Trial Design for Testing and Evaluation in Humanitarian Mine Clearance

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Summary

This thesis proposes a design of experiment for testing and evaluation of the equipment and the methods used in manual mine clearance. The thesis is based on several metal detector trials and a trial of manual demining methods.

The core of this dissertation comprises four metal detector trials performed in Germany and Croatia in 2003 and 2005. The purpose of these trials was to investigate the feasibility of the tests described in the CWA (Comité Européen de Normalisation /CEN/ Workshop Agreement) 14747:-2003, the standard for testing metal detectors for humanitarian demining. The goals of the trials were: to find an appropriate design of experiment for testing metal detectors; to establish the use of ROC diagrams (Receiver Operating Characteristics) and POD curves (Probability of Detection) in the analysis of the experimental results; and to gain practical experience in organising and conducting metal detector trials. A part of this thesis is devoted to a trial of manual demining methods performed in Mozambique in 2004. The main goal of that trial was to compare the speed of various manual demining methods, including the most common excavation methods. The outcome of this work are the proposals and recommendations for an update of the standard for testing metal detectors CWA 14747:2003.

Maximum detection height measurements were performed as a part of the metal detector trial carried out in Croatia in 2005. The results reveal a high variability of the maximum detection height. This high variability needs to be taken into account in all experiments. A part of the variability is caused by the differences between the operators and by the setup of the metal detector. It is therefore recommended that two kinds of experiments with the maximum detection height as a response variable are defined in the next update of CWA 14747:2003. The first kind should include the setup, the soil and the operator as factors in the design of experiment. The in-soil measurements with the same detector should be performed with repeated setups and with several operators. The second kind of experiments should be experiments evaluating the influence of other predictor variables. In those experiments, it is recommended to perform one-factor or multiple-factor in-air measurements with the operators and the setup as a block.

The main part of the metal detector trials described in this thesis were

the detection reliability tests. Detection reliability tests as described in CWA 14747:2003 come closest to representing the real field conditions in demining. They include many environmental influences and, most importantly, many of the human factor influences. However, each test design is a compromise between fully representative conditions and cost effectiveness. In this thesis, a fractional factorial design based on the Graeco-Latin square is proposed as a solution to the experimental problem. The results are reported in the form of ROC diagrams and POD curves. The crossover design enables each operator to work with fewer detector models within a certain time. The variations of the design enabled an unbiased comparison of detectors in each soil and with each target model separately. It is recommended that the solutions proposed in this thesis be incorporated in the standard CWA 14747:2003.

It has been shown that maximum detection height measurements provide the information about the best possible performance of a metal detector in a reliability test.

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