MATEC Web of Conferences **214**, 04004 (2018) https://doi.org/10.1051/matecconf/201821404004
ICIPCE 2018

Aspects regarding the Conception, the Practical Realization and the Use of the "ETC - Mines" Tracked Mini Robot Functional Model in Humanitarian Demining Operations

Petrişor Silviu Mihai

"Nicolae Bălcescu" Land Forces Academy, Technical Sciences Department, 3-5 Revoluţiei Street, 550170, Sibiu, Romania

Abstract. In the present paper, the author want to highlight the construction and the possible implementation of a functional tracked mini-robot model within special humanitarian demining operations, a technological product developed within the *Advanced Logistic Technologies Laboratory* of our institution. The objectives and the hypotheses of the research, the methods and the instruments used in the process of the practical realization of the mechanical structure of the tracked mini robot as well as certain aspects related to its implementation and operation in humanitarian demining operations, a stage that was based on a study regarding the possible explosion by sympathy of a category of anti-tank mines, are presented in detail. We also mention the fact that the practical realization of the functional model of the "*ETC - Mines*" mini robot represented the starting point for the filing at the State Office for Inventions and Trademarks, Bucharest, Romania, of the patent application no. *a 2017 00562* representing the organological construction at a 1:1 scale of an innovative robotic technological product necessary for humanitarian demining missions.

1 Introduction

The usefulness of robotic technologies in operations of humanitarian demining of fields can no longer be questioned due to the innumerable advantages that they offer to the engineers in the theaters of operations (flexibility, minimal energy consumption using renewable energy sources, modular construction, robustness, small size, audio and video equipment, etc.) directly protecting them from being exposed to the hazards associated to the operations in question or to the detection of improvised explosive devices (IED) or of explosive devices, Explosive Ordnance Disposal (EOD) missions. However, the robot structures used in humanitarian demining operations are not only used in times of conflict but also in peacekeeping missions, all of these being part of the *United Nations Mine Action Program* (UNMAS) within the Department of Peace Keeping Operations, in countries where there have been military confrontations such as the Democratic Republic of Congo, Lebanon, Libya, Somalia, Sudan, etc. In all these states, the implementation of robust and flexible advanced technologies capable of demining mine fields without the direct involvement of the human factor and, subsequently, the replacement of the classic manual demining or by using oversized technologies to produce intentional detonation of mines are being attempted. The humanitarian demining of minefields represents a process of neutralization or destruction of the mines that can be found in a certain area or objective, this thing leading to the clearing of the affected land and it's rendering to the administrative authorities responsible for putting it into use. The humanitarian mine clearance operation is considered to be successful and the land is considered safe to use if 99.6 % of this is achieved [1].

2 Study on the explosion by sympathy of the main categories of anti-tank mines

The present study highlights the virtual explosion by sympathy for the destruction of a buried anti-tank mine using the trinitrotoluene explosive (TNT), this representing the most commonly used material in engineering operations. In this respect, we used a 3D simulation program in which detonation products in Euler-Godunov environments were introduced, and the buried mine is considered to be constituted of Lagrange-type elements, this being covered with a thin layer of polycarbonate. The model thus conceived is considered complete and the barrier conditions on the outside of it are of the Flow Out type thus allowing for the phenomenon to take place under similar conditions and outside these. In the simulation hypothesis (Figure 1), the following characteristics imposed by the existing environment of the action: a mine buried at 0.5 m with 9 kg of TNT explosive, an external environment considered air and two sensors that measure its pressure were taken into consideration. In order to carry out the explosions by sympathy, we used the model of Lee

Tarver-TNTCASTJJ1 material and during the simulation we followed the initiation by sympathy of the ALPHA variable, which represents the proportion between the detonating and non-detonating products, its value being 1 if the detonation is complete.

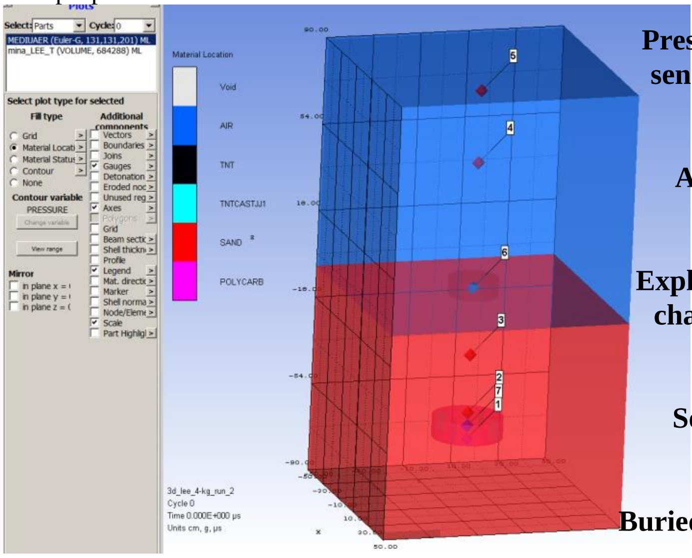

Figure 1. Presentation of the work environment.

Simulation no. 1: 4 Kg TNT. In the case of the first simulation, we used a quantity of 4 kg of TNT explosive in a cylindrical shape disposed over a 9 kg mine buried at 500 mm above the ground (Figure 2). At the moment 1.129 ms the mine begins to initiate and the so-called *hot spots* that demonstrate its initiation by sympathy appear (Figure 3).

Simulation no. 2: 1 Kg TNT. In the case of this simulation, a relatively small amount of TNT was used to test the behavior of the mine. At the moment 2.0 ms the mine is not initiated, thus one can consider that 1 kg of TNT disposed over the mine does not initiate it, the value of the ALPHA variable recording a small value (Figure 4).

Simulation no. 3: 1.17 Kg TNT. Since in the case of the previous simulation, the TNT quantity was insufficient to initiate the mine at 0.5 m from the surface of the earth, the amount of TNT was gradually increased until the mine was initiated, thus reaching the amount of 1.17 kg (Figure 5).

The conclusion of the simulations indicates that the quantity necessary to initiate a mine of about 9 kg buried at 500 mm in the earth should be between 1 and 4 kg. The exact quantity can be determined for each mine, depending on its characteristics, and a number of simulations similar to those briefly presented above should be made. On the basis of the above, steps could be taken for the practical construction of the tracked mini-robot model intended for the operation of humanitarian demining.

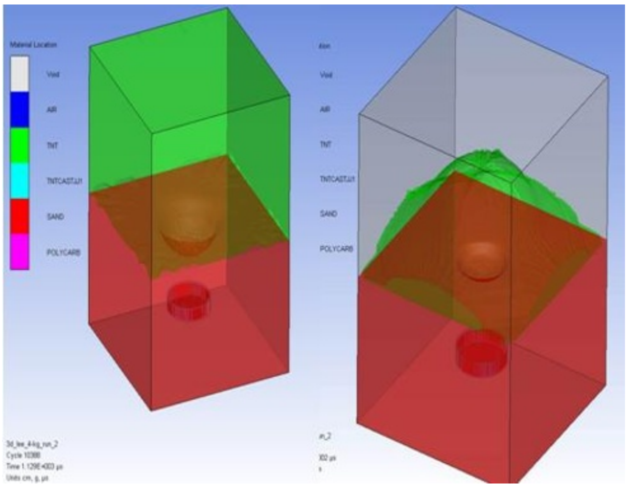

Figure 2. The explosion at 0.125 ms and at 1.129 ms respectively.

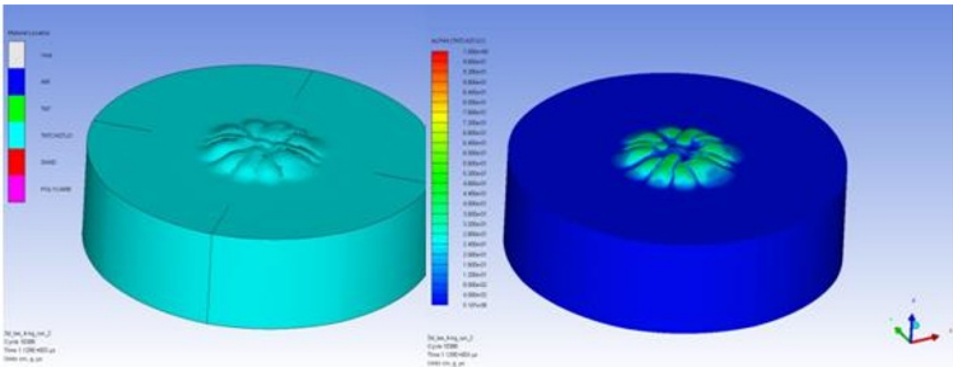

Figure 3. The ALPHA coefficient at the moment 1.129 ms of the simulation.

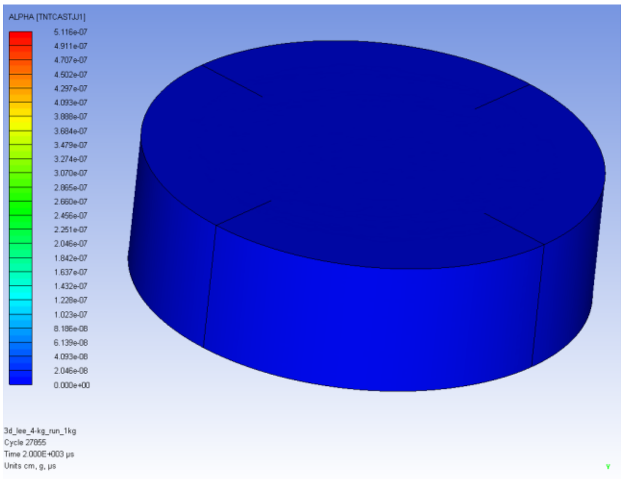

Figure 4. The ALPHA coefficient at the moment 2.0 ms of the simulation.

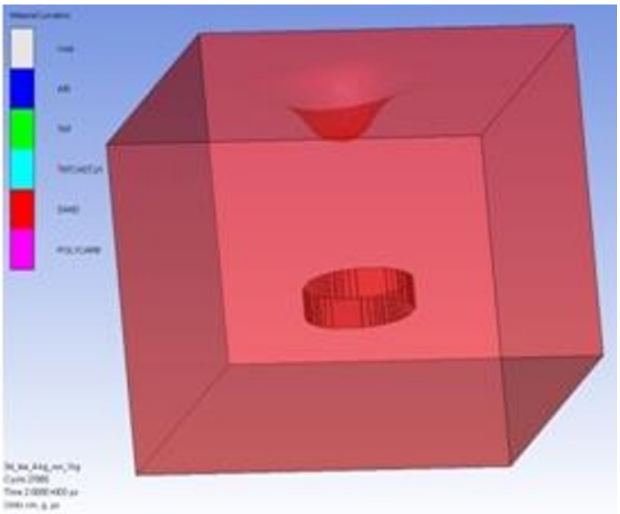

Figure 5. Explosion at 2.0 ms.

3 Concept and practical realization of the functional model of the *"ETC - Mines"* tracked mini-robot

In order to conceive and make the tracked mini-robot model intended for humanitarian demining operations in varied terrain (smooth or rough) during the time allocated for each mission, the following functional characteristics imposed to this were considered: to search and scan the land, to mark the lanes made in the minefields and to be capable to destroy the mines autonomously, to have a relatively low manufacturing cost (about USD 300) and a demining speed of at least 1.5 m/s, tobe able to funtion on the basis of solar energy being provided in this respect with photovoltaic cells that preserve energy in order to ensure uninterrupted operation, at the normal parameters of the minirobot organological configuration, both during daytime and at night. The mini robot locomotion is achieved by means of a smartphone and a bluetooth master slave module, the chassis of the structure is made up of two tracks with five carrier rollers driven by a driving wheel mounted by means of screws on its platform with a 40 cm opening (Figure 6). The driving wheel and the carrier rollers are fixed to an aluminum plate by means of a 2 cm long spindle. The tracks, 32 cm long and 5 cm wide, are made of plastic and are made up of 79 joints and oriffices necessary to move the mobile translation crew of the base of the mini robot (Figure 6). The *ETC-Mines* mini robot is powered by two 12 V DC motors that take energy from some photovoltaic cells and are controlled by a dual driver module, which also includes an Arduino Leonardo mother board (Figure 7) that helps to control the engine turation by means of the existing pins. Three ultrasonic distance sensors able to measure the distances up to a possible obstacle were attached on the mechanical structure of the mini robot model. By means of the programming code, the sensors will stop the mini robot at a set distance from the obstacle, and then they will help the mini robot by pass it. In order to achieve the placement of the trotyl packs on the ground, two arms that carry the packs of trotyl from the storage chamber of the mini robot by means of a mechanically driven conveyor belt were manufactured and attached to the mechanical structure of the mini robot. The conveyor belt is driven by a motor that mechanically transmits the motion to the drive drum towards the conveyor belt.

Figure 6. ETC – Mines mini robot– functional model.

In order to program the mini-robot structure (of the autonomous module), a programming language specific to C++ was used and in order to highlight the cleaned lane, the functional mini-robot model will mark the terrain during demining. In this sense, the mini robot was also provided with two red light led's simulating the marking of the lanes (Figure 8 a)).

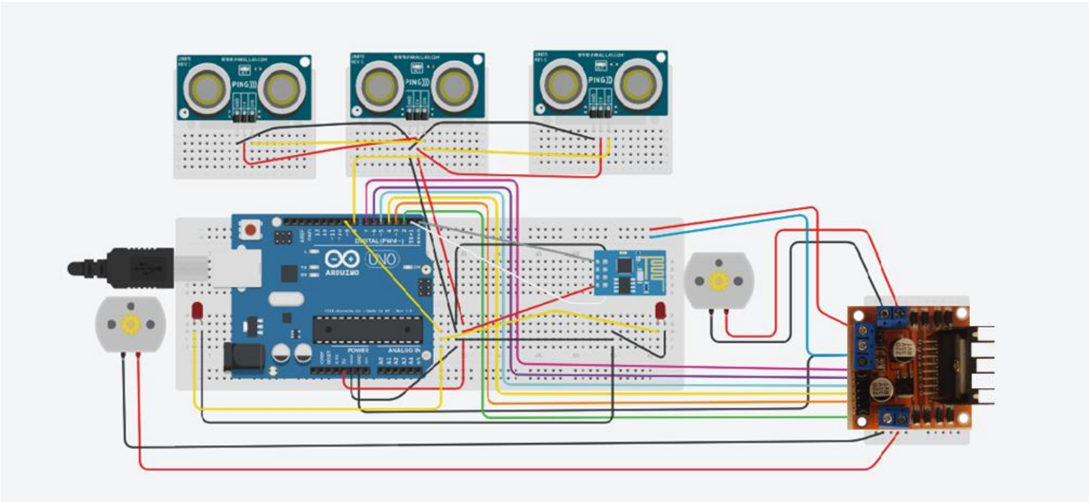

Figure 7. Scheme of the electronic components of the *ETC – Mines* mini robot.

This function is useful if it is vital to clear a lane in the minefield in high-risk areas such as CBRN - contaminated areas or areas that are under direct enemy fire. The function is not effective for achieving total mine clearance of a mine field, in this sense the wireless control performed by an engineer operator is needed. The mini robot can be remotely controlled by using an Android device that can make a bluetooth connection with a recognition device mounted on the mechanical structure of the model. The fact that the scanning of the mined ground can be done by means of a simple or infrared camera mounted on the mechanical structure of the mini robot is also mentioned; this camera transmitts, in real time, information to the engineer operator who is at the control desk and who, after the processing, can order the minirobot structure to carry out the demining of the field of anti personnel mine sand to avoid the obstacles encountered by the model. Figure 8 b) shows a scheme of total demining using wireless control.

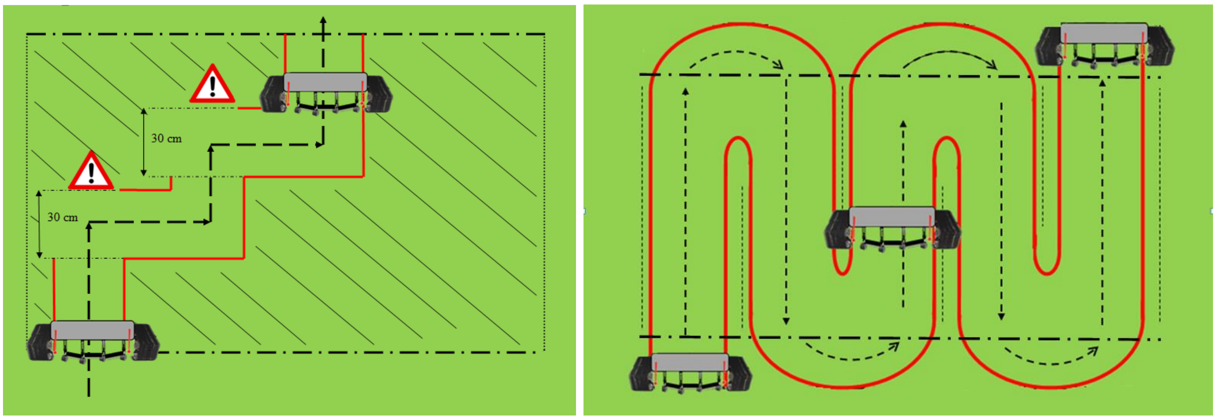

Figure 8. a) Scheme of the lanes in the mine fields using the "*obstacle-avoiding*" C++ programming; b) Scheme of total demining of mine fields using wireless control of an *ETC - Mines* mini robot operator.

4 Conclusion

Taking into consideration the advantages and the disadvantages of the robots used during the missions of demining mine fields, the author believe that their implementation within the demining groups that provide missions to ensure the mobility of the friendly troops is vital. This aspect is particularly highlighted by the need for safety and security of the demining groups in high risk areas. Thus, the preservation of the human resources is the most plausible argument that makes it possible today to rethink missions in accordance with the help received from robotic innovative products.

5 Acknowledgment

Participation with this paper was funded a grant type *PN-III-P1-1.1-MC-2017, No. 153* by *UEFISCDI*, Romania.

References

1. M. Habib, *Mine Clearance Techniques and Technologies for Effective Humanitarian Demining*, Journal of Mine Action, Issue 6.1, April, 2002.
2. R. Doare et all, *Robots on the battlefield – Contemporary issues and implications for the future*, Kansas, Combat Publisher Studies Institute Press US Army Combined Arms Center Fort, 2014.