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The GICHD Mechanical Application in Mine Clearance Study

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Abstract

The GICHD Mechanical Application in Mine Clearance Study consists of four sub-studies; Ground Processing, Risk Assessment, Area Reduction and Ground Preparation. The study also includes two annexes; Guidelines for the Protection of Vehicles and Plant Equipment Used in Mine Clearance, and Mechanical Cost-Effectiveness

1. Introduction

The greater share of humanitarian mine clearance is carried out by manual deminers and specially trained mine dog detection (MDD) teams. Machines make a contribution to the work of these two systems, creating safer conditions and greatly speeding-up the overall clearance process.

In various forms, machines have been employed for mine clearance since the First World War. For many years, demining machines were the preserve of the military. Until the advent of the humanitarian demining movement in the late 1980s, the development of specialist vehicles for mine clearance had been relatively limited.

As humanitarian demining gathered pace, it was assumed that machines would inject a much needed increase in clearance rates with a higher safety level. Thus far, this has occurred to a lesser extent than was expected.

Mechanical mine clearance systems are employed on an ever widening scale and the choices of machines on the international market continues to expand. However, there exists a belief that machines have not been applied to clear mines to their fullest potential. There is little continuity of opinion amongst the demining community as to why this might be. It could be as a result of accumulated experience, suggesting that current technical limitations on mechanical abilities to clear mines effectively prevent the success expected; or it could be that mechanical demining has become beset by conservative thinking in deployment solutions, preventing machines from realizing their productivity potential.

Cost-effectiveness implications of machine assisted mine clearance are not thoroughly understood by non-commercial organizations.

The factors of risk assessment in deciding where and when to deploy a machine have not yet been rationalized.

The most appropriate roles for mine clearance machines are known to a minority of the mine clearance community.

Guidelines regarding the standard of operator protection required for a machine before it is safe to deploy to live operations had not previously been established.

The GICHD recognized the opportunity to contribute to the better understanding of machines employed for mine clearance. A study intended to cover the main aspects of mechanical demining was commissioned in December 2001. The GICHD Mechanical Application in Mine Clearance Study is to be published during the last quarter of 2003.

1.1. Ground Processing

Mechanical ground processing implies that a machine is deployed into a minefield in order to provide the main clearance method of a task, rather than merely preparing the ground for subsequent clearance systems such as manual deminers or mine dogs.

If particular machines can prove themselves capable of clearing a stated mine type in stated topographic and soil conditions, it may be possible to curtail back-up assets to a minimum, used only to remove the residual threat expected to be left by the machine. A reduction of back-up clearance systems behind machines would save time and therefore money.

The employment of machines for ground processing is a possible goal for mechanical application in mine clearance. It is not currently in wide practice. It is slowly being recognized within the demining community that some machines have the potential to become primary clearance assets followed by scaled-down, secondary clearance methods. Rather than machines supporting manual and MDD, in certain conditions with specific systems, manual and MDD teams could support the machine.

The main conclusions of the Ground Processing sub-study are:

- Numerous examples exist of machines employed in the ground preparation role achieving ‘full clearance’ unintentionally. In some cases, subsequent clearance assets (manual and MDD teams) are recording that all AP blast mines are detonated or sufficiently broken-up so that the hazard is removed.

- Primary ground processing is already successfully practiced using the mechanical excavation method.

- Machines are under-employed and no attempts are being made for their use as primary ground processors (except mechanical excavation). The demining community is conservative regarding machine employment. For primary ground processing with flails or tillers, a culture of ’not doing it’ has prevailed.

- For flail and tiller systems, limited scientific research and extensive empirical experience has exposed potential technical reasons why mines are missed or not destroyed. Better understanding of these negative effects may lead to their suppression, thus better controlling the outcome of machine work. Empirical data shows that for some systems, technical problems identified are not seriously detrimental to machine performance.

- Research to understand which environmental conditions are optimal for clearance by machine (terrain, soil and vegetation type, mine type) is required. Once best conditions are identified, machines could be employed with greater confidence of success.

- There exists no solid evidence to suggest that machines are less effective or more prone to missing mines than are dogs or manual deminers. Scepticism surrounding mechanical efficacy is commonly held.

1.2. Risk Assessment

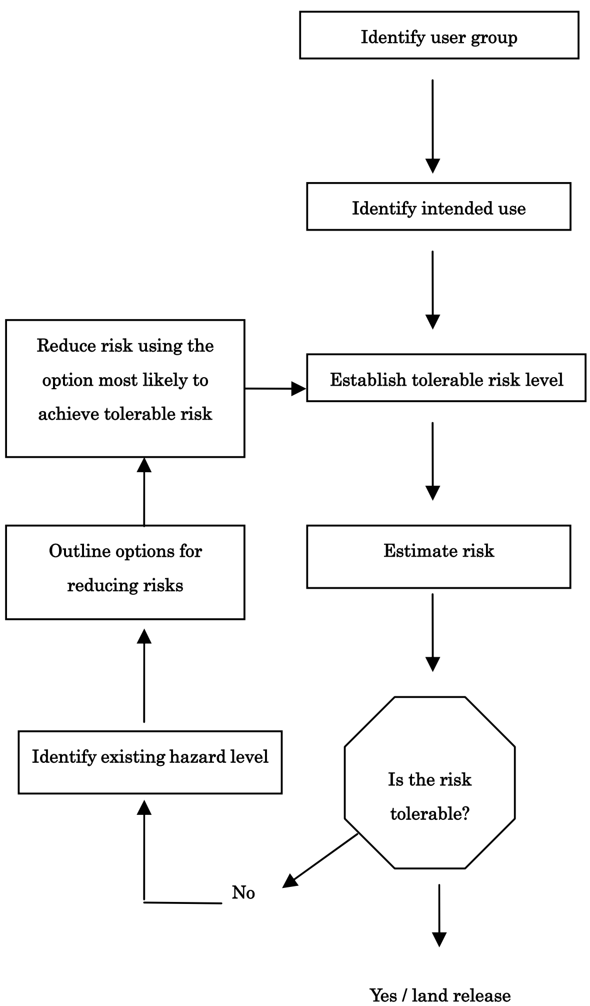
Risk assessment is a tool used to make qualified decisions about how to optimize the use of scarce resources. Risk assessment provides the basis for determining the risk involved in certain processes and justification for the actions that have been undertaken.

The aim of the Risk assessment sub-study is to provide background information on the principles of risk assessment and what these mean within the context of the use of mechanical assets. It is aimed at raising issues of machine deployment and the roles they can fulfil. The sub-study aims to stimulate thinking into the greater use of machines based on the concept of reliability of a particular system and the probability of mine and UXO presence in clearance tasks.

The focus of this report is on the product risk and implications that residual risk plays in the approaches to machine use.

The study begins by defining the basic concept of risk assessment as the basis for explaining how risk assessment is carried out. Case studies are used to highlight how risk-based concepts are currently utilized. The level of risk is discussed based on tests and empirical resources, highlighting potential areas that may impact on machine results.

Risk assessment is a combination of analysis and evaluation which may lead to a risk reduction. This process is illustrated in Figure 1:



The main conclusions of the Risk Assessment sub-study are:

- Currently, identified minefields are cleared with the intention of achieving 100% clearance. Potentially, depending on future debate, measurement and management of risk could be viewed as being determined by local tolerance and acceptance of risk. Disciplined and methodical approaches to risk assessment will strongly influence operating procedures and desired clearance outcomes in a demining task. Impact and probability of an accident should be considered. A focus on impact alone however may lead to clearance standards which are unduly restrictive or prohibitive (i.e. tasks take too long). The extremes of clearance requirements for a particular community could range from full clearance to only area reduction. The application of risk management theory to demining could result in increased safety (due to a greater number of tasks being completed), productivity and cost-effectiveness.

- Machines could be well employed to provide information about a mine field prior to clearance. Rather than assuming that all suspect land requires full clearance, information gained from machines could be used to estimate the risk of mines being present. From this, follow-up clearance can be formulated to the requirements of each situation. Follow-up can be based on information available concerning risks remaining after a machine has been deployed. This process is seldom put into practice.

- Limited research has been conducted as to the reliability of mechanical systems to clear mines. Empirical evidence has however shown that in many cases, machine capabilities are high. A standardized, higher quality of clearance data for machines will aid the build-up of empirical information in order to gain a more accurate picture of mechanical system efficacy. Especially useful would be records regarding mechanical systems effects on mines by type, at what depth and in what condition (if not detonated) they were found in by follow-up clearance methods. A definition as to what constitutes a 'broken-up' mine – no longer a hazard – needs to be attempted. There may be circumstances where broken-up ordnance can be left in situ so long as fuse mechanisms have been neutralized. Exposed explosive material left behind can naturally deteriorate through weathering.

- Tolerable risk criteria can be established prior to clearance activities. This occurred in Kosovo where high risk areas were identified and targeted. Suspect areas that did not represent a direct risk to communities were deemed tolerable and left to be dealt with by the national clearance agency at a future date.

1.3. Ground Preparation

Demining machines have already established respected credentials as ground preparation tools for manual and MDD demining methods. The Ground Preparation sub-study attempts to demonstrate the operational (and by implication cost–effective) benefits of employing machines to prepare ground for manual and MDD teams. The three levels of ground preparation are explained:

- Level 1 Ground Preparation: The removal of vegetation and tripwire threat. This level generally involves two types of machines; non-intrusive – machines which operate from previously cleared lanes using commercial bush-cutters attached to hydraulic arms that extend to cut vegetation in un-cleared areas; intrusive – small, remote-controlled machines specially designed for vegetation cutting from within un-cleared areas.

- Level 2 Ground Preparation: The removal of vegetation and tripwire threat plus a ground-penetrating tool to break-up soil. This method often involves flail and tiller type tools attached to armoured prime-movers that operate by remote-control or are operator driven from within uncleared areas (intrusive).

- Level 3 Ground Preparation: The removal of vegetation, tripwire threat, breaking-up of the ground and removal of metal contamination. This will often involve machines commonly engaged in Level 2 preparation but with the addition of a magnet to collect metal fragments from over-turned soil.

The Ground Preparation sub-study involved using selected case studies, existing clearance data from implementing agencies, visits to operational headquarters and programmes in the field in five countries. The sub-study aims are to:

- Identify the optimum ground preparation procedures.

- Document results from experiences of area preparation in order to assess its advantages.

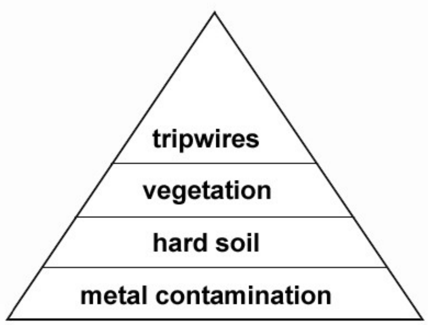
- Recommend a ground preparation methodology.

The main conclusions of the Ground Preparation sub-study are:

- Level 1 ground preparation brings limited benefits to manual and MDD team demining. Intrusive machines can support more deminers than non-intrusive machines. Both are highly dependent on their association with follow-up clearance and the distance between demining lanes.

- Level 2 ground preparation offers a marked improvement in the benefits brought to manual and MDD teams. According to tests carried out by the GICHD, the speed of manual excavation of metal signals is significantly increased. The turning-over of soil may allow dogs to work ground for longer periods in theatres where winter hinders their deployment. Machines that carry-out Level 2 ground preparation are always intrusive.

- As well as including the benefits of Levels 1 and 2, Level 3 ground preparation has the potential to greatly increase the speed of manual demining in areas where metal fragments hinder progress. The optimum machine is one that can achieve Level 3 preparation in one pass. The ability to achieve Level 3 would generate the greatest value for follow-on clearance techniques. Level 3 ground preparation removes all common obstacles faced by manual deminers. These obstacles can be grouped in a hierarchy (i.e. removal of metal contamination has the greatest impact on efficiency). The hierarchy is expressed below:



1.4. Area Reduction

Area reduction has the potential to develop into one of the most positive roles for machines in mine clearance. Within the large and indistinct suspect areas, it is of great benefit to quickly and efficiently elucidate where mines are **not** located as part of the survey process, and to delineate actual parameters of a minefield. This not only frees-up large areas of land previously considered unusable, but also facilitates rapid deployment of other clearance assets straight into true mined areas. The greatest drag on time in mine clearance is spent clearing land where mines are subsequently not discovered. Cancelling out non-mined land by machines provides a significant contribution to demining operations. Allocating this task to manual or MDD methods is vastly time consuming and therefore expensive. The benefits of area reduction by machine are illustrated using data from two case studies of actual operations; The HALO Trust front-end loader with Pearson Mine roller in Abkhazia, and the Thailand Mine Action Centre's (TMAC) use of the Pearson Engineering Survivable Tractor and Tools (SDTT) along the Thailand-Cambodia border.

The main conclusions of the Area Reduction sub-study are:

- In patterned minefields, machines can be used to identify a line where mines begin. In non-patterned minefields, machines can be used to identify areas containing mines.
- In patterned minefields, there is a high reliance on verbal and/or documented survey information. Machines can be used to confirm information. In non-patterned minefields, machines are used to obtain information as to true areas containing mines.
- Locating the perimeters of actual mined areas could potentially cancel-out non-mined areas where manual and MDD teams spend the majority of time clearing. Worldwide, the majority of time spent in mine clearance is wasted searching for mines. If machines are incorporated to reduce area as part of the technical survey process significant time may be saved.

1.5. Mechanical Cost Effectiveness

Demining organizations that use machines in their operations understand that mechanical assets bring significant operational advantages. Some instinctively realize that much of the advantage is financial. While this might be the case, few of the non-commercial demining NGOs are able to quantify the cost-effective benefits that machines deliver. The Mechanical Cost-Effectiveness annex to the study sets out to explain the means of calculating cost-effective advantages of machines. A software programme to help achieve this has been developed. The software assists managers to conduct a comparative analysis of costs and productivity between available demining methods - MDD vs. manual vs. machines. The tool may help improve the planning ability of field managers by helping them to allocate machines to the most appropriate tasks in the most appropriate locations, in order to extract the maximum operational and cost-effective gains.

1.6. Guidelines for the Protection of Vehicles and Plant Equipment Used in Mine Clearance

The armouring guidelines form an annex to the GICHD mechanical study. These guidelines focus on armouring and protection of vehicles employed in all mine clearance roles. Currently, the demining community does not have access to centralized information or industry norms on this important subject. When applying protection to machines, organizations must often rely on gut feeling rather than on results for scientific research. The GICHD commissioned the South African defence and research establishment, CSIR, to provide guidelines to machine operators on making vehicles safe for use in a live minefield. Understanding the threat, and the measures required to counter it, are crucial components of mechanical mine clearance operations.

2. Conclusions

The GICHD Mechanical Application in Mine Clearance Study is designed to give direct conclusions on the way machines are currently used, and possibilities for their improved employment in the future. Previous mechanical mine action studies have tended to be more along the lines of situation reports, listing existing machines and the programmes on which they have operated but tend to stop short of venturing an opinion. The GICHD study attempts to highlight areas requiring further research as well as identifying the most suitable and apparently successful roles that machines can play.

A recurring theme throughout the report is that in general, machines have been underemployed. Worldwide, current clearance rates using the two most common demining methods of manual and MDD teams are just too slow. Efforts should be made to achieve greater productivity. Despite some of the scientific and high-tech solutions that are currently undergoing research and development, effective machines exist today that can be exploited in order to increase the pace of freeing-up land and reducing risks to civilians.

The main conclusions of the GICHD Mechanical application in Mine Clearance Study are:

- Given suitable conditions of topography, soil and mine type, some machines currently employed in mine clearance have proven capable of performing ‘full clearance’ against sub-surface, AP blast mines. Examples occur incidentally as a result of ground preparation operations. Machines therefore show potential as primary ground processing systems. Grater understanding as to the optimal conditions for machines is required.

- Machines in the excavation role already achieve full clearance but at a relatively slow rate.

- A more structured system of risk assessment in mine clearance could lead to levels of clearance selected that are particular to localized levels of risk tolerance and acceptance. Some clearance tasks could be more quickly expedited where conditions allow.

- Instead of assuming all suspect land should receive full clearance treatment, machines could be used to provide information as to the risks of mines being present (e.g. machines employed as part of technical survey).

- Where feasible, machines should aim to achieve Level 3 clearance in order to provide maximum operational and cost-effective benefit to clearance operations.

- The benefits brought by machines employed in ground preparation can be listed in order of priority as:

    1. Remove metal contamination
    2. Break-up ground and expose metal contamination
    3. Clear vegetation.
    4. Remove tripwires.

- Machines are an efficient way to locate mines, delineate mine patterns and cancel-out non-mined areas.
- In mine clearance operations, the majority of time is spent searching for mines. Machines are able to dramatically reduce the time spent on this process.

There remains much scientific investigation to be conducted, and much empirical data to be collected before a better understanding of just how effective machines are can be accurately stated. What does seem certain is that machines have much to contribute to demining efforts – both operationally and financially. It is hoped that the GICHD study might form the basis for future research into this field.

Acknowledgments

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