SLNMAS 04.40

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Mechanical Demining

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Warning

This document is current with effect from the date shown on the cover page. As the Sri Lankan National Mine Action Standards (SLNMAS) are subject to regular review and revision, users should consult the Sri Lankan National Mine Action Centre.

Contents

Introduction

Demining machines are employed on an ever-widening scale and the choices of machines on the international market continue to expand. Demining machines have been used on mine clearance operations for many years now and have already demonstrated their potential in several areas for significantly increasing output and for making mine clearance a safer activity.

A wide range of demining machines and mechanical systems such as flails, rollers, vegetation cutters, mechanical rakes, armoured front-end loaders, excavators, stone crusher, etc are available and in use in Sri Lanka. It is therefore important that a national standard is produced to provide guidelines and specifications that promote the safe, efficient and effective use of machines in mine clearance operations.

Mechanical Demining

1 Scope

The standard provides specifications and guidelines for mechanical demining operations.

2 References

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

3 Terms and definitions

A complete glossary of the terms and definitions used in the SLNMAS is given in SLNMAS 01.

The term "**mechanical demining operations**" refers to the use of demining machines on demining operations and may involve a single demining machine employing one mechanical tool, a single demining machine employing a variety of tools or a number of machines employing a variety of tools.

The term "**demining machine**" refers to a unit of mechanical equipment used on demining operations.

The term "**mechanical demining unit**" may refer to a single demining machine or it may refer to more than one machine that works as part of a system for example a front end loader and a screening plant.

The term "**mechanical tool**" refers to the working component(s) attached to a demining machine, such as flails, tillers, sifters, rollers, excavators, ploughs, magnets, etc. A single demining machine may utilise a number of different tools, which may be fixed or interchange.

The term "**intrusive demining machine**" refers to those demining machines that are designed to work inside a hazardous area, while the term "**non-intrusive demining machine**" refers to those designed to operate from a cleared or known safe area, with it's mechanical tool working in the hazardous area.

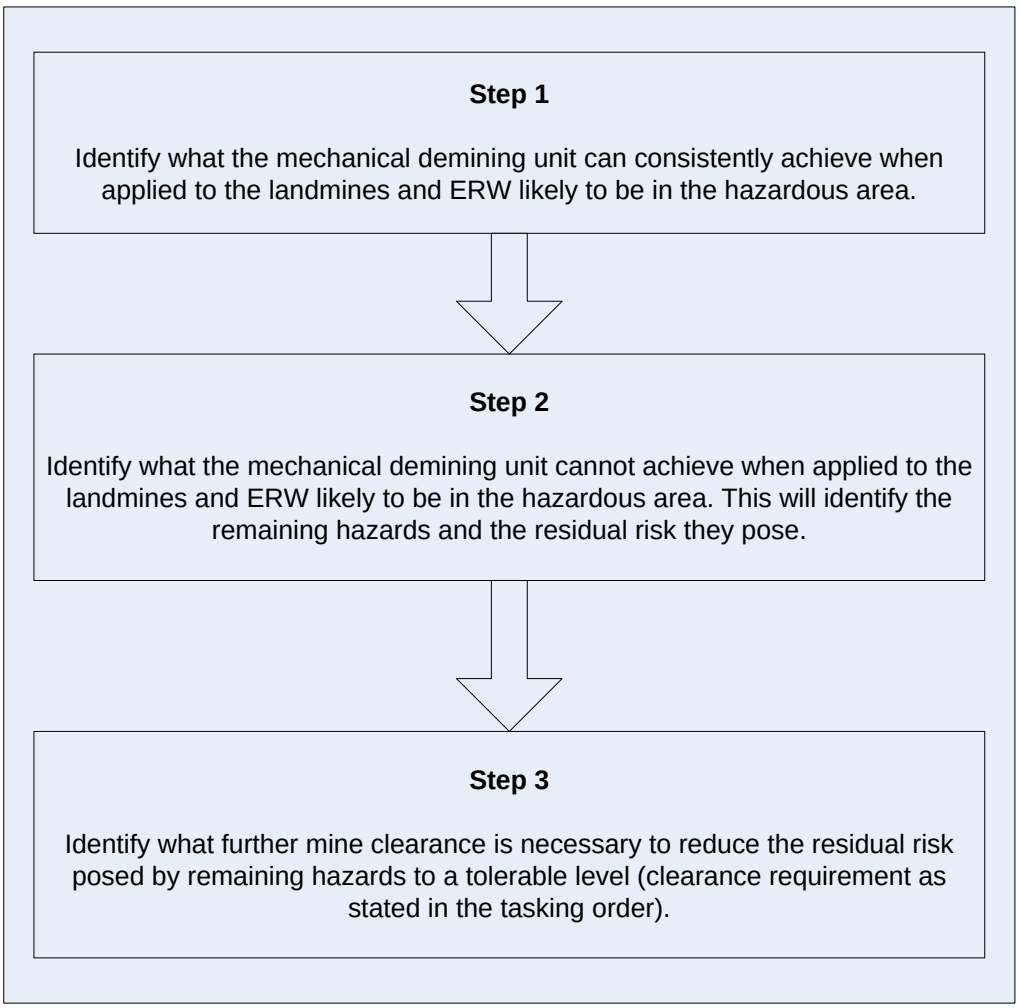
In this national standard the term "**residual risk**" relates to the hazard remaining from mines and/or UXO following mechanical demining in a particular hazardous area.

4 Systems approach to mechanical demining

Demining machines are not mine Clearance machines. This is because "clearance" is defined in the IMAS as the removal of *all* mines and ERW to a specified depth. No currently available demining machine is able to *remove all* the mines and ERW as specified in a mine clearance task. They cannot reliably *detonate* all pressure-operated devices and stand little chance of detonating devices with pins that must be pulled, or of disrupting common ERW other than mines. On uneven ground, all demining machines can fail to process the ground to a constant depth, and so may miss mines or ERW altogether. They can also leave mines and ERW damaged and in a more sensitive condition than they were before the machine was used.

The **system approach** is about demining machines being integrated with other mine clearance resources (other machines and manual demining teams and/or MDD teams) to ensure that the most effective outcome is achieved and the area is cleared from all mines and ERW to the specified depth.

Below is an example of the steps involved in the system approach to mechanical demining leading to the selection of an appropriate method to deal with a hazardous area.



Despite their limitations, demining machines can increase the speed with which land is released very dramatically as long as their use is sensibly integrated with the use of other available tools/resources and procedures.

4.1 Tolerable risk

The tolerable risk accepted in Sri Lanka after an area was cleared from mines and ERW is when none of the items listed below are found in the cleared area to a minimum depth of 15 cm (or to the depth specified in the task dossier):

a. Mines and UXO.

b. Landmine mechanisms and detonators.

c. Pieces of explosives larger than 15mm in diameter.

d. UXO casings containing explosives.

e. UXO fuses.

5 Use of demining machines in Mine Clearance Operations

Machines are used in mine clearance operations for two main reasons. The first is to enhance the safety of demining staff, and the second is to increase the speed with which land can be released.

To apply each machine appropriately, the clearance agency's staff involved in task planning shall know each machine's optimal operating conditions, availability and deployment constraints. This will allow the clearance agency to select the appropriate machine or combinations of machines and tools to ensure the most effective outcome.

Demining machines in Sri Lanka are used to:

a. Locate mined areas by detonating one or more mines in an area;
b. Remove vegetation before manual and MDD search;
c. Prepare ground for manual and MDD follow up;
d. Excavate ground and move it to be searched in another place;
e. Crush and neutralise excavated hazardous debris;
f. Locate areas in which there is a high probability of mines and ERW; and
g. Raise confidence for the end-users of land with No Known Threat.

The demining machines used in Sri Lanka can be divided into two categories; mine clearance machines and ground preparation machines.

5.1 Mine Clearance Machines

Mine clearance machines are those machines whose stated purpose is the detonation, destruction or removal of landmines. A consequence of their use is that the necessity for post-mechanical follow-up clearance is reduced to the minimum possible, or in certain cases, eliminated.

In mine clearance operations in Sri Lanka the intent of utilising machines as a mine clearance tool should be to:

- find mines;
- clear mines; or
- prove there are no mines.

Mine clearance operations can occur both on, and off, the hazardous area. Off-site operations are activities that involve the removal of the earth/sand/soil from the hazardous area to an area where some other activity is conducted to remove the hazards, such as sifting, soil inspection and processed crushing. Onsite operations are activities that occur in the hazardous such as using the machine:

- in a technical survey role – where the intent is to find the general location of mines;
- to detonate mines – where the intent is to clear mines; or
- to process ground in an area suspected to be hazardous even though the evidence suggest that there are no hazards - in this case the intent is to verify the area to "prove that there are no mines".

5.1.1. Off-site

When a machine is used as part of an integrated off-site mine clearance operation there is no requirement for follow-on procedures in the original hazardous area when the soil/sand is replaced, provided adequate QA and QC procedures are in place at the off-site location. However, it should be noted that the guarantee of clearance is restricted the depth of the earth/sand/soil removed, processed and replaced. The minimum depth to which earth/soil/sand shall be removed is 20 cm.

5.1.2. On-site - Technical Survey

When machines are employed in technical survey operations, the information they provide is used to make an informed judgement about what to do next. This is no different from technical survey conducted using dogs, manual deminers or some other observational or sensory method.

Follow-on procedures behind the machine during technical survey may not be required, if the machine ***does not*** encounter a hazard, and has been proven capable of detecting and destroying similar hazards in similar conditions. If the machine ***does*** encounter a hazard then follow-on shall be required. The specific follow-on activity can only be determined at the site – and would normally be either manual mine clearance or mine detection dogs (MDD). The specific area for follow-on procedures will be determined on the site on a case by case basis.

If MDD are available and the optimum climatic and topographical conditions for using MDD are met and the area under clearance need to be followed-on behind the machine only one dog may be used because a single dog is effectively a second tool to the machine.

5.1.3. On-site - Clearance

When machines are employed to detonate mines and where the intent is to clear mines follow-on procedures shall be required in order to ensure that mines indeed have been cleared. The specific follow-on activity can only be determined at the site and would normally be through manual mine clearance. The ground will be contaminated with explosives as a consequence of detonations and the breaking up of mines which will make the employment of MDD in the area difficult unless a considerable soak time is applied. In situations like these the follow-on capacity shall clear the area to a minimum depth of 15 cm from:

a. All mines and UXO.

b. Landmine mechanisms and detonators

c. Pieces of explosives larger than 15mm in diameter.

d. UXO casings containing explosives.

e. UXO fuses.

All follow-on procedures by manual deminers will be in accordance with SLNMAS 04.30.

5.1.4. On-site – Area verification

The purpose of area verification is twofold, firstly to prove that there are no mines in an area where evidence suggest there is no threat, and secondly to verify an area free of mines after all the mines laid in accordance to a pattern in a hazardous area were removed/destroyed by manual mine clearance techniques. If the machine does encounter a hazard then follow-on procedures shall be required.

6 Demining machines: General requirements and Principles for Employment

Demining machines used in mine clearance operations shall conform to certain general requirements:

a. Each demining machine shall be Tested and Evaluated (T & E) to determine its suitability for the task(s) it is expected to carry out in the Sri Lanka environment and local conditions.

b. The operation of each demining machine shall be assessed and confirm as safe for the operator and any other person on the worksite. The protection level for machines shall be established through a risk assessment.

c. Standing Operating Procedures (SOPs) shall be developed for each demining machine by the clearance agency using the machine. The SOP should include general mechanical operating procedures, procedures specific to the machine, and where necessary, procedures for the integration of the machine with other machines, manual deminers and/or MDD.

Cost effective and appropriate utilisation. Machines shall not be used beyond design specifications or used on tasks for which they were not designed for.

Operational accreditation of a demining machine in accordance with the requirements of SLNMAS 2, The Accreditation Process, shall also be based on the fulfilling the requirement of this clause of this standard.

Demining machines shall not be used with tools, or on tasks, or in conditions for which they do not have operational accreditation.

Prior to the deployment of any machine in Sri Lanka an assessment shall be made of the in-country infrastructure and support systems to ensure that a demining machine can be operationally maintained in the areas where it will be used. Machines that cannot be supported logistically will not operate in Sri Lanka.

7 Off-site mine clearance

The following machines are currently being utilised in Sri Lanka during Off-site mine clearance operations:

a. Armoured front-end loaders

b. Armoured excavators

c. Tipper trucks

d. Stone crusher

7.1 Armoured Front-end loaders (mechanical excavation)

Front-end loaders are built in numerous forms by a multitude of companies worldwide. A common feature 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, managing the logistics in country is relatively simple.

For mine clearance the front-end loader's operators cabin shall be armoured in order to guarantee the safety of the operator. Wheels and tyres may be guarded in the event of an anti-personnel detonation by applying protective, heavy-duty chain mesh, or the use of solid rubber or foam filled tyres.

The armoured front-end loader is utilised to conduct mechanical excavation tasks by removing the top layer of soil from a hazardous area including any mines or UXO contained within it.

The depth of excavation shall not be less than 20 cm and should not be more than 30 cm unless where a suspicion of deeply buried mines exist. Operators should prevent removing more soil than necessary for subsequent inspection or crushing.

To prevent loose items and soil falling from the bucket during manoeuvring of the machine the operator shall not load more than ¾ of a bucket of soil during each excavation. Before reversing from the excavation “end” the bucket should be shaken once or twice to level the soil within the bucket.

The operator shall ensure that the wheels of the loader do not leave the safety of the excavated area at any time whilst manoeuvring within the lane.

Widening of the lanes shall be done with a minimum of 50 cm overlap of the previous lane. This will ensure that contaminated material is not pushed aside by the bucket into the cleared area. In hard ground this overlap should be increased to concentrate excavation onto a smaller area of ground.

The boundary between the cleared area and the un-cleared area shall be marked using short red-topped pickets or red stones at one meter intervals. Marking shall be placed one meter away from the excavation “end” into the cleared area to allow for loose or moving spoil.

The excavated contaminated soil shall either be deposited in a marked “tipping area”, loaded onto a tipper truck for transporting to the crusher or transport it by reversing down it’s own track to the safe route previously established between the hazardous area and the soil inspection area.

When the perceived threat is only anti-personnel mines the minimum safety distance shall be 50 meters from the front-end loader while wearing PPE with approved eye protection or visor down. When larger UXO or anti-tank mines are suspected a minimum safety distance of 100 meters shall be maintained.

Where anti-tank mines are suspected the front-end loader should be equipped with an armoured bucket with a specially designed separator grill or gill to separate anti-tank mines from soil and anti-personnel mines.

When excavating for ant-tank mines the operator shall only remove enough soil per cut to flow through the separator grill or gill.

7.2 Armoured excavator (mechanical excavation)

Excavation by excavator is similar in some respects to excavation by front-end loaders. The contaminated soil however should either be loaded directly onto a tipper truck or deposited into a marked “tipping area” for later removal to the crusher or inspection area.

The excavator, tipper truck and tipping area should be position in such a way to reduce the amount of slewing and manoeuvring by the excavator as both are time consuming.

The depth of excavation shall not be less than 20 cm and should not be more than 30 cm unless where a suspicion of deeply buried mines exist. Operators should prevent removing more soil than necessary for subsequent inspection or crushing.

To prevent loose items and soil falling from the bucket during manoeuvring of the machine the operator shall not load more than ¾ of a bucket of soil during each excavation. Before reversing from the excavation “end” the bucket should be shaken once or twice to level the soil within the bucket before slewing to deposit elsewhere.

Widening of the lanes shall be done with a minimum of 50 cm overlap of the previous lane. This will ensure that contaminated material is not pushed aside by the bucket into the cleared area.

Only excavators with steel tracks may drive onto un-clear areas to make the excavation process easier. One edge of the excavator shall however remain adjacent to a cleared area at all times to aid the recovery of the operator in case of an accident or a breakdown. Wheeled or rubber tracked excavators shall be positioned in cleared areas from where the bucket in the un-cleared area will be operated.

Care shall be taken by the operator to ensure that contaminated soil from the un-cleared area is not dragged into the cleared area in particular the area around the tracks/wheels and body of the excavator.

When the perceived threat is only anti-personnel mines the minimum safety distance shall be 50 meters from the excavator while wearing PPE with approved eye protection or visor down. When larger UXO or anti-tank mines are suspected a minimum safety distance of 100 meters shall be maintained.

7.3 Tipper trucks

Tipper trucks are used to transport contaminated soil from the mechanical excavation site to the crusher or to inspection areas and also to transport the cleared soil from the crusher/inspection area to be replaced in the cleared excavated areas. The crusher location and inspection sites should be as close as possible to the excavation site keeping safety distances and the terrain in mind. The routes between the excavation sites and the crusher/inspection area should be marked and maintained daily to ensure efficiency and the ease of movement and to prevent spillage of contaminated soil along the route.

When the tipper truck approach the loading area and the tipping area at the crusher or inspection area the driver shall ensure that the wheels do not move onto previous tipped soil or uninspected soil.

During offloading (tipping) at the crusher or at the inspection area a safety distance of 100 meters shall be maintained. Any personnel within this safety distance shall be protected by hard cover.

7.4 Off-site soil inspection process

An inspection area needs to be prepared. The inspection area needs to be large enough for at least one armoured front-end loader or tractor to manoeuvre freely. The surface shall 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 field location. In many soil types (although not all) the ground layer beneath the topsail 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. The inspection area shall be marked clearly with short red topped pickets at one meter intervals and mine signs.

The contaminated soil from the excavation site is transported and deposited on the one side of the inspection area by tipper truck or the front-end loaders conducting the excavation. A second armoured front-end loader works concurrently to the excavating loaders, but in the inspection area. Its job is to rake (back-blading) the contaminated soil into a thin layer for manual inspection for mines and UXO. The raked soil should not exceed 8-10 cm 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 by the front-end loader can be achieved by placing the bottom of the armoured bucket on top of a half bucket load of soil, exerting downward pressure as the front-end loader 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 the manual examination. As the contaminated soil is being raked deminers should be under cover or at least 300 meters away.

After the soil is prepared for inspection two deminers using rakes or a rake and a metal detector shall inspect the soil for mines and UXO. Each machine raked bucket of soil should have two deminers inspecting them at any one time. They shall work facing each other, to obtain maximum protection from their PPE. Inspection teams should work 25 meters apart.

The two deminers shall start working directly across each other. Starting at one end of a windrow the deminer shall rake the soil towards him looking for any suspicious items amongst the soil. The deminers shall continue until their windrows are completed where after they will continue with the next windrow. They shall continue working like this until all of the raked soil is inspected.

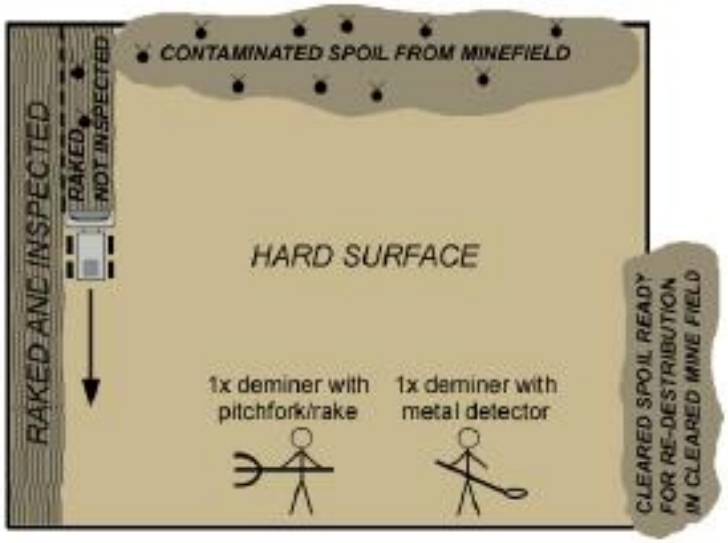


Fig. 1: Inspection area

Large lumps of soil may contain mines/UXO and require inspection. The deminers shall not break these lumps up but shall gather it into an identified area to be raked by the front-end loader for a second time. The team leader shall then inspect this soil to ensure it is free from mines/UXO.

On finding a hazard the deminer shall stop work and inform the team leader. The team leader shall visually inspect and identify the item. In case of small arms ammunition and common mines found in Sri Lanka the team leader shall remove it to a previously prepared collection pit. Any other unknown items and UXO shall be dealt with by qualified EOD personnel. Where the EOD operator is not immediately available the clearance agency's operations manager may permit the mechanical team to move the hazard using the armoured front-end loader to a previous identified marked collection area.

Once the soil has been inspected, it should be placed into an uncontaminated pile to await eventual redistribution in the excavated hazardous area once that is cleared.

7.5 The stone crusher

A commercial stone crusher is utilised to crush anti-personnel mines and small arms ammunition and to detect anti-tank mines and UXO. Contaminated soil is transported by tipper trucks from the mechanical excavation site to the crusher where it is loaded into the hopper by a front-end loader or excavator.

The contaminated soil is feed into the crusher's impactor by conveyor. The feeding conveyor shall constantly be monitored to stop any UXO or anti-tank mines entering and damaging the crusher. The feeding conveyor could also be monitored by camera and/or metal detectors.

The contaminated soil will pass through the impactor and will exit the crusher via the forward conveyor into a waiting tipper truck or unto the ground. The tipper trucks will transport the processed soil back to the excavation site for replacement.

A demolition pit shall be prepared to the rear of the crusher in which UXO and anti-tank mines will be deposited into when observed on the feeding conveyor. The demolition pit shall be a minimum of 2 meters deep and lined with sandbag walls with access to allow UXO to be destroyed in it without damage to the crusher or to be removed from by hook-and-line. An angled ramp should be constructed from the bottom of the feeding conveyor into the demolition pit to allow UXO to roll to the bottom of the pit rather than fall from the feeding conveyor.

7.6 The Allu bucket

The Allu (SM & SMH) buckets are processing buckets designed to fit onto an armoured excavator. The bucket is hydraulic operated and use 4 sets of rotating hammers to crush/shred the soil and any anti-personnel mines contained within it. The bucket is designed to withstand the blast from an anti-personnel mine.

Contaminated soil from a mechanical excavation site is dumped in a pile from where the bucket will be loaded to not more than ¾ capacity prior to processing. The operator shall position the bucket over the cleared soil pile and then only engage the auxiliary hydraulics to process the contents of the bucket. The hammers should be driven in both directions to ensure that as much of the material passes through the bucket as possible. When the processing is completed the operator shall position the bucket over a previous identified and marked inspection area and any remains within the bucket tipped onto the inspection area. The excavator returns to the spoil pile to collect another load of contaminated soil and to repeat the process.

When the excavator with the bucket completed a spoil pile or filled the inspection area the team leader will stop the process and inspect the unprocessed soil in the inspection area for any mines or unrecognised items. The inspection may also be done by deminers with rakes.

Spoil piles and inspection areas shall be marked using short red topped pickets one meter apart and mine signs.

8 On-site mine clearance

The following machines are currently being used in Sri Lanka during on-site mine clearance operations:

a. Mine rollers.

b. Mini-flails

c. Vegetation cutters

d. Mechanical rakes

The vegetation cutters are to be used in the support of the manual mine clearance by removing the vegetation and thereby enhancing the speed of clearance.

The mine rollers and mini-flails are good tools to identify the location of mines during technical surveys by detonating the mines.

The mine rollers and mini-flails are also good tools to verify suspected areas as free from mines.

The mechanical rakes are good tools to prepare ground and to remove vegetation for manual deminers and MDD during technical survey and mine clearance operations.

Mini-flails should not to be utilised on known locations of mines and mine lines to prevent the braking up of the mines, mines being hit deeper into the ground and/or mines being thrown into cleared or safe areas. The principle should rather be to identify the mined areas and/or mine lines using the flail, to clear the mined area and/or mine lines by manual clearance techniques and then to verify the area in between to be free of mines using the flail.

8.1 Utilising machines during Technical Survey

The term **"Technical Survey"** describes a detailed intervention with clearance or verification assets into a CHA, or part of a CHA. It should confirm the presence of mines/ERW leading to the definition of one or more DHA and may indicate the absence of mines/ERW which could allow land to be released when combined with other evidence.

One of the main purposes of the Technical survey is to confirm the presence of mines and ERW, (identify the type of hazards and the boundaries of hazardous areas) which will then require clearance.

In Sri Lanka the following machines should be used during a technical survey to expedite the process.

- Mini flails.
- Mine rollers consisting of separated disks.
- Mechanical rakes.

The machines should be utilised to identify the position of the mines by cutting exploratory lanes into the CHA. When a mine is hit or found the machine will reverse back to the base line and cut the next lane until a mine is hit or find and then move back to cut the next line. Distances between the exploratory lanes shall be determined on the ground. Figure 2 below gives a good description of how it is to be done. When the approximate mine pattern is determined the manual mine clearance resources are deployed and the mine lines cleared. After the mine lines are cleared the machines may be utilised to verify the areas in between the cleared lines.

Where the machine encounters no mines during the cutting of exploratory lanes through the CHA it is not necessary to follow-on with manual clearance resources as long as the machine has been proven capable of detecting and destroying similar expected hazards in similar conditions. If a machine encounter a hazard then follow-on shall be required.

Where mines are found by the machine but no pattern can be determined the area should be covered with the machine and the areas where the mines have been hit are to be covered by manual mine clearance techniques.

Where single mines are hit the buffer zone principle as described in SLNMAS 04.20 shall be applied by the manual capacity in clearing a 10 meter buffer zone around the location where the mine was hit.

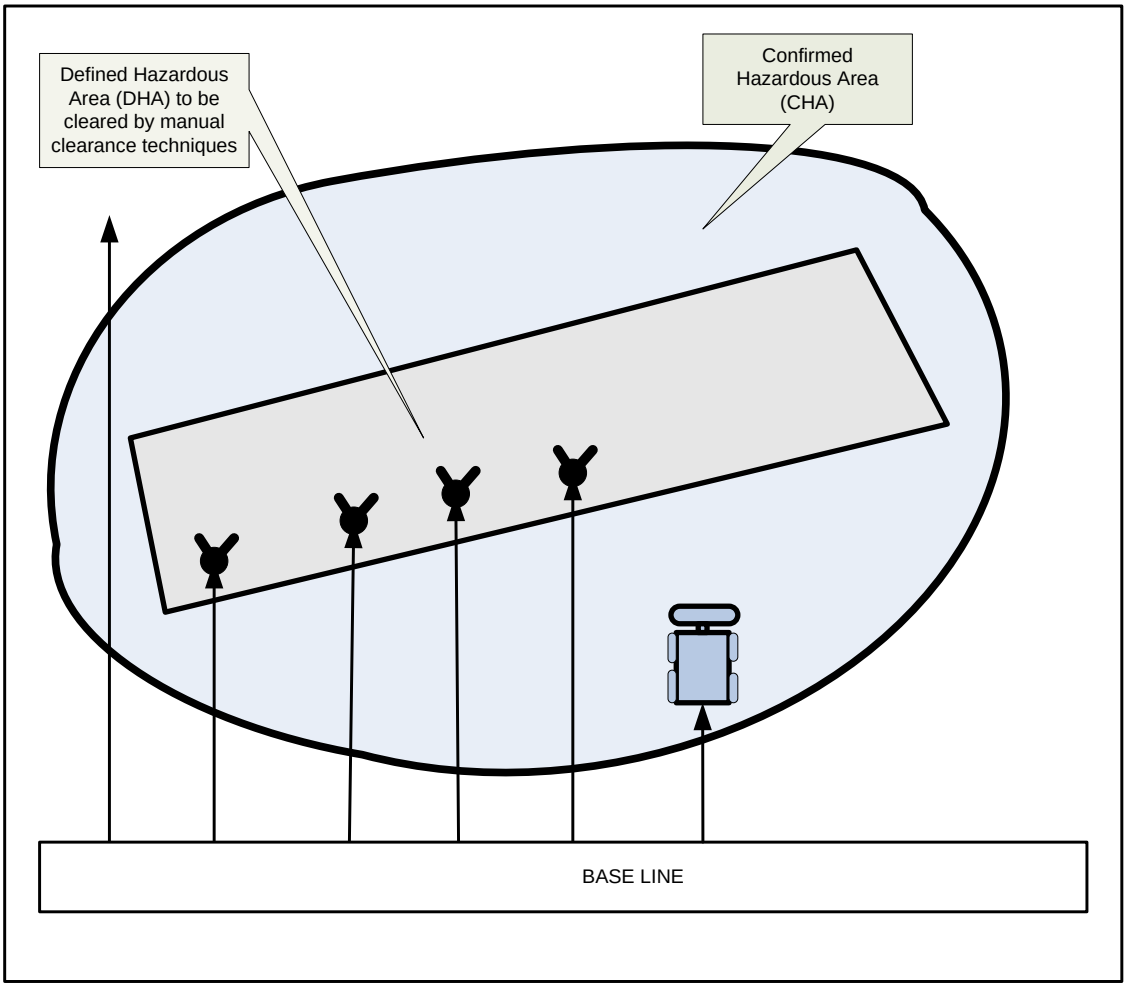


Figure 2: Identifying the location of the mines and the approximate pattern

Where many mines are hit but no pattern is identifiable in an area the detonations will enable the agency to define the hazardous area and this DHA shall be followed on by manual mine clearance techniques. Figure 3 gives an example of such a situation. The whole area of the DHA could be covered by the machine before the manual mine clearance capacity is deployed.

In all cases as soon as manual mine clearance resources are deployed to follow-on the drills and techniques utilised shall be in accordance SLNMAS 04.30 and the agency's manual mine clearance SOP. Safety distances as defined in the SLNMAS 04.30 shall be maintained.

Where mechanical rakes are utilised the machine shall commence operations from a safe lane. It will open the exploratory lane by first removing the vegetation for the distance its boom can reach. It will place the vegetation directly behind the machine. An observer wearing PPE will be situated within ten metres directly behind the machine who is responsible to observe if anything drops from the rake and boom when it is swung to the back to drop the removed vegetation and to inspect the removed vegetation for any explosives hazard. The machine shall not work while the observer is inspecting the removed vegetation and the observer shall not work while the machine is operated. After the vegetation is removed for the boom reach distance the machine shall rake the area. If no mine is find the machine shall move forward for two metres and repeat the process. When a mine is found the machine shall extract from the exploratory lane, a manual deminer/EOD operator shall be called from the rest area to remove the mine and mark the location. The mechanical rake will start a new exploratory lane.

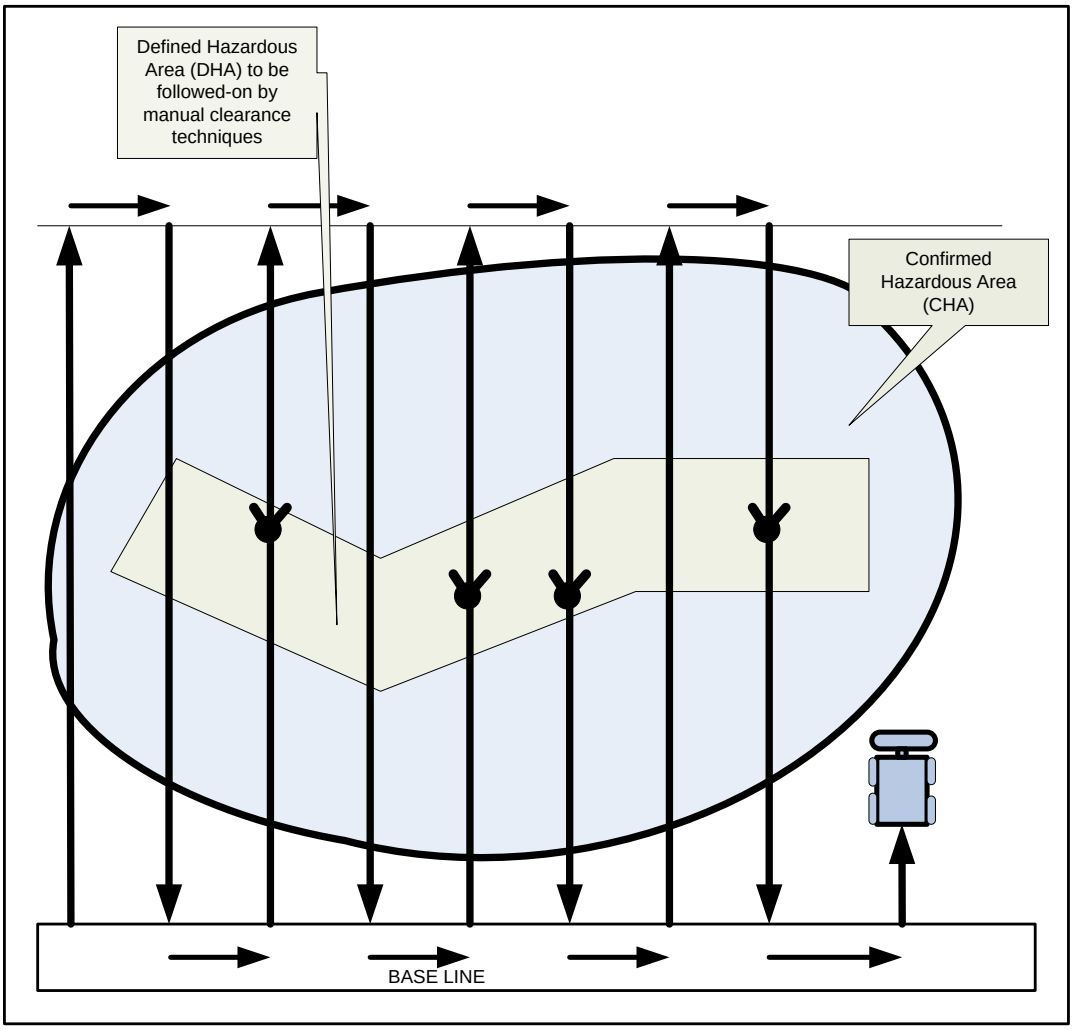


Figure 3: No mine pattern is identifiable

8.2 Ground Preparation

Ground preparation can be conducted by utilising vegetation cutters mechanical rakes and mini-flails. These machines are to be supported by a medical and manual clearance capability. The main object of ground preparation is to speed-up the manual clearance process and to reduce the danger during manual clearance.

Where vegetation cutters are utilised the machine shall worked from a defined safe area and the wheels or tracks of the machine shall also remain within the safe area. While the vegetation cutters are operated the manual deminers and other personnel shall withdrawn to a minimum safe distance of 200 metres or to a previous prepared shelter.

Where mechanical rakes are utilised the machine shall commence operations from a safe lane as described under technical survey. As the mechanical rake progress into the hazardous area the observer behind the machine shall inspect removed vegetation. Where mechanical rakes and manual deminers are utilised on the same work site a safety distance of a hundred metres between the machine and the deminers shall be maintained.

When the machine found mines a hazardous area shall be defined (area that contained the mines) and manual deminers shall be deployed to follow-on, covering the whole defined hazardous area. Follow on procedures shall be as described above under utilising machines during technical survey.

In cases where a small area is suspected of mines but the presence cannot be proven, a machine may be used to prepare the ground and if any mines are found the area will be follow on by a manual mine clearance capability. Where MDD are also integrated, a machine may prepare the lanes to be cleared by the manual team dividing the area into boxes.

8.3 Area Verification

Verification tasks are to be conducted under the following circumstances:

a. Where local population is concerned about a specific area, however the information available to the MACC indicates that mines do not exist in the area. There should be an extremely high probability that the area is not mined before this clearance approach is taken.

b. Where the mine-laying pattern is known and manual teams have removed the mines in the rows. Machines can be used to verify the area between the mine rows.

Where local population is concerned about a specific area, the area can be verified as being safe by multiple passes of a roller or a mini-flail. The decision as to which system to use and the number of passes will depend on ground and vegetation conditions.

Where the mine-laying pattern is known or becomes known to the manual capability, the rows of mines may be manually cleared according to the organisation's SOP. The un-cleared areas between the cleared rows may then be verified as being clear by multiple passes of a roller or mini-flail. When the machines are used in this role, the manual team is responsible for completing the clearance report for the entire area. The report is to show the area cleared manually and the area verified by the machine between the rows. If during the verification process mines are detonated or located by the machine a hazardous area is to identified and a manual mine clearance capacity to conduct the follow-on.

9 Mechanical Standing Operating Procedures

Mine/ERW clearance organisations shall ensure that operating procedures developed for mechanical operations include the following topics.

9.1 General

Demining machines are only employed within the limits of their operational accreditation as established during T&E and as documented in SOPs.

Soil expansion (the increase in volume of soil as a result of mechanical processing) is to be taken into consideration when planning follow-up demining. The depth of ground processing shall be measured from the original undisturbed ground surface to a depth of 20 cm.

9.2 Landmines, ERW and other hazards

If during operations, a hazard is identified which a demining machine was not designed or approved to be used against, the mechanical operation shall cease and a review of the task shall be carried out.

Demining machines shall be checked prior to moving from hazardous to safe areas to ensure that no landmines, ERW or hazardous components including unexploded sub-munitions remain in the working or moving parts of the demining machine or are attached to the machine.

9.3 Management of mechanical demining operations

Management of mechanical demining operations shall be carried out in a manner that ensures that adequate control is exercised over the operation and that it is possible to provide emergency support in accordance with accident response and equipment recovery plans.

9.4 Medical

See SLNMAS 09 'Medical support to clearance operations' for demining medical response plans. In addition, accident response plans for mechanical operations involving crewed demining machines shall include procedures for the extraction of a casualty from the inside of a machine.

9.5 Communications

Communications between the site supervisor and the mechanical operator shall be in place at all times while a demining machine is working in a hazardous area.

9.6 Personnel requirements

Mechanical demining worksites shall have sufficient qualified male and female personnel on site while operations are ongoing; to ensure that:

a. standards for operations are maintained;

b. where applicable, the effective integration with other demining operations is achieved; and

c. the necessary support is provided in an emergency.

10 Demining machine support

10.1 Maintenance and servicing

Demining organisations should make provisions for the maintenance and servicing of demining machines. Such provisions should ensure that:

a. demining machines are maintained and serviced in accordance with the manufacturers' recommendations;

b. maintenance and servicing is carried out by qualified male and female personnel and authorised agencies;

c. routine checks are made on the working components of demining machines and where working components critical to the effective operation of a demining machine are damaged or lost, these components are repaired or replaced before further work continues;

d. routine inspections of safety features on demining machines are carried out and where damage is identified, the damage is repaired before further work continues; and

e. whenever a demining machine is subject to a detonation that may have affected the safety of the operation, the demining machine is immediately withdrawn from the hazardous area and inspected. Where damage to a demining machine may place personnel in danger from subsequent detonations, the demining machine should not return to work until the damage is repaired.

A key component of good demining machine maintenance is the way that a machine is operated. Machine operators should be qualified and experienced in the operation and maintenance of their machines.

10.2 Recovery requirements

Operating procedures for mechanical demining operations shall include provisions for the recovery of the demining machine and operator in the event of a demining machine becoming stranded in a hazardous area. Such procedure shall ensure the safe extraction of the operator as quickly as possible, and the safe recovery of the demining machine in a reasonable time.

10.3 Fire precautions and drills

Demining organisations employing demining machines shall develop procedures to be followed in the event of a fire on a demining machine. These procedures shall cover the immediate actions to be taken and ensure the safe extraction of an operator from a hazardous area. Where an onboard operator is present, demining machines shall be fitted with fire extinguisher or fire suppressing systems. On no account shall any person to be permitted to enter an uncleared area to fight a fire on a burning demining machine. Fire fighting equipment shall be available at all places where refuelling of demining machines is carried out.

11 Environmental considerations

11.1 General

The ground over which mechanical operations are carried out shall be left in a state whereby the land is suitable for its intended use when handed over. Where mechanical operations involve the removal of vegetation, or occur on ground that may be subject to erosion, demining organisations shall ensure that measures are taken to limit such erosion. The operation, repair, maintenance and servicing of demining machines shall be carried out in an environmentally acceptable manner e.g. by preventing ground or watercourse contamination from fuel, oil and lubricants.

11.2 Protection of property and infrastructure

Planning for mechanical operations shall take into account any possible damage to property or infrastructure. Where damage to property or infrastructure is possible, the property owners or local authorities should be consulted prior to the operations.

12 Responsibilities

12.1 The Sri Lankan National Mine Action Centre

The Sri Lankan National Mine Action Centre shall:

a. operationally accredit demining machines in accordance with the requirements of this standard;

b. develop and implement national standards for the employment of demining machines on demining operations;

c. implement QM systems to ensure the safe, effective and efficient use of machines on demining operations;

d. develop an environmental policy for the use and maintenance of demining machines; and

e. provide advice to prospective demining machine users.

The Sri Lankan National Mine Action Centre should:

a. establish procedures to ensure the proper T&E of demining machines prior to their deployment on demining operations;

b. establish reporting systems and procedures for the gathering of data on mechanical and follow-up demining operations. Such data should be made available to all stakeholders; and

c. provide advice and assistance to demining organisations in establishing tolerable risk for demining operations.

12.2 Mine/ERW Clearance Organisations

The mine/ERW clearance organisation shall:

a. support the SLNMAC with the T&E of demining machines to be used on demining operations;

b. obtain (from the NMAA) the operational accreditation for each different demining machine (model, make, type) to be used in demining operations;

c. comply with the national standards for the employment of demining machines on demining operations;

d. apply management practices and operational procedures which aim to clear land to the requirements specified in national standards or contracts and agreements;

e. establish and maintain reporting systems and make the information available on mechanical and follow-up demining operations as specified by the NMAA; and

f. establish systems and procedures to ensure that demining machines used on mechanical demining operations operate effectively, are properly maintained and serviced and remain safe for the operator and support staff.

Amendment record

Management of SLNMAS amendments

Amendments to this document will be published periodically. An accurate record of amendments is to be maintained in the table below.

Any comments, suggestions or proposed amendments to this document should be addressed to: The National QA Coordinator, Sri Lanka National Mine Action Centre (SLNMAC), Colombo.

Serial No.	Date	Paragraph		Amendment	Remarks
		Old	New		