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Original article

Concept of using the artillery simulator – trainer Antracyt Plus in the process of training Missile and Artillery Forces

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INFORMATION

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ABSTRACT

The article was written in consequence of works carried out in the Military Institute of Armament Technology related to the design of the artillery simulator – trainer Antracyt Plus. Research and development works focused on establishing current training needs of artillery subunits at the squadron level and proposing a simulation solution, which will enable the realization of all training undertakings in the scope of Fire Control Training and Individual Shooting Skills Training.

An additional goal was to develop the simulation environment so that it would enable gunners to undertake training impossible to be realized under conditions other than combat. Given the modern battlefield conditions, several scenarios were developed to enable the realization of any fire tasks in real-time.

The article describes the Missile and Artillery Forces' training process and presents the capabilities of the simulator in this context. In conclusion, there are references to the work outside the automatic fire control system and the role of perfecting the artillery "craft" in the context of the growing role of artillery during recent armed conflicts.

KEYWORDS

artillery, battlefield simulator, Anthracite Plus, Fire Control Training, Missile and Artillery Forces

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Introduction

This article was written within the framework of the realization of a computer simulator for artillery training "Antracyt Plus", allowing conducting exercises with units and subunits of artillery in the execution of fire tasks, by the Military Institute of Armament Technology.

The scientific objective of the article is to present the results of research and development works on the development of artillery simulator-trainer within the framework of the "Antracyt Plus" project.

The subject of the research was a process model of directing fire in an artillery squadron.

The research process has assumed the following research problem: *How should the artillery simulator-trainer "Antracyt Plus" function to increase training effectiveness in directing gunfire in the Missile and Artillery Forces subunits in conditions similar to real ones?*

The research process was carried out in four stages. In the first stage, an analysis of the current state of training in artillery subunits in the scope of conducted exercises concerning the process of directing fire was made. The analysis allowed identifying needs and possibilities for improvement of the training process.

In the second stage, a model of directing gunfire and conducting exercises in the artillery squadron were analyzed. In the process analysis, a technique of mapping processes using BPMN (Business Process Model and Notation) notation was used.

In the third stage, a model of the fire control process was implemented in the VBS simulation environment during the realization of different types of fire tasks within fire control training and individual shooting skills training.

In the fourth stage, there were conducted experiments on the model, as the result of which the developed model of directing fire process was verified on specific tactical scenarios.

The primary objective and purpose of the system are to meet the most urgent needs in the scope of training the Missile and Artillery Forces troops, subunits, and functionaries, including reconnaissance, preparation of shooting and directing fire, as well as directing fire, in possibly faithfully reproduced realities of the modern battlefield with the use of leading computer simulation tools, namely, the Virtual Battle Space (VBS) software package. The primary, default configuration of the system is oriented towards the execution of exercises by an artillery squadron as the elemental fire and training module of the VRS – see Figure 1.

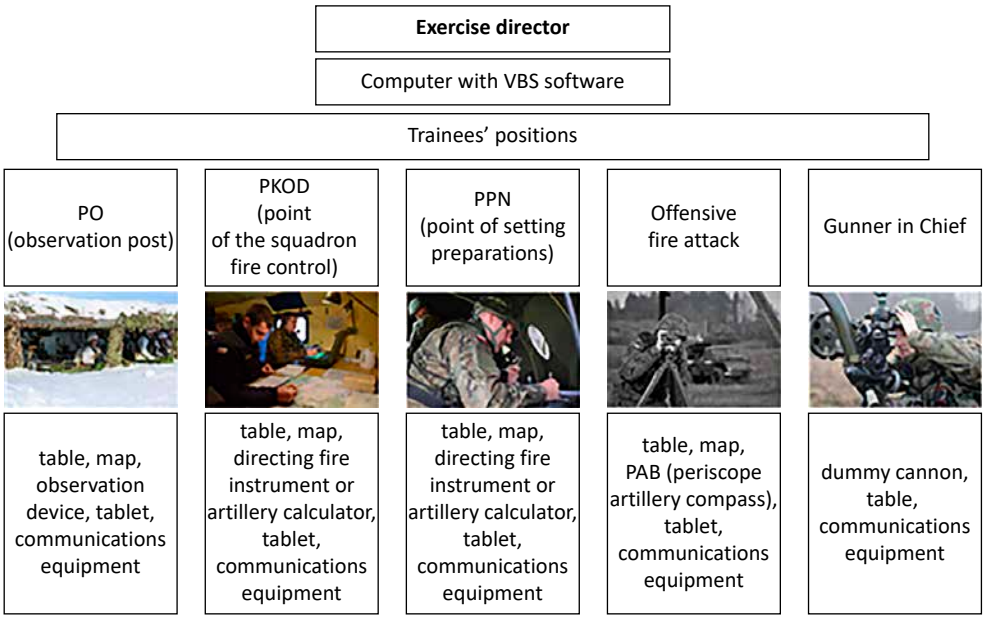

Fig. 1. Equipment of work stations and trainees
Source: Own study.

Multi-station system configuration is designed to enable simultaneous work and cooperation of all functionaries responsible for fire tasks execution. A simulator allows conducting exercises in a reduced composition depending on current needs in a given scenario. In addition to the simulation server (one or more), the system includes many additional devices (referred to as "peripheral devices") that imitate the operation of real equipment, including:

– PAB (periscope artillery compass) at the fire officer's station,
– PAB and rangefinder at the observation post,
– dummy/imitators of battery guns,

required to simulate the operation of the various cells involved in the action. Each of these devices sends to the simulation engine its status resulting from the action of exercising (e.g., direction and angle of elevation of the barrel of the dummy gun, the direction of looking of the PAB), while the simulator generates an appropriate view displayed on the screen of the device.

The technical construction of the system allows to extend (multiply) the set for the needs of training artillery units in a few squadrons simultaneously and to use other (than sections of advanced observers) means of reconnaissance (e.g., radiolocation, BSP). Moreover, the applied communication mechanism in a distributed simulation built in the VBS engine and the compatibility with DIS (Distributed Interactive Simulation) standard gives vast possibilities of connecting with other existing simulators. It means that all currently used sets based on the same simulation engine will be able to be connected directly to the Antracyt Plus system. That gives the possibility to implement joint exercises, including combined fire support (CFS), in which, in addition to the use of artillery (barrel and/or rocket), helicopters and combat aircraft will also be simulated. An obstacle may be then the organizational issue (logistics of realization of exercises for a large group of functionaries of different levels and branches of the Armed Forces) and doctrinal issue (a need to work out detailed instructions and procedures, e.g., for FPS) and hence the assumption that for the time being the use of the system in a configuration other than the default one (division/regiment) will be an exception rather than a norm.

1. The Missile and Artillery Forces training process

The Missile and Artillery Forces training takes place within the framework of the Land Forces Training System. It constitutes a purposefully and dynamically operating system of elements including subjects, objectives, content, forms, methods, and the training base, closely linked and mutually influencing each other, ensuring the preparation of commands, staffs, troops, and personal reserves to perform tasks in the national, allied, and coalition systems. Structurally, it includes the command subsystem and the following executive subsystems:

1) personnel preparation,
2) command and staff training,
3) training of troops,
4) training of personnel reserves [1].

The subjects in training are professional soldiers and reserve soldiers, and in institutional terms commands and staffs and artillery units and subunits.

The training system is subject to continuous improvement according to changing conditions resulting from:

1) required operational capabilities,
2) accepted directions of operational and tactical training and development of tactical concepts, considering the ongoing transformation processes,
3) possibilities of material and financial security,
4) manning levels and degree of professionalism of artillery units and subunits and the duration of basic military service in relation to conscript soldiers,
5) changes in the equipment of military units with weapons and military equipment (introduction of new equipment, withdrawal from use, or its modernization),
6) development and modernization of the training base,
7) applicable legal standards affecting the implementation of the training process.

The program training may be conducted in garrisons and training centers.

The former is aimed at training and perfecting individual specialist skills and training and coordination of crews, services, teams, subunits, and commands and staff for operations. Training in garrisons ensures the unity of action of commands, staff, and troops in the preparation, combat (operations), and functioning of the combat system. The scope of training depends on the capabilities of the garrison training base.

The training on the artillery range aims to increase the combat efficiency of a unit (subunit) in the actual field conditions. Within the training framework, there are realized military exercises, shooting, activities with the use of dangerous substances, and other activities that are not possible to be conducted in garrison conditions. Field training is conducted in stages by checking individual (team) skills in combating enemy forces and means within organizational structures, training within specialist groups, and conducting tactical exercises in the composition of subunits or task (combat) groups as well as exercises with troops, including the coordination of the combat system.

The training program constitutes the basis for planning and organizing the training process in the 36-month task preparation and execution cycle. Its scope includes improving soldiers' skills and harmonization of subunits of the Missile and Artillery Forces up to the squad level, which is the basic training module. In terms of training content, the program enables the preparation of a subunit in terms of a gradual, systematic achievement of operational capability and readiness to perform tasks in the country and abroad in the national, allied, and coalition configuration [2].

The program covers a 36-month cycle of preparation and task execution of the Missile and Artillery Forces subunits. The above cycle is divided into two stages:

– Stage I (24 months) – training,
– Stage II (12 months) – task implementation.

The main decision maker in planning and organizing training is the squadron commander, and the main factor determining the training process of a squadron is its combat purpose.

The basis for training planning is the task of the subunit, its purpose, and material support calculations. It is recommended to use training devices supporting the training process to intensify the training and tasks execution with the use of combat means [2]. In planning and conducting training with the use of battlefield simulations, the emphasis should be put on maximum realism and approximation of training to the battlefield conditions.

Training of artillery units and subunits is a continuous process, the essence of which is the acquisition of knowledge and practical skills to achieve and maintain the ability to perform

the set tasks. The training process is subject to constant modification and adjustment of its content, forms and methods in accordance with changes that occur in the armed forces. The main factors affecting the organization of the artillery training include organizational location and equipment of artillery units and subunits in combat equipment, tactical conditions of artillery use in combat as well as the normative principles in force in the land forces [1-3].

In the organizational structure of the Polish Land Forces there are the following basic artillery units[1]:

– at the division level – an artillery regiment,

– at brigade level (from the division level) – a self-propelled artillery division,

– at mechanized battalion level – a support company.

Artillery units and subunits differ in their purpose, organizational structures, and equipment. Presentation of their basic organizational framework, emphasizing the specificity of performed tasks, will show the scale of training problems. They are proportional to the number of homogeneous subunits in the form of platoons, squads, and often even single functionaries, characterized by deep specialization.

An artillery regiment is an artillery detachment designed to perform tasks of deep action support in division combat operations and increase the firepower of brigade divisions performing tasks in the direct support relationship. Firepower augmentation can be carried out in a reinforcement support relationship or general support and reinforcement. The regiment consists of the command and staff, logistics, command squadron, self-propelled artillery squadrons (24 152 mm AHS DANA – Figure 2, 24 155 mm HS KRAB – Figure 3), rocket artillery squadrons (24 WR40 LANGUSTA/BM-21/RM70 launchers), and logistics subunits.

A self-propelled artillery squadron from a mechanized brigade (armored cavalry), equipped with 122 mm HS 2S1 GOŹDZIK or 152 mm AHS DANA, is designed to perform direct support

Fig. 2. 152 mm AHS DANA – view through fire officer's observation device
Source: Own study (VBS image).

[1] Artillery is also present, but in a much more modest form, in two independent brigades (6BDSz and 25BK-Pow) and in territorial defence brigades. In the brigades of the first type, there are support companies (platoons, squads), subordinate to commanders of battalions (companies, platoons), equipped with light equipment capable of transport. Depending on the type of battalion, these are 98 and 60 mm mortars, SPIKE PPK launchers.

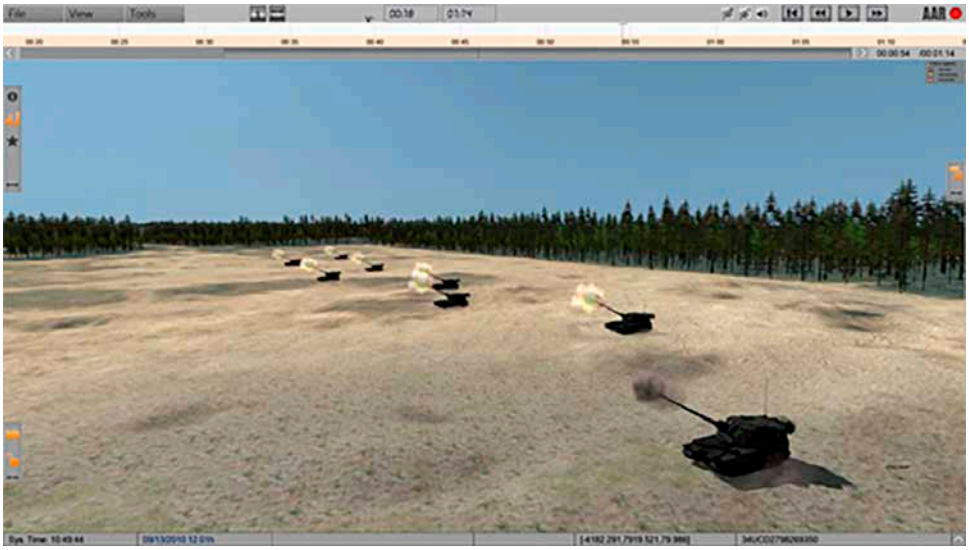

Fig. 3. View of firing 155 mm HS KRAB
Source: Own study (VBS image).

tasks. It can hit with high accuracy various targets (uncovered and hidden, moving and stationary, observed and unobserved), efficiently performing maneuvers and continuously supporting fighting subunits (mechanized and tank companies). Its organizational structure and equipment are similar to self-propelled and rocket artillery squadrons from the artillery units; it has analogous basic components, i.e., command and staff, logistics, command battery, three fire batteries, and logistic subunits (platoons: supply, repair, medical). It differs from the squadrons as mentioned above in the command battery as it additionally possesses forces and resources for ground visual reconnaissance. The command battery is designed to conduct reconnaissance, support shooting, ensure communication and carry out basic geodetic, meteorological, and ballistic preparation activities. It consists of a headquarters, a command platoon, and three advanced observer platoons (each with four advanced observer sections).

Self-propelled artillery batteries (8 guns in the mechanized battery) perform fire tasks following the squadron commander's decision. They consist of a command platoon and two fire platoons (4 guns each).

Most brigade squadrons are equipped with the automated fire control set (ZZKO) TOPAZ, which, thanks to the applied computer technology (specialized software), replaces the traditional way of determining the firing settings and transmitting them to the guns and significantly shortens the flow of all kinds of information. The set includes many new generation command vehicles and terminal equipment functionally located in the SD of the squadron, battery command points, places of work of reconnaissance elements (platoon commanders of advanced observers and sections subordinate to them), and guns. Consequently, there are some changes in the organizational structure of the squadron (e.g., the resignation of foot topographic teams in fire batteries, changes in the structures of command vehicle teams), and fundamental ones in the technical equipment (new command vehicles).

However, it should be noted (based on the conflict in Ukraine) that due to the threats arising from the use of means of radio-electronic warfare (WRE) by a potential enemy, disruptions in the work of ZZKO TOPAZ may occur. It means that it is necessary to improve the individual

shooting skills of functional persons with the use of "traditional" tools, e.g., the Fire Control Instrument (PKO) [4].

A support company is a full-time fire support subunit of a mechanized battalion. It ensures continuous and effective execution of tasks with fragmentation and demolition ammunition, smoke, and illumination in all types of tactical operations. It consists of two platoons of 120 mm RAK self-propelled mortars or 120/98 mm towed mortars and an anti-tank platoon equipped with the SPIKE PPK.

A mortar platoon is a subunit consisting of a command team/High Altitude Observer Section and three mortar operators. The platoon performs fire tasks independently or as part of a support company, with indirect or semi-direct fire. The command team is intended to carry out visual reconnaissance of the enemy, operate shooting, and maintain communication.

Artillery units (subunits) are organizational units at which an artillery training cycle at a given command level is completed. It aims to improve (check) the readiness of the artillery unit (subunit) to perform specific tasks resulting from its tactical purpose.

Commanders of appropriate command levels: regiments, squadrons, batteries (equivalent to companies), platoons, and squads (equivalent to guns and services) are responsible for the quality of training in artillery units and subunits.

2. Exercises implemented in the Missile and Artillery Forces units and subunits

The following forms of exercises are conducted in the Missile and Artillery Forces units and subunits:

– tactical and special classes (ZT-S),
– tactical and special exercises (ĆT-S),
– artillery training.

Tactical and special classes (ZT-S). They are a practical form of military training during which the level of training of a platoon (battery, support company) in the execution of tasks, as intended against the background of a conventional (specified) tactical situation [3].

The aim of ZT-S is to evaluate commanders and artillery subunits to perform tasks as intended (in conditions similar to real ones).

The content of ZT-S is the practical performance of tasks by the Missile and Artillery Forces subunits during the preparation and conduct of operations.

Tactical and special exercises (ĆT-S). These are a type of exercises in which an assessment is made of the training level of a squadron (artillery regiment) in the execution of tasks, as intended, against the background of a conventional (specified) tactical situation [3].

Artillery training is a systematic performance of specific activities aimed at achieving optimum efficiency of their execution by artillery commands, units, subunits, and individual functionaries.

The artillery training includes:

– individual firing skills training (TIUS) – conducted with functional members of the Missile and Artillery Forces units (subunits),
– training in directing the fire (TKO) – the Missile and Artillery Forces units (subunits).

Depending on the content of issues to be discussed, level of training (coordination) of subunits, skills of trainees, pieces of training may be conducted in the field with or without shooting with combat ammunition, on reduced artillery ranges, lecture halls, with or without the use of imitating means, training devices, and simulators.

Training in individual shooting skills (TIUS) is a preparatory exercise, during which the individual practical skills of functional persons are improved in the field of shooting and directing fire [3].

The training aims to prepare and perfect the skills of functional persons in performing fire tasks through mastering the knowledge of principles of instructions on shooting and directing fire, and consequently, raise the knowledge and skills of personal resources of the unit (subunit) in performing fire tasks in different conditions and tactical situations.

The essence of TIUS is individual performance of fire tasks. The content of TIUS is solving fire tasks.

Training in directing fire (TKO) is a preparatory exercise during which team elements of a subunit are coordinated in the execution of the tasks included in the preparation and execution of fire tasks of the artillery unit (subunit) and the skills of command and cooperation in shooting and directing fire are perfected [3].

The following types of TKO are distinguished:

– training in directing fire – coordinating (TKO-Z),
– training in directing fire – perfecting (TKO-D).

The purpose of TKO-Z is to harmonize and prepare the unit (subunit) to execute fire tasks within the framework of fire control system.

The purpose of TKO-D is to maintain the unit's (subunit's) skills in performing fire tasks within the framework of the fire control system.

The essence of TKO is to prepare commands and troops to perform fire tasks in various conditions and tactical situations.

TKO with live ammunition firing should be preceded by training without live ammunition firing (with the use of imitating agents, training devices, simulators).

3. Capabilities of the artillery simulator – trainer Antracyt Plus

When analyzing the process and training capabilities of the Missile and Artillery Forces units and subunits, it can be stated that the artillery simulator – trainer Antracyt Plus enables training oriented on the realization of the basic artillery task – fire support of combat subunits. Therefore, it should be used in the following exercises:

1) training of individual shooting skills (TIUS) – in full range,
2) training in directing fire (TKO) – to the extent when training cannot be executed with combat ammunition or in preparation for firing,
3) tactical/special training – in preparation for the activity/exercise.

The afore-mentioned types of exercises are aimed at perfecting the issues related to the basis of gunnery combat activity, i.e., firing [5], thus, the Antracyt Plus system enables the implementation of the following issues included in the activities related to the widely understood process of directing gunfire:

1. Conducting reconnaissance.
2. Preparation of shooting and directing fire (SiKO).
3. Calculation of firing settings.
4. Conducting effective fire, including to columns in real time.
5. Directed fire.
6. Fire effects assessment and correction.
7. After Action Review – records and evaluation of each stage of the exercise and each trainee.
8. The system offers the entire freedom to the exercise director to create additional situations influencing the realization of the SiKO process by exercisers.

The issues mentioned above are implemented following prepared scenarios. These scenarios assume that they should be based on the currently functioning system of command, including fire support, applicable theory (rules of warfare), standards (doctrine, regulations, instructions, standing operational procedures), and practice of conducting tactical operations by an artillery squadron and general military subunits (platoon, company, battalion, brigade).

The developed scenarios allow conducting artillery exercises based on tactical activities of general military subunits and execution of fire tasks by the training subject which is an artillery squadron or a support company in different environments of the battlefield: coastal, forest, lowland, mountainous terrain, and in different tactical situations: defense, assault, actions within the framework of crisis response operations or peacekeeping operations [6].

An essential part of the preparation of each exercise is the development of documentation for its conduct, which requires a lot of work. One of the essential documents allowing for the efficient conduct of an exercise is the initial situation. Each scenario was developed based on a prepared tactical situation. Therefore, it is enough for the exercise director to get acquainted with a given scenario before the exercise and in the case of its acceptance he/she prints it out from the system and attaches it to the documentation. In addition, the exercise director can make changes to the scenarios and modify them to meet the training objectives.

A crucial part of each exercise or single fire task is its assessment. Thanks to the applied "evaluation module" the system allows evaluating the results of actions of individual functionaries and the whole trained subunit involved in the execution of tasks connected with target firing. The fire task is presented as a BPMN process sewn into the system logic (Fig. 4). Due to this, the exercise director has the possibility of continuous insight into the course of the fire task realization and its progress assessment.

A very useful function supporting the exercise director in the evaluation process is the possibility to record the whole process of fire task preparation and execution (After Action Review function). It enables the exercise director to reconstruct every action performed by exercising persons and indicate exactly the place in which they made a mistake. Independently from the observation of the fire results conducted on the OP (Fig. 5), the system allows collecting precise data and their presentation for training purposes.

One of the main advantages of the system is that it does not require additional investment in the existing infrastructure of military units. A single room, e.g., a soldier common room divided into workplaces for individual trainees and access to electricity is sufficient to prepare the system for operation.

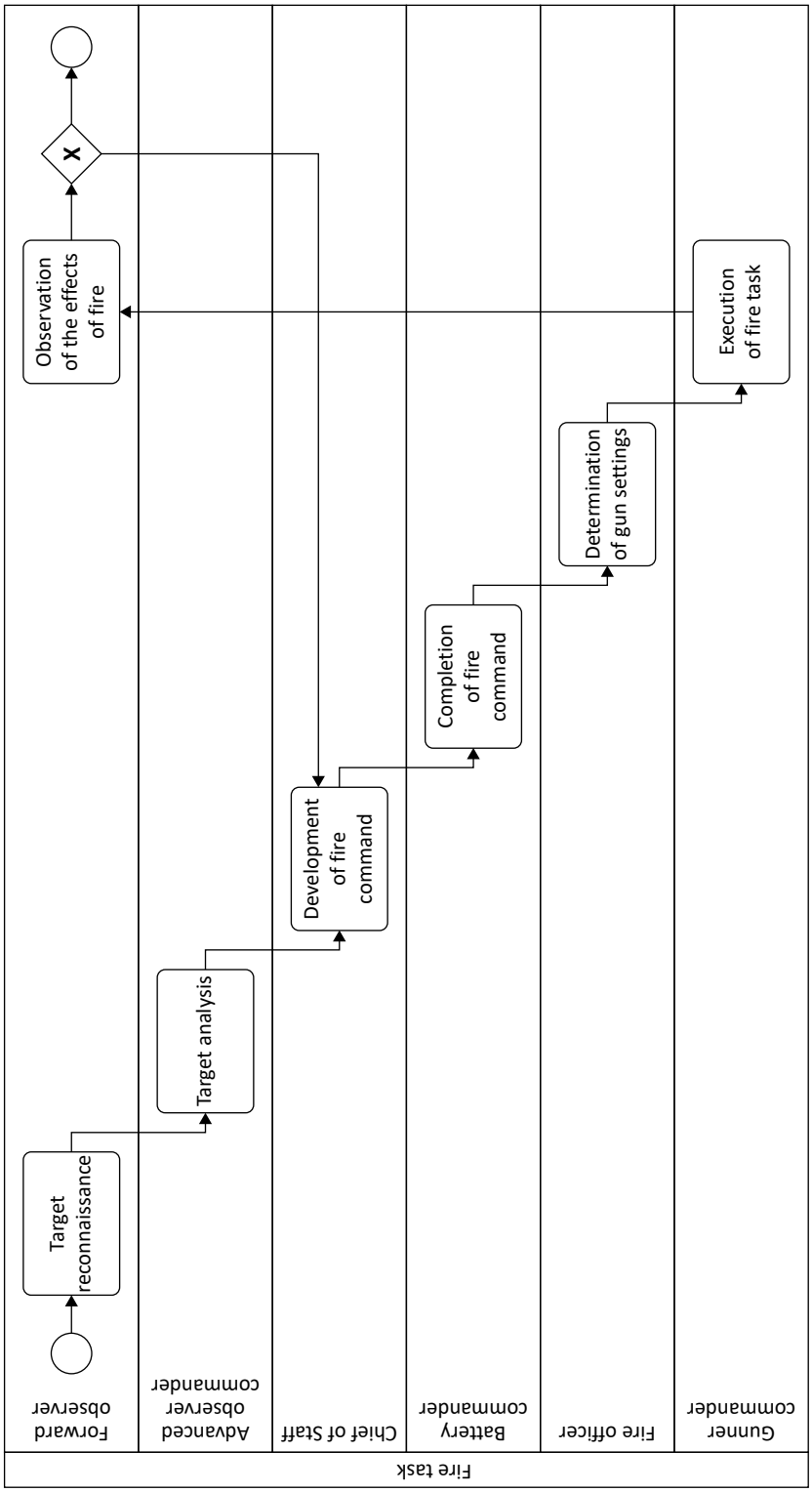

Fig. 4. The course of the fire task realization illustrated with the use of BPMN process
Source: Own study.

Fig. 5. PAB image – Fire performance observation on the PO
Source: Own study (VBS image).

Conclusions

Summing up, it can be stated that the artillery simulator – trainer Antracyt Plus allows for significant reduction of training costs without limiting its quality. Moreover, it enables the training of the Missile and Artillery Forces units and subunits regardless of the limited possibility of using training ground centers. Due to artificial intelligence (AI), each exercise will be carried out in conditions very similar to those which the trainees will "collide" with on a potential battlefield. During training with the use of the simulator, the process of training (exercise) preparation will significantly shorten and simplify. One of the important functions of the simulator will be perfecting artillery "craft", which consists in determining firing settings with the use of traditional tools such as fire control instrument (PKO), artillery calculator (UKART) or any other programmable calculator.

Given the above and based on analysis of the current state of training base of the Missile and Artillery Forces units and subunits it can be concluded that the artillery simulator – trainer Antracyt Plus should replace the functioning Reduced Artillery Shooting Ranges (ZSA). Because of the training needs, this system could be implemented in the following military units and military education units:

1) the Military University of Land Forces (AWL),
2) the Center of Artillery and Armament Training (CSAiU),
3) brigades (for squadrons, battalions),
4) artillery regiments.

Further development directions of the simulator will include preparation of positions for various means of reconnaissance such as BSL, RZRA LIWIEC, etc., development of a position sensor mounted on guns, allowing training of the entire training module (together with gun

crews). An additional direction of the simulator development beyond the training function may be the research function, allowing to investigate the following issues:

1) evaluation of the effectiveness of different types of artillery ammunition,
2) development of new methods of executing fire tasks (including target firing),
3) determining norms of consumption of artillery ammunition when firing at various categories of targets,
4) estimating the risk of causing unintended losses and damage (Collateral Damage Estimation) with a given type of munitions.

The tool in the form of a simulation training system is primarily dedicated to learning the artillery "craft" and performing fire tasks without the use of automatic fire control systems (ASKO). The system is to teach the logic of artillery operation and prepare for the situation when, also due to the actions taken by the enemy, the use of ASKO will be hindered. The main advantage offered by the virtual reality environment taking account of the enemy's AI should not be overlooked since it offers the possibility of trying out new tactical concepts and confronting them with the tactics used by the enemy and accurately "reproduced" by the AI.

The role of artillery, as the recent events in Donbass have shown, where artillery fire is responsible for about eighty-five percent of fatalities [4], is apparently not losing its importance. The Ukrainian experience proves that in the case of technological asymmetry of the fighting armored subunits, artillery remains the only available anti-tank means (both conducting indirect and direct fire). The role of artillery in interaction with independently operating tactical groups and as an anti-tank means is growing, its actions must be increasingly coordinated in real time with drones both if the objective is to perform precision strikes and when drones initiate mass fire in real time. There is also a growing need to coordinate artillery operations with battlefield radars to strike enemy artillery. These conditions cause that there is a huge number of variants and ways of using artillery on the modern battlefield, and the simulator can be a way to model specific variants and evaluate the results, and, most importantly, develop appropriate habits and decision-making skills.

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Conflict of interests

All authors declared no conflict of interests.

Author contributions

All authors contributed to the interpretation of results and writing of the paper. All authors read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

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Biographical note

Tomasz Całkowski – Lt Col., PhD, Deputy Dean for Academic Affairs at the Faculty of Military Studies, War Studies University. He graduated from the General Józef Bem Officer School in Toruń, the University of Warmia and Mazury in Olsztyn (geodesy and cartography), and the National Defense Academy. He performed his professional military service in the Missile and Artillery Forces units of the 15th Warmia and Mazury Mechanized Division, and then held research and didactic positions at the National Defense Academy and the War Studies University. His scientific and didactic activity is conducted in the areas of use and command of the Missile and Artillery Forces, Joint Fires, and combined fire support.

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Koncepcja wykorzystania symulacyjnego systemu szkolenia artyleryjskiego Antracyt Plus w procesie szkolenia Wojsk Rakietowych i Artylerii

STRESZCZENIE

Artykuł powstał w konsekwencji realizowanych w Wojskowym Instytucie Technicznym Uzbrojenia prac związanych z opracowaniem systemu szkolenia artyleryjskiego Antracyt Plus. Badania i prace rozwojowe skupione zostały na ustaleniu bieżących potrzeb szkoleniowych pododdziałów artylerii na szczeblu dywizjonu i zaproponowaniu rozwiązania z obszaru symulacji, które umożliwi realizację wszystkich przedsięwzięć szkoleniowych z zakresu Treningu Kierowania Ogniem oraz Treningu Indywidualnych Umiejętności Strzeleckich.

Dodatkowym celem stało się takie rozbudowanie środowiska symulacji, aby umożliwić artylerzystom podejmowanie treningów niemożliwych do realizacji w warunkach innych niż bojowe. Biorąc pod uwagę uwarunkowania współczesnego pola walki opracowano szereg scenariuszy umożliwiających realizację dowolnych zadań ogniowych w czasie rzeczywistym.

W artykule opisano proces szkolenia WRiA oraz w tym kontekście przedstawiono możliwości symulatora. W podsumowaniu znalazły się odniesienia do pracy poza automatycznym systemem kierowania ogniem oraz odniesienie do roli doskonalenia „rzemiosła" artyleryjskiego w kontekście rosnącej roli artylerii w przebiegu najnowszych konfliktów zbrojnych.

SŁOWA KLUCZOWE artyleria, symulator pola walki, Antracyt Plus, Trening Kierowania Ogniem, WRiA

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