Reducing Accidents in Demining: Achievements in Afghanistan

James Trevelyan
Department of mechanical and Materials Engineering,
The University of Western Australia, Nedlands 6907
E-mail: jamest@mech.uwa.edu.au

Abstract

This paper describes recent developments in the Afghanistan demining program which have resulted in a significant reduction in the accident rate. Many changes have been made to operating procedures and the culture of the organisations involved since 1996. It is interesting to observe that many of the changes reflect practices which would be regarded as "world best practice" in Western industries. The fact that most of these developments have taken place in isolation reflects great credit on the program management and the participants. The experience in Afghanistan could serve as a useful model for other demining organisations where accident rates are causing serious concern.

The safety issue is closely linked to quality. Quality in demining can only be achieved with careful work by deminers, and the same work practices also lead to safety. Demining programs are now recognising the need for rigorous quality control in order to achieve safety at the same time.

Introduction

An expatriate military adviser in Bosnia inspired me to write this paper when he explained his opinion that demining accidents were "a statistical certainty". I had just arrived in Bosnia after visiting Pakistan where I had conducted extensive interviews with deminers and their advisers to learn how they had managed to obtain large reductions in demining accidents. I realised that some of the techniques that the Afghan deminers had devised for themselves had much wider applicability.

Two days previously I had attended a meeting of demining managers in Bosnia at which the Mine Action Centre director, Mr. Filipovic, had demanded that from henceforth all demining procedures would be followed rigorously. His remark had been prompted by a run of fatal accidents involving the feared PROM-1 fragmentation mine in which, it had been shown, deminers were not following the standing operating procedures (SOP). His words had barely faded from the echoing walls when yet another accident occurred for the same reason.

By 1997, demining operations in Afghanistan had acquired a reputation for fatalism and risk taking by deminers. With 50 to 60 accidents each year among 2000 deminers, the Afghanistan mine action program was seen by many in the industry as intrinsically dangerous and perhaps, even, out of control.

Bill van Ree, the program manager at the time, explained to me later that Afghan deminers would approach him after a run of accidents and ask him "Mr Bill, what are you going to do about these accidents?" Yet by 1995 he had realised that the accident rate would only be reduced once deminers themselves accepted their part in the responsibility for accidents.

It is easy to accept the stereotypical view of the Afghan deminer as a fatalist: "If it is the will of Allah that today I will have an accident, then, today I will have an accident". However, Bill van Ree realised that stereotypes can be incorrect and started a complete overhaul of attitudes in the demining program. His successor, Ian Bullpitt, continued this effort which was extraordinarily successful. In the first half of 1999 there were only 10 demining accidents in the entire program. 1998 had brought a 50% reduction in accidents compared to the previous year. The trend was continuing in 1999 until the third quarter when there was a significant upturn in the accident rate which has prompted a further review of the program. In spite of this the Afghanistan demining program has achieved an enviable safety improvement which could provide a useful example for other demining programs.

A comparison of accident rates between Afghanistan and Cambodia, which have similar extensively manual demining programs, shows that the accident rate in Afghanistan before 1997 was much greater than that for Cambodia. (See Appendix 1) However, close analysis reveals that most of the Afghanistan accidents occurred while deminers where prodding and investigating PMN-1 mines. These mines are intrinsically more dangerous than the common PMN-2 mine in Cambodia. Furthermore, the ground conditions in Afghanistan are more likely to lead to prodding accidents: extensive vegetation roots grow around buried mines in Cambodia reinforcing the soil. This means that it is easier to detonate a PMN-1 mine by accident in Afghanistan than to do the same with a PMN-2 mine in Cambodia. This hypothesis remains to be formally tested but it could explain most of the difference in accident rates between the two programs before 1997.

One further observation is useful. The construction industry in Pakistan accepts an accident rate of 3 percent as normal. Only serious accidents are included in this: those which result in serious injuries requiring hospital treatment or causing death. With 2000 deminers, one could expect 60 accidents per year on this basis. While this accident rate would be entirely unacceptable in a Western environment, it serves as a useful comparison.

Western Industrial Practice

Industrial practices in the West have led to immense improvements in safety in many industries. Aviation, the chemical industry, the nuclear industry, construction, mining, offshore oil and gas production: all these industries have devised strategies to minimise accidents. Many lessons have been learnt from these industries.

One of the main lessons is that there is an intrinsic link between safety and quality. The practices which lead to high quality work also, usually, lead to safe working conditions. The methods of quality improvement pioneered by Deming and applied so successfully by Japanese companies can also lead to significant safety improvements. "Kaizen", the practice of continuous improvement with small changes, has been widely applied in all these industries. Another practice, widely applied, is the distribution of responsibility within work teams. Authoritarian models of organisations proved to be inappropriate for achieving high quality and high safety. Industries learned that high quality results could only be achieved through high quality work practices. This could not be achieved through rules, regulations, and close supervision without the active cooperation of the workforce. By placing more responsibility in the hands of individual workers, even to the extent that they could choose their tools and equipment, companies found improved quality, safety, and even productivity.

Many of these techniques are well documented in industrial literature. They are part of the normal teaching curriculum for industrial engineering students in most Western universities.

What surprised me most about this research was the discovery that many of these techniques had been reinvented by Afghan demining organisations in response to their particular problems in safety and quality.

Initial Investigations

By 1997 a large database had been collected on demining accidents by the Mine Action Program for Afghanistan (MAPA). Each accident is investigated by an independent monitoring agency and a detailed report is submitted to the mine action program manager. This report runs to 30 of 40 pages and includes:

A summary report by the investigators

Interviews with the deminer (S.) involved

Interviews with the supervisor and team leader

Report of an inspection of the accident site with photographs

Medical reports from the hospital receiving injured personnel

Post recovery reports on injured personnel

Details of injuries received together with photographs of injured personnel immediately after the accident

Recommendations for changes to procedures or protective equipment.

One of the first steps towards reducing the accidents was a statistical analysis in an attempt to discover factors common to the majority of accidents. As a result it was possible to describe the "typical demining accident". Such an accident occurred at 08:30 in summer while a deminer was prodding a PMN-1 mine, often when the deminer was working in a difficult position such as in an irrigation channel, on a steep slope, in thick vegetation or in ruined houses.

Some factors turned out to be false leads. While one might have suspected that deminers would become fatigued in the heat of summer, most accidents occurred well before the hottest part of the day.

We became involved on the periphery of this effort as we worked to devise cost-effective protective equipment for deminers (Trevelyan 1999). We focused on prodding accidents and produced prototypes of improved head and face protection visors and helmets, prodders with safety guards to protect hands, and an apron to protect the body. We focused on the reasons why most deminers worked in the squatting position, contrary to standing operating procedures which require that deminers lie on the ground while investigating targets. We devised effective protection to enable them to work in the squatting position. We concluded that the squatting position is far more comfortable and probably more effective from and ergonomic standpoint. We also discovered that deminers are reluctant to lie on the ground because it is so difficult to keep their uniforms looking smart. Deminers are widely regarded in Afghanistan as a high status group: wearing dirty clothes detract from their status in their own eyes.

However, the main priority for mine action program management was in avoiding accidents.

Demining Organisations in Afghanistan

The United Nations Office for Coordinating Humanitarian Assistance in Afghanistan (UNOCHA) operates the mine action centre at its head office in Islamabad, Pakistan. The program manager, deputy manager and logistics officer and a technical adviser (expatriate staff) are based in the office with an Operations Manager and support staff (Afghan). Communications are provided by the main UNOCHA office. The other expatriates are a technical adviser based with META in Jalalabad and a regional manager based in Kabul. All the other 4000 (approx) staff are Afghans working for a number of independent non government organisations (NGO's) that implement the mine action program in Afghanistan.

The Monitoring, Evaluation and Training Agency (META) is based in Jalalabad (near the eastern border with Pakistan) and provides training courses for the entire program. As the name suggests, META is an independent agency responsible for accident investigations, monitoring demining quality standards, quality control checks and several other tasks, under the general direction of the program manager. Their role in quality control is currently undergoing a major restructuring.

The Mine Clearance and Planning Agency (MCPA), with its head office co-located with MAPA in Islamabad, carries out level 1 and level 2 surveys and maintains maps and databases for the entire program.

Afghan Technical Consultants (ATC), a UNOCHA partner, is the oldest and largest demining NGO in Afghanistan. It was established in October 1989 by the present director Mr. Kefayatullah Eblagh. ATC started demining operations in early 1990 with an initial staff of thirty-five. Since then, it has undergone significant change and expansion. ATC has developed into a highly organized and effective NGO employing about 1300 personnel. The head office is in Peshawar, Pakistan.

The Mine Dog Centre (MDC) was formed early in the program to train and operate the mine detection dog program which also commenced in 1990. Originally based in Pakistan, MDC has now moved to a new headquarters and training centre in Kabul.

Two other Afghan NGO's carry out demining operations: Demining Agency for Afghanistan (DAFA) in Kandahar and Organisation for Mine Clearance and Afghan Rehabilitation (OMAR) in Heart (Maley 1998).

HALO Trust is the only foreign demining NGO and operates in Kabul and the northern areas where fighting continues.

Mine clearance operations primarily rely on manual demining, with dogs being used on suitable tasks, and mechanical support (back hoes) in residential areas and for excavating mined irrigation channels. For more details, refer to Trevelyan (2000).

Organisational Changes

Work procedures

Kefayatullah Eblagh, director of ATC, explained to me that his first step towards reducing accidents was to accept responsibility. ATC is a paramilitary organisation modelled in a uniquely Afghan style. The director is not only an authoritarian figure but also a caring parent to his entire workforce. He has to assume responsibility for caring for the families of deminers

injured or killed in accidents. Deminers take their personal problems to the director at any time: it is a demanding job for any person. ATC has undergone many changes in the effort to reduce accidents and improve quality and safety.

ATC deminers work in teams of 30 men. Each team has 12 breaching parties of 2 men each. In the early days of demining each breaching party consisted of three men. One man would be responsible for using the metal detector. The second man would investigate targets located with the metal detector with a prodder and the third man would watch from a safe distance to monitor the actions of his colleagues.

In the 3-man drill, and initially with the 2-man drill, deminers were specialised: one was trained to operate the metal detector while the other investigated targets with the prodder. Later the 2-man drill was changed: each deminer operated the metal detector and investigated the targets he located. This reduced the chance of incorrectly marking target locations, the suspected cause of several incidents. It should be noted that Afghan deminers use painted rocks to mark minefield boundaries and suspected target locations. Lane boundaries are marked with steel rods and rope. On the other hand, Cambodian deminers always operate on a half metre deep by a 1 metre wide strip at the end of the lane which is marked by wooden poles. Although the Cambodian practice takes slightly more time, it is probably safer than the Afghan methods.

The two-man drill was initially introduced to improve efficiency and productivity. The first man used the metal detector and investigated targets with a prodder while the second man watched from a "safe" distance. After 20 to 30 minutes they would exchange roles. A rest break would be taken by all personnel after a two-hour spell.

Four section leaders monitor the actions of the breaching parties and record their work. A team leader monitors the entire team, coordinates transport, and handles communications, record keeping and other administrative functions. Each team also has a driver and a paramedic on standby in case an accident occurs.

One of the first changes made to improve safety was to change the 2-man drill. ATC suspected that the deminers needed more rest. Therefore they decided to test a new arrangement in which one man would work for 20 minutes with metal detector and prodder while his partner rested some distance away, in the shade, with refreshments if required. The entire responsibility for supervision was placed with the section leader instead. With the deminers resting every 20 minutes and the section leaders sharing each other's supervision the rest breaks every two hours could be dispensed with. There was a reduced risk of dehydration in the summer heat and greater working efficiency.

Sleep

Lack of sleep was also a suspected cause of fatigue among deminers. The Afghan deminers wake as early as 3:30 in summer for dawn prayers yet "lights out" time in the evening is 9:30pm. While there was an opportunity to rest between prayers and breakfast ATC decided that more rest was required. Therefore the daily schedule was rearranged. The original summer time schedule is shown in Table 1. Times are approximate: prayer times depend on sunrise and sunset and other activities are scheduled around prayer times.

4.00	Wake, prepare for prayers

4.30	Breakfast
5.30	Morning parade, prayer for safety, address by site manager
6.00	Depart for work site (approx half hour transit)
6.30	Commence work
8.30	1st Break
11.00	2nd Break
1.30	Finish work in minefield, prayers, return to camp
2.00	Lunch
3.30	Afternoon prayer, equipment maintenance
6.00	Sunset prayer
6.30	Dinner
7.30	Evening prayer
9.30	Bed and lights out
10.30	Radio shut-down

Table 1: First Summer Schedule

4.00	Wake, prepare for prayers
4.30	Breakfast
5.30	Morning parade, prayer for safety, address by site manager
6.00	Depart for work site (approx half hour transit)
6.30	Commence work
12.30	Finish work at minefield, on-site safety review.
1.00	Return to camp, prayers
1.30	Lunch
2.00	Compulsory sleep
4.00	Afternoon prayer
4.15	Training session, review of operations, daily activity reports, equipment maintenance.
6.00	Sunset prayer
6.30	Dinner

7.30	Evening prayer
9.30	Bed and lights out
10.30	Radio shut-down

Table 2: Revised summer schedule to improve sleep pattern.

Safety Awareness

Accident investigation reports nearly always emphasised a failure to follow standing operating procedures as the main contributing cause. While deminers often did not follow the correct procedures this was often due to circumstances at the particular site rather than negligence.

This is apart from the widespread practice of squatting during demining, contrary to the required standing operating procedure (SOP. Some other variations on the SOP's are widely practiced, such as reducing the number of marking stones when marking the location of a metal detector indication. This information comes from deminers: when they are aware of the presence of staff of site manager or higher status, or visitors, they will always revert to SOP's.

ATC recognised that if there was to be any variation in the standard procedures the implications had to be examined first. Therefore they decided to implement a daily meeting among the deminers to discuss safety and the need for special procedures at the particular site. The daily safety briefing, therefore, was used to review this and to discuss particular safety hazards or technical problems at the site. Deminers could voice their own opinions to their team leader and also report "near misses": situations which could have led to an accident but did not.

Weekend Leave

A further move to improve rest and reduced fatigue was to place restrictions on weekend leave for deminers. Deminers are normally based at camps close to the work site. 3 teams are normally based together at the same camp which is called a "project site" with a resident site manager. ATC decided that deminers would not be allowed to travel home at the weekend.

Before this was enforced there were many problems:

> There were transport difficulties and deminers arrived back late on Sunday night because transport is so unreliable. For many deminers visiting their families meant travelling all awayto Peshawar in Pakistan.
>
> There was also loss of sleep due to social activities with the families on the weekend.
>
> There were security problems. For example deminers were arrested and detained by authorities for being in areas in which they were not authorised to stay.
>
> There were traffic accidents and deminers were delayed because of them.
>
> While at home, the deminers chatted with their friends and families and, as a result of this, distorted and incorrect information was passed on to the Taliban authorities causing problems for the mine clearance agencies.

Leave schedule

Deminers have 30 days of paid annual leave. Eight days are set aside for the Eid holiday leaving 22 other days. Each team is given eight days paid leave after two months. ATC allows two

days for travelling to reach family homes and two days to return. Many deminers take four extra days from their annual leave to increase these breaks to 12 days.

Responsibility in supervision

ATC also recognised that when deminers failed to follow agreed procedures, supervisors had to share the responsibility. Section leaders often have a problem when a deminer persistently refuses to follow their directions. It is not uncommon for the section leader simply to "give up" in such circumstances and let the deminer take responsibility for his own safety.

To reduce the chance of this ATC decided that section and team leaders would be demoted one level immediately after an accident and their pay and position would only be restored if the subsequent investigation showed they were carrying out their responsibilities correctly. To implement this ATC required prompt feedback on the causes of an accident. The independent accident investigator, the Mine Evaluation and Training Agency (META) required several weeks, even months, to complete their accident report. Therefore ATC had to have their own investigation capability. Staff are delegated for accident investigation whenever the need arises. Typically, the site manager and two section leaders from other teams will be assigned to the investigation.

Changing the culture

Just as experience in western industries has shown, it is necessary to change the culture of an authoritarian organisation to obtain significant safety and quality improvements. Responsibility has to be delegated and shared appropriately at different levels of the organisation. Deminers have to have a degree of discretion in deciding how to approach each task. It is simply not possible to devise foolproof procedures for every conceivable minefield situation on every different type of ground, slope, soil type, vegetation type and for each different kind of mine threat.

Afghan culture tends to resent centralised authority so it is remarkable that organisations as large as ATC with 1500 staff can operate with such high levels of reliability. This is all the more remarkable when one realises that the demining organisations are practically the only sign of large-scale disciplined organisation in the entire country. They operate in a vacuum, surrounded by chaos, disintegration, extreme poverty and deprivation. The social institutions we take for granted in western countries simply do not exist. There is usually no electric power, no police force, no coherently organised system of justice, no social security, no post office, and no telephones.

Sharing responsibility could be regarded as foolhardy in these circumstances. Yet the experience of ATC shows that it is possible and has led to significant safety improvements. The other demining organisations adopted many of the changes pioneered by ATC.

The Views of Deminers

As part of research on the technology needs of deminers we interviewed several deminers and staff in different organisations. Some of their opinions and quotes make interesting and informative reading.

In the words of an operations manager based in Peshawar, "The only time I experience a bad day in my job is when I receive a report of an accident in a minefield. That is a very depressing

experience. Fortunately we are making big improvements. In the first six months of 1997 we had 17 accidents. In the same period of 1988 we had seven accidents. This year (1999) we have had only one accident in the same period. I am still concerned about July: it is the hottest months of the year and a bad time for accidents."

In the words of a deminer, "One of the teams at our site had two accidents last month. One of the deminers had several arguments with his partner. His original partner had fallen sick and had gone home for several weeks leave. The new partner did not get on with him well at all. Then there was an accident. I do not know what the cause was but I am sure that if they had not been arguing the accident would not happened. In my team if a deminer is upset or angry he is not allowed to work that day. Even though it is harder to keep up with the schedule, we feel safer that way. Also, deminers are less likely to be angry or upset if they know that all the rest of the team has to make up for their work."

In the words of another deminer, "One of our problems is that we are always being asked to work faster. We have heard that teams which work too slowly may not get any work contracts. It is difficult when you work in a minefield with many many fragments and you can only work slowly in this kind of minefield."

Another deminer remarked: "The safety meetings are good idea. We discuss mistakes to make sure the work is done correctly. People forget the correct procedures and when the problem is discussed we remember our training. Sometimes I mention mistakes I have made myself. Often I only tell them to my friends in my tent and I give thanks to God that I am safe and I try and tell them not to do it again. Sometimes I also tell the team leader but not always. The team leader says please be careful and don't do that again".

Training

The Afghanistan demining program has a highly organised system of training deminers and providing them with refresher courses every six months. Separate training courses are run for supervisors, team leaders, UXO specialists, communications staff by the independent Mine Evaluation and Training Agency (META). In addition to this ATC runs many internal training courses for its staff. English classes are provided both for administration and demining personnel who want to learn. Practically all of the administration staff have been trained to use computers. Many other specialised training courses have been run using both internal and external instructors. The level of training has reached the point where a significant number of ATC staff are being recruited by international demining agencies for work in other countries. ATC deminers, supervisors, and administration staff are now working in Iraq, Somalia and elsewhere.

Comparison with Western Practice

We can see several significant parallels between the changes introduced to ATC to improve safety and what would be regarded as "best practice" in western industries.

The organisation devotes significant resources to improving its "human capital". Apart from support for deminers families and help with personal crises, the organisation provides significant training and career development opportunities to its staff.

Responsibility is delegated across the organisation rather than being concentrated at the top. Team leaders, supervisors, and deminers all contribute to discussions on safety and the techniques which should be used to deal with particular minefield problems. Team leaders and

supervisors carry significant responsibility and pay the penalty if an accident occurs in their team.

Safety and the need to be cautious is reinforced daily at the safety briefings. Deminers are not allowed to forget the need to be careful at all times to avoid accidents.

The organisation pays careful attention to the health and well-being of deminers. While recognising the importance of home leave, discipline is imposed to ensure that deminers are in top physical condition for the job they have to do.

In contrast to the stereotypical fatalist image of an Afghan deminer, all staff accept that accidents have human causes and can be prevented. An accident represents organisational failure as much as human failure.

Further Improvements

Broadly speaking there are three classes of accidents in demining. One class of accident occurs while a mine is being investigated or destroyed. Another class of accident occurs because deminers walk on a mine which has been missed. The third class of accident occurs when deminers walk in areas of ground which have not yet been cleared.

Understanding this leads to the close link between safety and quality in demining, as in any other industry. If a deminer steps on a mine which has been missed, he is the victim of poor quality work by other deminers, or possibly his own work. It is this link which is being targeted in the Afghanistan mine action program currently in a major overhaul of quality assurance procedures.

Currently, deminers check their work in an informal manner. As one deminer walks forward to resume work at the end of a lane he sweeps his detector from side to side to check for metal targets which may have been missed. From our observations of deminers working in a simulated minefield in Islamabad, Pakistan, this checking is not very thorough but it does reveal missed targets. After completing the clearance of a significant area, deminers may check the area once again with a metal detector.

In a carefully documented test we observed an instance of a serious error which could lead to accidents. When one deminer has finished working at the end of a lane he usually marks the last position cleared with a painted stone or by leaving his detector lying across the lane at the end of the safe area. We observed how one deminer located a metal target forward of his position and on the left-hand side of the lane. (See diagram) After he had located the metal fragment, he marked the target location with a stone. His partner thought that the stone marked the end of the safe area. As the diagram shows it did not: it marked the location of the last target removed. The area to the right of the stone had not been cleared but the second deminer missed this area which happened to contain two targets which could easily have been discovered with a metal detector. The targets were missed again when they carried out a final check of the area.

In an effort to overcome errors such as this, Afghan demining NGOs are working on a system of comprehensive quality checking. It has been proposed that each deminer will thoroughly check the ground cleared by his partner in the most recent spell. The partner will commence checking at the point at which he last worked and work forward to he reaches the end of the area his partner cleared. In addition, each section leader will also conduct a 100 percent check of the area cleared by the deminers working under him. Finally the team leader will check 25% of the entire area cleared by the team. This procedure will add significant costs to clearance operations. It is clearly impractical for a supervisor to check ground adjacent to where deminers are currently

working. Further, the supervisor cannot do the checking while he is expected to supervise deminers at the same time. Approximate calculations suggest that the extra work involved will add perhaps 10% to the cost of clearance. However this reflects a significant emphasis on safety and quality and will reduce the amount of reworking required.

Another important issue is that quality ultimately depends on the care with which the work is done in the first place by the original deminer. The comprehensive checking procedure described above may not improve the quality of the initial demining without significant incentives. If deminers know that the area they have cleared is going to be checked again, they may think that it is okay to leave at target unchecked every now and again. On the other hand, especially if there is some degree of embarrassment or penalty associated with the discovery of a target missed by a deminer, working standards could improve.

Finally it is necessary to remember that this proposal has been stimulated by a significant rise in the accident rate after a long period of decline. It is possible that this reflects a common industrial problem. Major changes to work practices which improve safety have a limited lifetime. After a while workers develop a false sense of security and stop paying so much attention to their work practices. It is necessary to introduce further changes to avoid this. Constant vigilance is necessary to maintain standards and experience in Western industries suggests that constant change is also required.

Acknowledgements and Principal Sources

Much of the material for this paper was obtained through interviews with Kefayatullah Eblagh, director of ATC (Afghan Technical Consultants) between June 1997 and January 2000. Other material was gathered from interviews with deminers, senior staff of demining agencies, and expatriate Technical advisers and program managers of the mine clearance program for Afghanistan. There assistance in providing this information is gratefully acknowledged.

For further details, readers are asked to contact the author or the Mine Action Programme for Afghanistan head office in Islamabad, Pakistan.

Some additional material was obtained from interviews with staff and deminers in Bosnia-Herzegovina and Croatia in August 1999. Their assistance is also gratefully acknowledged.

Most of our work is supported financially by the Night Vision and Electronic Sensors Directorate of the US Army, Fort Belvoir, Virginia. The author would like to acknowledge contributions from colleagues, Hameed and Ali Research Centre, many demining personnel who have helped with this research, and Sabbia Tilli, and Samina Yasmeen and her family.

Other Sources

Blaikie, N. (1993) Approaches to Social Equity; Polity Press, Oxford.

Maley, W. (1998) Mine action in Afghanistan, School of Politics, Australian Defence Force Academy, Canberra, available from: http://www.pol.adfa.oz.au/resources/mine_action.html.

MAPA (Mine Action Programme Afghanistan) (1997), Notes of interviews on standing procedures - available from the author.

MAPA (Mine Action Programme Afghanistan) (1998). United Nations Mine Action Programme Afghanistan: Work Programme 1998.

Trevelyan, J. P. (1997). Better tools for deminers, Proceedings of International Workshop on Sustainable Humanitarian Demining, Zagreb, September 1997, pp s6.1-s6.12.

Trevelyan, J. P. (1998) Web address http://www.mech.uwa.edu.au/jpt/demining/; Department of Mechanical & Materials Engineering, University of Western Australia.

Trevelyan, J. P. (1999) Protecting Deminers and Reducing Accident Frequency, Proceedings of Mine Warfare Association Conference, Sydney, July 1999 (to appear - available from author).

Trevelyan J. P. (2000) Demining Research at University of Western Australia, CD-ROM and web site, Department of Mechanical and Materials Engineering, The University of Western Australia, Nedlands 6907, http://www.mech.uwa.edu.au/jpt/demining/.

Appendix 1

Table A1 - Summary of Afghanistan Demining Incidents Jan - Nov 1997

36 prodding incidents	30 with PMN
	3 with PMN-2
	1 with grenade fuze
	2 with POM-Z tripwires
7 incidents step on blast mine	7 on PMN (all on soft ground or hillsides)
	1 on PMN-2 (late November - wet ground?)
5 non-prodding UXO	1 touching, 2 carrying, 1 detecting, 1 placing charge
1 booby trap incident	detecting
Prodding incidents by month:	
January	3
February	1
March	2
April	1
May	6
June	6
July	3
August	6
September	3
October	4
November	1

Table A2: Summary of Mine Incidents in DU2 of CMAC 1993 - May 1998

1: deminer lost left leg after treading on a PMN-2 mine.
2: deminer lost right leg after treading on a PMN-2 mine.
3: deminer lost left leg after treading on a PMN-2 mine.
4: deminer lost right leg after treading on a type-72 mine.
5: deminer blinded in one eye after type-72 mine exploded during prodding.
6: deminer lost right leg after treading on a type-72 mine.
7: deminer blinded in one eye and lost one finger after pressing detector on top of PMN-2 mine - deminer may have slipped on slippery slope.
8: deminer lost left arm, fingers on right hand, and blinded in one eye by PMN-2 mine explosion: was trying to dismantle live mine to recover explosive for fishing.

Tables 1 and 2 enable a comparison between Cambodian and Afghanistan demining operations. In the Cambodian operation examined, one sees only one prodding incident per year whereas one would expect 12 per year given Afghan incident rates. There have been 7 other incidents whereas one would expect 3 per year.

We are waiting for statistics from other Cambodian demining operations. However, given the large number of deminers working in DU2, the available statistics provide a large enough sample to draw some interesting conclusions.

The difference in the prodding incident rate is much greater than the difference in rates for other incidents. This suggests that there may be some fundamental factors which explain the differences between prodding incident rates and that deminer discipline may not be so significant.

The difference in rates for other incidents is significant, but not by such a huge margin.

Civilian Casualties

A further informal observation from Cambodia is a surprisingly low rate of civilian and animal casualties. Many hundreds of desperate displaced people have moved into mined areas on either side of roads and have set up villages, roadside stalls and have ploughed rice padis with bullocks.

When demining starts, it is common to find many mines within a metre or two of the road edge and round huts where many people and animals have been regularly walking by.

Given the density of human and animal activity one is left to wonder whether many of the mines may no longer be operable, or whether there are other factors which prevent the mines from being triggered.

Why so Few Prodding Incidents in Cambodia?

The design of different AP mines provides an interesting hypothesis to explain these differences.

The most common AP mine in Afghanistan is the PMN-1 mine which is activated by a pressure plate under a rubber cap which extends across top of mine. About 3 kg nominal force is needed at the centre. About 1 kg of soil is carried by the cap for each 5 cm of depth though the soil will generally be stable until disturbed. Given the mechanical action of the mine, the force needed to set it off is considerably less than the 3 kg nominal force if applied at the edge of the pressure plate. In Cambodia, in the area examined, the most common mine is the PMN-2. The activation force is slightly greater but only 30% of the area of the top of the mine responds to pressure. The rest supports the soil over the mine, greatly increasing the soil failure load needed to set the mine off. In addition, the virulent root growth around mines in the ground in Cambodia provides additional soil strength. Only in the wet season will the ground soften sufficiently to enable people to set off mines. And this is what informal reports suggest. Cambodians living in mined areas take more precautions in the wet season.