Quality Standards for Demining

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In the last two years, several authors have commented critically on the 99.6 percent standard for humanitarian mine clearance adopted by the United Nations and its agencies. These standards are being redrafted, yet from the literature and recent comments, it is clear that there is little intellectual foundation on which to build a new standard. There are three issues that need to be addressed. First, what is an acceptable quality standard for humanitarian demining? Second, how can one measure the quality levels actually achieved in humanitarian demining? Third, how can one implement a cost-effective training and monitoring process to ensure that the desired standard is achieved consistently?

Acceptable Risk and Quality in Demining

The ultimate aim of demining activity is to reduce the risk of incidents causing death or injury to land users. Clearly, the risk of mine incidents depends on several factors. One factor is the intended use of the land. A public footpath or marketplace carries a greater risk for a civilian to inadvertently trigger a single device than does a comparable area of open grazing land. Another factor is the number of people who are likely to use the land. This factor is clearly related to the (level of) surrounding population, which can change dramatically after mine clearance. As people gain confidence and return to formerly mined areas, populations build rapidly. A third factor is the type of mine and UXO threat in the ground. Certain kinds of mines (PMN 1) are more dangerous than other types. A final factor is the local climate and environment. In Cambodia, there are numerous mined areas routinely used by civilians during the dry season when the ground is hard and reinforced by grassroots. Local families know that they must keep their children and animals off the ground during the wet season when mines can be more easily triggered. Casualties also rise dramatically in the wet season.

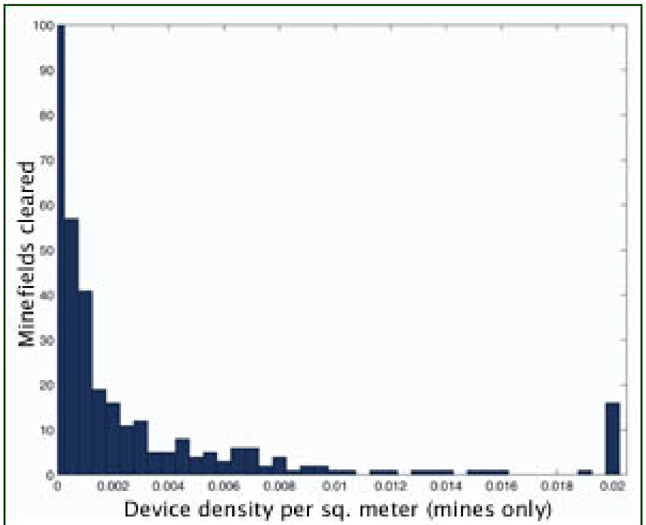

Figure 1: Data on mine density from 336 residential mine fields cleared in Afghanistan between 1993 and 1997.

Data from Mine Action Program for Afghanistan.

It is highly desirable to obtain quantitative data. There are extensive sets of data available for such an analysis. Most mine-affected countries keep accurate records of civilian incidents in mined areas. Mine action agencies keep records of areas cleared and the mines removed from those areas. Useable data exists on which to base quantitative assessments of risk. So far, we are not aware of any attempt to analyze this data in order o assess actual risk levels.

The socioeconomic impact of mines in Afghanistan has been documented in a recent report (MAPA 1999) that provides many useful details. No one would dispute the notion that the level of mine casualties has been and continues to be unacceptable. The perceived risk of mine accidents significantly affects the habits of the civilian population, and it prevents many of them from leading anormal life. There are accurate statistics on the number of mines removed from areas already cleared, and from this data we can calculate the density of mines per sq. m, which is what has given rise to this unacceptable risk level. Figure 1 presents this information graphically, and the following table presents numerical results.

In recent discussions (on a new quality standard for demining) (GICHD 2000), there was a proposal for a new approach to demining quality standards: an acceptable quality level (AQL) derived from international standards on quality control inspection (ISO 2859). It is presumed that this specification applies at a certain depth below the ground surface. An acceptable quality level of about 0.3 percent (0.003 or three devices per 1000 sq. m) was proposed. We can see from Figure 1 that a majority of mine fields in Afghanistan had lower device densities before mine clearance started.

It is not easy to decide what level of risk is acceptable. It is difficult to assess the actual extent of mine clearance in terms of the percentage of devices removed. It is generally accepted that the level of risk on cleared land be acceptably low in order for the population to resume a normal life. Let us assume, as a reasonable estimate, that 99 percent of devices have been cleared. Using the data presented in Figure 1, we can then estimate an acceptable quality level for demining. Given that nearly all mine fields have a contamination level of greater than 0.01, we can expect that the contamination level after clearance is less than 0.0001 because we assume clearance removes 99 percent of all devices. We know from field experience that current clearance levels achieved by demining teams are acceptable. There is clearly a considerable degree of uncertainty; the data tells us that 0.001 is unacceptable since around half the mine fields have a lower level of contamination before clearance. The few mine fields that have higher than 0.01 mine densities are likely to attract more care in clearance, which may result in clearance of greater than 99 percent. Given that most mine fields will have less than 0.00001 after clearance, we can conclude that an acceptable quality level for Afghanistan lies somewhere between 0.00001 and 0.0001 devices per sq. m.

The factor missing from this argument is the link between device depth and the risk of an accident. This correlation is strongly dependent on the type of device and the ground conditions resulting in a large variation. Given that about 90 percent of mines cleared in Afghanistan are PMN-1, which are very sensitive compared to other common mine types, it is possible that clearance levels have to be better in Afghanistan than in countries with less sensitive types of mines. The depth of clearance will be strongly dependent on the detectability of the mine. Minimum metal mines pose well-known problems in this respect.

This method of calculating acceptable quality levels is relatively simple, but it does not take into account regional variations in land use or the higher risk of incidents that may occur once a large population returns to the land. The statistical data has been analyzed for one country, but similar data is readily available in most other countries with mine clearance programs

Inspection Requirements

How can we prove that this level of quality has been achieved? The standard formula for quality control inspection can be applied (ISO2859). The probability of finding any mine is small, especially after clearance. Given an acceptable quality level of 0.0001, the standards tell us that we have to inspect almost the entire mine field area in order to be confident of clearance. Clearly, the five or 10 percent inspection typically carried out is not adequate to prove clearance at this level of quality. There is additional difficulty with this approach. In many instances, the technique used for quality control is the same as, or is a minor variation on, the manual demining method used for clearance. A target missed in the original clearance may be missed again in the quality control check.

Measuring Quality Levels During Demining

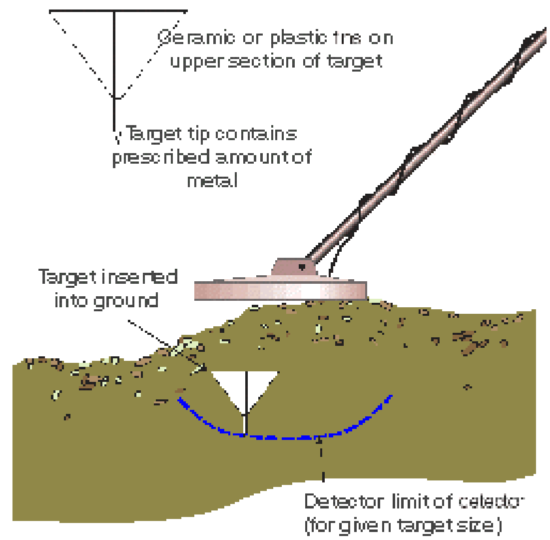

Figure 2: Target for measuring detection probability. Target can be detected by probing or metal detector (Trevelyan 1999).

Normal quality inspections cannot reliably confirm clearance quality because the probability of finding a missed mine is likely to be exceptionally low. If the original number of mines was larger and the demining quality level was numerically larger (i.e., more mines remaining per sq. m), then the probability of finding a missed mine would be higher. The area of ground that needs to be inspected therefore would be smaller, and the inspection would be less expensive.

We can overcome this problem by inserting a reasonable number of known targets into the mine field before or during clearance. Targets can be placed randomly in an area to be cleared. Given an appropriate number of targets, we can calculate the deminers' quality level of demining by measuring the ratios of recovered targets to missed targets.

There are two groups of targets required. One group is inserted into the ground at varying depths up to the limit of detection for the particular metal detector being used. The proportion of targets recovered will reveal the effective detection depth of the demining tool. The second group of targets is placed on or near the surface so that they are easily detectable. The proportion of these targets recovered by deminers will reveal the proportion of the mine field area that has been missed by the deminers. If deminers find all of the 200 targets distributed randomly across an area, we can be 90 percent sure that the deminers have covered 99 percent of the area. This level of clearance will usually be sufficient to achieve the acceptable quality level calculated for Afghanistan.

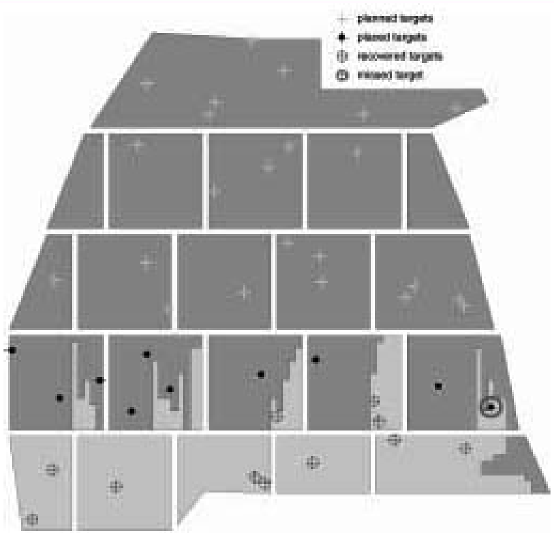

Figure 3: Progressive insertion of targets in a mine field clearance operation. The diagram shows clearance proceeding from the bottom upward. Safe lanes have been cleared manually to subdivide the mine field into manageable blocks (or boxes). Targets have only been inserted close to the current area of clearance activity. One target is marked as "missed," but this oversight could be due to minor errors. The adjacent area is still to be cleared, and the target may be found in this area.

Practical Issues

For this method to be effective, it is important that the targets are randomly placed and that the deminers have no way of telling the location or number of planted targets. A computer program is a convenient way to generate target positions and depths to meet this requirement.

There are a number of practical issues to resolve. Perhaps the most obvious is the difficulty of inserting targets into uncleared mine fields. Fortunately, there are a number of feasible approaches to solve this problem.

There is no need to distribute all the targets in one operation. The targets can be placed every day or two, given a typical rate of manual demining. Manually cleared access lanes provide more than sufficient access to any area likely to be cleared the following day or week. Figure 3 illustrates this progressive method of distributing targets. There are two kinds of targets: shallow targets to check area coverage and deeper targets to measure detection depth.

In the case of a Standing Operating Procedure (SOP), which requires deminers to find and remove all metal fragments using metal detectors and prodding, the standard targets can be made as small pieces of metal stamped with a unique identification number. The shallow targets can simply be thrown to their locations by hand. The maximum throwing distance is likely to be only five to seven m (the distance from the nearest safe lane, as shown in Figure 3). In most terrain, it will not be possible to find the targets except with a metal detector. They will simply disappear into the vegetation and ground cover. It would be advisable to ensure that the targets are of a similar color to the ground cover. Encasing the targets with molded plastic would be a cheap and durable solution.

The next issue is avoiding errors in recording located targets. The target numbers need to be designed with check digits to detect transcription errors. Deminers will need a special procedure for marking target positions. Deminers could mark the position of each located target using a small green flag containing a pocket into which the target is placed. A few minutes later, the section leader or team leader would collect the target and mark the position of the flag on the mine field maps. This mapping is essential to check that the targets were found in the correct sequence and location. Finally, any missed targets must be located. There is also the chance that the target will be discarded as a metal fragment.

The deeper targets required to check the depth of detection can be placed in the cleared areas of the mine field, which are then checked again by deminers using metal detectors. Fewer targets are required for this analysis; 40 to 50 should be sufficient.

In situations where probing is used to avoid the need to remove all metal fragments, a target detectable by metal detector and probing would be desirable, as shown in Figure 2. This kind of target requires deliberate insertion and cannot be thrown. One method of inserting this kind of target would be for a team leader (or QA inspector) to use a metal detector, to work his way into an uncleared area and find a suitable location to insert a target with a simple hand tool.

We have begun a design study for a remote target insertion tool illustrated in Figure 4. This tool is also designed to be used from a nearby access lane. The target insertion tool operates like a builder's nail gun, but it is triggered remotely when the deminer has retreated a safe distance.

Mechanical Support

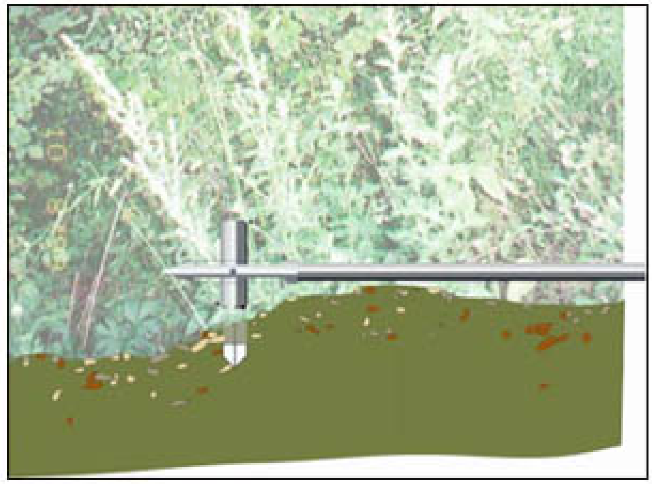

Figure 4: Concept drawing of target insertion tool. The tool is inserted through scrub and vegetation from a safe area up to six meters away. On remote activation, the target insertion "gun" rotates to a vertical position (shown) and injects a target into the ground beneath it to a prescribed depth.

If machinery used in a mine field supports manual deminers, the machine itself can be a protected platform for target insertion. A simple manually operated device would be feasible, though the concept illustrated in Figure 4 may be a useful improvement. The only satisfactory way to resolve practical problems and to test the validity of this method of measuring demining quality is to carefully conduct controlled field trials with several different demining organizations.

Why is Quality Measurement Important?

Measurement of achieved quality lies at the heart of all quality management programs. In typical industrial situations, quality can be measured using standard instruments or inspection techniques. Quality improvement processes rely on measurement for evaluation. One cannot claim to have improved quality without being able to measure it accurately.

Without quality measurement, it is difficult to compare the quality level from different sources of supply. This discrepancy lies at the heart of demining debates in several countries. Are the commercial operators cutting corners by working too fast? Are the NGOs wasting donor funds by working too slowly and cautiously? How much does demining quality depend on the degree of supervision? What is the quality variation between different demining teams? How much does the quality of demining suffer if teams are given incentives to work faster?

Deminers will make fewer mistakes if they receive immediate feedback. The quality measurement process introduced in this paper provides an effective way of carrying out this objective. The more traditional approach, which uses quality control inspections weeks or months after the original clearance operation, is less successful and needs to be changed.

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1 Check digits are commonly used to control transcription errors and there are several well-known techniques used for bar codes, credit card numbers, book reference numbers and so on. See for examplehttp://www.augustana.ab.ca/~mohrj/algorithms/checkdigit.html