Humanitarian Demining Technology Toolbox

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ABSTRACT

This is a keynote address surveying the field of Humanitarian Demining (HD) from the viewpoint of a participating company. The controlling bodies, funding structures and some of the important sources of R&D relevant to HD are identified. The various techniques and technologies in common use as also technologies freshly put into field use are mentioned. The way in which they all fit into the demining toolbox is explained. Finally a view of future technologies that are potentially able to change HD efficiency and safety is discussed.

1. INTRODUCTION

When Russell Harmon asked me to give this lecture he indicated it would be good if I included a bit of a forward vision. I am writing the first pages in the first person because of personal opinion and experience. When I get to the Technology this was mostly team efforts and I will revert to the normal style of writing.

I have given the Toolbox or Demining Golf bag lecture at workshops before, this was while I was running a South African Government owned demining company called Mechem. Then my personal passion was to introduce some of our own more advanced techniques into Humanitarian Demining (HD) and so get to use them in UN controlled contracts. I used some exiting thunder and noise videos to keep the audience going and I am sure at least half of this audience has seen these HD videos at some time or another.

The gist of those lectures can be read about in an article I wrote for the JMU Journal of Mine Action (1), the videos show how the rollers and steel wheels of the Casspir and Buffalo Mine Resistant Vehicles (MRV's) were detonating some of the Anti Personnel (AP) landmines while doing Ground preparation and Vegetation Clearance. It also shows how the Mine Detecting Dogs (MDD), our Remote Explosive Sensing Technique (REST) called the Mechem Explosive and Drug Detecting System (MEDDS) and some MRV's and their blast tests. Also shown is the use of a Metal Detector Array on a MRV in the field. All of these were tools being used in our clearance contracts. Copies of these Videos are available on request.

This lecture however, will touch on some of the same steps in the Mine Clearance (MC) operation and show very short clips of the techniques in use but I will concentrate on the newest work and where this can lead to in the future.

For the past two years I have been a consultant, working for the CSIR who are the South African Government R&D laboratories. This is where the Government has moved the R&D people of Mechem into. The intention is for them to do Mine Action R&D in support of, amongst others the Southern African Development Countries (SADC) in their MC efforts. I am reporting some of these R&D projects here.

2. CONTROL OF HD MINE CLEARANCE

This is important because it affects the composition of the Tool box one is allowed to use.

In my experience the following happens as opposed to the official International system.

Detection and Remediation Technologies for Mines and Minelike Targets VIII,
Russell S. Harmon, John H. Holloway, Jr., J. T. Broach, Editors, Proceedings
of SPIE Vol. 5089 (2003) © 2003 SPIE · 0277-786X/03/$15.00

3. MAIN PLAYERS in TECHNOLOGY and MC CONTRACTS:

Roughly in order of influence:

3.1UN and its designated groups UNMAS, UNDP and UNOPS
3.2Government Offices of the Mine Contaminated Countries known as Mine Action Centers (MAC's)
3.3DONORS of aid monies for Mine Action.
3.3.1US State Department although they should group with the other DONORS warrants a separate mention.
3.3.2World Bank and other sources of money for in country projects, not DONORS in the true sense of the word
3.4NVESD
3.5Geneva International Centre for Humanitarian Demining (GICHD)
3.6European Commission (EC) of the EU in Brussels.
3.7Various Militaries and their R&D groups.

The last four are sources of new Technology developments that can support HD.

The role of ITEP and other International bodies to control technology has not impacted strongly yet but some movement is taking place.

For a Technology to break through into MC Field use is extremely difficult because of the mixture of players and their resistance to change.

The biggest hassle is to prove performance. Test site performance in one area is not accepted across borders and into other political and physical conditions.

4. THE GENERAL HD TOOLBOX TODAY:

4.1Area Reduction
4.2Ground Preparation
4.3Manual Detection
4.4Removal

Let us look at each of these steps:

4.1 Area Reduction

4.1.1 Word of Mouth
4.1.1.1 Level one Surveys
4.1.1.2 Military records
4.1.2 Rest
4.1.2.1 Dogs: MEDDS, NPA (Norwegians People Aid) and NOSHK (a Norwegian Company)
4.1.2.2 Rats: APOPO
4.1.2.2 Elephants (?!) with Satellites
4.1.3 MDD
4.1.3.1 Block searches
4.1.3.2 Free Roaming Explosive Detecting Dogs (FRXDD)
4.1.4 Mechanical
4.1.4.1 Steel wheels on MRV's
4.1.4.2 Flails (NPA and others)

4.2 Ground Preparation

4.2.1 Mechanical
- 4.2.1.1 Vegetation cutters
- 4.2.1.2 Light Flails
- 4.2.1.3 Heavy Flails
- 4.2.1.4 Rollers and steel wheels on MRV's
- 4.2.1.5 Tiller Machines
- 4.2.1.6 Ploughs
- 4.2.1.7 Rippers

4.2.2 Fire
- 4.2.2.1Natural
- 4.2.2.2Induced

4.2.3Manual
- 4.2.3.1 Hand held vegetation cutters
- *4.2.3.2 Magnets used on the surface to remove metal false signals*

4.3 **Manual Detection**
- 4.3.1 Hand held Metal detectors
- 4.3.2 MDD in block searches for further area reduction
- 4.3.3 Prodding devices
- 4.3.4 Quality Assurance (QA) or back up sweeps with MDD

4.4 Removal of the Landmine or UXO

- 4.4.1 Lifting by hand
- 4.4.2 Destruction with explosive charge
- *4.4.3 Destruction by burning*

Amongst these are some new ones (*Italics)* of which some are already accepted

5. AVAILABLE TECHNOLOGIES NOT USED

These are as yet only been used in isolated cases but show good potential for HD:

5.1 Metal Detector Arrays

Mounted on MRV's and used in MC clearance contracts with some success:

5.1.1 MECHEM: Used a modified Schiebel Vamids on a Casspir in Mozambique. Mechem raised the coil search height and improved the marking system to make the system more selective and have 15 fold less False Alarms (FA). A 2 Hectare portion of a minefield with non metal AP mines was cleared in half a day without missing one of the PMN and PMN-2 mines. The back up manual deminers and MDD found no more but did find an extra 1203 FA's due to small pieces of shrapnel that the array managed to avoid. They took two weeks to re-clear the 2 Hectare.

5.1.2 UXB: They used modified Ebinger UPEX-740 Deep Search System coils on a Rhino MRV in an UN road clearance contract in Eritrea. UXB calls the system KIMS (Kinematic Induced Magnetic Survey). By backing the first sweep of a 65km road in the Tempory Security Zone (TSZ) with Manual held coil frames and then MDD they managed to turn 1169 signals into 75 to be lifted. Some Mines and UXO's were lifted at depths of up to 750mm.

Both the mentioned examples above, showed the time and area coverage to be at least 20 times better than for the presently used manual MC techniques

Some people believe that the abundance of Mechanical machines and techniques can deliver the final solution to HD.
It is only Array detectors on MRV's that can at present find all the AP landmines COST EFFECTIVELY.

In both cases mentioned the arrays saved time and money but were backed up by other accepted techniques like Manual hand held detection and MDD to establish credibility.

This problem will in all probability be solved by:

5.2 Confirmation Detectors

In the above examples both companies used Manual Deminers and MDD as confirmation. With UXB it was also for signal reduction.

5.2.1Vapor Detectors.
- 5.2.1.1 Already the company Nomadics has an electronic vapor detector called FIDO that with a correct sampling device would be a reliable confirmation detector.
- 5.2.1.2 The company Biosensor Applications AB (BAAB) in Sweden has also developed a Biosensor that finds TNT vapors quickly and they are busy with sampling techniques.

5.2.2 Quadrupole Resonance (QR) of Quantum Magnetics
Used in GSTAMIDS
5.2.3 Nuclear Detectors Like PELAN
5.2.4 Ground Penetrating Radars
5.2.5 HSTAMIDS of Cy Terra
5.2.6 ERA in the UK have also a operational GPR/Metal detector
5.2.7 Acoustic detectors reported during the 2002 Monterey Conference to be under R&D
5.2.8 Mechanical
- 5.2.8.1Rippers have been used
- 5.2.8.2 Disc Rollers have been used

5.2.9 Air Spade

All can be used on a second Confirmation MRV.

5.3 Mine Resistant Vehicles (MRV)

These vehicles serve as platforms from which a variety of tasks can be done in a mined environment with more safety and efficiency. Some companies and NGO's have started using them.

In my opinion they hold the key to significant advances in cost effective HD.

Traveling in mined areas has proven hazardous in unprotected vehicles and the UN has been providing MRV's to their personnel in certain areas. As yet very few companies and HD NGO's use them.

Because of the costs HD have shied away from Military MRV personnel carriers except where they have been able to purchase reconditioned or second hand functional equipment
For the rest PROTECTION KITS that enhance AT Landmine survival when traveling on mined rural roads have been asked for.
During the Southern African wars cheaper armored hull MRV's were developed with high mine resistance for use by Farmers and Civil Authorities in the mine threat areas. These are being looked at by the UN for their purchases.

6. PERSONAL PROTECTION EQUIPMENT

Previously when concerned with Higher Technology HD in the field we did not consider equipment like Mine Boots, Helmets, Visors and Bomb suits as part of the Toolbox. This was mainly because our experience with safety was that to work on the ground in the mine fields was simply too dangerous when compared with being inside a MRV and using some demining tool

In this regard the safety record of Mechem during demining operations when measured against the quoted norms by the UN for Manual deminers was about seven times better. So we did not propagate that one should be in the minefield on your feet wearing protective gear.

As pointed out by Col George Zahaczewski there will always be deminers doing something on the ground in a minefield, so we may as well get involved with the equipment. As it turned out, this advice led down the line to a R&D contract for CSIR from NVESD. This was to develop a new concept and testing methods for Mine Boots.

7. NEW PRINCIPLE OF PROTECTION

The principle is specific for BURIED charges for when they are detonated under a foot or wheel. The explosive shockwaves that generate in the detonating explosive is normally calculated using gas phase dynamics.

Very close to an above surface explosion the air shockwave runs out ahead of the fireball of hot gasses and explosive products. This can clearly be seen as an optical diffraction moving away in a regular spherical shape. This slows down as the pressure differential in front and behind the wave front gets smaller. Initially it is hyper- then super-sonic till it is speed of sound some distance away. Also at some point depending on the size of the charge, the expanding fireball of gases and glowing solid products of the detonation like carbon catches up and passes the air shock wave.

The people doing simulations of explosive effects do proven predictions for these surface explosions and the air shock close in, plays quite a role. For airburst blasts against targets simulation works fine.

7.1 Buried Charges

These show quite different primary properties for damage predictions. Up to now the attempts at simulation have not been able to predict damage reliably. Since the late 1970's we have been observing and measuring damage in Landmine explosions without being able to do mathematically sound predictions. We have, after the sanctions years, reported these findings to various knowledgeable groups who in turn could still not do predictions for real world situations but some results did emerge.

In controlled test conditions some results (2, 3) showed damage predictions were Impulse Transfer driven and not just due to the Overpressure the explosive develops against the target. These Impulses transferred in very short time regimes (less than a millisecond) and generally happened inside the fireball, making measurements difficult.

We from our side we continued our observation and experimentation route till it became apparent that the shock waves in the solid materials of the landmine, soil, sole of the boot or rubber of the tire and what is down line of these, play a major role in the direction and size of the damage done.

To measure these solid material shock waves and where they go, we built mechanical Impulse measuring equipment. We could calibrate and test our electronic and optical techniques against these.

The result is that some new protection possibilities have emerged which could result in viable protection against 120g TNT class mines (PMN-2) and possibilities for even beating the heaviest AP charges like in the PMN and PMD-6 which have main charges of more than 200g TNT.

Importantly the blast wave that is deflected can be controlled not to hit some other parts of the victim's body.

It is hoped that the same principles can be used for light vehicle protection. There are already tire inserts that provide some protection against wheel explosions e.g. from the company Hutchinson's. These are based on physical deflection of the blast wave to the outside of the wheel and away from the vehicle.

The improvements we are hoping for when solid material shockwave manipulation is introduced will be that the amount of deflection and the positions from where one can pick these waves up and still manage to do a significant deflection can be bettered.

Our test experiences show that once the Blast wave has established a direction and size, you must use strong deflection plates to move it aside. It is much easier to point it in the new direction you want before the blast effect builds up momentum in a direction.

When it comes to gloves, prodding equipment and other near proximity to the explosive objects and equipment, the new approach is sure to add some improvements to safety of the Deminers.

7. REFERENCES

(1) M Held: Blast Distribution of Cylindrical HE Charges
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(2) Prof Dr. Held TDW Ermittlung der Wirkung von Blast-Minen mit der Momentum-Metode.