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Systematic Test and Evaluation of Metal Detectors: The EC's STEMD Project

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Systematic Test and Evaluation of metal detectors The European Commission's STEMD Project

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There is an international need for people within the humanitarian demining community (HDC) to be informed about appropriate metal detectors for the clearance process. Those involved in information exchange within the HDC know that metal detector trials are performed regularly. User requirements and test results can easily be published because a network exists within the HDC. The *Journal of Mine Action* itself is part of this network and readers are probably also familiar with the websites and publications of the International Test and Evaluation Program for Humanitarian Demining (ITEP) and the Geneva International Centre for Humanitarian Demining (GICHD). The GICHD periodically publishes a metal detector catalogue containing manufacturers' specifications and references to test reports. Since the mid-1990s, efforts have increased to improve testing and develop reliable and systematic methods. The European Commission's (EC's) project, Systematic Test and Evaluation of Metal Detectors (STEMD), is a new step in this development.

Current Practice in Detector Testing

Different detectors perform best under different trial conditions, so these are often set to satisfy one customer with specific needs and requirements, such as certain targets or soil types. We cite, for example, the series of tests under the U.N. umbrella, which began in January 1997 when the United Nations Mine Action Service (UNMAS) performed a trial in Sarajevo and Mostar. The tests continued with the Mine Action Programme for Afghanistan (UNMAPA) trials in Peshawar, Jalalabad and Kabul (September 1999 to March 2000)[1] and with those of the Accelerated Demining Programme (UNADP) in three southern provinces of Mozambique: Inhambane, Gaza and Maputo (Autumn 1999 and Autumn 2000)[2] and another UNMAPA trial[3] in 2002.

Other users want to read reports of trials such as these and infer how useful a device would be for their own needs. It can be difficult to do so when each trial is conducted differently, so the problem is twofold: to gather sufficiently complete test data to be able to understand how a detector will perform under all conditions and to standardize test protocols to avoid more variation in test methods between trials than is necessary.

A breakthrough was achieved in 1998 when the International Pilot Project for Technology Co-operation (IPPTC) was launched. IPPTC was the most comprehensive trial of metal/mine detectors ever conducted. Five research organisations and two national mine action centres carried out a broad range of tests on 28 devices under controlled conditions in laboratories and in blind field trials in two countries, with the intention of assessing their performance under as wide a range of conditions as possible. The results were made broadly available in a consumer report[4] in 2000.

By the time the IPPTC Final Report was published, some new detectors had already been released to the market. It was recognised that it was impractical to organise repeats of IPPTC to keep the information current. Instead, it was better to use the experience to agree to a standardized set of test procedures. Other standards exist for metal detectors, but they are designed for users such as the military, security organisations and police, whose requirements are somewhat different from those of humanitarian deminers. In humanitarian demining, detectors are in constant use in rough conditions. Any mistake can be instantly life-threatening. Sensitivity to minimum-metal mines, compensation for soil properties, ergonomics, ruggedness, battery life and electromagnetic immunity are the main factors to assess.

In 2001, the European Committee for Standardization (CEN) organised CEN Workshop 7, "Humanitarian Mine Action—Test and Evaluation—Metal Detectors" (CW07) under the leadership of the Joint Research Centre (JRC), the EC's in-house research organisation, to examine the detector situation. ITEP recognized this project as Project 2.1.1.1.[8] It resulted in the publication of CEN Workshop Agreement (CWA) 14747:2003 for Test and Evaluation of Metal Detectors for Humanitarian Demining in June 2003. Details of the process have been described previously in this journal.[5] The CWA incorporates contributions from experts worldwide and distils the experience gained in IPPTC and other recent projects.

Applying and Disseminating CWA Methods and the Birth of STEMD

After publication of the CWA, it was obvious that it would remain just a paper exercise unless someone took the initiative to apply the methods and organise training and dissemination—to "fill it with life" and get it used by the wider HDC.

A validation study led by the German Federal Materials Laboratory (BAM) was conducted in partnership with the JRC in the second half of 2003 in which just five models were subjected to CWA tests, including exhaustive statistical testing in three blind field trials (ITEP project 2.1.1.2).[8] In the same year, the JRC published a handbook[9] on metal detectors, which included descriptions of the CWA test methods. The JRC started to select and buy new detectors that had not been included in the IPPTC for testing to the CWA.

So, at the end of 2003, a tool for testing had been provided in the form of the CWA, new detectors were emerging and a means to disseminate the results was available via the existing HDC network. Missing was the organised in-depth training of the detector users. A training seminar was held in January 2004 in Ispra, Italy, in which users and manufacturers worked through the CWA tests in hands-on exercises. During this seminar, we found that the commercial clearance organisations and non-governmental organizations were indeed interested in improving their knowledge of metal detector use under field conditions. Representatives of southeast European and African mine action centres, demining organisations, UNMAS and detector manufacturers participated in this seminar, and, to our surprise, everyone learned something new.

At that time, the idea of a project with the following aims was born:

- To perform tests of metal detectors according to the CWA.
- To deliver in-depth training in the CWA to users of metal detectors and collect feedback from the organisations involved.
- To deliver the results of the trials for publication by the GICHD.

The EC's EuropeAid Cooperation Office agreed to fund the JRC to conduct the STEMD project. ITEP recognized STEMD as project 2.1.2.3.[8] The intention of STEMD is to cover as many of the lab and field tests prescribed in the CWA as possible, which requires significant time and effort. We therefore sought help from ITEP partners and the GICHD, which was forthcoming (see "Acknowledgements" below).

Current Progress of STEMD

It was initially planned to conduct all laboratory measurements first at the JRC's test facility in Ispra and proceed to field trials in southeast Europe and then southern Africa using the same

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Reliability test of a CEIA Mil D-1 DS detector at Test Site 1, Saravan, Laos.

detector set. A final field trial would be conducted in southeast Asia. As the project was in final planning, UNMAS said that the Lao National Unexploded Ordnance Programme (UXO Lao) was planning a procurement in autumn 2004 and had urgent need for test results. Therefore, the project plan was revised so a trial in Laos would be conducted first. A preliminary investigation was undertaken to select suitable sites in Laos, and metal detector manufacturers were informed. Manufacturers were then able to provide trainers and propose models adapted to the requirements of UXO Lao. When the project started on 1 August 2004, detailed plans were made, and the trial took place between 27 September and 5 November 2004 at three villages in the south of the country—Saravan, Thateng Tai and Pakxong.

A full report of the UXO Lao trial is available from the ITEP website.[7] We focussed on two items of UXO of particular interest to UXO Lao: BLU 26B cluster bomb submunitions and 20-mm cannon projectiles. We followed the methods of CWA Chapter 8, "Detection Capability for Targets Buried in Soil," in particular those of Sections 8.3, "Detection Capability for Specific Targets in Soil," and 8.5, "Detection Reliability Tests." The detection capability tests were performed at all three sites and the reliability tests at two of them. Eight commercial off-the-shelf detector types from six manufacturers were tested—four large-head types designed for UXO items and four small-head types for mines. All but one manufacturer sent representatives to the training. Particular attention was paid to the selection of sites with a range of soil properties, from "neutral" to "very severe," according to the classification of the CWA. Detailed magnetic measurements were made on-site. Care was taken with the design of the reliability tests to ensure that the results would be unbiased and statistically significant; the experience gained during the 2003 validation study with BAM was very valuable here.

Laboratory measurements were conducted in Ispra during the periods before and between the field trials. Most in-air sensitivity and speed test measurements of CWA Chapter 6 were performed, but more work is required on sensitivity profile (footprint) measurements. A substantial fraction of the ergonomic tests of CWA Chapter 7 also were conducted. More work is required on temperature and battery-life tests. In-soil measurements, according to CWA Chapter 8, were performed at Ispra using ferromagnetic soils from the Siena and Napoli areas, which complement the results obtained during the Laos trial.

Further Work: Can Detector Performance be Predicted?

The main factors that influence the maximum performance of a metal detector are quite well-known: the quantity, type, shape and disposition of metal in the target, the target depth, and the soil's electromagnetic properties. Actual performance also depends on human factors, such as sweep pattern and how the operator behaves when the detector alarms.

The key soil properties are magnetic susceptibility and its frequency dependence and, to a lesser extent, the electrical conductivity. Simple measurements are possible that allow a general picture of the conditions of the soil and its influence on the detector performance to be assembled. A new ITEP research project (2.1.1.4),[8] led by the Canadian Centre for Mine Action Technologies and supported by the Agropedology Institute of Sarajevo, the JRC, and others, is under way and should increase our knowledge in this area. Data on the relevant soil characteristics are not available for most mine-affected countries but they could be quite easily gathered during the

Country and Technical Surveys, which are carried out before clearance activities start. The STEMD project should provide enough empirical data to study the possibility of extrapolating detector performance under different conditions and recommending detectors for particular targets under those conditions.

Conclusion

The STEMD project now is well under way and already has returned useful data. A substantial body of laboratory results has been collected and the first field trial has been completed. From this data, it is possible to compare the performance of the individual detectors in the key areas of interest, including maximum detection depth for various targets, soil compensation ability and probability of detection as a function of depth. It is also possible to compare the large-head detectors as a group to the small-head detectors as a group. The next field trial in Mozambique is scheduled for April 2005 and will focus on detection capability tests for AP mines of interest there. The third field trial in southeast Europe is scheduled for the summer of 2005. After STEMD, trials of the emerging ground-penetrating radar/metal detector dual sensors are planned under the title "Test and Evaluation of Dual Sensors" (TEDS). ❖

See "References and Endnotes" on page 108

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Roadmap for mine action robotic technology development

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This paper presents some of the AMI-02 project preliminary work. The project is being developed by Integrators for Robotic Systems (IntRoSys) with funding from the Portuguese National Defence Ministry. The strong bond between Portugal and some African countries (i.e., former Portuguese colonies) is the main drive for the application of this project.

African countries are usually underdeveloped, requiring a sustainable approach to the mine action (MA) problem; in fact, the MA community shifted from a number-based approach to an impact-based approach,[1] targeting the locals' priorities.[2] This means that the success of a demining campaign is not measured by the quantity of demined land but whether its output is used by the community,[3] which has other problems besides landmines, such as starvation. In this sense, research and development (R&D) and technology applied to this specific domain should address this concern. Thus, the motto of this paper is to provide analysis, design and template tools to attain sustainable development.

Problem Definition

Unfortunately, as it will be shown below, demining is spread in both time and space, resulting in a high number of opportunities for the application of technology in demining operations. However, an incorrect assessment of the available opportunities in a given scenario for the application of a certain technology may end up in non-acceptance of the referred technology. Taking this into account, this section contributes a catergoristation of opportunities in a three-dimensional framework, composed of a temporal, a geographical and an economic component.

Temporal component. The temporal component can be described in terms of the different phases of an MA process, which are as follows:

1. Conflict and immediate post-conflict (humanitarian emergency)
2. Post-conflict (reconstruction)
3. Development (development assistance)

The different characteristics of each phase require different approaches; for instance, during the first phase, the international community is usually impelled to contribute strongly, empowering high-tech applications. In long-term phases, low-cost, simple and locally available resources for demining are required. However, for specific commercial applications (e.g., clearance of primary roads), there should be enough incentives to implement high-cost *nouvelle*—modern—solutions such as the one presented in the *International Conference on Requirements and Technologies for the Detection, Removal and Neutralization of Landmines and UXO* (pp. 32–40),[4] which defines a model of agricultural exploitation in which the machinery is mine-resistant and therefore exploration of the land can be carried out even in the presence of the mine risk.

Geographical component. The geographical component can be categorized as follows:

- **Military actions.** Militaries are usually provided with high-tech tools; thus, they are potential buyers of technology.
- **Third-world affected countries.** The demining process has to be low-cost, locally maintained, and operated by local people trained and supervised by non-governmental organizations,[5] hindering massive use of high-cost technology. Nevertheless, high-cost approaches may be applied on area-reduction since there is less danger of damaging equipment and the total cost of performing close-in detection in a wide area may supersede the high-cost solutions for area reduction.
- **Developed countries as affected countries.** Countries that can better afford high-cost technology are interested in R&D programmes and high-tech solutions to handle today's problems, such as terrorism or internal conflicts.
- **Developed countries as humanitarian helpers.** The donor community provides training, logistical support and operational support to countries in need. In specific short-term situations, the application of high-tech tools may be attained.

According to the *Guide to the Procurement of Mine Action Equipment*,[6] the nature of the environment is also an important factor in the geographical component, and a set of improvements that would augment demining productivity in 12 operating scenarios has been identified.

Economic component. The economic component could have the following motivation: economic interests in third-world affected countries (e.g., clearing access to oil wells). In this case, economic interests may be enough to acquire high-tech equipment for fast demining. Market studies[7, 8] were produced, and the main conclusions are that humanitarian demining is not an efficient market. It is small and shrinking;[8] henceforward, the product's development usually requires direct or full funding.[7]