Technical notes for mine action

TNMA

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Guide to mechanical mine clearance/ground preparation using commercial tractors and front loaders

Rolling in extreme terrain, Afghanistan. The pattern of mine placement can be observed by the detonation marks on the hillside. This allows the subsequent manual clearance team to approach (from the bottom of the hill) to a start line of at least 10m from the pattern exposed by detonation. Rolling has also saved time. In this case approx. 90% of the mines on the hillside were detonated. The manual team will not be required to down tools so often each time a mine is found. The rolling operation took less than a day.

Warning

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Contents

Foreword

Management practices and operational procedures for humanitarian mine action are constantly evolving. Improvements are made, and changes are required, to enhance safety and productivity. Changes may come from the introduction of new technology, in response to a new mine or UXO threat, and from field experiences and lessons learned in other mine action projects and programmes. This experience and lessons learned should be shared in a timely manner.

Technical Notes provide a forum to share experience and lessons learned by collecting, collating and publishing technical information on important, topical themes, particularly those relating to safety and productivity. Technical Notes complement the broader issues and principles addressed in International Mine Action Standards (IMAS).

Technical Notes are not formally staffed prior to publication. They draw on practical experience and publicly available information. Over time, some Technical Notes may be 'promoted' to become full IMAS standards, while others may be withdrawn if no longer relevant or if superseded by more up-to-date information.

Technical Notes are neither legal documents nor IMAS. There is no legal requirement to accept the advice provided in a Technical Note. They are purely advisory and are designed solely to supplement technical knowledge or to provide further guidance on the application of IMAS.

Technical Notes are compiled by the Geneva International Centre for Humanitarian Demining (GICHD) at the request of the United Nations Mine Action Service (UNMAS) in support of the international mine action community. They are published on the IMAS website at www.mineactionstandards.org.

Introduction

The majority of machines deployed worldwide on mechanical mine clearance tasks are not vehicles specifically designed for the job. Currently, commercially available standard tractors and front loaders specially armoured[1] and adapted for mine clearance or bush cutting are tackling a major proportion in some areas of mechanical mine clearance.

Unlike most purpose-built mine action machinery, commercial vehicles are versatile and can perform tasks beyond mine action alone. After the close of a working day in the minefield, a front loader for example can be set to work for the local community building or improving roads, digging water ditches for agriculture and drinking, or digging sanitation trenches. These are tasks that cannot be performed by a 50 tonne tiller or heavy flail unit.

Cheaper, less complicated, easier to maintain and more cost effective, such machines represent a serious alternative to the growing number of specialist vehicles being introduced in the market. The techniques described here were developed in the field, and are explained in outline.

A Pearson Roller attached to a CASE front-end loader working near Senafe, Eritrea.

[1] The question of how much armour constitutes a safe minimum is the subject of a study to be carried out at the GICHD. The armouring of tractors and front-end loaders for The HALO Trust has thus far proved adequate to the task.

Guide to mechanical mine clearance/ground preparation using commercial tractors and front loaders

1. Scope

This Technical Note provides guidance on the how commercial vehicles can be directly employed to assist mine clearance or carry out mine clearance. Not all mechanical mine clearance concepts that have been developed are covered here. All the examples are of standard machines that have been tested operationally in the field.

Front-end loaders, tractors and mine rollers are employed to remove and inspect mine-contaminated soil, cut vegetation, or verify ground as part of area reduction. All techniques are simple and have so far proven to be safe and cost effective.

2. References

A list of normative references is given in Annex A. Normative references are important documents to which reference is made in this Technical Note and which form part of the provisions of this Technical Note.

Rubble clearance with armoured front-end loader, Kabul, Afghanistan

3. Terms and definitions

A complete glossary of all the terms, definitions and abbreviations used in the IMAS series and Technical Notes is given in IMAS 04.10.

In the Technical Notes series, the words 'should' and 'may' are used to indicate the intended degree of compliance. This use is consistent with the language used in International Mine Action Standards (IMAS) and guides.

a) 'should' is used to indicate the preferred requirements, methods or specifications.

b) 'may' is used to indicate a possible method or course of action.

4. Front-end Loaders

Front-end loaders are built in numerous forms by a multitude of companies worldwide. A feature common to most of them is that they are robust and can be put to work to perform a variety of tasks. They are simple to operate and maintain. For the more common types, locating a dealer, finding spare parts, and managing the logistics for international operations, is relatively simple.

Inspecting soil raked by loader bucket in inspection area, Cambodia.

For mine clearance, front-end loaders must be armoured in order to guarantee the safety of the operator. Wheels and tyres can be guarded in the event of contact with anti-personnel mines by the application of protective, heavy-duty chain mesh, or the use of solid rubber or foam-filled tyres. Mine protected front-end loaders have previously been used in A/P minefields only, due to the damage that would be sustained in the event of an A/T mine detonation during excavation. However, recently developed units have been fitted with specially devised buckets specifically for work within A/T and mixed A/T, A/P minefields.

Demining with front-end loaders has accounted for the clearance of thousands of square metres of suspect land in mine-affected countries. Commercial machines have a successful track record of labour in the field at least equal to any purpose-designed system as of late 2001. The use of front-end loaders must therefore be a serious contender for selection within the mechanical 'tool-kit' of any mine-clearance organisation. Some of the roles identified for front-end loaders successfully used in mine action follow:

4.1 Mine roller

Mounted on an armoured front-end loader or armoured tractor, the roller[2] is used to rapidly reduce areas adjacent to locations where landmines are suspected. This greatly hastens the process by which clearance teams reach the real start point of a mined area, a necessary phase of mine clearance which can take a manual team much time to complete. The weight of the roller is designed to activate sub surface mines, and is capable of withstanding blast from AP mines. AT mine rollers do exist, but have not yet been used in the scenarios below. It has been found that rollers are not suited for direct mine clearance, but are a useful tool for confidence building, clearance verification and area reduction. Rollers typically consist of segmented, weighted plates, each turning separately on a central axle. As the attached vehicle moves forward, the roller contacts the ground. The roller follows undulations, bumps and rises with each independently rolling wheel. The roller should be used in a set pattern over a suspect area.

The Pearson Roller

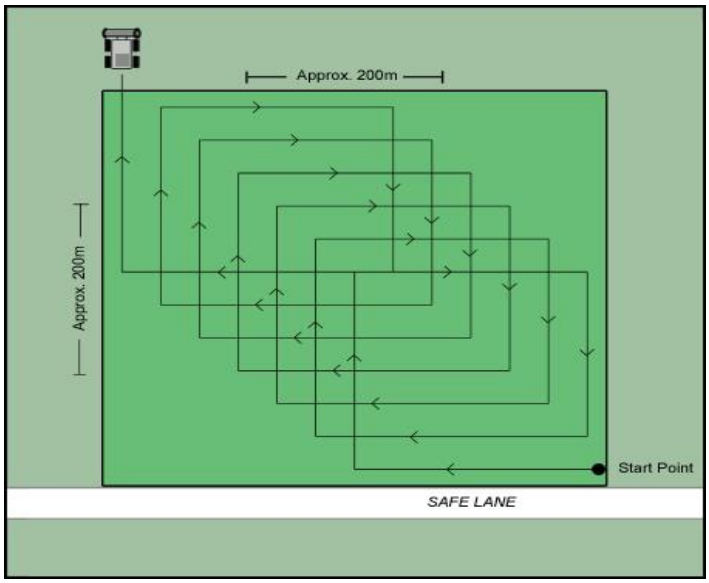

Fig. 1: Section of a piece of land in a suspect area (approx. 200m x 200m). 1st phase of rolling in concentric box pattern in area where mines are not expected. Pattern is optional but this technique has been proven effective

[2] The depth that a roller is likely to detonate a mine is determined by soil types and conditions and cannot be conclusively determined.

In situations where information as to the location of mines is accurate, the roller need not be used for locating mines by detonating them. The roller can cover the ground close to the expected safe clearance start line in order to ensure that the land is clear of mines before deploying an excavation vehicle or manual demining team (confidence rolling).

In areas where the location of mines is unclear, the roller can be deployed, working in a set system to find mines that are expected to be found in identifiable patterns only. The use of the roller for area reduction in cases where mines are potentially laid sporadically is inadvisable (e.g. Cambodia). Using the roller in this way could lead to accidents from a false sense of security, as the roller is not guaranteed to set off all mines.

Once the presence of mines has been verified, direct clearance assets can be brought to bear in the smaller area where mines are actually laid.

With the Pearson roller for example, each individually 'floating' disc exerts a ground pressure of 50kg. The roller weighs 1000kg /m of width and is available in any width up to a maximum of 3.5m to suit the size of the attached prime mover.

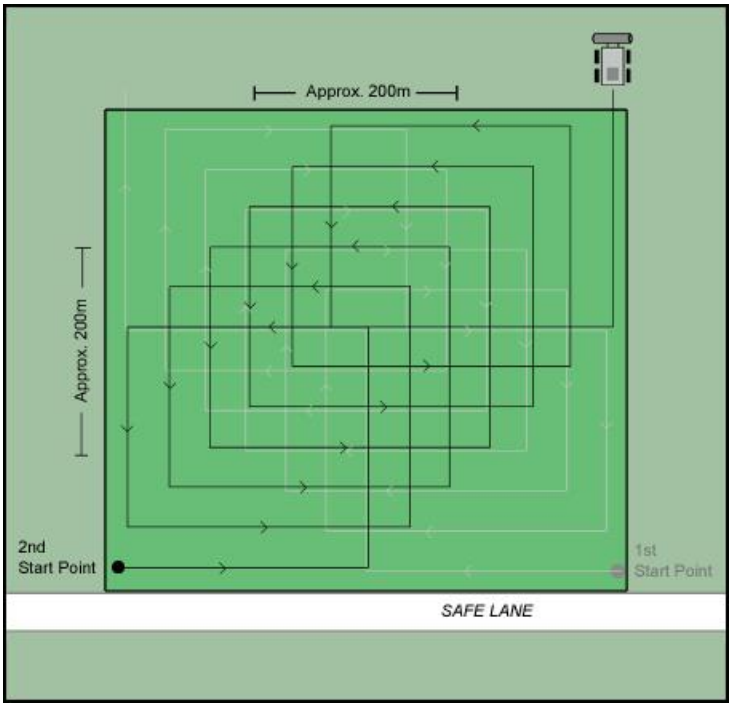

Fig. 2: Phase 2 of rolling operation (grey lines are from previous rolling). The concentric box pattern ensures that the centre of the area is rolled four times from four directions. This pattern is a suggested technique.

Mine rollers have been adapted for use on extreme angled terrain. As with the use of the roller on flat terrain, rolling from a winch is suitable only for areas where mines are expected to be laid in a set pattern. An armoured front-end loader positions itself at the top ledge of a slope too steep for a vehicle to operate by traversing the ground in the conventional manner. A mine roller can be attached to a standard winch, and the roller released under winch control down the face of the slope. Once the roller has reached the set limit of exploitation (or the end of the winch cab), it is then winched back up to the vehicle along the same path. It is probable that mines present along the path of the winched roller will detonate, and therefore present the location of the reduced area where mines can be found – area reduction and location finding. The vehicle and winched roller then move to one side to begin the process down a fresh path.

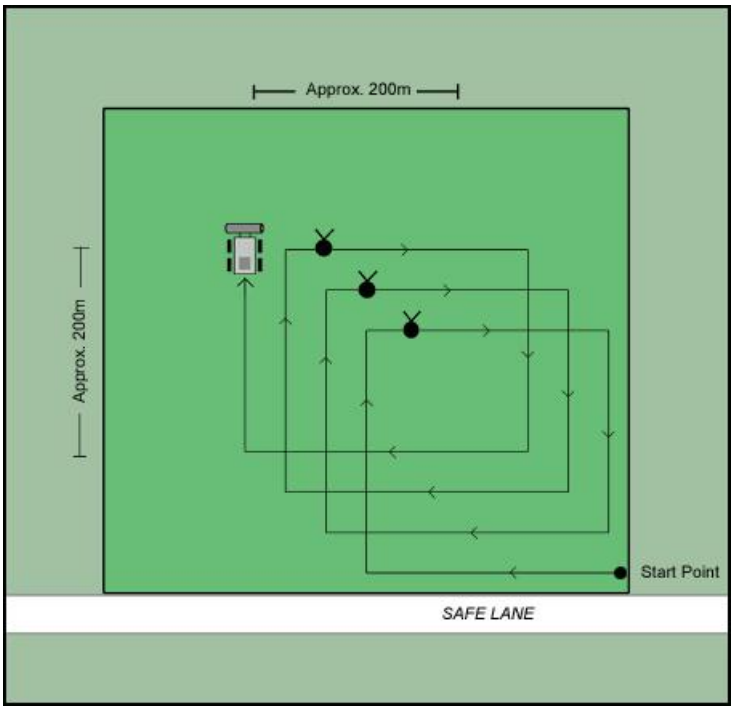

Fig. 3: Rolling area using concentric box pattern where mines are not suspected but are subsequently encountered. In this example, an approximate mine pattern is revealed. Rolling should stop and clearance assets take over. Note: rollers should not pass a detonation point, but reverse back along its cleared route to avoid expensive damage from potential wheel strikes.

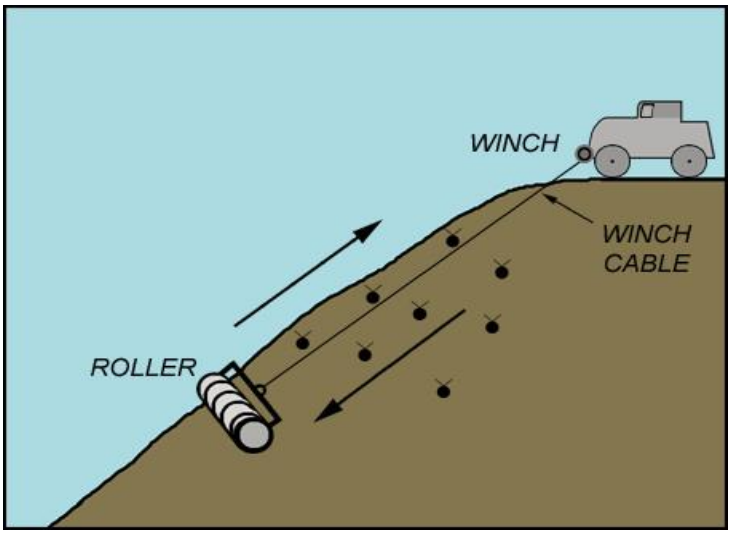

Fig. 4: Winch rolling over extreme terrain. Concept developed by The HALO Trust in Afghanistan.

4.2 Armoured bucket mine clearance

Successful use has been made of armoured front-end loaders with armoured buckets in direct mine clearance. Once a mined area is established by reliable information or by detonations caused by a mine roller, an armoured front-end loader starts operating in the minefield. The vehicle begins from an established safe line. The driver contacts the ground with the bottom front blade of the bucket, and drives forward. Using the manual controls, the bucket is angled to skim off the desired depth of soil. Once the bucket has become half full with potentially contaminated soil (in order to avoid spillage) the loader reverses down its own track to the safe route previously established between the suspect area and soil inspection area.

To avoid time wastage, the soil inspection area should be as close to the suspect area as possible while observing safety distances. The machine dumps its bucket load of skimmed, contaminated soil at one end of the inspection area, then drives back to the minefield to continue with excavation. In this way, it will continue to shuttle loads of soil from the minefield to the inspection area. The inspection area needs to be large enough for at least one armoured front-end loader or tractor to manoeuvre freely. The surface must be hard. Concrete areas such as car parks and the like are ideal, but a section of field can also be used. Prior to the start of clearance, front-end loaders can prepare an inspection area by removing the topsoil of the selected location.

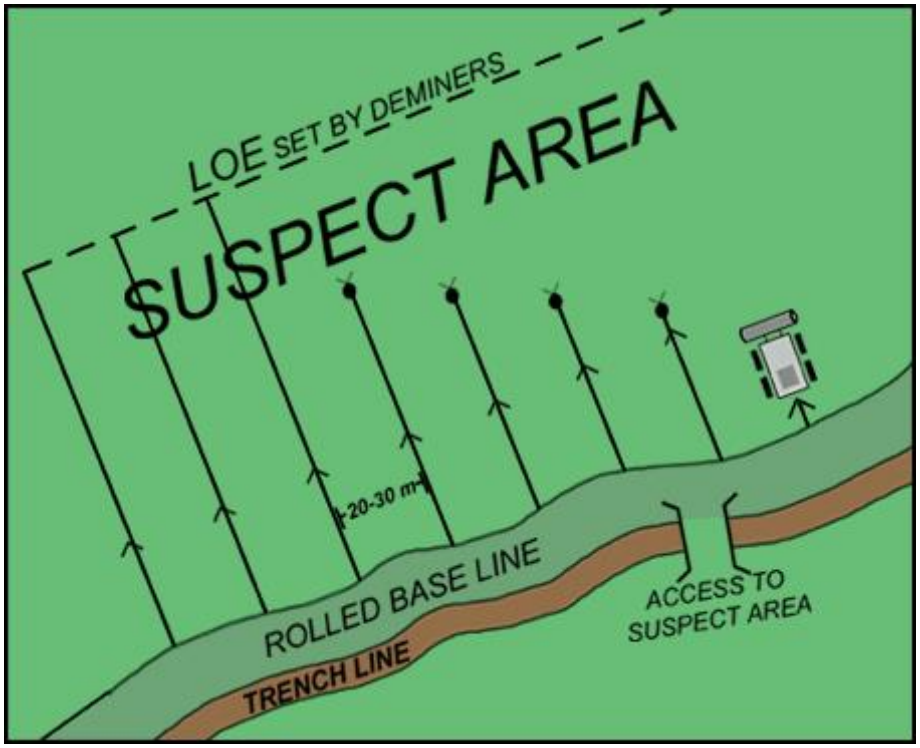

Fig. 5: Rolling in perpendicular lines from a baseline out to a pre-determined LOE in an area where AP mines are suspected. Once the roller has established the presence of, and approximate pattern of AP mines, clearance assets are deployed. This diagram is included here as this type of rolling task immediately precedes clearance by armoured bucket and is integral to it.

In many soil types (although not all) the ground layer beneath the topsoil can be made almost as hard as concrete by using a mine roller on the exposed surface. Such ground has been found to be suitable for subsequent inspection of contaminated soil. A second armoured front-loader or an armoured tractor works concurrently to the excavating vehicle, but in the inspection area. Its job is to rake the contaminated soil into a thin layer for manual inspection for mines or UXO. The raked soil should not exceed 8-10cm in depth for this technique to be effective. It is probable that a mine contained within the raked soil will be visible. The raking action can be achieved by placing the bottom of the armoured bucket on top of the spoil, exerting downward pressure as the vehicle moves back. The teeth on the bottom plate of the bucket impart windrows down the length of the soil layer, lines which can subsequently be used as reference marks to control manual examination.

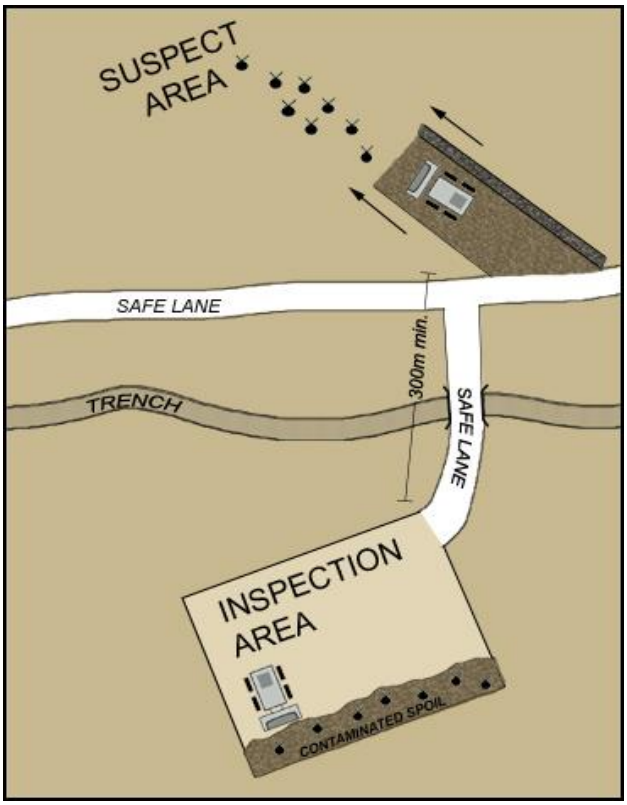

Fig 6: Suggested positioning of inspection area in relation to suspect area for armoured bucket mine clearance.

Other systems for raking the spoil can be devised, such as a trailer or sledge with an underhanging rake consisting of staggered pattern tines to distribute the earth evenly. Demining staff must then inspect the soil. In past operations, the inspection team consisted of one deminer with a pitchfork or rake, and one deminer with a metal detector.

Experience has shown that AP mines usually survive the violence of excavation, transportation to the inspection area, dumping into a pile and the raking back by an armoured front-end loader/tractor. Once the soil has been inspected, it should be placed into an uncontaminated pile to await eventual redistribution in the excavated minefield once that is cleared.

The HALO Trust have further adapted armoured buckets with the addition of a gill[3] at the front designed to let spoil and potential AP mines through, but to stop any AT mines from impacting at the back of the bucket and detonating. This has so far proved successful in operation and is a particularly positive development for work in areas where knowledge of likely mine types is unreliable.

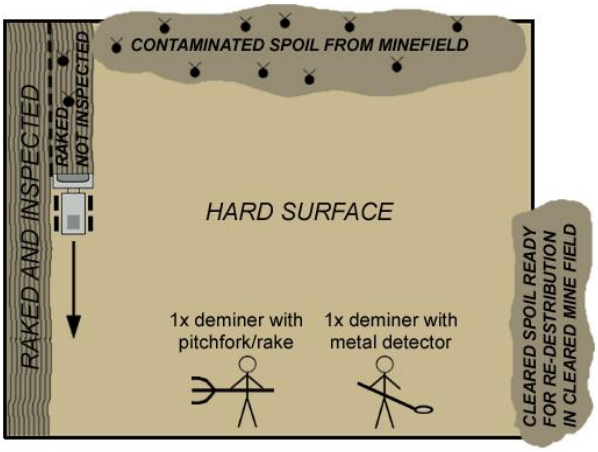

Fig. 7: Inspection area. As contaminated soil is being raked, deminers should be under cover or at least 300m away. They move back once the machine has raked one row of one-bucket width.

[3] The description 'gill' is that given by The HALO Trust. AT mines remain on top of the gill, visible to the operator, and are transported along with the rest of the spoil to the inspection area.

HALO has adapted armoured buckets with a gill to separate AT mines from soil and AP mines for use in areas where the occasional AT mine may exist.

5. Tractors

Standard agricultural tractors can be employed in mine action in much the same way as front-end loaders outlined above. For demining operations, the driver's cab must be armoured. In general, tractors are more limited than front-end loaders as they are lighter and not as powerful. Ideally, they can be employed in roles where the use of a more powerful front-end loader would be less economical.

As an example, during excavation demining, a tractor would be best employed in the inspection area raking the contaminated spoil in order to free a front-end loader to operate in the minefield. Tractors have however proven to be an excellent asset is in the roles of vegetation cutting or obstacle removal.

5.1 Vegetation cutting

Vegetation cutting heads and strimmers are produced by a large number of manufacturers worldwide. Cutters are usually sold with a hydraulic arm and can be fitted to many tractor types as long as the linkages are compatible. SOPs for bush cutting have been developed by numerous demining organizations and will not be covered here.

Vegetation cutter on armoured tractor, Cambodia.

Vegetation cutting as assistance to manual demining teams has been proven beyond doubt to increase the efficiency of manual mine clearance, but this will depend largely on how and where a bush cutter is deployed. The designation of vegetation density can be deceptive. A minefield full of long grass but devoid of bushes and small trees will usually take longer for a manual deminer to clear than an area of shrubbery, even though the latter appears to be more dense.

5.2 Obstacle removal

Armoured tractors have been used to remove obstacles and debris, (for example, concertina wire, metal junk and burnt-out cars), from mine sites that would otherwise slow clearance operations, either manual or mechanical. Once clearance has reached a point where the debris can be gained, a tractor moves into the location and drags it out from a position on the edge of the cleared area. This task is usually conducted by a backhoe on a hydraulic arm. Once the obstacle is removed, demining continues.

6. Summary

Experience has shown that armoured front-end loaders and tractors can make a major contribution to mine and UXO clearance. The roles discussed in this paper have been tried and tested successfully in the field, and armoured front-end loaders and armoured tractors are currently removing mines in many areas throughout the world. There are many options in the field of mechanical mine clearance systems. The use of commercial machines is not the only answer, but does represent a safe[4], effective and cheap alternative.

7. Recommendations

Programme managers can find more details of the techniques described in this Technical Note by contacting The HALO Trust (www.halotrust.org) or the GICHD at Pehr Lodhammar, Advisor on Mechanical System and Contracting (p.lodhammar@gichd.org).

[4] HALO began full clearance with front-end loaders in 1996. Although in mine clearance, no system can be said to be 100% safe, thus far no accidents have occurred using the techniques described in this Technical Note.

Annex A
(Normative)
References

The following documents when referred to in the text of this Technical Note, form part of the provisions of this guide.

a) IMAS 04.10. Glossary of demining terms.

The latest version/edition of these references should be used. GICHD hold copies of all references used in this Technical Note. A register of the latest version/edition of the IMAS standards, guides and references is maintained by GICHD, and can be found on the IMAS website www.mineactionstandards.org. National mine action authorities, employers and other interested bodies and organisations should obtain copies before commencing mine action programmes.

The latest version/edition of the Technical Notes can be accessed via the IMAS website www.mineactionstandards.org.

Amendment record

Management of Technical Notes amendments

Technical Notes (TN) are subject to review on an 'as required' basis. As amendments are made to this TN they will be given a number, and the date and general details of the amendment shown in the table below. The amendment will also be shown on the cover page of the TN by the inclusion under the version date of the phrase *'incorporating amendment number(s) 1 etc.'*

As reviews of TN are made new versions may be issued. Amendments up to the date of the new version will be incorporated into the new version and the amendment record table cleared. Recording of amendments will then start again until a further version is produced.

The most recently amended TN will be the versions that are posted on the IMAS website at www.mineactionstandards.org.

Number	Date	Amendment Details
1	01 Jul 2013	1. Inclusion of amendment No, date in the title and header. 2. Updated links and email addresses. 3. Minor text changes in fifth Paragraph of foreword. 4. Removal of Annex B. 5. Inclusion of amendment record.