Norwegian Peoples Aid (NPA) MINEBURNER TRIAL LEBANON

Carried out on behalf of NPA by:

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RK Consulting Ltd

TRIAL REPORT

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NPA MINEBURNER TRIAL IN LEBANON

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Contents

Figure 1. Cover photo: MineBurner prepared for a burn against a BLU 63 target.(Photo by the author)

Executive Summary

The war has caused extensive damage to residential areas and key civilian infrastructure, including bridges and road networks. The immediate effect has been access problems for relief operations and inaccessible communities in the south. The more long term effect is expected to be timely and costly reconstruction. This process will be difficult and dangerous due to threat of explosive remnants of war (ERW) including substantial amounts of cluster munitions.

MineBurner combines oxygen with liquid petroleum gas (LPG) to provide a high temperature cutting flame that burns through the case of a landmine and ignites the contents.

The aim of this Report is to record the findings of the consultancy mission carried out by RK Consulting Ltd on behalf of NPA Lebanon to determine the potential use of the MineBurner system to deal with cluster munitions. Dr Robert Keeley, the Director of RK Consulting Ltd, is a former British Army Bomb Disposal Officer who has been working in humanitarian mine action since 1991.

In conclusion, the trial was limited in scope but it was successful in that it showed the ability of the MineBurner against two different types of submunitions and highlighted some areas for improvement.

The MineBurner was successful against the M42 and BLU 63 submunitions.

The MineBurner is not yet rugged enough to withstand sustained use in field conditions, however the Designer already has a number of improvements in hand and the Consultant and the many observers of the trial were able to suggest some more.

There are problems positioning the nozzle. The final metre of the gas hose has an elastic ‘memory’ and this must be eliminated. Similarly, the nozzle needs some method to improve the precision of its positioning.

The MineBurner is not as complicated as it looks. It is merely different. A short training program and an opportunity to practice with the equipment assuaged the initial doubts and scepticism of the Consultant in this regard..

The economic analysis suggests that MineBurner is also an economically viable option for mine action programs, especially where there are logistic, administrative or political difficulties in obtaining high explosive.

MineBurner is unlikely to *totally* replace high explosives in all situations, but its use should significantly reduce the problems faced by mine action agencies obtaining explosives and other demolition ancillaries.

Introduction

Background to the war in Lebanon

The current conflict in Lebanon between Hezbollah and Israel started on 11 July. According to the OCHA Situation Report on 1 August, 784 people have been killed and 3,240 injured. The total amount of internally displaced persons are approximately 787,649, of which most comes from South Lebanon.

The war has caused extensive damage to residential areas and key civilian infrastructure, including bridges and road networks. Lebanon's Higher Relief Committee reported on 26 July that 27 vital infrastructure installments had been destroyed, together with 600 km of roads, 62 bridges, and 6100 housing units. Most of these damages were caused by the Israeli Defense Force.

The immediate effect has been access problems for relief operations and inaccessible communities in the south. The more long term effect is expected to be timely and costly reconstruction. This process will be difficult and dangerous due to threat of explosive remnants of war (ERW). Such remnants are expected to be new landmines, unexploded ordnance (UXO) such as bombs, missiles, improvised explosive devices and ammunition. This also includes stockpiles of explosive ordnance left by military units.

ERW represent an immediate threat to lives and livelihoods of civilians, aid workers and reconstruction workers during and after warfare. It will be a central element in all planning and implementation of humanitarian emergency measures and the rebuilding and stabilisation of the country when the hostility ceases.

Lebanon has a significant landmine and UXO problem from previous conflicts, and clearance operations were ongoing all over the country under the auspices of the government and the UN (South Lebanon). Previous landmines and UXO have primarily affected communities in South Lebanon.

Currently the situation on the ground is difficult to assess. The current conflict has significantly exacerbated the problem in the south, but also in the Bekaa Valley and the southern suburbs of Beirut. In a status report from UN Mine Action Service dated 7 August, rough estimates from UNIFIL suggests that approx. 300 heavy aerial bombs, 300 missiles, 200 artillery shells from ground forces and 200 artillery shells from sea forces are fired into Lebanon on a daily basis. Human Rights Watch reported on 24 July that Israel had used cluster munitions in Lebanon. It is likely that the situation will remain unclear until the hostilities have stopped and access for rescue workers and civilians has been restored.

Background to Norwegian People's Aid[1]

Norwegian People's Aid (NPA) is the humanitarian organisation of the Norwegian trade union movement. In its work NPA is guided by the values of national and international solidarity, human dignity, freedom and equality. NPA is a voice for the vulnerable, the poor and the oppressed in Norway and abroad. Today, NPA is one of the largest Norwegian NGOs.

Founded in 1939, NPA aldready has a long history of operation, both nationally and internationally. Our roots are to be found in both fields, but for some time from the 1950s till the 70s much of the work was concentrated within Norwegian society. Since the early 80s, however, there has been a tremendous growth in NPA's international operations. Whereas much of the international work was conducted in Africa and Latin America in the 80s, Europe has once again become a major area
of operation in the 90s primarily a consequence of the collapse of Former Yugoslavia.

Norwegian People's Aid works in close collaboration with other Norwegian NGOs as well as international organisations; NGOs and NGOs - and not at least the United Nations system. Likewise, the Norwegian government is a partner in both our national and international work.

In the 1990's NPA entered into a new field of operations, mine clearing activities. Today, NPA is one of the major NGO operators in this field of work.

NPA Mine Action has humanitarian mine action programs ongoing in 14 countries all over the world. In the Middle East we have ongoing Mine Action programs in Jordan and Northern Iraq. After the second war in Iraq in 2003 NPA established am emergency Battle Area Clearance Program in the city of Baghdad that contributed to the effective survey and clearance of most battle areas in the city through training of and close cooperation with the Iraqi Civil Defense.

Background to NPA activities in Lebanon

Norwegian People's Aid became actively involved in Lebanon following the Israeli invasion in 1982. Today we have a strong and professional organization with a head office in Beirut directed towards development cooperation through local partners all over Lebanon. The main objective has been to improve living standards and the educational level of Palestinian refugees and impoverished Lebanese. The focus is on emergency relief, human rights, physical rehabilitation, vocational training for youth and public health. Work is carried out through or in close cooperation with national partner organizations and the government. The Ministry of Foreign Affairs and

[1] Source: the NPA website. See http://apu.idium.no/folkehjelp.no/?module=Articles;action=Article.publicShow;ID=591;lang=eng

NORAD donate funds to this work. NPA is continuing advocacy for a solution to the refugee problem on the basis of UN Resolution 194.

NPA's Mine Action program in Lebanon has focused primarily on Mine Victim's Assistance and Mine Risk Education. Since 2002 NPA has been considering the establishment of a mine clearance programme in Lebanon.

The Norwegian People's Aid Emergency Mine Action Program in South Lebanon objectives are:

- To reduce the threat to the Lebanese population from cluster munitions and UXO

- To remove and destroy all cluster munitions, UXO/mines in assigned areas in south Lebanon.

- To assist the National Demining Office in building up national capacity related to cluster munitions removal and UXO and leave behind a sustainable capacity to deal with potential similar problems in the future

Background to MineBurner[2]

MineBurner combines oxygen with liquid petroleum gas (LPG) to provide a high temperature cutting flame that burns through the case of a landmine and ignites the contents. Oxygen is obtained by pumping atmospheric air through a filter to remove the nitrogen. LPG (cooking gas) is locally available, thereby eliminating the requirement to transport hazardous cargo to the minefield.

One of the actions during a mine clearing or demining operation entails the destruction, removal or rendering safe of the mine once it has been detected, excavated and identified. Most of the detected mines are destroyed in situ with the aid of high explosive. ..Problems are most often encountered in the field due to the unavailability of high explosives and accessories. This often results in improvised methods being used to dispose of the detected mines and other explosive remnants of war (ERW). These methods vary from burning the mines with fuel oil and straw to the dismantling of mines and the removal of the detonator and explosives, the latter being used to counter-mine the remainder of the detected mines. These methods are not only unreliable, but also dangerous.

The destruction of mines through burning is an acceptable practice and various pyrotechnical systems are available today; however these are also classified as Hazardous Goods for shipping.

An independent inventor from Hermanus in the South Africa recognised this gap in the "demining toolbox" and developed the patented MineBurner. An extensive trial programme has proved it to be a strong contender to fill the

[2] Based on text extracted from the MineBurner website. See: www.MineBurner.com

operational need for a system to dispose of ERW using non-explosive components or sub systems

The MineBurner and accessories are all air transport classified as non-hazardous.

Background to RK Consulting Ltd[3]

Dr Robert Keeley, the Director of RK Consulting Ltd, is a former British Army Bomb Disposal Officer who has been working in humanitarian mine action since 1991. His work has taken him to several countries including Kuwait, Bosnia, Croatia, Mozambique, Cambodia, Vietnam and Laos. He was the first humanitarian deminer to be sent to the Former Yugoslavia to help with the transition from the UN peacekeeping mission and was the head of the UN Mine Action Centre in Croatia until 1997. He has also worked for Handicap International (during which time he helped set up the first Bosnian NGO and also provided technical advice to the International Campaign to Ban Landmines) as a consultant for the European Commission, for the Japanese Government, and for a commercial demining agency, European Landmine Solutions. This consultancy work has encompassed the whole range of mine action and explosive ordnance disposal activities, including provision of mine safety training and establishment of a trauma care project in Vietnam.

He has a PhD in Applied Environmental Economics from Imperial College London. His thesis was on “The Economics of Landmine Clearance” and included the development of a costing model that allows users to estimate the full commercial costs of a mine clearance project.

Acknowledgements

This trial was set up at short notice and would not have been possible without the efforts and cooperation of a number of people, including all the staff in the NPA mine action project in Lebanon, and those people in Mines Advisory Group (MAG), Bactec International Ltd and Swedish Rescue Services Agency (SRSA) whose kindness made this trial possible.

Aim

The aim of this Report is to record the findings of the consultancy mission carried out on behalf of NPA Lebanon to determine the potential use of the MineBurner system to deal with cluster munitions. The mission was carried out between 13 and 21 October 2006.

[3] More information on RK Consulting Ltd is available at www.rk-consulting.net

Scope

The objective of the consultancy mission is to conduct operational trials of the new MINEBURNER to record the practically of the MINEBURNER system to deal with cluster munitions and to write a detailed report of the Consultant's findings and recommendations for use[4].

The report covers the results of the technical trials of the prototype MineBurner system, and also includes an economic analysis intended to estimate the cost-effectiveness of the equipment compared with high explosive demolition techniques. Finally, the report includes a qualitative multi-criteria analysis intended to set out the main issues to compare MineBurner with HE techniques and alternative methods also available to the humanitarian mine action community. Included in an Annex is the list of recommendations made by the Consultant and other observers for the improvement of the prototype system before it is sent for industrial production.

Methodology

The methodology proposed for the trial by the Consultant was to utilise a step by step approach intended to test the characteristics and performance of the MineBurner in a safe manner that did not leave target UXO in a more hazardous condition than they were found, or place the user or other team members in any additional hazard whilst operating the equipment. There was also a need to ensure that the Designer of MineBurner, whose presence was necessary to ensure that the equipment was properly assembled, did not put himself or others at risk whilst moving in an area contaminated by submunitions.For practical reasons, the trial adopted a team approach ("the Team") between Dr Keeley ("the Consultant") and Mr Paul Richards, the designer of MineBurner ("the Designer"). However, the findings of this report are solely those of the Consultant.

The trial plan, as set out in Table 1 below, was set out to move from a known environment to an increasingly 'unknown' environment, to test and therefore control for variables that would be encountered later in the trial. The first activity was thus against dummy targets in a sterile environment away from the contaminated areas, in order to see whether there were any gross problems with the MineBurner equipment that would preclude its deployment to a task site, and also to confirm that the MIneBurner, in its current configuration, would have sufficient capability to burn through submunitions. A period was also spent at a submunition site without the MineBurner equipment, to familiarise the Designer with the conditions on a typical task site.

[4] Extracted from the short term consultancy contract for MineBurner trial between NPA Lebanon and Dr Robert Keeley of RK Consulting Ltd, dated 13 Oct 06.

Table 1: Planned Timetable for MineBurner Trial in Lebanon			
Ser	Date	Activity	Remarks
(a)	(b)	(c)	(d)
1	13 Oct 06	Travel to Beirut	
2	14 Oct 06	Move to Tyr, Admin brief from NPA Liaison visit from South Lebanon MAC	
3	15 Oct 06	1. Familiarisation with MineBurner Equipment 2. Burn against dummy target 3. Safety inspection by NPA Training Officer	Components Assembly Use Fault finding drills Repackaging
4	16 Oct 06	Familiarisation of MineBurner designer with CBU task site environment	With assistance from MAC and MAG
5	17 Oct 06	Use of MineBurner against live UXO targets in controlled 'range conditions' on NPA site	Live UXO but not in difficult terrain or other difficult conditions
6	18 Oct 06	Use of MineBurner against live UXO targets in 'difficult conditions' on NPA site	May include more 'range' burns if necessary.
7	19 Oct 06	Stakeholder analysis/demonstration	If MineBurner has performed safely and effectively. Presentation open to other agencies
8	20 Oct 06	Return to Beirut Write up draft report	May include liaison visit to NDO
9	21 Oct 06	Depart Lebanon	

Once it was deemed safe to begin live trials against submunitions, a similar incremental approach was taken, with the first attacks being made on targets that were in a comparatively safe condition and position. Only once the Consultant had tried the MineBurner against these targets did the trial proceed to attacking more complicated targets.

Finally, given the limits to the trial (which are discussed below) it was planned to allow as many different personnel as possible to observe the MineBurner. This stakeholder analysis was achieved by inviting personnel from SRSA and Bactec International Ltd to observe the trials as they were conducted.

Limitations

There were a number of limitations to the trial. These were mainly a result of the short duration of the trial period.

- There were a limited number of targets and hence statistical significance is difficult to infer.

- The team were unable to deploy MineBurner on other UXO, especially thicker cased items such as mortar rounds.

- The Team were unable to fully observe the possibility to train local staff in using the MineBurner, although some 'on the job' training was possible with the assigned driver. This is discussed in more detail below.

Finally, the trial did not address the effect of MineBurner on landmines; this was covered in earlier trials by NPA in Jordan.

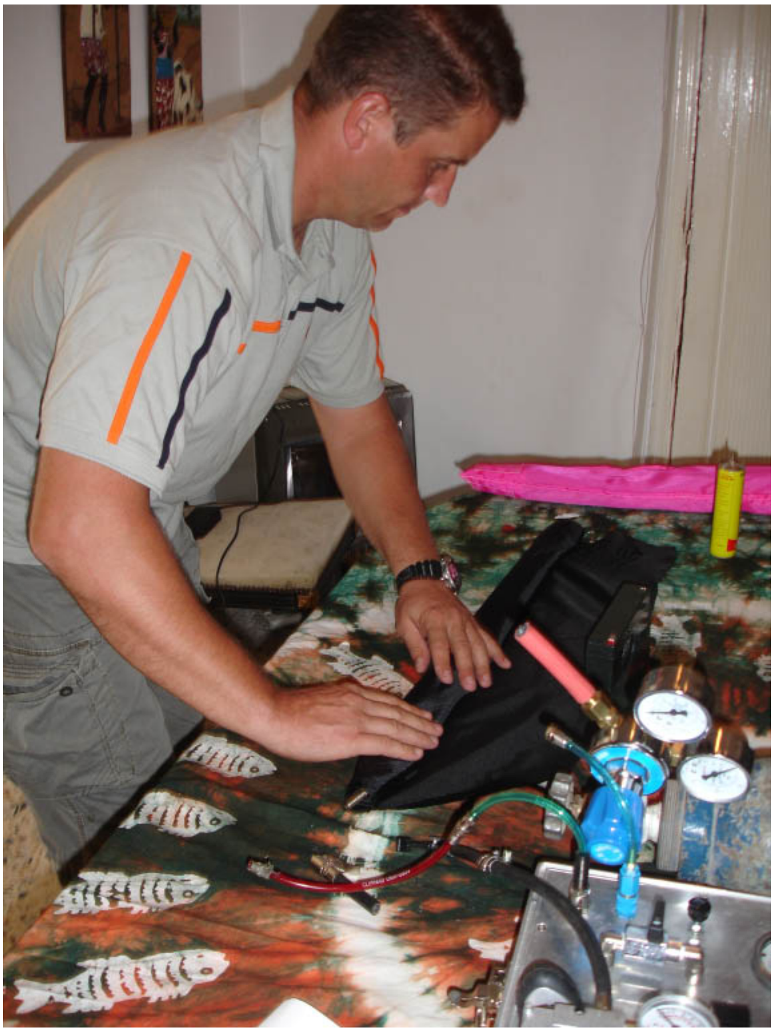

Figure 2. One of the NPA technicians learning to prepare a MineBurner (photo by the author).

Detailed Findings from Trials

Day One (14 October): administration, including search for oxygen and gas

The Team had arrived the previous evening by civil flight from London Heathrow; there was no trouble getting the MineBurner equipment through customs. The Team was then driven on the morning of the 14th October from Beirut to Tyre, arriving around mid-day. On arrival, it was found that there were problems with the local medics. These problems, the details of which are outside the scope of this report, meant that the NPA personnel in Tyre were fully occupied sorting them out. As a result the Team had themselves to obtain the necessary gas and oxygen to be used in the trial. In fact, from the point of view of testing the logistic issues around MineBurner this turned out to be a benefit, as the Team, neither of whom had worked in Lebanon before, were able, with effectively non-existent Arabic language skills, to source adequate supplies of gas and oxygen within an hour, with use of an interpreter to complete the arrangements for rental of the oxygen bottle. The team then discussed the proposed methodology, which is set out in Table 1 above. The remainder of the day was used on administrative arrangements for the Team.

Day Two (15 October): testing against dummy targets

As agreed in the works plan, the second day was given over to testing the MineBurner against dummy targets. The aim of this was to:

- Familiarise NPA personnel with the equipment
- Allow the Consultant to develop safe operating procedures[5]
- Confirm whether MineBurner was likely to be effective against submunitions, based on its ability to cut through metal of similar thicknesses
- Obtain formal permission from the NPA staff to allow MineBurner to be used on live targets on NPA sites.

The day started with a demonstration of MineBurner to the Consultant, followed by practice by the Consultant to establish an operational procedure. This was followed by a demonstration of the system to two of the NPA

[5] The Consultant decided that, on observing the MineBurner equipment for the first time, it would be more appropriate for him, as a trained bomb disposal officer, to set up the equipment against a live target than it would be for the Designer. In particular, the main differences in setting up the device for real rather than for a dummy are (a) it is important to remember that there are other hazards on a site than the single UXO on which the operator is focussing, and (b) in real use one must remember that it is the tool which must be positioned at the target, rather than the target being positioned at the tool. It was agreed that, when the Team worked on live targets, the Designer would remain at the stores area until being invited to move forwards to observe the targets and the results.

personnel, with opportunities for them to practice assembly, positioning and operating of MineBurner against a dummy target.

The main findings of the activities on this day were as follows:

- The MineBurner looks more complicated than it is, merely because it is different to the normal equipment deployed by EOD teams in similar circumstances today. It is actually about only as complicated as a water jet disruptor (often referred to as a ‘Pigstick’) which is a common piece of EOD equipment. All of the new users were able to pack, assemble and deploy the equipment after the demonstration by the Designer.

- The MineBurner was effective at burning through dummy targets with similar thickness to the walls of submunitions.

- The nozzle of the MineBurner can be awkward to position; the hose has a memory which can cause the nozzle to flick back against the target. Whilst this does not impart a lot of energy it can be a little unsettling and would be a bad practice against a real target. It is possible to employ a drill to resolve this problem; the hose is positioned so that the nozzle is about 60 cm from the target, and the nozzle is then moved incrementally, about 10cm at a time, closer to the target. This allows the hose to settle in position. When the nozzle is 10cm from the target, a weight was placed on the hose approximately 10cm back from the nozzle (i.e. the weight is approximately 20cm from the target) before the nozzle is placed at the optimum burn position with the nozzle 9mm from the target. Even so, it became difficult to aim the nozzle *exactly* where it was wanted. However, the Designer has undertaken to develop a new nozzle design that will ease positioning.

- The MineBurner equipment has undergone significant development since its last trial against mines in Jordan earlier this year; however it is not yet as rugged as the Designer intends it to be. This is consistent with its status as a pre-production prototype and many of the observations made by the NPA technicians and the Consultant are already covered by planned modifications.

Finally, the NPA technicians agreed that the MineBurner was intrinsically safe enough to be deployed on a live target.

A list of individual observations on the equipment that were made during this phase of the Trial is set out at Annex A to this report.

Day Three (16 October): observation of BAC operations

The aim of the second day was to:

- Familiarise the Designer with the nature of a UXO site, so that he could learn the nature of the environment in which MineBurner was being asked to operate. Doing this without having the MineBurner equipment present meant that he was able to concentrate on the environment.

- Ensure that the Designer learned safe practices on a UXO site, so that when he was allowed access to the site, he would be able to move and act safely even whilst concentrating on the MineBurner.

Because of the problem encountered by NPA with their medics, it was arranged that the Team would visit a site run by Mines Advisory Group (MAG). The Team was accompanied by an NPA technician who would explain any significant operational differences between MAG and NPA.

The Team were able to observe many M42 submunitions lying in the uncleared areas of the site. These submunitions were all laying on their side, even in what was comparatively soft soil; discussions with the MAG and NPA technicians confirmed that this was the most common attitude for unexploded M42s and related UXO[6]. The technicians also reported that many of the M42 were found in difficult positions, which confirmed the plan to consider procedures for deploying MineBurner against such ‘difficult’ targets.

The NPA technician confirmed that the basic process used by MAG and NPA was similar in that it involved a two stage procedure: the first stage was the use of a team to search the site for UXO and mark their finds; the second stage was the destruction phase. This meant that it is possible for the MineBurner to be deployed in relatively safe ground after the area has been searched and the UXO marked.

The fact that the M42 are largely found on their side has implications for their destruction, as they contain what is referred to as a ‘shaped charge’ which fires a jet of copper in plasma form in the direction in which a copper cone contained in the M42 is pointing. This type of jet will penetrate some 10cm and, according to EOD personnel operating in Lebanon, can reach a distance of several hundred metres in open air. It is therefore important that, when attacking an M42, either (a) the MineBurner can prevent the jet from forming or (b) the operator employs suitable protective works to prevent the jet from becoming a long-range hazard.

[6] Readers with a technical background will be aware that there are a number of submunitions in the M42 ‘family’, including the M77 and M85. There are no significant differences for the purpose of this report and so they are all described by the term ‘M42’, which is in effect a generic term used for the family within the EOD industry.

The second half of the day was therefore spent using MineBurner against copper targets to see if it could penetrate them. If it could, it might be possible to use MineBurner to attack the M42 through the cone, so that, even if the target UXO burns to detonation, the cone cannot form into a jet. According to the Designer, copper is more conductive than steel and there could therefore be problems in using it in this way. The problems predicted in using this method were that

- The cone of the M42 is set back some way inside the body of the submunition, which was particularly significant considering the 'memory' problems encountered in placement. It therefore seems inappropriate to employ a drill that involves inserting the nozzle within the front of the UXO.

- This placement issue was exacerbated by the fact that the UXO observed on the MAG site were seen to be obstructed with soil. Trying to insert the nozzle into the UXO under such circumstances was therefore considered unfeasible and it was decided that the cone attack technique would be based on placing the nozzle at the mouth of the UXO but not within it. The Designer pointed out that the resulting standoff was greater than the optimum (i.e. 9mm)

However, when used against copper coins (which are even thicker than an M42 cone) at an equivalent standoff, the MineBurner was able to penetrate with ease. It was therefore decided to proceed with attempts to attack the cone on a live M42 target.

Day Four (17 October): attack on live targets #1 (M42)

The day begun with the Team accompanying one of the NPA technicians to the ammunition storage site operated by the United Nations, and where all of the demining teams had their explosive stored. Travel time to the storage was approximately 30 minutes, with an hour's wait for the explosives to be issued, followed by a drive to the NPA task site. These times represent a logistic cost to existing operations and do not apply to the use of the MineBurner; they should therefore be considered in any quantitative evaluation of the cost-effectiveness of the MineBurner with any alternative system that employs high explosives.

Once arriving at the task site, the MineBurner was assembled and the communications between the Remote Firing Unit and the Field Modules tested. The day then consisted of a series of attacks against two live targets, the first of which would be in 'range' conditions against UXO that had been found in partially disassembled states and were thus safe to move and place in a safe position with the cone facing into an earth bank. The third target that had been identified by the NPA technicians was fully armed and also in a more difficult attitude, being on a gravel bank with a risk of being moved (and hence initiated) by any disturbance to the gravel. This was therefore selected as the final target, to be attacked only once the Consultant (and the NPA technicians in charge of the site) were confident in the performance of the MineBurner.

The results against the first target (which had a slider but no pin) were interesting, in that an attack against the cone actually caused the jet to function. A concrete block positioned in front of the M42 as a ‘witness plate’ had been destroyed, confirming this observation. This ‘high order’ result is believed to be as a result of the decision not to insert the nozzle into the cone for the reasons of safety described above; in turn this meant that the cone was not heated fast enough by the MineBurner, thus allowing the heat to be transmitted to the detonator before the cone could be penetrated. Positioning the nozzle inside the cone may rectify this but it is still judged to be too great a risk in the case where the M42 target is fully functional. Although the Designer offered to create a thinner nozzle the fact that the Team was able to observe, on the previous day, that many M42 are found with the cone obstructed by soil. There is therefore a risk that a deminer might try to push the cone through the soil. This technique was therefore disregarded and no further tests were made using it.

The second attack involved placing the nozzle at right angles to the major axis of the M42, with the nozzle some 10mm from the shoulder at the rear of the device and pointing into the major axis. The second attack was against a target where the slider was missing (thus making it safe to move) but where a replacement slider had been re-positioned. No detonation was heard. A 40 minute soak time was applied (30 minutes plus the time taken to re-approach the target). The result was that the target burned: a hole some 4mm across burned through the case and ignited the explosives, and the detonator and percussion cap (in the slider) were heard to ‘pop’ during this process. The detonator could also be seen to have functioned. The target was now cool to the touch and was judged as being safe to move. On close examination it could be confirmed that all the explosives had burned out and the copper cone was intact.

Figure 3. The M42 target showing the results of a burn.

There had been no noticeable problem in deploying the MineBurner against a real target, instead of against a dummy target, and so it was judged appropriate to use the MineBurner against the third available target, which was ‘difficult’ target described above. This had originally been intended as a target for the next day, but the comparative speed with which it had been possible to deploy MineBurner on the first two targets (even allowing for the other constraints, including time collecting explosives and coordination issues described below) meant that there was still enough time to attack the third target. Given its condition, the positioning of the nozzle was treated as a ‘one man risk’, with the Consultant wearing full PPE for this action. The same observation of the ‘memory’ inside the nozzle hose was observed, but the drills developed by the Consultant during the dummy burns meant that the positioning of the nozzle could be done safely.

Figure 4. Positioning the MineBurner against a difficult target on a gravel bank. The 'memory' in the hose made the nozzle difficult to position (photo by the author).

The result of this attack was what appeared to have been a deflagration, approximately 2 minutes after the burn was initiated. A five minute soak time was then observed. A deflagration, or ‘low order’ explosion does not generate the same amount of energy as a ‘high order’ detonation, and this observation was supported by the large fragments that were found at the target position (on a high order these would not be expected) and the comparatively soft sound of the ‘bang’ that was generated. Thirdly, there was no evidence of a jet being shot into the bank, which acted as both protective works and witness plate for this attack.

The operation of the MineBurner had to take place within the safety constraints of operations on the NPA site, and this meant having to periodically stop work in order to shelter whilst a detonation of other targets took place. The situation was further compounded by the fact that the Swedish Rescue Services Agency (SRSA) had been deployed, on instruction from the United Nations staff of the Mine Action Coordination Centre (MACC), on a neighbouring task only a few hundred metres away. Luckily, amicable relations between NPA and SRSA personnel meant that their various search and demolition phases could be managed at the site, but the result was a lot more 'down time' for both parties as they waited for each other to complete various demolitions. Without this overlap there would have been ample time for MineBurner to have been employed on at least one more target that day. This was however beneficial to the Team as they were thus able to observe the amount of TNT explosive that SRSA were having to employ to destroy the M42 on their site. Furthermore, SRSA were also interested to observe the MineBurner, as they are also having problems obtaining explosives in the current arrangements. SRSA were able to observe the results of the first two burns, thus contributing to the stakeholder analysis element of the trial.

Day Five (18 October): attack on live targets #2 (M42)

Figure 5. The Designer training the Team's driver how to assemble the MineBurner (photo by the author).

The day started in the same way as the previous one, with the NPA technicians having identified two M42 targets that appeared to have been thrown into the task site. On arrival at the site, the Team proceeded to prepare the MineBurner, this time using the local driver to assemble the device. The driver had had approximately 30 minutes of 'on the job' training in the assembly of the equipment the previous day. The equipment was assembled successfully within nine minutes of arriving at the site. Unfortunately, as the devices were being positioned at the targets, the Team and the NPA technicians observed a demolition on the other side of the valley, at a location later measured to be around 200 metres from the task site. This was assessed as being too close for comfort and the operations at the site were suspended. Two visits to the MACC – and a visit by the NPA technicians to the other side of the valley, where the UNIFIL Chinese Battalion (CHINBAT) was discovered to be conducting the other demolition - were not able to deconflict the problem. The Team then accompanied the NPA technicians to a number of alternative task sites, but none of them contained suitable targets. As a result nothing further could be done in terms of the program. This was to delay the implementation of the intended program.

Day Six (19 October): attack on live targets #3 (BLU 63)

Day Six had originally been earmarked as a day for stakeholder analysis, namely through soliciting opinions from other EOD organisations in order to widen the range of views on the equipment. However, as a result of losing the work on Day Five it was decided to combine stakeholder analysis with live trials.

As it was not clear whether CHINBAT would be active within the task area this day, action was taken by the Consultant to obtain access to an alternative site, one operated by Bactec International Ltd. The Bactec task site was contaminated by a different submunition, namely BLU63. The BLU63 presents different problems: it is not a directional shaped charge weapon, but it has a thicker fragmentation jacket and it has its fuse buried in the centre of the weapon. Furthermore, the fragmentation jacket is surrounded by an outer, aluminium alloy case in which a number of vanes are moulded. The outer jacket also increases the stand off between the MineBurner and the fragmentation jacket, which may be critical to its effective operation.

Bactec had identified an area of their task site where the Team were able to operate; however the Team suggested that the first attack be conducted against a section of case that had been separated and which comtained no explosives or detonator. This initial burn did not penetrate the case of the BLU63, although bubbles on the inside suggested that the case had *nearly* been burned through. Furthermore, the inside of the casing had been discoloured, suggesting that the casing had been heated up significantly. The EOD technician in charge of the Bactec site was happy to allow the Team to try the second target, which involved half a BLU63 that contained explosive but did not have a detonator fitted. The burn was conducted and a fifteen minute soak time observed.

The results of this second burn were encouraging; the explosive had been burned out and a crust formed inside the target, which appeared to be a result of the high temperatures heating up the sandy soil on which the target laid. The burn had also penetrated the casing, leaving a whole about 8mm wide. This result suggested that the MineBurner generated enough energy to cause the explosive fill within the BLU63 to burn out. The case was still warm to the touch and this suggests that a soak time between 15 and 30 minutes be used in future.

The third burn was against a fully intact target. This was unsafe to move and so the MineBurner nozzle had to be positioned at the right position and attitude, avoiding the outer vanes in order to ensure that it is aimed at a place where the standoff from the fragmentation jacket is at a minimum. The nozzle was difficult to place. Furthermore, when the UXO was examined after the burn, the burn appeared to be off centre and had not penetrated the UXO, which however appeared significantly discoloured. A combination of the geometry of the BLU63, and the memory within the nozzle assembly, meant that the nozzle may have moved when the burn initiated. The inconclusive nature of this result was exacerbated by the ‘unsafe to move’ nature of the BLU63, which prevented the Consultant from simply picking up the target and seeing if the explosive had burned out! A portable x-ray set (as used by EOD teams in other operations) would have been very useful in this situation.

Figure 6. Postioning the MineBurner nozzle against the BLU63 #1 (photo by the author).

The fourth burn was carried out against another fully intact BLU63. More care was taken in the positioning of the nozzle and three minutes after the burn was initiated a loud 'pop' was heard from the firing point. On approaching the target the target was observed to have separated into its two halves and the explosive completely burned out. The halves were some six metres apart. The components of the detonator were also observed to be separated. This result suggests that the MineBurner is also suitable for use against the BLU63, especially once an improved nozzle positioning tool is developed by the Designer.

Figure 7. Results of the attack against the last intact BLU63. The two halves of the UXO were separated by six metres and the explosive burned out (photo by the author).

Day Seven (20 October): attack on live targets #4 (M42)

Day Seven had originally been planned as a day for moving back to Beirut and writing up the results. However, it was decided that, as CHINBAT had not returned to the NPA task site, and because the original targets earmarked for MineBurner still existed, to return to the NPA site for three hours in the morning of the site to conduct some more burns against these remaining live targets. This was discussed with the NPA Country Manager, who agreed to the delay in writing up to make the most of the opportunity of the remaining targets.

By this stage, the NPA technicians had identified five targets for the MineBurner. Two were safe to move, as their slider assembly was missing. The remaining three were fully intact and thus designated as unsafe to move. The final two of these unsafe to move targets were also in 'difficult' situations as they were both on a loose rock bank below the road. These two were attacked last.

Figure 8. One of the final five M42 attacks resulted in a burn (photo by the author).

Figure 9. Three of the final five resulted in a deflagration, leaving large fragments and no evidence of a jet being formed (photo by the author).

All five of the targets were destroyed. A burn was achieved on one, with deflagration achieved on three of the others. The final target, which had been discovered between the fronds of a large cactus-like plant, was a high-order detonation, with the jet forming and shattering a large stone that acted as witness plate. There appeared no particular reason for this weapon to 'high order' compared to the others that had been found in similar condition (although EOD technicians will be familiar with the precept "never conduct a low order technique without preparing for a high order"). This should be considered a limitation of the trial, as more time, with more targets, would have generated more significant statistics.

Figure 10. The final attack was against an M42 on a gravel slope lodged between the stems of a large plant. This attack resulted in a detonation with evidence of the jet shown in a 'witness plate' (photo by the author).

However, the key observation to be made from the final day's work was that all five targets had been successfully attacked within three hours work time. This was broadly similar to the time being taken to destroy other targets by conventional (explosive) means by the NPA technicians working at the site. It should be recalled that this rate of work was achieved after only a few days handling, and one could reasonably expect the productivity of EOD teams using MineBurner to improve to the point where the assembly and deployment of the equipment was no longer on the critical path for the time taken for EOD operations in such circumstances. The degree of variance between MineBurner and conventional attacks was less than the degree of variance caused by other environmental factors such as the proximity of all the various targets from the administrative area. This issue is addressed in more detail in the time and motion analysis set out below.

Table 2: Summary of MineBurner results against live targets

Ser	Date	Item	Condition	Attitude	Attack	Result	Remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
1	17 Oct 06	M42	No percussion cap	Flat ground	Attacked cone	High order – jet formed	
2	17 Oct 06	M42	Percussion cap replaced	Flat ground	Attacked 1cm from shoulder	Burn; hole in side	
3	17 Oct 06	M42	Complete	Difficult: on stone bank	Attacked 1cm from shoulder	Deflagration: no jet, large frag remains	
4	19 Oct 06	BLU63	Casing only	Flat ground	Attacked between vanes	Burn, nearly penetrated casing	
5	19 Oct 06	BLU63	Half casing with explosive but no detonator	Flat ground	Attacked between vanes	Burn; penetrated casing	No explosive left in target.
6	19 Oct 06	BLU63	Complete	Flat ground	Attacked between vanes	*Probable* burn	Burn was off centre. Target was intact so not possible to confirm condition
7	19 Oct 06	BLU63	Complete	Flat ground	Attacked 1cm from shoulder	Deflagration	Target separated
8	20 Oct 06	M42	No percussion cap	Flat ground	Attacked 1cm from shoulder	Deflagration: no jet, large frag remains	
9	20 Oct 06	M42	No percussion cap	Flat ground	Attacked 1cm from shoulder	Burn; hole in casing	
10	20 Oct 06	M42	Complete	Flat ground	Attacked 1cm from shoulder	Deflagration: no jet, large frag remains	
11	20 Oct 06	M42	Complete	Difficult: on stone bank	Attacked 1cm from shoulder	Deflagration: no jet, large frag remains	
12	20 Oct 06	M42	Complete	Difficult: on stone bank and in plant	Attacked 1cm from shoulder	High order; jet formed	Attitude of target *may* have meant burn was off centre

Economic Analysis

Overview

The preceding section of the report has examined the technical effectiveness of the MineBurner system. This section of the report deals with the cost-effectiveness of MIneBurner when compared to the alternatives. This economic analysis is done in three parts. Firstly, a quantitative cost-effectiveness analysis[7] is conducted using a previously created budgetary analysis tool, the 'Model Mine Action Centre' (MMAC)[8]. This measures the relative cost against a standard benchmark and identifies the additional (or otherwise) cost of employing MineBurner compared to the cost of using explosives.

The second comparative method used here is a time and motion study examining the time costs of an EOD team deploying on two identical sites: the first site is cleared by explosives and the second by using MineBurner. This analysis is repeated, taking account of the time needed to detour in the morning and afternoon to obtain and then return high explosives.

The third form of economic analysis used here is a qualitative comparison of MineBurner with its closest competitors, in order to identify which demolition method has the least number of associated logistic burdens. This will allow potential users to determine which of the attributes will be the greatest (or otherwise) problems in their program and therefore select the most useful tool for their use. It will also allow those wishing to make quantitative comparisons using any particular program as a basis identify the issues which must be taken into account and thus ensure that the various alternatives are compared on a 'like with like' basis. For example, if the capital costs of purchasing MineBurner are to be taken into account, the costs of establishing an explosive storage capacity should also be considered, even if the explosives themselves are provided free of charge[9].

[7] CEA is defined as "a systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective". Source: http://www.nps.navy.mil/drmi/definition.htm

[8] The MMAC CEA model was developed in earlier research by the Consultant and was also utilised in the Manual Demining Study carried out by the Geneva International Centre for Humanitarian Demining (GICHD). More information about this study and the MMAC can be seen at http://www.reliefweb.int/rw/lib.nsf/db900SID/AMMF-6TDHBQ?OpenDocument

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[9] More detail on the cost capture issue in mine action can be found out in the following paper by the Consultant: http://maic.jmu.edu/JOURNAL/7.3/notes/keeley/keeley.htm

Assumptions and Sensitivity Analysis

Like any economic analysis, the large number of potential variables means that there must be a series of assumptions made in order to concentrate on the key issues. These assumptions are set out below.

Assumption: the estimated prices of MineBurner are accurate.

The estimated costs, set out at Annex B, have been provided by the Designer and are therefore the most accurate available.

Assumption: The MineBurner equipment can be used repeatedly over its working life.

The working assumption is that the equipment can be used daily, over a 200-day working year, for a total of five years. This is a standard planning figure used in the MMAC model, and, according to the Designer, well within the MineBurner design specifications. Of course, a lower usage rate would drive up the 'cost per burn,' but a similar reduction in actual usage rate would also drive up the equivalent 'cost per kilogram stored' which is one of the main fixed costs in a conventional, explosives-based regime.

Both of these assumptions are tested using 'sensitivity analysis[10]'. For example, a reduction in the number of burns per day from 6 to 5, will increase the cost per burn of MineBurner from $0.74 per burn to $0.77. Either of these is well within the cost per explosive charge and considerably cheaper than other incendiary alternatives currently on the market. Indeed, one would have to reduce the average number of burns per field module to 2.5 burns per day to breach the $1.00 per burn mark. Furthermore, fluctuations in the purchase costs of the capital items are comparatively insensitive: a 10% increase in the cost of a field module will only change the cost per burn by 2c. The equipment is, however, sensitive to changes in the cost of the consumables: a doubling of the cost of the nozzle assembly (i.e. increasing it by 50c) will result in a similar increase in the cost per burn, reflecting the fact that each burn requires one assembly as a sacrificial element. MineBurner should take steps to ensure that the cost can be assured over the working life of the equipment, perhaps by offering the customers the opportunity to buy a large stock of consumables 'up front' in order to guarantee the price.

Assumption: MineBurner and explosives are 'perfect substitutes'.

The initial run of the CEA assumes that MineBurner can completely replace the use of high explosives. In practice this is unlikely to be the case. The model is then recalculated using 80% mineburner usage, with a reduced

[10] Sensitivity Analysis is the study of how the variation in the output of a model (numerical or otherwise) can be apportioned, qualitatively or quantitatively, to different sources of variation. Source: http://encyclopedia.thefreedictionary.com/Sensitivity+Analysis

explosives holding and a 50% reduction in the cost of explosive storage; this conservative estimate takes account of the practical need to hold more explosives than might be used on average for those periods when a greater amount of explosives are used.

Cost Effectiveness Analysis

The forecast prices of MIneBurner and its ancillaries are set out at Annex B. These costs are entered into the MMAC, assuming that there will be one MineBurner per demining platoon and one Per EOD team. The MMAC model measures the effect, all other things being equal, on the cost per square metre of cleared land.

Firstly, the comparative cost of using MineBurner when explosives are provided free of charge are modelled; secondly, the comparative cost of using MineBurner when explosives are purchased are modelled; and thirdly, this figure is then modified to model the scenario when the explosives usage rate is 20% of its previous figure.

Finally, the MMAC model is adjusted to see the effect of reducing waiting times for explosive by around 30 minutes per day. This is measured by increasing the productivity figure for each demining platoon by 5% (which is a conservative estimate of the possible time saved).

Table 3: Results of MineBurner CEA

Ser	Scenario	Cost $/m2 using explosives	Cost $/m2 using MineBurner	Remarks
(a)	(b)	(c)	(d)	(e)
1	Explosives free	$1.22	$1.26	
2	Explosives purchased	$1.42	$1.26	
3	20% explosive usage	$1.31		MineBurner plus some Explosive
4	Implications of reduced waiting time	$1.19		As for Ser 3 but with reduced waiting time

The MMAC model suggests that, when explosives are free (and readily available) the MineBurner is more expensive to the program, even though the cost of purchasing MineBurner is partially recouped by saving the cost of ammunition storage. Where explosives are purchased, the saving using MineBurner is more evident: the cost of MineBurner remains constant at $1.26 per square metre cleared, whilst the cost of clearance to the program would rise to $1.42 per m2. Using some of both would increase the cost to $1.31, but taking account of reduced waiting times though a 5% increase in productivity would further reduce the cost to the program to $1.20 per m2.

The CEA would suggest that, where programs have either to bear the cost of purchasing explosives, or bear the loss to productivity of having to travel to collect explosives, then MineBurner appears to offer a cost-effective alternative.

These calculations assume that the introduction of MineBurner has no significant negative impact on the productivity of the teams using it. The validity of this assumption is measured in the following time and motion analysis.

Figure 11. This multi-item demolition, being prepared by SRSA, shows the amount of high explosive that is required to demolish M42 targets (photo by the author).

Time and Motion Analysis

There are a number of different scenarios under which MineBurner might be employed. In this case the first one chosen for detailed analysis is where a mobile EOD team would employ a single MineBurner for use on a UXO which has been discovered and reported by a member of the public. The second scenario is where an area of 1 Ha is searched by a battle area clearance (BAC) team and 10 UXO have been discovered. In this case the team prepares a MineBurner set with 10 modules for simultaneous firing. In both cases the time and motion study is compared with an identical scenario where the team uses standard explosive charges. The third variation in both cases is where MineBurner is given a shorter soak time as a result of achieving a deflagration or detonation rather than a burn.

The times undertaken for each task are based on a combination of the Consultant's own experience and his observation during this trial. For example, given that the driver assigned to the team was able to prepare two MineBurners within nine minutes of arrival at a site, after just a few minutes of training, suggests that a planned assembly time of 10 minutes is reasonable and conservative.

The final impact, which was remarked upon by several of the observers but which the trial could not measure in the time allowed, was that of non re-contamination. One effect of blowing UXO in situ using high explosives is that they re-contaminate the task site with metal fragments. This can be a significant problem when quality control techniques involve the confirmation of a metal free area. The deflagrations achieved in most of the 12 MineBurner attacks would mean a significant reduction in this problem.

ID	Task Name	Duration
1	**EOD Mobile Team**	**0.19 days**
2	Team arrives on site	0 days
3	Team Leader Questions witness	15 mins
4	Remote reconnaissance of UXO	30 mins
5	Team Leader instructs No 2 to prepare	15 mins
6	Close Reconnaissance	30 mins
7	**1.1 HE charge**	**0.11 days**
8	Explosive charge prepared	5 mins
9	Firing cable checked and positioned	15 mins
10	Charge positioned and detonator connected	5 mins
11	Charge initiated	1 min
12	Soak time	5 mins
13	Rewind firing cable	10 mins
14	Recovery	10 mins
15	Task complete	0 days
16	**1.2 MineBurner with 30mins soak time**	**0.13 days**
17	MineBurner Prepared	10 mins
18	MineBurner checked and Positioned	10 mins
19	MineBurner initiated	2 mins
20	Soak time	30 mins
21	Recovery	10 mins
22	Task complete	0 days
23	**1.3 MineBurner with 5 mins soak time**	**0.08 days**
24	MineBurner Prepared	10 mins
25	MineBurner Positioned	10 mins
26	MineBurner initiated	2 mins
27	Soak time	5 mins
28	Recovery	10 mins
29	Task complete	0 days

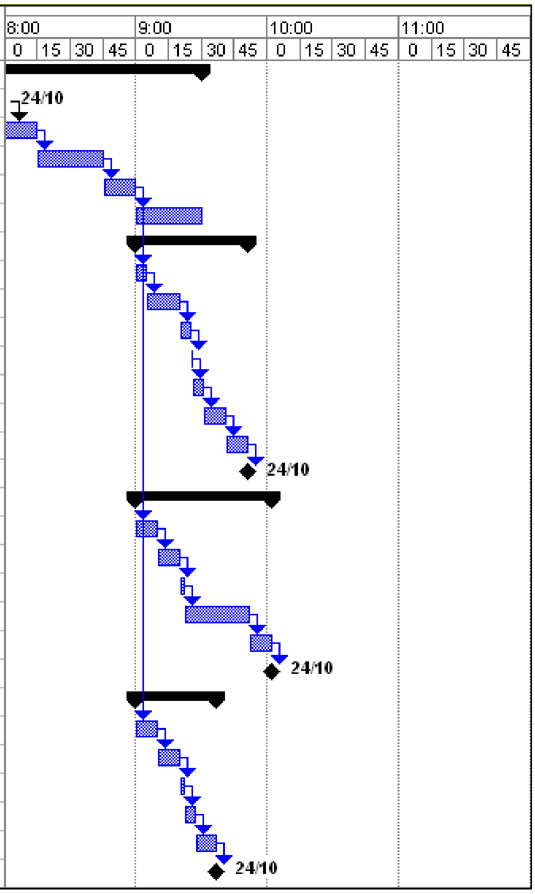

Figure 12. Time and motion study of EOD task using HE and MineBurner with 30 and 5 minutes soak time.

ID	Task Name	Duration
1	**BAC Task**	**0.25 days**
2	Team arrives on site	0 days
3	Team Leader Questions witness	15 mins
4	Remote reconnaissance of UXO	30 mins
5	Team Leader instructs No 2 to prepare	15 mins
6	Visual search	1 hr
7	**1.1 HE charge**	**0.22 days**
8	Explosive charge prepared	45 mins
9	Firing cable checked and positioned	15 mins
10	Ringmain positioned	15 mins
11	Charge positioned and detonator connected	5 mins
12	Charge initiated	1 min
13	Soak time	5 mins
14	Rewind firing cable	10 mins
15	Recovery	10 mins
16	Task complete	0 days
17	**1.2 MineBurner with 30mins soak time**	**0.28 days**
18	MineBurner Prepared	60 mins
19	MineBurner checked and Positioned	30 mins
20	MineBurner initiated	5 mins
21	Soak time	30 mins
22	Recovery	10 mins
23	Task complete	0 days
24	**1.3 MineBurner with 5 mins soak time**	**0.23 days**
25	MineBurner Prepared	60 mins
26	MineBurner Positioned	30 mins
27	MineBurner initiated	5 mins
28	Soak time	5 mins
29	Recovery	10 mins
30	Task complete	0 days

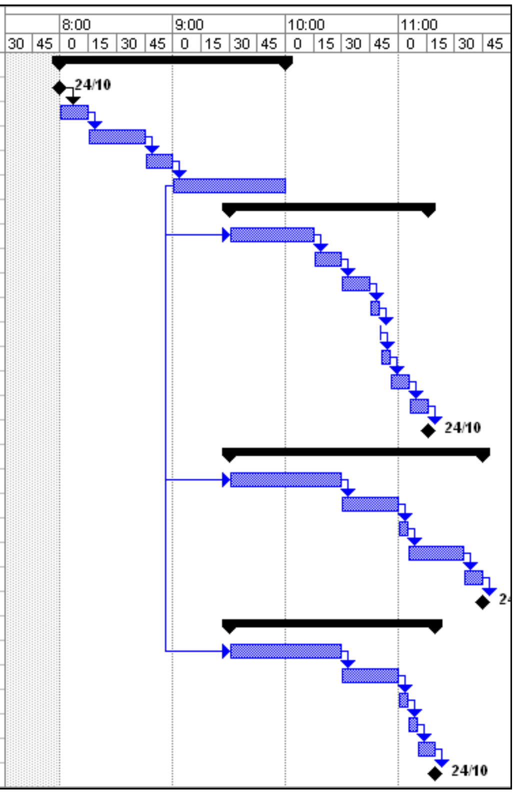

Figure 13. BAC task using HE and MineBurner with 30 and 5 minutes soak time.

The Gantt charts used to represent the activities in both scenarios are set out at Figures 12 and 13 above. The results show that, allowing for some concurrent activity in all cases, the time taken to complete each task is actually very similar, and the variance in each task duration as a result of the method used – and indeed the soak time employed – is actually well within the variance normally experienced during the questioning of witnesses or conducting reconnaissance of the target. It may be concluded therefore that using MineBurner endows no particular advantage or disadvantage on the time taken to conduct a task than an explosive solution. This does not of course take into account any delays spent collecting explosives from a central ammunition storage area.

Multi-Criteria Analysis

The final type of economic analysis to be carried out is a qualitative comparison of the MineBurner with high explosive and other close competitors. This Multic-criteria analysis (MCA) lists the four alternatives considered in the columns of the tables below, with the different criteria scored in each row. This gives a pictorial representation of the issues facing mine action organisations wishing to deploy each of these different techniques. Apart from the high explosive solution, this MCA provides the ability to consider techniques, currently considered the front runners by the United Nations Mine Action Service (UNMAS) as alternatives to high explosive that are not currently available in Lebanon and thus not available for more quantitative scrutiny. This MCA was prepared by the author and validated by the NPA technicians in Lebanon as part of the drafting process.

Table 4: MCA of UXO demolition alternatives							
Ser	Criterion	HE	MineBurner	Imported Torch	Fabricated Torch	Recycle	Remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
1	Local purchase available	XXXXX	XXX				
2	Safe to move by Air		XXXXX	XX	N/A		i.e. detonators or similar initiators
3	Ease of import		XXXXX	X	XXX	XXX	Torch and recycle can import tools for fabrication materials
4	Safe storage		XXXXX	XXX	XXX		
5	Ease of fabrication	N/A	XXXXX	XXXXX	XX	XX	
6	Speed to start operations	XXX	XXXXX	XXX			
7	Batching available to monitor quality	XXXX	XXXX	XXXXX	XXX		MineBurner bags can be batched to record name of packer and date
8	Freedom from need for demolition accessories		XXXXX	XXX	XXX		
9	Impact of delays in collecting from storage		XXXXX	XXX	XXX		
10	Potential of increased soak time	XXXXX	XX	XX	XX	XXXX	Providing recycled explosives are able to achieve same quality as purchased explosives
11	Risk of fire	XX	XXX	XXX	XXX	XX	
12	Fragement Contamination	X	XXXX	XXXX	XXXX	X	
12	Sustainability	XXX	XXXXX	XX	X	X	

The pyrotechnic torch burns the target in a similar fashion to MineBurner, but is delivered in a pre-formed solid form (similar in size to a large tube of toothpaste) whereas the explosive recycling system relies on a specialist team having access to unexploded munitions which they cut open and extract the explosive content. The torches can either be imported or production can be established in country, so these are considered as separate alternatives in the analysis below. Because of the nature of the recycling method, it is not possible to export the products from one fabrication plant to another country.

There are many different techniques for laying out an MCA: in the analysis below each X represents a positive grading; therefore the greater number of X the ‘better’ the alternative’. The reader must, however, choose their own weighting of the relative importance of the different criteria.

Analysis of the result suggests that, where explosives supplies are a problem, MineBurner and the explosive torch dominate the two other alternatives. Where explosives are freely available, use of conventional explosives appears to dominate the recycled option, though this will depend on a more detailed analysis of the true costs of the recycling option. The biggest advantages of MineBurner over the torch option is the speed with which MineBurner can be set up in country and the ease of importing the equipment. Therefore, if the increased soak times and slightly increased risk of fire can be tolerated, and the build quality and positioning issues are addressed, MineBurner does appear to be an economically viable option.

The suggested way ahead for MineBurner

The MineBurner is not yet perfect but it does appear to be a potentially sound option. The following points set out a suggested way ahead for MineBurner to be improved to make it usable.

Pre-sales

1. Incorporate modifications as set out in Annex A
2. Confirm costs in Annex B
3. Develop clear assembly instructions
4. Develop clear user guidelines that include advice on drills and standing operation procedures (SOP)
5. Develop a training program for instructor cadres and maintainers

After sales

6. Maintain a newsletter or ‘blog’ to keep users updated on latest tips
7. Incorportate user recommendations into subsequent versions of MineBurner

Conclusions

In conclusion, the trial was limited in scope but it was successful in that it showed the ability of the MineBurner against two different types of submunitions and highlighted some areas for improvement. More experience will generate more significant statistics.

The MineBurner was successful against the M42 and BLU 63 submunitions.

The MineBurner is not yet rugged enough to withstand sustained use in field conditions, however the Designer already has a number of improvements in hand and the Consultant and the many observers of the trial were able to suggest some more.

There are problems positioning the nozzle. The final metre of the gas hose has an elastic ‘memory’ and this must be eliminated. Similarly, the nozzle needs some method to improve the precision of its positioning.

The MineBurner is not as complicated as it looks. It is merely different. A short training program and an opportunity to practice with the equipment assuaged the initial doubts and scepticism of the Consultant in this regard. A formal training program and the production of related instructions and user guidelines will help overcome the conservative nature of potential end users.

The economic analysis suggests that MineBurner is also an economically viable option for mine action programs, especially where there are logistic, administrative or political difficulties in obtaining high explosive.

MineBurner is unlikely to *totally* replace high explosives in all situations, but its use should significantly reduce the problems faced by mine action agencies obtaining explosives and other demolition ancillaries.

Annexes:

A. Observations for the improvement of the MineBurner design
B. Estimated MineBurner Prices

Annex A: Observations for the improvement of the MineBurner design

Note: these observations are recorded in the approximate order they were made during the trial.

Table 5: Summary of Observations

Ser	Observation	Remarks
(a)	(b)	(c)
1	Need a ‘soldier’ proof T-piece adaptor for double gas bag fitting	
2	Training needs to incorporate check for position of 20/40 second switch	
3	Use braided cable to minimise RF hazard	
4	Need combination of spike, weight and tripod for positioning of nozzle	
5	Increase sacrificial element	Has cost implications
6	Training needs levels, e.g. user, instructor, maintainer	
7	Include battery level LED	
8	Quick couple on gas fitting, with error proof selection	In hand
9	Training should include bag filling error recognition	
10	Need components list, list of consumables, spares pack	
11	Different colour on gas bag tubes	In hand
12	Flatter button on Remote Fire Unit	
13	Weather proof charger sockets	
14	Weather proof box, flap on switch	
15	Different colour for signal and heater cables	
16	Pre-set regulator for gas bag inflation	
17	Training needs to give advice on safe stowage for oxygen bottle	
18	Batteries need more robust terminal OR	
19	Use multiples of standard rechargeable batteries to improve ease of access to batteries	
20	Include option to fire Field Module without using Repeaters	
21	Need shade for stores area	
22	Need holder for filled and empty bags, and training regime	
23	Include signals after 5 and 30 minutes	
24	Push fit for flashback connection	
25	Sleeker flashback design	hand In

Ser	Observation	Remarks
(a)	(b)	(c)
26	Move bridge wire to improve standoff	
27	Cover to protect bridge wire in transit	
28	Need drill to prevent accidental connection to used bag	
29	Nozzle assembly needs to solve ‘memory’ problem	
30	Fireproof protection also needs frag protection – consider a ballistic nylon liner for the bag.	
31	Interest in separate use of Remote Firing Unit	Possible ‘spin off’
32	Fit posts to allow use of firing cable in the event of comms problems	
33	Sort out range issues with Repeaters	In hand
34	Include label to show who packed bag and when	
35	Improve weather-proofing of boxes	
36	Make RFU smaller, and more visible	
37	Put nut on air valve to stop it falling into bag	
38	Needs operational guidelines/SOP to improve effective use, plus training pack	
39	Sort out failure of audible signal of one of the Field Modules on last day	
40	Training needs to emphasise need to leave 10sec pause between multiple firings	

Annex B: Estimated MineBurner Prices (Source: MineBurner)

Ser	item	unit cost(1)	quantity	total cost	max no of uses	forecast use (2)	forecast cost per burn	remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
MineBurner Field Set Components								
1	Remote Firing Unit	500.00	1.00	500.00	100,000			Includes pair of repeaters
2	Filler Unit	400.00	1.00	400.00	100,000			
3	Field Module	1,000.00	10.00	10,000.00	100,000			
4	Sub total			**10,900.00**	100,000	60,000	0.18	
MineBurner supplied consumables								
5	Bladder Assembly	40.00			1,000	60,000	0.04	
6	Wrapping	0.5			30	60,000	0.02	
7	Nozzle set	0.5			1	60,000	0.50	incl all sacrificial elements: tube, wire
8	Sub total						0.56	and paper wrapping for air bag
Total purchase cost for MineBurner								
9	Year One			17,580.00				
10	Subsequent year			6,680.00				
11	**Total over 5 years**			**44,300.00**			**0.74**	

Notes:

1	All costs in US$		
2	Forecast use based on:		
	No of burns per day	6	per field module
	No of burns per day	60	per field set of 10 modules
	No of days per year	200	working days
	Working life	5	years
	Forecast use:	60,000	burns per field set over 5 years
3	Cost of gas and oxygen insignificant over these scales		