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# Technology Needs: Mine Clearance in Egypt and Jordan

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# Technology Needs:
## Mine Clearance in Egypt and Jordan

**Jordan and Egypt have different mine clearance problems, but there are some interesting parallels between them. In both countries the military have exclusive responsibility for mine clearance, and while the technical problems are distinctly different, the avenues for improvement are surprisingly similar.**

by James Trevelyan, University of Western Australia

The back end of a large British bomb can be seen inside the hole. The bomb was dropped on a British position heading south. The bomb was discovered during routine mine clearance in the area. It is awaiting an EOD team to destroy it in place, and the evacuation of the adjacent bedouin camp.

I visited Egypt, Jordan and Lebanon in September and October 1999 to learn about mine clearance techniques being used in the Middle East (*Trevelyan 2000*). This paper summarizes some of my observations and suggestions for further developments.

The Egyptian Government, in particular, regards landmine and UXO contamination as a sensitive issue. For this reason, it is not possible to present a detailed discussion of Egyptian problems.

### Mine and UXO Problems in Egypt

The Egyptian Military Engineering Organisation (MEO) is responsible for all mine clearance work in the country, reporting to the Egyptian Army and Ministry of Defence. I arranged the visit through the Egyptian Government, the Australian Department of Foreign Affairs and Trade and the Night Vision and Electronic Sensors Directorate of the US Army at Fort Belvoir, Virginia.

My only field visit was to the Western Desert area near El Alamein. Information on other areas was provided by the Military Engineering Organisation, and several other sources.

Egypt has been listed as the country most contaminated by landmines in the world with an estimate of approximately 23,000,000. This includes UXO and the number of landmines is much less than this. However, the number of devices that need to be removed is not a useful indication of the magnitude of the problem.

Tourist, agricultural and irrigation development projects in Egypt are significantly constrained by mine and UXO contamination and, in the affected areas, the civilian casualty rate seems high in proportion to the populations in those areas. (No precise figures were available to the author.) The old age of much of the UXO may result in greater risk of spontaneous or accidental detonation, so it is not useful to consider the mine and UXO problems separately. There are very large areas of land affected, and some estimates put the total area at 25,000 sq kilometres.

### Origin and distribution of contamination

During the second World War (called the second International War in Egypt) Britain and its allies conducted a series of military campaigns to defend themselves and the vital Suez Canal from several invasion attempts by German and Italian forces. Most of the fighting was along the northern fringe of the Western Desert between the Qatara Depression and the Mediterranean Sea, between 1941 and 1943. The well-known battle at El Alamein was only one of many. A wide coastal strip is affected by mines and UXO, all the way to the Libyan border (and beyond).

In 1956, Israeli forces invaded the Sinai Peninsula and advanced

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Col. Mahrous, (Rt) Commanding Officer, Engineers Brigade responsible for demining Alamein area, exchanging gifts with author.

almost to the Suez Canal in a joint operation inspired by Britain and France to attempt to recover the recently nationalized canal. British and French troops occupied the canal zone in the face of vigorous Egyptian resistance. Shortly afterwards, Israeli, British and French troops were withdrawn under strong international pressure.

In 1967, Israel again invaded the Sinai Peninsula in a pre-emptive strike. Eyptian and Isaeli forces confronted each other along the canal zone, with extensive intermittent bombardments between them. In October 1973 Egyptian forces fought a more successful campaign but Israeli forces continue to occupy practically all of the Sinai peninsula. Following extensive negotiations, Israeli forces withdrew from Sinai to the current border. In 1979 Egypt and Israel signed a treaty (Camp David Accords) which has ushered in a new era of peace and cooperation.

Apart from the large Western Desert area, there are mine and UXO contamination problems along the Suez Canal zone, across the Sinai Peninsula and along parts of the Red Sea coast. Most of the remaining contamination is in the Suez Canal zone, and nearby coastal regions. Much of the contamination in the coastal region is in salt lakes, salty mud and swamps which are difficult to work in. The local environment is very unpleasant for manual work with high summer temperatures, high humidity and salty dust on windy days. Other mines lie under deep wind-blown sand as in the Western Desert.

## Social Impact

Until recently the only major social impact has been on nomadic (Bedouin) people who are mostly very poor and live on the socio-economic fringe in Egypt. However, the development of the tourism industry in the 1980's and 1990's is bringing new wealth to the upper classes of Egypt. The Mediterranean Sea coast is warm and has a very comfortable year-round climate, particularly in summer. Development is taking place along most of this coastline. This development is creating a new demand for adjacent land for irrigated agriculture and recreation. Because of this, the nomadic Bedouin are being pushed into yet more contaminated land. Therefore, mine clearance has recently become more important for the government.

Similarly, recreation tourism along the Gulf of Suez and Red Sea coasts is creating a demand for improved port facilities and clearance of coastal land.

The Egyptian government, like many poorer countries, has a hard time raising tax revenues and faces strong political pressure to invest in infrastructure for large population centres such as Cairo and Alexandria. At the present time, there seem to be limited prospects for channelling some of the huge financial investments along the coast towards demining projects.

## Current Solutions

The Egyptian Army has developed techniques for demining which are different from those used by most humanitarian demining organisations. However, they are fundamentally similar in principle, and are affected by the well known limitations of metal detectors and prodding methods. UXO clearance follows conventional techniques which would be familiar in any other country. The procedures are changed from time to time, and are adapted for local conditions.

Quality assurance has been performed with tanks equipped with American mine rollers. However, this is now considered too dangerous after several large unexploded bombs were found.

## Problems with Current Solutions

For an Army which has developed *mine field breeching* methods, the prospect of demining thousands of square kilometres of wind-blown desert and salt marsh is a huge challenge.

The major problem is that the cost required to achieve a 'satsfactory' level of clearance is too great. Appeals to Britain and Italy have yielded little assistance so far. Germany has been more generous: in 1998 the German Government provided about 100 modern detectors (Föster 4400) and offered to try the 'MineBreaker' machine in the Western Desert. The US Government contributed US$500,000 in 1999 for training and some equipment such as mine rollers.

Most mine field problems are seen by the Army engineers in terms of detection. They need better ways to detect and locate mines and UXO in deep sand and mud. Once the ordnance has been located, neutralisation or destruction is well within their capacity. However, lower cost solutions might come from looking at the problem differently. One approach might be to look at alternatives such as processing the soil to remove mines and UXO, using modern sand mining techniques used in many countries.

### *Western Desert Problems*

Each region of Egypt has special technical problems. The principal technical problems in the Western Desert are:

- Wind blown sand burying mines and fragments up to 2 metres deep in places, though mostly less than that.
- High fragment density in many areas.
- Age of mines - up to 60 years.
- Unknown, or partially known location of mine fields.
- Many, large and sometimes unstable UXO's distributed across area, many UXO's considered to be more dangerous than the mines.

### *Salt Mud Problems*

The principal technical problems in the Suez Canal and coastal areas are:

- Mines and UXO lie in grey mud that is either occasionally or daily flooded by salt water. Mines may lie on surface or deep under mud surface.
- The mud is extremely difficult to traverse. Feet either sink right in, or slip sideways.
- High fragment density in many areas.
- Age of mines - up to 45 years.
- Unknown, or partially known location of mine fields.
- Many, large and sometimes unstable UXO's distributed across area, many UXO's considered to be more dangerous than the mines.

### *Sinai Problems*

The principal technical problems in the Sinai Desert are:

- Medium and low metal content mines. Egyptians refer to PMN mine as minimum metal, though it contains much more metal than many other mines.
- Wind blown sand burying mines and fragments up to 2 metres deep in places, though mostly less than that.
- High fragment density in many areas.
- Age of mines - up to 45 years.
- Unknown, or partially known location of mine fields.
- Many, large and sometimes unstable UXO's distributed across area, many UXO's considered to be more dangerous than the mines.

Perhaps the most exciting find for deminers in the Jordan valley lies here at Bethany-in-Jordan: it is now recognised as the most likely place for the baptism of Jesus Christ. Deminers found stones and part of a mosaic floor. After the mines were carefully removed, archaeologists moved in and excavated a complex of water treatment facilities, chapels and even a flagstone covering a human head. The site is due to be opened to the public in time for the millenium celebrations. Dr. Mahommad in the photograph is the chief archaeologist responsible for identifying and excavating the site.

## Mine and UXO Contamination Problems in Jordan

In terms of the value of the affected land, the most immediate problem for Jordan is the Jordan valley where a large number of mine fields were laid, mostly before and during the Arab-Israeli conflict of 1967. These were prepared along the lower part of the Jordan flood plain, and along the lower East slopes of the valley. The mines were used to strengthen defences along the valley as Jordan was anticipating an Israeli invasion across the Jordan river.

In later years there were periods of artillery bombardment exchanged between Jordanian and Israeli positions across the river. These exchanges have left a large number of UXO among the defensive positions, and shell fragments distributed over some of the mine fields.

There are two major zones: the northern Jordan valley near lake Tiberias (Sea of Gallilee) and southern Jordan valley near Amman and the Dead Sea.

Since the mines were laid there have been flash floods down the sides of the valley and the Jordan river has also flooded several times. Mines have been moved. Mostly, the movement is only a few metres. However, mines have been found floating on the dense salt water of the dead sea, and one swimmer is reported to have lost a hand from a mine.

The next most serious problem lies along the Yarmuk river where there are strong fortifications designed to resist an attack from the north. I met land holders who had land taken from them in order to prepare the defences and lay mine fields, and who now know of mines which have been washed onto their land by floodwaters.

The third area is the Araba valley which extends from the southern end of the Dead Sea in a straight line due south to Aqaba and Eliat at the head of the Red Sea. Mines were laid here by Israeli forces during the 1967 conflict. Until recently, the Jordanian government expected Israel to clear these mine fields. However, the Army Engineers expect they will have to clear them "sooner or later".

*Casualties*

The number of casualties is quite small compared with other countries affected by mines. In the last 30 years, about 470 peole have been killed or injured according to military statistics, of whom 280 were military personnel (140 were deminers), and the rest civilians. (Egset and Hammad, 1999). Because there is no formal procedure for medical services to report landmine incidents, the actual figure is probably higher, but less than 900.

Most casualties occur in the Jordan and Yarmuk river valleys. A few occur in the south, but the problem in the Araba valley (Wadi Araba) seems to be declining.

A plaster lined baptism pool, with a column base in the foreground. The location of the column is not yet known.

## Jordanian Mine Field Clearance Methods

Minefield clearance methods, for the most part, follow entirely different procedures from those used in other countries. Jordanian deminers enjoy the unique advantage that they laid their own minefields, and most were laid to precise patterns learned from British Army instructors. The minefield locations are accurately known and marked with steel marker posts which remain in the ground. However, they also have a large number of M14 anti-personnel mines which are about the hardest mines to locate because of their tiny metal content and small size.

Not all mine fields follow this pattern, however, Some were laid under fire, and at night, and thus may be poorly marked and recorded. Others (in the Araba valley) were laid by invading forces and their locations are poorly known and most seem to be unmarked.

Clearance starts by locating the steel marker posts. Deminers then clear the central (safe) lane by probing and digging if necessary, locating the larger anti-tank mines. Then the smaller anti-personnel mines are located. Typically 80 - 90% of the mines are located in this way and destroyed by burning out the explosive.

After manual clearance, Aardvark flail machines are used, clearing a strip wider than the original minefield. Each detonation is recorded, adding to the number of mines destroyed. Originally, six Mk 1 Aadvark machines were in use. Two Mk 2 machines were being used, and two Mk 4 machines were expected to be in use. The older Mk 1 machines were being upgraded.

The number of mines originally laid is generally known precisely. Some were accounted for by accidental explosions (wild animals) and these were sometimes recorded by troops watching that sector. However, there are usually still a few mines unaccounted for at this stage.

The next step is to drive bulldozers backwards and forwards across the mine field, again watching to see if any further detonations occur. If mines are still unaccounted for, the top 15 cm of sand is cut away by bulldozers, screened and replaced.

If there are still "too many" missing mines after this step, an equivalent area on the downhill side of the minefield is treated with the Aardvark flail and bulldozers.

The land is then released. According to the military, if there are unaccounted mines, the land remains fenced and signed with danger signs. However, I was shown a letter informing the land holder which only states that "demining operations have been completed". This was in response to a request to certify that the land is free of mines. The land in question is on the slopes of the Jordan valley above the King Abdullah canal, and has deep erosion gullies, with rocks and hard silt soil, and little vegetation to stabilise the soil. I could appreciate that finding all the small M14 anti-personnel mines after 30 years in that terrain would be almost impossible. Mines could easily have been washed into gullies and lie deeply buried under eroded material, or washed downstream.

The difficulty now is that many of the remaining mine fields have mines which are too deeply buried for mechanical clearance, and digging by hand is the only way to ensure clearance.

## Jordan Valley Mine fields

The climate in the Jordan valley is oppressively hot and humid, and work is suspended for two months at the height of summer. Temperatures above 35 degrees are normal. High temperatures have affected the plastic materials used in some of the mines making them possibly more dangerous to handle.





The types of mines where were used are:

- M14 (American) - a small AP mine containing very small metal components which makes it extremely difficult to detect with normal metal detectors, even if it is just below the surface. Newer detectors can detect this mine at depths of 6 - 12 cm.
- M19 (American) - an AT mine using similar fuse mechanism to the M14 and therefore just as difficult to detect.
- Mk 5 (British) - an old AT mine with a metal case which is easy to detect, but can be dangerous to handle when corroded.
- SACI - an older plastic AT mine which comes in several versions. This can be very dangerous when the materials of the mine have decayed.

The next sequence of photographs shows what the Jordanians regard as their major problem. A series of minefields in river flood plains have accumulated silt and sand as a result of floodwaters flowing through surface vegetation which grows because people stay away from the minefields. This accumulation has buried the mines to a depth of 1 metre or more. In this particular example, a team of 20 men have worked for 8 months to clear about 30 metres of minefield (along the centre line), with a width of about 8 metres. If we assume that the cost of deminers is about US$150 per month, with 100% charge for supervision, equipment support, accommodation and other costs, this has cost nearly $50,000. This roughly corresponds to a cost of US$200 per square metre.

## Suggestions for Improvements in Both Countries

Current mine and UXO clearance methods are slow and expensive. It is now clear that there will be no short or even medium term improvements in detection technology. However, there are many possibilities for improvement by looking at the problem in different ways. Significant funding support would be needed within military demining organizations in both countries to support innovation and change. Outside agencies could assist in making such funding available.

*Mine Detection Dogs*

In my opinion, of all the technologies considered, mine detection dogs offer the best chance of significant improvements in clearance production rate and quality level. Because of cultural sensitivities and cost factors, the most attractive options to pursue this are:

- A trial of Afghan or Iraqi mine detection dogs (with handlers) in Jordan, Sinai Desert and Western Desert areas of Egypt. Iraqi handlers would be able to communicate in Arabic. Afghan handlers have more experience and a common religious background. Such a trial should be coordinated with similar trials in Yemen, Lebanon and Jordan where similar problems exist and dogs could make effective contributions.
- Investigate whether sufficient dog capacity exists in the Cairo Police Academy, Egyptian Customs and counter-terrorist organisations to build an indigenous mine detection dog capacity.

*Aerial Photography*

Although the officers I met claimed they had tried aerial photography, I think that the techniques demonstrated by ITC in the Netherlands should be evaluated. It is likely that the Egyptian air force has the necessary equipment and capability. Aerial photography would show where there is little or no sand cover and clearance teams can work without the need for detection equipment. It is possible that sand cover may change during the year, so repeated photographic surveys may be useful. High precision GPS registration of photographs will be essential as there are no permanent landmarks in most areas.

*Special detectors for deeply buried mines*

By using a larger diameter coil on a metal detector, the detection depth can be increased almost in proportion to the coil size. Detector manufacturers need to be approached to see if they will provide optional large diameter metal detector coils.

Ground Penetrating Radar (GPR) could be evaluated for special detection problems in deep sand, particularly in the Western Desert of Egypt where mines have metal cases.

It may be possible to use ultrasonic imaging technology to detect the deeply buried mines that are causing problems in wet marshland and mud. Considerable experimentation may be needed. However, these mines are currently very expensive to clear (in terms of time, machinery and manpower) and improving location ability may help to reduce costs.

*Slurry Pumping and Water Jets*

There is the possibility that water jets and slurry pumping technologies used in modern sand and slurry mining operations in countries such as Malaysia and Australia could be useful for mine and UXO clearance tasks. The cost of treatment is suprisingly low. The cost of moving the soil with this mining method is between US$0-17 and $0-40 per tonne of material removed. Assuming that, on average, about 1 metre of material needs to be removed from the surface layer of the minefield, this works out to a cost range of US$0-35 to US$0-80 per square metre. The cost will depend on many factors, and dealing with surface vegetation will require some ingenuity, but these costs are far less than existing techniques. The major operating cost is electricity to drive the pumping machinery. These figures are based on electricity at US$0-055 per kilowatt hour which is typical for a remote installation.

*Long Term Research*

In the longer term, careful research is likely to result in large cost savings in the demining program. Apart from slurry and water jet technologies, research into the manipulation of wind for removing sand cover and into risk factors for civilians is likely to substantially reduce operational costs.

*Regional Cooperation*

Since there are extensive mine and UXO clearance problems in most of the countries in the region, there could be extensive benefits from regional cooperation, especially for countries trying to provide cost-effective assistance. This could best be achieved by being sensitive to the political and cultural differences in the region.

*Demining Machinery*

The MEO said they were considering the use of demining. Machines such as 'Minebreaker' have been used extensively in Croatia and more recently in Bosnia, but expert users are cautious about recommending them except for vegetation clearance (not a problem in Egypt). Aadvark Flails are being used in Jordan in the final stages of mine clearance to neutralise mines which have not been located by manual deminers. All demining machines have failed to achieve their makers' expectations, except in certain limited circumstances.

The particular problems of demining in Egypt have made me extremely cautious about the use of large machines of this type.

The variable depths of mines under wind blown sand (many areas more than half a metre) make these machines of doubtful effectiveness for mine clearance. They can be expensive to operate (approx US$0-50 per sq metre) with high maintenance costs, particularly if mines and UXO are detonated by the machine. Evidence from other countries shows that the presence of rock or large stones greatly reduces the effectiveness of mechanical clearance.

However, in the long term, using mechanical clearance could be an effective means of *risk reduction* where manual demining (or other methods) cannot be used. However, this can only be effective with careful research and evaluation of the risks, costs to reduce risks, degree of risk reduction actually achieved, and the relative effects of spending funds on other ways to reduce risk to health.

*Wind*

In dry sandy areas, it may be possible to control sand movement to selectively remove sand cover from contaminated sites over a period of time. This would allow visual inspection and easy removal of mines and UXO. However, research and experimentation is needed to explore these methods.

*Avenues for Real Improvement*

Most of the engineering staff working on mine and UXO clearance in Jordan and Egypt are not fluent in English, nor are there reference works in Arabic on recent developments in mine and UXO clearance.

The lack of reference material in Arabic seems to be a major impediment towards progress in reducing costs. Further, we have found that translating the reports on which this article is based has not been possible without an intimate understanding of the field.

For this reason, we are in the process of exploring a scholarship scheme that would enable engineers to study part-time for research Masters degree qualifications in engineering. This would build a collection of literature in Arabic, as well as English, on problems and possible solutions. ■

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**All photos courtesy of the author.*

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