MINEHOUND™ trials, 2005-2006

Summary report

ERA Technology Ltd
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MINEHOUND TRIALS 2005 and 2006

1 Background

The UK Department for International Development (DfID), in collaboration with the German Foreign Ministry (Auswärtiges Amt), contracted ERA Technology of the UK to carry out extensive trials in Cambodia, Bosnia and Angola of an advanced technology, dual sensor, and hand-held landmine detector system. The main difficulty faced by deminers is the huge amount of metallic debris left in the ground to which the conventional metal detector responds. This original aim of this new technology was to reduce the false alarm rate by at least 2:1 as this should make a significant difference to the efficiency of demining operations, in the event a much greater improvement was achieved. To carry out the trials, ERA Technology worked with the following Non Governmental Organisations (NGOs); Mines Advisory Group (MAG) of the UK in Cambodia and Angola and with Norwegian Peoples Aid (NPA) in Bosnia.

MINEHOUND™ is designed for use in humanitarian demining operations. The Mine Action Research (MAR) project sponsored by DfID is the only project carried out to date that has successfully developed an affordable detector for humanitarian use and has carried out extensive field trials in live minefields of pre-production units. The timeline for the project is shown in Figure 1.

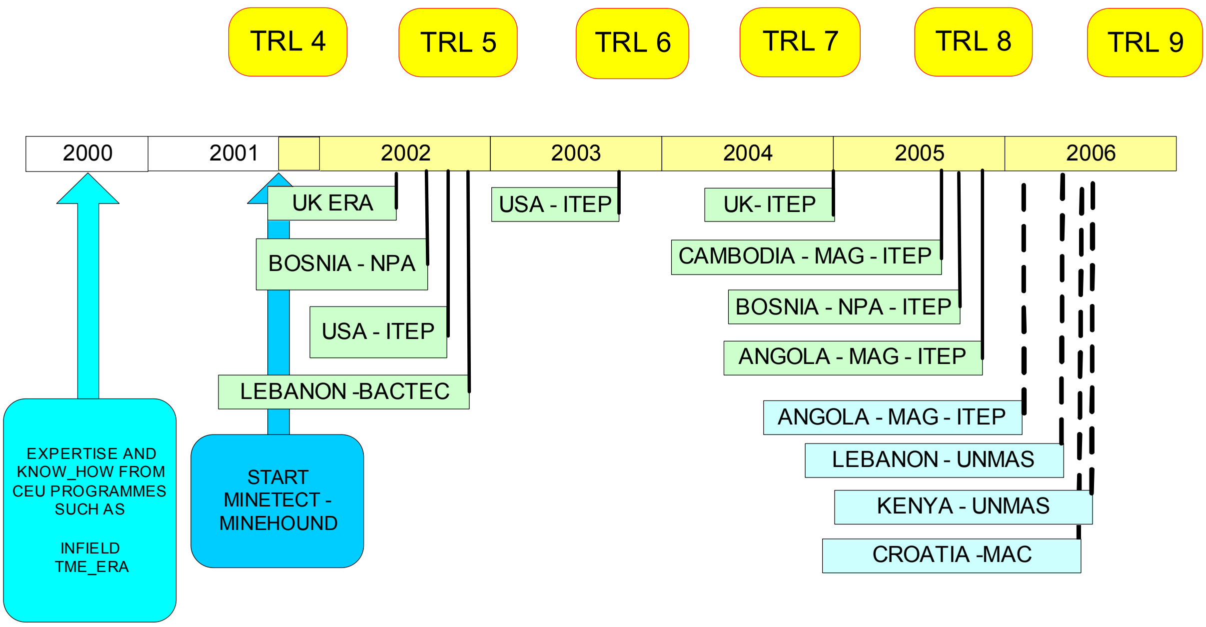

Figure 1 Timeline for MINEHOUND project

The early phase of work on the project, entitled MINETECT, showed that it is entirely feasible to achieve a significant improvement in detection performance. This is realised by means of a dual sensor detector using both a metal detector and ground penetrating radar (GPR). The GPR is able to discriminate between mines and small metallic clutter and thus significantly reduce the false alarms generated by current metal detector technologies. The GPR provides its indication to the operator in a simple and effective way, which has the benefit of reducing the complexity of the equipment and hence its cost. MINEHOUND™ is designed for low cost quantity production, this being a key entry requirements into the market.

Pre-production versions of MINEHOUND™ were built to a standard appropriate for extended in-country field trials, but had to be used as a follow up detector, after existing standard operational procedures had been applied to the mine affected areas. At no stage during the trial were the detectors operated as a primary detector. There was a requirement on the participating MAC/NGO to record sufficiently accurate data on detector performance. ERA Technology provided training and logistical support during the trials and carried out an overall analysis of performance from the trials data

The objectives of the programme were to:-

- Re-package and re-engineer the earlier MINETECT design to a form suitable for in-country trials by deminers.
- Build units for the trials.
- Carry out trials in Cambodia, Bosnia and Angola.
- Determine (document against ground truth) the performance of the dual technology detector in terms of detection and false alarms.
- Determine the potential improvement in efficiency of demining operations.
- Review and report on the trials, including both quantitative performance data and qualitative feedback from the deminers.
- Set up a partnership to take the technology into production.

ERA Technology Ltd (UK) and Vallon GmbH (Germany) worked together to design and build MINEHOUND™, which incorporates the state-of-the-art technology in landmine detection equipment. Fifteen units were built for the trials and five units were shipped to each country for the period of the trials. Both MAG and NPA provided excellent support for the trials, which could not have succeeded without their practical assistance in logistics, site preparation and committed support from the deminers and their supervisors.

2 NGOs involved with trials

MAG has been operational in Cambodia for more than 12 years, clearing many thousands of mines and items of unexploded ordnance (UXO). It now employs approximately 500 local personnel, working across six provinces in 22 Mine Action Teams (MATs), 8 Explosive Ordnance Disposal (EOD) teams, 10 Community Liaison (CL) teams and 7 scrub cutting teams. Around 30 per cent of MAG Cambodia's employees are women. MAG also employs about 50 mine victims and amputees, who are provided with metal-free prostheses by the International Committee of the Red Cross (ICRC).

Angola is emerging from a 40-year-long civil war that killed some one million people, uprooted a third of the population, and destroyed much of the country infrastructure. In spite of wealth derived from oil, gas, and diamonds, it is one of the poorest countries in the world, ranking 166 on the UNDP Human Development Index. MAG has been operational in Angola for more than 10 years, clearing thousands of mines and items of UXO. The end of the war and the dramatic increase in access and security has allowed MAG to strengthen its programme. It now runs 12 Mine Action Teams 4 Rapid Response Units, 5 Community Liaison Teams and 4 Mechanical Support Units. This range of operational units ensures that MAG is able to adopt a variety of mine action techniques. In addition, MAG is one of five implementing partners in the Landmine Impact Survey (LIS) currently being conducted in Angola.

NPA has been heavily involved in demining in Bosnia and Herzegovina but report that the landmine problem will stay a serious issue for a very long time in Bosnia and Herzegovina, not only because of constant danger for safety of local population but also as an obstacle for reconstruction and further development of the county. Ex-confrontation lines and mine suspected areas are sometimes in easy accessible urban areas but also in terrains that could have large agricultural capacity for the very weak economy of Bosnia.

The trials were invigilated by representatives of the International Test and Evaluation Programme, which includes Belgium, Canada, the Netherlands, Sweden, Great Britain, Germany, the United States, and the European Commission. ITEP's mission is to develop standards, coordinate and perform tests of materials and methods, and disseminate information about the results to all other interested parties. The trials started in August 2005 and continued through to February 2006 and trialled pre-production units in live minefields. Representatives from ITEP attended a familiarisation course at ERA in preparation for the trials.

Figure 2 Representatives of ITEP undergoing familiarisation at ERA Technology.

The main aim of the trials was to determine the reduction in false alarm rate that can be obtained when a dual sensor detector comprising a metal detector (MD) and ground penetrating radar (GPR) is used in a minefield. Five MINEHOUND™ units were issued to the NGO in each country. The trials, which took place over a 8-week period in each country, assessed the side by side performance of

MINEHOUND™ in the actual minefield when compared with the existing in-service metal detector. MINEHOUND™ was not used for actual clearance detection and its performance was only recorded for analysis. The deminer used the existing in-service metal detector to detect potential targets and having found one, then used MINEHOUND™ to determine firstly whether the latter provided an indication of the metal content of the target and secondly what was the GPR response of the target. When the target had been uncovered, the deminer recorded the type and size of target as well as its depth. These results were recorded and a database of MINEHOUND™ performance results in a live minefield was built up.

3 MINEHOUND™

Figure 3 MINEHOUND™ detector.

The MINEHOUND™ pre-production units used in the trials were designed to operate firstly in the metal detection mode, where all metal threats are noted. The operator then uses the GPR to confirm the presence of a threat. The output to the operator from both the MD and GPR is by means of audio signals. The MD audio provides accurate position information and a mass-of-metal indication. The GPR provides accurate position information, depth information and target radar cross-section information. It is possible to use both detectors together. The GPR responds to even the smallest of flush buried mines but not to small metal fragments. As a result, a large amount of metallic clutter (such as bullet casings, small arms rounds and shrapnel, which cause false alarms) is rejected by the system. Typically, the reduction in Probability of False Alarms (PFA) lies between a factor of 2 and a factor of 7 compared with a MD. The GPR also detects zero metal mines that are undetectable by the MD. In situations where metallic fragmentation makes detection of minimum metal mines difficult, the GPR makes detection easy . The GPR uses a radically different and patented approach from conventional ground penetrating radar (GPR) designs. MINEHOUND™ offers simplicity of use and affordability, both key factors in humanitarian demining operations.

The typical performance of both the MD and GPR expected in average soil conditions will meet the requirement to detect AP mines similar to the PMA3 at 13cm but will vary depending on soil conductivity, soil moisture, soil magnetic content and mine size. The larger the mine, the better the performance with GPR and the greater the mass of metal, the better the performance with the MD.

The MINEHOUND™ pre-production units comprises a MD produced by Vallon GmbH (VHM3) and a custom designed 1 GHz GPR designed by ERA Technology Ltd. The GPR is time-domain radar transmitting 1ns duration impulses at a repetition frequency of 1MHz. The GPR transmitter- receiver and associated control and signal processing is mounted on a compact purpose designed module. A dedicated, state-of-the-art, Blackfin® Digital Signal Processor (DSP) is used to provide all control and signal processing functions. The pre-production system weighs 4.75kg and operates from 4 rechargeable D cell batteries, which can also be carried on the operator's belt, reducing the weight of the unit by nearly 1kg.

4 In country trials

The trials took place in Cambodia, Bosnia and Angola. Fifteen MINEHOUND™ units were built and five were shipped to each country. ERA shipped ten units to MAG headquarters in Manchester of which five units were then shipped to Cambodia and five to Angola. ERA shipped five units to NPA Bosnia. In each country the same process was followed in terms of setting up and training.

On arrival at the minefield the ERA team, and any ITEP staff, worked with the NGO to clear suitable areas for training. One lane was created for calibration of the MINEHOUND™ and two lanes for the blind tests. A further area was cleared for ITEP activities. Clearance involved removal of the local vegetation and metallic contamination of any kind. In all countries this was protracted due to the extensive local metallic contamination and soil mineralisation. Once the sources of false alarms were removed the surrogate targets were emplaced.

The training sites were established in close proximity to the live minefields and during trials, setup of the pre-production MINEHOUND™ was carried out by ERA using laptop computers. Production models are set-up from functions within the equipment. The deminers were trained using programmes devised by ERA with support from ITEP. In Cambodia the training was carried out via an interpreter while in Bosnia and Angola training was carried out with English speaking members of the NGO staff.

5 Trials procedures

To ensure the safety of the deminers, MINEHOUND™ was only used to follow up on an indication from the existing metal detector. MINEHOUND™ was used to investigate that alarm with both the metal detector and GPR, and the results recorded. The alarm is then investigated according to the SOPs of the demining organisation. A SOP was prepared for use in the trials and the cardinal points for the trials are given below:

- *Deminers must not use MINEHOUND™ as a detector in a clearance operation under any circumstances*

- *Existing and approved SOPs take precedence over the use and operation of MINEHOUND™ during these data gathering trials.*

- *If, while surveying, MINEHOUND™ indicates the presence of a metal target that the existing metal detector did not detect, the QA section personnel are to be informed and they will report to the Team Supervisor who will implement existing SOPs.*

- *Deminers should only use MINEHOUND™ for gathering data in accordance with the Data Gathering Procedure (DGP).*

- *The Deminer will ensure that at the start of each day the MINEHOUND™ detector is functioning correctly on the calibration lane in MD and GPR modes and will confirm this with the trials invigilator.*

5.1 Cambodia

Figure 4 Map of Cambodia with the border town of Kamrieng highlighted.

The trial was carried out near the town of Kamrieng on the Cambodian/Thai border. All those participating in the trials arrived at the capital Phnom Penh, and were briefed by MAG on their activities. The road journey from Phnom Penh to Kamrieng requires a stop over in Battambang, which is a five-six hour drive from Phnom Penh on a good road. In Battambang the MAG province manager again briefed staff. The journey from Battambang to Kamrieng, some 140km from Battambang, can be done in about four to-five hours in the dry season and 4WD vehicles are needed. The Khmer Rouge heavily mined the Kamrieng area during the Pol Pot regime and the usual problems of reconstruction in such localities still exist.

The Mines Advisory Group (MAG) provided four deminers. These experienced deminers were Savom, the Team Leader, Kimsay, Mith, amputee deminer, and Roth, a female deminer and were trained in the operation of the MINEHOUND™ detector for two weeks. The training was conducted through an interpreter, who played an essential role. The soil in the area was heavily mineralised and very wet and required MINEHOUND™ MD setup, for laterite soil, and GPR setup for wet conditions. The main mines encountered were PMD6s and PMNs with a ratio of approx 80:1 fragmentation to mines. The current detector in use by MAG in Kamrieng was the Schiebel ATMID.

Two "blind" test lanes were also created to assess the trainees' performance throughout the trial in a controlled manner. The deminers' performance was also assessed weekly using a 12m "blind lane". This contains 12 GPR test pieces (buried in 3 groups of 4 at 10cm, 5cm and 1cm depth of cover) and 12 items of clutter.

The deminers worked in the minefield recording their findings. Any notes or comments on these sheets were also translated from Khmer into English to provide as much information as possible for analysis. The conditions in Cambodia were hot and there was much rain causing waterlogged ground for the GPR. The soil was also heavily mineralised and these conditions provided a demanding test.

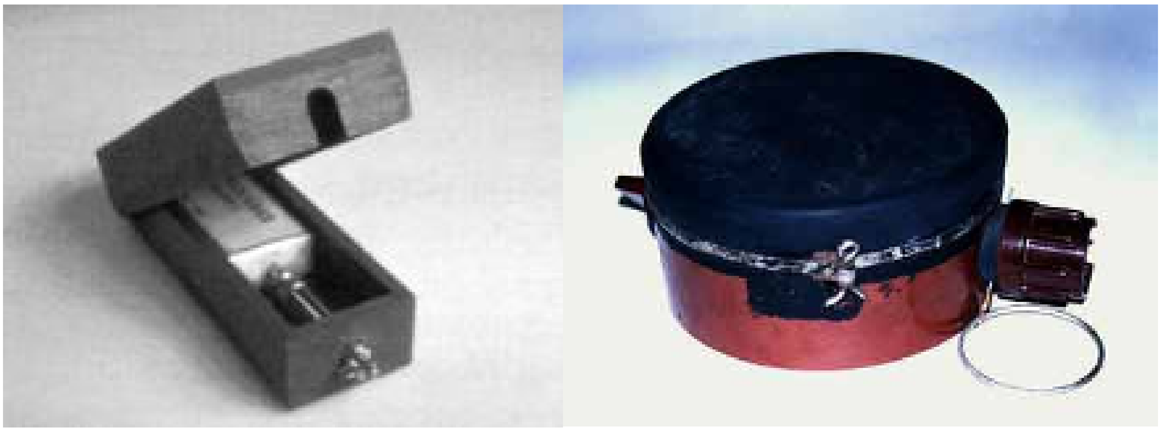

Figure 5 PMD6 and PMN landmines found at Kamrieng

Figure 6 Blind lanes after the afternoon's rain

Figure 7 Training session at Kamrieng

Figure 8 PMN6 AP mine in Kamrieng minefield shown uncovered prior to detonation

5.2 Bosnia

Figure 9 Map of Bosnia with Sehovici highlighted

The trial was conducted approximately 30km north of Sarajevo near the village of Sehovici. NPA (Norwegian People's Aid) was the sponsor for this trial and provided two deminers. The team leader, Dado and two deminers, Menseur and Gerard, were trained in the operation of the MINEHOUND™ detector and were competent users within less than a day. As for the Cambodia trial, two "blind" test lanes were also created to assess the trainees' performance.

Figure 10 Training session with Bosnian deminers

Figure 11 Soil conditions at Sehovici minefield.

After the training sessions, the deminers were keen to get the detector into the minefield. In a similar manner to the Cambodia trial, the deminers' performance was assessed weekly using a 12m "blind lane" containing 12 GPR test pieces (buried in 3 groups of 4 at 10, 5 and 1cm) and 12 pieces of clutter. This data was examined alongside records from the minefield to see if there was any change in performance over time. In Bosnia the ground was waterlogged ground and also heavily mineralised and these conditions again provided a demanding test for the equipment.

5.3 Angola

The first trials in Angola were carried out near the town of Luena in the southeast of the country, which is about 1 hour by plane from the capital Luanda. The initial commissioning of the training site and deminer training was implemented at the MAG main base. The soil was very dry at the start of work, but the rains then arrived. The format of the trials was identical to those carried out in Cambodia and Bosnia.

Figure 12 Map of Angola with Luena and Luau highlighted

Figure 13 Training in Luena

Figure 14 The minefield in Luena

Figure 15 Typical bush conditions near Luena

The first trial in Luena gathered considerable information on fragmentation, but no mines were encountered. Therefore, a different area of the country was examined. Discussions with the MAG team in Angola recommended that Luau, where a number of mines had been found, would be a suitable site.

Luau is about 300 km east of Luena but, due to the condition of the roads, requires a 10hour road trip between the two towns. Luau is situated 40 kilometres from the border of the Congo on the very easterly tip of Angola. During the civil war conflict there were many mines laid around the perimeter of the town by a number of different forces making it a large strong point for whoever occupied it at the time. The town is laid out in the usual grid system, however the roads are less than perfect and most of the infrastructure put in place by the Portuguese is now destroyed or in ruins. The train station and storage area are derelict with six stationary locomotives rusting away.

The MINEHOUND™ team was deployed to a bairro (village) to the east of Luau, situated 5km off the main road from Luau to the Congo. Due to the number of people now moving back into Luau via the UNHCR repatriation programme, more farmland and housing areas are needed near this bairro.

Previous demining on this land has found 4 PPM2 anti personal mines. During the 6 days of demining the 2 teams removed 106 targets from the ground, 3 of which were mines. They cleared an area of 1,300m².

6 Trials results

6.1 Cambodia

6.1.1 Live minefields tests

In the live minefields in Cambodia, the deminers, using the Schiebel ATMID, recorded a total of 1,143 detections from which 13 were mines. Using MINEHOUND™, the deminers detected all the mines, but only a further 210 suspect items giving an overall reduction of better than 5 to 1 in terms of rejection of clutter.

6.1.2 Blind lanes tests

Using specially designed small calibration targets; both deminers and ITEP staff carried out blind tests. The calibration targets were comparable in size and content with a PMA2 mine and were buried at depths up to 10 cm of cover in proximity to metallic clutter of various sizes. In every blind test lane an equal number of calibration targets and clutter were emplaced.

In the blind lanes in Cambodia over the 8-week trial period the four deminers achieved an averaged PD of 92.5% and an average reduction in false alarms of 2.15:1. However, by the last week of the trial the averaged PD had risen to 98% and the reduction in false alarms to 4.6:1

6.2 Bosnia

6.2.1 Live minefields tests

In the live minefields in Bosnia, the two deminers, using the CEIA MIL D1, recorded a total of 1069 detections from which 7 were mines. Using MINEHOUND™, the deminers detected all the mines but only a further 142 suspect items giving an overall reduction of better than 7.4 to 1 in terms of rejection of clutter.

6.2.2 Blind lanes tests

In the blind lanes in Bosnia over the 8-week trial period the deminers achieved an averaged PD of 92.5% and an average reduction in false alarms of 1.89:1. However by the last week of the trial the averaged PD had risen to 95.5%.

6.3 Angola

6.3.1 Live minefields tests

In the suspect minefields in Angola, the four deminers encountered a total of 1,153 detections but encountered no mines. Using MINEHOUND™, the deminers detected 272 suspect items giving an overall reduction of better than 4.24 to 1 in terms of rejection of clutter. In the minefield in Luau the deminers, using the Ebinger detector, recorded 106 detections of which 3 were mines. Using MINEHOUND™, the deminers detected all the mines and a further 14 suspect items giving an overall reduction of better than 7.57 to 1 in terms of rejection of clutter.

6.3.2 Blind lanes tests

In the blind lanes in Angola over the 6-week trial period, the deminers achieved an averaged PD of 96.5% and an average reduction in false alarms of 3:1. However by the last week of the trial the averaged PD had risen to 100%.

7 Summary

- All the trial objectives were achieved.
- Over 3,000 alarm encounters in live minefields were recorded.
- 100% of the mines encountered in live minefields were detected by deminers using MINEHOUND™.
- In live minefields an overall improvement of greater than 5:1 in false alarms was obtained compared with the in-service metal detectors.
- Working in a live minefield and following up the in-service detector with a new technology was effective and safe.
- The time to train experienced deminers was measured in hours.
- The feedback from the trials showed that the dual detector was effective.
- The deminers contributed to optimising the production design with valuable feedback.

MINEHOUND™ is now being jointly prepared by ERA Technology and Vallon GmbH for product release in 2006 and contact details are provided.

8 Acknowledgements

The support of the UK Department for International Development as well as the German Foreign Ministry was crucial to the MINEHOUND™ trials and we are extremely grateful to Andy Willson and Alistair Craib for their support. I would also like to thank Noel Mulliner of UNMAS for his input to the programme. The assistance of ITEP, Dai Lewis and in particular, Ian Dibsdall, ensured that the trials received the support that was critical to their success. The help and support of both MAG and NPA was essential and Gary Fenton in Cambodia, Per Breivik in Bosnia and Greg Crowther in Angola were key to ensuring that the in-country logistics ran smoothly. The engineering and trials team at ERA and the Vallon company were dedicated to meeting the objectives and this together with the support of the Directors enabled a successful outcome.

David Daniels Chief Consultant -Sensors ERA Technology Cleeve Road Leatherhead Surrey KT22 7SA UK tel 00 44 1 372 367 084 fax 00 441 372 367 081 david.daniels@era.co.uk www.era.	Dr Jürgen Braunstein Sales Director Vallon GmbH Im Grund 3 72800 Eningen Germany Tel. +49-7121-9855-11 Fax. +49-7121-83643 vallon@vallon.de : www.vallon.de