April 2002

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Mine Clearance Techniques and Technologies for Effective Humanitarian Demining

To improve mine clearance performance and to enhance safety of demining personnel, there is a need for efficient humanitarian mine action equipment. Accurate and reliable mine detection techniques and technologies capable of area detection and clearance are crucial for successful demining.

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Introduction

The removal and the destruction of all forms of dangerous battlefield debris—particularly landmines—are vital prerequisites for any region to recover from their impact. These tasks involve a great deal of effort and time, and high risk, all of which result in high clearance cost per surface unit. Many conditions have to be observed, such as soil, topological and topographic factors of contaminated land. In most situations, the priority ranges from simple to highly technical devices. Pressure, vibrations, tension or pressure release, electromagnetic influence and seismic signals can detonate mines. Some landmines are “hardened” against neutralization by explosives, and other landmines have anti-detonating mechanisms. In addition, a mine may have a booster charge to enhance the power released by the detonator to a level that is enough to initiate the main charge. Mines may have been in place for many years; they may be concerted, waterlogged or impregnated with mud or dirt, and they can behave quite unpredictably. Some mines were buried deep in the soil in order to prevent more organized forces from finding them with metal detectors. Deeper mines may not detonate when the ground is hard, but rain may later soften the ground to the point where even a child's footstep will set them off. Modern landmines are fabricated from sophisticated non-metallic materials and incorporate advanced electronics. They are harmful because of their unknown position and because they are often difficult to detect.

Humanitarian Mine Clearing “Demining” Phases

The landmine clearance process can be divided into the following basic parts:

1. Locating and identifying a mine field in order to begin the process.

2. Preparing the mine field for the clearance operation, which can include cutting vegetation, collecting metal fragments from the surface, etc.

3. Locating and marking individual mines within the identified area.

4. Identification and processing of the detected mines by neutralization (either removal or detonation).

5. Enforcing quality control measures.

There is a need to notify that the cleared area is free from mines with a high level of confidence.

A clearance priority rating should be given to each mapped mine field by taking into consideration factors of a social and economical nature, as well as those related to weather and ground conditions. It is necessary to classify this step with a mine awareness program, which aims at reducing civilian casualties caused by mines and other explosive devices. Locating the contaminated land will help to separate the danger from people and to make the unmined land available for use immediately.

Solutions and Priorities

Current demining technology is slow, expensive and dangerous, and it can only cover a few hundred square meters per day. It becomes urgent to develop detection (individual and area), identification and removal techniques to increase the efficiency of demining operations by several orders of magnitude to achieve a substantial reduction to the threat of AP mines in a reasonable time frame and at an affordable cost.

The priorities for research and development in the humanitarian demining field require strategies that should start with the following needs:

• To develop reliable and accurate techniques that can enhance the performance of the demining process and allow efficient area detection of mines.

• There is an urgent need to recognize and reliably locate mine fields and isolate them by defining proper signs and limits to make the public aware and to avoid further accidents.

• To have quality training programs that fit the needs of local environments. Such training programs need to integrate cultural, environmental and operational considerations when developing.

• To enhance the safety of deminers by providing them with suitable clothing and equipment and by isolating them from direct physical contact with mines.

• To enhance the performance of the sensor and the deminer.

• To have light, reliable, easy-to-use handheld multi-sensor systems to support clearance in difficult and narrow environments (woods, uneven terrain, residential, etc.) and vehicle-based systems to support mine clearance in open areas.

• To use information and communication technologies in enhance contact, experience, research, planning and the sharing of results and data among all parties and personnel within the demining community.

• To have mechanized vegetation cutting, however, it would be wise to find a technology that can detect and mark mines without having to cut vegetation.

• To speed up the mine detection process with an array of sensors that can be integrated to cover wider areas.

• To automate/mechanize detection and removal of mines and to improve deminer safety through the use of efficient, reliable and cost-effective humanitarian mine action equipment (such as robots, flexible mechanisms, etc.) with minimum environmental impact.

• To have efficient quality control methods that are reliable and accurate in ensuring that an area is clear of mines.

Demining Approaches and Techniques

The demining methods currently being used are not safe for those clearing the mines or for those who must occupy the land after it has been cleared. The methods are neither effective nor efficient. Mine clearance itself can be accomplished through different methods with varying levels of technology, but the most laborious way is still the most reliable. We should favor technologies that can be manufactured in mined countries, that are transferable and that provide employment and economic infrastructure where it is most urgently required.

Manual Demining

Manual Demining is a procedure in which mines are manually detected and neutralized by a human deminer [1-5]. The deminer first scans the ground with a metal detector. Then the deminer uses a pointer in order to feel, locate and identify the object causing the signal, after which the deminer carefully uncovers it. When operating in this way, the detection phase still relies heavily on metal detectors, whereby each alarm needs to be carefully checked until it has been fully understood and/or its source removed. Most mines contain enough metal to be detected by this method, however, only one in every 1000 signals detected belongs to a mine or UXO. In general, the ground being cleared is often saturated with metal fragments, shrapnel and cars, making manual demining methods slow, extremely dangerous and expensive. Complicating matters more, about one-third of all AP landmines currently deployed are metal free. The accuracy of metal detection depends heavily on the level of mineralization and debris in the ground in which the type of mine used and the time needed to clear land varies enormously, depending on local conditions.

The Use of Animals, Insects and Bacteria

So far, dogs are considered the best detectors of explosives. Their sensitivity to this kind of substance is estimated to be 10,000 times higher than that of a man-made detector. Specially trained dogs are used to detect the characteristic smell of explosive residue that emanates from mines regardless of their composition or location. The dogs can be very trained. This enables the dogs to detect mines with low metal content that are undetectable by metal detectors. In addition, because dogs do not respond to metal, soil or non-explosive objects, they eliminate much of the time-consuming shortcomings of manual detection techniques. Mine detection dogs can work in almost all types of terrain. They are also easy to transport and highly reliable, and they can screen land up to five times faster than manual deminers. South Africa and Afghanistan have reported success, but it was more in locating the edges of mine fields than in finding individual mines. Dogs can be overwhelmed in areas with dense landmine contamination. Moreover, they can only work for short periods each day (about a couple of hours a day). Dogs can become confused if they can smell explosive coming from several sources at once. The effectiveness of the dogs depends entirely on their level of training, the skill of their handlers and, on their correct use.

Trained rats may be the best and cheapest detectors of mines. They have certain advantages over dogs. They have a better sense of smell, are cheaper to keep and maintain and they are more effective in locating targets. They can be used to detect mines in mixed environments, where dogs cannot be used. The litter of a trained rat is more likely to detect a mine than the rest of the litter. Each litter is trained to detect a specific mine type. Rats can find and verify all types of AP mines, whether intact or buried. Rats can work in almost all types of environments and can work in the highest levels of contamination. Rats can also work in the dark and in areas with dense vegetation. They can detect mines even when covered with water. They can be used in arid and desert areas, in large open areas and in urban areas. They are excellent detectors of mines, and they are cheap. They can work for 60 days at a time, and they are easy to transport. However, they are not as accurate as dogs, and they are not as adaptable to other types of mines.
Robots and Humanitarian Demining

Most people in the mine clearance community would be delighted if their work could be done remotely or, even better, robotically. The benefits of mounting a mine detector, and the cost of labor, are substantial. Autonomous robots, whether for humanitarian demining or some other use, are being considered for their possible use as mine detectors. Researchers at Sandia National Laboratories and the University of Montana are trying to determine whether foraging bees can reliably and efficiently search and locate landmines. The Geneva initiative to ban antipersonnel landmines under the provisions of the Ottawa Convention (1997) has reinvigorated research on land mine detection and clearance technologies. These technologies (such as armored vehicles, plows and so forth) have been developed to meet the need to have a reliable set of global standards for assessing the availability, suitability and affordability of technology with common information tools that allow for these assessments and evaluations. This can be enhanced by benchmarking the performance levels to develop equipment, strategies and systems. The development of multi-sensor systems involving two or more sensors linked to computer-based decision support systems with advanced signal processing techniques is attractive and is advocated by many as a fruitful line of development. A critical need is the ability to distinguish fragments or stones from the target material in real time.

Conclusions

Due to the complexity of the landmine problem and poor coordination of new technologies, development and field requirements, a well-coordinated plan needs to be developed to achieve the national, regional and international levels to address the issue of humanitarian mine clearance. Any single approach in technology should be viewed as yet another tool available for use in the demining process, but we must realize that no one technique will be sufficient. Furthermore, careful study of the limitations of any tool with regard to the location, environment and soil composition is critical. It is also essential that the technical operation and maintenance skills are important, as it is remembering that not all high-tech solutions may be available in different soil and environmental conditions. The development phase of such new technologies requires a well-established basis in the field of experimental design and technology development. The development phase of such new technologies requires a well-established basis in the field of experimental design and technology development. The development phase of such new technologies requires a well-established basis in the field of experimental design and technology development.