Main study conclusions and recommendations

Conclusion 1.

Under certain circumstances, machines are capable of achieving full clearance.

Even when employed only in the ground preparation role, some machines have shown, through the testing and empirical performance data available, and when operating in a suitable environment no live mines are left in a condition that could pose a further threat. Where mechanical excavation is concerned, clearance is achieved down to the depth at which operators remove suspect soil.

Recommendation 1.

Machines used for primary clearance can achieve the IMAS specification of mine clearance quality in suitable environments against certain mine types. The residual threat — ordnance that is unlikely to be fully destroyed by a particular machine in a particular environment — should be understood by the operator and the relevant demining authority. Any post-mechanical clearance by manual or mine detection dogs (MDDs) should be tailored to meet the identified residual threat in order to make clearance operations more rapid.

Conclusion 2.

With regard to flails and tillers, the physical interaction between the destructive tool, the ground and the mine/UXO, is not completely understood.

Some of the negative effects — such as throw-outs or burying — have been identified but their exact causes can not yet be fully explained.

Recommendation 2.

The demining and the scientific communities need to conduct further research into the following areas:

- *To determine how the following issues:*
  - *impact stress and soil movement;*
  - *limits imposed by soil/terrain/vegetation;*
  - *flail hammer geometry;*
  - *engine power;*
  - *flail shaft height above the ground;*
  - *forward speed, and;*

- *mine type*

are responsible for the negative results of:

- *soil bulking/overburden;*
- *throw-outs;*
- *skipped zones;*
- *slipstreaming (tillers only), and;*
- *burying and bow wave (tillers only).*

Better understanding of the causes will lead to suppression/control of the effects; mechanical clearance results should be predictable.

- *Where mines/UXO are not detonated but are broken up by machine use, the remaining fragments may or may not constitute a further threat. Relating to different mine types, guidelines should establish the level of damage to a mine such that it no longer poses a threat to subsequent clearance personnel or users of the land. Where ordnance fails to detonate, a definition of what level of destruction constitutes a non-hazardous mine/UXO, when broken up, is required.*
- *Some mechanical tools penetrate the ground, often resulting in removal of top soil, leaving pulverised earth and destroying shallow root systems. The short- or long-term ecological damage that might be caused to soil and the implications this has for agriculture should be established.*

Conclusion 3.

The clearance capability of some mechanical demining systems is not always predictable.

In part this is due to a lack of testing with a sufficient number of ordnance targets. Due to the efforts of the European Committee for Standardization, Workshop 12 (CEN WS 12), more and better testing data is likely to be available in the coming years. Another reason for the lack of understanding of machine effectiveness is the limited availability of machine clearance data from field operations which could be used to assess mechanical systems empirically. With such information, a greater understanding of mechanical clearance capability would emerge.

Recommendation 3.

The demining community should record mechanical clearance data in a standard, internationally recognised format. This would provide a clear, comparative format for assessing the true capabilities of various mechanical systems involved in demining. Empirical data could then be used to argue the case for further employment of machines in mine clearance. Templates and software for the collection of standardised mechanical clearance data is under development at the GICHD.

Conclusion 4.

Mine clearance is in reality a risk reduction process. However, the total removal of risk cannot be guaranteed due to the limitations applicable to all known clearance methods.

A structured risk assessment with its attendant understanding of local, tolerable risk criteria will assist deminers in making the most appropriate decision as to where to carry out clearance (prioritisation), and by what means. Currently, the worst case scenario is generally applied, resulting in an attempt to clear all suspected hazardous areas — often not the most efficient use of scarce resources.

Recommendation 4.

- *Demining agencies should consider using a structured risk assessment process to get the best out of their clearance. General survey information should be assessed by physical action, i.e. technical survey, in order to make the decision whether or not to commit deminers to an area.*

- *In the right physical environment, machines are often the most effective means of acquiring accurate information about the ordnance hazards in a suspect area.*
- *Machines should be used for technical survey as part of a risk assessment process. Currently, this use for machines is not practised widely. Increased use of machines in this role will allow deminers to confidently rule out the necessity for further clearance in some areas. In areas where subsequent demining is required, the risk to deminers is reduced as quantities of existing ordnance may be destroyed and ground will be prepared making subsequent post-mechanical clearance faster. The attempt to clear all suspect areas all the time is not required and will only slow down the worldwide effort to remove landmines and UXO.*
- *Manufacturers should consider the information gathering abilities afforded by clearance and detection tools attached to mechanical systems, and attempt to incorporate such assets in their designs. Further research on machine attachments other than the primary working tools, such as vapour detectors, magnets, ground penetrating radar, global positioning systems (GPS) and thermal imaging is encouraged.*

Conclusion 5.

Today, the great majority of suspect land cleared is subsequently revealed not to contain mines.

Much time is spent in the search for ordnance, particularly where general survey information is poor. Data analysed by the GICHD from 15 separate national demining authorities indicated that of all land cleared, it is possible that an average of less than less than three per cent of suspect land ever contained mines or UXO. Knowing where landmines are located and therefore where to clear, is possibly the best way to increase demining efficiency.

Recommendation 5.

Where no clear evidence of a threat is confirmed, suspect areas can be eliminated through a systematic mechanical area reduction process. The same would apply to areas where hard evidence of the presence of mines exists but quick confirmation as to true disposition is required.

Conclusion 6.

Preparing ground by machine for subsequent demining methods — manual or mine dog detection — significantly increases the speed at which clearance can be conducted as many common obstacles will be removed.

The greatest benefits brought to manual or MDD clearance teams are the cutting of vegetation and the removal of tripwires, the breaking up of soil surfaces, and the removal of metal scrap contamination. The hierarchy of importance of these obstacles can vary, depending on the physical environment, threat type and the machine available to prepare the ground. A machine that can remove all of these obstacles, in as few passes as possible, will contribute the most to manual and MDD clearance operations.

Recommendation 6.

Manufacturers should develop machines that can remove all main obstacles facing deminers; cut vegetation and remove tripwires, break up soil, and expose and remove metal fragments.

Demining organisations should buy and use machines that can defeat as many of the common obstacles as possible in order to bring the greatest operational and cost-effective benefits to their programmes.

Conclusion 7.

The involvement of machines in the mine clearance process can contribute to significant improvements in productivity.

Evidence of this is found in the case studies included in the chapters of this report covering area reduction and ground preparation; the productivity increase in the most extreme example was in excess of 2,000 per cent. Although more moderate figures are typical, in general, machines will improve the cost-effectiveness of demining operations.

Recommendation 7.

Where conditions are suitable, the wider employment of mechanical systems in demining programmes, particularly for area reduction and ground preparation, will often significantly enhance productivity and cost-effectiveness.