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Armoured Fighting Vehicle Destruction System

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Abstract. The paper presents a system that is a worldwide-unique means designed for building engineering barriers, fitting into the quasi-intelligent battlefield concept. The weapons employed are an innovative solution that integrates acoustic, seismic, thermal and laser scanner sensors into a single quasi-intelligent decision-making system. The system enables deploying a minefield section which, after deactivating 1st and 2nd degree safeties, operate autonomously, selecting targets and eliminating them with an explosively formed projectile. The paper presents the concept of the system's design and results of tests of individual elements.
Keywords: anti-tank mines, explosively formed projectiles

1. INTRODUCTION

The purpose of the study was to develop an armoured fighting vehicle destruction system that is intended to constitute the next stage in the evolution of engineering barriers, enabling prevention of enemy troop movements (combat vehicles, means of transport). The approved Tactical and Technical Principles (TTP) served as the basis for the study. The project was carried out as part of a research and development study.

With the design solutions and engineering technologies used, the project is related to the following areas specified in the "Priority research directions in the national defence department for the years 2013–2022" document:

– sensors and surveillance (4.2) – application of a detonator utilising an integrated sensor suite (acoustic, seismic, thermal) for target detection, identification, tracking and destruction.
– precision weapons and armament (4.3) – application of ordnance in the form the newly developed explosive charge generating an explosively formed projectile (EFP). Through the execution and control systems, the charge works closely with the detonator systems, enabling destruction ability to be improved in comparison with classic off-route mines.

1.1. System design

The system comprises a minelaying unit, which is made up to 21 pcs. of ordnance with sensors, as shown in Fig. 1, and a set of systems enabling their remote operation and control, and managing the deployed minefield.

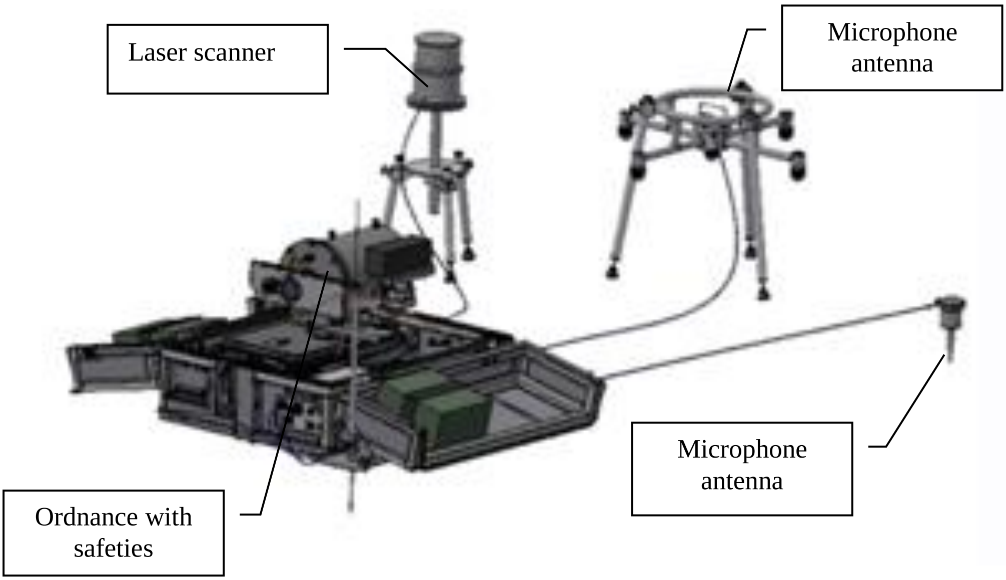


Fig. 1. Main elements

The system is intended to enable:

- deploying a minefield or a group of mines;
- autonomous aiming of individual mines at targets located at significant distances;
- autonomous engagement (destruction or neutralisation) of targets located at significant distances (up to 80 m), regardless of the target's position relative to the mine (omnidirectional engagement);
- monitoring the operation status of all mines after their deployment on the minefield;
- remote control over the status of all mines deployed on the minefield;
- streamlining the demining process through the ability to deactivate the deployed minefield and remove the mines;
- re-deployment of the minefield using the same components at another place;
- increasing the minefield's resistance to demining (manual, mechanical, explosive);
- operating under any weather conditions or time of day;
- reducing the number of people involved in laying a minefield.

1.2. Essential system parameters

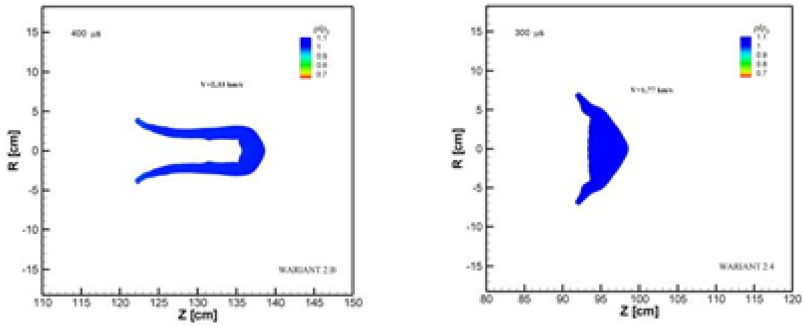
The most important tactical and technical parameters, from the functional point of view, are:

1. Minefield width: up to 1.0 km;
2. Mine deployment: 3 people (2 operator soldiers and a vehicle driver);
3. Mine personnel: 2 people;
4. Minelaying step: 80 m±10 m;
5. Distance between mine lines: 160 m±10 m;
6. Full configuration deployment time: up to 30 minutes;
7. Target detection range: up to 200 m;
8. Engagement range: 2 m to 80 m;
9. Penetration of side vehicle armour: up to 100 mm of armoured plate;
10. Weight: 195 kg/set;
12. Engagement angle: 0 m to 360 m;
13. Deployment height adjustment range: 0.5 m to 1.2 m;
14. Systems: non-removability, self-disposal, self-neutralisation;
15. Reuse ability: removal from the deployment site and re-deployment at another location;
16. Minefield control: ability to control a mine's status by a remote operator using radio signals;
17. Radio communication range: up to 1.0 km;

2. STAGES OF THE STUDY AND THEIR RESULTS

During the first stage, the EFP charge was developed – in cooperation between the Military University of Technology in Warsaw and the French company ERENCO. An ordnance design with reduced susceptibility to external agent effects (mechanical, thermal) was developed, which generated an explosively formed projectile, ensuring penetration of up to 100 mm of steel armour from a distance of 2 to 80 m.

During the first phase of the study, a series of digital simulations of the projectile formation process were performed for various boundary conditions (charge design, its geometry, the explosive material utilised), as shown in Figure 2.



a) *(b)*

Fig. 2. EFP charge simulations: a), b) correctly formed

Next, after physically producing a series of charges, these simulations were verified during test range experiments related to the armour plate penetration ability. The process of flight and penetration through the obstacle was monitored using a Phantom ultra-high-speed camera, as shown in Figure 3.

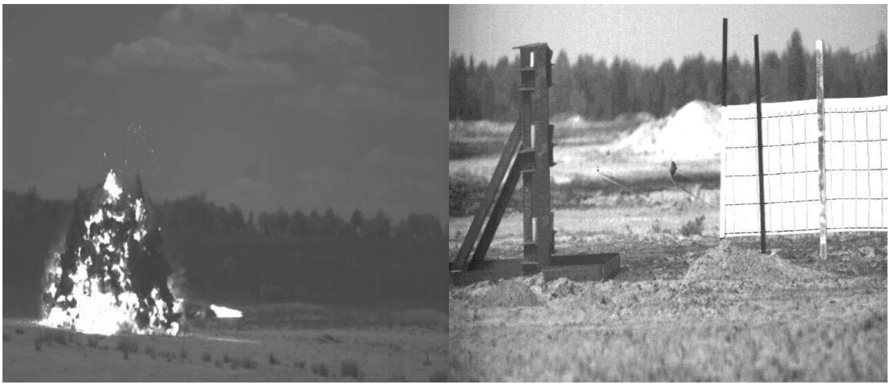


Fig. 3. EFP charge tests

At the same time, design details of the explosive charge casing and payload were perfected. All this resulted in improving the engagement parameters of subsequent model series, until the prototype's 100% engagement effectiveness was achieved (under state trial conditions).

The tests enabled verifying the computer simulations and analysing the effects of changes in geometric relations of the insert on obstacle penetration effectiveness. It was decided to introduce minor changes to the casing cover design (strengthening) and the shape of the four insert types: one of Armco iron (conical) and three made of copper (two conical and one spherical). For each series, two charges were produced. These charges were loaded with PBX material (density 1.65 g/cm^{-3}, detonation velocity 8.25 km/s), which was activated by electrical fuse EF and an intermediate detonator partially glued into the primary charge. In order to improve casing filling with the explosive during loading, its internal surfaces were covered with a layer of an anti-adhesive material – polytetrafluoroethylene (PTFE).

Fig. 4. Effects of EFP charges

During the second stage, the following were developed:

a) signal processing algorithms. In cooperation with the Telecommunication, ICT and Acoustics Institute of the Electronics Faculty of the Wrocław University of Technology (Poland), target detection, recognition and motion prediction systems were developed, operating on the basis of analysis of acoustic signals received from a microphone set and a seismic sensor. The use of complex signal processing algorithms enabled achieving high system sensitivity and precision.

   During the study, different configurations of acoustic sensors and algorithms processing acoustic and seismic signals were tested, which were to enable obtaining information about the presence of a vehicle within the detection zone, its type, direction of motion and distance. The selected solutions were tested under laboratory (on a stationary station utilising an acoustic signature database) and proving ground conditions (using armoured fighting vehicles and other vehicles). This enabled achieving effectiveness exceeding 80% during state trials.

Fig. 5. Testing the effectiveness of the system

b) detonator systems related to target engagement – in cooperation with Vigo System S.A., a thermal sensor was developed that enabled additional verification of the target's direction of motion and precision detection of targets in the mine's line of engagement.

During the study, different configurations of thermal sensors were tested, whose purpose is to verify the target motion direction, determined by the acoustic systems, and to select the optimum moment of detonation of the EFP charge. Under proving ground conditions, the effects of environmental conditions (illumination, heating and reflections) on system functioning were tested. During the qualification tests, over 80% effectiveness of functioning was achieved.

c) control console and control software – in cooperation with MIKROB S.A., functional software controlling the system's operation was developed, which was installed on a control console built on the basis of a portable computer with a reinforced structure. In order to improve the system's ergonomics, a portable device (configurator) for configuring mines deployed on a minefield was developed, which serves as an intermediate element in transmitting data between the mines and the control console.

d) During work on the model and prototype, the ability to configure and monitor the status of all mines and remote (radio-based) supervision of mines deployed on the minefield was tested.

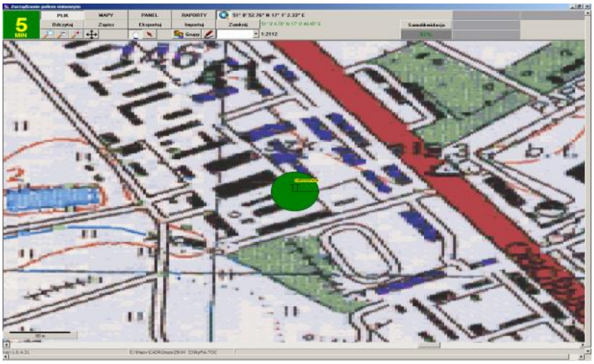


Fig. 6. Control console screen during testing

3. CONCLUSIONS

As demonstrated by the tests, the system's parameters (both functional, such as penetration ability, and operating, like omnidirectional operation ability) are superior to those of classic off-route mines (e.g. the Polish MPB), which were its predecessors.

The sensor systems detect the target, determine its direction and destroy it if it is located at a distance closer than 80 m. The ordnance is an EFP moving at a speed of approx. 2,500 m/s and capable of penetrating 100 mm of armour. The projectile hits one of the weakest armoured parts, i.e. the vehicle's side at the drive system height and below the turret (within the height range of 0.4–1.2 m). The energy of impact that affects the vehicle is much greater than anti-tank gun shells and missiles.

The system's ordnance and sensors operate automatically by design, which provides high effectiveness of armoured vehicle engagement, at approximately 80%. The operator may control the moment of charge detonation.

The minefield's structure is such that the use of classic demining methods (mechanical, electronic, or explosive demining using line charges) does not guarantee that a clear breach in the minefield can be achieved. This stems from the fact that combat vehicles attempting to cross the minefield along the demined section can still be engaged by neighbouring mines.

The system's design allows deactivation of the entire minefield or parts of it, e.g. during the retreat of friendly troops or in order to allow demining vehicles, recon vehicles or the first group of combat vehicles to pass through the minefield, and subsequently specific mines or the entire field to be reactivated.

The system enables forming a 900 x 300 m minefield. Defending a similar area with classic anti-tank mines would require using from approx. 1.2 thousand (influence or scatterable mines) up to 4 thousand (contact fuse mines) pieces of ordnance.

The relatively low number of mines in the system leads to a lower minefield price compared to fields of similar size, laid with classic or scatterable anti-tank mines.

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System niszczenia pojazdów pancernych i wozów opancerzonych

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Streszczenie. W pracy zaprezentowano system, który jest niespotykanym w świecie środkiem przeznaczonym do budowy zapór inżynieryjnych wpisującym się w koncepcję quasi-inteligentnego pola walki. Zastosowane środki rażenia są innowacyjnym rozwiązaniem, które integruje w jeden quasi-inteligentny system decyzyjny czujniki: akustyczne, sejsmiczne, termalne i skaner laserowy. System umożliwia ustawienie odcinka pola minowego, które po wyłączeniu zabezpieczeń I i II stopnia działają autonomicznie wybierając cele i niszcząc je wybuchowo formowanym pociskiem. Praca przedstawia koncepcję budowy systemu oraz wyniki badań poszczególnych elementów.

Słowa kluczowe: miny przeciwpancerne, pociski formowane wybuchowo.