released – 12,130 people, but these were trained specialists, including 6,120 engineers, logistics specialists and assembled teams, which the military later needed.

The reasons that led to the great shortage of staff are complex. It is reported that the MoD is aware of the scale of the problem of military shortages, but a more in-depth analysis of the reasons for the shortage in critical specialties is needed. Data on the leaving personnel are collected, but not fully analysed, as well as the specific factors causing higher levels of leaving in certain specialties. A more in-depth analysis of specialties and factors would make it possible to better understand where a larger shortage of personnel could occur and create risks for the performance of defence tasks. Some long-standing models for minimising problems by partially increasing pay make it more difficult to identify the real problems, as mentioned in some motivational theories. This necessitates the establishment of an effective body to carry out a strategic assessment of the future need for military personnel, which did not happen in the UK MoD. Therefore, the problem of critical shortages in 96 out of 102 specialties is not expected to be addressed in the next five years [5].

Since 2010, the British Army has introduced a number of changes to its personnel policies designed to improve motivation, recruitment and retention and make service conditions more attractive.

The first MoD program was introduced in 2010. The MoD introduced a 'New Employment Model' [8] aimed at improving motivation, recruitment and retention and developing an up-to-date support system for military personnel. The focus of the programme is on improvement in four areas: staff accommodation; evaluation and stimulation; working conditions and career development; training and education. With the introduced programme, the MoD consolidates its current motivation projects to the number of 30 within this programme.

The changes that are underlying include:

- Introduction of a new pay model in 2016 in order to eliminate the accelerated gradual increase of salaries and increase the split pay through targeted bonuses for activities with greater complexity, skills or qualification requirements;
- Assistance from the army for the purchase of the first home, which allows servicemen to receive a loan of up to 50% of their salary. The aid was introduced in April 2014 and subsequently extended until the end of 2018. The scheme provides an interest-free loan of up to 50% of the salary, limited to £ 25,000, to help servicemen buy a home. By the end of December 2017, the total amount reached over £ 202 million and help was provided to 13,400 military;
- Expansion of the project for a standard training loan for the military, including employees in the reserve from 2014.
- Experimental introduction of a service with flexible working hours in October 2015 in the Land Forces, Navy and medical authorities, educational and training structures for a period of one year is envisaged;
- Supporting outsourced training by purchasing licenses for support software for schools and their use in teaching and training in electronic and distance form from 2015.
- Enabling the return to service from January 2016;
- Introduction of a new system of rental fees for military families in the UK from April 2016, allowing the determination of fees by a new fairer and non-subjective method.
- Introduction of a new system for charging for family accommodation services abroad from April 2016, changing the valuation of accommodation and fees abroad.
- Improving training through additional training and higher education schemes from April 2016 and introduction of automated enrolment;
- Introduction of the 'Talent Management for Officers' project, providing new ways to identify, assess and develop the abilities of officers in order to recruit the right people to the right places.

The original design of the new model included 30 projects, but gradually the scale of the programme decreased and 19 projects remained, and the other 11 did not start, were completely eliminated or postponed. The introduction of the new flexible working hours is delayed due to the need for legislative changes. Instead, a part-time pilot project is being tested in the Navy, the Land Forces and the Air Force.

As a weakness of the new employment model it is stated that in 2014, when it was launched, it 'determined the criteria for the success of the project, but not for its progress' [5]. The MoD defined a set of proxy indicators to support the subjective assessment of benefits. It was only in April 2016 that the military department came to the conclusion that the programme did not have tangible indicators to measure success. This made the MoD update the programme in July 2017 and introduce new performance indicators, committing itself to assessing the impact of the programme and afterwards define the achievement of the 2014 baseline recruitment and retention targets.

In July 2017, the MoD concluded that it was too early to identify the impact of the programme and identified difficulties in finding out the effects of the changes due to the complexity of human behaviour, influenced by many factors and motives. The conclusion is that the programme gives greater opportunities to servicemen, and the negative impact of some changes is not recognised.

For example, the effect of the new pay model is likely to mask the MoD's policy of keeping service pay and the risk of retention if terminated. Projects with a negative impact on some servicemen have been identified, i.e. the changes in rent fees for accommodation of families, leading to their increase for 81% of the families.

The results of a survey of attitudes towards the armed forces in 2017 compared to 2010 show a decrease in military satisfaction after the introduction of the programme. Overall pay satisfaction in 2017 decreased to 33%, compared to 52% in 2010. Similarly, satisfaction with military life decreased from 60% in 2010 to 42% in 2017. [4] The analysis of these results shows that the measures set out in the programme are not adequate to the changing requirements for people's work.

Following the publication of the Strategic Defence and Security Review for 2015 and the shocking reports on the state of defence personnel, the MoD recognises the impact of the programme on the new employment model and seeks to improve the policy of military retention. As a result, two new projects are launched in January 2018 – 'Future Accommodation Model' and 'New Entry Proposal', while aiming for savings totalling £ 1.2 billion.

The model for future accommodation is aimed at reducing future investment costs and expanding the right to official accommodation for staff and their families. A trial in one city started in September 2019 and in two more in 2020 with four options for use: accommodation for single people; family accommodation; accommodation for free rent/private sector and acquisition of own dwelling (purchase or repayment aid). [9] The benefits of the project cannot yet be assessed, as this is expected to happen in 2023 and, depending on the outcome, the project will expand or not.

The newcomer proposal is aimed at those joining the army from 2020 on. It aims to improve recruitment and retention while reducing costs in the overall pay package by providing them more efficiently. Unfortunately, it fails to attract a sufficient number of supporters. Research shows that future generations have different career expectations and requirements and focus on diversity, freedom of choice and employment flexibility. This led to a review of the project by the MoD and its termination in May 2018.

As a result of the legislative changes made on 1 April 2019, flexible working hours for service were introduced. It allows full-time employees to work part-time (reducing it by 20% or 40%), work from home (no more than 35 days a year) or a combination of both. The limit for its use is set at no more than 1095 consecutive days or a total of 1460 days for each 12-year period. [10] The possibilities of the flexible service project are quite attractive and have gained many supporters after its introduction. They give servicemen with family problems the opportunity to be minimally away from home, and others to use the reduced working hours to solve important tasks. Given the changing requirements for work and those of people in society, it is a good prospect for both the performance of official duties and satisfaction with the military.

3. Conclusion

The considered model of motivation in the British Army reveals many problems, as well as good solutions for some of them. The conclusions that can be drawn are that easy solutions do not exist, and behind each of them there are both advantages and disadvantages. Although Great Britain has large defence resources, the analysis shows that they are not sufficient to maintain good

military pay comparable to the country's standard. It is not difficult to establish the relationship between pay and leaving. Servicemen need to be rewarded for the service to their country, because when they think they can earn more elsewhere and have a better quality of life, it is difficult to persuade them to stay. Patriotism is an important but not a sufficient condition for lifelong practice of a profession, and service in the professional army is a profession. It must satisfy all human needs, like any other profession, in order to be attractive and desirable.

The implemented projects, such as buying a home, flexible working hours and educational benefits, are good, but clearly insufficient. Other initiatives such as retention bonuses, tax breaks, and the possibility of returning to service are also popular. The military rightly acknowledges that improving staff recruitment will also improve retention due to a reduction in the workload of current employees. All this shows that it is essential to conduct an in-depth analysis of the reasons for leaving and to develop and follow a comprehensive strategy to motivate staff throughout their careers in order to overcome the problems of shortage of servicemen and increase their motivation.

4. References:

1. UK Defence Personnel Statistics, House of Commons Library, September 2019, p. 3
2. Recruiting and Retention of Military Personnel, Final Report of Research Task Group HFM-107, Research and Technology Organisation (RTO) of NATO, Oct 2007
3. Recruiting and Retaining Armed Forces Personnel, Fourteenth Report of 2007–08, House of Commons Defence Committee, July 2008, p. 30
4. UK Regular Armed Forces Continuous Attitude Survey Results 2018. MOD, Annual, United Kingdom, May 2018
5. Ensuring Sufficient Skilled Military Personnel, Report by the Comptroller and Auditor General, National Audit Office, April 2018, pp. 4 - 13
6. National Security Strategy and Strategic Defence and Security Review 2015, HM Government, Presented to Parliament by the Prime Minister by Command of Her Majesty, Williams Lea Group, UK, NOV 2015
7. Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review, HM Government, Presented to Parliament by the Prime Minister by Command of Her Majesty, The Stationery Office Limited, UK, Oct. 2010, p. 32
8. The New Employment Model, Ministry of Defence, Last updated 19 February 2018, <https://www.gov.uk/guidance/new-employment-model>
9. What you need to know about the Future Accommodation Model, Ministry of Defence, <https://www.gov.uk/government/publications/future-accommodation-model-what-you-need-to-know/what-you-need-to-know-about-fam> (Last updated 30 March 2020)
10. Guidance Flexible Service in the Armed Forces, MOD, Updated 7 May 2019, <https://www.gov.uk/government/publications/flexible-engagements-system-what-you-need-to-know/what-you-need-to-know-about-the-flexible-engagements-system>

Fire and explosive hazards for explosives and ammunition storage

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Abstract: This report presents the different types of explosives. It presents a classification of explosives according to their sensitivity to external influences, as well as a classification of the permissible quantities of explosives, ammunition and pyrotechnic articles that can be safely stored in one room. An analysis was performed and the possibility of safely combined storage of explosives and ammunition was considered. The need of applying specific requirements for the design and exploitation of sites for the production, storage and trade of explosives, ammunition and pyrotechnic articles is described.

Keywords: EXPLOSIVE HAZARD, EXPLOSIVES, AMMUNITION, STORAGE

1. Introduction

Incidents involving the production and storage of explosives and ammunition carry risks for both staff and population, as well as the environment. One of the main issues for reducing the harmful effects of explosive and munitions incidents is the determination of their fire and explosive hazard. The sites for the production and storage of explosives and ammunition are of interest, both in terms of the requirements imposed in their design and construction, and in terms of the permissible quantities for the combined storage of explosives and ammunition.

In this regard, the report examines the types of explosives and the basic rules for ensuring safety in activities related to the production, use and storage of different types of explosives and ammunition. [1-5]

Explosives are chemical compounds or their mixtures capable of exploding under the influence of certain external effects, releasing heat and gases.

"Explosion" means the very rapid transformation of a substance or mixture of substances from one state to another, which is accompanied by the release of heat and the formation of gases and vapors capable of mechanically destroying and displacing the environment.

2. Classification, comparison and analyses of explosives

According to Ordinance No. RD-02-20-1 of January 19, 2017 on the planning and design of constructions intended for the production, storage and trading of weapons, ammunition, explosives and pyrotechnic articles, depending on their sensitivity to External impacts and how explosives are used, explosives are divided into:

1. Initiating (primary);
2. Blasting (secondary):
 - a) explosive compounds;
 - b) explosive mechanical mixtures;
3. Throwing (gunpowder);
4. Pyrotechnic compositions (mixtures and articles).

The types of explosives and their basic representatives, depending on their sensitivity to external influences, are divided into four groups and are discussed in Table. 1.

Table 1: Classification of explosives depending on their sensitivity to external influences [6]

No	Types of explosives	Basic representatives
1.	Initiating (primary) explosives	- diazodinitrophenol; - thundering mercury (mercury fulminate); - lead azide; - teneres (lead trinitroresorcinat or TNRS); - initiating mixtures and compositions of mercury, potassium chlorate (bertoleth salt), ammonium sulfide (antimony), etc.
2.	Blasting (secondary) explosives: a) explosive compounds b) mechanical explosive mixtures	- tan, hexogen, octogen, tetryl, TNT, nitroglycerin, nitroglycol, picric acid, dinitronaphthalene, nitropentane and others. - nitrosilitrenes (dynamites); - dynamos; - plastic; - ammonium nitrate; - naphthalenes; - water-filled; - emulsion, etc.
3.	Throwing (gunpowder)	- smoke gunpowder - all types; - smokeless pyroxylin and nitroglycerin gunpowder - all types – etc.
4.	Pyrotechnic compositions and articles	compositions and articles having inflammatory, tear, smoke, sound, light and other effects

The initiating explosives are used to initiate the explosion (fig.1). They are very sensitive to temperature and mechanical influences. For this reason, they are used for the production of capsule igniters or detonator capsules. The most commonly used are mercury, lead azide, lead trinitroresorcinat and others.



Fig. 1 Initiation of an explosion

Blasting explosives are used in military equipment as projectiles, as well as for the preparation of explosives. They are also used for blasting in the mining industry. The most common explosives are TNT, ammonol (a mixture of TNT, ammonium nitrate and other substances), melinite, hexogen in the alloy with TNT, dynamite and many others (fig.2).



Fig. 2 Explosion

Metal explosives or gunpowder (fig.3) do not detonate but burn. They are mainly used for the production of shots - giving a bullet or cannon to a firearm, as well as for propelling rockets and some rockets. The most common are pyroxylin and nitroglycerin gunpowder.



Fig. 3 Gunpowder

Pyrotechnic mixtures and articles can be lighting, signaling, incendiary and can be used for the preparation of special ammunition. When burned, they give a pyrotechnic effect (fig.4).



Fig. 4 Pyrotechnic effect

The fire and explosion hazard of storing explosives, ammunition and pyrotechnic articles depends on the quantities of stored substances and materials, as well as on the possibility of storing the various articles in one room. A major problem with the storage of explosives is the storage of large quantities of materials, as well as the storage of explosives and ammunition that are not compatible for storage in one room or site. This, in turn, is a prerequisite for the occurrence of serious incidents with permanent material and non-material damage to the building stock, environment, life and health of the staff and population. Ordinance No. RD-02-20-1 of January 19, 2017 on the planning and design of constructions intended for the production, storage and trading of weapons, ammunition, explosives and pyrotechnic articles defines the maximum permissible quantities of different types of explosives, ammunition and pyrotechnic articles for storage in one room, depending on their degree of explosion hazard.

Table 2 presents the classification of explosives, ammunition and pyrotechnic articles and their permissible quantities placed in one room, identifying thirteen compatibility groups.

Table 2: Classification of explosives, depending on their sensibility to external influences and permissible quantities placed in one room [6]

No	Description of the explosive or article	Compatibility group	Permissible quantity in one room
1.	Primary explosives	A	150 kg
2.	A product containing primary explosives and not having two or more reliable safety devices. Some articles are also included, although they do not contain primary explosives, such as explosion detonators, assembled components, capsule igniters	B	2 000 000 pcs.
3.	Throwing explosives or other explosive deflagrant or article containing such substance	C	100 t
4.	Secondary detonating BB (pure chemical compounds or mechanical mixtures) or black gunpowder	D	50 t ^a
	Secondary detonating explosive device, in any case without fuse or throwing charge, or primary explosive device and equipped with two or more reliable safety devices		150 t ^b

5.	Product containing secondary explosion-free BB with metallic charge (other than charge containing flammable liquid or gel or hypergolic liquids)	E	150 t
6.	Product containing secondary detonation explosive, self-igniting, with a metallic charge (other than a charge containing flammable liquid or gel or hypergolic liquids) or with no metallic charge	F	150 t
7.	A pyrotechnic substance or article containing a pyrotechnic substance or an article containing both explosive and a substance having a luminous, inflammatory, tear-forming or smoke-forming effect (other than a water-active article or article containing white phosphorus, phosphides, pyrophoric substance, inflammatory fluid)	G	50 t ^c
8.	A product containing both explosive and white phosphorus	H	150 t
9.	A product containing both explosive and a flammable liquid or gel	J	150 t
10.	A product containing both explosive and a toxic chemical agent	K	150 t
11.	Explosive or substance or article containing explosive and presenting a particular risk (eg due to its water activity or the presence of hypergolic fluids, phosphides or pyrophoric substance) and necessitating the isolation of any species	L	150 t
12.	A product containing only substances with extremely low sensitivity to detonation	N	150 t
13.	Substance or article packaged or designed to limit within the package any hazardous effects caused by accidental actuation and, in the event of damage to the package in the event of fire, all effects of the explosion or the ejection of particles are so minor that almost no prevent fire fighting and other emergency measures in the immediate vicinity of the package	S	without restriction if it meets the relevant test of product

* The markings in the table are as follows:

a - the figure refers to pure chemicals in crystalline type and articles thereof.

b - converted to TNT.

c - calculated quantity in pyrotechnic mixture.

The exploitation of sites related to the production and storage of explosives, ammunition and pyrotechnic articles have a high risk of accidents and incidents. Due to the high fire and explosion

hazard, the facilities for the production and storage of explosives, ammunition and pyrotechnic articles have the risk of explosion, significant harmful effects on the environment or the spread of toxic or harmful substances during their exploitation. In this regard, an emergency plan of action is required for these sites, which contains:

- the biggest possible consequences for the staff, the population and the environment from an accident at the site, determined on the basis of a risk assessment;
- measures for limiting and eliminating the consequences of an accident at the site;
- personnel protection measures;
- the allocation of responsibilities and responsible structures and persons for the implementation of the envisaged measures;
- the resources needed to implement the measures;
- the time, necessary to be prepared for response and the procedure for informing the executive authorities when necessary to introduce disaster protection plans. [7]

In the planning and design and construction of sites for weapons, ammunition, explosives and pyrotechnic articles, qualitative and quantitative analyzes must be carried out in order to determine the type of explosion hazard, depending on the type and estimated quantity of the produced and / or stored weapons, ammunition, explosives and pyrotechnic articles, as well as risk assessment and management. Due to the high fire and explosive danger of explosives, firearms and ammunition, specific requirements are made to the sites for their production and storage, in terms of their location, the distance to neighboring buildings and equipment, electrical installations and etc. The specific requirements are intended to ensure safe distances for people and property inside and outside the territory of the sites that produce and store weapons, explosives and ammunition, as well as environmental hazards.

Depending on the degree of danger in the production, transportation, storage and exploitation, explosive materials can be divided into five groups:

1. First group - explosives with a content of nitroesters above 15% (dynamite), hexogen, tetryl, nitropenta, octagen;
2. Second group - ammonium nitrate explosives, TNT, mixtures of TNT with other nitro compounds, dinitrotoluene, dinitronaphthalene, explosives with a content of nitroesters up to 15%, phlegmatized hexogen, detonating cord, petroleum nitrates, emulsifiable;
3. Third group - smoke gunpowder, smokeless gunpowder, pyrotechnic compositions and articles made of them, fire-fighting cord and means for its ignition;
4. Fourth group - capsule detonators, detonators, delayers for detonating cord, non-electric systems and other explosive means;
5. Fifth group - finally fired explosive devices and anti-theft devices.

When carrying out explosive works, as well as any kind of activities related to explosives and ammunition, in view of their high fire and explosive characteristics, it is necessary to observe strict safety rules:

- explosive materials with different hazard groups are stored and transported / transported separately;
- the explosive materials are packed in such a way that they do not allow movement in the packaging;
- the gross mass of one pack of explosive materials may not exceed 32 kg;
- polymer and other materials with antistatic properties are used in the production and packaging of explosive materials;
- when carrying out blasting operations or other activities involving blasting materials, persons who are not related to their performance are not allowed in the protected area;

- explosive materials are not allowed to be thrown, dragged, overturned, struck or rubbed;
- maximum safety at work must be ensured when operating explosive materials;
- it is forbidden to smoke, to light a fire, to carry out fire and other open fire work at a distance of less than 100 m from the place where explosive materials are located;
- all activities with frozen nitro-explosives having a content of nitroesters above 15% are prohibited, except for defrosting.

For international transport (import, export and transit), it is also necessary to comply with the international norms of separation according to the degree of danger and compatibility. [8]

3. Conclusions

In conclusion, it can be noted that the study, classification and analysis of the types of explosives with regard to their fire and explosive hazards contributes to their adequate identification and proper risk assessment in the production, storage and handling of them.

The identification of hazards, the providing of safe distances for people and property inside and outside the territory of the sites that produce and store weapons, explosives and ammunition, as well as environmental hazards is a prerequisite for avoiding enormous property and human losses.

Proper identification of the fire and explosive hazard of different types of explosives and ammunition leads to a significant reduction in the risk of accidents and to the reduction of their consequences.

Compliance with the regulatory requirements, regulated by laws and regulations, minimizes the damage caused by incidents and accidents with explosives.

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4. References

1. Petkov S. P. "Model for formatting of high – speed long striking elements", mag. "Engineering sciences", 3/2008. IMSETH-BAS-Sofia, ISSN 1312-5703, (2008)
2. Petkov S. P. "Mathematical model for the interaction of the cumulative jet on dynamic protection", mag. "Engineering sciences", 4/2008. IMSETH-BAS-Sofia, ISSN 1312-5704, (2008)
3. Baranov V. L., Petkov S. P., "Modeling the behavior of metals under high-speed impact loading", mag. "Engineering sciences", 3/2005 XLII, page 41-48, IMSETH-BAS-Sofia, ISSN 1312-5702, (2005)
4. Petkov S. P. "Features of the interaction of the cumulative jet with active elements of dynamic protection", mag. "Engineering sciences", 1/2009. IMSETH-BAS-Sofia, ISSN 1312-5702, (2009)
5. Petkov S., Petkov P., Tumbarska A.. Modelling the Process of Forming the Initial Kinematic Parameters of the Fragmentation Field. *International Scientific Journal "Mathematical Modeling"*, 3, 1, Scientific Technical Union of Mechanical Engineering, ISSN 2367-8380, 41-43, (2018)
6. Ordinance No. RD-02-20-1 of January 19, 2017 On the planning and design of constructions intended for the production, storage and trading of weapons, ammunition, explosives and pyrotechnic articles, Obn. DV, br.11, 31/01/2017г.
7. Disaster protection act, Obn. DV, br.102, 19/12/2006
8. Rules on occupational safety in blasting operations, 01/07/1997

Hong Kong's innovative practices for better fire safety in tall buildings.

Conclusions for Bulgaria.

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Abstract: The information and ideas in this article are results of a six months PhD internship of the author Eng. Martin Ivanov in Hong Kong Polytechnic University and Hong Kong Fire Services Department in the field of fire safety in tall buildings in the second part of 2019. The main methods used in the paper are included observation and case studies. The reason for choosing this megalopolis for this internship was that in the world tall buildings database, developed by the Council on Tall Buildings and Urban Habitat, Hong Kong is the world leader with the biggest number of skyscrapers over 150 m with 355 buildings (runner up by New York City with 284). Also only in Hong Kong are half of the Top 100 tallest residential buildings in the world, some of them over 200 m.

A short retrospection of the worst fires in tall buildings in the world history was made and therefore the importance of the problem was shown clearly.

Two innovative practices from Hong Kong for better fire safety environment in tall buildings were shown – refuge floors and sky bridges. The first option provides a safety and fire proof place in different levels of the tall building. The second option represents bridges in different levels between two tall buildings which provide an opportunity for evacuation direction not only downstairs, like in “normal situation” in case of fire, but also upstairs, using the sky bridge and then going downstairs and evacuation from the next tall building. Conclusions for Bulgarian fire safety requirements in the field of tall buildings were made.

Keywords: HONG KONG; FIRE SAFETY; TALL BUILDINGS; SKYSCRAPERS; REFUGE FLOOR; SKY BRIDGE

1. Introduction

Nowadays in the modern times fire safety in new tall buildings all around the world is a big challenge for fire engineers with the weapons of active and passive systems as well as innovative fire engineering approaches. There are some counties (towns) in Asia-Oceania region, where there are lots of tall buildings and the fire authorities and population have a big experience to build, work and live in these kinds of buildings.

Hong Kong is a great example for a modern town with lots of tall buildings. It is in the first place for the biggest numbers of skyscrapers over 150 m in the world with 355 finished buildings followed up by New York with 284[1].

A picture of Hong Kong with its skyscrapers is shown in Fig.1.



Fig. 1 Hong Kong
(Picture made by the author M. Ivanov in 2019)

“Tall buildings” is a topic of competition of the biggest economies in the world. A general definition about tall building is not an easy task.

The Council on Tall Buildings and Urban Habitat (CTBUH) is non-profit organization in the field of tall buildings and sustainable urban design based in the city of Chicago, United State[1], which announces the title of “The World’s Tallest Building” and is widely considered to be an authority on the official height of tall buildings database.

According to the classification of CTBUH there is not absolute definition worldwide about tall building. The definition is

subjective, considered against one or more of the following categories: Height Relative to Context (some multistory buildings may not be considered in high-rise city as Hong Kong for example, but the same building may be considered as a tall one, taller than the others in a provincial city); Proportion (there are numerous buildings that are not particularly high, but are slender enough to give the appearance of a tall building) and Embracing Technologies Relevant to Tall Buildings (such as specific vertical transport technologies, structural wind bracing as a product of height).[2]

The CTBUH also announced definitions about “supertall building”, which is tall building 300m or taller and “megatall building” which is tall building 600m or taller. As the moment of publishing this article there are worldwide 150 complete supertall buildings and only 3 megatall complete buildings, which are Burj Khalifa in Dubai, United Arab Emirates, 828m, completed in 2010, Shanghai Tower in Shanghai, China, 632m, completed in 2015 and Abraj Al-Bait Clock Tower in Mecca, Saudi Arabia, 601m, completed in 2012.

The CTBUH ranks the height of buildings using three different methods[2]:

- Height to architectural top: This is the main criterion under which the CTBUH ranks the height of buildings. Heights are measured from the level of the lowest, significant, open-air, pedestrian entrance to the top of the building, inclusive of spires but excluding items such as flagpoles and antennae. Classification from this method is shown in Fig.2.

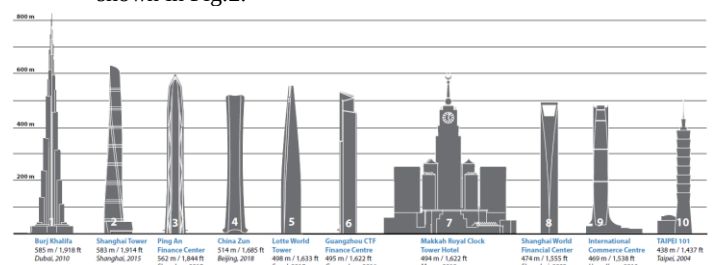


Fig. 2 First method for classification of tall buildings and Top 10 tallest buildings in this classification

- Highest occupied floor: Height to the floor level of the highest floor that is occupied by residents, workers or other building users on a consistent basis. Classification from this method is shown in Fig.3.

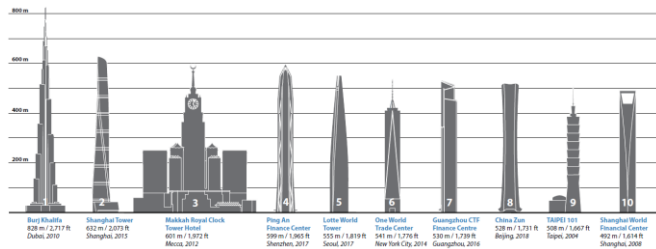


Fig. 3 Second method for classification of tall buildings and Top 10 tallest buildings in this classification

- Height to tip: Height to the highest point of the building, including antennae, flagpoles, and technical equipment. Classification from this method is shown in Fig.4.

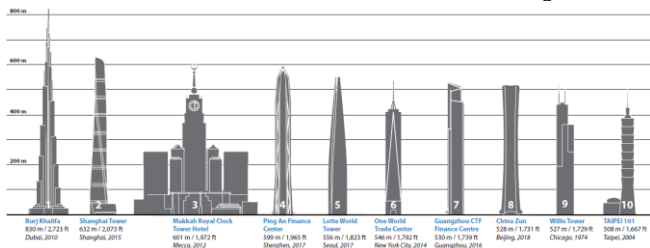


Fig. 4 Third method for classification of tall buildings and Top 10 tallest buildings in this classification

The tallest building in Bulgaria is an office building (128 m)[3] in Sofia and the highest one which is in construction is planned to be 202 m [4].

From firefighters' point of view the definition about tall building looks much easier. Tall building from a firefighter's point of view is every building in which the highest level cannot be reached by fire serial ladders. In most medium to large cities, the fire aerial ladder is typically 30 meters.

Normally the definition is pointed in the national fire codes. In Bulgaria all buildings with height above 28 m are categorized as tall buildings[5].

In HK all buildings of which the floor of the uppermost floor exceeds 30 m above the point of staircase discharge at ground floor level are categorized as high-rise (tall) buildings[6].

In China all residential buildings above 27 m and all office building above 24 m are categorized as tall buildings [7].

In USA all buildings more than 75 feet (23 meters) in height, measured from the lowest level of fire department vehicle access to the floor of the highest occupant story are categorized as tall buildings [8].

Tall buildings are the perfect decision for business but this is a big challenge for the firefighters in case of fire or emergency.

A short retrospection of the worst fires in tall buildings in the world is given in the next point, which is the biggest reason to implement so strict active and passive requirements for tall buildings. Also interesting decisions about better fire safety have to be seen by cities like Hong Kong with lots of tall buildings. These kinds of decisions are refugee floors and sky bridges.

Conclusions for Bulgaria were made in the conclusion.

2. A short retrospection of the worst fires in tall buildings

There are a lot of different reasons about fires in tall building. These are aircraft crashes, unintentional fires associated with daily life, façade fires, arsons and many more.

Here is a retrospection of top fire worst fires in tall buildings with human casualties.

- 1 and 2 World Trade Center, New York, US, 2001

Deaths: 2606

The World Trade Center twin towers in New York were 110-floors steel construction office buildings completed in 1973. With a hundred of tenants including international trading companies, investment and law firms, etc. there were more than 5500 people working in the buildings. The date of 11th September, 2001 is remembered as the worst day in fire history all around the world. It's a turning point of fire science and firefighting action in tall buildings after the terrorist attacks when two hijacked aircrafts Boeing 767 hit the towers and aftermath fires and collapses[9]. As a result of the 2606 people who were in and around the Twin Towers were killed. A total of 343 firefighters, 72 law enforcement officers and 55 military personnel lost their lives working as well.

- Joelma Building, São Paulo, Brazil, February 1, 1974
Deaths: 179–189

The building's height is 105 m with 25 floors above ground, a combined building with offices and residential estates. From a fire protection point of view the building was so bad place to stay in – no fire alarm, no sprinkler system, no emergency lights, single staircase and no emergency lift.[10]. It was a normal working day, Friday when around 8:50 AM a small fire occurred in an air conditioner in a widow of the twelfth floor of the building. The fire increased so rapidly because of the all flammable materials in the building – carpets, furniture, desks, ceilings tiles, curtains all of them so combustible. After only 20 min all the façade was burning. Unfortunately, at this time there were 756 people inside the building. Some of them managed to escape, but there were others trapped in the building. Some of them when there was no way down, went up to the roof of the building, waiting for rescue. Unfortunately, this fire cost a lot of lives – in total 179 people died, including 13 people in the lift and 40 jumped from the windows. After 1974 and this big fire, fire regulations in Brazil were strictly updated. The fire in Joelma building in São Paulo was the worst fire in tall building in the world's history until the date of September 11, 2001.

- Taeyongak Hotel, Seoul, South Korea, 1971
Deaths: 163

The building has 21 floors above ground, a combined building separated vertically to offices from the second to twentieth floors and hotel with 223 rooms from the sixth to twentieth floors. From a fire protection point of view the building had working fire alarm (not connected to the fire department), heat detectors in the hotel rooms and manual pull station in every floor, as well as standpipe system and two inside the building staircases. These two internal staircases were designed for use in case of lift failures and not as fire exits, and filled with smoke during the fire, acting as chimneys[11]. A fire occurred just on Christmas day 25th of December, 1971 started from a coffee shop in the second floor[12]. 20kg LPG cylinder failed and the fire increased so rapidly. Fire attacks were mainly from outside the building using fire ladders. The water supply from the street hydrants was limited, so mainly they used tank trucks. Around a hundred people were rescued by the fire services, including six people rescued from the roof of the building with helicopters. Taeyongak Hotel fire is deadliest hotel fire in world's history with 163 victims[13], including 40 people jumping from the windows, holding mattresses in an attempt to survive the fall.

- Asch Building, New York City, United States, 1911
Deaths: 146

Asch Building is 10 floors building located in Greenwich Village, Manhattan. It still exists and today it's known as The Brown building, owned by the New York University[14]. In 1911 on the last three floors there was a Shirtwaist Factory with around 500 workers, mainly young emigrants - women and girls. The factory produced women's blouses, known as "shirtwaists" with highly flammable textile materials. The building was well fire designed by its time with number of exits, including two freight elevators, a fire escape, and stairways down to street. The fire occurred at around 4:40PM on the 25th of March, 1911 in a trash bin under one of the cutter's table on the 8th floor. The Fire Marshal

concluded that the likely cause of the fire was the disposal of an not extinguished match or cigarette in the scrap bin, which held two months' worth of accumulated cuttings by the time of the fire[15]. Although the floor had all mentioned above fire provisions, flames prevented workers from descending the Greene Street stairway, and the door to the Washington Place stairway was locked to prevent theft by the workers. The locked doors allowed managers to check the women's purses[16]. Terrified employees crowded onto the single exterior fire escape ladder, which twisted and collapsed from the heat and overload. The fire costs the lives of 146 people, 123 women and girls aged between 14 and 43 years old and 23 men. This fire was the deadliest industrial disaster in the history of the New York city, and one of the deadliest in U.S. history[17].

- Winecoff Hotel, Atlanta, United States, 1946
Deaths: 119

The hotel has 15 floors above ground. From a fire protection point of view the building was advertised as a "absolutely fireproof"[18] at that time. The steel structure of the building had fire protection by structural clay tile and concrete fireproofing[19]. The building had H-shaped corridor with (only) one stairway with non-combustion construction, but without fire doors and two elevators. Standpipe system on each floor was installed. There was not an automatic sprinkler system. The hotel is located just next to the fire department. Hotel interior was made by combustible material. Unfortunately, the fire started at the night on the 7th of December, 1946 and was first noticed by the bellboy of the hotel at 3:15 AM. The cause of the fire is unknown but the origin was on the third floor in temporary placed items near the stairway. All the people in hotel were trapped by the smoke in the stairway. At that time in that hotel there were 304 people, including the hotel's owner, who had been living there. The first call to the fire department was made at 3:42AM and the first engine and ladder arrived after 30 seconds. The building fire alarm didn't sound at all. Mainly the evacuation was made by the fire ladders, but the fire was notable for the number of victims who jumped through the windows to their deaths. Firefighters were hampered, and in some cases injured, by falling bodies. Winecoff hotel fire is deadliest hotel fire in US history with 119 victims, including the owner of the hotel, 65 people are injured and 120 were rescued uninjured[19].

As shown from the retrospection the causes are so different in the different cases but as a general conclusion we can say that the fire safety in tall buildings is a big challenge and we have to think a lot about it.

Apart from the conventional active and passive fire requirements there are lots of innovative practices for better fire safety environment. Examples are refuge floors and sky bridges.

3. Refuge floors

A definition for refuge floor is given in the Hong Kong local code and means a protected floor that serves as a refuge for the occupants of the building to assemble in case of fire, for a short period of time, before reaching an ultimate place of safety[20]. Refuge floors should be provided for all buildings in Hong Kong exceeding 25 floors in height above the lowest ground floor.[21]

The requirements for the refuge floor are as follows: the net area for refuge should be not less than 50% of the total gross floor area of the refuge floor and should have a clear headroom of not less than 2300mm; the minimum dimension of the area for refuge should be at least 50% greater than the width of the widest required staircase passing through the refuge floor; the area for refuge should be open-sided above safe parapet height on at least two opposite sides to provide adequate cross ventilation; the open sides should comply with the requirements; any required staircase passing through a refuge floor should be discontinued at such level so that the exit route is diverted to pass over part of the refuge area before it is continued to exit downwards; every part of the area for refuge should be provided with at all time with lighting of a horizontal illuminance at floor level of not less than 30 lux; refuge floor should

be provided with fire service installation and equipment; refuge floor should be served by fireman's lift but no other lifts. The fireman's lift should not open onto the refuge floor in normal operation and the lift landing door at this level should be locked at all times until automatically released upon actuation of the fireman's switch.

A picture of refuge floors is shown in Fig.5.



Fig. 5 Refuge floors in tall buildings in Hong Kong
(Picture made by the author M. Ivanov in 2019)

4. Sky bridge

The sky bridge represents bridges in different levels between two tall buildings which provide an opportunity for evacuation direction not only downstairs, like in "normal situation" in case of fire, but also upstairs, using the sky bridge and then going downstairs and evacuation from the next tall building.

Normally there are not requirements about sky bridges in the codes for tall buildings. Sky bridges are not only an emergency element in the building, but also an architectural and comfort aspect for the occupants.

The idea for sky bridges is not new. There are a lot of buildings all around the world with sky bridges: the National Congress Complex built in 1960 in Brazil; Kajimi Corporation Headquarter built in 1971, Kashii Twin Towers built in 1989, Umeda Sky Building built in 1993 all of them in Japan; Tuntex & Chein Tai Tower built in 1997 in Taiwan; Petronas Towers built in 1998 in Malaysia; Plaza 66 Building built in 2000 in China; Kingdom Centre built in 2001 at Saudi Arabia and many more.

An examples from Hong Kong (Nina Tower) and Kuala Lumpur, Malaysia (Petronas Towers) are shown in Fig.6 [22].



Fig. 6 Sky bridge in Nina Tower in Hong Kong and a better example from Kuala Lumpur, Malaysia
(Pictures made by the author M. Ivanov in 2019)

5. Conclusion

In Bulgaria there are not so many tall buildings.

In the local fire codes there are lots of conventional active and passive fire requirements, which nowadays are good enough.

In the near future more and more tall buildings will be erected in the big cities and fire safety of tall buildings will be a big challenge because we don't have a big experience in the topic. That's the reason to take a look at East in our case and study the codes and mistakes of more experienced nations.

Upgrading in the Bulgarian fire codes is needed.

Fire engineering approach is not so common in Bulgaria but when big innovative and high architectural buildings starts to grow soon, this approach will be the main item used by the engineers to provide fire safety.

In some codes there is a definition about fire engineering approach, which is an alternative to the prescriptive requirements way to provide a fire safety environment in a level of safety not lower of the prescriptive requirements. This fire engineering approach shall be scientific defended by the engineers in front of the local fire authorities for approval.

Some of the interesting options for fire engineering approach are just the refuge floors and sky bridges as an innovative fire safety decision.

When we take a look in the history we can see that almost in every country with lots of tall buildings strict requirements are implemented after big disaster fires with lots of deaths and population disagreements and protests afterwards. Recent examples are Garley building fire in Hong Kong on November 20, 1996 with a total of 41 deaths[23], unnamed high-rise apartment block fire in Shanghai, China on November 15, 2010 with a total of 58 deaths[24] as well as Grenfell Tower fire in London, United Kingdom, on June 14, 2017 with a total of 72 deaths[25] [26]. All of these fires are followed by big, strict changes in tall buildings requirements. Also the terrorist attacks in New York are a benchmark of the new beginning of fire safety science in the whole world.

Fire safety of tall (and not so tall, old) buildings' façades is another aspect and really big challenge, as we can see the example in the Grenfell Tower fire in London. This topic must be heavy researched and stricter requirements must be implemented because most of the thermal insulation materials used in the façades are combustible (EPS and XPS). Fire barriers with non-combustible materials in the façades in the fire codes are not enough to stop a well-developed fire.

There are two options. The first one is to act preventive, proactive trying to implement new style of fire requirements for tall buildings in advance looking from more experienced nations. The second option is to wait for the bad experience and implement new fire requirements in HOT environment afterward. In the second option lots of deaths are possible.

It's our Bulgarian decision!

An example of how difficult is to act afterwards when a disaster has already been on scene is the COVID-19 pandemic. Here are heavy decisions in heavy times, not only for Bulgaria, but for EU and whole world.

6. References

1. Council on Tall Buildings and Urban Habitat, <https://www.ctbuh.org/about/about/>.
2. CTBUH Height Criteria, <https://www.ctbuh.org/criteria/>.
3. Capital Fort Business Center, https://en.wikipedia.org/wiki/Capital_Fort. 2020.
4. List of tallest buildings in Bulgaria https://en.wikipedia.org/wiki/List_of_tallest_buildings_in_Bulgaria. 2015.
5. Regulation No. I-1971 of 29.10.2009 for construction-technical rules and regulations for ensuring fire safety, Ministry of the Interior of Bulgaria and Ministry for Regional Development and public works of Bulgaria. 2009.
6. Codes of Practice for Minimum fire service installations and equipment and inspection, testing and maintenance of installations and equipment, F.S.D. website, Editor. Last revision: April 2012.
7. Regulation No. GB50016-2014, Revision 2018, "Code for fire protection design of buildings", issued by Ministry of Housing and Urban-Rural Development of the People's Republic of China.
8. NFPA 101 Life Safety Code, Paragraph 3.3.36.7, N.F.P. Association, Editor. 2012: Quincy, Massachusetts, USA.
9. World Trade Center Building Performance Study, Federal Emergency Management Agency, FEMA, May (2002).
10. Mungler, S. "The Towering Inferno for real: The story of the Joelma Building disaster". Retrieved 2015-12-02. <https://seanmunger.com/2015/02/01/the-towering-inferno-for-real-the-story-of-the-joelma-building-disaster/>.
11. "Fire turned hotel into death-trap chimney expert". South China Morning Post. United Press International. 28 December 1971.
12. "Insufficient fire exits pushed up hotel deaths". South China Morning Post. 30 December 1971. p. 18.
13. 章孝思 (Feb 1985). 《高层建筑防火》. 中国建筑工业出版社. ISBN 711200750X.
14. Gale Harris (March 25, 2003). "Brown Building (formerly Asch Building) Designation Report" (PDF). New York City Landmarks Preservation Commission.
15. "Complete Transcript of Triangle Fire". Cornell University ILR School DigitalCommons@ILR. November 1, 1911.
16. Lange, Brenda. *The Triangle Shirtwaist Factory Fire*, Infobase Publishing, 2008, p. 58.
17. "The Triangle Shirtwaist Factory Fire". OSHA. June 10, 2015.
18. Spignesi, Stephen J. (2002). *Catastrophe: The 100 Greatest Disasters of All Time*. Citadel Press. pp. 267–269. ISBN 0-8065-2558-4.
19. McElroy, James K. (January 1947). "The Hotel Winecoff Disaster" (PDF). Quarterly of the National Fire Protection Association. 40 (3).
20. Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment (FSI Code), Fire Services Department, Government of the Hong Kong Special Administrative Region. 2012.
21. Code of Practice for Fire Safety in Buildings (FS Code), Buildings Department, Government of the Hong Kong Special Administrative Region. 2011.
22. https://en.wikipedia.org/wiki/Nina_Tower.
23. Yau Wai-ping (22 November 1996) "Survivors recount their horror ; Workers relive escape from blaze Archived 22 May 2011 at the Wayback Machine", The Standard.
24. China's police chief calls for thorough investigation on cause of Shanghai high-rise fire". Xinhua. Xinhua News Agency. 16 November 2010.
25. "Grenfell Tower floorplan shows how 120 flats were packed into highrise". The Telegraph. Telegraph Media Group. 14 June 2017.
26. Chelsea, R.B.o.K.a., "Grenfell Tower Regeneration Project Engagement Statement" (PDF). October, 2012.

Investigation of the possibilities for the use of new items in the equipment for fire extinguishing in critical infrastructure sites

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Summary: The report examines the possibilities for using new modern elements, materials and their combination in the equipment for personal protective equipment of employees from fire safety and civil protection, part of the unified rescue system, in case of accidents in critical infrastructure.

KEY WORDS: FIRE SAFETY, PERSONAL PROTECTIVE EQUIPMENT

1. Introduction

With the development of technologies, the production, storage and use of substances with different physical and chemical properties, leads immensely to higher requirements for the protection of fire safety personnel involved in the reduction and elimination of accidents caused by fires [1-4]. The world's leading and economically developed countries have specific requirements for the equipment of fire safety officers depending on the nature of the incident.

For example, in the National Fire Protection Association (NFPA) in the United States as a global self-funded non-profit organization, established in 1896, dedicated to preventing death, injury, property and economic loss due to fires, electrical and associated hazards, has introduced a series of standards in the field. Regarding the personal protective equipment of the firefighter, the classification NFPA 1994, Standard for protective ensembles for the first response to the events for the fight against terrorism of the chemical, biological, radioactive and nuclear (CBRN) has been introduced.

It sets out design, certification and minimum requirements for the implementation of CBRN safeguards for the first response to CBRN incidents. Terrorism agents and first responders exposed to victims or materials during assessment, eviction, rescue, triage, decontamination, treatment, site security, crowd management and incident protection operations involving terrorism agents. Within the NFPA protective clothing project, protective equipment is designed to provide full body protection; torso, hands, legs, head, arms and feet. All NFPA 1994 clothing is worn with air breathing apparatus.

Despite the variety of personal protective clothing determined depending on the specifics of each case of fire or disaster, this report will conduct a theoretical study of the possibilities of using new modern elements, materials and their combination. Equipment consisting of personal protective equipment and clothing is classified into four levels, namely protective clothing for firefighters used in general firefighting activities to protect against heat, pollution, wetting, wind and other harmful effects.

A problem addressed in this report is the lack of a unified model of protective clothing depending on the type of protection, the shape of the clothing, so as to provide versatile protection of the body and to be comfortable to use.

Table № 1 presents the NFPA protection class of the firefighter's personal protective equipment.

Protective clothing for firefighters must provide the highest possible level of protection. In their design, in addition to the level of protection, the comfort of wearing must be taken into account, there must be freedom of movement when performing the relevant fire-fighting and rescue activities under the foreseeable conditions of use [5-7].

Protective clothing for firefighters must be designed and manufactured in such a way as to exclude the possibility of risks and other undesirable effects under the foreseeable conditions of use.

The materials from which protective clothing for firefighters and their parts are made, including decomposition products, must

not have a detrimental effect on the hygiene and health of the firefighter.

NFPA Protective Ensemble Class	Level of Skin Protection	Level of Respiratory Protection	Notes Concerning Use
1 Class (most protective) Level A equivalent	Protective ensemble totally encapsulates wearer and respiratory protective equipment	Mandatory use of NIOSH-certified CBRN self-contained breathing apparatus (SCBA)	Establishes minimum level of protection for first responders against: - Toxic vapors, liquids, and particulates during hazardous materials incidents - Specific chemical and biological terrorism agents in vapor, liquid-splash, and particulate environments during CBRN terrorism incidents
2 Class Level B equivalent		Requires use of NIOSH-certified CBRN self-contained breathing apparatus (SCBA)	For use in terrorism incidents involving vapor or liquid chemical or particulate hazards where concentrations are at or above levels immediately dangerous to life or health
3 Class - Level C equivalent		Requires use of NIOSH-certified CBRN air-purifying respirators (APRs) or NIOSH-certified CBRN powered air-purifying respirators (PAPRs)	For use in terrorism incidents involving low levels of vapor or liquid chemical hazards where concentrations are below levels immediately dangerous to life or health

4 Class (least protectiv e) Gallery - Level D equivale nt	Ensembles not tested for protection against chemical vapor or liquid permeability, gas- tightness, liquid integrity	Permits use of NIOSH- certified CBRN air-purifying respirators (AP Rs) or NIOSH- certified CBRN powered air- purifying respirators (PA PRs)	For use in terrorism incidents involving biological or radiological particulate hazards only where the concentrations are below levels im mediately dangerous to life or health
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The surfaces of any part of the protective clothing for firefighters which are or may come into contact with the firefighter during use must not be rough or have sharp edges and protrusions which could cause severe irritation or injury to the firefighter during operation of clothing

Protective clothing for firefighters must, to the least extent, impede movement, occupy various positions of the body and must not cause movements that would endanger the firefighter using the clothing or his colleague working near him.

Protective clothing for firefighters must be designed and manufactured in such a way that:

- be placed as very easily and tightly as possible on the body of the firefighter and remain in place throughout the period of work them, taking into account the high temperature, adverse environmental conditions, movements and positions of the body of the firefighter.
- allow possibilities for their adaptation to the morphology of the firefighter by all appropriate means, such as adjustment and fastening devices or by a sufficient variety of sizes.

Protective clothing for firefighters must be as light as possible without affecting the strength of their construction and their effectiveness when working in or around places with high temperatures and humidity. They must also be strong enough to withstand the harmful effects of direct fire and work in areas with high temperature levels, as well as to meet the additional requirements associated with specific risks. In addition, protective clothing for firefighters must have high-visibility reflective strips.

The main current normative act for determining the requirements for protective clothing for firefighters is the Bulgarian State Standard (BDS) Euronorm (EN) 469 [8]. This European Standard specifies minimum levels of requirements for the performance of protective clothing used in firefighting operations and related activities, such as rescue and disaster relief operations. This clothing does not provide sufficient protection during operational actions related to cleaning of released chemical products and gases

This European Standard includes general requirements for the performance of clothing, minimum performance levels of the materials used, as well as test methods to be used in determining these performance levels. The required levels of performance can be achieved by using one or more garments.

Protective clothing for firefighters must be made of waterproof products and heat-resistant materials, providing protection against penetration of water, heat, flame, sparks and cold to the body of the firefighter. It (on the inside) must bear the pictograms required by the standard, including the CE marking, proving its intended use as a personal protective equipment for firefighters.

Protective clothing for firefighters must be able to remove moisture from the body of the firefighter, because under intense stress a person's body reaches a state of profuse sweating. They must also allow easy and quick dressing and undressing, given the nature of the work and the fact that every second lost is valuable. It should not be forgotten, however, that they must also have a level of protection under current legislation [8].

As garments are directly exposed to all kinds of dirt, they must be designed to be washed in washing machines at a certain water temperature and/or by dry cleaning, without damaging their

protective functions, reflective strips or in general to damage the integrity of protective clothing for firefighters.

The tensile strength of the outer material of the garment when tested in the longitudinal and transverse directions must not exceed that specified in the Standard "Protective clothing for firefighters. Requirements for the implementation of protective clothing for firefighting" [8]. Respectively, the tensile strength of the seams of the main connecting seams of the outer material of the garment must not be less than that specified in the same standard. Torn resistance of the outer material of the garment in the longitudinal and transverse direction must also comply with the standard

Protective clothing for firefighters must not change their dimensions (longitudinally and transversely), regardless of the number of cleanings, with a coefficient clearly specified in the standard [8]. They must have good abrasion resistance, which does not allow rapid disintegration of the outer tissue and fibrous balls on the surface of the outer fabric. All materials used and clothing in general must have the necessary durability, be easy to clean and wash (by hand and in washing machines).

Protective clothing for firefighters must be multi-layered and consist of:

- Outer layer - must be made of materials with high thermal protection and antistatic fibers in proportions specified again in the standard [8].

- Intermediate layer - flame retardant breathable membrane, protecting from the penetration of liquids.

- Lining - insulation of flame retardant stitched material. [9-11].

The type and cut of the models must be consistent so as to ensure a higher degree of protection from more harmful factors and to provide good freedom and comfort when moving. The garments must be service-resistant and reusable. Which in turn requires new engineering solutions regarding the type of materials used to make the garments.

The development of technologies, respectively, affects the materials from which the clothes of firefighters are made, as there is a tendency to increase the use of technical textiles, due to the possibility of "property management".

The use of technical textiles is growing from year to year and the companies of the highly developed countries are entering the production of technical textiles more and more intensively.

A very important property of technical textiles, especially for fire-resistant clothing, is its limited oxygen index (LOI) - the percentage of oxygen in the environment than the flame. This property is very important for organic textiles, which are used near a source of flame - clothing for firefighters. The LOI has been introduced into the international standardization organization ISO through the ISO 4598-2 Limited Oxygen Index.

Fibers with a LOI of more than 23 are fire-resistant in a normal environment (after elimination of the flame source they are extinguished). On the other hand, the LOI of paraaramide and metaaramide are the same, but the flammability of the tissues of these fibers is different and depends not only on the nature of the fibers of the stock, but also on the parameters of the tissue structure (weaving, linear densities and thread set) also [12].

The most important of the mechanical properties of fabrics for protective clothing against heat and fire are tear strength, air permeability and surface density. There are many fabric structures that are used to make fireproof clothing. These fabrics differ in the percentage of meta- and para-aramid fibers, in the linear density of the yarns, in groups, in the surface density, and so on. Thus, they are produced not only from different meta-aramid yarns ("Nomex", "Kermel", "Conex"), but also have different fabrics - each company "Du Pont", "Akzo Nobel", "Rhône - Poulenc", "Teijin" and others) for fire-resistant clothing for the production of proposed own fabrics. Table №2 shows the main characteristics of various meta-aramid fabrics used to make protective for firefighters.

Table №2 - some characteristics of metaaramid tissues

Property	Nomex III twill 3/1	Nomex Delta TA twill 3/1	Kermel HTA ripstop	Teijinconex Xfireplain
Percent composition, %	Nomex – 95 paraaramid–5	Nomex – 75 paraaramid– 23 carbon – 2	Kermel–64 paraaramid–36	Conex – 90 paraaramid–10
Superficial density, g / m ²	265	205	200	210
Tensile strength N Based on On the fabric	1440 1250	1080 1045	2000 2000	1400 1200
Tear strength, N Based on On the fabric	56 60	46 49	200 200	140 120
Thread length, mm	10	13	5	10
LOI [%]	28	28	30-32	30

The fabric characteristics presented in Table 2 suggest that the fabrics used differ not only in structure but also in end-use properties. Protective clothing for firefighters according to standard EN 469 is designed to protect the body by excluding the head, arms and legs from the effects of heat and flame, as well as to prevent the ingress of water from the outside, but must also be breathable.

Studies have shown that various attempts have been made to prove the fire-retardant properties of metaaramid tissues, Fig.1

**Fig.1** Mannequins dressed with "Nomex" for test in a camera

For example, the company "DU PONT" publishes the following results:

The experiment was performed in a chamber, on a male mannequin, equipped with 122 heat sensors located over the entire surface. The manikin was exposed to an abundant flame (intensity of thermal radiation 2 cal / cm² / s, corresponding to 84kW / m²) on all sides for 4 seconds (simulation of an explosion in an airfield).

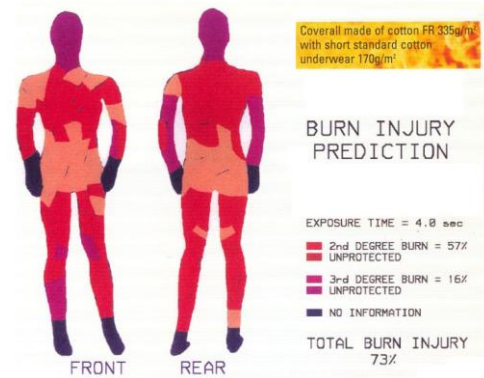
On the first attempt, the mannequin was dressed:

- outerwear - flying overalls made of cotton fabric with an area of 335 g / m²;
- underwear - summer type cotton underwear (T-shirts with short sleeves and shorts with short legs) made of fabric with an area of 170 g / m².

As a result of the impact of the flame on the mannequin, the sensors have detected temperatures that cause the following damage:

- 2nd degree of burning - on 57% of the total area of the mannequin;
- 3rd degree of burning - 16% of the total area of the mannequin.

The total area of lesions in this experiment was 73%, Fig.2

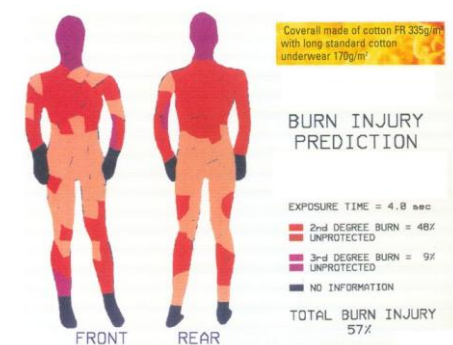
**Fig.2** First attempt, burn rate

On the second attempt, the mannequin was dressed:

- outerwear - flying overalls made of cotton fabric with an area of 335 g / m²;
- underwear - winter type cotton underwear (T-shirts with long sleeves and long leg pants) made of fabric with an area of 170 g / m².

As a result of the impact of the flame on the mannequin, the sensors have detected temperatures at which the following damage is caused:

- 2nd degree of burning - on 48% of the total area of the manikin;
 - 3rd degree of burning - 8% of the total area of the manikin.
- The total area of lesions in this experiment was 57%, Fig.3

**Fig.3** Second attempt, burn rate

On the third attempt, the mannequin was dressed:

- outerwear - flying non-combustible overalls made of metaaramid fabric with an area of 150 g / m²;
- underwear - non-combustible winter type underwear made of a mixture of meta-aramid fabric and viscose FR (long-sleeved T-shirts and long-legged pants) made of non-combustible fabric with an area of 170 g / m².

As a result of the impact of the flame on the manikin, the sensors have detected temperatures at which the following damage is caused:

- 2nd degree of burning - on 6% of the total area of the manikin;

- 3rd degree of burning - 7% of the total area of the manikin.
The total area of lesions in this experiment is 13%, Fig.4

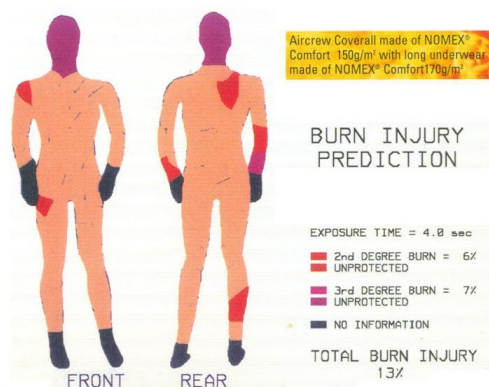


Fig. 4. Third attempt, burn rate

Other experiments were performed with a thermo-mannequin wearing only clothing made of fabric, which has a composition of a mixture of metaaramide and viscose "FR" with an area of 220 g / m². It is placed in a chamber in which the occurrence of a fire explosion is simulated. The mannequin was exposed to fire for 4 seconds.

The result showed that a human body placed under these conditions would receive 33% 2nd degree burns and 5% 3rd degree burns. The total affected areas of the human body can reach up to 38%.

The obtained results refer to used metaaramid fabrics with an area mass of 170-220 g / m². The same properties are possessed by the non-flammable jersey from a mixture of metaaramide and viscose FR, which provides greater comfort and a better feeling of softness. Studies have shown that it is more comfortable to make underwear. Its surface mass is about 280 g / m².

3. Conclusions

The analysis of fire-resistant fibers shows that the flammability of the fabrics of these fibers is different and depends not only on the nature of the fibers, but also on the parameters of the fabric structure. The end-use properties of the various meta-aramid fabrics used in the world as an exterior fabric by firefighters are also different.

The analysis of the characteristics of various protective clothing intended for firefighters used in the world shows that the most promising are clothing consisting of two layers:

- external fire-resistant fabric and at the same time with an internal breathable layer for protection against water penetration from the outside,
- a second inner tissue with a layer resistant to heat

4. Literature

1. Petkov SP "Model for the formation of high-speed elongated striking elements" 2008Sp. "Engineering Sciences", book 3/2008, BAS-IMet, ISSN 1312-5703
2. Petkov SP Mathematical model for the interaction of the cumulative jet in dynamic protection, 2008, Engineering Sciences Magazine, book 4/2008, BAS-IMet, ISSN 1312-5704
3. Baranov VL, Petkov SP, "Modeling the behavior of metals under high-speed shock load" 2005, Magazine. "Engineering Sciences", vol. 3/2005 year XLII, 41-48 pp., Sofia, BAS-IMet, ISSN 1312-5702
4. Petkov SP "Features of the interaction of the cumulative jet with active elements of dynamic protection" 2009 Magazine. "Engineering Sciences", book 1/2009, BAS-IMet, ISSN 1312-5702.
5. Yaneva S. Ergonomic requirements to the individual equipment of the anti-terrorist, used in critical infrastructure sites. IV International scientific technical conference. Technics. Technologies. Education. Safety'17, Proceedings, Issue 1 (1), Sofia, Bulgaria 2017, Volume 1, Military sciences and national security, Scientific technical union of mechanical engineering "Industry-4.0" June 2017, ISSN 2535-0315 (print), ISSN 2535 -0315 (online), pp.70-71
6. Yaneva S., Materials used in the means for individual ballistic protection. Analysis, advantages and disadvantages, International Scientific Conference "Asymmetric threats, hybrid wars and their impact on national security", March 16, 2018, New Bulgarian University, Department of National and International Security, Proceedings, Publisher: NTS in Mechanical Engineering Industry-4.0, ISBN 978-619-7383-09-6, pp.439-447 15.
7. Vasileva P., M.Sc. eng. Yaneva S. PhD, Analysis and evaluation of the EU action plan to enhance preparedness against chemical, biological, radiological and nuclear security risk and the national program for its implementation, III International Scientific Conference "High Technologies. Business. Society 2018", 12-15.03.2018, winter resort „Borovets“, Bulgaria, Proceedings, Year II, ISSUE 2 (4), Sofia, Bulgaria 2018, Volume II "Business. Society", ISSN 2535-0005(print), ISSN 2535-0013 (online), Publisher: Scientific Technical Union Of Mechanical Engineering, Industry-4.0, p. 199-201. Published: INTERNATIONAL SCIENTIFIC JOURNAL "SCIENCE. BUSINESS. SOCIETY", Year 3, Issue 1/2018, ISSN PRINT 2367-8380 и ISSN WEB 2534-8485, p.35-37. Publisher: Scientific Technical Union of Mechanical Engineering, Industry-4.0
8. BDS EN 469: 2005 / A1: 2006. "Protective clothing for firefighters. Requirements for implementation of protective clothing for firefighting";
9. Achtsnit, H.-D. Heat Protection Textiles Manufactured from Textile Silica Sliver Technical Textiles 2 1995: pp. 19 – 20.
10. Bristol Uniforms, Dusseldorf, 2001 (in German).
11. Fire Protection "Model Hamburg", Sächsische Schutzkleidung, Zwenkau, 2001 (in German)
12. ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 9, No. 4. 2003 Investigation of End-use Properties of Fabrics From Metaaramid Yarns .

Potential of using holographic subsurface radars for mine detection

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Abstract

The use of holographic subsurface radars is a relatively new technology that enables the detection and recognition of non-metallic objects beneath the ground, including plastic explosives and mines with small or absent metal parts. The Moscow State Technical University (MGTU) "N.E. Bauman" has developed subsurface radars capable of registering such objects and determining their type using holographic methods for information processing. This article discusses the features and principles of operation of holographic subsurface radars. The capabilities of the radar holographic systems of the „Raskan“ family developed by the MGTU are presented with a view to their use in the research activities within a joint scientific project carried out by the MGTU and IMSETHAC "Acad. A. Balevski"- BAS. The main results achieved by MGTU in using Raskan for mine detection and recognition are summarized and analyzed.

KEY WORDS: SUBSURFACE HOLOGRAPHIC RADARS; MINE DETECTION

Introduction

One of the most serious problems in local conflict zones and post-conflict areas is the large amount of installed anti-personnel and anti-tank mines, as well as improvised explosive devices (IEDs). The relatively low cost of such devices makes them widely used. Despite the ban on anti-personnel mines and international efforts in this regard, resulting in the continuous demining and destruction of available arsenal, huge quantities are still installed within the territory of many countries and there are considerable stocks of such mines. The combatants are well trained and have some means of detecting and neutralizing mines, however the civilian population, most often women and children, have been the main victims of these mines long after the conflict ended. According to statistics [1] 7,239 accidents caused by mines and other explosive remnants of war were recorded only in 2017 (2,793 people killed), 87% of them – civilians, nearly half of them were children.

At present, demining is done mostly by mechanical digging, trained dogs or rodents, and metal detectors. The metal detector is one of the most widely used short-range mine detection systems, however, currently landmines are made of plastic and other non-metallic materials, making them difficult to detect in areas contaminated with metal waste. The use of some sensors may increase the sensitivity of the instrument, however this will dramatically increase the number of false alarms triggered by pieces of metal such as grenade and cartridges fragments. The high frequency of false alarms and the inability to detect anti-personnel mines without or with a small metallic content make mine clearance operations dangerous, expensive and time-consuming. [2]

A relatively new technology that allows the detection of both metal and non-metal objects below the surface is Ground penetrating radar (GPR). The designs of subsurface radars are based on classical principles of radar technology. Signal emitted in a surveyed medium is reflected from heterogeneities if their permittivity or conductivity differ from that of the medium. The reflected signal is received by the radar antenna and amplified. After processing, the recorded information is visualized on a computer display.

In recent years, GPR has been subject of increased interest and research activity. Thanks to technological advances, significant improvements to key characteristics and the effectiveness of these systems have been achieved. New hardware and improved

algorithms have been created, and modern computing resources enable the fast processing of large amounts of data. Humanitarian demining is among the many potential applications of these radars, thanks to their ability to detect underground objects of different sizes and shapes, including those made of non-metallic materials.

One of the recent achievements in this field is the family of 'RASCAN' holographic subsurface radars (HSRs) developed by the Bauman Moscow State Technical University. The wide practical applications have shown many advantages compared to devices using other methods, including real-time plan-view imaging and high lateral resolution in examination of low electrical conductivity media at shallow depths.

Principle of operation of the holographic radars

Ground penetrating radar (also known as subsurface radar) utilize powerful burst of electromagnetic energy pulses send into the ground from a transmitter antenna located on the surface. Subsurface structures, such as bedding, cementation, changes in moisture and clayey content, cavities, voids, fractures, intrusions, man-made objects and many others, possessing a contrast in dielectric properties, cause some of the pulse energy to be reflected back to the surface, while the rest of the energy continues to penetrate deeper. The reflected pulse energy is picked up by a receiver antenna on the surface. These signals are then processed and plotted in a distance versus time-depth display. Thus, as the radar antenna is slowly towed across the surface, continuous cross-sectional "picture" of subsurface conditions is generated. [3]

Impulse radar is the most common type of radar that is being produced commercially and used in practice. This radar uses real time measurements of short emitted pulses to reconstruct an image of the subsurface, and to measure the distance to buried objects (based on electrical properties of the media). Apart from impulse radars, there is also a class of subsurface radars that employ continuous signals, including frequency modulated radar, stepped-frequency radar, and holographic radar. [4] Frequency modulated radar transmits a continuously changing carrier frequency known as a chirp pulse. Reflected signal from the object is mixed with a reference signal to produce an intermediate or difference frequency, which in turn depends on the range to the reflector. [4] Stepped frequency or synthesized radar transmits consecutively a set of discrete frequencies registering the amplitude and phase of reflected

signal at each frequency. Obtained in such manner, the frequency response function can be converted to time domain by Fourier transform to yield range information. [5]

The holographic radar (HSR) is a special kind of GPR that uses unmodulated continuous-wave signals. This holographic subsurface radar differs from other GPR types in that it records plan-view subsurface holograms. Penetration depth of this kind of radar is rather small (20–30 cm), but lateral resolution is enough to discriminate different types of landmines in the soil, or cavities, defects, bugging devices, or other hidden objects in walls, floors, and structural elements. Holographic subsurface radar, operating at one or several discrete frequencies, illuminates a sufficiently extensive area of a surface to be inspected to register the signal phase and amplitude distribution reflected from objects beneath the surface. Obtained in such a manner, the dataset can be used to mathematically synthesize a large effective aperture, and eventually reconstruct the subsurface image by methods analogous to those used in optical holography.

Unlike pulse radar measurements, single point measurements using monochromatic holographic radar do not produce informative results, so the reflected signal must be detected on a specific fragment of the surface to obtain a microwave hologram. Scheme of the subsurface holographic radar measurements is presented in Fig. 1 - (x, y, z) are the Cartesian coordinates, and z_0 is the depth of the object relative to the radar plane. [6]

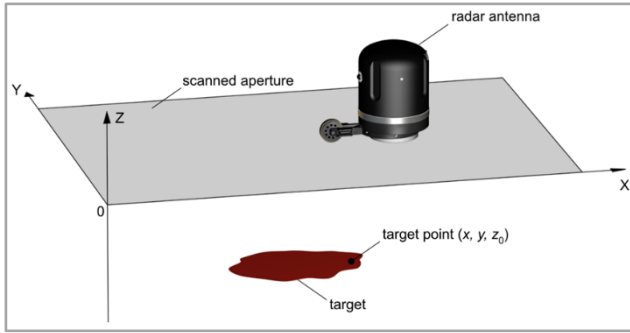


Fig. 1. Scheme of the subsurface holographic radar measurements. [6]

The signal emitted by the transmitting antenna is reflected from the subsurface object (object wave) and is mixed in the detector with a reference wave that is obtained from a generator. The signal that is directly transmitted from the transmitting to the receiving antenna may also serve as the reference wave. Such a configuration is used in the measurements of amplitude holograms. A specific feature of the holographic subsurface radar under study lies in the fact that the transmitting and receiving dipole antennas are located in a unit that represents an open-end circular waveguide. The waveguide diameter, antenna positions, and the remaining parameters are optimized with respect to the radar sensitivity. [7]

The algorithm of hologram reconstruction can be generally described by the following equations:

$$F(k_x, k_y) = \frac{1}{(2\pi)^2} \iint E(x, y) e^{-i(k_x x + k_y y)} dx dy$$

$$S(k_x, k_y, z_0) = F(k_x, k_y) e^{i \sqrt{4(\omega \sqrt{\epsilon})^2 / c^2 - k_x^2 - k_y^2} z_0}$$

$$E_R(x, y, z_0) = \iint S(k_x, k_y, z) e^{i(k_x x + k_y y)} dk_x dk_y,$$

where:

$E(x, y)$ is the registered hologram, i.e. the complex amplitude distribution registered by the radar receiver on the scanner aperture at $z = 0$;

$F(k_x, k_y)$ is the plane-wave spectrum of hologram;

$S(k_x, k_y, z_0)$ is the plane-wave spectrum at parallel plane at $z = z_0$;

$E_R(x, y, z_0)$ is the image reconstructed for plane $z = z_0$;

ω is the angular frequency;

ϵ is the dielectric permittivity of the medium;

c is the speed of the electromagnetic wave in the medium

k_x and k_y are the spatial frequencies corresponding to x and y , respectively.

Based on principle briefly described above, variety of models of "RASCAN" family radars has been created at the MGTU that have different operational frequency ranges and different applications. Two representatives of the "RASCAN" family are presented in Fig.2 and Fig.3.

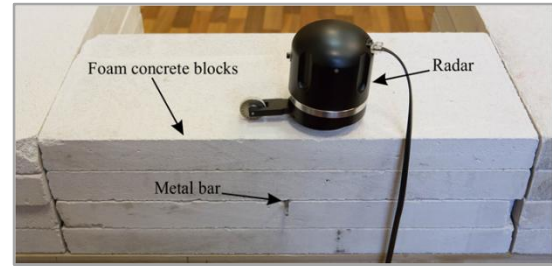


Fig.2. Holographic subsurface radar of RASCAN type 4/7000.



Fig.3. Holographic subsurface radar of RASCAN type 5/15000.

Extensive research and experimentation, including comparison of results obtained by other methods, has shown that the main applications for "RASCAN" radars are connected with tasks in which sounding to great depths is not required, i.e. sounding of shallow layers is sufficient. In these cases there is usually no specific requirement to measure the depth at which the object is located. Depth estimation may be desirable but not as critical as detecting and classifying an object from its recorded microwave image. For example, when searching for buried mines or "bugs" in buildings, the primary purpose is to find the hidden object, and the depth to which it is placed is not essential. Therefore, imaging the shape of a hidden object is one of the main advantages of the holographic method. [8] Observation of shallow subsurface objects, defects, or inhomogeneities is an increasingly proven area of these radars application, including in civil engineering, preservation and restoration of cultural heritage objects, security, humanitarian demining, etc. [8-12]

Use of holographic radars in mine detection

Existing detection systems for "inconspicuous" mines installed in the ground in plastic cases, as a rule, use radio sensors. The principle of detection in these systems is associated with measuring changes in the dielectric properties of the soil at the site of the installation of the mine. Given the low contrast of the mine, with a

sufficient level of detection, the probability of false alarms per unit of the investigated area is unacceptably high. This is primarily due to reflections of radio signals from natural inhomogeneities in the soil and its surface. This drawback is due to the low information content of traditional mine detectors that identify mines using only the amplitude of the signal reflected from it.

An approach to overcome the difficulties is the use of broad size mine detection systems. The advantages of radio frequency countermine system with broad size detector are their higher performance and the possibility of increasing the information content of mine detection due to spatial selection and, as a result, reducing the likelihood of false alarms during mine clearance. The image obtained in this way is recognized even at high levels of background reflections. Thus, knowing the characteristic size of a mine, it can be distinguished against the background of the heterogeneity of the ground in its shape and size. [13]

This method has been realized by developing the “MiRaskan” - combined GPR and metal detector system, which makes it possible to detect and identify shallow (up to 20 cm) objects by their shape. The radar design is based on the principle of multi-frequency sounding of condensed matter (building structures, soils, etc.), Fig.4. [14]

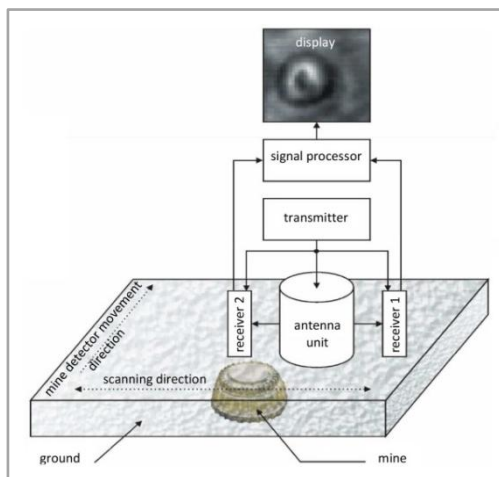


Fig.4. Structural scheme of the “MiRaskan” radar. [14]

The radar has 5 operating frequencies in the range from 1.5 to 2.0 GHz, and the signal is received in two polarizations. The radiated power of the generator at each of the successively switched frequencies is 10 mW, which ensures complete safety for the operating personnel. In the process of scanning over the earth's surface, signals are sequentially received at each of the frequencies and in both polarizations. The frequency switching provides spatial coincidence of radio images at individual frequencies. Experimental results has shown that proposed method for obtaining radio images of objects in the soil with the possibility of their subsequent recognition can serve as the basis for creating promising mine detectors. [14]

As a result of the active scientific and experimental work, several systems have been developed, which allow obtaining high-resolution images of shallowly buried objects suitable for application in humanitarian demining. Fig.5 shows microwave hologram images of 50 mm rocket and 80 mm shell recorded by „RASCAN-4/4000“ subsurface radar. [8]

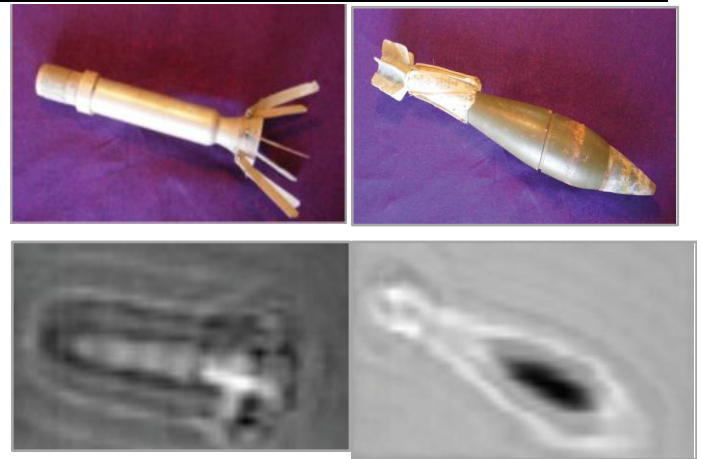


Fig. 5. Microwave hologram images recorded by RASCAN-4/4000. [8]

Further advancement in improving the capabilities of this type of devices has been made by developing a detection system by an international team of researchers under the International Science and Technology Center (ISTC) Project #2541. The system consists of holographic radar that automatically performs electromechanical scanning of ground surface, equipped with an additional induction metal detector channel. [8] Scanning of a line in this radar is performed by automatically sweeping the radar head across the device chassis, perpendicular to the movement direction of the entire system. The metal detector coil is placed on the radar antenna's lower face. This allows registration of the same area both in the radar and metal detector channels simultaneously. Images of objects, buried in sand at a depth of 5 cm, recorded by this radar, are presented in Fig.6. The left column has photos of the objects, the middle column shows radar images and the right column presents coincident images recorded in the metal detector channel. [8]

Within this project investigations on the system performance under different conditions have been carried out in order to study the effect of moisture, surface condition and target features on holographic radar response: experiments made in Japan considered the same target at different moisture levels; experiments made in USA considered the effect of the trigger on the detectability of a PMA-2 antipersonnel mine; experiments made in Italy considered different surface conditions in an outdoor setup. [15] An algorithm that applies variations of received signal along frequency abscissa has been developed and used as a comparison mean. Experiments from Japan and Italy showed that moisture level highly influence the detectability of buried objects because it tends to create a confused (foggy) background. Experiments from the USA and Japan showed that the detectability of a PMA-2 antipersonnel mine in air is quasi-independent on the presence and type of trigger. Experiments from Italy showed that there can be the case where the same object in the same medium can be better detected at higher depths. [15]

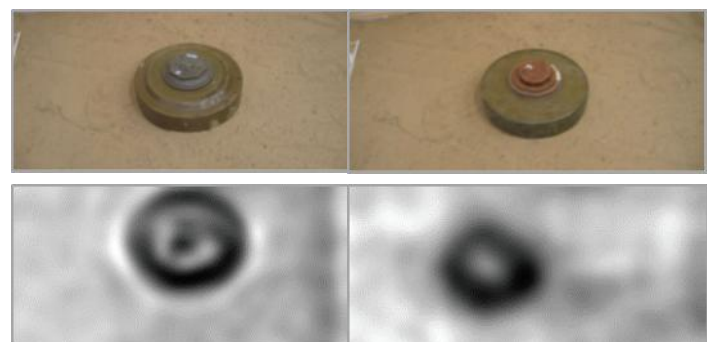




Fig.6. Images of Russian anti-tank mines TM-62M (metal body) and TM-62P3 (plastic body) recorded by subsurface radar and metal detector. [8]

In general, studies results show that the main obstacle that complicates the use of subsurface radars, irrespective of their type, in humanitarian demining operations, is the presence of different heterogeneities on the ground surface or at shallow depths. Reflections of electromagnetic waves from such heterogeneities and other objects of anthropogenic origin create a cluttered background difficult for detection and identification of mines. [8]

Conclusions

The paper presents the principle of operation of the holographic subsurface radars and the basic characteristics of the “Rascan” family radars developed by the MGTU. Main experimental results obtained by using these radars for detecting mines with low metal content are also presented. Experimental data show an extremely high efficiency of the holographic subsurface radars in recognizing various types of mines. At the same time, their use is limited to relatively shallow buried mines and in dry soils. It is therefore appropriate to use sub-surface radars to detect and identify landmines and improvised explosive devices located in dry soils at depths of up to several tens of centimeters. Subsurface holographic radars can also be used as complementary means of demining to identify suspected objects detected by other devices.

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References

- [1] Landmine and Cluster Munition Monitor. International Campaign to Ban Landmines. Press Release, 20 November 2018. http://the-monitor.org/media/2918822/PressRelease_LandmineMonitor2018_embargoed_revised.pdf
- [2] Tellez, O.L.L. and B. Scheers. Ground- Penetrating Radar for Close- in Mine Detection, Mine Action - The Research Experience of the Royal Military Academy of Belgium, 2017, DOI: 10.5772/67007.
- [3] Prokhorenko, V. An impulse generator for the ground penetrating radar. <http://viy.ua/download/pub/01.pdf>
- [4] Daniels, D.J. (Ed.), Ground Penetrating Radar. 2nd Edition, IEE, London, UK, 2004. 761 p. <http://fivedots.coe.psu.ac.th/Software.coe/mit/Ground%20Penetrating%20Radar.pdf>
- [5] Iizuka, K., and A.P. Freundorfer. Detection of nonmetallic buried objects by a step frequency radar. Proc. of the IEEE, Vol. 71, Issue 2, Feb. 1983, pp. 276 – 279.
- [6] Ivashov, S.I., A.S. Bugaev, A.V. Zhuravlev, et al. Holographic Subsurface Radar Technique for Nondestructive Testing of

Dielectric Structures. Tech. Phys. 63, Springer, March 2018. pp 260–267. <https://doi.org/10.1134/S1063784218020184>

- [7] Razevig, V.V., I A. Vasiliev, A.I. Ivashov, S.I. Ivashov, V. I.Makarenkov, RF Patent No. 2482518, 2013.
- [8] Ivashov, S., V. Razevig, I. Vasilyev, A. Zhuravlev, T. Bechtel, L. Capineri, The Holographic Principle in Subsurface Radar Technology, International Symposium to Commemorate the 60th Anniversary of the Invention of Holography, Springfield, Massachusetts USA, October 27-29, 2008, pp 183-197.
- [9] Ivashov, S., V. Razevig, I. Vasiliev, A. Zhuravlev; T. Bechtel, L. Capineri. Holographic Subsurface Radar of RASCAN Type: Development and Applications. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 4(4), 2012, pp 763 – 778. DOI: 10.1109/JSTARS.2011.2161755
- [10] Pehlivaniski, V.I. Estimation of the detection distance of a particular class of radar sensors. Scientific Announcements of the Scientific and Technical Union of Mechanical Engineering, Issue 12, 2015, ISSN 1310-3946.
- [11] Bossi, L., P. Falorni and L. Capineri. Performance comparison for the detection of defects in thermal insulating materials using microwave holograms acquired manually and with a robotized scanner, Journal of Electromagnetic Waves and Applications, 33:16, 2019, pp 2081-2095, DOI: 10.1080/09205071.2019.1663273
- [12] Ivashov, S., L. Capineri, T. Bechtel, V. Razevig, A. Zhuravlev and P. Falorni. Use of holographic subsurface radar analysis in the preservation and restoration of cultural heritage objects. Surface Topography: Metrology and Properties, Vol.7, Issue 4, December 2019. IOP Publishing Ltd. <https://iopscience.iop.org/article/10.1088/2051-672X/ab4fa2>
- [13] Vasiliev, I., S. Ivashov, V. Makarenkov et al. RF Band High Resolution Sounding of Building Structures and Works. Seventh International Conference on Ground-Penetrating Radar, GPR'98, May 27-30, 1998, University of Kansas, Lawrence, Kansas, USA, Vol. 2, pp 707-710.
- [14] Vasiliev, I., E. Genadieva, S. Ivashov, et al. Multi-frequency microwave sensor for detecting min. Radio engineering. No. 2, 1999, pp. 49-52.
- [15] Bechtel, T., L. Capineri, P. Falorni, M. Inagaki, S. Ivashov and C. Windsor. Investigation of Holographic Radar Capabilities for the Detection of Shallow Buried Plastic Antipersonnel Landmines, Progress In Electromagnetics Research Symposium, PIERS 2012 in Kuala Lumpur, Malaysia, on March 27-30, 2012.