Understanding Landmines and Mine Action

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The aim of this document

In order to conduct any analysis of mine action programs, or to propose the use of new technologies, it is first important to review the background of the mine action sector since its first inception in 1988[1].These notes set out an introduction to the problems of landmines, explain how mine action programs are organised, and provide a short explanation of how mine clearance is carried out. A brief summary of the campaign to ban antipersonnel mines is also included.

Any questions or requests for further technical advice may be submitted to the author via the following email address: *BobKeeley@compuserve.com*

Note: this document is intended to provide an introduction to the issue of landmine contamination and the structure of mine clearance programs. It is not designed to provide safety advice and is not a replacement for formal safety training.

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[1] The first humanitarian mine clearance project was carried out by a British Non-government organisation (NGO) 'The HALO Trust' in Afghanistan 1988 (source: presentation by Paul Jefferson, ex-HALO deminer and project manager)

Understanding Landmines and Mine Action

Introduction

According to the International Campaign to Ban Landmines (ICBL)[1]:

> *"Landmines are now a daily threat in Afghanistan, Angola, Bosnia, Cambodia, Chechnya, Croatia, Iraq, Mozambique, Nicaragua, Somalia, and dozens of other countries. Mines recognize no cease-fire and long after the fighting has stopped they continue to maim or kill. Mines also render large tracts of agricultural land unusable, wreaking environmental and economic devastation. Refugees returning to their war-ravaged countries face this life-threatening obstacle to rebuilding their lives*
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> *Those who survive the initial blast usually require amputations, long hospital stays, and extensive rehabilitative services. In Cambodia alone there are over 35,000 amputees injured by landmines--and they are the survivors. Many others die in the fields from loss of blood or lack of transport to get medical help. Mine deaths and injuries in the past few decades total in the hundreds of thousands."*

Landmine and unexploded ordnance (UXO)[2] contamination have significant humanitarian implications. Mines can hamper reconstruction after conflict, perhaps by blocking the route of a new highway or a power line. Mines can deny the use of agricultural land or riverbanks. They can even prevent tourism bringing in valuable foreign currency through denying access to cultural heritage sites. Development project personnel who are not warned of the dangers can become casualties.

However, most of all, mines effect the poor[3]. Mine contamination denies the safe use of agricultural land. Many people leave the land and drift to the towns; others, often the poorest elements of society in mine-affected countries, have to take risks to survive: many people living in mine-affected countries engage in various kinds of deliberate risk-taking activities, such as gathering firewood or herding cattle in areas they know to be mined, simply because they have no choice. Faced with stark economic imperatives, some people even take on 'do-it-yourself' demining to clear land for their own use or to salvage the metal cases of weapons for sale as scrap metal[4].

Unfortunately, such activities only add to the burden to the country caused by casualties, the large numbers of which can overwhelm the limited resources of rural health centres. Casualties cannot support their families; they become beggars and drift to the towns. Women who become mine casualties can suffer an extra burden: they may lose the chance to get married, or their husbands might desert them. Furthermore, curious children are also particularly at risk. Surviving casualties often lose limbs, and the prosthetic support they need for the rest of their lives can often only be met with external support.

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[1] http://www.icbl.org/

[2] For the purposes of clarity, the terms 'mine action' and 'mine clearance' include clearance of unexploded ordnance (UXO).

[3] See the UN website http://www.mineaction.org/misc/dynamic_overview.cfm?did=140

[4] Handicap International covered the issue of such 'spontaneous demining' in research in 1999-2000.

Landmines and Unexploded Ordnance: definitions and descriptions

Landmines

According to International Mine Action Standards (IMAS)[5], a (land)mine is a 'munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or a vehicle'[6].

Mines can be either designed as 'anti-personnel' or 'anti-tank'. Anti-personnel (AP) mines are designed to be activated by people, whilst anti-tank (AT) mines are intended to defeat tanks or other armoured vehicles.

Anti-personnel (AP) mines

There are hundreds of different types of AP mine[7], though probably only about 50 or so are found in any significant numbers in the mine affected countries around the world. All AP mines can be broken into 2 groups. These are:

AP blast mines

AP fragmentation mines

Figure 1. The key is placed next to this Yugoslavian AP mine to give an idea of its size (Photo by the author, 1996)

AP blast mines. AP blast mines tend to be small, flat and cylindrical, typically 60-140 mm in diameter. They rely on the effect of explosive blast to damage the victim, and are designed to detonate when the victim steps on them. They are often buried in order to camouflage their presence. AP blast mines are deliberately designed to be small: this makes them cheaper and easier to store, carry and deploy. Furthermore, the small size means that the wounds are generally not immediately fatal. In combat this means that more soldiers are needed to evacuate and care for the casualty, whereas a bigger mine that causes an immediately fatal wound only removes one soldier[8].

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[5] The United Nations has a general responsibility for enabling and encouraging the effective management of mine action programmes, including the development and maintenance of standards. UNMAS is the office within the United Nations Secretariat responsible for the development and maintenance of international mine action standards (IMAS). The work of preparing, reviewing and revising these standards is conducted by technical committees, with the support of international, governmental and non-governmental organizations. The latest version of each standard, together with information on the work of the technical committees, can be found at www.mineactionstandards.org (source: IMAS Glossary of Terms).

[6] IMAS definition 3.120

[7] 'Jane's Mines and Mine Clearance' compiled by Colin King

[8] Some further detail about the design of anti-personnel mines is included at Annex A

Figure 2. The wooden stake of this Yugoslavian anti-personnel fragmentation mine is driven into the ground, the mine placed on top, and a tripwire run out from the fuse on the top of the mine (photo by the author, 1996)

Figure 3. A selection of bounding fragmentation mines found in Cambodia. These examples have been neutralised and kept by the demining program for training purposes (photo by the author, 1999)

Figure 4. A selection of directional fragmentation mines on display in Cambodia. The cap in the foreground gives an idea of scale (photo by the author, 1999)

<u>AP fragmentation mines</u>. AP fragmentation mines use the detonation of their explosive content to drive metal fragments into their victims. They are usually able to be initiated by the victim walking into a tripwire, and can thus often kill or injure several victims at once[9]. The simplest design of an AP fragmentation mine is basically a hand grenade mounted on a stake driven into the ground, with a trip wire attached to a pin. When the trip wire is pulled, the pin is withdrawn and the mine functions. However, there are two main variations on this basic theme. These are:

> *<u>Bounding fragmentation mines</u>*. Unlike simple 'stake' mines, bounding fragmentation mines are buried, making them harder to detect. When initiated, the first explosive charge propels the mine casing into the air to a height of approximately 1 metre, where it detonates. These mines are some of the most dramatic – and devastating – as they are camouflaged like AP blast mines but can also strike anybody who is in the danger area.
>
> *<u>Directional fragmentation mines</u>*. This device is crafted in such a way that the main explosive force is directed outwards (the original, American version of this mine – the M18 'Claymore' - even includes the helpful direction 'front towards enemy' cast into its plastic casing!) and was originally designed to be placed in front of defensive positions and command detonated in the face of human-wave type frontal assaults. The Claymore was soon fitted with the means to fit a trip-wire (thus making it a 'mine' by modern definitions) and has been widely copied around the world. Such mines tend to have a lethal arc of about 45 degrees.

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[9] The lethal range of an AP fragmentation range is around 15-25 metres, though they can be dangerous out to a range of 100 metres or so (King, 1997).

Anti-tank (AT) mines

Figure 5. This Yugoslavian mine has the shape and size of a typical anti-tank mine. (photo by the author, 1996)

The main difference between an AP and AT mines is that an AT mine is much larger and filled with more explosive, hence making it able to defeat a tank. Usually (but not always) AT mines are also designed to have a minimum operating pressure so that, unlike AP mines, people do not set them off[10]. The usual aim of AT mines is to achieve a 'mobility kill' by blowing the track off a tank, immobilising it and thus making it an easier target, though there are some AT mines that are also designed to detonate under the belly of the tank.

Figure 6. Items ordnance from the First World War unearthed in Belgium (Published on line at the Belgian WWI archaeological website (www.diggers.be))

Unexploded Ordnance and Ammunition

An item of unexploded ordnance is, in essence, a piece of explosive ordnance or ammunition[11] that has 'failed to function as intended'. UXO may include all natures of explosive ordnance including naval ordnance, land-service ammunition and air dropped weapons. Typically, only the latter two of these categories are relevant to humanitarian programs[12].

Battlefields may be strewn with any number of items of UXO, which vary greatly in size from hand grenades the size of an apple to large aircraft bombs weighing more than 1000kg. Although they have failed to function as intended, UXO can sometimes require only the slightest disturbance to detonate. Their age and appearance can be deceptive – lethal items are still found in France and Belgium from the First World War[13], and although rusty on the outside, are often found to be in perfect working order.

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[10] This was not for any particular humanitarian purpose; an AT mine is more expensive than an AP mine, requires more resources to store, transport and deploy, and would, in the 'science of killing' that underpins modern war-fighting doctrine, be 'wasted' if it was detonated by a person and not a tank.

[11] In military terminology, the term 'explosive ordnance' is used to describe weapons that have some sort of explosive content, thus leading to the terms 'unexploded ordnance' for the left over items and 'explosive ordnance disposal' (EOD) for the teams that clear up such items. However, because landmines are items of explosive ordnance but not items of UXO (as they haven't been activated yet) this can get very confusing for non-specialists. There is a growing tendency for non-specialists who are active in advocacy issues to use the term 'explosive remnants or war' (ERW) to cover both landmines and UXO.

[12] A figure that is commonly quoted by some EOD specialists is "10% of all ordnance". The provenance of this figure is difficult to determine exactly but it is believed to come from a technical assessment carried out by German weapon designers after the Spanish Civil War.

[13] *"Every year we handle approximately 250 tons of ammunition from these wars. Within these 250 tons, some 20 tons are doubtful ammunitions which could be chemical shells from WWI."* Michel Lambrechts, quoted in Mine Action Information Centre Journal Edition 4.2, 2000 (http://maic.jmu.edu/journal/4.2/Features/ww2/ww2.htm)

The problem caused by UXO may be exacerbated by their unpredictability. Two apparently identical items of ordnance might behave very differently when handled, depending on what has happened to that item before it is discovered.

Figure 7. A selection of aircraft bomb casings kept in a museum in Vietnam. The large tail fins at the rear of the bomb in the centre are designed to slow down the bomb so that it explodes behind the low-flying aircraft that drops it (photo by the author 2000)

Cluster-bombs, submunitions and bomblets

Figure 8. This American air-delivered submunition, found in Kuwait after the first Gulf War, is about the size as a soft drink can. Recently (in Afghanistan) its bright yellow packaging was often confused with yellow emergency food parcels dropped (photo by the Author, 1991)

These items of ordnance have received a great deal of media attention in the last few years and are worth a brief explanation. In the Second World War, German weapon designers realised that the effect of a typical aircraft load of bombs could be dramatically increased if bombs were designed to carry a number of small ‘sub-munitions’ that could spread evenly over a larger footprint than that affected by a single large bomb of the same total weight[14]. This idea was put to the test in a series of air raids on England and the concept has been widely copied by a number of nations in the years since. The large carrying canister is generally now called a ‘cluster bomb unit’ whilst the submunitions are the items that it dispenses. Submunitions can come in two main types – ‘bomblets’ (i.e. small bombs that are designed to explode on impact or after a short delay) or ‘scatterable mines’ (i.e. devices that are intended to be initiated by the victim). Many bomblets fail to function as intended and thus become UXO.

It should also be noted that submunitions could also be delivered by artillery.

Figure 9. This type of submunition can be delivered by artillery or surface-to-surface rocket. It is about the size of a U2 (type D) battery, but its small size belies its deadliness - it is regarded by EOD specialists as one of the most sensitive and dangerous items of UXO that can be encountered (photo from the UN Mine Action Centre Croatia, 1995)

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[14] Briefing from the UK Defence Explosive Ordnance Disposal School, 1988

Abandoned ammunition

One problem that is often encountered soon after a conflict is the stockpiles of abandoned, unexpended ammunition left over from the conflict. Whilst this is not ‘unexploded ordnance’ as such as it has not been expended, it can and does pose a hazard as items of abandoned ordnance will deteriorate over time and can become unsafe to move. This is particularly the case with poor quality or old ammunition items and the problem can also be exacerbated by conditions of high temperature. There is an additional problem where stocks of abandoned ordnance include small arms and their ammunition, which can be plundered by armed gangs seeking to exploit lawless conditions at the end of an armed conflict.[15]

Figure 10. An ammunition stockpile in the town of Srebrenica, Bosnia and Herzegovina. Poor ammunition management can increase the risk of accidental detonation (photo by the author, 1994)

Figure 11. The effects of high temperatures exacerbate the risk of accidental detonation of abandoned ammunition. These items were found in the Kuwaiti desert where they had lain in the sun for several months (photo by the author 1991)

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[15] This is a common problem in Iraq at the time of writing (Source: email posting by Roger Hess on the Menschen Gegen Minen (MgM) website June 2003) but it has been a problem for many years (discussions with Professor Branko Kopjar, then of the University of Oslo, 1996).

How landmines are used

History of landmines

Although the history of mines can be traced back as far as Roman times[16] it was the introduction of tanks in the First World War that led to the development of the first modern mines. Anti-tank mines were introduced to provide defending troops with the means to create an obstacle to armoured vehicles that were seemingly unstoppable by the conventional barriers of ditch and wire. Later, as attacking troops learned to pick up these anti-tank mines in the path of their tanks, the anti-tank mines were protected in turn by the introduction of anti-personnel mines. These would slow down the progress of engineers sent into the minefields to breach paths through the minefield and their detonation would also alert the defenders to the fact that an attack was in progress. Mine warfare reached its peak in the North African campaign in World War II when the desert provided few other obstacles to manoeuvring armies, and huge minefields, extending many miles, were built. The lessons of mine warfare were well learned by post war armies, and the armies of both NATO and the Warsaw Pact incorporated tactics of employing minefields and also breaching them under fire. Mine clearance techniques are covered below.

Economics of mine warfare

Landmines are cheap, simple technology. One figure commonly quoted in anti-landmine advocacy literature is '$3 to make[17].' Although this figure grows significantly when modern, western mines are taken into account (one American type of AP mine is reported to cost $386[18]) It is certainly true that landmines can be one of the 'lowest-tech' weapons available today: one common example, the Chinese-made Type 72A has only one moving part, and there is no precision engineering required of the sort needed to machine a rifle bullet. Furthermore, because of their low technology landmines are easy to store compared to some more complicated weapons, and usually require nothing more than a shovel to emplace[19]. In military parlance, landmines act as 'force multipliers' in that they

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[16] The Romans would deploy 'caltrops,' spiked tetrahedrons that would pierce the feet of attacking troops and thus work in much the same way as anti-personnel mines would some two thousand years later. For more on the historical elements see "The History of Landmines" by Mike Croll.

[17] Commonly quoted in International Campaign to Ban landmines (ICBL) literature in the leadup to the 1997 Ottawa Treaty banning anti-personnel landmines. The $3 price is understood to be the price of one of the simplest anti-personnel blast mines, the Chinese Type 72A. However, the same quote also usually goes on to say "…a thousand dollars to clear", which while spuriously accurate (it was apparently arrived at by dividing one year's budget from a demining program in Cambodia by the numbers of mines reported cleared that year) it can easily be shown that this figure is actually almost meaningless, as it costs nearly as much to clear a square kilometre with one mine in it as it does to clear the same area of a thousand mines. The extra cost of actually dealing with detected mines is only one of a number of costs (both fixed and variable) incurred in mine action.

[18] The M74 AP mine (US Munitions Command)

[19] Many NATO and Warsaw Pact nations developed a number of more complicated landmine delivery systems, such as the BARMINE and RANGER systems developed by the British. Artillery, helicopter and fixed-wing aircraft can also deliver 'scatterable' mines, usually when contained as 'submunitions' within a 'cluster bomb unit'.

can help a small defending force defeat a larger attacking force, and can do so more cost effectively than other weapons, particularly more expensive modern anti-tank weapons[20]. It is for this reason that nations who were willing to endorse the 1997 Ottawa Treaty to ban AP mines were unwilling to extend the treaty to cover AT mines.[21]

The simplicity and cost-effectiveness of mines is also a major factor in explaining the widespread use of mines throughout the numerous countries that are now faced with dealing with the mine contamination problem. Indeed, as one of the earliest humanitarian deminers said "a landmine is the perfect soldier: Ever courageous, never sleeps, never misses[22]"

Conventional minefields

According to International Mine Action Standards (IMAS)[23], a 'minefield' is an area of ground containing mines laid with or without a pattern[24].

Typical burying depth

Mines tend to be buried, in order to camouflage them from attacking troops. In order to achieve this, soldiers may only need to excavate a few centimetres to accommodate the mine. It is clearly quicker for the soldier to bury the mine as shallowly as possible, and in most cases mines are found very close to the surface[25].

Typical minefield components

A typical, 'conventional[26]' mixed minefield (i.e. one with both AT and AP mines) consists of:

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[20] In the conventional sense, minefields and direct-fire weapons (i.e. weapons fired in line-of-sight) are intended to be used together. The minefield acts best when attacking forces are stopped short by a minefield, or forced to change direction to manoeuvre around the obstacle. It is easier to hit a stationary target than a moving one, and armoured vehicles tend to be less heavily armoured on their flanks, exposed when turning, than on their front.

[21] Comments of delegates to the author during the Oslo Conference in September 1997 to draft the Ottawa Treaty

[22] Paul Jefferson, 1991

[23] The United Nations has a general responsibility for enabling and encouraging the effective management of mine action programmes, including the development and maintenance of standards. UNMAS is the office within the United Nations Secretariat responsible for the development and maintenance of international mine action standards (IMAS). The work of preparing, reviewing and revising these standards is conducted by technical committees, with the support of international, governmental and non-governmental organizations. The latest version of each standard, together with information on the work of the technical committees, can be found at www.mineactionstandards.org (source: IMAS Glossary of Terms).

24 IMAS definition 3.132

[25] However, mines can sometimes be found at quite deep depths. This is covered in more detail below.

[26] In this case, the word 'conventional' is used to refer to minefields compliant with Protocol II of the Convention on Conventional Weapons (CCW)(1980 amended in 1996). As will be shown below, mines used in many countries rarely complied with these requirements.

Anti-personnel (AP) mines to act as an obstacle to troops, and hence delay clearance of anti-tank mines

A boundary fence and markers to indicate the presence of mines[28]

Typical conventional minefield layouts

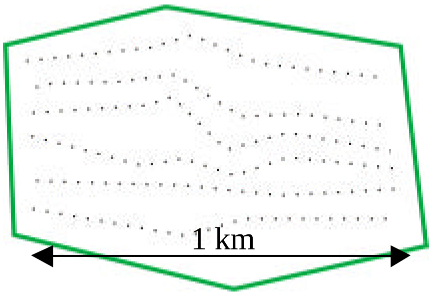

Figure 12. A typical NATO (pre 1997) mixed minefield layout

Mixed Minefields. Within a boundary fence, a conventional mixed minefield might consist of a number of rows of AT mines. A main minefield designed to act as a barrier to advancing troops might consist of some six rows of AT mines, with the AT mines some 5-6 metres apart[29]. There could be anything from 10-100 metres between mine rows[30] and between the first and last mine rows and the perimeter fence. The front rows of the minefield might include special fuses designed to help defeat minefield breaching machines such as tanks fitted with rollers or ploughs.

Some armies trained soldiers to place AP mines in a 'cluster' around AT mines. Such a cluster could consist of 3 AP mines, placed at approximately 10, 12 and 2 o'clock. There was much variation: sometimes the AP mines would only be clustered around the front AT mine row.

This technique was found by deminers to have been used by Iraqi forces in Kuwait in 1990. The Iraqis also fenced and marked their minefields. However, as well be described below, the experience of humanitarian demining teams suggests that these conventional minefields are rarely encountered elsewhere.

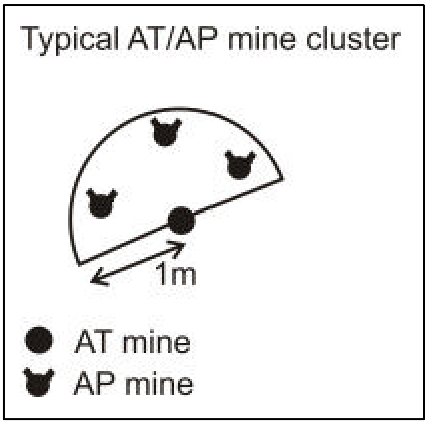

Figure 13. Typical NATO ATAP mine cluster (pre 1997)

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[27] An anti-tank mine is one that is exploded by the presence, proximity or contact with a vehicle but not through the presence, proximity or contact with a person unless that person undertakes a deliberate act to move or dismantle the mine.

[28] Both NATO and the Warsaw Pact included mine marking as part of their operational doctrine; surprising as it may seem, both alliances realised that the minefield fence acted as a powerful deterrent and could cause the attacking troops to hesitate or deviate from their intended course, so improving the defenders' ability to shoot at them. Indeed, the use of minefield fences without any mines to utilise this effect was a recognised tactic (in NATO this was referred to as a "Phoney Minefield). CCW also requires states party to map and record mined areas; however in many cases (especially where mines are used by non-state actors) this is not done. Even when minefield records have been produced, they are often of dubious quality: "Like any other country, the real mine situation is confused. The infantry laid mines but failed to record them, some engineer records have been destroyed, lost or are incomplete and the LTTE occasionally infiltrated the army's positions and laid mines among them" (comment on the MgM demining website, July 2003).

[29] Clearly the smaller the distance between mines, the more mines there are in a given sized minefield, but this has obvious resource implications. Mine spacing and the number of rows were the result of involved operational analysis calculations by the potential users, to get the most resource-effective 'stopping power.' Use of patterns helped ensure that the minefield achieved the correct balance.

[30] The minimum distance between rows would be dictated primarily by the need for the mine-layers to maintain a safe distance between rows whilst rowing. The bigger the distance between the rows, the longer a potential attacker would have to search for mines.

Table 1 - Typical mined areas[31]
Routes and lines of advance (especially at choke points such a bridges, tunnels or fords
Check points
(Abandoned) defensive positions
Infrastructure (power lines, dams)

Large mixed minefields could be used, as they had been in the North African campaign of the Second World War, to place obstacles across large areas of featureless terrain. However, in many cases minefields would be 'tied in' to natural features to enhance their value as an obstacle to attackers. Thus, terrain must be taken into account when planning clearance of such mined areas. For example, mines might be placed on the banks of a river either side of a ford or a demolished bridge, mines might be placed in a narrow valley or cutting where attackers cannot avoid them, or around an obstacle such as an 'abatis' (a pile of felled trees) across a road, to harass troops attempting to clear the obstacle. Mines might also be used to deny the use of 'dead ground' (ground that cannot be seen from the defensive position) to an attacking enemy. Table 1 provides a summary of places where troops might use landmines

Figure 14. A deminer clears an AP minefield in Cambodia. The minefield consisted of two rows of AP mines, 1 metre apart. The mines are buried a few millimetres below the surface and there was no minefield fence (photo by the author, 1999)

Anti-personnel minefields. Smaller designs might be employed, often without AT mines, as 'protective' minefields in front of defensive positions, intended to harass attacking infantry assaulting the position. For example, a typical Vietnamese protective minefield (as used in Cambodia between 1979-89) might consist of two rows of AP mines, with 1m spacing between each mine, and 1m spacing between the mine rows. In the former Yugoslavia protective minefields might consist of a row of AP fragmentation mines, with directional fragmentation mines at either end of the row, followed up by a row of AP blast mines. Use of AP fragmentation mines operated by tripwire meant that it was possible to spread out these mines to the limit of their 'killing area', so such mines might be spaced 20-30m apart.

Protective minefields can be very small: for example, in the fighting in Cambodia Khmer Rouge raiding parties might carry a small number of AP mines to put out every night around their positions to provide early warning of any attempts at infiltration[32]. Although such mines were supposed to be picked up again every time they moved on, any number of reasons might have prevented this from happening, not least soldiers forgetting where they placed all of the mines! Mines can therefore be expected around any area that was occupied by a defending force for any length of time.

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[31] From a mine awareness briefing prepared for the Register of Engineers for Disaster Relief (RedR) on behalf of Handicap International, 1997

[32] "The War of the Mines" by Paul Davies and Nic Dunlop

Unconventional minelaying

Effect of not having fences

Although both NATO and the Warsaw pact trained to fence their minefields[33], in practice users of mines since the Second World War have rarely used fences, and most minefields in place in the world today are unmarked.

Figure 15. In the foreground of this photograph is a typical minefield fence in the Falkland Islands (the penguins are evidently not heavy enough to set off the mines!) However, British military engineers erected this fence after the end of the war (photo by the author 1984)

This means that, although people still talk about ‘minefields’ the problem is that deminers are faced by clearing large areas[34], usually without defined boundaries. This can mean that far more resources are employed to clear mined areas than is actually necessary.

Deep buried mines

Although there has been little systematic and independent research on the question of deep buried mines, there are three main explanatory variables that explains the phenomenon of deep buried mines. These are set out below.

Figure 16. Minefields in the former Yugoslavia were rarely marked at the time of laying, though there were attempts after the fighting to mark hazardous areas. The white police tape used here (ineffective against the winter background) was observed after the end of the war in Croatia (photo by the author 1996)

Mines that become buried over time. The first explanation of deep buried mines is that they can start off near the surface but become buried over time. This is often through landslips or subsidence, but there are other possible causes, similar to the geographical effects that causes stones to rise in ploughed fields

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[33] However, CCW 1980 (and NATO and Warsaw Pact doctrine) also allowed for the deployment of ‘non pre-planned’ minefields that did not require marking, and mines have been emplaced by remote delivery means, notably the use of helicopters by the Soviet forces to deliver mines in Afghanistan between 1979-89, and the use of air-delivered scatterable mines by the coalition forces in the first Gulf War, 1990-91.

[34] The IMAS definition of a ‘mined area’ is an area which is dangerous due to the presence or suspected presence of mines (IMAS 04.10 Para 3.131)

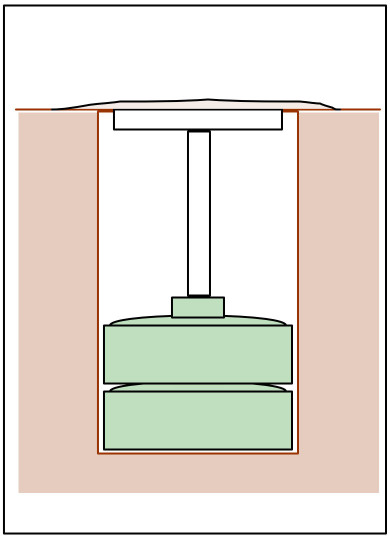

Figure 17. *In this diagram an anti-tank mine has been buried deeper than usual, in order to take it out of the range of mine detectors. A wooden plate and post are used to transmit the pressure from the target vehicle to the mine's pressure plate. In order to make up for the attenuation of blast caused by the deeper depth, the mine has been 'double stacked'*

Mines that are deliberately buried deeply. There have been some reports that mines are buried deeply to defeat conventional mine detection techniques. One such deep buried method is shown in the diagram opposite. It is clearly much more labour intensive to dig mines in like this, it increases the risk of the perpetrator being caught and it adds no value for strikes on normal vehicles. It does however reduce confidence in the clearance work, as it might mean that such a mine blows up after a demining team has passed that way.

Missed mines. There is a third possible explanation for mines that are reported as 'deep buried' mines after they detonate under a vehicle passing over an apparently cleared area – perhaps the mine was indeed missed by the clearance team. Again, there has been little or no systematic, independent research of this issue.

The effect of time

The most evident effect of time on mined areas is the growth of vegetation. Land not in use, because of fighting or because of the fear of mines being present, quickly becomes overgrown. A large proportion of the time spent in the field by deminers is spent clearing vegetation so that they can search for mines.

Figure 18. This photograph, taken in Cambodia, shows the degree to which vegetation can overgrow a mined area (photo by the author 1999)

The second effect of time, as referred to above, is the possible variation on burying depth. It is believed that mines may move in the soil over years. However, there is little scientific research in this area at present.

Typical landmine injuries

The force of the explosion attenuates as the distance from the explosion's centre increases (the explosive force is inversely proportional to the cube of the distance from the explosion's centre[35]) and thus it is very possible to sustain a major injury from a small explosive charge in close contact (such as an anti-personnel mine under the foot) whilst experiencing much less injury from a much larger explosive charge several metres away. There is hence an enormous variety in the range of explosive injuries from landmines and UXO.

Nevertheless, the International Committee of the Red Cross (ICRC) has been able to identify three main patterns of landmine injury[36]. These are:

Pattern One Injury. Traumatic amputation of one or both legs, usually caused by stepping on an AP blast mine. The resulting explosion destroys the foot and often part of the leg. The explosion also drives fragments of the mine casing and parts of the victim's own shoe and clothing into the wound, along with other debris such as soil and vegetation. The resulting injuries can easily become infected and the victim can require several operations. Traumatic amputation of the affected leg is the usual result.[37]

Figure 19. Bilateral below-knee amputation resulting from a landmine injury. (Photo from UN Mine Action Centre Croatia 1996)

Pattern Two Injury. Multiple lacerations caused by fragmentation. Usually caused as a result of the victim being in the vicinity of a detonating AP fragmentation mine or item of unexploded ordnance. It is believed that many of the most severely injured pattern 2 casualties do not survive the trip to the nearest hospital.

Figure 20. Scars left from multiple lacerations caused by an exploding UXO. The severity of Pattern 2 injuries will vary with the proximity and size of the explosion (photo: Project RENEW, Vietnam 2002)

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[35] AV Smith: posting on "blast effects" on the MgM

[36] Source: ICRC Video: "Anti Personnel Mine Injuries Surgical Management (1993)"

[37] The extent of the injuries varies with the size of the mine and of the victim. A small mine may only take of part of a foot of an adult wearing strong footwear such as army-issued boots, whilst some of the largest AP mines may take off both legs; injuries to children can be particularly severe.

Pattern Three Injury. Traumatic amputation of one or both hands, accompanied by injuries to the face and eyes. Such injuries are usually caused by handling landmines or items of unexploded ordnance.

Figure 21. These casualties are examples of Pattern 3 wounds and show the range of injuries possible. The man on the left was in close proximity to the detonation of a mid-range UXO; the man in the centre, picked up a small UXO out of curiosity (apart from losing his right hand, he was also blinded), whilst the third man escaped with light scarring whilst searching for buried UXO with a home-made mine detector (All photos by the author 1998-2001)

Impact of mine injuries

Mine/UXO injuries have two main impacts. Firstly, they affect the lives of the casualty and their family; secondly they have impacts on the medical infrastructure of the affected country.

The main economic effect on the victim is the limiting of ability to earn income to support themselves and their family.[38] After suffering an injury the ability of the casualty to make a living is greatly curtailed. As well as obvious physical injuries, the casualty may suffer psychological damage. Female casualties are regarded as being particularly vulnerable as the extensive physical damage can severely limit their chances of marriage. Even when married at the time of the accident, organisations specialising in mine victim assistance report that it is common for husbands to desert the casualty.

The effects are not limited to the casualty or their immediate families. Treating mine injuries drains the local medical infrastructure of developing countries, as these sorts of wounds inevitably become infected and usually require 2-3 operations to debride the wounds of debris and necrotic tissue. Pattern 1 casualties will require a prosthesis or a wheelchair if they are to regain any mobility and, in the case of prostheses, will also need intensive physiotherapy to learn how to use the artificial limb. Furthermore, most amputees will require a new limb ever 2-3 years as the old ones wear out. Where the casualties are children, the situation is exacerbated, as growing children will need their limbs adjusted or replaced several times each year.

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[38] Farmers using contaminated land are usually already among the poorest of their society, hence they have no choice but to take the risk of using the land – even, in many cases, when they know the land is contaminated.

Mine action programs

The increasing understanding of the global impact of land mines on non-combatants has encouraged the development of mine clearance programmes designed with humanitarian concerns in mind. In many cases, for a variety of reasons, aid managers have not always been able to coordinate their requirements with the local military (see below), and professional demining organizations have taken the lead in conducting wide-scale humanitarian mine clearance. For the purpose of these notes, Mine Action[39] is defined as a "comprehensive, structured approach to dealing with the tangible consequences of mine and UXO contamination, involving mine survey, mine awareness and mine clearance"[40].

The Inter-relationship of Mine Action Programme Elements

Demining

The core element of an effective mine action programme is the clearance of mines and unexploded ordnance. No matter what effort is spent on mine risk reduction education, survey, victim assistance or campaigns to ban mines, the mines and UXO that are in the ground must at some time be removed in order to remove the threat that they pose. The large-scale clearance of land of mines and/or UXO is called 'mine clearance' or 'demining'. However, in order to make demining cost-effective, and maximise the effect of limit resources available to most demining programmes it is necessary to carry out several other ancillary activities. These are explained below. The inter-relation of these components is shown in the diagram at Figure 22 below.

Area Reduction

The use of suitably trained dogs and specialist dog handlers can also speed up overall productivity by helping project managers to determine the extent of contamination and thus ensuring that deminers are only deployed in areas that actually contain mines and UXO. The use of suitable machines in an appropriate manner can reduce the overall cost of some projects as it can speed up the mine clearance process and make ground accessible to dogs and deminers. See notes on the use of dogs and machines in the section on mine clearance.

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[39] Further detail on principles of humanitarian mine action was set out by Handicap International, Mines Advisory Group and Norwegian People's Aid on 22 Nov 1997. A *precis* is included at Annex B. Further background may be gained from the ICRC Code of Conduct for Disaster Relief and the Bad Honnef Declaration 1997 (coordinated by Medico International).

[40] International mine action standards (IMAS) published in 2001 include a wider definition of mine action that includes mine victim assistance and anti-landmine advocacy. However, these notes use the earlier, narrower definition as it more closely encapsulates the activities directly related to mine clearance.

Mine Risk Education

Mine risk education (MRE) can assist in reducing casualties by providing practical advice about safe behaviour. It can be optimised for any target group.

Explosive Ordnance Disposal (EOD)

Small mobile EOD teams can be deployed quickly to deal with reports of one or two items of ordnance as they are reported. These teams normally have more technical skills than normal deminers and can deal with a variety of more complex items of ordnance, including, for example, unexploded aircraft bombs.

General Survey

A General Survey is a deductive process intended to provide an approximate guide to the extent of contamination by mines and UXO. When socio-economic factors are included, the 'impact' of the contamination can be assessed. The core to most general surveys is a community-based data gathering process intended to gain basic information about location and impact. This community data-gathering process can be augmented by other data such as hospital records of casualties and historical information about the conduct of the conflict. When this information is processed using a geographic information system (GIS) it is possible to print the locations of reported contamination and victim incidents on a local map. This can then be compared with information about population densities and development needs and priorities for clearance established. The GIS system also acts as the basis for an historical archive that allows future development to find out what type of clearance has already been done in a particular area.

Other related activities

In common with any similar activity, mine action programmes also need management, training, logistics and administrative support and a quality system in order to make sure that they are effectively supported and directed. These elements are effectively 'overheads' on the 'productive' elements of the mine action program.

Mine action implementing organisations

Demining NGOs

Work to redress the humanitarian impact of mine contamination started in 1988, with a project in Afghanistan carried out by the 'HALO Trust', a British non-government organisation (NGO). There are now a number of NGOs active in mine action with many more active in mine victim assistance and anti-landmine advocacy activities[41].

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[41] A summary of the anti-landmine campaign is included at Annex C.

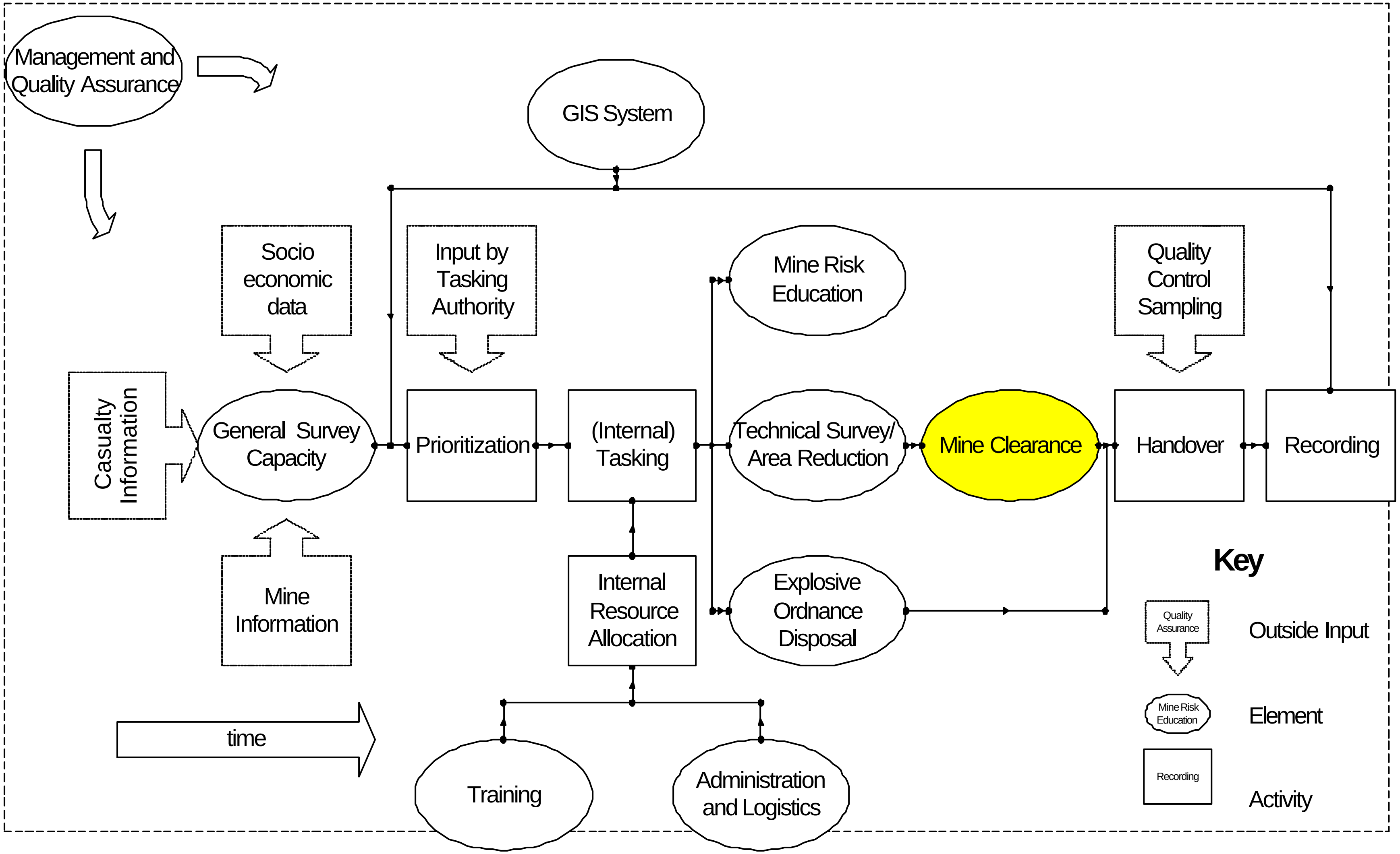

Figure 22. The inter-relationship of mine action components in a mine action program (John Dingley and Robert Keeley, 1998)

Commercial Demining organisations

Although a number of area clearance projects have been carried out under contract for many years, contract demining started in Kuwait in 1991 after the first Gulf War. A number of companies have been active in humanitarian demining ever since.

Mine Action Centres

The need of a body to coordinate mine action projects was recognised from the earliest days of mine action. Most countries with an active mine action program now have a 'mine action centre' (MAC) to carry out this role. There are two main structures used: the first structure, as used, for example, in Laos and (until recently) Cambodia, saw demining programs integrate the coordination element into a vertically-integrated structure along with the implementing elements; the second form (as used in Kosovo) sees the coordination body separated from the implementing agencies.

The role of the United Nations

The United Nations is mandated to have a role in mine action by votes in the UN Security Council. A number of UN agencies contribute to mine action through the provision of technical assistance[42] and assistance in fund-raising.

Military contributions

Anyone who watches the opening minutes of the film "Saving Private Ryan" will see the intense pressure for armies to seek high speed demining solutions. Because mines are used as obstacles to attackers, and minefields may be covered by weapons fire from the defending forces, armies need to minimise the time needed to get through the minefield. This has traditionally led armies to concentrate on 'minefield breaching' techniques that is willing to take some risks[43] in breaching the minefield in order to minimise casualties from defending fire[44] though recent problems with mine contamination in a number of peacekeeping missions has led to the increasing attention to more careful mine clearance.

In developing countries, armies may not have the training or the resources to address the problem of widespread mine contamination, and many donors may not be willing or able to provide resources to local military units. For example, neither the World Bank nor Asian Development Bank is allowed to deal directly with local military units[45]. The United States is a notable exception, as the US has provided resources to military-run demining programs in Thailand and Central America.

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[42] In many cases this technical assistance consists of provision of expatriate technical advisors – usually ex-military engineers or bomb disposal officers.

[43] A NATO planning rate for manual mine breaching is square metre a minute – this is some thirty times faster than common humanitarian mine action progress rates.

[44] See "Churchill's Secret Weapons" by Patrick Delaforce published by Hale, 1998

[45] Interviews with bank officials in Laos and Vietnam, 2002

Landmine clearance

There are many variations to the drills and procedures used by different demining organizations in different parts of the world; the common elements of a systematic manual demining process are set out below[46].

Composition of a demining team

There are also almost as many variations to the composition of a demining team as there are demining organizations. The terminology is also confusing, with a number of terms such as 'platoons' being borrowed from military vocabulary. In essence, there are 4 elements to a demining team. These are:

A control element with a leader qualified to supervise all elements of the task under his/her control and communicate with all elements of the team and any external parties

The deminers, who may be sub divided into smaller sub-teams or groups on large task sites. They often work in shifts, depending on the procedures followed by the demining organization.

A medical team capable of providing first aid to any casualties

Site sentries who can assist in restricting ingress of local populations into dangerous areas, especially when demolitions are in progress[47].

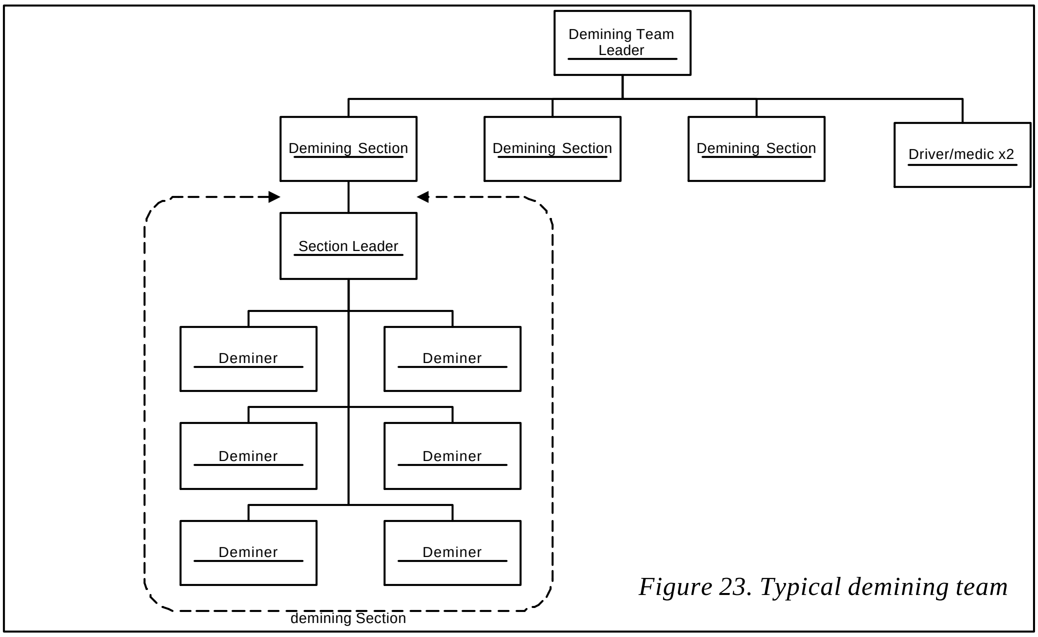

Figure 23. Typical demining team

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[46] International Mine Action Standards (IMAS) provide guidance on the standards of demining operations, including levels of medical support and evacuation guidelines.

[47] Site sentries may be found from resting deminers or from local police or security organisations.

The Demining Cycle

The demining process is a cycle. Working from a known safe area, the deminer moves forwards along a 1-metre wide lane that is marked as he goes. The lanes are spaced about 20m apart to minimise the risk of nearby deminers being hurt by an explosion, and only one person works in the lane at a time.

Vegetation clearance

The deminer begins from a base line, often marked by a stick laid across the lane. The first step in the process is to clear the vegetation ahead of the deminer. He does this by using hand tools to cut the vegetation out to about 20cm ahead. Because of the risk of initiating a mine operated by a tripwire[48], he may use a 'tripwire' feeler to first feel for any tripwires across his path. This process involves pushing a thin metal rod or wire horizontally ahead (about 20cm), and lifting it slowly to feel for any resistance from a tripwire. In thick vegetation this is impractical and hand tools are used to cut the vegetation away. The vegetation clearance process is very, very slow.

Using the mine detector

Once the area immediately to the front of the base line marker has been checked for trip wires and cleared of vegetation, the deminer will use a mine detector[49] to search this area. The search head is passed over the area, and any metal present will cause the detector to alarm. The detector is used to pinpoint the source of the alarm as much as possible and the site is marked.

Prodding for mines

The detector is then moved to the rear and the deminer now begins to search the area for the

Figure 24. The systematic approach to demining can be seen in this photograph of a deminer preparing to start work in Mozambique. The wooden stick next to the deminer's left foot is the base line that marks the forward edge of the cleared area. The area to the front of the deminer has already been cleared (as can seen from the shorter vegetation). The deminer's protective equipment and mine detector are laid out in the cleared area (photo by the author, 1997)

Figure 25. The extent of the vegetation problem is seen in this photograph of a minefield fence in Mozambique. The brush has nearly completely obscured the mine marking sign in the centre of the photograph (photo by the author, 1997)

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[48] This part of the process may be dispensed with if the demining team are confident that there is no risk of tripwire-operated mines. They may be able to make this decision if they have definite intelligence that such mines were not used, or if a machine has already been used on that site to clear vegetation and tripwires (see below for notes on mechanical assistance).

[49] At the time of writing, the terms terms 'mine detector' and 'metal detector' are often used interchangeably as metal detection is still the prime search technology. See notes on new technology below.

source of the signal. It is assumed at this stage, for safety purposes, that the metal content of a buried mine has generated the signal.

In the most common search technique, a strong thin metal probe (a “prodder”) is inserted into the ground in order to feel for hard objects that may be mines. The prodder is inserted at an angle of 30^0, every 3cm along the baseline, perhaps to a depth of 10cm. The angular attack is used to minimise the risk of hitting the pressure plate on the top of a buried mine. Once a hard object is found, it is excavated using a trowel.

Once the entire piece of ground in front of the baseline marker has been checked out to a distance of about 20cm, the baseline marker is moved forwards to the far side of the area that has just been searched. It is placed on the ground and marker pegs placed at the ends. The deminer now moves forwards, up to the baseline marker in its new position, and begins the cycle again. The cycle takes about 15-30 minutes to complete.

Dealing with a mine once found

Once the object has been uncovered it is examined. If it is a mine, it is marked for demolition and is not further disturbed. The lane is closed and the deminer moves back to the safe area and starts work on the next lane. If it is not a mine, the search continues as above.

At the end of the day, the team leader will usually blow up all of the mines that have been found that day. This prevents the mines being re-used or curious onlookers disturbing them after the team have gone home for the day.

If no mine is found

Once the area around the location of the mine detector’s alarm is checked for objects, and if none is found, the chances are this is a piece of metal scrap rather than a mine. However, the deminer may spend more time, alternating between use of the detector, the prodder and the trowel to find and remove the fragment. This is because in many projects the production of a ‘metal free area’ is used as a way of proving to quality control inspection teams that the area has been completely searched.

Figure 26. The demining cycle in Cambodia. In the first picture, the deminer searches the ground immediately to the front of the baseline with his mine detector (this team uses a second stick to mark the forward edge of the search area). In the second photograph the deminer uses a prodder to investigate a detector signal by probing for a possible buried mine (the prodder is just visible under his left hand). In the third photograph the deminer has found and excavated the mine using a trowel (photos by the author, 1998).

Figure 27. Metal scrap recovered from a minefield in Cambodia around an old defensive position. Much of the contamination is waste material discarded by the inhabitants. However, note the large number of caltrops also used! This ancient weapon was resurrected in a war where most of the combatants wore simple open sandals (photo by the author, 1999).

The estimates of fragments found per mine vary greatly: one example of such variation is "1000:1 in Yugoslavia to 10:1 in Cambodia[50]". There may be a lot more metal scrap found in built up areas, and in the former Yugoslavia a lot of the fighting (and hence the mine-laying) took place in built-up areas such as Mostar, Sarajevo and Vukovar. Indeed, in Bosnia and Croatia it is not uncommon for deminers to give up on their metal detectors entirely and revert solely to prodding.

A second explanation for these huge variations in reported numbers of false alarms may be due to the way that the numbers of fragments may be counted. For example, if a demining team is searching an area of a square kilometre for an unmarked mine field that is only a few hundred square metres, then all the area around the minefield (and indeed, between the mines) has to be searched. A superficial division of the amount of metal found in the *whole* search area by the number of mines eventually found may produce a large ratio of fragmentation to mines, even in an undeveloped agricultural area[51].

Figure 28. Deminers working in built up areas, such as this area outside Mostar in Bosnia, may sometimes abandon their metal detectors because of the large number of false alarms caused by metal scrap and fragments in the area (photo by the author, 2001).

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[50] Discussions with Andrew Heafitz, MIT, 2003

[51] The average density of fragment per square metre in agricultural areas (which is a more useful figure) may actually be much lower, perhaps 2-3 pieces per m2

Demining and Explosive Ordnance Disposal (EOD)

Most minefields are found in places where conflict has taken place and, as a result, deminers will encounter a variety of items of unexploded ordnance (UXO). Demining teams therefore need to have access to some level of EOD support. This is provided in a number of ways, either by providing the senior deminers with EOD training or by having specialist EOD teams available on call to assist.

Figure 29. An EOD team works on an unexploded aircraft bomb in Cambodia (photo by the author 1998).

Figure 30. A team clearing an area contaminated by submunitions in Laos (photo by the author, 2002)

In some areas, such as in Kuwait, Laos or in Kosovo, most of the area clearance is actually conducted in areas contaminated by unexploded submunitions or 'bomblets' rather than true landmines. In such areas the procedures are, in effect, an amalgam of EOD and conventional demining procedures. EOD teams will also generally conduct mobile operations clearing UXO reported by members of the public, local authorities or non-government organizations (NGO).

Figure 31. EOD teams may be used to respond to more complicated tasks than conventional mine clearance. For example, clearing abandoned armoured vehicles (above) or abandoned ammunition stockpiles (right). Note that the EOD team has marked this vehicle to show it has been cleared.

The Application of Technology

The clearance of mines by manual means (i.e. a man using a mine detector and a probe to find mines) is slow. If the deminer is not highly trained and stringently supervised, there is also considerable risk[52] involved. This has led to a widespread interest in the application of new technology. Although this has provided some assistance it is, in general, only valuable when used to support manual demining techniques, which remain to this day the only means by which the desired standard of clearance can be achieved. Some notes about the use of new technology are included here as an introduction to the issue.

Advanced mine detection devices

The conventional method of detecting mines involves the use of a metal detector to find mines. However, with the widespread use of plastic-cased, minimum metal content mines, the use of metal detectors is less effective in some areas. This has resulted in a drive to develop and introduce new means of finding mines. There have been many technologies tried (ever since the use of plastic mines in the Falklands conflict in 1982), including ground penetrating radar, magnetic resonance imaging and infrared detection, and many are revealed to the world every year. However, they are always described as being “close to completion” and, at the time of writing this, ***no*** advanced mine detection system has been developed that is capable of operating in the field and achieving the necessary levels of confidence[53].

Mine detecting dogs

Figure 32. Dogs being used in Somalia. Note the protective equipment used by the handler (photo by European Landmine Solutions)

All dogs can smell explosives, and it is possible to train dogs to react in a particular way when they smell the explosives contained in mines. However dogs have a limited attention span, the training is complicated and there are a variety of environmental factors that mean that dogs are not always 100% effective at finding individual mines. Even when they react, there is an area of several square metres that must be searched by a deminer who must then take care of the mine or item of unexploded ordnance that the dog has detected. Properly trained dogs can make a valuable contribution to determining the edges of contaminated areas.

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[52] However, with the correct use of the right techniques, good supervision and effective protective equipment, the risk can be minimised (discussions with Tim Lardner of Cranfield Mine Action, April 2003).

[53] The most promising new technology appears to be a combination of metal detection and ground penetrating radar (GPR), where the GPR is used to check the area around the source of the metal signal to see if it is different to the surrounding soil. However, at the time of writing, such devices are still only in the prototype stage and it is by no means clear if they will actually work.

Demining machines

Figure 33. The TEMPEST vegetation-cutting machine working in Cambodia. The TEMPEST was designed and built by Development Technology Workshop (DTW) (photograph by DTW).

The Allied forces developed a series of demining machines in the Second World War to assist them in breaching paths through enemy minefields. However, these machines were often ineffective and sometimes many of them would be destroyed just to make a single lane of a few hundred metres in length[54]. The resulting lanes were also not 100% free from mines.

In the last twenty years, a wide number of demining machines have been produced, and a summary of the most common types is included below. Some machines can be very expensive, can be limited by the terrain and in some cases can be less cost-effective than manual deminers[55].

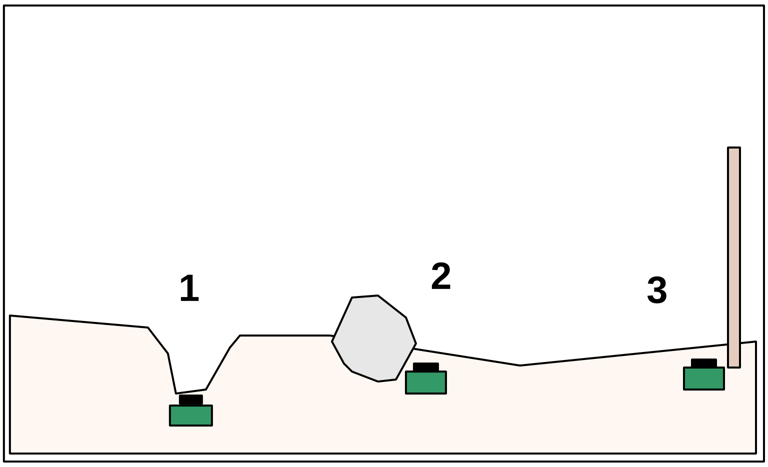

Figure 34. Machines may be less effective over irregular ground than over flat surfaces: mines laid in the bottom of holes (1), behind rocks or other obstacles, or close to fences, walls or other boundary markers (3) may be missed by machines. Operators of remote cotnrolled machines may also have trouble seeing when small areas of land have been missed.

Even in terrain that is suitable to demining machines, small obstacles (such as in Fig 34 above) can reduce their effectiveness. The situation may be exacerbated by the presence of 'blast resistant' mines, such as the Italian VS-50 mine and the PMN2 developed by the former Soviet Union[56]. These were originally designed to resist explosive over-pressure but have been found to also be resistant to sudden impacts such as those generated by flail machines.

Figure 35. The PMN2 AP blast mine (photo by the author, 1998)

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[54] See "Churchill's Secret Weapons" by Patrick Delaforce published by Hale, 1998

[55] Discussions in May-Sep 2003 with David Lewis of Qinetic, the British defence research agency responsible for collaborating with the International Test and Evaluation Program (ITEP) to develop an internationally-agreed standard for mechanical demining equipment testing.

[56] See "Jane's Mines and Mine Clearance" for more technical detail on mine types and design.

Mine Rollers

Mine rollers are heavy wheels pushed along a route by an armoured vehicle. Rollers actuate mines on or just under the surface and can be designed to cope with some undulation but may not be able to deal with deep buried mines or irregularities in the surface produced by rocks, ditches or hedges. The vehicles carrying the rollers may be difficult to operate in soft ground or in areas where manoeuvrability may be restricted by trees or walls.

Mine Flails

Mine flails actuate, disrupt or destroy mines by punching them with weighted chains hung from a revolving drum held in front of an armoured vehicle. Flails are less effective in soft soils, and against sustained-pressure or deep buried mines, and can throw intact mines out into a previously cleared area. Flails are also vulnerable to entanglement in wire obstacles and fences. Note that there is also a variation in size with many small flail machines operated by remote control.

Figure 36. A flail machine being used in Kuwait. Note the chains rotating around the central drum and the use of a protective shield between the flail and the rest of the vehicle (photo by the author, 1991).

Tillers

A 'Tiller' (sometimes called a 'soil mill') is a generic term for a recent series of mechanical mine clearance devices that all use a similar concept. At a first glance tillers can look like mine rollers but operate completely differently: they use an active, powered rotating drum that is fitted with a series of spaced teeth. The teeth eat into the soil ahead of the vehicle and detonate or destroy the mine. Tillers share many of the advantages of flails and, additionally, do not scatter mines as flails can. However, tillers are susceptible to directional AT mines and the immense power needed to drive the drum can make the vehicle very heavy and susceptible to mechanical failures.

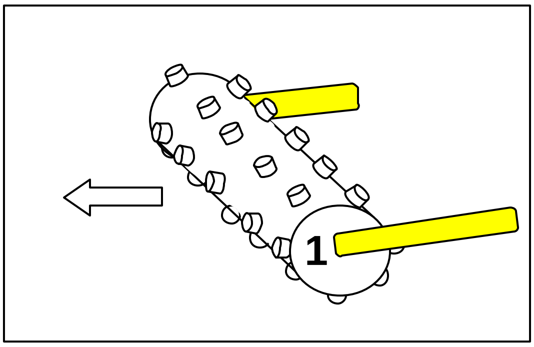

Figure 37. Diagrammatic representation of a tiller ready to be mounted on the front of a vehicle. The arrow shows direction of travel. Some of the mechanism (1) is very close to the potential site o f a detonation

Tillers can deal with most vegetation (they were originally designed to 'mulch' old forestry areas containing tree stumps) and can cope with small undulations (such as furrows in ploughed fields) but are susceptible to problems when encountering very rocky or uneven ground). Furthermore, if the teeth are not 'sacrificial' their replacement can be very difficult.

Figure 38. This machine is mounted on a tank body and uses a roller and plough in combination. It suffers from many of the disadvantages of both tools (photo by the author, 1996).

Mine Ploughs

Mine ploughs are not intended to clear mines; they merely move them out of the way of the tracks of the vehicle to which they are attached. They are more suited to use in military mine breaching operations than in humanitarian mine clearance as the mines end up at the side of the ploughed route in heaped soil berms which can be more difficult to clear than the original, unploughed field.

Armoured Plant - Excavators

Armoured plant can be very useful, particularly for the clearance of building rubble thought either to contain UXO, or that might have collapsed onto a mined area. They have limited uses elsewhere in demining operations unless tools such as flails or tillers can be mounted on them.

Figure 39. This piece of armoured plant is being used to build fortifications for a UN peacekeeping unit in Bosnia. However, the main of such equipment in a humanitarian demining context is rubble removal in built up areas (photo by the author, 1994).

An integrated approach to mine clearance

The most appropriate application of mine detecting dogs and demining machines is most commonly recognised as part of an integrated approach[57] where they are used to support – but not replace – manual deminers. Machines can be good at removing the vegetation that hampers deminers, and dogs can be effective at determining the boundaries of contaminated areas where minefields are not marked.

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[57] Discussions with Henry Hirst, Chief of Operations of European Landmine Solutions, Oct 2002.

Personal Protective Equipment (PPE)

Demining agencies have a duty of care to protect their deminers, and international humanitarian demining standards have been very careful in attempts to set out targets for protection. The aim of demining PPE is to ensure no deminer will be hurt by an anti-personnel mine that he initiates whilst following correct mine clearance procedures. PPE must be comfortable and must be designed to be ergonomically compatible with the activities carried out by the wearer (see notes on the demining cycle above).

Figure 40. One type of PPE ensemble provided for use in Cambodia. The simple apron provides ground-to-neck protection to a kneeling or squatting deminer, with a simple polycarbonate visor to provide eye and face protection. Note the overlap between apron and visor, and the wimgs to facilitate arm movement.

Eye Protection

According to IMAS, eye protection should be provided by a polycarbonate visor (the norm is about 5mm).

Body protection

Body protection (when provided) is generally provided by a Kevlar-type jacket or apron. The eye protection will stop fragment and soil particles being driven into the eyes and face by an antipersonnel mine being detonated by the deminer. The body protection will protect the vital organs from the same threat and also protect the deminer from a nearby detonation of a fragmentation mine, perhaps by another deminer.

Hand tools

It is now also widely recognised that the deminer’s hand tools should be recognised as a form of PPE. Long handled tools (i.e. with a handle of around 30cm) help keep the deminer’s hand away from blast if he[58] accidentally detonates a mine. The tools should also be made of a metal that deforms rather than shatters in the event of an explosion.

Full details of the requirements for personal protection are included in IMAS.

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[58] The use of the word ‘he’ is for convenience as there is no technical reason why a deminer should not be female; indeed many organisations have employed female deminers to great success.

Annex A: Generic landmine design

A brief explanation of the construction of typical landmines is included here. This may aid the reader's understanding of mine detection and clearance techniques and technologies[59].

AP blast mines

The diagram at Fig A-1 shows the construction of a typical AP blast mine. The mine is not armed until the detonator is inserted and the safety pin removed. At this point the mine can be activated with a pressure to the pressure plate at the top of a mine. In many cases a pressure of just a few kilograms is sufficient. The downward force drives the striker pin onto a percussion cap, which ignites, firing the detonator, which then initiates the explosive fill. It is not always possible to replace the firing pin or safely remove the detonator once mines have been armed. In some cases the metal firing pin is the only metal content of such mines.

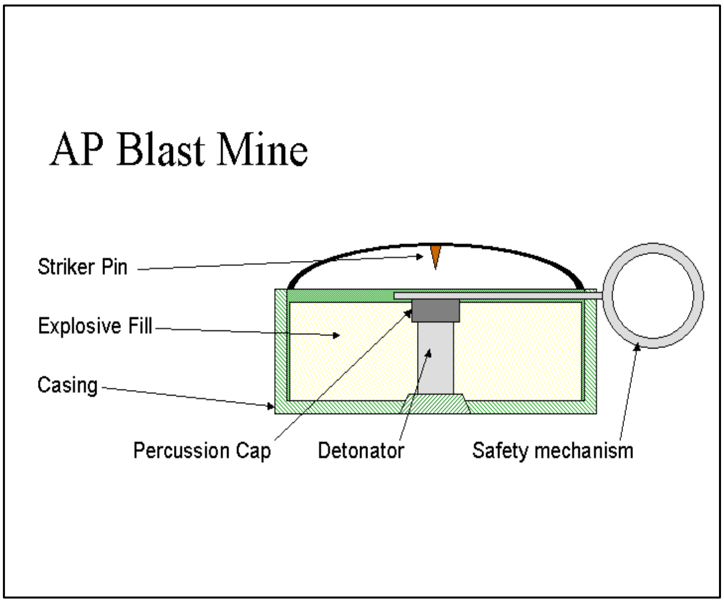

Figure A-1. Typical AP blast mine construction

Notes on 'plastic' mines

Plastic-cased mines were cheaper to produce than metal cased mines; they have longer shelf lives and are lighter, and are hence easier to store and to transport. They are also easier to deploy (light plastic designs aid dissemination by helicopter as well as by hand). However, buried plastic-cased mines also have the unfortunate (dis)advantage of being harder to find by metal detector, which would further slow down the progress of advancing armies through minefields[60]. However, nearly all plastic-cased mines have some metal in them (they are thus sometimes referred to as "minimum metal" mines) and can be found by sensitive metal detectors. This does mean that, however, when such mines are deployed in areas that have metal scrap (or even metallic soils) there are many false alarms – indeed, increasing sensitivity of detectors increases the number of false alarms.

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[59] More comprehensive detail on mine construction can be found in "Warsaw Pact Mines" by Paul Jefferson, 1992, and "Janes Mines And Mine Clearance 1996-2002" Edited by Colin King

[60] The proof that this attribute was recognised by manufacturers can be seen by the addition of removable metal elements that could be taken off the plastic case on deployment. One example of such a mine was the C3 'Elsie' mine produced in Canada.

AP fragmentation mines

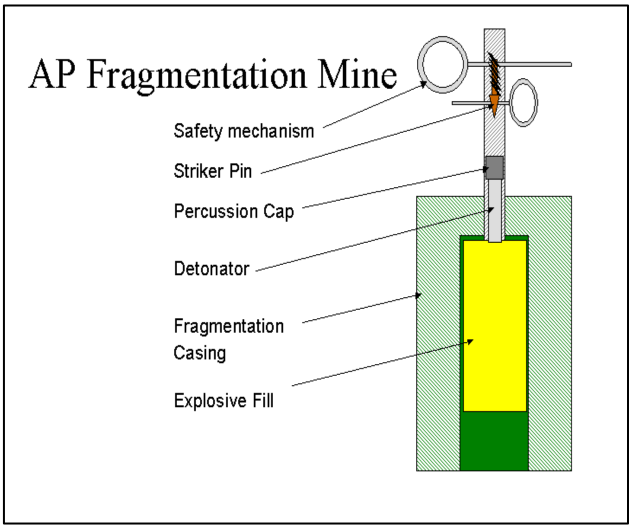

Figure A-2. Typical AP fragmentation mine construction

The diagram at Fig A-2 shows the construction of a typical AP fragmentation mine. It has similar components to an AP blast mine though in this case the mine is triggered by a trip wire that is attached to one of the pins in the ignitor mechanism screwed into the top of the mine. The mine is armed when the second pin is removed. The mine casing is generally made of metal, though some examples of improvised mines using concrete fragmentation casing were used in the former Yugoslavia. Again, it is not always possible to replace the firing pin and safely remove the igniter.

Complex mine designs

Most mines found in mine affected countries have simple designs such as described above. However, there are a significant proportion of mines that include more complex designs, though comparatively few of these more complex models have been deployed in mine affected countries in large numbers[61]

The mine in figure A-3 includes an anti-handling device that operates when the mine is tilted a few degrees from the horizontal. Once the safety pins are removed, this mine is indistinguishable from a similar model that contains no anti-handling device

Figure A-3. This Chinese AP mine includes an electronic anti-handling device (photo by the author, Cambodia 1998)

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[61] See Janes Mines And Mine Clearance for a comprehensive list of mine types and summaries of where these different types have been deployed.

Annex B: Statement of principles for humanitarian mine action[62]

Humanitarian Mine Action programmes should address the following:

The need for objective analysis of the requirements of affected communities, and the structuring and conduct of operations to meet these requirements;

The need to take account of cultural sensitivities;

A responsible approach to the welfare of personnel employed by these agencies involved in mine action;

A commitment to the continued development of existing methodologies;

A realistic and objective approach to mine clearance technologies and methodologies;

The need to avoid impractical, "quick-fix solutions"

A commitment to continual improvement of quality; and

The need to support the principle of transfer of competence to the affected communities.

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[62] The following principles were developed by Handicap International, Mines Advisory Group and Norwegian People's Aid in Brussels, November 1997

Annex C: Anti-landmine campaigns and the 1997 Ottawa Treaty[63]

Background

Aid workers and other observers of a number of civil wars (or 'wars of national liberation') in the late 1980s and early 1990s, were appalled by the sight of mine casualties, and a number of Non-Government Organisations (NGO)[64] cooperated to form a campaign against landmines. The International Campaign to Ban Landmines (ICBL) as it become known, worked for several years to advocate a ban of these weapons[65], on the grounds that they were 'excessively injurious' and 'indiscriminate,'[66] both of which had been used in previous articles of international law to regulate use of weapons in conflicts. A weapon that is 'excessively injurious' creates more suffering than is needed to place a combatant 'out of combat' whilst indiscriminate weapons cannot be targeted specifically at combatants. The ICBL – and particularly, the ICRC - made a case that landmines were covered by both of these criteria, particularly as landmines could remain active decades after wars had ceased.

Until 1996 landmines had been regulated by the UN 'Convention on Conventional Weapons (CCW)[67] and the ICBL was excluded from meetings to review and amend CCW in Geneva in 1996. They were however, very active in the margins, and immediately after CCW 1996 concluded (with a number of comparatively narrow, technical revisions that fell far short of the ban demanded by ICBL) the then Foreign Minister of Canada, Lloyd Axworthy, called on likeminded nations to join Canada in a 'fast track' approach to achieve an absolute ban by December of 1997. Canada was soon joined by a number of other countries, such as Belgium, that took up the aims of the ICBL as national policy[68].

However, although many members of the ICBL wished it to be an absolute ban covering all landmines and 'mine like' weapons[69] such as cluster bombs, some serious horse-trading had to be undertaken to get the proposed treaty accepted. Anti-tank mines were largely excluded, as were anti-handling devices that are incorporated into some AT mines to prevent dismantling by attacking soldiers, because many of the countries that were prepared to forgo use of AP mines still wanted to keep AT mines for their own defence. Claymore type weapons that required a 'man in the loop' were also not covered by this ban, as the process of

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[63] This section was reviewed by Robin Collins of Mines Action Canada, an organisation that has had a key part in the Ottawa process,

[64] The six founders were: Handicap International (France and Belgium), Human Rights Watch (USA), Medico International (Germany), Mines Advisory Group (UK), Physicians For human rights (USA) and Vietnam Veterans of America Foundation (USA) (Source: Mines Action Canada 2003)

[65] The campaign was assisted greatly by the International Committee of the Red Cross, which, although it never formally joined the ICBL, worked in parallel, and was mainly responsible for work on the legal arguments, which are summarised above.

[66] Numerous ICRC publications 1996-1997. One key example is "Friend or Foe" 1996

[67] Specifically, Protocol II of the United Nations 1980 Convention on Conventional Weapons

[68] Some countries included a mine ban as part of national policy as early as 1996, including Austria, Belgium Canada, Denmark, Ireland, Mexico, Norway and Switzerland.

[69] UXO that have similar effects as anti-personnel mines, but were not intended to do so

adding a trip wire and fuse to a claymore mine could also be done to just about any other type of weapon, and there was no international support for a treaty that would thus make all weapons illegal.

There was a sustained attempt by some countries, particularly the Americans, to allow AP mines that had a ‘limited laid life’ through the use of self-destruct or self-neutralising mechanisms. The Americans argued that such mines were less indiscriminate as they would not remain active for long. However, such arguments were unsuccessful as they were felt to generate too many loopholes, not least in the difficulty in developing suitable definitions for what constituted a ‘smart’ enough mine. The 1997 Ottawa Treaty was the result of this initiative.

The Ottawa Treaty and its Requirements[70]

To date, 146 countries have signed and 131 countries have ratified the Ottawa Treaty[71].

The Ottawa Treaty requires states party to:

- Cease the production, stockpiling, trade and use of AP landmines
- Mark all minefields on their territories within 4 years, and
- Clear all minefields within 10 years of accession to the Treaty.

It also allows countries to maintain a small stock of AP mines for the purpose of developing and training in new technologies and techniques for mine clearance.

Achievements and limitations of the Ottawa Process

The Ottawa process did:

- Develop a workable definition of what constituted an anti-personnel mine
- Create a normative framework that has stigmatised the use of landmines and limited their deployment even by non-signatories
- Involve ‘civil society’ in a major piece of international legislation, notably in the recognition of campaigning efforts of national groups in persuading their governments to accede to the Treaty
- Establish a process that should reduce the number of new mines in circulation and thus available for deployment

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[70] The full text of the treaty can be found at http://www.icbl.org/

[71] As of 8 July 2003. Source: http://www.minesactioncanada.org/home/index.cfm?lang=e

?? Establish an independent research body (the “Landmine Monitor”) to observe and report on compliance

The Ottawa process did not:

Cover all landmines, as anti-tank mines were not included in the ban

Get support from many of the major mine-producing countries, such as China, India, Israel, Pakistan, Russia and the USA[72]

Cover ‘mine-like’ weapons

Directly effect the number of mines already in the ground[73]

The future

One major product of the campaign process is the creation of an international monitoring process, which provides a source of information, the “Landmine Monitor[74]”about mine problems in affected countries and on compliance with Ottawa Treaty requirements.

There continues to be efforts to address some of the areas that were not covered by the Ottawa Treaty. In particular, work is under way to develop a treaty to cover the long-term effects of ‘mine-like’ weapons and other unexploded ordnance, referred to in this new campaign as ‘explosive remnants of war (ERW)’[75].

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[72] Although some of these countries have introduced bilateral moratoria on the export of mines.

[73] Although the Treaty did, as stated above, establish a normative requirement for states party to deal with mines, it was widely recognised at the time that the ability of affected countries to do so would be dependent on the availability of funds. According to Mines Action Canada, It could be argued that the political pressure inherent in becoming a signatory has encouraged donor nations to maintain funding levels for mine action programs

[74] See http://www.icbl.org/lm/

[75] See the notes on the ICRC website: http://www.icrc.org/Web/Eng/siteeng0.nsf/htmlall/57JRGS?OpenDocument