CLEARANCE

The most familiar and visible part of mine action is the clearance of mines and ERW. It is also the most expensive of the five pillars. Clearance refers to an intrusive information-gathering and threat removal process that fully defines a hazardous area whilst removing explosive hazards.

The aim of clearance is to create safe land by locating and then destroying all mines and other explosive hazards within a defined area to a specified depth. This requires management systems and clearance procedures that are appropriate and effective, safe and efficient. Besides conducting the clearance, demining organisations are expected to update nearby communities on the extent of any remaining threat and the progress of the operation. Community liaison is an important part of the demining process and an effective means of building confidence amongst key stakeholders, especially users of released land.

The term demining toolkit is frequently used in mine action, typically composed of three elements: manual clearance, animal detection systems and mechanical systems. The use of machines and animals has become common in demining operations, although the majority of landmines and ERW continue to be cleared manually.

The decision to select a particular combination of techniques in a country setting is influenced by the extent and type of threat which the munitions pose, as well as other important factors such as financing and security, infrastructure and terrain, and national laws.

Manual clearance

Manual mine clearance methods have not changed significantly since World War II. Techniques continue to rely on a deminer working along a marked lane using a metal detector, prodder, rake or an excavation kit until a suspicious object is encountered. Although these methods often mean relatively slow progress, they are widespread and popular in mine action programmes, in recognition of the very high levels of confidence associated with the land they release. Some organisations involved in manual clearance choose not to use alternative methods and assets.

Manual deminers are used to create and clear lanes and grid systems, performing targeted and systematic investigations as well as area clearance. Deminers are usually placed at a defined safety distance from each other, continuing clearance drills until discovering a suspicious object. The deminer then carefully excavates around the object and, if it appears to be a mine or an item of explosive ordnance, it is either blown up in situ or defused and moved for destruction at the end of day.

It is uncomplicated to train teams of manual deminers and surveyors. In countries where labour costs are low, manual deminers can be cost-effective. They are well suited to clearing minefields for which laying records and maps are available, and where mines have been laid in rows or other identifiable patterns. Thick vegetation, rubble, debris, and urban areas are all factors that slow down manual clearance, prompting consideration of alternative means. Conversely, manual deminers can assist mechanical ground processing and clearance systems greatly in places with obstacles restricting machine access, and are used for community liaison tasks.

Metal detectors

In the 1960s the increasing use of plastics in mine manufacture decreased metal content sharply. In most modern anti-personnel mines, metal components are reduced to a few grams and include, at most, the firing pin, spring, and primer casing. To address the minimal metal content, modern detectors are sensitive and, compared to the cumbersome tools of the 1940s, they have become lighter, more durable, reliable and easy to use.

Unfortunately, as sensitivity has increased so has the susceptibility of metal detectors to signal false alarms from small metal fragments, and metallic compounds found in certain soils, such as laterite. Despite these limitations, metal detectors remain the most common means of detection and continue to undergo improvements in design.

NPA female deminer (Jordan)

Most modern detectors are built on the magnetic induction principle, able to compensate and filter out signals from unwanted metallic compounds in the soil. Some of them also feature ground penetrating radar (GPR). Despite enhancements in software and sensor technology, they are required to be durable and simple to use, easy to repair and recharge, with little need for maintenance.

Prodding

The prodder remains a common tool used to confirm the exact location of a buried mine. It is cheap, simple and effective and is used to feel the mine gently from its side as it lies in the ground. This is achieved by piercing the ground surface at a maximum angle of 30 degrees, to avoid disturbing the top of the mine, which is, in most types, the location of the triggering mechanism.

Prodders are made of many materials, from expensive plastics to steel, aluminium and iron. The disadvantages of prodding include the increased cost of more sophisticated designs, the close proximity of the deminer's head and hands to the investigated mine and the effort required to use it in rocky terrain. Prodders are not used when there is a possibility of encountering mines with an anti-disturbance fuse, or that have rotated in their position.

Rakes

Rakes are used for excavation and mine detection in sandy beaches, deserts and other soft terrains without significant root systems, thick undergrowth or stones. The operating principle is either to approach the mine from the side as with a prodder, or to scoop and pull the mine from beneath: the former aims to pinpoint the exact location of the mine for follow-on excavation; the latter to lift the mine to the surface in one pull.

The rake offers the advantages of an increased distance between the deminer and the mine, faster clearance progress, low cost and the potential for local manufacture. In terrains littered with metal fragments, the raking method is considered significantly more efficient than the use of metal detectors. In sandy or otherwise suitable soft terrains, some demining operators have replaced metal detectors entirely with rakes.

The downside of the raking method is the rough approach to a mine, and the potential for unwanted explosions. The deminer is well protected and stands at rake shaft distance away from the seat of an explosion, so s/he is likely to avoid serious injury, but the blast, sound and catapulting earth fragments may still cause some injury. When applied with care, however, the rake remains a useful tool for mine clearance.

Excavation

Full excavation can deliver the highest level of confidence of all the manual clearance methods, but it is the most time-consuming. Removing all soil to a specified depth is easy to supervise on site, but the technique is generally limited to:

- Areas on steep hill slopes or other places where it is difficult to move safely.
- Certain urban areas.
- Hard soil combined with high metal contamination.
- Areas with very low metal content mines that are unsuitable for mechanical or animal detection systems.

Progress and efficiency

Daily progress varies greatly depending on the method and technology used as well as the operating terrain, type of soil and current weather. Daily clearance output for one deminer has been observed between five and 150 m^2. Manual clearance is most effective and efficient when integrated with other detection and clearance methods.

Full excavation method by a steep hill (Afghanistan)

While manual clearance procedures for individual deminers are regularly reviewed and assessed to identify opportunities to improve speed, safety and confidence, most observed inefficiency is found at team and operations management level. Lack of resource-sensitive planning and supervision, wrong priority-settings, too little attention to important study of time and motion, as well as weather, terrain and logistics variables, can all be significant.

The factor most influencing efficiency is that of confidence in taking land release decisions, either as a result of lack of relevant information, or because management structures do not authorise and equip managers at the right level of take decisions. As manual demining is labour intense and expensive, more emphasis is now placed on maximising outreach and accuracy of surveys preceding clearance, increasingly enabling decisions to deploy deminers only in areas that are actually contaminated.

Animal detection systems

The animal most commonly used for mine detection is the dog, owing to its proven ability to work with and be trained by humans. Rats are also used. They are trained to detect odours from specific vapours associated with the explosive or other components of mines and munitions. This is referred to as an animal detector system (ADS).

Dogs have been used for tracking for centuries and in demining since World War II. The animal indicates the presence of a mine to its handler, who then passes responsibility for investigation of the indication to a deminer.

Animals, like any other survey and demining asset, have some limitations, but experience shows that with good training, practice and planning, many of the weather and environmental limitations can be overcome.

Explosive detection animals can detect mines with a low metal content, deep buried AT mines and mines buried in areas with a high metal contamination

Free running mine detection dog and handler wearing mine boots (Sarajevo) where the use of metal detectors would be difficult. ADS can be faster and more cost-effective than manual demining detector methods. Daily progress has been recorded from 300 m^2 to 2,000 m^2, depending on environmental conditions, the type of task and the operational concept in use. ADS are at their best when indicating individual mines or minefield boundaries, rather than trying to work within dense concentrations of mines.

Other recommended tasks include rapid sampling of areas already cleared by manual and mechanical demining, areas inaccessible for machines and approach routes to hazardous areas, as well as clearance of cluster munitions strikes and battle areas. Animals can be used with advantage in technical survey roles.

Animals, in particular dogs, have also been used in Remote Explosive Scent Tracing (REST). REST involves collecting dust or air samples in filters from mine-suspected areas and roads. The filters are then taken to a controlled environment where they are presented to specially trained animals for scent analysis. Samples are presented to several animals in succession. If none of them indicates the presence of mine or ERW scent, the area from which the sample was taken is no longer classified as hazardous.

REST has mostly been used for road verification, and has been applied for more than a decade in countries such as Afghanistan, Angola, Mozambique and Sudan. The majority of road verification work done around the world has used REST.

The main challenge with REST lies in the difficulty of quality assessing samples, ensuring that no cross-contamination has affected the filters during transport from the sampling area to the analysis area.

ADS cannot replace deminers, but is a powerful tool when used in combination with manual and mechanical systems, and can significantly increase productivity of a demining programme.

Mechanical systems

A variety of mechanical systems to detonate or destroy mines are manufactured to detonate or destroy mines. They can be highly cost-effective components in a demining programme, accelerating the progress of other assets, through removing vegetation and tripwires and breaking up soil. They can perform important functions in technical survey and, in some cases, can be used as a primary clearance method. The most common types of machines used in demining operations are equipped with flails, tillers and rollers.

Successful use of larger mechanical systems may impose demands on existing road and bridge infrastructure. All systems require the ready availability of spare parts and the tools and skills necessary to use them. The need for trailers and trucks to transport heavy mechanical equipment and the logistical support burden required to keep systems operating and serviced, often influences decisions about whether to use machines.

Anti-tank mines and large explosive munitions may damage or even destroy all but the heaviest and best protected demining machines. During preliminary surveys it is essential to identify the types of ordnance likely to be encountered to inform decisions about the use of machines.

Interest increased in the possibility of employing machines for humanitarian purposes as the modern mine action sector developed. Tremendous improvements have been made from the first mechanical system in 1942. Early machines were often cumbersome, unreliable and under-powered, and the achieved clearance results fell well below expectations (and the demands of modern humanitarian programmes).

Today a multitude of demining machines is available, equipped with reliable power trains, remote controls, navigation and positioning systems, and comprehensive service and support packages. Some machines are mass produced while others have been made in limited numbers or are one-off prototypes. In some cases agricultural and construction vehicles have been converted and armoured for mine clearance, offering savings for investment in terms of the availability and low cost for spare parts.

Mechanical systems conduct technical surveys, determine the boundaries of suspect hazardous areas, and play an important role in the overall land release process. Confidence in their use for clearance, under the right circumstances, has increased, as it has in their role as a risk reduction tool complementing the two mainstays of clearance methodology: manual deminers and mine detection dogs.

In 2004, the GICHD published a study of mechanical mine clearance equipment, examining factors influencing their efficiency, productivity and cost-effectiveness. The study concluded that in suitable conditions (threat type, soil and topography) machines can be used as a primary clearance system.

A decade later, confidence has increased and some mine action programmes use machines as a primary clearance system. The land release IMAS (07.11) emphasises the need to collect performance data during ongoing practical operations using machines, to build up a body of data on the basis of which decisions can be taken about when and where it is appropriate to use machines in a primary clearance role.

Machines used in demining can be divided into those designed to:

- Detonate hazards
- Prepare the ground
- Detect hazards.

Some are designed to fulfil more than one of these purposes.

Many machines make use of human operators and are designed to protect their occupants and equipment from detonation effects. Others use remote-control systems to keep operators well away from the hazard.

Purpose-built systems include flails, tillers, vegetation cutting machines, sifters and other machines. Adapted systems can be fitted to front loaders and excavators, often armoured to enable clearance of explosive hazards either from within the hazardous area or from outside its boundary, reaching in.

Some mechanical systems serve simultaneous purposes. For instance, if a ground engaging tool is used as a flail during demining operations it may destroy mines, remove vegetation and loosen soil. If its prime mover is also fitted with a magnet it can remove metal debris and collect information on mine and ERW contamination.

Mechanical crusher and sifter at work

Ground preparation machines can be used to increase the productivity and safety of mine clearance operations for other clearance assets. They may prepare areas for further clearance operations by cutting minor vegetation down to ground level and by destroying tripwires, or breaking ice and crust in cold conditions.

Suitable ground preparation machines may be used in the technical survey role to confirm whether a suspected area contains mines (usually be relying on the fact that any mines encountered will be detonated).

While there are numerous purpose-built machines and tools available for mechanical clearance, these are rarely able to defeat all mine types and are very unlikely to detonate all ERW. A systems approach is required, where machines with a combination of tools, a combination of machines with different tools, or manual demining and/or ADS procedures are applied at different stages of the demining operation.

One important factor when considering whether to deploy machines into an area is their impact on information and the extent to which decisions on when to stop technical work can be taken. In some cases, more cautious use of machines may be appropriate to preserve patterns of contamination. Balance between the use of a machine as a technical survey tool and as a clearance asset depends not just on the level of confidence associated with its clearance capabilities, but also on its ability to preserve and deliver, or disrupt and degrade, information.

Other demining technologies

Two notable new technologies are ground penetrating radar (GPR) and the detection of explosive vapours.

GPR consists of a transmitter that sends a pulse of energy (or a continuous wave at a certain range of frequencies) into the ground, matched with a receiver taking in the radar signals reflected from buried features or objects. The radar energy passes through the ground and is reflected back at different speeds depending on the material through which it passes.

GPR is particularly useful when built in to complement a traditional metal detector, enabling detection of plastic cased mines which contain little or no metal. Although the technology continues to be developed, GPR variations have been successfully used to improve productivity of deminers in minefields with high metal contamination, reducing the time wasted in excavation of false positive metal signals.

In explosive vapour detection two mainstream methodologies are currently under development – chemical sensors and insects. The method showing the greatest application and practicability is that of gas chromatography. Most gas chromatographs are more suited for laboratory than field use as they are large, delicate and require reliable supplies of electricity and gases. The system can be built into a mobile laboratory, which can then be transported into the field where vapour samples are brought for analysis, as with the remote explosive scent tracing (REST) described earlier.

Experiments in detection of explosive vapours have also been carried out with insects such as flies and bees. The insects can be bred to have excellent detection capability and sensitivity. However, ensuring that they can be made to return from the first task, to be used repeatedly in the field, is something which has not yet been established.

Other new technologies include expected improvements to protective equipment, on-going research in the use of handheld magnets, introduction of unmanned aerial vehicles (UAV) for surveys, and fitting magnets onto existing mechanical systems to reduce the amount of metal left behind them, speeding up manual clearance or verification procedures following their use.

Battle area clearance

Battle area clearance (BAC) is the systematic and controlled clearance of ERW from hazardous areas in a former combat zone where the threat is known to not contain mines. Most ERW found during demining are small items such as submunitions, grenades and mortar ammunition which have been fired but have not exploded. These are often cleared by deminers. Unexploded ordnance refers to larger items such as artillery ammunition, guided missiles and air-dropped bombs. The complexity of UXO requires that special attention be given to the management of BAC and EOD.

BAC involves a surface search of a specified area by a team visually inspecting the ground for evidence of a hazard. It can also make use of procedures similar to those used in mine clearance locating items on and below the surface, in marked lanes. If both mines and ERW are present in the same area, the situation is first treated as a mine hazard, before addressing the ERW hazard using BAC techniques after the mine threat has been removed.

There are hundreds of types of UXO and fuzing mechanisms. Becoming an EOD technician requires years of practice. Once an EOD technician encounters an item of UXO s/he identifies it and its fuzing system, possible booby traps, and then decides whether it is safe to handle. UXO is normally destroyed in situ. If that is not possible for safety reasons, or for environmental or infrastructure considerations, render safe procedures (RSPs) are applied to neutralise[6] or disarm[7] the item prior to moving it to another location for final disposal.

Underwater EOD operations

A number of States are affected by old naval mines, dumped ammunition and other ERW in harbours, territorial waters or inland waterways and lakes. A request has been proposed to develop an international standard and guide to best practices in underwater EOD operations. This process is now ongoing and once completed, it should contribute to the safety, quality and cost effectiveness of underwater surveys and clearance.

In addition to the humanitarian dimension, underwater munitions present a security risk and may be an impediment to development of infrastructure and economic growth. With exposure to water for prolonged periods, ammunition and ERW degrade and may become unstable. In time they release toxic substances, presenting a hazard to local livelihoods and infrastructure. Ammunition lying at shallow depths may also end up being used in Improvised Explosive Devices (IEDs).

As standards[8] and guidelines[9] already exist for military and commercial diving involving EOD, the forthcoming international underwater EOD standard will be

Underwater EOD operations