Humanitarian Demining
Research Programme

Working Paper No. 48

Equipment for Post-Conflict Demining

ACKNOWLEGEMENTS

This working paper reproduces part of a report to the Sir Halley Stewart Trust which generously funded a research programme into the equipment needs of demining organisations and the feasibility of manufacture of such equipment within southern Africa. The research was undertaken by the Development Technology Workshop (DTW), a charitable company closely associated with the

DTU

A study to examine the equipment needs of land mine clearance organisations, and to assess the local capacity for manufacture of such equipment.

The fact-finding team worked in the South of Mozambique, in the Province of Maputo, during the second half of November 1995.

The United Nations Accelerated Demining Programme in Mozambique provided invaluable assistance during our study, answering all requests positively and patiently. Without the help of Lt. Col. Paul King and Cameron Whyte this study would not have been possible.

The DTW/DTU are indebted to Brigadier John Hooper (Rtd) for his voluntary advice and assistance throughout this programme. The Brigadier is a Royal Engineer who has worked with the Halo Trust in humanitarian mine clearance in Cambodia. With his help, DTW/DTU staff were able to attend a two day "Mines Awareness" training session hosted by the British Army on 7/8

November. This training included an introduction to military mine clearance methods and equipment. The Brigadier's other assistance has including arranging interviews with experienced humanitarian deminers, representatives from the arms industry and military research staff. With his help we have been able to approach this study with appropriate prior knowledge and so target it more appropriately.

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SUMMARY

The aims of this study were:

1. to find out what equipment mine-clearance groups use and its sources, and to inquire what alternative/further equipment they want;
2. to assess manufacturing capability relevant to the possible production of mine clearance equipment at rural and urban levels.

Mine clearance

A number of mined areas were visited and mine clearance observed. At some sites, mines were placed defensively around possible targets. At others, mines were laid to destabilise the infrastructure by denying access to an area.

Nine groups involved in mine clearance in Mozambique were interviewed, one in their Zimbabwe offices, one in the UK and the others in country:

- UNADP
- Cap Anamur Demining (CAD)
- Norwegian People's Aid (NPA)
- USAID
- The HALO Trust
- MECHEM (British Aerospace)
- Minetech
- Special Clearance Services
- Handicap International

All the above were asked about their working methods and the equipment they use.

Mine clearance groups usually distinguish between the detectors, which are the single most expensive item of equipment used, and all other equipment which they call "ancillary,'.

Of the detectors used the Schiebel and Ebinger models were the most common. No detectors were entirely satisfactory and the best were considered overpriced. We found a wide range of ancillary equipment in use, some of which was locally made.

Appendix D: Comment for discussion

Each group was asked if there were any items of equipment they did not have but would like, and what variations on existing equipment they would find most useful. Of equipment not used, body armour was the most obvious but there was no enthusiasm to use it. No one wanted mine-proof boots either (although one individual said he would try them). Most groups said they would try protective shields for use at "high-risk" times.

Alternatives wanted included cheaper detectors that were as good as those currently used, and better eye-protection. Other new or alternative ancillary equipment would be tried by most and tested by all.

Industrial capacity

There is little in the countryside although the small

There is little in the countryside although the small towns have something that could be exploited. In the capital city there is some sophisticated activity and great potential. Corrupt practices are rife, making import of raw materials and tooling expensive or time-wasting, or both. This situation does not seem likely to change quickly.

In Zimbabwe or the Republic of South Africa (RSA) the industrial situation is different. In

Zimbabwe, ideally situated to serve both Mozambique and Angola with specialist equipment, we found a range of industrial capability including advanced electronics manufacture.

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ABBREVIATIONS

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Throughout this document the United Nations Accelerated Demining Programme in Mozambique is referred to as the UNADP. Its full title is the UNDP/DHA Accelerated Demining Programme.

Other abbreviations used are:

D1WDevelopment Technology Workshop

DTU Development Technology Unit

GPSGlobal Positioning System

SCS Special Clearance Services

NPANorwegian People's Aid

USAID US Agency for International Development

RSARepublic of South Africa

ZIMZimbabwe

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1 BACKGROUND

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The DTW has undertaken this study as part of a broader mine-clearance support initiative that has been awaiting funding support for over a year. In October 1994 a representative from the Mines Advisory Group (MAG) visited the Development Technology Unit (our "parent" body) in the Engineering Department of the University of Warwick and asked whether we could support local production of mine-clearance equipment in Africa and Cambodia. We carried out a preliminary investigation of equipment needs using MAG as our sole source of information. Our previous experience supporting small-scale industrial initiatives in developing countries led us to believe that we could answer their needs across a range of technologies from detectors to protective clothing and ground probes. As a result a programme proposal was prepared with MAG for submission in December 1994/January 1995. MAG were to use their existing contacts to gain funding support as quickly as possible.

Several members of the DTU took a personal interest in the mine-clearance problem and began background research. The requirements of some of the work made it advisable to have a base outside the University where overheads, public access and restrictions on space made it difficult and expensive to work. Accordingly, a non-profit making limited company (the DTW) was registered with senior DTU members as directors/trustees. A proposal to start work on the ancillary equipment needs was prepared with MAG's approval and submitted to the Halley Stewart Trust. That proposal was to visit a mined area in Angola where MAG was working in order to determine the industrial potential in a post-conflict region. Prototype protective equipment would also be designed, produced and results disseminated. The Halley Stewart Trust provided 21,560 to carry out this work in late October 1995. The programme was started immediately. This report details the results of the overseas "survey". The results of the research into specific articles of ancillary equipment and its dissemination will be published at the end of the programme.

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2 OBJECTIVES OF THE SURVEY

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The survey was to take place in Angola and serve two main purposes:

- to assess skills and training needs in mine affected areas
- to determine the availability of materials in rural and urban workshops.

This information would allow us to design ancillary equipment that could be made where MAG was working in Angola. Those designs were to be made freely available to all other mine clearance groups we could identify and, where possible, support offered to help start manufacture.

Variations to those objectives

Despite prior arrangements, our travel to Angola became irnpossible because the agreed visa requirements were not met by our in-country partner. By thattime, programme staffhad been appointed and travel arrangements made. The need to carry out the "survey" before finalising product design and prototyping was considered imperative. Connections we had made with other mine-affected destinations were hurriedly investigated and we were offered support by the

United Nations Accelerated Demining Programme (UNADP) in Mozambique. A decision was made to transfer the survey to Mozambique and to vary the objectives to include:

Interviewing as many mine clearance organisations as possible to determine their working methods, wants and needs. This objective was added because we had been made aware that mine clearance organisations work in different ways and to varying priorities. Our contact at the Mines Advisory Group (MAG) in the UK was unable to furnish us with any information about their "competitors", their methods or requirements. Our aim was to support humanitarian demining generally, so it was decided to spread our knowledge base as widely as possible.

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3 Mine Clearance in Mozamique

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3.1 Mozambique

covers an area of about 801,600 sq Km with a 2,500 Km coastline on the Indian Ocean. It has a tropical and sub-tropical climate. Its population is an estimated 15 million. The annual income per capita is US$80, making Mozambique among the very poorest of countries in the world.

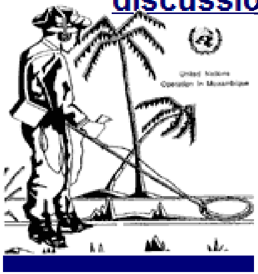
In 1975 Portugal withdrew from Mozambique after a bitter independence struggle led by the communist group FRELIMO. Within a few years RENAMO, with external funding to destabilise the FRELIMO regime, had engaged in civil war that did not end until 1990 and further incidents occurred until 1993 when UN peacekeeping began. Elections were held in 1994. Isolated incidents of banditry continue, possibly reflecting widespread resentment within the country about a North/South imbalance of wealth and power.

Despite being Portuguese speaking, Mozambique was admitted to the British Commonwealth in November 1995.

3.2 National mine clearance plan

A mine clearance plan for Mozambique was prepared in 1992 for the UN. This identified four key areas of work:

- a national survey of the mine problem
- the emergency clearance of mines from roads and tracks
- the need for long-term funding for the development of an indigenous mine-clearance capacity
- the need for civilian mine awareness training



The UNADP Mines Awareness "Logo"

The national survey was carried out during the first half of 1994 by the British mine clearance charity Halo Trust. It was published by the UN in July 1994 and is made available to all agencies operating in Mozambique. The survey was never intended to be comprehensive, but in the absence of detailed follow-up its findings are frequently criticised.

The priority clearance of roads and tracks was started in several ways. Contractors were employed by the UNDP, then co-ordinating demining.

USAID contracted LONRHO (GB), MECHEM (RSA with British Aerospace) and RONCO (USA) to clear roads. The Halo Trust and Norwegian People's Aid (NPA) began training local people to clear mines in the North, and the EC funded clearance in the central Provinces. The quality of some contracted clearance work has been questioned, but it has been successful in reopening all major routes and most minor ones.

A training centre designed to provide an

An ex Frelimo soldier finding mines by hand clearance

indigenous mine clearance capacity was finally established in 1994 by the UNDP. Despite early problems, it is now operating with 450 trained mine clearance staff.

The UNHCR urgently began mine awareness training in refugee camps in bordering countries. It also established a Mine Training Centre within Mozambique to promote awareness. The current status of this is not known. However, the UNADP's own Mine Clearance Training wing has recently given Mines Awareness presentations and the NGO Handicap International are active in this field.

3.3 Current situation

The UNADP estimate that there are between 2 and 4 million mines to be cleared in Mozambique. They aim to clear 99.6% of mines from an area. Because they now work alongside the national mine-clearance initiative and (along with USAID) channel much of the money available for clearance, 99.6% is taken as the required standard nationally.

Mines are sometimes in very poor condition, like this PMD6 wooden-box mine

There are currently at least a dozen organisations working to clear mines in Mozambique. Most of these are commercial organisations working under contract: some of those have connections with arms manufacturers and land-mine suppliers. Those asked thought that mines would continue to be a restriction to the country's development for at least ten years. Some were of the opinion that the problem would "never" be eliminated.

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4 ORGNISATIONS INTERVIEWED

CONTENTS The mine-clearance organisations we interviewed are:

UNADP (NMCC)

We interviewed Lt. Col. Paul King, M. Croll, C. Whyte, A. Nogueira and Novella. The UNADP is working with the National Mine Clearance Committee (NMCC) to establish an indigenous demining capacity. It has 450 "deminers" in 10 platoons, scheduled to increase next year to 600 deminers. The HQ staff numbers 50 responsible for mine surveys, medical and logistical needs, finance and administration. Over the past year they have cleared more than 0.5 million square meters of priority land at 23 sites in nine districts of Inhambane and Maputo Provinces.

Cap Anamur Demining (CAD)

We interviewed Hans-Georg Kruessen (Georg), Technical Director. CAD are subcontracted to survey reported mined areas for the UNADP. CAD staff clear individual mines that they find. Portuguese speakers, they interview local people and gather as much information as possible about the mined area, record its position using GPS and their report is added to the UNADP database.

Norwegian People's Aid

We interviewed the country project manager Kristen Holmegaard and his deputy Arne Oygard in Maputo. At a mined site at Manhica, North of Maputo, we interviewed the field operatives Sam Christensen, Peder Kaaber and one other. NPA work in Manhica district, Maputo Province; Cahora Bassa District and Angonia District, Tete Province; and Caia District, Safala Province.

USAID

We interviewed the country representative, Jack McCarthy, at his office in Maputo. USAID (the United States Agency for International Development) intends to take over premises and staff from RONCO when they leave Mozambique in early 1996. They currently contract commercial groups to clear mines.

The HALO Trust

We interviewed Francisco Tivane (Operations Officer at Quelimane) and several ex-Halo Trust staff in the UK. The Halo Trust is a British based NGO and registered charity working in many post-conflict areas around the world. It works in Maganja da Costa District, Milange District, and Gurue District in Niassa Province (with the NGO Concern).

Minetech

We interviewed Lionel Dyck: operations director. Minetech is a commercial company clearing the power line that runs from the Cahora-Bassa Dam through the Tete, Manica and Gaza Provinces of Mozambique.

Special Clearance Services

We interviewed Richard Keith Byng (Operations Manager). SCS are a commercial organisation currently working in Niassa (NW Mozambique) and

Cabo Delgado (NE).

Handicap International

We interviewed Phillippe Dicquemare and Mr Hassane Jamu (Responsave da Logistica). Handicap International are a charitable NGO that has approached mine clearance by way of providing prosthetics for mine victims and Mines Awareness activities. They perceive a need for clearing "low-priority" areas and intend to meet that requirement with "community involvement"

MECHEM

We interviewed Stewart Granger of British Aerospace in the UK. He was subcontracted to work with MECHEM on road clearance in Mozambique last year. MECHEM is a commercial company with close links to the South African arms industry.

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5 PRIOR TO MINE CLEARANCE

New and existing reports of mined areas are usually investigated by a UNADP survey team (subcontracted from organisations such as Cap Anamur Demining) before clearance. Heavily mined areas are recorded (using a Global Positioning System), marked and the information returned to UNADP. Mined areas are given a priority for clearance. When assessing this, relevant factors are commercial value, freedom of movement, number of injuries, and the likely hazard to road users: this list is not in order of priority, which is case-dependent. The UNADP then either use their own demining groups to clear the area, subcontract the work, or otherwise arrange for it to be undertaken by another organisation. Priority areas are cleared by squads of mine clearers who live/camp in the area while they work. Each mine clearance group is required to have logistic support including a vehicle to serve as an emergency ambulance. Some, such as Minetech, resurvey the area to be cleared using "walk and talk" teams to ask local people where the problem areas are in detail.

Before clearance a minefield is usually overgrown bush

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6 MINE CLEARANCE METHODS

Mines are found by men with detectors and ground probes, by dogs on the ground, by a combination of dogs and air-sampling vehicles, and by mine-proof vehicles. The hand-clearance methods are those we have most interest in, but the others are dealt with briefly under separate headings below.

6.1 Clearing mines by hand

This heading covers clearing mines with the aid of hand-held metal detectors and by probing the ground. Being labour intensive, it is the method that employs most people. Several organisations argued in its favour because it gives ex-soldiers an alternative to banditry, keeps some of the "profits" from mine clearance in-country, and provides employment over a sustained period while the country recovers from the economic and social instability of war.

6.1.1 Training and conditions

Individuals clearing mines are referred to throughout the "industry" as "deminers". The UNADP sets the standards of demining practice, which is sometimes exceeded and sometimes cut. It is frequently used as a reference point in the following.

In the UNADP each deminer receives 2 weeks of initial training. Section leaders get more training. Deminers have no formal "refreshers" but are retrained "when needed". The basic deminer's salary is US$110 per month, from which the cost of their food is taken. Other groups provide longer training, and some have formal "refresher" sessions at set intervals. Some pay less than the UNADP standard. In most cases, hand clearance is undertaken by locally recruited ex-soldiers working in a regime modelled on a military hierarchy. Norwegian People's Aid's (NPA) demining workforce includes ten women who are also ex-soldiers. Some commercial organisations recruit in neighbouring countries, which can cause problems of communication and resentment. MECHEM, for example, reported problems taking injured staff to local hospitals because of the racist tattoos they had on their bodies. UNADP trainers and team leaders are sub-contracted from Special Gurkha Services (SGS), a company used by others and much praised. Deminers are usually insured against injury or death: the only insurance policy we were given detailed information about paid under US$3500 in the event of death (this is about 30 months salary). An attempt to form a "deminer's union" to gain better working conditions was made in Maputo while we were there. Those in management were dismissive of the union, saying that the pool of potential workers far exceeds demand so it would have no power.

6.1.2 Working practices

A mine clearance team on the Mozambique/ Swaziland border

Deminers usually work in a standing, crouching, or kneeling position. The positions are dictated by comfort, allowing full freedom of movement in arms and hands. In the UNADP they work in pairs from 6.30am to 1.00pm each day, working 20 minutes then resting for 20 minutes. This is intended to maintain concentration. Some organisations work individually or in threes. One commercial organisation claims that its deminers work for ten hours each day.

The ground is often cleared in advance by judicious burning off of grasses and light undergrowth. Remaining undergrowth is usually cut as the deminer advances. Minetech and Security Clearance Services do not always clear vegetation, and so we infer that commercial organisations clear undergrowth on a case-by-case basis.

When ground is

Humanitarian mine clearance is not exclusively concerned with removing articles designed as mines. Some organisations report nineteen out of twenty finds to be unexploded ordnance (including

cleared of vegetation as well as mines, it is often planted with food crops immediately. The earth heaps here show maize has been planted: the few discovered mines, have yet to be exploded

bullets) some of which are booby trapped. (MECHEM, clearing roads, say the ratio of ordnance to mines is 1000s: 1.) All clearance groups are supposed to clear at least 99.6% of all explosive ordnance from bullets, through anti-personnel and anti-vehicle mines, to shells. With this in mind, it is not surprising that it was widely observed that the best detection tool is actually the human eye. Many dangerous objects are visible after the ground has been cleared. Perhaps because Minetech do not always clear the ground, they sometimes detect tripwires by 'shooting' a piece of coloured cotton over a strip to be cleared and looking at the way it flies and lies, or they fire/throw a grappling hook over an area to be cleared and pull it back to trigger trip-wired devices.

UNADP and NPA deminers start from a "baseline " spaced 25 meters apart and work to clear a meter wide strip at right angles from the baseline. At the end of the required strip, usually 25 meters in length, they move to the next strip on their right. This is supposed to keep each active deminer

A POMZ fragmentation mine (trip wire detonated)

Probing with an NPA trident

approximately 25 meters away from his counterparts. Other groups use other formulae to keep the distance between deminers, but 25 meters seems to be a standard distance.

Safe or cleared areas are marked in some way. The UNADP use white plastic tape or painted white stones. Plastic "posts" have been used but tend to be stolen for other uses.

UNADP deminers do not wear protective clothing. They are given military-style boots, overalls and low-quality industrial safety spectacles. In areas where falling coconuts are a problem, they are issued with helmets. The UNADP standard is common, with only the Halo Trust routinely issuing helmets, full face visors and apron body-armour. Both Minetech and Security Clearance Services use a deminer wearing full upper-body armour to prepare a find for detonation.

6.1.3 Finding mines

When possible, the search for mines begins with a

NPA's PMN2 defusing tools

metal detector. A standing deminer usually moves along the "lane" to be cleared searching for any metal object When detectors cannot be used, the deminer must kneel or crouch and probe the ground at a shallow angle at close, regular intervals. Special Clearance Services were the only organisation to lie flat when probing. All objects found when probing have to be investigated to ensure their safety. One NPA employee believed that this is the most reliable and sustainable way to clear mines, but all acknowledged that it is very slow.

One UNADP deminer will clear 525 square meters a day: a pair should clear 1050 meters a day. Some commercial groups claimed a much higher rate of clearance.

The Halo Trust, when clearing dirt-roads with a high iron content in the soil, have used a trenching method whereby a shallow trench is cut along one side of the road with small hand trowels. Mines near the surface are found, those lower down are revealed by the relatively loose area above them.

With a primary "lane" cleared along the road, deminers trench out from them at right angles to allow many deminers to work together at a safe distance from each other.

Norwegian People's Aid, RONCO and MECHEM use dogs to indicate where mines are. This is described under the heading *6.2 Using Dogs* later.

6.1.4 Dealing with a *find*

However detected, when a mine is discovered, it is uncovered by hand using tools from a range of probes, trowels and brushes: different organisations favour specialist tools. Exposing the mine confirms what it is and allows an explosive charge to be laid close enough to it to either detonate it or deflagrate it (blow it to bits). The UNADP mark uncovered mines and destroy them all at a set time in the day, (a process relying on imported explosives and detonation equipment). Most other groups follow the UNADP method. NPA turn over all mines with a grappling hook to guard against "clever" mines or booby traps, then defuse the mines. The separated and detonators are then blown up in bulk at a distance. Minetech blow up all finds immediately to avoid possible accidents when using a "mark and destroy later" policy.

6.2 Using dogs

Dogs are used by NPA and RONCO (the latter subcontracting to MECHEM and British Aerospace for road clearance). NPA use dogs as part of their hand-clearance practice. MECHEM have used dogs to identify explosives remotely as part of road clearance. RONCO are reported to have used dogs to find mines prior to hand-clearance of a region (although this sounds unlikely). RONCO are reported to be in the process of leaving Mozambique.

NPA imported ten untrained dogs to Mozambique a year ago and within six months had five dogs and local handlers in operation. They use German Shepherds and Springer Spaniels (the latter ex-Met Police). They use their dogs to double check a cleared area and sometimes to survey the extent of a minefield before clearance begins: their main use is to confirm suspected mined areas. One person reported that the dogs have a short working time, which explained why they were not used more extensively. The use of dogs goes some way to explaining why NPA defuse mines: a detonation can contaminate the minefield with explosive particles (for up to two weeks) and so confuse the dogs.

MECHEM's remote use of dogs uses an air sampling technique whereby special filters are exposed to the air at a known site, then presented to dogs. A chemical on the filters reacts vigorously with any molecule of explosive in the air. With multiple filters mounted on mineproof vehicles, this method has been used to clear roads. When the filters are exposed to the dogs back at the vehicle's base, the dogs detect the reaction on the filters rather than the individual molecules that cause the reaction. The stretch of road identified as "contaminated" is then cleared by hand.

NPA are reported to have already taken over some of RONCO's trained personnel. NPA were not impressed by MECHEM's remote use of dogs. They believed that the methods used implied that either the users were not very confident or the method used was inaccurate. A British Aerospace employee of MECHEM denied this, claiming 100% clearance and blaming inter-agency rivalry for NPA's adverse opinion. There have been instances of mines found later on cleared roads, but these *could* all have been laid following clearance.

MECHEM is reported to be an offshoot of ARMSCOR that is now an "independent" consultancy, so avoiding the awkwardness of making money by both making/supplying and by clearing the mines. This awkwardness appears to have driven out British Aerospace, or at least obliged them to adopt a low profile.

6.3 Mine-clearance vehicles

These are vehicles designed to find mines. Often they have alternative applications as "mineproof" vehicles, able to withstand an anti-vehicle blast without serious injury to the occupants. The money needed to perfect these vehicles is so great that they usually rely on defence budgets and so have military roots. Generally, the military want to use vehicles to speed their access through a mined area and are prepared to accept incomplete clearance. They usually find mines by detonating them with rollers or flails. In one case special steel-plate wheels are used and the vehicle detonates its finds with its wheels.

A vehicle with detectors mounted on it can locate mines, but would have to be moving very slowly to stop safely before detonating a find. Even if the vehicle were mine-proofed, the detectors would be vulnerable to expensive damage in a blast. Such vehicles do exist, including one designed to exert a ground pressure light enough not to detonate a conventional vehicle mine, so capable of moving quickly. This kind of vehicle appears to have some potential for use in road clearance but we found no evidence of its being used in Mozambique.

It was observed that available vehicles can only work on relatively clear and flat open ground, which is not often a good description of any land abandoned for years because of mines.

It was claimed several times that mine clearance vehicles were only capable of clearing 70% of the mines in any given area, so follow-up by hand demining is always needed to achieve the UNADP standard. The estimated daily cost of running an average vehicle would equal the cost of employing 40 local deminers for a month: the deminers would still be needed so the vehicles would add to the costa disincentive to the commercial demining groups. Despite this Minetech occasionally use a mine-proof vehicle for clearance. They acknowledge that mechanical clearance must be followed up with men on the ground.

Although some UNADP staff expressed the opinion that the use of indigenous labour for mine clearance makes more sense than using any of the available heavy demining vehicles, the UNADP currently has an experimental mechanical clearance team attached. This is a German funded initiative in which forest clearance vehicles capable of shredding mature tree-stumps have been adapted for mine-clearance and are undergoing trials in Mozambique. This vehicle is very expensive and was reported to be missing and "throwing" mines at this stage of development. Those in charge were unwilling to reveal details or admit the vehicles' existence, so leading us to anticipate an eventual military application if successful. The off~cial UNADP line is that the vehicle is being refined and improved to meet its 99.6% clearance target.

We saw no indication of vehicles being used to clear primary routes through a minefield, which deminers could then use as a baseline. Neither did we hear of mineproof vehicles being used to determine the outer extents of a minefield. There was no evidence of mine-clearance vehicles designed to meet humanitarian demining requirements, such as low-cost, easy maintenance and very high clearance rates.

The general view seemed to be that available

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7 EQUIPMENT USED FOR HAND DEMINING

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The equipment can be grouped by cost, with the electronic mine detectors usually costing far more than all the other equipment issued to a deminer put together.

7.1 Electronic mine detectors

Of the detectors used the Schiebel ANl9 was by far the most common. It was used by NPA and UNADP. The Ebinger 535 is used by the Halo Trust. The new Ebonex 420 (with screw-in handle extensions) elicited excitement from all who had seen it. During a field trip to a minefield at Namaacha, we saw the Schiebel and the Ebinger give false alarms continuously: the soil was wet and iron-rich. Similar difficulties were encountered at the industrial site visited Ebinger and Schiebel detectors are further discussed in Appendix B. Other detectors used included the WRS density variation detector, still used by Minetech in their clearance "toolbag", although Special Clearance Services staff said that it was too difficult to use properly. The German Vallon is well , thought of but rejected as too expensive by most. Two commercial clearance companies interviewed used a "toolbag" approach to detectors and carried several kinds, including Barcom detectors made in Durban. They are of heavy and robust construction, which is preferred, but have low sensitivity. Barcom are reported to be working on improvements. Minetech reported Fooks, Guernica and Brunel as other detector manufacturers in RSA.

It seems that large organisations restrict themselves to one detector supplier (possibly with cost advantages) while smaller organisations favour having a range for use in different conditions.

Ebinger Detectors

Appendix C: Mines and ordnance reported

Appendix D: Comment for discussion

7.2 Ancillary equipment

The UNADP had a list of 260 items, comprising all the ancillary equipment they use. This list included paint and thinners to mark cleared areas, and so is more comprehensive than usual. Other organisations listed between ten and twenty items that were in every deminer's toolbag. The UNADP had similar items in the deminer's toolbag.

A Schiebel detector

Most organisations sourced the majority of their ancillary equipment regionally. The main exception to this was body armour, helmets and visors when they were used, which were European made imports. Organisations with an office in Zim (such as NPA) have specialised items (such as defusing tools) made in Zim. The UNADP sourced most of its equipment from RSA, exceptions being soft pouches for protective glasses and toolrolls that were tailored locally. NPA run a range of training courses, enabling local artisans to make some ancillary equipment in their working areas: this reflects a stated policy to source as much

Contents of a UNADP deminer's toolbag

equipment as possible very locally. The Halo Trust buy probes and secateurs on the local market and have trowels made in a local workshop.

There is a general desire to source ancillary equipment locally, partly to support the local regeneration of small industries and partly because of problems getting equipment through the Mozambican importing bureaucracy. However, only a few of the NGOs take the policy to the point of providing the training needed to stimulate local production. Some worries about quality control were voiced. We heard of no specialists in small-scale industrial support or training being employed.

Deminer's safety glassesone lens has been

7.2.1 Personnel protection

The typical weight of explosive in an anti-personnel mine in Mozambique (older types of mine) is 200250 grams. It is usually Russian TNT. Persons detonating this much TNT by stepping on it can expect to lose at least one leg to the knee. Many lose a hand on the same side, and some lose

blown out in a blast

both legs. Blindness is also a common consequence. Several organisations were asked about the risks of blast inhalation and the general view was that it was not a problem worth protecting against.

UNADP deminers are effectively unprotected. They are issued with military boots, overalls and protective spectacles (industrial standard, low-grade) The UNADP expressed no interest in anti-mine boots , describing the British army demining boot as "providing an unstable platform to work on" and "useless". Given that the typical explosive force encountered is ten times that in a 'modern" anti-personnel mine, there is force in their argument (the boot is designed to be effective against small blasts). Only one individual asked showed any interest in boots. The UNADP do not use body armour because it is "too hot" and "would affect concentration": cost is said to be a minor consideration.

NPA personnel protection equipment was very similar to UNADP' except that we were told body armour was available for the defusing specialists if they wanted it (the implication was that they did not). They do not use body armour or helmets routinely, saying again that they are "too hot" (Minetech said the same). They run tailoring courses to make their worker's overalls. Among their equipment was a visor made of thin polycarbonate sourced from RSA which we were told was pretty useless and not used. (It was a polycarbonate product 1 or 1.5mm thick, offering significantly more protection than any of the safety glasses we saw, but looking flimsy.) Several of the organisations interviewed said that visors were inappropriate because they restricted vision by steaming up, were easily scratched and too costly to replace. It was also reported that deminers habitually lift visors away from their mouths to prevent them steaming up: this leaves their eyes and faces at greater risk from a blast that could be trapped inside the visor. NPA prefer to use industrial quality protective spectacles (usually bought in Zimbabwein the North they buy from Zimbabwe, in the South from RSA).

Most commercial organisations have some body armour available but it seems to be rarely used, and never used routinely. Only the Halo Trust issue each deminer with a helmet, visor and armoured "apron". It was reported that they did not always wear it, but we did not see this. Outside Mozambique, the British Mines Advisory Group (MAG) also issue full protective clothing to their deminers. Both the Halo Trust and MAG deny that it is too hard to work in.

The general lack of protective clothing was justified several times with a "less the better" argument, explained as being because deminers are more "aware" when they feel more vulnerable. "The deminer has to be at risk or he will not work well" was said more than once.

7.2.2 Deminer's ancilliary equipment

The main items used by UNADP below.

- Safety glasses (with soft fabric cases)
- Standard issue army boots

NPA's demining probes

An NPA deminer's toolbag

- Overalls & floppy hat
- Garden shears (with handle extensions)
- Small pruning cutters
- Long handled long pruning cutters
- A screw-driver for probing
- Two-edged woodsaw
- Paintbrush
- Trip wire feeler
- Mine markers
- Canvas equipment roll
- The UNADP was also experimenting with defoliants as a means of expediting ground clearance.
- A site will also have medical equipment and explosive equipment for general use.

NPA equipment seen is listed below.

- Kit bag (made in Zim)
- Machete (made in Zim)
- Probes

Each site has an explosives store

Battlefield ordinance that may be booby trapped

- Trident (locally made)
- Small Rapier (made in Zim)
- Bayonets (ex-military stock)
- Gloves (made in RSA)
- Trowel-flat (made in Zim)
- Scrap bag (locally made)
- "Hook" scythe (made in Zim)
- Fabric tape for area marking (made in RSA)
- Saw (made in RSA)
- Secateurs (made in RSA)
- Sharpening stone (made in RSA)
- "key" for defusing PMN2 (made in Zim)
- NPA also use rechargeable batteries and battery chargers.

The Lee Enfield bayonet is widely used as a probe: this is probably because it is available, although one organisation believed it would bend rather than shatter or be driven back into the person when a mine explodses. We have heard of one accident where this was not true.

Chinese T72A mine, dismantled by NPA

Soviet PMN mine

Minetech ancillary equipment includes water bags.

Handicap International equipment list with some prices:

Detector	$2,300
Prodder	$350
Trowel	$1.14
Brush	$0.55
Sharpening Stone	MC20,000
Safety glasses	$3.64
Mine marker	
First aid kit	
Secateurs	
Pliers	
Saw	$4.19
Two hand lopper	$2.10

Shears $4.85

Tripwire feeler	
Meter sticks and marking tape	Randl80,000
Equipment bags	

Handicap International use "locally made" trowel, shears, sharpening stone, brush, tripwire feeler and mine markers.

Handicap International report a 100% import duty on goods from SA. They have problems importing other goods, for example, being expected to pay a US$1000 bribe to bring in office computers.

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8 COOPERATION NATIONALLY

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Cooperation and competition are evident at all levels. The UNADP and USAID are the biggest players.

The UNADP organisation has a database of mined areas and is working with the government's seven minister executive National Mine Clearance Committee (NMCC) to establish a "sustainable" "indigenous" clearance programme.

USAID want to use RONCO's Beira base when they leave in January 1996. They plan to use it as a centre for training, a dog installation, and a radio and car maintenance point for all demining organisations. USAID also intend to establish a minefield database in Beira and independently co-ordinate clearance in the country. This appears to be a plan to compete with or duplicate the UNADP and the NMCC database. There may also be a conflict of interest between NPA's taking over some of the RONCO staff and USAID's perceived aim to take over the lot.

UNADP staff are frustrated by being ignored by some clearance organisations, this making it impossible to maintain their database. Their record is currently the most comprehensive available although it has significant failings. Their entire computerised record system needs a higher level of capital investment to work as it should but this is unlikely to be forthcoming. If USAID intend to take over and improve the UNADP database before handing it back to the NMCC, its duplication of effort might be worthwhileas long as it provides the hardware and training needed to operate it.

Of the smaller players, the NGOs all support the UNADP's attempts to co-ordinate clearance. Handicap International and NPA were vocal in their support of UNADP, both expressing as a major aim their support for the formation of an indigenous capacity (the latter expressed doubts over this being possible within the period for which external

and ordnance reported

Appendix D: Comment for discussion

funds will be available). The commercial organisations often rely on UNADP approval, so say they support it too.

The competition between commercial organisations for road demining contracts was described as "cut-throat". They said they made "serious" money on road clearance, other work being harder to assess in advance.

To put the demining effort into national perspective, we were told by senior NGO staff that demining is not currently a major priority for the Mozambican government: not in their top five objectives and possibly not even in their top ten.

8.1 UNADP future plans

The UNADP definitions of "sustainable" and "indigenous" are loose enough to allow for their indigenous programme to continue to rely on aid funding and imported equipment, which they assume will be forthcoming.

UNADP staff are on short term contract extensions. It is not known when they will be withdrawn or another long-term commitment made. There can be little doubt that the uncertainty inhibits long-term strategies (such as capital investment) and the implementation of "lead-in" plans.

In the short term, the UNADP plan to establish an experimental *Community Mine Clearance Capacity* early in 1996. This may be in conjunction with Handicap International, who told us of a very similar plan. This initiative will train members of the community on Moamba District to clear mines locally in answer to local defined priorities and needs. It is hoped that this will support the regeneration of the local economy (the deminers will be paid) while being more cost-effective than current methods. It will also reduce the needs for support by using home-based deminers and, of course, bring abandoned land back into use. Safety precautions and procedures would mirror other UNADP conditions.

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9 REPORTED WANTS

We introduced the DTW/DTU with a brief explanation of our field experience in Africa. Each organisation was asked if there was any existing equipment that could be improved, or any equipment that they did not have but would like. Those that did not already buy locally were asked if they would be willing to buy the same equipment from a local source.

9.1 Needs table

The table below shows those who would test and use equipment produced for their use.

Equipment		Organisations Expressing Significant Interest						
		UNADP	NPA	SCS	Minetech	Handicap Internat'	CAD	Halo Trust
Eye Protection	Visors "Spectacles"							

Body Protection	Armour Shield Boots
Detector	
Exploder	
Solar battery chargers	

Note: All those listed have said they will appraise *any* mine clearance or ancillary equipment

9.1.1 Eye protection

All active field organisations except the Halo Trust (who already use a visor) wanted to try alternative eye protection that was more comfortable and at least as effective as the low quality safety glasses used. No one defended our criticism of their obvious inadequacy, (the photograph on page 13 shows a pair of low quality spectacles that had been damaged in a blast without the wearer's eyesight being damaged, but there was large element of luck in this). The UNADP specified that an alternative should be able to stand a 200g TNT blast at lm. Protective spectacles currently used do not fit some of the deminers comfortablythe side supports are not always long enough. Also, when folded the arms tend to scratch the inside of the lenses. There is a

Ebinger Detectors

Appendix C: Mines and ordnance reported

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need for the solution to be a "one size fits all" product, and for it to be made regionally or locally.

There was a preference for a variation on what was already used rather than visors, which have the steaming-up problem outlined previously.

9.1.2 Body protection

Cap Anamur Demining staff were the only people keen to try any protective clothing that was not too heavy. Others would try equipment but did not request it. The shield for use at high-risk times was liked by all those currently active (Handicap International are not yet "on-line").

9.1.3 Detectors

All people interviewed wanted better detectors than those currently on offer and there seemed to be a consensus view that better detectors could be made if the will was there. In the absence of a better detector, all except UNADP would try a locally produced detector and change to it if it were as good but cheaper. The UNADP are constrained by a central sourcing policy. Most thought that the ergonomic design of the detector could be improved and it could be made simpler and more robust, even if the electronic operation could not be significantly improved.

Minetech said that, when working amongst vegetation, they would find a probe and short hand held detector useful.

9.1.4 Exploder

The UNADP expressed a desire for a cheap dynamo-type exploder, suggesting that the exploder and circuit tester used for detonating the mines could be combined in one unit. All other groups would try this equipment, but no others identified it as a need. Currently, exploders and circuit testers are available as separate items. Some import them from Western suppliers, others (such as the UNADP) import from RSA.

9.1.5 Solar battery chargers

NPA use rechargeable batteries in the electronic detectors. They would like a robust and reliable means of charging their batteries in the field. We believe that such equipment is actually available already.

9.2 Consequences of the equipment needs survey

The DTW's original equipment targets were revised as a result of this field experience. We now realise that MAG use equipment criteria that are not standard, or even common, although they may still be the best (or safest). We had wrongly assumed that all demining groups either provided basic protective equipment or wanted to.

Our programme aim can be summarised as a wish to provide equipment that would:

- allow demining to take place more quickly;
- be economically sustainable within the community;
- allow demining to be carried out with a greater degree of protection.

These aims had led to preliminary research into protective equipment that could be made locally and would be alternatives or additions to equipment already used. The chosen items were protective footwear and body armour.

In order for any equipment we develop to be used, it must be approved by the main clearance organisations working in the field. To achieve their approval, it must be wanted by them. We have assumed that the people working in the minefields know what they need, or at least are more likely to know what they need than we are (being newcomers to the field).

Field organisations have expressed their priorities as being a need for improved eye-protection and a desire for (or willingness to try) a shield. No other kind of personnel protection was wanted by more than one organisation, from which we infer that boots or body armour would be unlikely to support production if we developed and introduced them. It may be that such equipment would be more widely used than implied, but we have decided to concentrate our current efforts on the equipment that the organisations say they need, (a need confirmed by our own observations).

9.2.1 Eye protection

DTW engineers are designing and developing an alternative means of eye protection for routine use by deminers. The preliminary design criteria are:

- the material used must be strong enough to enter the STANAG fragment protection band;
- the article must be capable of fitting a wide range of head sizes;
- the article must not steam up in use;
- the article must not be prohibitively expensive;
- the production process(es) should be as simple as possible;
- the materials used must be available in the region.

Details of this equipment and the research behind it will be given in a later report.

9.2.2 Protective shield

DTW engineers are designing and developing a protective shield for use at high risk times by deminers. The preliminary design criteria are:

- the article must be capable of withstanding blast fragmentation to the

STANAG standard;

- it should be designed to be used when kneeling or crouching, supported by one hand;
- deminers of any height should be able to use it;
- it should be as light as possible;
- the production process(es) should be as simple as possible;
- it should be as cheap as possible;
- the materials used must be available in the region.

The reluctance to wear or try body armour on grounds of it being too hot was surprising. A shield will not be hot, but will only provide protection when a problem is anticipated. Body armour provides protection from the unexpected and so is preferred. It is anticipated that the situation in Angola, where there are far more modern mines, will be more dangerous. Accordingly, some research into lightweight body armour capable of local production will continue.

Details of this equipment and the research behind it will be given in a later report.

9.2.3 Regional logistics cell

The idea of providing a regional logistics cell where quality ancillary equipment was manufactured for use throughout the industry was raised by NPA. The others consulted agreed that it could make their life simpler, expressing some reservations about local quality control standards. It was generally agreed that such problems were not a worry if the manufacturer were based in Zimbabwe or RSA, a site that could also serve Angola. Not every organisation was asked about this.

The DTW may decide to support such a cell by extending existing capacity at an existing supplier or other means. Currently, negotiations are under way with a view to establishing manufacture of a better and cheaper detector in Zimbabwe under a different DTW programme that is not yet funded.

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10 INDUSTRIAL CAPACITY

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The Mozambican economy does not support a solid consumer base. The currency is undervalued on the world market (around 15,000 Metacas to one sterling). Thirty years of war have driven out many industries, although the infrastructure (road, power, communications) is working (after a fashion) and considerable interest is being shown in exploiting the country's commercial potential

10.1 Industry in Maputo city

In Maputo there were many imports from RSA and China, of low quality and relatively high price. Imported German tyres were for sale in several places. Indian bright steel domestic implements were found in small shops. The markets had many cheap Chinese and Indian imports. Despite this competition, we found factories working with industrial moulds and tools imported from South Africa and Portugal, and a plastic/rubber factory that was still Portuguese owned. Other production we found centred around the recycling of scrap metals, which are in plentiful supply.

The following industrial activity was heard about rather than seen:

Rubber: MABOR tyres, established up in 1974. It was initially dependent on subsidies but is now self supporting (or almost so). They manufacture new tyres and re-tread used ones.

Cement: A factory is present and still working.

Glass: A factory is present and working (public industry) although the staff have apparently not been paid for 6 months.

Shoes: There is a factory at Chimoio, the main town in Manica Province. Also a factory in Maputo - see FABOCOL below.

Engineering: metal fabrication was widely carried out.

discussion

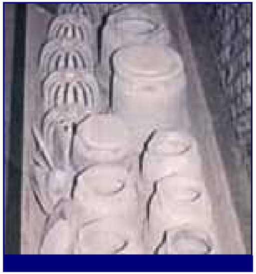
The war did not enter the capital directly, but 30 years of neglect often shows

The following factories were visited:

FACOBOL, rubber factory: they get their raw material from RSA and manufacture mats; sheeting; small rubber components (e.g. bushes, chair leg ends, etc.); a range of shoes; reinforced matting/machine belts, hose, rubber bearings, rubber foam, and cycle tyres. The fabric used for shoes and reinforcing is made in Mozambique. This is a large factory with an extensive range of equipment for rubber preparation, moulding, forming, stitching, sewing, pipe extrusion, etc.

LIMETAL, recycling non-ferrous metals: The factory was casting ingots of Zinc, Lead, Brass, Bronze and Aluminium from scrap. The factory manufactures cast aluminium cooking pots of good quality in a range of sizes.

POLYPLASTICO, Plastic Injection Moulding factory: processes at the plastic factory include



[Metal recovery, casting and manufacture of metal products in Maputo]

HDPE/Polypropylene pipe extrusion for a number of diameters and wall thicknesses; injection moulding of a range of buckets, bowls and beer crates; die forming using milling machines and lathes. They have a plastic shredder to recycle thermoplastic material. Raw materials for the factory are imported from RSA in the form of plastic granules (HDPE and polypropylene). The factory manufactures its own dies in an internal workshop (equipped with lathes, milling machines, and a kind of CNC machine). Staff told us they were in competition with other manufacturers, but these were not identified. We found products from Quelliman, so infer that they have a competitor based there.

10.1.1 Market in Maputo

We found locally made welding rods, nails and batteries at a large open-air market outside the city centre. The locally made goods for sale provided evidence of lathe work, welding, bending, pressing, guillotining, brazing and plastic mould-injection and extrusion.

Steel Wire and metal and plastic products available in the market

Imported products sold in the market and made in China/South Africa included hacksaw blades, bolts, sharpening stones, scrappers, fine mesh, a large range of plumbing fittings (brass, steel and galvanised steel), braided wire, and cycle parts.

10.1.2 On the streets of Maputo

Locally made terracotta plant pots were for sale. Hoe heads and machete blades, ironing boards (wood, wire, nails, linen and padding), window cleaning squeegees (wood, strip rubber cut from 3mm sheeting)all made locallywere for sale in small shops. In side streets we saw vehicle repair with electric arc welding, grinders and gas cutting torches being used.

10.2 Urban industrial prospects in Mozambique

Maputo is close enough to the RSA and Swaziland to import raw materials easily. This makes it likely that the apparent growth of light industrial activity will continue. Larger investment may be made

Scrap metal is made into ingots or made into local products such as this clothes iron

through speculators taking advantage of favourable labour costs and flexible working practices. It seems reasonable to think that all mine clearance related equipment, with the exception of the detectors, could be made in or around Maputo. We found no evidence of electrical or electronic manufacturing capacity, and little evidence of any service and repair capability.

Senior officials told us of severe problems importing raw materials and manufacturing equipment. They recommended allowing 100% of value for bribes, or great patience. We asked about export problems and were told that, since the same customs staff are involved, we should expect the same difficulty.

10.3 Urban industrial prospects in Zimbabwe

To provide a comparison, and to investigate the possibility of establishing a regional logistics cell, we spent three days in Zimbabwe examining the manufacturing potential. In and around the

Other scrap metal is recycled directly into products like these cooking stoves

Engineering works are equipped with good, if ageing machinery

capital, Harare, we found an industrial capacity that is highly developed. We spoke to two electronic manufacturers capable of making electronic mine detectors: both expressed an interest in doing so. Suppliers of high quality polycarbonate (suitable for protective eye-wear) were found, along with a wide range of production industry already established and geared for export.

The town of Mutare on the border with Mozambique is another industrial centre. Here we found car assembly and component manufacture and sophisticated engineering workshops. Mutare is on the road and rail link to Beira in Mozambique and might make a suitable site for an equipment manufacturer supplying Mozambique. Harare, on the other hand, would make a better site if the goods were also to go to Angola.

10.4 Rural industry in Mozambique

Rural industrial capacity is very limited, perhaps as a result of Portuguese reliance on imports followed later by Soviet style 5 year industrialisation plans:

A plane in a timber yard

Bucket Manufacture

both of which must have squeezed out the entrepreneur. Although in small towns artisanal industry was active, at village level there were no workshops in evidence and little economic activity beyond agriculture and processing of charcoal. We found no evidence of blacksmithing, although skilled metalworking with power tools was widely in evidence in towns. Skilled artisans seem to be centred in small towns with power supplies, as is usually the case. Typical towns and villages are introduced below.

10.4.1 Namaacha

Namaacha is a small town on a major road served by buses and with a reliable electricity supply. We found a wood mill, well equipped to cut and plane raw timber (but there was no one present). We also found a mechanic and workshop with a pillar drill, a 3-phase arc welder, gas welding facilities, lathe, and a good range of hand tools such as spanners, pullers and valve compressors. The mechanic seemed to be a capable artisanhis skill acquired by repairing farm vehicles. The mechanic

Scrap metal is everywhere

was a local farmer (of Portuguese origin) who collected scrap metal, manufactured trailers and rear sections for trucks and rebuilt Massey Ferguson Tractors. There was also a small puncture repair workshop at the border-post with Swaziland.

10.4.2 Boane

Boane is a town on a major road, larger than Namaacha by about 3 times. It has a large sprawl of grass huts to the South. In the town artisans ~ carried out shoe repairs on the street. carrying out puncture repair had compressors and home-made equipment to dismount truck tyres. We found a small workshop making galvanised steel buckets, water tanks and funnels. The tin-snips used for cutting the sheet steel were imported. Jenny machines were used to impress a pattern of strengthening ribs on the buckets. The tin sheet was sourced Bucket manufacture from "Imo" in Matola 700. There was a factory making high quality carved furniture: tables, armchairs and bureaus. There was also an industrial storage area where dismantled water-tanks and support frames were stored in the open without apparently attracting thieves (there is so much scrap metal around that this may explain it). Brick making was also in evidence.

10.4.3 Mafavuca 1

Mafavuca 1 is a small settlement without a store about 50 miles from Maputo. It is off the road, so only indirectly served by buses and has no electricity supply. The only economic activity is farming (growing maize, onions, carrots and tomatoes). No formal trading was taking place, although one man was effectively the village "mechanic", repairing items for others. There was a good deal of scrap metal around the settlement. Family members working in the city are relied on for the provision of such consumer items as are used. There are mines in the vicinity, but not hampering farming.

10.4.4 Mafuiane

A large "dormitory" village with a petrol station. Most houses have no power. Water is from boreholes feeding standpipes. The market, sells food only. There were no official traders but we saw animal skins drying (goat?) and crude uncut timber could be bought. Charcoal was being made for subsequent sale in towns. Crops were being grown mainly for own use. We saw evidence of shoe-sole making (from car tyres) and block-making (not offered for sale).

10.5 Conclusions of the industrial capacity study

Assuming an aim of providing equipment with as wide an application as possible that can eventually be purchased locally, a strategy to achieve this has arisen from the study.

While it would be possible to manufacture all items of demining ancillary equipment in the urban industrial sector in Mozambique, the process would be complicated by restrictions on tools and materials supply. The same restrictions would not apply if the materials were manufactured for regional supply in Zimbabwe or RSA. They would, however, cost more and incur import tariffs (official and otherwise). These are currently negotiated and might be easier to circumvent if the goods had only one purpose and so could be designated tariff free "demining equipment".

At present, different demining organisations operate in varied ways and some use uniquely specialised equipment. The quality of the equipment seen was sometimes questionable, and the design and local manufacturing methods employed in some tools was potentially hazardous (welding re-bar can make it dangerously brittle and prone to fragmentation, for example). The obvious advantages of manufacturing commonly used equipment in one place are a standardisation of tools across the industry (helping deminers move from job to job) and assured quality control. There should also be a price/profit agreement that guarantees fair wages to the producers and a fair price to the purchasers. From the development point of view, it broadens the skills base, empowers local initiatives, and also keeps as much demining money as possible within the local and regional economy.

Research is needed to determine a core of "standard" demining equipment that is as easy to use and as safe as possible. Even where similar items are currently used, the quality and design details vary as the equipment is drawn from different suppliers (the safety-spectacles are an example of this).

When the common core of equipment has been identified, it could be made in a regional logistics cell, leaving other specialised tools for local manufacture. If such a cell were established by an NGO with practical field-engineering and training experience, that NGO could have as an aim the eventual dispersal of all manufacturing to the countries concerned. From the start it should offer to help establish local manufacture of simple items whenever demining groups want it. This would help to reduce current mistakes in manufacturing methods. Later, as conditions in the mined country improve, the assembly, then manufacture, of more complex items could also be transferred.

Clearly, such an initiative cannot be imposed. Its success would rely on being supported by the NGOs in the field, and specifically by the UNADP in Mozambique. Once established, it should be useful enough for demining organisations (commercial or NGO) to want to use it.

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9 Reported wants

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Case study 4

10,000 litre partially below ground brick built tank, Sri Lanka

Background

This tank was built by Mr G. Victor A. Goonetilleke in the hill town of Kandy , Sri Lanka. Mr Goonetilleke decided to build his RWH tank after experiencing difficulty in sinking a well to sufficient depth to have a reliable perennial source of groundwater at the site of his newly built home. Drilling through the bedrock was too costly and there was no guarantee of securing a reliable supply. After 6 years of carrying water during the dry season Mr Goonetilleke started to research the idea of building a tank to store the rainwater that fell on his roof. There was very little encouragement from friends and neighbours who said that the water would provide an ideal site for mosquito breeding and algae growth. At the time there were no organisations to give advice on the benefits and drawbacks of roofwater harvesting. Three years after first contemplating the idea of a RWH tank, and after many helpful discussions with an Australian Radio Ham who convinced Mr Goonetilleke that RWH was a viable technolgy (and widely used in Australia), he decided to go ahead and build.

Technical details

The tank

Once the decision was made to build then certain design choices presented themselves. The determining factors for the tank capacity were:

1. sufficient capacity to store 100 litres of water for a period of 60 days

2. sufficient capacity to hold two bowser loads of water during the dry season it is possible to purchase bowsers of water, but storage is required for this purpose. Each bowser contains 5,000 litres of water, but are not always available immediately upon request.

It was therefore decided to build a tank which would hold 10,000 litres. The next choice was what kind of tank to build. Mr. Goonetilleke had 3 obvious choices:

1. an underground tank - this type of tank needs excavation, care is needed to prevent roots penetrating the tank, contamination from ground can occur if not properly sealed, leaks are hard to detect and, finally, a strong cover is required to prevent children or animals from falling in. This type of tank does have the advantage, however, of being unobtrusive and benefitng from the support of the surrounding ground, making it cheaper to build.
2. a surface level tank these require more space and can be ugly, but water is easier to extract under the influence of gravity and leakage is easier to detect. Covers need not be so sturdy, as little weight will be placed upon them.

3. an overhead tank this type of tank is good in as much as little space is needed at ground level and the water is pressurised due to the head of water. They are, however, expensive and it is difficult to transport water from the catchment system to the tank.

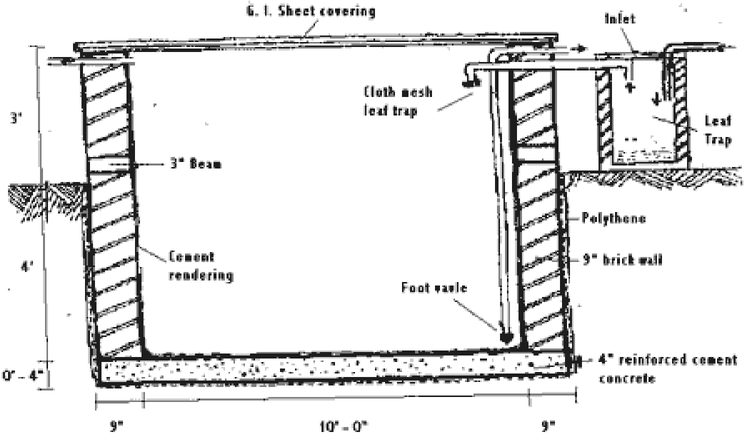

Figure 1 sketch of $10m^3$ brick-built tank.

The decision was made to build a tank which combined the advantages of the below ground and the surface tanks. Figure 1 shows a plan of the tank which was eventually built, partly below ground with 3 foot walls protruding from the surface of the ground. The next choice was what material to use for constructing the tank. Locally available plastic tanks were expensive and so Mr Goonitelleke decided to hire a mason to build a brick tank with a concrete base. Bricks are available locally.

The tank has a 4", 10 foot square, concrete base which is reinforced with ribbed steel bar. Polythene was laid underneath the concrete and brought up to ground level. The walls of the tank are of 9" brickwork. A 4" concrete ringbeam was cast at ground level to give added strength. The gap between the walls and the excavated pit were lined with concrete to allay fears of root penetration. The wall was then continued to 3 foot above ground level. The inside of the tank and exposed external walls of the tank were rendered no waterproofing additive was added. The tank was covered with some galvanised steel sheets. A pump was fitted to pump water to a header tank situated in a tower near the house (which also houses an old 200 litre oil drum which collects rainwater for irrigating the garden). The overflow from the main tank goes into a shallow ditch where there is a flourishing stand of bamboo.

The total cost of the system was around Rs. 25,000 (US$550), but Mr Goonetilleke says that minimum cost was not the primary objective.

The roof and guttering

The roofing material is asbestos sheeting with an area of about 2000 square feet being used for catchment which is half the total roof area. S-lon brand, PVC, U-channel guttering is used to catch the water and the downpipe leads to a 1" PVC pipe (not ideal but it was freely available at the time) which then transports the water to the tank. The first flush system is a simple connector which enables the pipe to be diverted to the garden pond. The filtration system is simply a piece of mesh and some discarded mosquito net, but the aim is to improve on this.

Maintenance

During the 4 years the tank has been in use there has been no need for any major repair. The tank is cleaned once or twice a year and the cover is swept of leaves and dust regularly. Internal inspection of the tank is easy because of the low walls.

Uses for the harvested water

The water is used for mainly for washing and bathing and is occasionally used for drinking, but is then boiled. During the dry season waste (grey) water is used for watering the plants. There is little need to be overly conservative with the water because it is possible to order a bowser when the water level gets low (4500 litres at a cost of approximately US$7.00), although so far this has not been necessary.

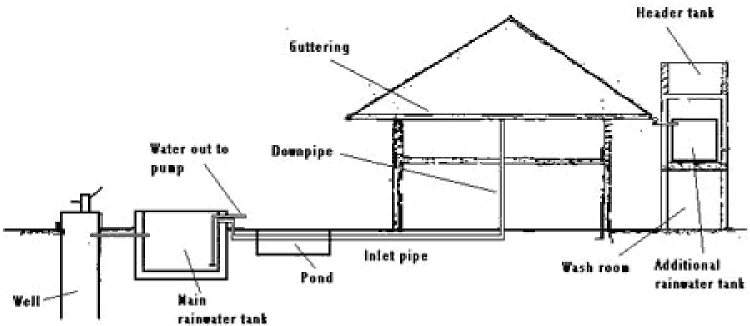

Figure 2 Sketch showing the whole scheme including the water tower

Mr. Goonetilleke gives the following suggestions for improved awareness of RWH techniques:

- better information dissemination and educational awareness should be carried out at all levels.
- where possible, credit and technical advice should be made available in conjunction with other incentives.
- more concern should be given to the improper application of treated water there is no need for water to be of exceptionally high standards if it to be used for clothes washing or bathing.
- architects should be aware of the principles of RWH and incorporate the technique in the house design where this is appropriate.
- care and attention are necessary (moreso than money), to maintain and improve the quality of harvested water.
- there are many myths associated with the concept of RHW which can be easily dispelled when the technology is put into practice.

Source: Mr. G. Victor A. Goonetilleke, Rainwater Harvesting, a case from Pilyandala, Proceedings of the Symposium on Rainwater Harvesting for Water Security, February 1998, Lanka Rainwater Harvesting Forum and the Open University of Sri Lanka.

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Case study 11

Twelve cubic metre ferrocement water tank, Thailand

Introduction

Much of the information for this Case Study is taken from a paper presented by Chayatit Vadhanavikkit of Khon Kaen University, Thailand at the Rainwater Catchment Regional Seminar and Workshop, held in Khon Kaen in 1983.

Much work has been carried out in Thailand, both on rainwater catchment systems and on the development of ferrocement as a construction material. Two important institutions, the Environmental Systems Information Center (ENSIC), and the International Ferrocement Information Centre (IFIC), both found at the Asian Institute of Technology (AIT), can be found in Bangkok, Thailand. During the early 1980s a great deal of work was done in Thailand to promote the use of RWH systems for domestic water supply.

Background

Ferrocement is a technology that is well suited to use in developing countries. It requires materials which are commonly available in most sizeable towns throughout the world, tools which are owned by any respectable mason and skill levels which are compatible with those of artisans in most areas of the developing world. It is a technology which has received a great deal of attention over the last

30 or 40 years, and is used diversely for such applications as boat building, low-cost housing and storage tank construction.

This Case Study looks at a ferrocement tank which was developed by the author of the paper mentioned above.

Technical detail

Firstly, it is pointed out that Silica cement was used to construct the tanks. This is because silica cement was more readily available in the area and at a cheaper price. It does, however, have a strength which is only 70% that of Ordinary Portland Cement (OPC). Silica cement has a slower hardening time, which is favourable under the circumstances as it provides more time for construction work.

Tests were carried out on mortar specimens to find a suitable sand for construction of tanks, and it was noticed that local sands from different sites gave remarkably different results. The tensile strength varied by a factor of 2 and the compressive strength by a factor of 1.7.

Vadhanavikkit points out that different types of wire mesh have different properties which are suitable for different applications. Whereas hexagonal mesh (chicken wire) has low strength and rigidity, it is well-suited to applications where flexibility is required, where corners and changes in contour have to be dealt with. The heavier gauge square wire mesh is more suited to giving strength and rigidity where it is required, in the base for example. The square mesh was also cheaper in this case. The reinforcement chosen consists of 9mm steel rods for the tank skeleton, sandwiched between two layers of 25mm square welded mesh. Vadhanavikkit briefly analyses the structure to show that the stresses in the tank are more than adequately catered for.

The design of the tank is governed by the construction technique rather than by forces present in the finished tank. This is because the stresses set up in the tank are very low compared with the strength of the reinforced mortar. The designer chose a tank with the following specification:

Diameter	2.5m
Height	2.5m
Wall thickness	40mm
Capacity	$12m^3$

Table 1 Initial tank specification

The tank dimensions are shown in Figure1 and materials required are shown in Table 2

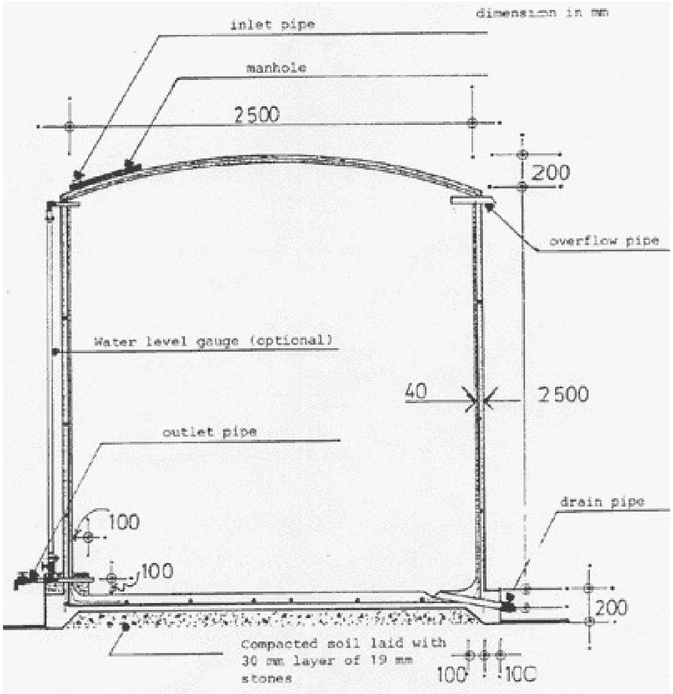

Figure 1 Details and dimensions of the Khon Kaen ferrocement tank (Chayatit Vadhanavikkit)

No	Material	Quantity
1	Silica cement (50 kg bag)	19 bags

2	Sand	$2m^3$
3	Stones 19mm	$0.7m^3$
4	9mm steel bar	11 bars
5	Square weld mesh (25mm mesh; 0.9 x 30.5m roll)	2 rolls
6	Tying wire	2 kg
7	Pipe fitting	various

Table 2 materials required for the tank

Construction technique

There are three distinct stages in the construction of the ferrocement tank:

Preparation of the skeleton and mesh reinforcement

The first step is to build the tank skeleton. This is done remote from the actual tank site and then cast into the base later. Vadhanavikkit gives the cutting list and configuration for the steel skeleton (not given here). The skeleton has a base, walls and roof, all constructed by sandwiching a 9mm steel rod sub-skeleton between two layers of 25mm square steel mesh (see figure 2 below). The 9mm steel sub-skeleton is made of a series of hoops (5 in all) and vertical members, which forms the tank walls. The base and roof skeletons are formed using a series radial bars and concentric hoops, again sandwiched in wire mesh. The whole assembly is tied well using the tie wire, loose ends being pushed inward to prevent obstruction during the plastering stage.

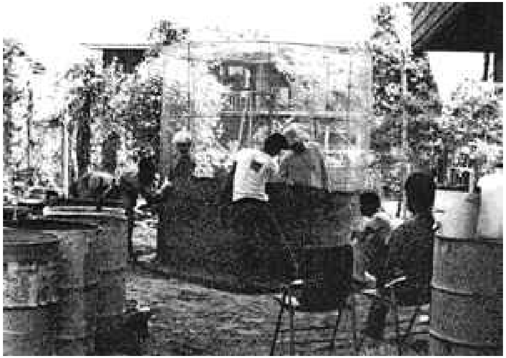

Figure 2 the tank skeleton being moved to site (Chayatit Vadhanavikkit)

Preparing the base

The ground is prepared for the base by laying a 100mm layer of compacted soil and stone aggregate. A 50mm layer of concrete (1:2:4, cement:sand:stone) is laid roughly, the skeleton is then moved into position and a further 50mm of concrete placed on top. The base is then finished using a cement water slurry for water tightness.

Plastering the walls and roof

A mortar mix of 1:3 cement:sand is used. The mortar is applied by hand. Plastic bags are used to protect the hands. The mortar is applied to the skeleton walls from the outside by one person while another person standing inside prevents the mortar falling through (figure 3 shows a partially rendered skeleton). The mortar has to be pushed carefully into the skeletal mesh to prevent voids being present. This core is then given a day to harden and then both inside and out are given a 5-10mm coat of mortar which is trowelled on. Finally, when this mortar has hardened, it is given coat of cement water slurry. The roof plastering is not as critical as it will not have to be water tight. Cement slurry is used liberally at all joints. The tank is cured for 14 days by whichever method is most suitable; sprinkling with water; covering with wet sacks; etc.

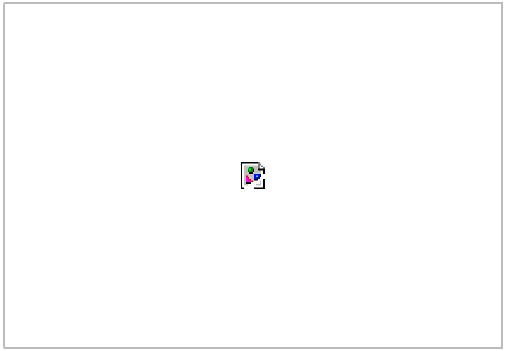

Figure 3 a partially rendered tank skeleton (Chayatit Vadhanavikkit)

Conclusions and observations

Four tanks had been constructed. All had been in constant use since completion (no indication is given of how long a period this was) and there had been no leakage or other problems. Villagers were at first sceptical of the tank because of the thin walls but were soon convinced of the tanks strength.

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Case study 12

12m^3 / 14.5m^3 Brick water tank, Thailand

Introduction and background

As with the previous Case Study, much of the information for this Case Study is taken from a paper presented by Chayatit Vadhanavikkit and Suthipol Viwathanathepa of Khon Kaen University, Thailand at the Rainwater Catchment Regional Seminar and Workshop, held in Khon Kaen in 1983.

As well as working on the development of the ferrocement water storage tank, a similarly shaped brick tank has also been developed for use with rainwater catchment systems. Two tanks sizes were built, both with a diameter of 2.5m, but one with a height of 2.5m (giving a capacity of 12m^3) and the other with a height of 3m (giving a capacity of 14.5m^3).

In Thailand bricks a commonly used for the construction of water storage containers. The benefits and drawbacks of brick tanks are listed below.

Benefits	Drawbacks
Brick is a commonly found building material in many parts of the world, and are easy to manufacture where suitable soil is available.	Bricks have a low tensile strength and provide little resistance to the stresses set up in a water tank.
Building with brick requires no formwork and the shape can be varied as required.	Brick tanks, therefore, require extra reinforcing if a significant tank height is required.
Most masons are accustomed to working with bricks.	If not properly constructed, the life of a brick tank will be short.

Table 1 The benefits and drawbacks of brick tanks

Five tanks were built and tested by the authors of the paper.

Technical detail

The 14.5m^3 version of the tank is shown in Figure XX1. The general principle of construction is that the single thickness brick wall is reinforced externally with steel wire and reinforced internally with hexagonal steel mesh. Both inside and outside are plastered to cover the reinforcing and to make the tank water tight. The roof style is similar to that in the previous Case Study, and so will not be considered.

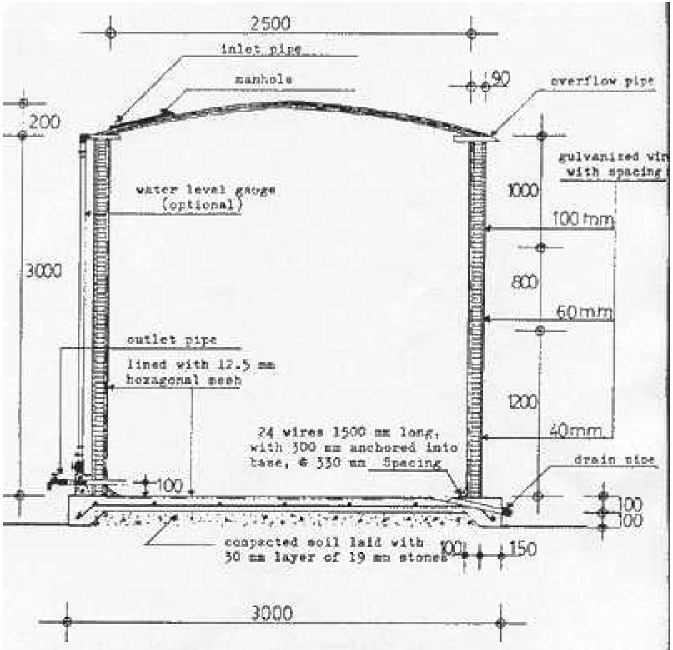

Figure 1 Detail of the 14.5m^3 water storage tank

Construction

The base

The ground is prepared with compacted soil and stone to accept a base of 3m diameter. The concrete base is laid to a depth of 100mm, with reinforcing steel of 9mm diameter laid both radial and concentrically at a depth of 50mm. A series of 24 galvanised steel wires, 1.5m in length, are cast into the base at a diameter of 2.3m. These are later nailed to the internal surface of the brick wall and plastered, giving extra resistance to shear at the base of the tank. They are buried to a length of 300mm.

The wall

A circular brick wall is constructed to a height of 3m. A mortar of 1:4 (cement:sand) is used, but the construction should be carried out in steps, with a maximum increase in wall height of 800mm before allowing the mortar to harden. The whole wall can be completed in two days. A plumb line was used occasionally to check the line of the wall. It is important that all the gaps between the bricks are filled as well as possible.

Figure 2 - a partially finished brick tank showing external rendering and hoop reinforcement (Chayatit Vadhanavikkit)

Plastering the outer surface of the wall

A mortar of 1:3 cement:sand is used for the plaster. A cement slurry is applied to the joint at the base of the wall. Rough plastering is applied and then galvanised binding wire is wound around the tank and embedded in the soft plaster. A series of three closely spaced wires are wound around the base of the tank and then single wires are wound at the following spaces:

Height	Spacing

below 1.2m	40mm
1.2m to 2.0m	60mm
above 2.0m	100mm

Two rounds finish off the top of the tank. It is recommended to work upward, plastering approximately 500mm per stage, so that the plaster remains soft enough to accept the wire. The wire should be wound tightly at all times. The wire should be unwound smoothly from the coil, avoiding twists and knots. Wire can be joined by simply tying knots.

A trowel finished layer of plaster 10mm thick is applied finally.

Figure 3 - inner tank wall surface showing wire mesh in place

Plastering of inner surface of the wall

The tie wires, which were embedded in the base, are now nailed to the wall. Now the whole of the inner wall surface is lined with hexagonal wire mesh (figure 3 above). This achieved by cutting nine 3.5m legths of mesh and running them vertically up the walls with a 30mm overlap. The mesh is held in place with short flat head nails. The base is also covered with mesh. The surface is then plastered to cover the mesh entirely. Later, a cement slurry is applied to give water tightness.

The roof

As mentioned earlier, the roof is constructed in a similar manner to that in Case Study 11. Curing is also carried out as described here.

Figure 4 - roof construction for both ferrocement and brick tanks

Construction materials

	$12m^3$		$14.5m^3$	
Material	**Quantity**	**Cost**	**Quantity**	**Cost**
Silica cement (50kg bag)	22		24	
Bricks	2500		3000	
Stones (19mm)	$1m^3$		$1m^3$	
Sand	$2.5m^3$		$3m^3$	
Steel bar (9mm)	8 bars		8 bars	
Hexagonal wire mesh*	1 roll		1 roll	
Galvanised wire No. 12 (2.7mm) No. 11 (3.3mm)	17kg		 25kg	
Flathead nails	0.5kg		0.5kg	

Tying wire	0.5kg		0.5kg	
Pipes and fittings				

*Roll size 0.91m x 45.7m (3 x 150)

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Case Study 20

'Tarpaulin'-lined Tank from Southern Uganda - ACORD from 1997

This 6000 litre tank is made by lining a 3m x 2m x 1m deep hole with a standard UNHCR blue tarpaulin (5m x 4m rip-stop plastic with eyelets near the edge). The tarpaulin is held up with string from nails down to these eyelets. A simple wall (wattle and mud, 600mm high) is built around the tank and roofed with slightly sloping corrugated iron sheets. The wall is lined with plastic sacking to prevent mud falling into the water. The wall-roof joint is sealed with mud. Water enters via a hole in the roof sheeting (covered by a filter cloth and fed by a sloping metal downpipe). Water is extracted by dipping with a modified (cut-away)10 litre jerrycan via a small wooden door in one wall - water is always within arm's reach. Some work has been done on developing a low-cost handpump to extract water.

There is normally no overflow and the householder is expected to move aside the downpipe feeding the store when the water level approaches the top of the tarpaulin lining.

Click to view picture of tank - inside the housing

Click to view picture of tank - showing housing

Click to view picture of the tank opening

Cost in 2000 include the 5m x 4m tarpaulin (about $$_{US}$20 equivalent on the open market as East Africa is full of such refugee relief items - price direct from manufacturer is similar). There is about $$_{US}$ 20 worth of iron roofing sheets. Other construction items (esp mud walling) and labour are provided by the householder, the latter probably does not exceed 2 day's work.
Agency = ACORD (Oruchinga Water Devt Prog, Mbarara District), Kampala HQ: plot 1272, block 15 Nsambya, POB 280 Kampala, Uganda, email = acordug@uol.co.ug, tel = ++256-41-267667/68, fax = ++256-41-267669

Some detail of the construction of such a tank is shown in Technical Release TR-RWH 05

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APPENDIX A: ACCIDENTS

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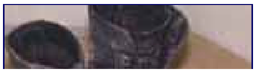
Acknowledgements

UNADP had an accident on the day we arrived (one of six this year). We examined the boots and safety glasses worn by the victim who lost his leg above the knee and his hand. He may have prodded the mine or trodden on it with the toe of his boot. Subsequent investigation by the UNADP revealed metal behind the accident site on the supposedly cleared lane. The victim's own detector was used to find it. The official conclusion was human error.

There have been 6 UNADP accidents this year. UNADP have had 8 car accidents during the same period. Of the demining accidents, the staff questioned believed that four of the six UNADP injuries would not have been mitigated by the use of protective clothing: the remaining two might have.

NPA report three casualties over two years, two work related, one stupid (taking a live mine home). Neither work related accident occurred while defusing.

We heard from several sources of a recent Halo Trust accident when a deminer and a supervisor were both seriously wounded. The deminer worked "carelessly" and the ex-pat supervisor who



went to compile an accident report walked along the deminer's cleared "lane" without checking: he was seriously injured.

Some commercial groups claimed to have had no accidents, but this was challenged by other groups: the individuals may have been talking only about men under their direct command. It seems likely that accidents occur at the same rate as with NGOs but may go unreported.

All accidents apparently occur because of human error or unpredictable acts of God. See the note on Accident Reporting under the "Discussion" heading in Appendix 4.

A mine victim's boots

Soviet OZM-72 anti-group bounding mine

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10 Industrial capacity

Appendix B: The Schiebel and Ebinger Detectors

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APPENDIX B: THE SCHIEBEL AND EBINGER DETECTORS

These detectors were discussed with as many individuals as possible with a view to discovering their strengths and weaknesses.

The Schiebel AN-19/2

The Schiebel has a clumsy handle extensionwith choices limited by locking pins and has no twisting option. The UNADP disliked the external wire to the head, the shoulder hung controls, and the headphones (which are worn on the shoulder and so are redundant). They find it difficult to use to zero-in on readings. They report the Schiebel normal battery life as about 7 days and say that rechargeable batteries last about hours and so do not use them. Also, although high iron-ore content in the soil causes detection problems, UNADP say that experienced users of the Schiebel can remain efficient: it is apparently a combination of both damp high iron-ore that makes detection virtually impossible.

Other problems with the Schiebel were the plastic on the head wearing thin (because of brushing the ground), and the plastic and fittings "giving out" generally. Norwegian People's Aid, who use rechargeable batteries in the same detector, confirmed UNADP's detector problems and added the head-hinge breaking and their concern about supply and service. Minetech had handle extensions added to the Schiebel to allow them to reach through undergrowth, but

the extra length cable that was needed made all their detectors fail(or so the Schiebel technician told them). They confirmed frustration with the cable between the shaft and head of the Schiebel detector catching on undergrowth, and said that the detectors were too light (weak). They said that high iron content in soil was not a real problem due to the high skill levels of their operators. Special Clearance Services reported Schiebel's as too easy to break: re-confirming the head-hinge

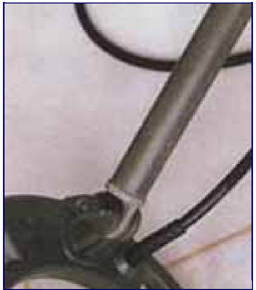
and ordnance reported

and the exposed wire at the head as design faults

Appendix D: Comment for discussion

The Schiebel

The Schiebel control box



Using the new Ebinger with a short handle

The Ebinger detectors

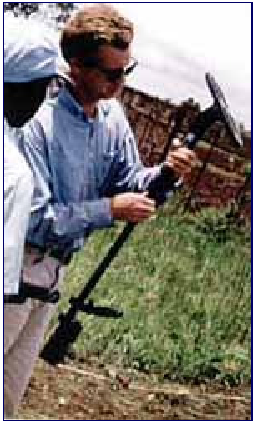
A surveyor subcontracted to the UN had an Ebinger 420 (Ebonex 420) which he claimed was better than the Schiebel for two reasons. It was easier to handle (having a single 9V battery (PP9) inside a short handle and no control box on the belt) and it was supposed to operate better on ore rich soil. The detector was designed with input from humanitarian demining groups (including staff of the UNADP). The headset could be replaced by a speaker on the handle. When he attempted to demonstrate its superiority over the Schiebel on the Mozambique/Swaziland border at Namaacha it did not perform any better than its rival: both failed. Two people reported that the small speaker

The speaker on the new Ebinger (not a handle)

mounted on the side of the handle can fail or be improperly connected and so not work. As usual, the 420 signals on contact, so a failure to signal could be a problem although both the Schiebel and the Ebinger are reported to "click" at intervals during operation as an indication that they are functioning properly. The arm mounting of the Ebinger 420 was also reported to be too low

The Ebinger 420 has recently won a competition for the best current detector. Other competitors included the Schiebel, Forster, Vallon, PIMDEC and Guartel.

The Halo Trust report non-specific breakdown problems with the detectors but said that Ebinger have trained one of their members of staff to carry out maintenance and repair (they may be using the Ebinger 420 as well). They say their detectors cannot operate when the soil has a high iron.



The Ebinger

The new Ebinger 420 has been designed to serve both military and humanitarian demining needs. Thus, while it is an improvement on the solely

with its handle extension screwed into place

military design, it still includes unnecessary features and weaknesses. By retaining the option to fit a headset, for example, it retains a user-assembly option that can cause problems. If the speaker were permanent it could double as a handle (which it appears to be, but it unscrews if held). It is also still produced in olive drab, making it obviously military and possibly harder to import/export as a result (a problem identified in Iraq and Angola by several mine clearance NGOs).

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Appendix A: Accidents

Appendix C: Mines and ordnance reported

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APPENDIX C: MINES AND ORDINANCE REPORTED

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REPORTED MINE TYPES FOUND IN MOZAMBIQUE (and numbers cleared during 1985when known)

	Common name	Note	Country of origin
AP mines:	PMN-1	240g TNT Cannot be defused	USSR
	PMN-2	100g TNT Needs key to defuse	USSR
	PMD-6	Wooden case 200g TNT	USSR
	PMA-3	Undetectable, plastic & polystyrene 35g Tetryl	USSR
	NR 409/M969	Hard to detect	Portuguese
	Type 72	Hard to detect (some derivatives	Chinese

		"clever" externally identical)	
	Type 59	MAPDV 59: plastic	French
	M14	Plastic	American
Anti-group mines	POMZ -2	Stake mine, 6 rows of fragments, 75g TNT	USSR
	OZM-3	Bounding 75g TNT	USSR
	OZM-4	Bounding 170g TNT	USSR
	OZM-72	Bounding 500g TNT	USSR
	Pp-Mi-Sr	Bounding 325g TNT	Czech
	MON50	Claymore type/directional	USSR
	Plowshare	Claymore type/directional	Rhodesian

Appendix D: Comment for discussion

Unexploded Ordnance	Grenades	Some USSR grenades have 0-fuse	Ordnance can be booby-trapped.
	Mortars/artillery rounds		
	Rockets and RPG		
	Detonators and fuses		
	Flares		
	Small arms ammunition	Over 20 x all other finds	
Anti-tank	TM46	Metal: can have anti-handling device	USSR
	TM-57	Metal: can have anti-handling device	USSR
	TM-62	Can have magnetic fuse, metal or plastic case	USSR
	Type 72		Chinese

			copy of TM-46?
	Pt-Mi-Ba-111	Bakelite case, hard to detect	Czech

Other mines recorded from conversation that may exist include the British Mark 5, RMB409, NR406, and the South African R2M2. NPA reported that the Portuguese mines (MAPS) that are listed as undetectable can be detected by a Schiebel. They report a greater variety of mines in the North, including some "devious" mines (with built in anti-demining features).

Anti-personnel mines known to be in Angola as well as those above include:

R2M1	57g explosive	South Africa
MAIGR-75	50g explosive	Romania
M409		Belgium
MAT~6	90g explosive	Romania
RSM2	50g explosive	South

		Africa
MAI-75	120g explosive	Romania
Mk.2	Fragmentation mine 450g explosive	UK
M16A1	Bounding mine 513g explosive	USA
DM11	All plastic: 114g explosive	GDR
DK31	Bounding fragmentation	GDR
MON90	Directional fragmentation	USSR

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Appendix B: The Schiebel and Ebinger Detectors

Appendix D: Comment for discussion

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APPENDIX D: COMMENTS FOR DISCUSSION

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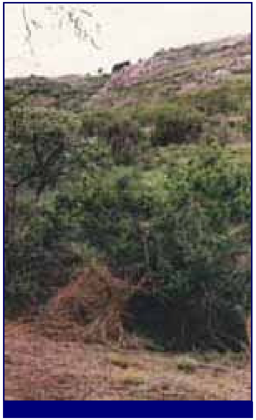
A number of issues have been raised by members of the study team that visited Mozambique, two of which seem important. The following comments are presented as points of view for discussion: all responses would be appreciated. We want to understand the world of demining better.

Accident reporting

From what we have heard, all accidents that result in injury are investigated and a report compiled (this may not always be true of commercial clearance companies). Also from what we have heard, all accidents occur because of human error and unpreventable bad luck. However, accidents tend to be investigated by the very people who devised or have implemented the day-to-day working practices that may have failed. This allows room for some doubt over the objectivity of the conclusions. For example, we heard of no accidents that had led to changes of working practice. Perhaps to have admitted a fault in working practice would have been to implicitly accept some responsibility for the accident? Also, accident investigators must know that if they find that a deminer was working properly according to the rules and was still injured, the effect would be to undermine the trust that deminers put in their supervisors.

At least one working practice is, on the face of it, dangerous. Deminers working with space between them of supposedly 25m were closer together when we saw them, and even if they were usually 25m apart, some fragmentation mines can kill at up to 100m. One death we heard of occurred when a man was struck by a fragment from a mine 32m away. It passed through his neck. This accident seems to have been accepted as a wholly unforeseeable act of God rather than a sign that the distance between demining personnel should be increased. It was cited as an example of the futility of body armour, since his neck would still have been unprotected, by a man responsible for deciding the working distance for hundreds of deminers.

Of course, clearance priorities are always a compromise. The faster you clear the fewer civilian casualties there are: the slower and more cautiously you clear, the fewer demining casualties there are. Deminers are civilians (even if they are ex-soldiers) which blurs the distinction. The question is "would increasing the distance between deminers slow things down?" The minefields are big enough, so the only obvious disadvantage is that the supervisors would have further to walk.



Edge of Minefield

The value of life?

The underlying tone of the senior demining personnel that we interviewed was perhaps only a reflection of a military mindset, but it involved an acceptance of risk that would not be allowable in non-military mine clearance in Western Europe. Their demining personnel are almost all drawn from both sides in a conflict that lasted many years and was preceded by an overtly racist colonial system. They all have little or no schooling and are unsophisticated. It is probably true to say they have no other means of earning a sustainable living in a country with a ruined economy. Also, their previous experiences must have often

UNADP toolsanother look

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involved higher daily risks than they take now, and smaller rewards. Many are obviously satisfied by conditions and grateful for the work. They have little choice. For US$ 120 a month indigenous deminers must accept the absolute authority of their better trained and "better" experienced superiors or else be immediately replaced. The senior personnel, by contrast, are there by choice, presumably attracted by the money and by the chance to do something useful.

The senior personnel we met were not macho. But if you work with explosives and a military mindset you run the risk of sinking into an acceptance that life is cheap that may lead to more risk being taken than is strictly necessary. This attitude may be reinforced when the ordinary deminers seem satisfied and do not complain.

"They take risks. They get careless. Its hard enough imposing the safety measures we have in practice now."

These voices make sense. But Halo Trust use body

Basketry in the market

armour, and it is not relevant that they also have accidents. The unspoken message attached to each protective item they wear is that they value their ground-staff more than others, even if that is not really the case. Shouldn't the valued-staff message be more general?

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Appendix C: Mines and ordnance reported

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