ITEP DUAL SENSOR TEST September/October 2009

Germany WTD 52 Oberjettenberg

Trial summary

This document is a preliminary document and includes a general overview of the DS trial and summarised results. The DS trial executed by Germany in collaboration with its ITEP Partners Belgium and the Netherlands (ITEP Project 2.4.2.13), was originally designed to provide information on the capabilities of dual-sensors for the humanitarian demining community. However, due to the fact that DS detectors also have a potential use in areas other than humanitarian demining, it was decided after the execution of the trial that the full trial data set and the detailed data analysis could not be released. The information provided in this document is therefore not complete, also concerning the recommendations as well as concerning the full evaluation of false alarms, and unexpected observations.

Thanks to the ITEP community and especially the ITEP MSWG , RMA, BE, TNO, and NL!

Summary

In autumn 2009 a Dual Sensor (DS) detector trial was carried out by Germany at the detector test facility of the Bundeswehr Technical Centre for Protective and Special Technologies in Oberjettenberg (WTD 52) in Germany. This trial was organised under the banner of the International Test and Evaluation Program for Humanitarian Demining (ITEP) and involved collaboration between Germany and its ITEP Partners Belgium and the Netherlands (ITEP Project 2.4.2.13). The WTD 52 test facility was specifically designed for the purpose of the DS trial and consists of six test lanes covering three soil types as well as a detector training/calibration area (ITEP Project 7.2.13).

The objectives of the trial were to compare the performance (probability of detection; POD and false alarm rate; FAR) of commercially available DS with the performance of: 1) stand-alone Commercial Off-The-Shelf (COTS) Metal Detectors (MD), 2) stand-alone COTS Ground Penetrating Radar (GPR) and 3) MDs with discrimination capabilities.

The DS developed by Tohoku University, Japan (Advanced Landmine Imaging System - ALIS), five COTS MDs (CEIA MIL-D1, Ebinger EBEX 422 GC, Minelab F3 S, Vallon VHM3 CS and Vallon VMH 1), two MDs with discrimination capability (Ebinger EBEX 422 GC and Minelab E-TRAC) and one COTS GPR participated in the trial which focused on the following tests each with a specific aim:

- Determination of the maximum detection depth and definition of the sensitivity area (footprint, sensitivity cone) to establish the intrinsic detector capabilities.

- Evaluation of the operational capabilities in reliability tests. The latter are "blind' tests during which the detector operators do neither know the test target location nor its depth. The blind tests were divided into four test series executed in the following sequence: MDs with discrimination possibilities, stand-alone COTS MDs, stand-alone COTS GPR as follow-on to the stand-alone MDs and DS. Test lane processing time was also recorded.

The ***maximum detection depth*** was established for: 1) mine-like objects specifically designed as targets for the trial, 2) the ERA Calibration Target (CaT) and 3) the Anti-Personnel (AP) mine PPM-2. The CaT imitates a minimum metal content AP mine whereas the PPM-2 can be considered to have a similar signal response as the PMN AP mine. The data analysis shows that the change in maximum detection depth with soil property, test target metal content and test target depth depends on the detector (detector specific). The results further demonstrated that the maximum detection depth of the GPR part in the DS is larger than that of the MDs. Thus, GPR is capable of detecting deeper targets than MDs and there should basically be no concern that GPR misses targets which are detected by MD, due to depth.

*The **sensitivity profile*** (also called ***footprint*** or ***sensitivity cone***) for a MD is very useful for defining the search advance in a minefield. For a GPR it is completely unknown and also not easily established. The measurements show that the sensitivity profile of the tested GPR is different from that of the MDs. The change of the sensitivity area with depth is much smaller than that of the MD and depends on the size of the GPR antenna; the width of the sensitivity area does either not change or gradually becomes wider with depth. The maximum depth of the GPR sensitivity profile was larger than that of the MD sensitivity profile.

In the ***reliability test series*** the test lanes were first processed by the ***MDs with discrimination capability***. This provided a first overall impression about the trial design and test lane layout. 'Difficult', was the common word used by the operators, especially with reference to the laterite soil (very high

absolute value and very high frequency dependence of the magnetic susceptibility) strongly affecting the MDs. This was the first time a reliability test of MDs with mine discrimination capabilities was carried out. About 75 % of mine-like targets were correctly identified by the detector. The results show that it is possible to exclude the clutter knowing the targets (mines, mine like objects) and both evaluated detectors (Ebinger EBEX 422 GC, Minelab E-TRAC) achieved promising results. The overall false alarm reduction was in general about 35 % but varied, depending on the soil type, from 30 % in laterite to about 40 % for the other soil types. The probability of discrimination strongly depends on the signal strength of the target, i.e. on the metal content of the target, the influence of the soil and the target depth. Despite the promising discrimination capability of the tested detectors, misidentification of mines still occurred leading to a reduction of the POD as compared to the conventional MDs.

The ***metal detector reliability tests*** confirmed earlier metal detector trial results. MD performance differences depend on the operator, the used detector, the detector sensitivity setting, the target depth and soil characteristics. When rating the MD performance using the overall POD and FAR obtained over all soil types, the performance of the two Vallon MDs tested was generally better than of the other MDs included in the trial.

The ***stand-alone GPR*** tested showed a very good performance. The POD and the FAR of the GPR in the different soils could not directly be evaluated because the GPR was used as a follow-on detector after the stand-alone MDs. However, the obtained FAR reduction was very high for all soil types in the test, especially in magnetite (very high absolute value and very low frequency dependence of the magnetic susceptibility). Overall, the stand-alone GPR demonstrated a high potential to increase the efficiency of landmine clearance operation although it was not specifically designed for demining. The GPR is a commercial system and it may have both advantages and disadvantages in comparison to DS designed for demining. The GPR does not have so much restrictions and it must be designed as it can work best, while DS in demining normally have many more restrictions on weight and other facts for making it autonomously usable in mined areas also for the armies. The performance of the GPR was outstanding in terms of FAR reduction but an unacceptable number of mines were misclassified during the discrimination/confirmation process, especially at shallow depth.

The ***dual sensor tests*** were the main activity in this trial and all previously described tests were meant to collect additional information to support the evaluation of the DS. The tested DS were used by four operators each. When comparing the results of the stand-alone MD and the DS tests it is clear that the DS performance strongly depends on the performance of the associated MD since the latter is used as the primary sensor. To evaluate the GPR part of the DS, the performance of the target discrimination (clutter rejection) after metal detection was analysed. The test data clearly demonstrated a higher level of FAR reduction obtained with the stand-alone GPR used as a follow-on detector than with the DS. However, this higher FAR reduction was achieved with a higher POD loss. Mines were missed using the stand-alone GPR because the metal signals indicated earlier by the MDs were misclassified by the follow-on GPR in 3% to 18 % of the cases, depending on the soil type.

The DS test data analysis also indicated that the degree to which the soil type affects the DS discrimination performance (clutter rejection) depends on the soil type and the DS system. As expected, soil inhomogeneity, stone content and rough ground surface all deteriorate the DS performance but the degree to which the performance is deteriorated seems different for each DS system. ALIS provided a relatively robust discrimination for all soil conditions tested, probably due to its sophisticated signal processing. The test data further clearly indicated that DS operators cannot reach the level of required expertise in two weeks of training. Unlike MD operators, the operators of the tested DS systems needed to make a mine-not mine decision based on the interpretation of the observed signal. The latter is far more complicated than the MD signal interpretation where basically only a YES or NO is required on the presence of metal. With a DS a certain level of understanding of the GPR's working principles is required and more practice is necessary.

The results of the DS also vary with operators and it may have been caused by the way of signal interpretation. The different operators applied different decision criteria based on their experiences and knowledge. Nevertheless, the test results have proved that the GPRs essentially have capabilities to distinguish mines from metallic clutter, but there still are problems in signal interpretation of the GPR that reduces the POD level by missing mines which are detected by the MD.

The ***search time*** needed by the detector operators is one of the tools that can be used to evaluate the detector efficiency. The assumption is that the optimum search speed to achieve the best detector results is the speed of the operators using the detector under safe conditions in a competitive situation. The operator's individual knowledge and experience, the inherent detector capabilities and the environment all contribute to the results that can be obtained with a detector.

The stand-alone MDs achieved a search speed ranging from four to seven minutes per square metre depending on the soil type and detector. For the DS, operators obtained an average speed ranging between about seven and thirteen minutes per square metre. In general, the more experienced DS operators processed the test lanes faster. The search time by a trained DS operator was about twice the time required by the DS specialist; the latter being similar to the search time obtained by the MD operators. An increased search speed was also observed towards the end of the trial. This analysis indicates the capability of the DS but also the importance of experience and training in achieving better search time results.

The trial results indicate that DS, if operated by experienced personnel, can improve the efficiency of the clearance operation, i.e. accelerate the clearance speed, assuming no miss-discrimination of mines. However, complete discrimination/clutter rejection cannot be guaranteed and a certain albeit reduced number of false alarms will remain to be investigated. Only a long duration field evaluation will show the real effect the performance of DS detectors can have on the operational clearance effectiveness. . There are several factors other than POD loss and FAR reduction which are not discussed in this report but will affect considerations about introducing DS systems for humanitarian mine clearance, such as price, COTS availability, service, and adaptability to existing standard operating procedures (SOPs).

The construction of the tested ALIS system is still not yet suitable for operational use. The environmental conditions during the trial (snow, slight rain) fully interrupted the operation. The system is still in the development phase and improvements, especially in search speed and a more solid construction to be more stable for use in real mine fields, are expected to be implemented in the finalisation process.

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