Engineering Skills in Mine Action

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Abstract

The global landmine problem came to the attention of researchers in the mid 1990's and by 1997 several advanced and expensive sensor research programs had started. Yet, by the end of 2004, there is still frustration with the apparent lack of productivity improvement in humanitarian demining, especially with new technologies. Given the motivation and dedication of researchers, public goodwill to support such programs, and substantial research resources devoted to the problem, it is worth asking why these programs do not seem to have had an impact on demining costs or casualty rates. Perhaps there are factors that have been overlooked.

A possible explanation is that researchers have accepted mistaken ideas on the nature of the landmine problems that need to be solved. Another explanation may lie in the political and economic realities that drive the worldwide effort to eliminate landmines. Most of the resources devoted to landmine clearance programs come from humanitarian aid budgets: landmine affected countries often contribute only a small proportion because they have different priorities based on realistic risk-based assessment of needs and political views of local people. Finally, there is a common misperception that costs in less developed countries are intrinsically low, reflecting low rates paid for almost all classes of skilled labour. When actual productivity is taken into account, real costs can be higher than industrialized countries. The costs of implementing technological solutions (even using simple technologies) are often significantly under-estimated.

A new appreciation of engineering skills can provide useful insights into these problems and an explanation for high operating costs. The current skill sets in typical mine action organisations need significant further development to achieve operating efficiency improvements.

1. Introduction

This paper aims to discuss the need for cost-effective sustainable mine action programs, principally the engineering components of survey and ordnance clearance.

Most of the funding for landmine clearance is supplied from foreign aid budgets in the major industrialised countries: USA, Canada, Europe, Scandinavia, Australia, United Arab Emirates and Japan. There have been many attempts at "local capacity building" with the aim of enabling countries to deal with their own landmine problems rather than relying on foreign aid donations. These attempts have not been widely successful because in many countries landmine clearance is not one of the highest priorities for their local populations. This may be surprising to many people who live in Western countries for whom landmines seem to be a major worldwide problem.

I visited Cambodia in 1998. As part of my visit I spent several hours discussing everyday problems with local people in Battambang, a town in the centre of one of the worst affected areas with landmines in Cambodia. I asked them to tell me about all the different problems that they faced. The first problem they talked about was finding enough water to drink: the typical house in that part of Cambodia has four large earthen jars in which rainwater collects, one at each corner of the roof. Usually there is almost no rain between December and June. A town water supply was their greatest need. They talked about poor drainage and sanitation facilities and how many of their children either died or were seriously ill from malaria, hepatitis, cholera and typhoid. They told me they would like medical clinics to provide more effective treatment for their children and schools with trained teachers to provide a sound education. At the time of my visit there were no telephones in Battambang except in government offices and the satellite phones owned by demining NGOs and other aid agencies. They also told me how much improvement in agricultural production would be possible if they had irrigation water, fertiliser and improved seed varieties. After two hours in which landmines had not been mentioned once, I finally had to ask them about landmines: how did the landmine problem affect their lives? They told me that if all the other problems were solved they would be able to deal with the landmine problem themselves. Of course, landmine contamination does interfere with the solution of some of their issues.

This perception can be further supported on a qualitative basis by comparing landmine incident statistics in Cambodia with road accident statistics in Australia. Although Cambodian statistics can be been questioned, it is generally acknowledged that the number of landmine incidents causing injuries and death is between 1000 and 2000 each year. Australia, with around twice the population of Cambodia, has approximately 40,000 deaths and serious injuries resulting from road accidents every year. (I have included injuries that involve serious hospital treatment roughly equivalent in physiological impact to typical landmine injuries). Although people in Australia see road accidents as a major problem there are many other issues that justify much higher levels of public expenditure where investment can achieve more significant benefits. Therefore it is not unreasonable that Cambodian government resources are directed at improvements in security, transport, water supply and sanitation, education and communications: these priorities reflect community views. Expenditure on landmines is still a priority but less so than other issues. This helps to explain why countries like Cambodia spend relatively little on landmine remediation and rely almost entirely on foreign aid donations.

1.1 High cost operating environment

Contrary to popular perceptions, operations in mine-affected regions, like many developing countries, tend to be expensive and it is easy to underestimate operational expenses.

There is a widespread perception in industrialised countries that costs in less developed countries are lower. Often this comes from experience as a "backpacker". Living and working in the same environment is quite a different experience. Whatever the activity, input costs are almost certainly higher. Electricity, when available at the meter, often costs more. However it may only be available for a few hours per day so most businesses will require their own generation capacity resulting in energy costs between two and 10 times higher than in a typical industrialised country. Most necessities have to be imported adding significantly to the cost: transport, customs duties, sales tax, bribes and facilitation charges can add between 50 and 200% of the original cost. Telephone facilities in some developing countries are very good but in others may be nonexistent and organisations may require satellite phones, VHF and HF radio for reliable communications. Mobile telephones are often available in urban environments but are seldom provided in areas where landmine contamination occurs.

Access to health facilities is expensive and typically remote. Exposure to disease pathogens in the environment is high and insurance premiums are high because of high risks. Accommodation providing a reasonable level of comfort and security, particularly for wives and children, can be as expensive as in any industrialised country.

Above all, general education levels are low, and the simple task of getting something done can cost far more than one might think.

Take for example the simple task of delivering a package to a business associate. In Australia your secretary would simply arrange for a local courier company to deliver the package for a fee of about $7. In a typical developing country environment you would usually entrust this task to an office boy. He would be required to wait at the destination and deliver the package to the intended recipient in person, obtaining his signature. He may have to wait for the whole day to do this. Packages left with typical reception staff can be placed under the desk and lie unnoticed for weeks. The office boy is probably paid a salary of $80 per month, around $1,000 per year. The overheads associated with employing a person like this can be between $4,500 and $7,000 per year, bringing the total daily cost to between $25 and $40. Add to that the cost of transport and it is not hard to see how the cost can be considerably higher than in Australia.

Beyond the priorities and cost issues affecting local capacity building lies the shortage of engineering skills discussed in the later parts of this paper.

2. Factors that affect research productivity

A different issue that is also relevant for this conference is the need to understand why extensive research and development aimed at solving the global landmine problem has produced disappointing results. Trevelyan (2004a) is a response to this issue but aimed at a largely technical audience.

Trevelyan (2004a) argues that researchers have accepted mistaken ideas on the nature of the landmine problems that need to be solved. The paper provides several examples where the realities of minefield conditions are quite different to what researchers have been led to believe. The paper also argues that most researchers have focused on the problem of *locating mines* rather than *confirming the absence of mines without removing vegetation or rubble*. A solution to the latter problem could greatly reduce mine clearance costs by avoiding the need to clear suspected contaminated land areas where there are no mines or UXO. Manual deminers work surprisingly fast in discriminating between scrap metal fragments located with metal detectors and mines or UXO. If this level of performance had been more widely appreciated, there would have been no need to research many rather slow detection technologies.

Since the initial rush of enthusiasm amongst researchers worldwide to find a solution for the landmine problem several other attractive research prospects for talented researchers have emerged in academic communities. Biomedical engineering is attracting some of the best academic talent worldwide as the reliability of robotics and sensor technology has reached the stage where large-scale application to medicine at last seems feasible. National budgets for medical research in industrialised countries dwarf most other sources of research funding. Advances in high-speed computing have attracted researchers to study a vast range of problems associated with monitoring the condition of machinery and process plants to predict failures. This is an attractive area for commercially sponsored research and development. Finally, alternative sources of energy and efficiency improvements are now, once again, at the top of the research agenda world-wide.

Research on landmine technology is still dominated by military interests who are more concerned with the threats posed by modern ordnance and improvised explosive devices than landmines that have been lying in the ground for decades.

Finally, a degree of operational stability is needed for a mine action organisation to collaborate effectively with researchers. Liaison personnel need to be in place for extended periods to learn what researchers can contribute and for researchers to gain effective access to observe operations at first hand. In Iraq and Afghanistan and some other countries, the lack of security and the continuing 'emergency' nature of mine action programs prevents effective collaboration with researchers. In other countries, liaison staff often change after a few months, once again preventing effective interactions.

All these factors are contributing to the low levels of success in research programs on humanitarian landmine problems.

3. Engineering Skills Issues in Mine Action

The essence of engineering is the effective application of technology to solve human problems with predictable cost, performance and timescale. This relies on a combination of appropriate technology and organisations with effective skills to deliver the results.

The agenda for this conference is primarily concerned with new technologies for mine action. However, there is now sufficient evidence over the last 10 years for us to see that technology alone has not delivered the desired results. Even though many might argue that the technology basis for mine action has not changed, we must recognise that several technology advances have helped:

- Use of mine detection dogs
- Improved metal detection technology
- Improved personal protection and hand tools
- Mechanisation (blast and fragment protection, vegetation cutting, ground preparation, loaders, sifters, adaptation of commercial machinery, magnets to collect fragments etc.)
- Data acquisition and data base management (IMSMA, Spatial GIS, Aerial surveys, GPS etc)
- Communications technologies (mobile telephones, portable HF radio, wireless internet, satellite internet etc.)

- Availability of useful information through internet (restricted largely to English language)

In comparison to technology R&D, little attention has been devoted to the other half of engineering: organisations with effective skills to deliver the results. One reason for this could be the relative absence of knowledge on the nature of engineering skills: while there is considerable research literature *about* engineering, there is no comprehensive analysis of the nature of engineering work or skills. We have started a major research project to correct this, and we already have significant results that could help with mine action problems (Trevelyan 2004b).

3.1 Engineering Skills Research

In 1997 we established a research centre in Pakistan (Hameed and Ali Research Centre, Islamabad) where we carried out much of our research on landmine clearance techniques. Through our work at that centre I came face-to-face with the problem of developing effective engineering skills in a developing country environment. We found that the cost of research was considerably greater than we expected as discussed in Trevelyan (2004a).

This experience focused my attention on the issue of engineering skills. Many of the techniques that we developed in our research could easily be applied in practical demining situations. A good example is the use of magnets as attachments to machines such as back hoes to recover a large proportion of the metal fragments that slow down the work of manual deminers. Even though many of the local staff in Afghan demining organisations have engineering qualifications it has proved to be very difficult to introduce process improvements through the effective use of machinery and management techniques. It was clear that the response of engineers in typical organisations in Afghanistan and Pakistan is very different to what one observes in an industrialised country like Australia.

Some of our most recent research uses statistical analysis and risk assessment techniques to justify a radical alternative to mine clearance: the use of mine-resistant commercial machinery for mechanised agriculture (Trevelyan 2003). However, we acknowledge that the primary limitation on this method is not technology but the availability of appropriate skills.

These are some of the issues that persuaded us to start a new research project looking at professional engineering skills in developing countries (Trevelyan et al 2004b). If we could understand why these skills seem to be rare in developing countries we might be able to devise a response that could not only address many of the problems in mine action programs but also have a much wider impact.

We started a program of qualitative research interviews with practising engineers in Australia and Pakistan and a thorough review of relevant literature. We looked at the issue of skilled migration commonly known as "brain drain". Although our research is far from complete we have some preliminary results that could be useful in mine action.

The first result that has immediate application in mine action programs is that there are highly skilled engineers who can effectively implement indigenous technologically based solutions in developing country environments but they are paid at internationally competitive (or even higher) salary levels. In Pakistan we have found a small number of these engineers working in sectors of the economy that have to compete in the international marketplace: specialised textile manufacturers, petrochemicals, and oil and gas production and distribution. In many humanitarian aid organisations there is a reluctance to accept that indigenous staff should be paid at internationally competitive salary levels with internationally competitive performance expectations. It is not uncommon to find an inbuilt assumption that only expatriate staff can bring the required skills.

The second result concerns labour cost perceptions. In a developing country environment there is a common perception that "labour is cheap". This perception is shared equally by locals and expatriates, regardless of educational background. However, when one compares actual productivity (results obtained for a given expenditure) the actual cost of labour is very high. It is difficult to escape the conclusion that this perception could be the explanation for the relatively low investment in human capital and skills development in developing countries. If one thinks that labour is cheap there is little incentive to make better use of it. It is only when labour is seen to be expensive, as is the case in industrialised countries, that engineers, managers and organisations search for the best possible ways to make use of labour resources.

In indigenous mine action organisations, usually supervised by expatriate "technical advisers" we can find quite a different logic. It is argued that the salaries paid to manual deminers sustain a much larger number of people in their immediate and extended families. Any reduction in labour requirements (for example by using greater mechanisation) could have adverse economic consequences for thousands of people in the communities being helped by the mine action program. In any case, it is argued, mechanisation cannot succeed because of the inadequate local skill base.

These perceptions reflect the lack of appropriate skills.

At this stage it is worth including a list of the types of engineering organisational skills, not all of which are well understood outside engineering practice in industrialised countries. These skills are mostly developed during the first few years of professional engineering practice: the initial engineering degree qualification deals almost entirely with purely technical issues. Not all engineers develop a full set of skills: much depends on their chosen career path and, to a less extent, their field of specialisation. The list that follows is independent of a particular specialisation: engineers in all specialisations will develop some or all of these skills. This is not an exhaustive list but it is sufficient for the argument that follows:

a) Technical documentation and information management
b) Use and adaptation of commercial off-the-shelf (COTS) technology
c) Building and maintaining a component and service supplier network
d) Use of codes and design specifications
e) Project planning and resource allocation
f) Procedure design and training for construction, operations and maintenance
g) Work package design for construction, operations and maintenance
h) Acceptance and quality compliance assessment testing
i) Failure mode analysis
j) Risk assessment
k) Asset management
l) Quality management
m) Technical staff recruitment
n) Technical team design and team building

o) Technical and contract negotiation
p) Technical and specification change management
q) Production capacity resource management
r) Progress monitoring and planning adjustment
s) Business case preparation
t) Accreditation, pre-qualification
u) Resource pre-positioning
v) Bill of materials, tender preparation
w) Working with local regulatory environment (labour practices and laws, environmental regulation, commercial rules and procedures etc.)

The upper echelons of a mine action organisation typically come from a military engineering or ordnance disposal background. Military engineers acquire a very different set of skills from civilian engineers. In particular, while d), e), f), j), n) and u) are likely to be reasonably well developed, ex-military personnel have few opportunities to develop skills in the remaining categories. In the same way, locally recruited staff with engineering training and experience are likely to have had good theoretical knowledge but only limited technical skills, and little practice with the technical organisational skills listed above.

This simple analysis helps us understand that skill deficits might explain why mine action organisations are not necessarily able to improve their performance, even when technological improvements are available.

3.2 Improving mine action

The Geneva International Centre for Humanitarian Demining has commissioned a new study of manual demining to be completed by the end of 2004 (Lardner 2004). They commissioned the study because they see only a small likelihood for overall improvement in mine action resulting from research on high-technology detectors, mine detection dogs and machinery. Therefore, they argue, it is worth taking another look at manual demining where there does not seem to have been much effort aimed at process improvement perhaps because so many people thought that the real prospects for improvement lay elsewhere.

While there are certainly prospects for improvements in manual demining the limiting factor, in my opinion, will be the lack of engineering and organisation skills rather than any lack of technology or even knowledge of management techniques.

Correcting this will require a large increase in investment in skills and organisation development as we argued in Trevelyan (2000). Investment in skill development is needed at all levels: not just at the professional engineering level. With this will come much higher salaries for local staff as they develop high level skills. However, the investment will have enormous benefits as these skills diffuse to other areas such as government administration, infrastructure development and so on. We have to expect that a proportion of the people being trained will leave and migrate to other countries. However, it is only by accepting international levels of remuneration and performance expectations that we can retain local staff and encourage skilled emigrants to return.

It is difficult to manage this process in isolation. In the words of a highly skilled Pakistan engineer in manufacturing "it is difficult, very difficult to maintain an island of excellence in a sea of mediocrity". There are many useful lessons to be learned from multinational companies that operate successfully in developing countries. They manage to recruit highly qualified staff and reward them appropriately. However, it is clear that even multinational companies find it extremely difficult to maintain high levels of skill and performance in developing country environments.

4. Conclusions

The main argument of this paper is that skill shortages and a widespread lack of understanding of the organisational side of engineering can explain the frustrations expressed by many people about lack of progress in mine action.

Local capacity building is also affected by the perhaps more realistic perceptions of immediate priorities by the people most affected by landmine and UXO contamination. Security, water and energy supplies, health, education and communication are more important issues for them.

The lack of engineering skills can also make significant contributions to the high operating costs typical in a developing country environment because this issue directly affects the cost of infrastructure, transport, energy and water supplies.

Mine action organisations, as they currently exist, do not necessarily have appropriate skills to improve productivity even with access to new technology because they do not have well developed engineering organisational skills. In Afghanistan, Iraq and some other countries, the lack of security and the continuing 'emergency' nature of demining operations poses a significant additional barrier to productivity improvement.

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