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CONTENTS

<i>Boris Katić</i> Factors that cause lack of concentration in the dog's work	5
<i>Boris Katić</i> Dog Handler – the Main Cause of Success or Failure of the Dog's Mines/Explosives and UXO Detection Work as Well as the Work of Detection Team Itself	7
<i>Christina Mueller, Mate Gaal, Mato Pavlovic, Martina Scharmach, Peter T. Wilrich</i> Reliability Tests for Demining – Latest Experiences.....	9
<i>C. Weickert</i> An Overview of ITEP and CCMAT Detection Activities.....	21
<i>Dieter Guelle</i> METAL DETECTOR TRIALS - Detector Test Results and Their Interpretation	31
<i>Dražen Šimunović</i> UXO in the MSA in the Republic of Croatia in Depths Greater than 20 cm - Detection, Removal/Destruction - ..	33
<i>Ivica Raguž</i> Daily Routine – Adjustment of Metal Detectors for Use in Humanitarian Demining	39
<i>Jun Ishikawa, Mitsuru Kiyota, Nikola Pavković, Katsuhisa Furuta</i> Preliminary Evaluation Results of Trials for Japanese GPR-EMI Dual Sensor Systems at Benkovac Test Site in Croatia.....	43
<i>Kaj Hörberg</i> Personal Protective Equipment for Use in Humanitarian Demining - Standardised Test and Evaluation Methodologies -	49
<i>Konstantin Fateev</i> Mine and UXO Detection in Russia.....	51
<i>Marijan Miklobušec</i> Dog - Handler Interaction	55
<i>Mirko Ivanušić, Davor Laura, Željko Šarić</i> Technical Requirements and Standards for Safe and Efficient Use of Dogs and Handlers in Detection of Mines, UXOs and Fragments – Experience in the Republic of Croatia	59
<i>Motoyuki Sato, Jun Ishikawa, Katsuhisa Furuta</i> Development of Japanese Dual Sensor Systems for Landmine Detection	67
<i>Nikola Gambiroža</i> Technical Requirements and Compatibility Assessment of Demining Machines and Metal Detectors Used for Demining Operations.....	71
<i>Nikola Kezić, Sabine Kemline, Nikola Pavković, Reinhard Noske, Hrvoje Gold and Milan Bajić</i> Use of bees in explosive devices detection	81
<i>Noel Mulliner</i> Conclusions from the Workshop Held in Geneva in February 2006.....	85

<i>T. Apih, A. Gregorovič, R. Blinc, J. Seliger, J. Lužnik, Z. Trontelj</i> Detection of Explosives in Landmines by Nuclear Quadrupole Resonance (NQR).....	89
<i>Tomislav Ban</i> Samplings in Humanitarian Demining.....	93
<i>Toša Ninkov, Sasa Vukadinović, Dragoljub Cvetković</i> Application of Advanced Methods in Clearance Projects of Rivers and Wet Areas from Unexploded Ordnances (UXOS)	101
<i>Vedrana Miličić</i> Capacity Exploitability of Croatian Mine Action Firms.....	109

Factors that cause lack of concentration in the dog's work

Boris Katić¹

The work on detection of mines/explosives and UXO must always be successfully done, it allows no mistakes for dog!

To assure that the dog is fit for this kind of task the quality conditions for work must be fulfilled in the way that the causes of lack of concentration come to minimum.

Only healthy dog can obtain positive and regular working results. Feeding must be balanced and various whatever the field conditions are.

If the dog has one resting day in the week, this day can be used for purifying organism i.e. it can be the fast day with minimum of food, but with more liquid.

Dehydrated food, it doesn't matter how quality it is, can't be the only food as well as canned food. Rise, cooked vegetables (except sweet vetch and potato), cooked meat (all food without spices, fish, and milk products – eggs) and other comestibles have to be the part of the meal.

Some comestibles can be served as a special reward for a done work. The dogs mustn't be famished under no circumstances to be stimulated for work.

Pavlov's reflex is the obvious indicator of the condition, but not of the work efficacy!

Feeding must be on time, balanced and adjusted to the dog's development and season.

The dog's accommodation must be appropriate to assure the quality dog's rest and it must be near to dog handler's family.

The vet care must be continuous preventive in the first place. The dog handler must be educated regarding the illness, physiological needs and dog's development.

On the field dogs meet various conditions of work, and one of them is climate i.e. humidity, temperature, wind, precipitation - all of this factors are crucial for the span of dog's capability to concentrate on work. All that climate-meteorological factors require enhanced dog's concentration and cause the hasten downfall of it.

The question of minimum and maximum working conditions is always important issue.

Dogs are working on all the continents, they survived on all the continents, the hunting instinct is their aboriginal task, and tracing for prey is used although in demining work.

Dogs-wolfs in the wild trace the prey in the sun and in the rain, in the wind and when the weather is calm, under the temperature from -30°C to +30°C day and night.

The fact that they are able to do it talks a lot about them.

Dogs are the perfect “detectors” of explosive's evaporation and they could be never replaced!!!

Anyway, the dog handler must know the conditions of the work, he must recognise and build them and give them to dog.

The prejudices, especially deminers' working with detector and needle, can be forgotten only with the work accomplishments.

All the statistics worldwide claim that the man is the one who makes most of the mistakes, then follow dogs and demining machine.

Longer the working conditions, smaller the concentration of the dog. The dog is only a animal that can't take responsibility for the lack of success.

The working concentration of the best dogs is 4 to 5 hours with small brakes. The dog must be helped with the working conditions and not disabled.

The handler is the one who must know what humidity or strong wind is, what too much pollen, is it too cold or too hot, etc. That is not the same parameter for all the same aged dogs on the same field.

Dogs are living creatures and they will give results only if we are preparing them correctly.

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Dog Handler – the Main Cause of Success or Failure of the Dog's Mines/Explosives and UXO Detection Work as Well as the Work of Detection Team Itself

Boris Katić²

Special problem is choosing young dogs. A team of experienced dog trainers, vets and dog handlers, after they have chosen 20 young dogs (till 14 months old), will probably have "waste" of 10% minimally, but very often even 20% during the training period. This loss is normal taking into account genetic, working and exterior potential which is potentiated by forefather, some dogs simply aren't determined for tracing. Some dogs don't have the impulse, and some of them are too aggressive on external stimulation.

Anyway, for all the companies who are specialised in training of dogs this problem is much more smaller than finding the quality dog handler, teaching and educating him permanently as well as keeping him at job.

The influence of dog handler on dog and his work is really crucial. Of course the dog also have influence on dog handler, but much less.

The dog handler is definitely the overbalance in team and gives the working character to the team.

Even the best dog can be ruined for maximum 30 days if it is "connected" to a "wrong" dog handler! The result is breaking of the team, but also destruction of the dog who very often, even with the best re-trainer and excellent other dog handler, won't be able to give results which it would be capable of, and maybe it wouldn't be useful after being connected with its first determined dog handler. Those are catastrophic consequences after 7-9 months working on the explosives and 3-6 months of preparing. Everything drops in water. Besides, about 10-15 months of financial investment is doomed on failure (food, accommodation, vet care, trainers wages, dog handlers wages, transportation vehicle – trailers, etc).

If the dog handler brings the dog as a puppy or a young dog, he must realise that he brings a new member (or members) of the family to his home. His family have to be prepared on that and should be informed about all the rules of the game which results with multiannual income for the whole family.

The socialisation is the best with the dog handler family. In fact, the first-rate dogs stay in job for 7-8 years after they have finished the training, which means that the dog handler will take about 100 personal wages during the working period of the dog or couple of dogs.

The worst situation is if the dog handler is attending mine clearance operations only because of temporary source of finances, without working previously with dogs, without education, without elementary knowledge about the dogs as a living creature.

A huge mistake is changing oftenly the dog handler handling the mine and UXO detecting dogs. Every dog is going through a lot of stress going from one hand to another, from one family to another. In those cases the dogs can lose their working capacity for more than 30 days.

Most of the companies have a job application forms for the dog handlers who are applying for job. The loss of attenders for dog handlers work, comparing the detection dogs is even bigger, 30% to 40% of candidates are permanently lost in first 60 days.

If dog handler wants to conduct the mine clearance using mine and UXO detecting dogs, he should be a "leader of the pack". The handler has to know the dog anatomy – physiology of the dog organism, how to provide nutrition and care, to recognise and prevent illness, parasites and intoxication in the working environment.

The dog handler should be the only and unquestionable authority, not a source of threat, pain or fear.

The handler should have a measure in everything - in punishing the dog but also in rewarding it.

Dissatisfaction, unhappiness, illness and all the other negative vibrations dog can feel and equally respond through working results.

Unfortunately all negative influences from dog handlers private and professional life leave strong impact on dogs behavior in work.

With some of them dog can fight, but in most of the cases, detection dog is losing the battle which is producing the changed working manners and often mistakes. That dog is losing working capability as well as the whole team.

The dog handler should recognise and regulate the working pressure. Overpressure should necessarily be avoided.

The love and trust is being deserved and built daily.

The only way to work with the mine and UXO detecting dog is through love, play and handler's attention during every day of the working period.

With the professional support of the instructor, dog handler should know how to use all necessary training methods, how to understand the dog and make the right assessment when the dog is mature for every training phase and especially when is ready for the final exam or when is ready for work in mine clearance operations.

The dog handler needs to amortise all the negative impacts appearing daily in front of demining team.

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In the end, it is necessary to mention that the dog handler is the one who is responsible for improving the dog's knowledge through the re-training and renewing of detection procedure and methods.

The dog is easily adopting negative impacts and wrong working methods, but hardly getting rid of them – oftenly that never happens and the dog can no longer be used for the mine and explosive detection.

I am finishing my exhibition with the fact that dog detection method is all the time in the conflict with the Syndicate of deminers who claim that detection dogs are stealing the job from deminers. Further more, CROMAC and MoI have a negative attitude about using the detection dogs in demining. They are constantly requesting for each square meter to be checked by deminers also, in spite of the fact that the area has already been cleared/demined using the mine and UXO detection dogs.

All those facts are decreasing the number of mine and UXO detection dogs which is already extremely small comparing other countries with existing mines problem.

The price of mine detection dog's exam is 600 Euro and it should be paid to CTRO which is built from CROMAC. Licences are valid for 3 or 6 months or one year (usually 6 months).

The dogs are getting the licence that can be used for mine, explosive and UXO detection in first method –, that means without using machines or deminers first.

Testing polygons are planted with grass and not conceived for the situation assuming that demining machine has broken the mines or UXO and the mine and UXO detecting dogs are supposed to check for the parts of mines or UXO which has been scattered all over the field treated with machines.

All those unregulations does not exist anywhere in the world and also, not in our closest neighbor countries like Bosnia and Herzegovina with the same mine problem like we have in Croatia.

Let us take a short look and compare with world wide mine clearance methods and operations to understand why Croatia does not have enough financial recourses for demining until the year 2009 – it is because all over the world the dogs are allowed to work in the first method. Comparing with Croatia where it is not possible to use the dogs even as a second method in mine clearance, it is obvious why the mine clearance program is so slow and expensive.

Reliability Tests for Demining – Latest Experiences

Christina Mueller³, Mate Gaal³, Mato Pavlovic³, Martina Scharmach³, Peter T. Wilrich⁴

The authors were involved in the creation of the CEN workshop agreement CWA 14747 for test and evaluation of metal detectors with focus on reliability tests and work currently on its practical verification and upgrading. Reliability Tests are blind trials aimed to simulate field conditions where the operators do not know the positions of the mines to show the most realistic, repeatable and reproducible detector performance. A former trial series was aimed to verify the statistical basis needed and to set up the statistical toolbox composed of design of experiments, ROC(Receiver Operating Characteristics) and POD(probability of detection curves). It turned out to be most useful to concentrate on a few mine types which are most critical and to determine the probability of detection or finding rate as a function of depth and record the number of false alarms per area for one detector in one soil for one mine type achieved with good trained and skilled deminers. The trial in 2005 carried out at the HCR-CTRO test site in Benkovac in strong cooperation with CROMAC had its focus on the proper treatment of the human factor. The deminers working in a test trial should currently be active in mine fields. The training needs to be appropriate and - most important - the local SOP should be implemented in the trials procedure so that the real working conditions for deminers are simulated as far as possible. The described procedure showed a considerable improvement in finding rates and reduction of false alarms.

Introduction and Background

The CEN Working Group 07 began the process of standardizing test and evaluation methods for metal detectors in humanitarian demining, including both laboratory measurements of detection capability and blind field trials (reliability tests). In reliability tests, the Probability of Detection (POD) and Receiver Operating Characteristics (ROC) curves help to summarize the performance results. Looking scientifically to the composition of the integral performance or reliability it reveals: The total detection reliability of a mine searching system is analogous to NDE-systems governed by three elements;

- intrinsic capability - which describes the basic physical-technical capability of the method
- application factors - including those due to environment
- human factor - the effect of human operators on the detection reliability.

Some of these can be determined in simple laboratory measurements in which the effect on detection capability of individual parameters is measured. However, the human factor and some aspects of the effects of environmental conditions on the system need to be treated statistically.

By far the most common "mine searching system" in use today is the metal detector. The test and evaluation procedures for metal detectors described in CEN CWA 14747: 2003 include the

above ideas. This is why, in addition to parameter tests, they include detection reliability or blind field tests under local conditions with local personnel.

A series of three field trials was performed in the ITEP-project 2.1.1.2 in 2003 "Reliability Model for Test and Evaluation of Metal Detectors" and another trial named ITEP-project 2.1.1.8 in 2005, in order to specify the optimum conditions to obtain reliable trial results with affordable effort. Each set of specific working conditions is characterized in terms of a combination of one mine type in one soil with one detector handled by local personnel. For each set of conditions, the searching system will deliver a working performance, expressed as mine detection rates as a function of mine depth, and a certain overall false alarm rate. During the ITEP-trials in Benkovac and Oberjettenberg, the authors learned to determine this function separately for each mine type in each soil. This is especially important for low-metal mines in soil that can influence metal detectors, as will be illustrated for the case of the PMA2. Two discussion points remained after 2003; how representative the trials are of field conditions and what is the statistical set-up required if we are to distinguish between the capabilities of individual detectors. In the trials of the ITEP-project 2.1.1.8 a more suitable design of experiment was applied (only two mine types in two soil types on fewer depths). The human factor was considered more carefully in applying some elements of the local SOP (Standard Operating Procedure), thus coming closer to the local practice and field conditions. Until then two

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detector models had been improved as a result of the previous trials.

In the following sections the background of the statistical instruments (ROC and POD and design of experiments), the set up of the parameters and trial conditions and finally the results and lessons learnt from the trials are described in more detail.

POD and ROC – Summary of Detection Rates and False Alarms

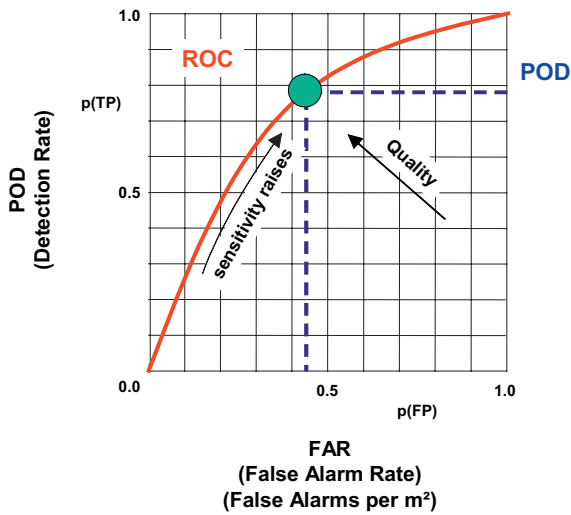


Figure 1: Explanation for ROC and POD diagrams

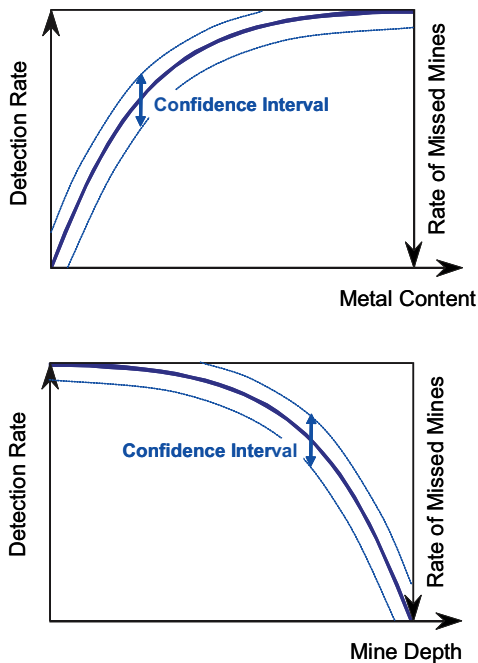


Figure 2: Schematic Representation of POD Curves

The ROC (Receiver Operating Characteristic) of a mine detection system [1] shows the detection rate or probability of detection versus the false alarm rate or number of false alarms per unit area (Figure 1). The ROC shows how well the system discriminates between signal and noise. The ROC shows how successful the system is in distinguishing between a real signal from a mine and a noise signal arising from any other possible perturbation (from the soil, from other buried artefacts, from the electronics). The closer to the upper left corner the position of a ROC point is, the better is the system.

In the case discussed here, the mine detection systems being tested are metal detectors. Whether detection alarms caused by metal pieces in the ground are considered “true” or “false” detections depends on the aims of the detection reliability trial. An ideal mine detection system would, in principle, be able to distinguish between a mine and a piece of scrap metal. Metal detectors currently used in demining do not have this capability.

For a fixed amount of false alarms the ROC point or operating point of the system for a fixed sensitivity can be taken and further analysed for its dependence on the main influencing factors like the mine depth or the metal content of the mine (Figure 2).

To fit a curve for the dependence of POD on depth, non-linear logistic regression was applied. The POD is transformed according to the following equation and a linear dependence on depth is assumed:

$$\ln\left(\frac{POD}{1-POD}\right) = ax + b,$$

where x is the depth and a and b are parameters of the fit. The parameters a and b are found by Maximum Likelihood.

All these points and curves need to be interpreted in connection with the corresponding confidence bounds to consider the scatter of results. The latter scatter depends on the underlying statistical basis (the number of opportunities to detect the mine) and the natural variability of the factors. The smooth POD or detection rate curves, presented in Figure 2 were determined by the advanced logistic regression model mentioned above [2]. A simple way of obtaining the

detection rate curves is by plotting the mean values of the experimentally measured detection rates for each step of burial depth [³, ⁴, ⁵, ⁶].

To achieve the described POD and ROC curve the accomplishment of a number of trials (mine searching experiments) are necessary covering all the devices of interest and parameter settings which might influence the device or mine searching system performance in practice. The four factors investigated in this test are detector model, operator, lane (related to the soil type), and start. A factorial design including all factor level combinations would be the optimum choice to achieve an unbiased estimate of the detectors in each soil type separately. However, such a test would require a lot of time. This is why a fractional factorial design had been proposed: each detector is tested with each level of each factor, but not with all the possible combinations of factor levels. This design is based on a Graeco-Latin square and it is shown in table 1 as an example (applied in Benkovac 2005). In the first week two operators (A, B) tested two detectors (alpha, beta) and the other two operators the other two detectors. In the second week they switched (A and B tested gamma and delta). Such a design, compared with an ordinary Graeco-Latin square, allowed the operators to concentrate on two instead of four detector models at a time.

Table 1: Design of the detection reliability test. The design is based on a Graeco-Latin square, letters A, B, C, D representing the operators, and α , β , γ , δ the detectors.

Week 1 18-20 May	Start			
	1	2	3	4
Lane	1 A alpha C delta B beta D gamma			
	2 C gamma A beta D delta B alpha			
	3 B beta D gamma A alpha C delta			
	4 D delta B alpha C gamma A beta			

Week 2 25-27 May	Start			
	1	2	3	4
Lane	1 C alpha A delta D beta B gamma			
	2 A gamma C beta B delta D alpha			
	3 D beta B gamma C alpha A delta			
	4 B delta D alpha A gamma C beta			

The main aim of the trials was to investigate how the device performance manifests itself in different application circumstances. The authors organized three sets of trials in 2003 and an other one in 2005 for which the main parameter set up can be seen in Figure 3. The first and the third took place in Oberjettenberg WTD 52 on the testing ground of the German Army and the second and the fourth in Benkovac, Croatia (CROMAC Center for Testing, Development and Training CTDt).

The conditions for the first trial in May 2003 were representative of poor circumstances, likely to


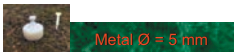
Devices	Soil	Mines	Human Factor
2003 → 2 pulse time domain U, X, W → 2 continuous wave Y, Z	Types of soil: → Cooperative (neutral) → Uncooperative (Frequency dependent; Constant susceptibility) → Metal contamination of the soil → Homogeneous / heterogeneous	Types of mines: → (metal content): biggest TM  smallest PMA-2  → Depths of mines	→ working time → Training mode: → Brief and extended → Status of experience, pre-experience with one device type, age → Current activity → Personal capability
2005 → 2 devices were improved: X, Y	→ Cooperative (Soil from Sisak) → Homogeneous uncooperative, frequency dependent susceptibility (Soil from Obrovac)	PMA-1A and PMA-2 only	→ Local SOP and System → Quality Assurance → long training → 5 working hours

Figure 3: Test Parameters - Overview of the Parameter Matrix of the Trials

yield low performance: inexperienced operators with a short training period and test lanes with significant metal contamination. Three neutral soils were used and a fourth lane was artificially made "uncooperative" by adding a layer of magnetic blast-furnace slag. (With the benefit of hindsight, we would not recommend this technique because the slag was found to contain metallic particles, creating additional metal contamination). The buried mines were characterized by a large to medium metal content. Some generic "ITOP" targets were also used, irregularly distributed over a predefined depth range.

The second trial set was organized in Benkovac, Croatia with eight experienced Croatian operators, three of whom were active as deminers at the time of the trials. A brief training period (half a day for each detector) was given. There were three types of soil on eight lanes: neutral soil, homogeneous uncooperative soil and heterogeneous uncooperative soil. Both of the latter had frequency-dependent susceptibility. The mines had large, medium or very small metal content and were systematically distributed over a depth ranging between 0 and 20 cm to allow statistical analysis. For testing metal detectors the normal target depth should be to the limits of the physical detection capability in the soil. The depth of 20 cm was chosen because it is the required depth for mine clearance under Croatian law. The lanes were "almost" clean of metal pieces.

The lessons learnt from the first two trials were applied to the third trial set in Oberjettenberg November 2003, with the intention of creating conditions likely to yield better performance. Three new lanes were set up, in addition to the ones available from the previous trial in May, and carefully cleaned of any metal fragments. Mines with large to medium and small metal content were selected and distributed systematically at a depth ranging from 0 to 20 cm. The operators, who were inexperienced, were trained carefully in open and blind exercises until they were confident about the reaction of each detector to each mine in each soil and at different depths. To avoid confusion between the different detector operating procedures the operators were assigned during the training, as well as during the first week of the trial, detectors belonging to one class only (double-D coil, static mode or single coil, dynamic mode). In the second week they changed to the other class of detectors.

The new trials in May 2005 (ITEP-project 2.1.1.8) were conducted in Benkovac, Croatia. The same

training scheme as in the Oberjettenberg November trials was applied, but the training was twice longer. Other improvements were: a reduction to two soil types, two mine types distributed to depths only between 0 and 15 cm and the implementation of the working conditions as close as possible to the conditions in minefields (protective equipment, working hours, section leader and quality assurance). Two metal detector models were new in these trials; the manufacturers improved the models used in the last trials based on their results.

Results of the Trials

Figure 4 shows the overall results of each trial set, in ROC diagrams. These diagrams illustrate the influence of the factors (Application factor and Human factor) degrading the performance of all the detectors, without distinguishing between individual detectors. The result of inexperienced operators with a short training on metal contaminated ground shows a mean detection rate of 70% and 0.3 false alarms per m². The artificial uncooperativeness reduces the performance to 60% detection rate and almost one false alarm per m², which is surprisingly poor.

Even more surprising are the total overall results for Benkovac in June 2003, where the operators consisted of eight experienced Croatian deminers. The detection rate of about 65% in neutral soil decreases to almost 50% in a real, local, uncooperative soil with frequency dependent susceptibility. The false alarm rate grows from 0.5 false alarms per m² to almost 0.6. Possible reasons for this extremely poor result are:

- 1) Many of the targets were very deeply buried and in some cases beyond the physical capability of some of the detectors. Minimum metal mines, which are inherently difficult to detect, were buried according to a systematic depth distribution, ranging from 0 to 20 cm in order to evaluate the detection rate as a function of depth. The maximum depth of 20 cm was chosen because it is the requirement of the Croatian clearance law. A more realistic mean value of detection rate for the region could be determined, if the real depth distribution of mines is known, by using the POD as a function of depth measured in the trial. Usually, AP mines are mainly buried at a depth ranging from 0 to 5 cm, which is much shallower than the range used in the trial and would be detected with higher average POD

than measured in the trial.

- 2) Only three of the deminers are currently active.
- 3) It has been suggested that experienced deminers may need a longer training phase because they are generally accustomed to using a particular detector model and cannot handle too many different device types at the same time.
- 4) In the trial, the deminers are not in danger and are less motivated to be careful than they would be in a real minefield.
- 5) The test schedule required the deminers to work more quickly and for longer hours than they would normally do.
- 6) The test lanes were contaminated with metal.
- 7) Heterogeneous soil with strong frequency-dependent magnetic susceptibility is a challenge for all detectors, especially in combination with minimum metal mines, since the soil signals often mask the mine signal.

The performance in the third trial is much better than in the first two, as expected from the conditions of the test with respect to the human factors and application factors. In Figure 4c upper left corner the ROC point is 90% detection rate and false alarms below 0.1 per m². The “secret” is in carefully-conducted and longer training, reduced workload, neutral and very clean soil and targets that are easier to detect. If we want to estimate a realistic POD it is therefore necessary to ask what is the appropriate scenario of application and human factors for the situation we want to investigate. We tried to find the answers to these questions in the trials accomplished in May 2005 again in Benkovac Croatia. This time all 4 deminers were actually working, the training was long and careful like in the November 2003 trial and the local SOP (Standard Operating Procedure) was implemented. The improvements from a) to c) and from b) to d) show how important the proper treatment of the human factor is.

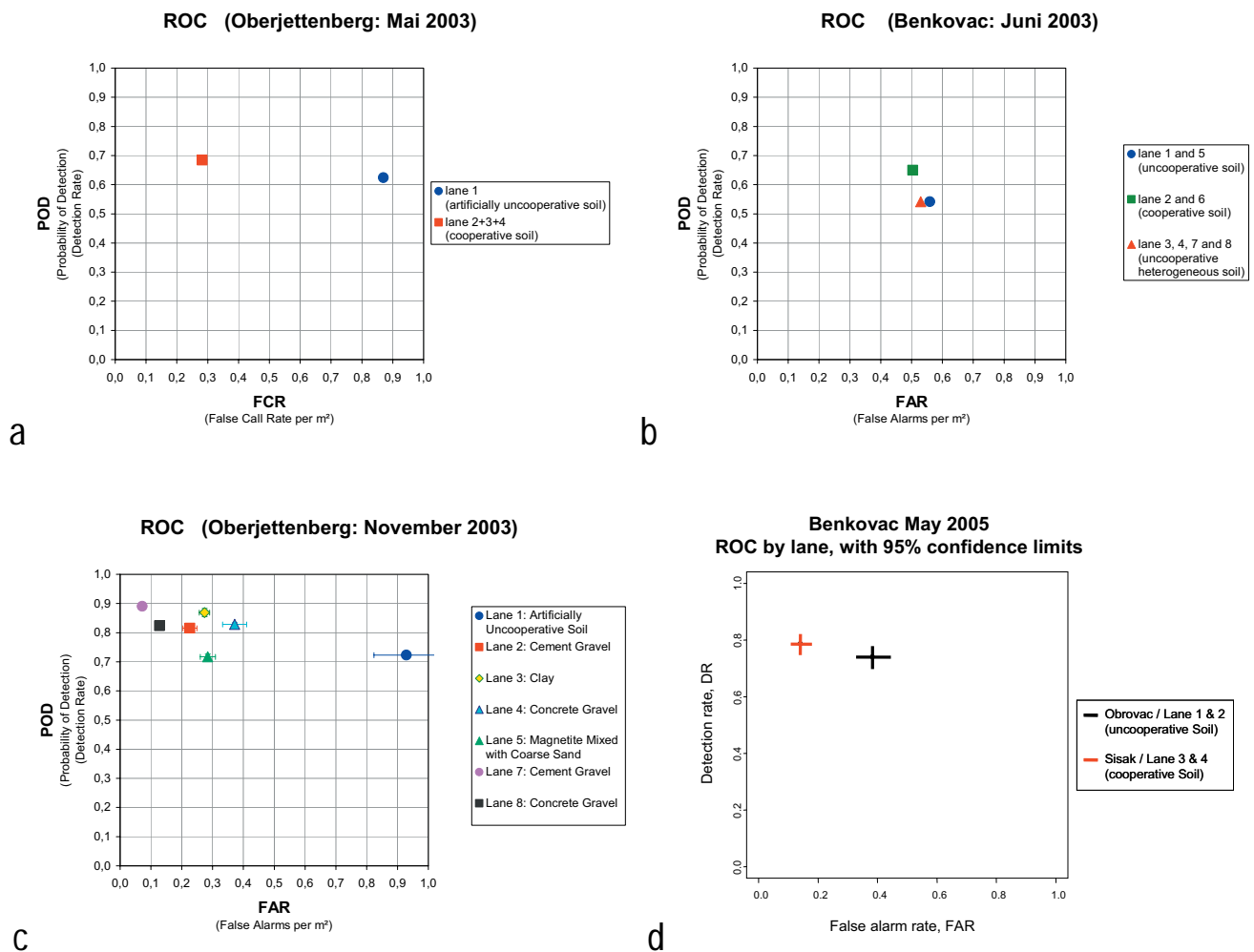


Figure 4: ROC diagrams for different soil and human factor conditions

Example of a set of Resulting Curves from Year 2003: Detection Rates as Function of Depth and False Alarms for the PMA2 in Different Soils

The following table gives an overview of soil parameters of all trials 2003.

Table 2: Overview of magnetic properties of the soils

Soil Types in Oberjettenberg Trials	Ground Reference Height (cm)	Susceptibility at 958 Hz (10^{-5} SI)	Susceptibility difference at 465 and 4650 Hz (10^{-5} SI)
Lane 1 artificially uncooperative soil	5 ± 2	244 ± 64	6,1
Lane 2 cement gravel	no signal	0 ± 1	- 0,2
Lane 3 clay	no signal	2 ± 1	- 0,5
Lane 4 concrete gravel	no signal	6 ± 1	- 0,5
Lane 5 magnetite mixed with coarse sand	$4,5 \pm 0,7$	3000 ± 500	6 ± 7
Lane 7 cement gravel	no signal	$-1,0 \pm 0,2$	$-0,1 \pm 0,2$
Lane 8 concrete gravel	no signal	7 ± 1	$-0,1 \pm 0,1$
Soil Types in Benkovac Trials	Ground Reference Height (cm)	Susceptibility at 958 Hz (10^{-5} SI)	Susceptibility difference at 465 and 4650 Hz (10^{-5} SI)
Lanes 2, 6 (neutral) Clay from Sisac	no signal	13 ± 2	0,6
Lanes 1, 5 (uncooperative) Laterite soil from Obrovac	$18,8 \pm 0,9$	154 ± 13	25,5
Lanes 3, 4, 7, 8 (uncooperative heterogeneous) local red Bauxite from Bencovac	$19,7 \pm 2,5$	190 ± 36	35,4

In the following figures the individual detector results are illustrated for the PMA2 minimum metal mine under ideal conditions, i.e. neutral soil without metal contamination, well trained operators and optimized working hours. Figure 5 show the detection rates as function of the burial depth for each device.

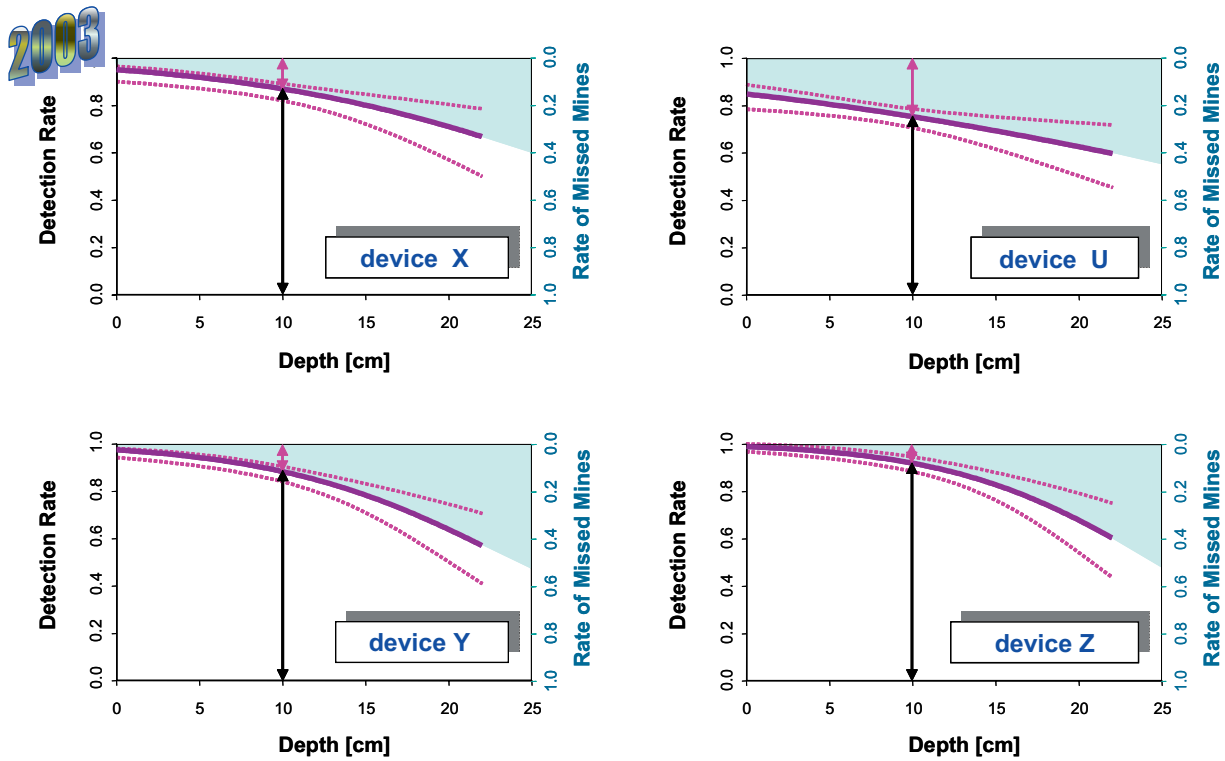


Figure 5: Neutral cooperative soil; only mine PMA-2. Mean value of ROC (detection rate versus false alarm rate) with 95% confidence limits for the different devices

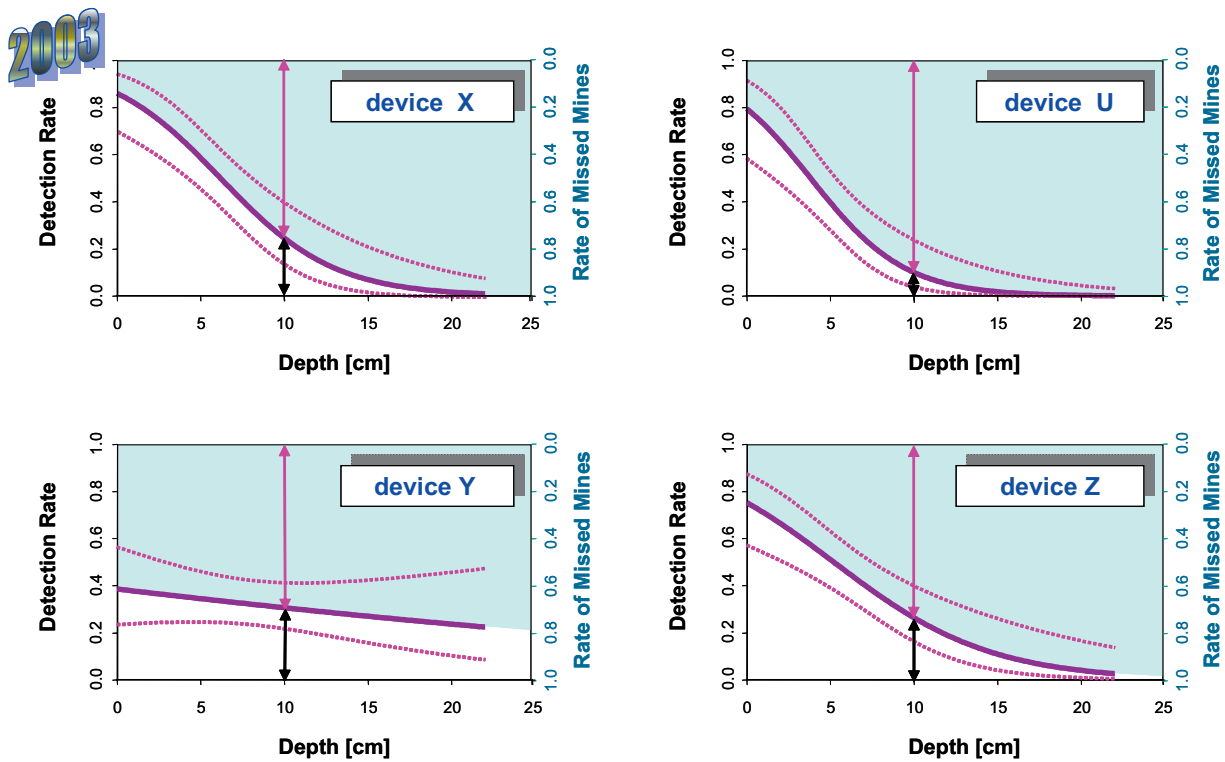
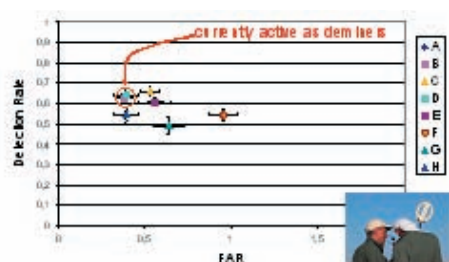
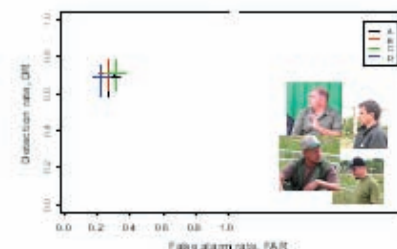


Figure 6: Uncooperative soil, heterogeneous, with frequency dependent susceptibility, red bauxite with neutral stones. Detection rate as function of mine (PMA-2 only) depth for the different four devices with 95% confidence limits



Results of the year 2003



Results of the year 2005, with 95% confidence limits, only PMA-2

Figure 7: ROC-Results for different deminers of the years 2003 and 2005 in Benkovac

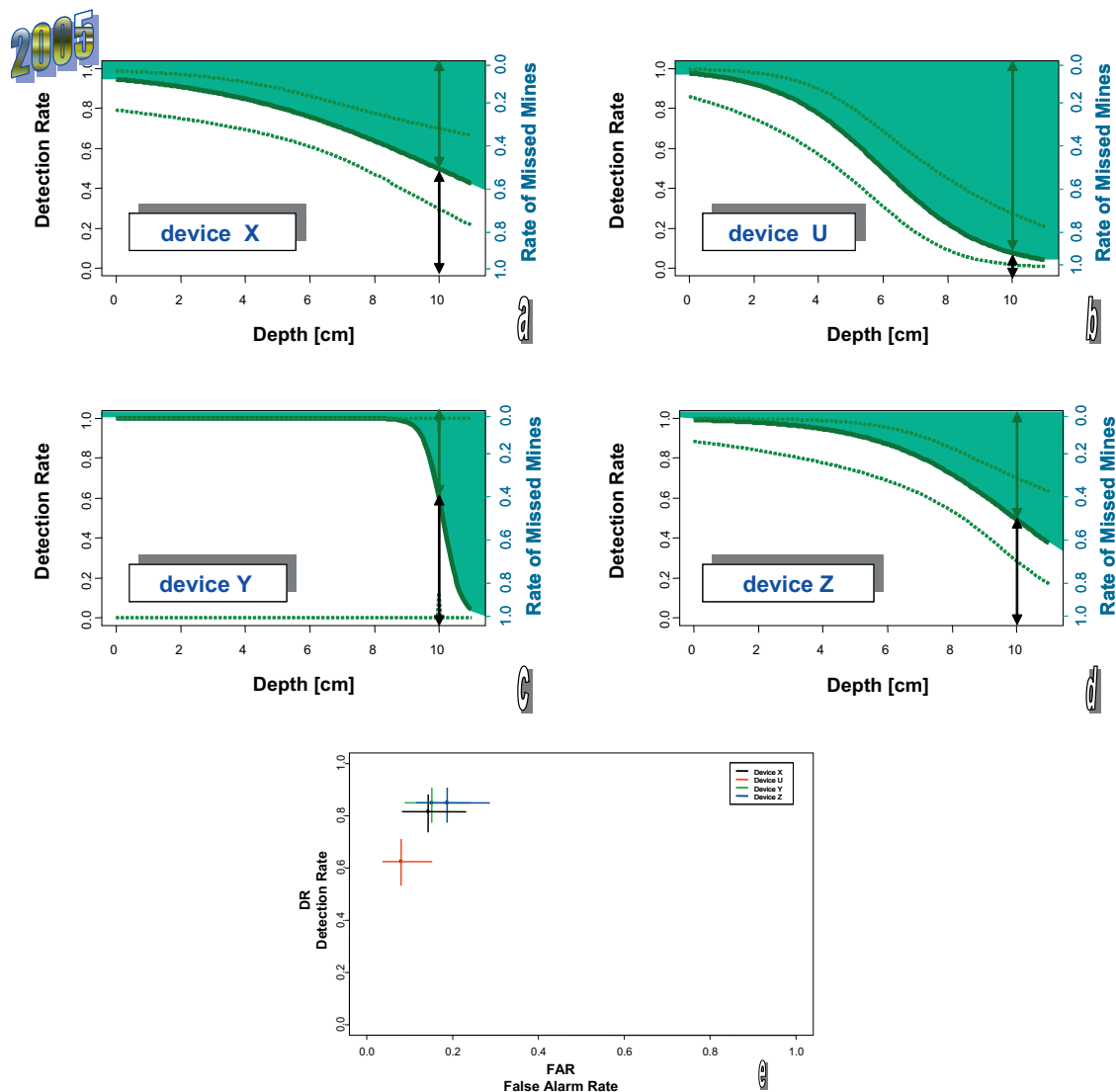


Figure 8: Lanes 3 and 4 (cooperative soil), estimated detection rate with 95% confidence limits for PMA2 – This diagram is comparable with Figure 5

Table 3: Overview of magnetic properties of the soils

Soil Types in Benkovac Trials	Susceptibility at 958 Hz (10 ⁻⁵ SI)	Susceptibility difference at 465 and 4650 Hz (10 ⁻⁵ SI)
Lanes 1 and 2 (uncooperative)	154 ± 13	25,5
Lanes 3 and 4 (cooperative)	13 ± 2	0,6

Figure 6 presents the same results for the most difficult soil. The anomalous result for detector Y is due to a high FAR in the uncooperative soil, up to one false alarm per m^2 and the spuriously higher detection rate at large depth. The latter phenomenon can be explained by the fact that some of the “true” positive indications appear to be signals from the soil that happened to fall within the halo of a target, so that the apparent POD does not approach zero at large depth. To avoid this type of anomaly, the soil compensation and sensitivity of the detector should be adjusted to produce an acceptable low FAR prior to starting the blind trial. CWA 14747: 2003 section 8.1.5 specifies a procedure for checking the adjustment of a metal detector to the soil under test. The test is only to be considered valid if the detector can be adjusted in a representative $1\text{m} \times 1\text{m}$ set-up area so that no false alarms are given when placed on the soil surface and then raised 30 mm above it. It seems likely that detector Y

was not adjusted (or not adjustable) according to this procedure.

Figure 7 compares the results of each individual deminer in the two trials in Benkovac 2003 and 2005 in ROC diagrams. The lower scatter between their results in 2005 clearly indicate that the human factor influence improved significantly by selecting currently active deminers and providing them adequate training and working conditions according to the local SOP.

Example of a set of Resulting Curves from Year 2005: Detection Rates as Function of Depth and False Alarms for the PMA2 in different Soils

In the following figures the individual detector results are illustrated for the PMA2 mine under cooperative conditions for Sisak soil (Figure 8a-d): detection rates as function of the PMA2 depth for each device separately and e) the ROC points of all devices together.

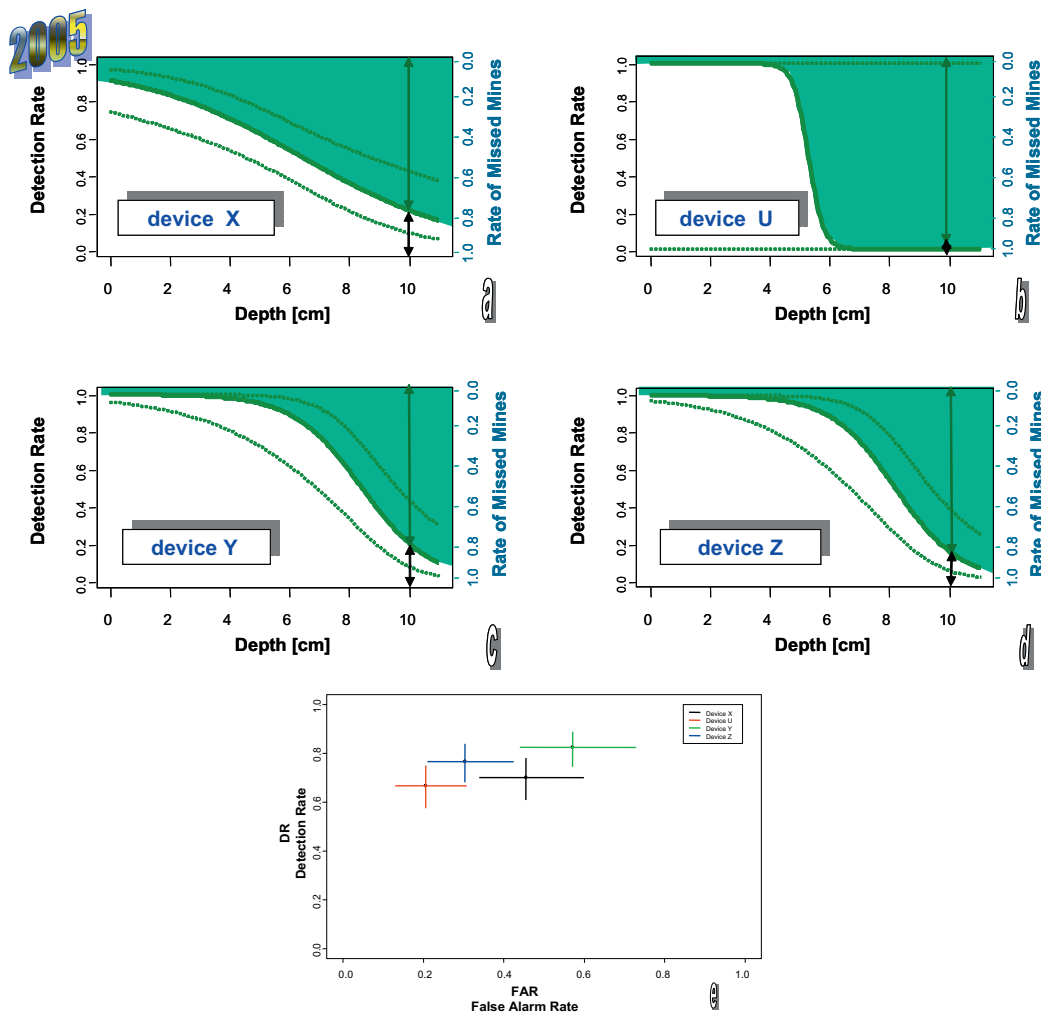


Figure 9: Uncooperative soil from Obrovac with a high frequency-dependent magnetic susceptibility; estimated detection rate with 95% confidence limits for PMA2. This soil is very similar to that on Figure 8, though less heterogeneous.

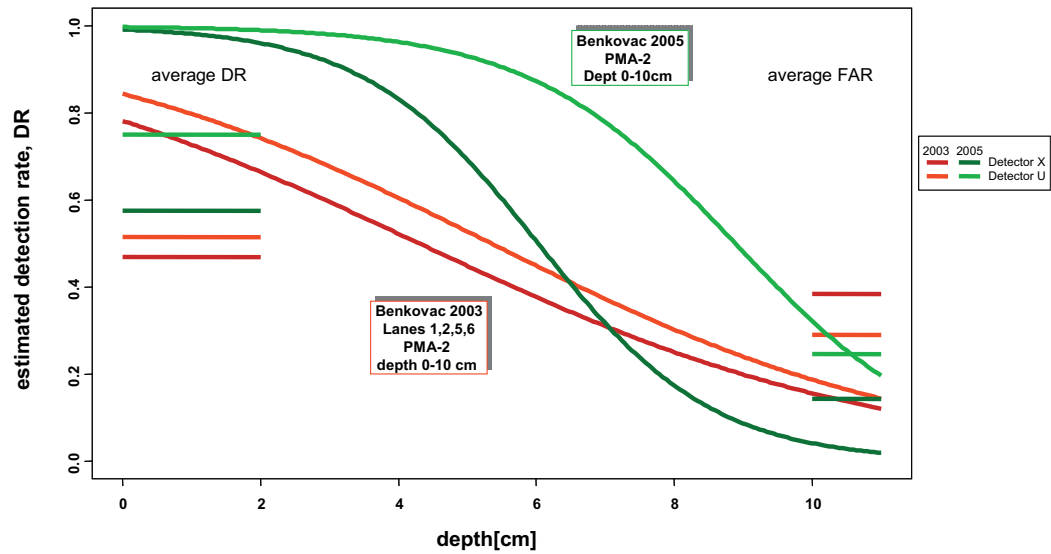


Figure 10: Comparison of individual results of the same detectors (U and X) in Benkovac in the same soils and on the same targets.

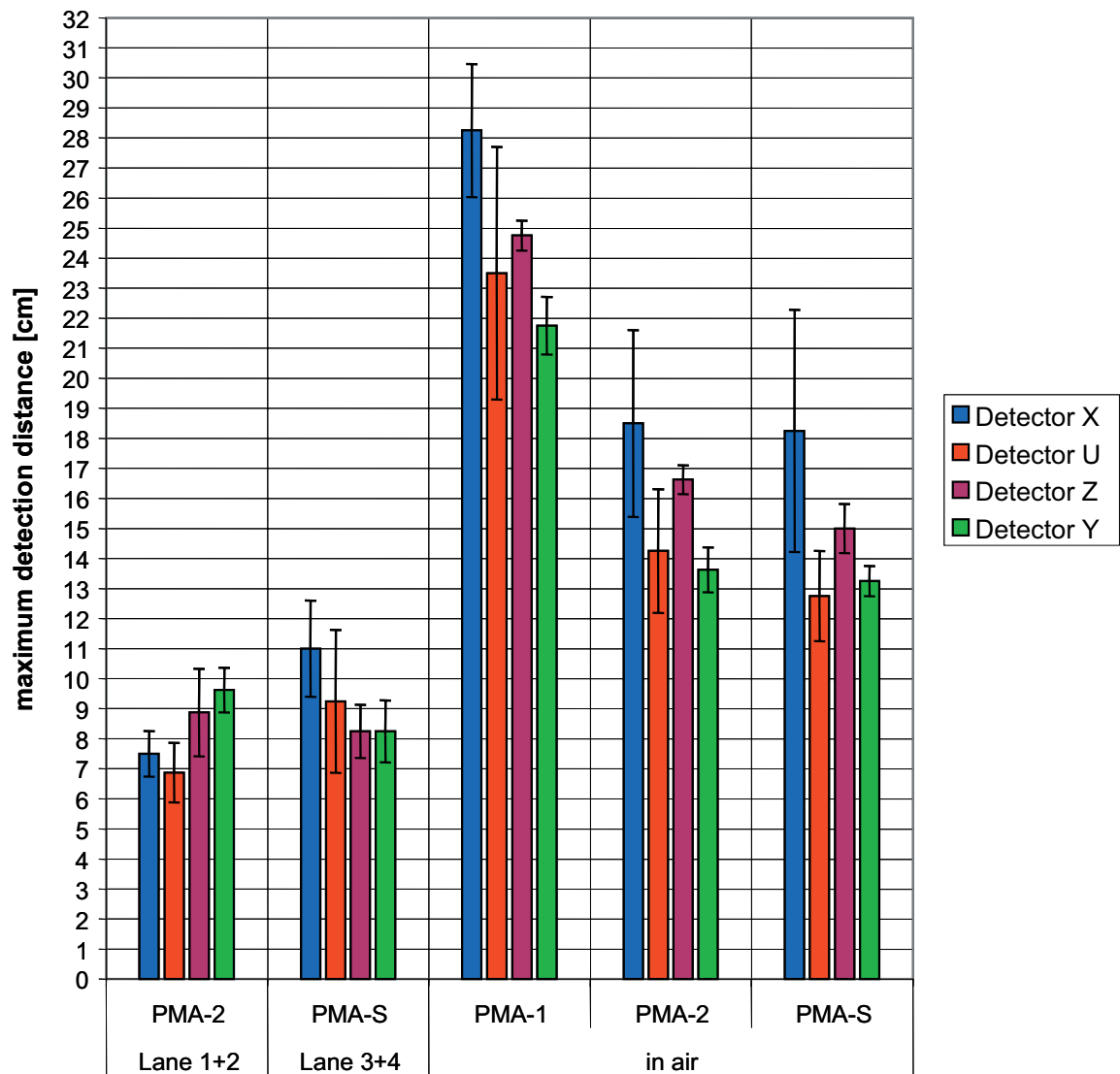


Figure 11: Maximum Detection Distance with the Corresponding Standard Deviations

The same curves for each detector but for uncooperative conditions (Obrovac soil) are shown in the Figure 9a-e. Especially the comparison of the results for uncooperative soil (Figure 6 – 2003 and Figure 9 – 2005) reveals clearly the improvement by i) better trial conditions and ii) the improvement of the hardware/software of detectors. To make the point i) clearer we put the results of 2003 and 2005 of the identical detectors for the same mines and soils in one diagram in Figure 10. The result from 2005 are closer to the realistic detection rates and also indicates more clearly the differences in device performance.

It is the opinion of the authors that the trial procedure with a clear experimental design, careful training and implementation of local working conditions should be added to the existing standard of testing metal detectors CWA 14747:2003, as well as the new insight about maximum detection distance measurements.

Maximum Detection Distance Measurements

For the first time ever (according to our knowledge) the maximum detection distance of a certain combination detector-target was measured several times with different operators (four deminers, twice). The maximum detection distance is the distance between the search head of the metal detector to the top of the target at which the detector starts to give clear signals. The results clearly show that there is a variance in the results that must be taken into account. It seems that the maximum detection distance measurements give results that change within minutes. These changes are not caused only by the operators (deminers), but also by the hardware of the devices.

Figure 9 shows the results for PMA2 in Obrovac soil (Lane 1+2) and Sisak soil (Lane 3+4) and in air for PMA2 and PMA1A as mean value and standard deviation of 8 single measurements. The results point to the conclusion that the maximum detection distance measurements should be performed with several operators and repetitions and that the measurements in air can not be considered as an indicator of the performance in soil.

In addition to the described experiments the trials in 2005 included the investigation of scanned voltage signals on the same test lanes as used for the blind trials. It is the aim of the authors to find

a clear relationship between the maximum detection distance and the depth at 50% decrease of the POD from the signal response POD and an assessment of the human factor influence from the comparison of the signal response POD from the scanned results to the POD from blind trials. The results of these attempts will be published in a following paper.

Conclusions and Outlook

For the results of detection reliability field tests the embedding scenario in terms of soil type and cleanness and human factor treatment has to be set up with care and explicit consideration of the local field situation and working system (SOP). The characteristics of a detector should be determined in terms of the detection rate as function of depth in each soil for each mine type and completed with the information about the corresponding false alarm rate. An expected mean value of the performance of a detector in a certain region can be determined from these basic curves by superposition, according to the local mine distribution.

Acknowledgment

The authors would like to thank the German Ministry for Foreign Affairs (Lt. Col. Johannes Dirscherl) and the German Ministry of Defence (Lt. Col. Joachim Sigmund) as well as the BAM's Presidential Board for sponsorship and support of the project. We are indebted about the fruitful partnership with the CROMAC-CTDT testing facilities in Benkovac and the WTD52 in Oberjettenberg as well as we thank for the hands on support of all colleagues from WTD52, BAM and CROMAC. Especially we thank all the soldiers of the German army and the deminers of Croatia for their brave work.

The authors are especially thankful to Adam Lewis and Dieter Guelle for continued support and fruitful discussions and exchange of experiences.

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An Overview of ITEP and CCMAT Detection Activities

C. Weickert⁵

Abstract

This paper provides an overview of humanitarian demining detection activities conducted under the auspices of the International Test and Evaluation Program (ITEP) and the Canadian Centre for Mine Action Technologies (CCMAT). The work plan of the ITEP Multi-Sensor Work Group and the Canadian National Program will be presented.

International Test and Evaluation Program

The International Test and Evaluation Program (ITEP) was established to strengthen worldwide humanitarian demining efforts by providing the efficient generation, collection, and distribution of objective, independent, scientifically-based test and evaluation data and information on equipment, systems, and methods for use in humanitarian demining. The current participants are Belgium, Canada, Germany, The Netherlands, Sweden, United Kingdom, United States, and European Commission. Other participants in ITEP projects include the United Nations Mine Action Service (UNMAS), Geneva International Centre for Humanitarian Demining (GICHD) and organizations from mine-affected states and entities.

The ITEP principles and objectives are as follows:

- Establish Test and Evaluation (T&E) capabilities for measuring performance and evaluating the effectiveness and suitability of all forms of equipment, systems, and methods for use in humanitarian demining.
- Conduct T&E of existing equipment, systems under development, and of promising technologies, processes, and algorithms.
- Establish and employ standards, protocols, and methodologies for cooperative T&E.
- Collect, generate, assess, evaluate, and distribute robust, scientifically objective data and information on the performance and effectiveness of such equipment, processes, and methods under a variety of environmental, physical, technical, and operational conditions.

ITEP conducts test and evaluation in three general categories:

- *Existing Capabilities:* T&E of existing equipment, systems, and methods will, in most cases, involve equipment for use in humanitarian demining which is commercially available off-the-shelf.
- *Capabilities Under Development:* The results of such T&E will be primarily beneficial to the developer by identifying areas where system improvements are needed, including performance, maintainability, and reliability.
- *Promising Technologies:* T&E of promising technologies is intended to result in better understanding for the development community of the phenomenology of the technology under investigation and its application to humanitarian demining.

To date the majority of the T&E has been conducted in the first two categories.

The ITEP 2006 Work Plan endorsed by all ITEP Participants, is available on the ITEP website (www.itep.ws) and provides an overview of national and collaborative T&E projects, executed under the ITEP umbrella. The bulk of the ITEP projects are in Mechanical Assistance and Detection (Figure 1.), however this paper covers detection only.

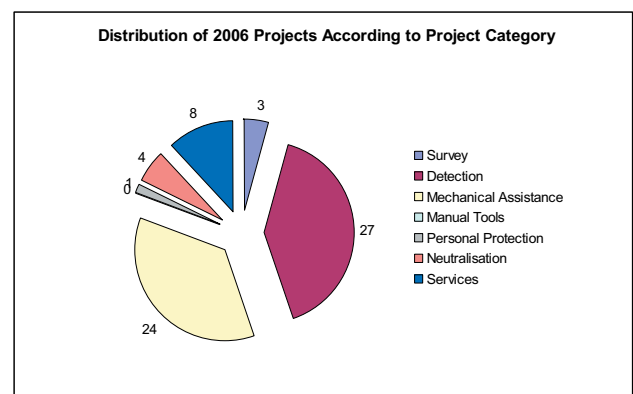


Figure 1. 2006 Project Distribution

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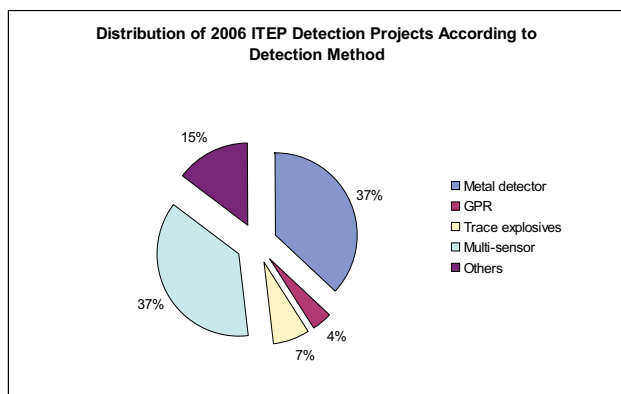


Figure 2. 2006 Detection project Distribution

The bulk of the detection projects are split between Metal Detection and Multi-Sensor Detection as illustrated in Figure 2.

Standards and Best Practices

One of the objectives of ITEP is to employ standards and best practices for T&E. Two “best practices” have been developed by the European Committee for Standardization with input from ITEP and several organizations. These CEN workshop agreements are shown in Figure 3. The agreements are currently in a phase of experimental verification and are included as normative references in the relevant International Mine Action Standards. It is planned to develop a best practice document for T&E of Dual (Multi)-Sensors using the CEN workshop procedure. This will be based on the test experience from the 2004-2006 dual-sensor detector test projects. Also planned is a Personal Protective Equipment (PPE) best practice document.

CEN	CWA 15044
WORKSHOP	July 2004
AGREEMENT	
<hr/>	
ICS 95.020	
English version	
Test and evaluation of demining machines	

CEN	CWA 14747
WORKSHOP	June 2003
AGREEMENT	
<hr/>	
ICS 95.020	
English version	
Humanitarian Mine Action - Test and evaluation - Metal Detectors	

Figure 3. CEN Workshop Agreements

The International Pilot Project for Technology Co-operation (IPPTC) was a multi-national technical evaluation of performance of commercial off the shelf metal detectors in the context of humanitarian demining. 29 detectors were assessed for performance in air; in a range of soils; and in realistic demining scenarios in Cambodia and Croatia. The IPPTC formed the basis for CWA 14747 Humanitarian Mine Action – Test and Evaluation – Metal Detectors. Since the completion of the project, new metal detectors have been developed and are in production. ITEP is in the process of testing these new detectors in the STEMMD project (see Project Updates Section below).



Figure 4. Sample of Metal Detectors



Figure 5. In Air Tests in Canada



Figure 6. In Soil Test in The Netherlands



Figure 7. In Country Tests in Cambodia

ITEP Work Plan Project Updates

Metal Detectors: Test and Evaluation of Metal Detectors (STEMD)

Objective: Assess currently available off-the-shelf metal detectors using the CWA 14747 test protocol

- Produce update performance data for the user and additional info for GICHD catalogue of Metal Detectors
- Train local entities on applying the CWA 14747
- Evaluate the CWA 14747 test protocol and formulate updates

3 regional trials (Laos, Mozambique, Croatia) with support of the local Mine Action Centres

- Laos trial: November 2004, completed, test report published
- Mozambique/SA trial: April 2005, completed, test report published
- Croatia trial: planned

Dual-Sensor Detectors: Handheld Stand-Off Mine Detection System (HSTAMIDS) Operational Field Trials and Demonstrations Project

Objectives:

- Evaluate the performance and suitability of the HSTAMIDS in multiple humanitarian demining environments,
- Train local deminers in the proper use and operation of the HSTAMIDS

- Assess the performance of metal detector operators after limited experience and training with the HSTAMIDS and evaluate the training methods, the human factor characteristics and the overall performance
- Demonstrate the HSTAMIDS to regional demining organizations 3 regional trials (Thailand, Namibia, South-West Asia/TBD) with support of the local mine action centres and/or NGOs
- Thailand trial: November-December 2004, completed, test report in progress
- Namibia trial: March 2005, completed, test report in progress
- Third trial: planned



Figure 8. Handheld Stand-Off Mine Detection System

Dual(Multi)-Sensor Detectors: Assessment of the ERA/Vallon dual-sensor mine detector (MINEHOUND)

Objectives:

- Determine the reduction in false alarm rate when a dual sensor detector is used in a minefield.
- Gather data on the performance of the MINEHOUND™ in different soil conditions to determine its performance with respect to depth / soil type 3 regional trials (Cambodia, Bosnia, Angola), with support of the local NGOs
- Cambodia trial: August-September 2005, completed
- Bosnia trial: September-October 2005, completed
- Angola trial: October-November 2005, completed



Figure 9. MINEHOUND Dual-Sensor Mine Detector

The ongoing and planned ITEP detection projects are listed below (see the work plan for details www.itep.ws).

Metal Detectors

- 2.1.1.1 – CEN Workshop Agreement on Test and Evaluation of Metal Detectors
- 2.1.1.5 – Metal Detector Performance Project
- 2.1.1.7 – Metal Detectors for Humanitarian Demining – Development Potentials in Data Analysis Methodology and Measurement Technology
- 2.1.2.2 – Test and Evaluation of Handheld Mine Detection Systems
- 2.1.2.3 – Systematic Test and Evaluation of Metal Detectors – STEMMD
- 2.1.2.5 – Evaluation of Metal Detector Arrays for Humanitarian Demining
- 2.2.2.6 – In-Soil and In-Country Performance Evaluation of Vehicle-Mounted Metal Detection Systems
- 2.1.2.7 – GEMINI Vehicular Array for Deep Buried Mines
- 2.1.2.8 – Trial of Kondor 7252 and Vektor 7260 Metal Detectors plus Two New Metal Detectors of Different Manufacturers

Ground Penetrating Radars (GPR)

- 2.2.2.3 – Integrate, Test and Evaluate the Mine Stalker NIITEK Ground Penetrating Radar System

Trace Explosives

- 2.3.2.5 – Test and Evaluation of Detection Dogs for UXO Clearance

- 2.3.2.6 – Evaluation of Conditioned Bees for Detecting Buried Landmines

Multi-Sensor Detectors

- 2.4.1.1 – Mini-Symposium on Multi-Sensor Systems for Mine Detection
- 2.4.1.2 – CEN Workshop on Characterisation of Soils for Electromagnetic Sensors – Test and Evaluation
- 2.4.1.3 – Test and Evaluation of Available Dual Sensors to be Used in Humanitarian Demining
- 2.4.2.4 – Assessment of the Next Generation of the ERA Dual-Sensor Mine Detector
- 2.4.2.1 – Development of the HD Version of the Handheld Standoff Mine Detection System (HSTAMIDS)
- 2.4.2.3 – Incorporate and Test and Evaluate Acoustic Vibration Sensing in HSTAMIDS
- 2.4.2.6 – HSTAMIDS Operational Field Trials and Demonstration
- 2.4.2.9 – Discriminating Mine Detector
- 2.4.2.10 – Test and Evaluation of Dual Sensors

Promising Technologies

Trace Explosive Detection

- Can honey bees assist in Area reduction and landmine detection?
- Active tracking of bees using Light Detection & Ranging (LIDAR) technology
- Trials in Canada in minefield with real mines – summer 2006

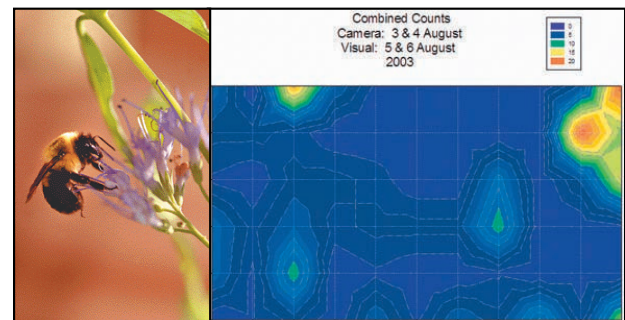


Figure 10. Bee-Generated Map of Minefield – Ft Leonard Wood

Messages

- Collaboration – saves resources \$, reduced duplication of effort
- International Test & Evaluation Standards and Best Practices – comparison of different

- equipment (manufacturer or machine type)
- In-country acceptance testing – testing of equipment to determine suitability for a particular country/area/project
- Involvement of Non-Governmental Organizations and Mine Action Centres
 - In-country tests (acceptance tests)
 - Performance and survivability tests
- Trends in ITEP
 - COTS Equipment
 - Equipment under development
 - Promising Technologies

The Canadian Centre for Mine Action Technologies

The Canadian Centre for Mine Action Technologies (CCMAT) was established in 1998 and funded for 5 years to develop low cost, sustainable technologies for mine action and to work toward their successful deployment in the field. The extension of the Canadian Landmine Fund (CLF) in 2003 has facilitated the continued provision of CCMAT support to the demining community. The mandate of CCMAT has evolved into the four priority areas listed below. In general, an increased emphasis is being placed on the fielding and promotion of new technology and improvements to existing equipment that will result in safer and more efficient demining operations in mine-affected countries.

- Technical Support (Test & Evaluation)
- Fielding and Promotion of Technology
- Research and Development
- International Cooperation & Outreach

Technology Areas

Detection

- Neutron Imaging
- X-ray Imaging
- Tripwire Detection
- Smart Plants
- Short Wave Hyperspectral Imaging
- Infrared Study
- Soils Studies

Enabling Technologies

- Targeted Excavator/Vegetation Cutter Teleoperation

Neutralization and Protection

- Protective Footwear
- Momentum Trap

- Personal Protective Equipment
- Mechanical Assistance Equipment
- Chain Flail Analysis
- Automated Excavation
- Vegetation Cutter

Electromagnetic Effects of Soil on Metal Detectors

- Understanding needed to help deminers plan and execute detection in-theatre
- Four pronged on-going program
 - measure magnetic susceptibility globally
 - develop techniques to measure EM properties
 - model effects of EM soil properties on metal detectors
 - characterize archived soil samples from BiH

Promising Technologies

Neutron Moderation Imaging

- Fast neutrons in – thermal neutrons out (detects H)
- Problems: water, surface, detector height variations
- Need imaging
- Prototype done
- Preliminary mine surrogate images in air
- Hardware/software improvements ongoing to
 - clean up images
 - reduce collection time
- Further tests planned

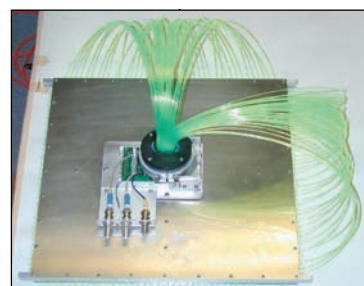


Figure 11. Prototype Imaging Hardware

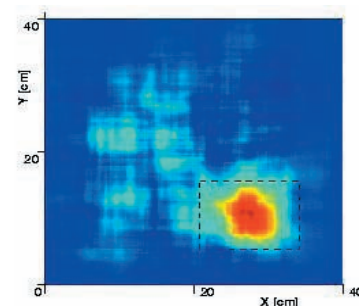


Figure 12. Image of Mine Surrogate

Coded Aperture X-ray Backscatter Imaging

- Photons (X-rays) in – photons out
- Detected plastic AP mines in sand box
- Prototype handheld being built for mine and IED detection
- Mine Pen tests planned
- Must improve analysis time

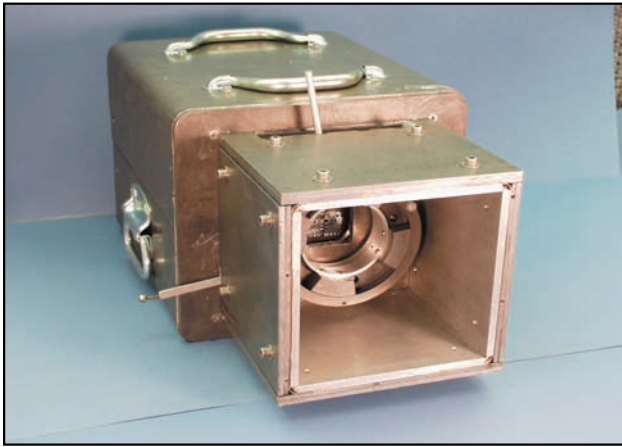


Figure 13. DRDC/UCSD Dual-Energy Jig



Figure 14. AP Mine Flush Buried

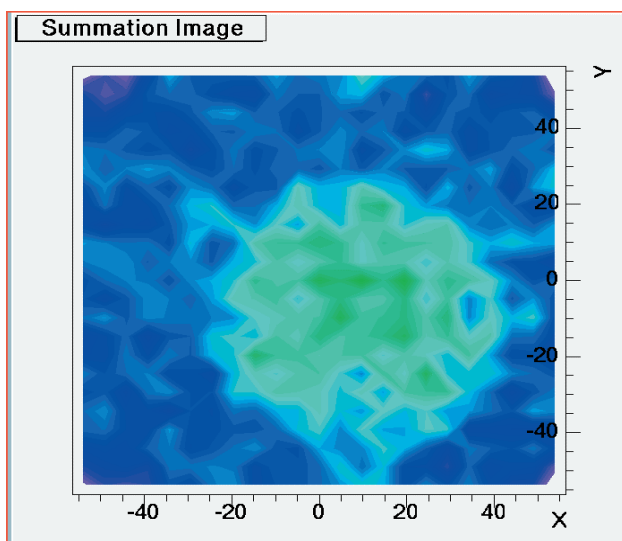


Figure 15. Image of Mine, 23 cm from Mask

Electrical Impedance Tomography

- Sets of v excitations/surface I measurements
- Forms image of subsurface conductivity
- Must insert probes near mine
- Wetter is better
- Useful for surf zone, berms
- Improving algorithm, doing submerged experiments

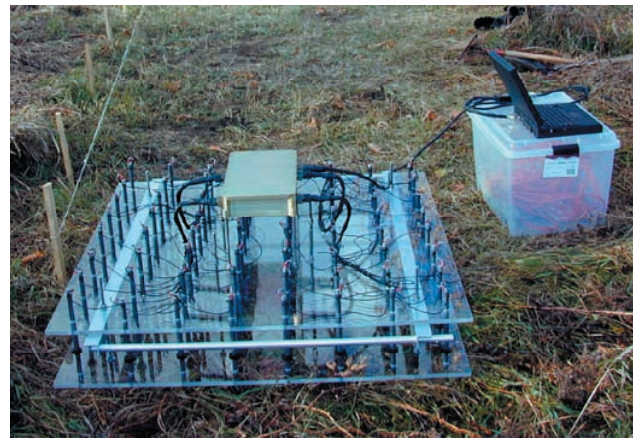


Figure 16. Electrode Array

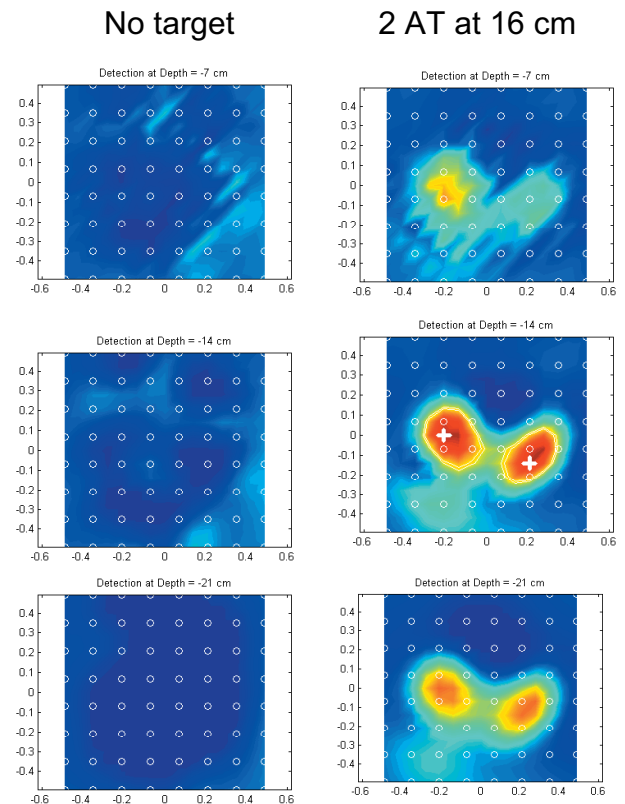


Figure 17. EIT Images at Various Depths

- Scale model measurements of mines buried in a sediment bed underwater
- Currently we are upgrading the instrument

and testing more sophisticated algorithms for both detection and reconstruction.

- Reconstruction = forming an image of the subsurface conductivity
- Detection = using subsurface conductivity to declare that a target of interest is there

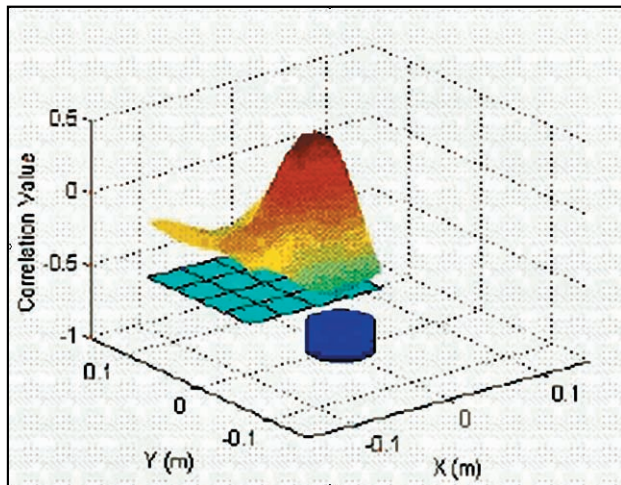


Figure 18. Water Tank with Electrode Array Sitting



Figure 19. Data from the EIT Array Passing Over a Target on Sediment Surface

Hyperspectral Imaging

- VNIR: since 1989
 - good surface detection
 - real-time hyperspectral imager development
- SWIR: improved surface detection, buried?
 - completed feasibility study
 - prototype imager development complete
 - first mine detection tests -2003
 - close-in with crane
 - can easily separate man-made materials from natural materials– independent of colour
 - mine pen tests conducted to increase classification database

- TIR: buried capability
 - prototype imager development
- collecting images as part of STREAM Project, Fall 2006, over real minefields in Angola, using VNIR, SWIR, & TIR hyperspectral imagers

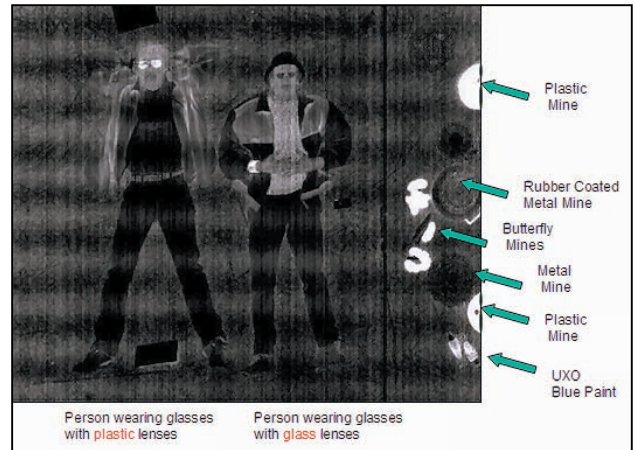


Figure 20. Overhead SWIR Image

Broad Band Mid-wave Thermal IR Imaging

- Trying to predict variable performance from simple environmental measurements and models
 - Long term imaging MWIR,TIR experiment
 - fully automated, full environmental data
 - year long data base for demining community
 - started October 2005

The images below show variability of IR image performance.

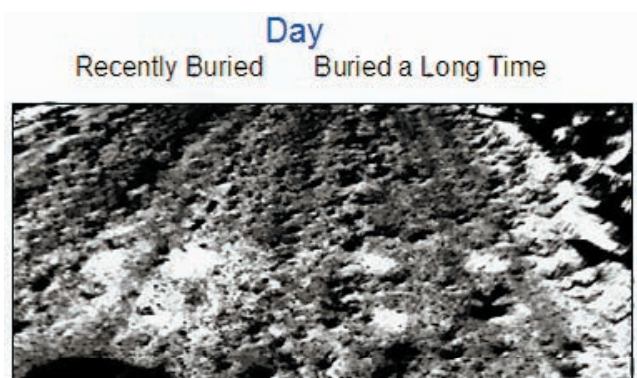


Figure 21. Daytime thermal IR image of mined road at Suffield. 2APs, 1AT in inverted L shape on left of image, same on right. Left set of mines were recently buried, right hand ones were buried long ago (months). Note surface clutter over new mines due to solar reflections, emissivity variation from soil disturbance.

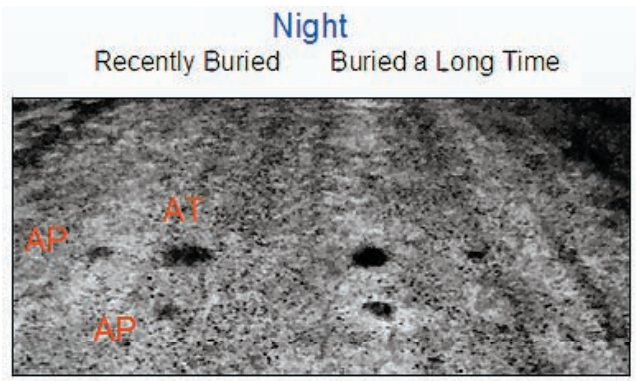


Figure 22. Same scene as Figure 21 at night. Surface clutter is gone.

Thermal IR Hyperspectral Imaging

- Few systems suitable for mine detection
- U of Hawaii AHI exception
 - not dedicated to mine detection
 - cooled MCT (mercury-cadmium-tellurium) focal plane array
 - expensive
- Investigating lower cost alternative – thermal airborne spectrographic imager (tasi)
 - microbolometer Focal Plane Array (FPA)
 - novel energy dispersion method
- To date camera thermal airborne broadband imager (tabi) with narrow band filter set
 - experiments Spring 2005
- DIR Project started Fall 2005 with prototype hyperspectral imager Fall 2006 to fly in STREAM Project

Optical Tripwire Imaging

- Key to success – high spatial resolution
- CMOS focal plane array with dual P3 processors
 - pseudo real-time processing
 - experiments in Mine Pen
 - good results in vehicle-mounted application
- On-going improvements
 - true real-time
 - better detection of broken, sagging, undulating wires
 - have investigated colour, polarization – no significant advantage
 - now looking at mid wave IR

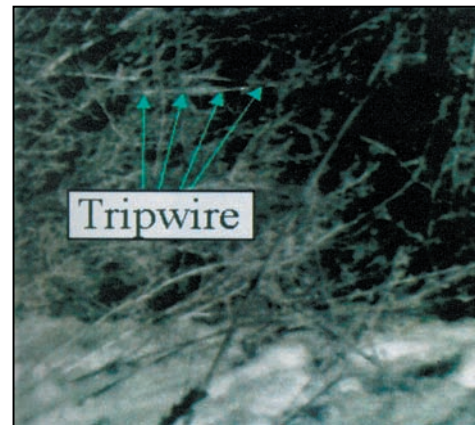


Figure 23. Trip Wire in Vegetation

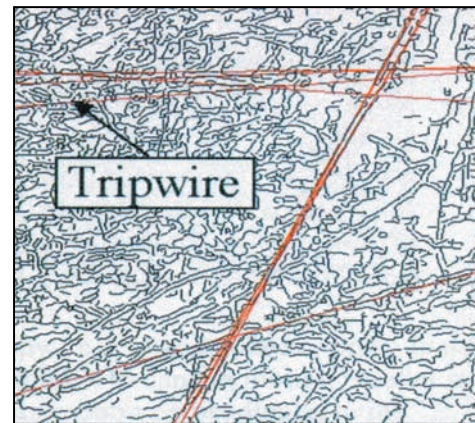


Figure 24. Processed Image

Trace Explosive Detection

- Detection by Genetically Modified indigenous plants
- genes contain reporting mechanism
- CCMAT/University of Alberta
- studying natural sensitivity to TNT, by-products
- emphasis on signal transport mechanisms

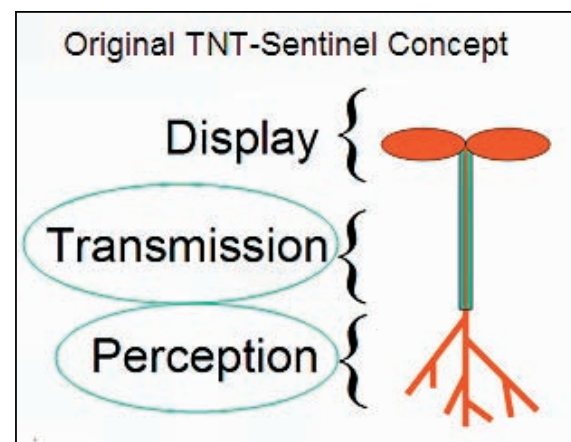


Figure 25. Plant Trace Explosive Detection Concept

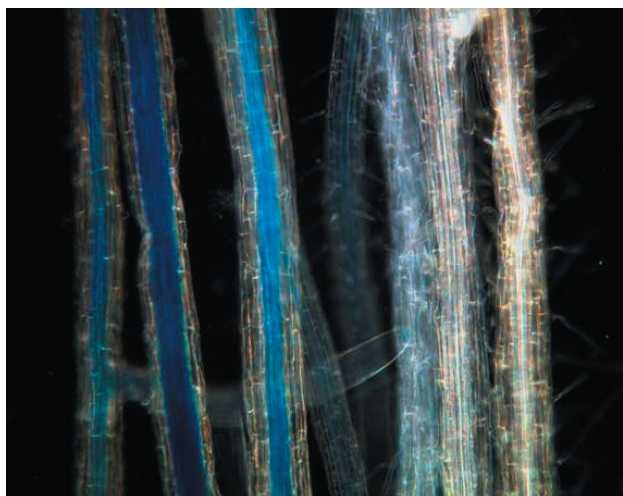


Figure 26. Arabidopsis plant roots; Left: Roots from 1,3-DNB treated plants (15mg/L) appear blue. Right: Roots from mock treated (control) plants of the same line do not display the blue color

- Plants responsive to the TNT-derivative 1,3-dinitrobenzene were produced
- Demonstrated that under optimal laboratory conditions, production of transgenic plants

that respond to explosive derivatives is feasible

- Translation of this basic mechanism into a practical field detection system will require significant further effort

Messages from a Canadian Perspective

- Collaboration – ITEP
- International Test & Evaluation Standards and Best Practices
- In-country acceptance testing
- Balance between T&E of existing equipment and R&D of new technologies
- Consider the increased use of technology
- Investigate what independent testing has been performed on equipment prior to purchase
- A clear focus on :
 - available technologies
 - independent and authoritative testing by experts
 - real world tests by working deminers
 - getting existing equipment into the field

METAL DETECTOR TRIALS - Detector Test Results and Their Interpretation

Dieter Guelle⁶

The attached presentation is based on a document written by D M Guelle, A M Lewis, P Ripka (EC Joint Research Centre). It will be published under the above given title. Below the executive summary gives an overview about the content of the document. The power point presentation gives some details out of the most important ideas of the document which should be understood in the overall content.

This document is devoted to eddy-current metal detectors used for finding mines. Its purpose is to collect the information split amongst the various test reports published during the period from 1997 and analyse it from a technical point of view and to evaluate the main factors influencing detector performance.

The second chapter gives an overview and background, describing the development of humanitarian demining operations into the modern Mine Action industry, with its main sensor technique remaining the metal detector. It lists the test campaigns that have taken place and the changes as they developed. Outstanding are the IPPTC and STEMMD trials, which give an overview about the capabilities of the metal detector at the time. Lab tests were added to the common field tests, and blind reliability tests, similar in content to those of non-destructive testing and evaluation, were introduced. With the introduction of a CEN Workshop Agreement in 2003, a new period began in which there was international agreement on how to conduct thorough tests.

The reliability test is the most complex test because it assesses all components of the detection system, based on statistically valid data, consisting of the intrinsic capabilities of the metal detector, the human factor, and the environment, including the rules for mine clearance operations. We describe how 3 basic components are split into evaluation criteria, which are demonstrated by test results. Various possibilities for design and statistics are included

as well as explanations of how to create Receiver Operating Characteristic (ROC) curves showing

the main factors which influence the test results.

Chapter 4 is devoted to the ground and its influence on the detection capability of the detectors. The frequency dependence of the magnetic susceptibility is the main factor directly influencing the metal detectors. The measuring instruments available for this are described. Other electromagnetic factors having less influence are mentioned. Using a metal detector for empirical soil measurements is good enough for establishing a rough overview about problem areas for metal detector employment. These data can easily be collected during impact or technical survey.

We explain the limits for using detectors without ground compensation and discuss the effectiveness of the ground compensation. Not all detectors have good enough ground compensation to cope in some regions with high frequency-dependence soil. The STEMMD trial in Mozambique focused on the influence of soil. 12 latest-models, representing all recognised metal detector manufacturers were tested against 13 targets and 7 soil types. The results showed, beside the limits of soil compensation of some detectors, also that in-air testing with a detector set up to the soil does not deliver reliable data and should not be used for detection prediction in soil. The special trial in Laos allowed a direct comparison of 4 UXO detectors to normal detectors. The trial results showed the advantages and limits of both types of detectors, concerning sensitivity, power consumption and pinpointing.

Next is a features assessment of currently available detectors. The general conclusion is that the basic sensitivities of the detectors are not very different but some other features are different, and make influence their effectiveness. Ground compensation and the interface to the user are a lot better in some detectors than others. There are several different approaches and possibilities for setting up and using the detector.

The authors believe that there are still possibilities for improving the metal detector's capabilities by improving the data analyses collected from targets. This may concern target discrimination and three-dimensional data signatures.

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UXO in the MSA in the Republic of Croatia in Depths Greater than 20 cm - Detection, Removal/Destruction -

Dražen Šimunović⁷

Summary

One of everyday problems in solving unexploded ordnance (UXO) on mine suspected area (MSA) in the Republic of Croatia is the existence of different types of artillery projectiles, missiles, aerial bombs, mortar shells etc. in depths bigger than the ones prescribed by relevant standard and determined by the project in the humanitarian demining process.

In practice up until present (1998-2006) there have been several CROMAC demining projects related to this problem area and we expect even more projects of this kind in the near future. Realization of UXO contaminated projects in the Republic of Croatia is extremely important especially due to the fact that there were many artillery-related activities on the area of the Republic of Croatia.

In view of UXO depot explosions, the ratio between mines and UXO found is 1:6 in favour of UXO (for the period since 2000).

In the Republic of Croatia, the UXO problem in bigger depths is only partially solved by existing statutory provisions.

Subjects (persons) involved in the process of solving this problem area are: the Ministry of Interior of the Republic of Croatia, CROMAC, demining companies specialized for this form of mine action, State Administration for Protection and Rescue and others.

Organization of one UXO detection project realization in bigger depths depends a great deal on a number of factors (space, time, UXO type, methods and techniques, safety zones...). Organization of such projects and their realization will be presented through the example of three UXO detection projects recently carried out in the Republic of Croatia. These are the projects in Slavonski Brod, Vrlika and border crossing Debeli brijeg.

In the foreseeable future CROMAC will, together with other subjects, put its efforts into improvement of methods and passing adequate statutory provisions related to UXO problem solving issues. UXO has been present on the area of the Republic of Croatia for years now and represents a threat for wider community.

Key words: UXO, depths bigger than 20 cm, detection, destruction, removal, statutory provisions, projects

Topic: UXO in the MSA in depths bigger than 20 cm -detection, removal/destruction-

1 INTRODUCTION (general information and statutory provisions related to UXO in the MSA, in the Republic of Croatia)

2 Subjects (persons) involved in solving UXO detection problem area in depths bigger than 20 cm

3 Organization of detection, removal/destruction of UXO in the MSA

4 Examples

5 Guidelines and CROMAC plans regarding UXO detection in the MSA

1. Introduction

One of everyday problems in solving unexploded ordnance (UXO) within mine suspected area (MSA) in the Republic of Croatia is the existence of different types of artillery projectiles, missiles, aerial bombs, mortar shells, in depths bigger than 20 cm, that is in depths bigger than the ones prescribed by standards in the humanitarian demining process.

Up until present (from 2000- March 2006), through the process of humanitarian demining in the Republic of Croatia, on the project area totaling 150 933 020 m² and 572 projects it has been found 17 253 AP mines, 12 827 anti tank mines, 142 847 of UXO, which explains the ratio between mines and UXO findings which is 5:1 in

favour of UXO. This indicates that UXO remains very important issue in the process of humanitarian demining in the Republic of Croatia.

In practice up until present (1998-2006) there have been several CROMAC demining projects related to this problem and we expect even more projects of this kind in the near future.

Realization of UXO contaminated projects in the Republic of Croatia is extremely important especially due to the fact that there were many artillery-related activities on the area of the Republic of Croatia, as well as for depot of ammunition and UXO, that makes this issue even more important (Volinja, Voćin, Vojnić, vojarna Logorište etc.)

In the Republic of Croatia, the UXO problem in bigger depths within mine suspected area is only partially solved by existing statutory provisions. Statutory provisions relating to UXO detection on

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surface being within mine suspected area is much more specific, but experience so far in detecting UXO in bigger depths and all related problems lead to the conclusion that statutory provisions for that matter should be better defined. In 2004, the UXO Law proposal was in preparation.

Valid Law on humanitarian demining Official Gazette 153/05 defines procedure in handling with UXO, whilst Rules and Regulations on demining Official Gazette 79/00, 87/02, 94/02, 149/02, 138/03 i 123/05 defines all important regulations related to UXO within MSA.

Also Law on explosive materials (Official Gazette 178/04) defines authorised subjects for destruction of UXO findings.

2. Subjects involved in UXO detection problem in the Republic of Croatia are:

Subjects (persons) involved in the process of solving this problem are: **Ministry of Interior in the Republic of Croatia, Croatian Mine Action Center, demining companies specialized for this form of mine action, State Administration for Protection and Rescue and others.** Organization of one UXO detection project realization in bigger depths depends a great deal on a number of factors (space, time, UXO type, methods and techniques, safety zones...).

Based on the information from State Administration for Protection and Rescue or from Ministry of Interior, CROMAC determines whether UXO is located within MSA. Should UXO is not within mine suspected area, it is under jurisdiction of Ministry of Interior. Should on the other hand, UXO is located within MSA, CROMAC will, based on survey determine on which depth UXO is located and develop a mine search/mine clearance project up to the UXO location.

In UXO removal/destruction process, within

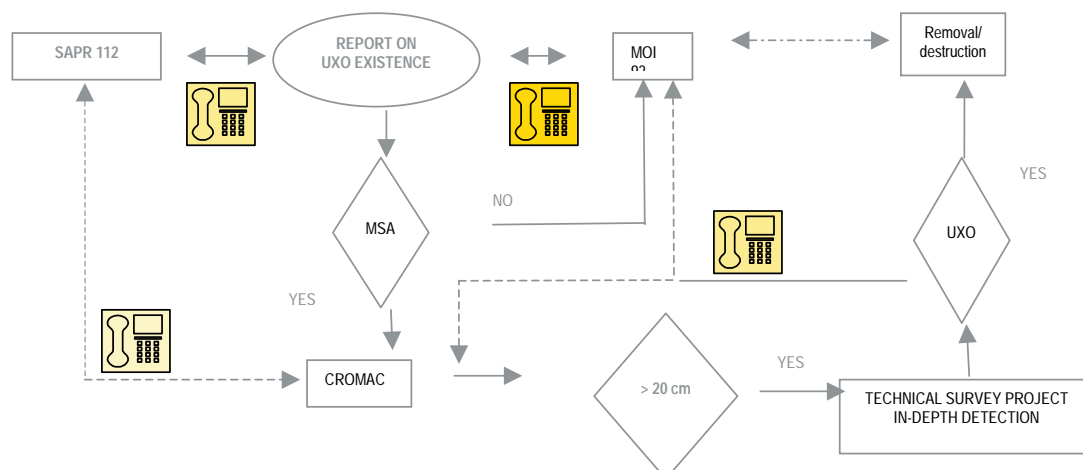
MSA, Ministry of Interior EOD team in coordination with the Contractor and CROMAC QA/QC department can take part in the process of UXO removal/destruction. In this case CROMAC QA/QC controls the removal/destruction process (in Slavonski Brod for example).

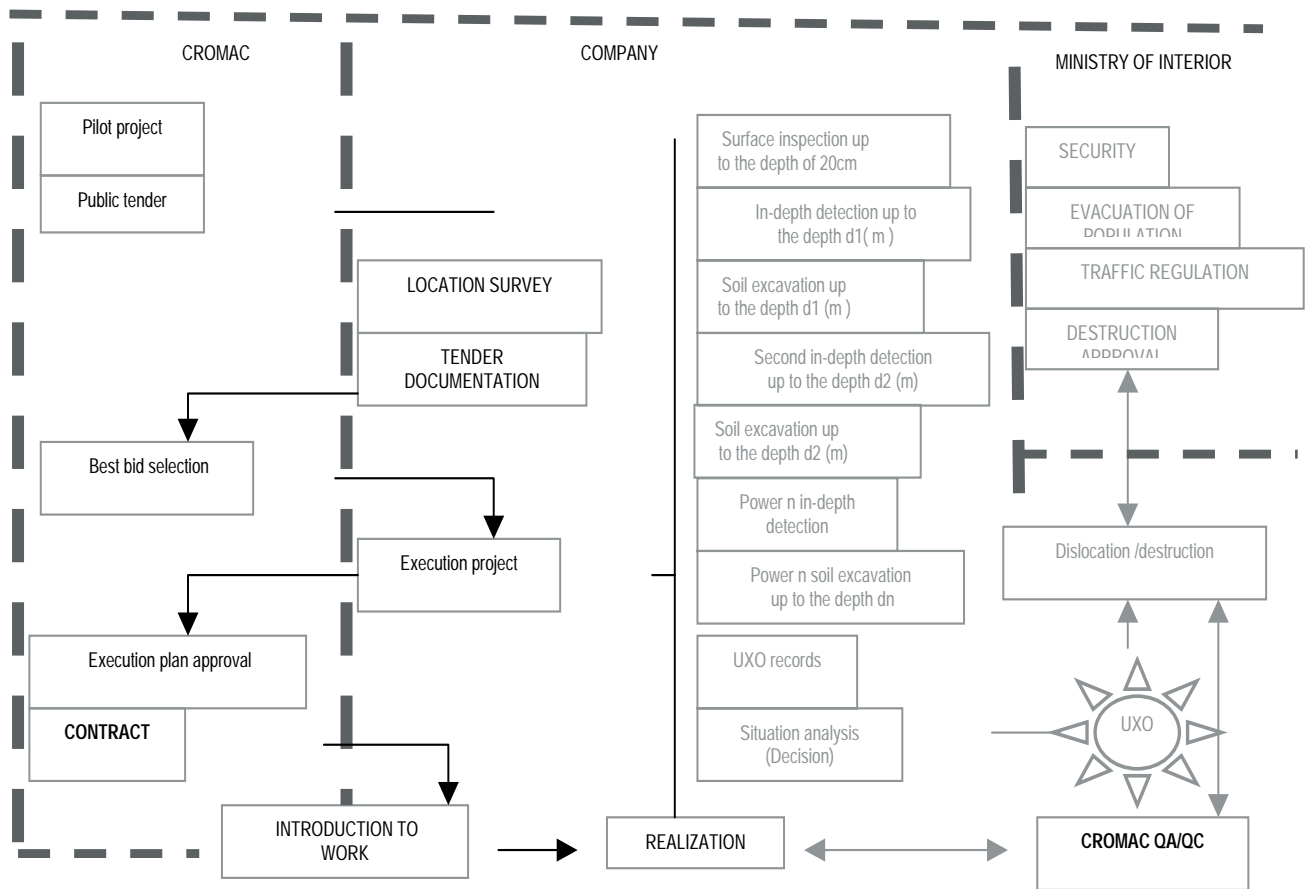
3. UXO detection, removal and destruction within MSA

Upon completion of the initial project and CROMAC bidding process, the eligible company for UXO in-depth detection provides survey in the area where UXO is located. Based on the information gathered, a company develops bidding documents and submits to CROMAC for a bidding process and selection of the best bid. Introduction to work of UXO detection is followed by completion of execution project (developed by a company) and signatory of a Contractor, CROMAC and (possibly investor/donor).

UXO detection is performed by following SOP guidelines that describe methods and scope of work. First step would be to search the area up to 20 cm deep in the ground by using metal detectors and vegetation removal. Afterwards, the area is searched up to 1 m, and based on results gathered, follows the decision making whether or not to sap the ground. The process repeats up to the moment when depth determined by a project is reached or when UXO is detected. Then UXO is registered and its condition analysed. If UXO can not be destroyed on the spot, it must be removed to the safe area. In the process of detecting and sapping the ground, all safety measures must be fulfilled.

If needed, officials of the Ministry of Interior in the Republic of Croatia provide: evacuation of the locals, traffic regulation, provide safety measures on demolition ground. Entire process is monitored by CROMAC.





4. Examples Three projects on UXO detection, recently completed in the Republic of Croatia are demonstrating the UXO problem in the Republic of Croatia.

These projects are as follows :

a) Debeli brijeg border crossing

area = 81.952 m² CROMAC project (DNKO-PP-008-09-03)

Mines and UXO found:

cumulative rifle grenade M60,
fragmentation aerial bomb 40 mm
counter-armor aerial bomb 82 mm
parts of aerial cluster bomb KPT- 150

1 piece DEPTH 40 cm
2 pieces DEPTH 60 cm
6 pieces DEPTH 60 -100 cm
several pieces DEPTH 50 – 100 cm

b) Slavonski Brod cadastre lot 2800/13 cadastre municipality Sl. Brod

area = 56 m² CROMAC project (BPSB-034-02-03)

Mines and UXO found:

HE grenade 155 mm1 piece DEPTH 4,0 m

c) Vrlika sewer network

area = 500 m² CROMAC project (SDVRVD -053-03-03)

Mines and UXO found: Nothing was found



Ph.1 UXO location in the centre of Sl. Brod



Ph.2 Location of detected 155 mm HE grenade in depth of 4 m from the excavation level



Ph.3 Status analysis of UXO found and PD M51A5



Ph.4 Preparation for dislocation of UXO to a fuse disposal site

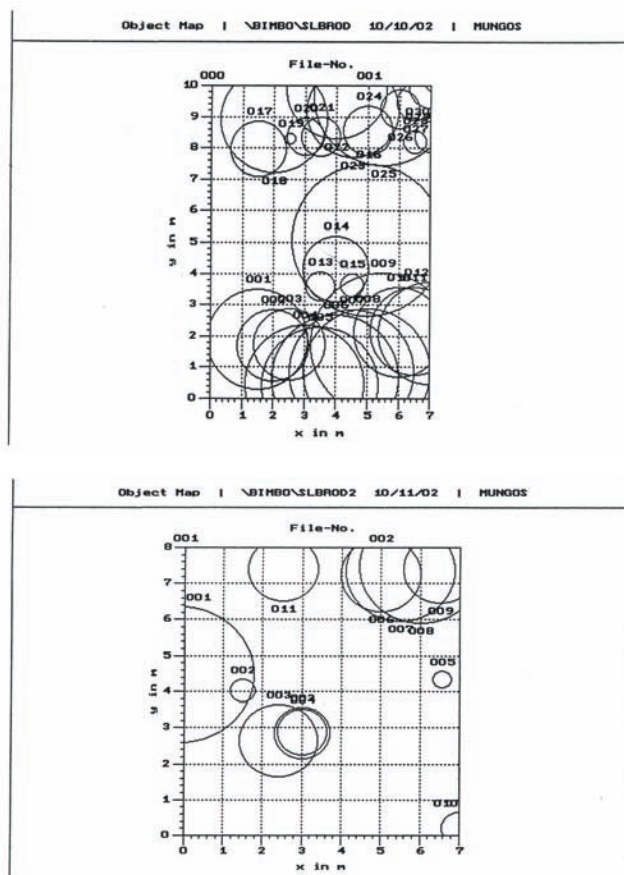


Figure. 5 Detection diagrams of metal objects on the project area

LOCATION MAPS OF THE AREA TO BE SURVEYED IN SLAVONSKI BROD





5. CROMAC's guidelines and plans regarding UXO detection in the MSAA's for this issue (in-depth UXO detection) in the Republic of Croatia, it is needed the following:

- Improvement of legislations concerning this issue (Law on UXO)
- Definition of space and location for which exist some indications on UXO existence at depths of over 20 cm
- Application of new methods, operating procedures and devices
- Improvement of safety measures
- Database

Daily Routine – Adjustment of Metal Detectors for Use in Humanitarian Demining

Ivica Raguz⁸

According to CROMAC information, there are more metal detectors currently in use in Croatia than the actual number of deminers. We can conclude that the companies are executing systematic replacement of metal detectors, but are still keeping the old ones too. The next conclusion is that most Croatian companies invest into new and more advanced technologies. In view of my personal cognitions and experience I believe that most companies always give the preference to the quality over the price during demining equipment procurement.

However, even the top-quality equipment can be useless or not useful enough in case of not being used properly and in the best possible way. I meet such cases during the execution of quality assurance activities at the Croatian Mine Action Centre (CROMAC).

In Croatia, Rules and Regulations on Methods of Demining regulate an obligation of every deminer on adjustment of metal detector prior to entrance to the mine suspected area. The record is made upon testing carried out. On the other hand, test procedure is not described in the SOPs and in most cases the companies follow the instructions provided by the manufacturer.

1. INTRODUCTION

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In Croatia, Rules and Regulations on Methods of Demining regulate an obligation of every deminer on adjustment of metal detector prior to entrance to the mine suspected area. The record is made upon testing carried out. On the other hand, test procedure is not described in the SOPs and in most cases the companies follow the instructions provided by the manufacturer.

During quality assurance execution, apart from record verification I often require a demonstration of metal detector adjustment. Everybody is more or less familiar with the procedure provided by the manufacturer, but there is no way for manufacturer to know what our depth de-

termined by the project is nor soil conditions nor specific target we are looking for. In this part I often conclude by saying that knowledge of metal detector adjustment is insufficient.

From 15 to 17 February this year I participated at the Technical Workshop in GICHD. One of Workshop topics were metal detectors. Afterwards, we were given a book (publication) «METAL DETECTOR HANDBOOK FOR HUMANITARIAN DEMINING» (group of authors) which I consider to be excellent also for the reason of partially covering this topic. I decided to bring together the experience of this book's author and some of my own on testing and adjustment of metal detectors.

That is the second reason why I decided to choose this topic.

2. MY PERSONAL EXPERIENCE IN WORK WITH METAL DETECTORS

I held a metal detector in my hands for the first time in mid-1992 as a member of 123rd brigade of the Croatian army. We got it from the Canadian Battalion (UNPROFOR) which arrived to the area of western Slavonia. Demarcation zone was established, the retreat from UNPA zones also started and there were some minefields to be cleared. It was the Minex but I have never worked with the one in a minefield.

The next metal detector was Schiebel AN19. We were using it in 1995 and 1996 as members of the Ministry of Interior – Civil protection. A group of 20 deminers had one metal detector of that kind.

«Serious» use of metal detectors in Croatia started with the establishment of AKD Mungos. In

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1996 and 1997 there were ca. 100 metal detectors of the Vallon ML 1620B type procured. As expected, deminers were distrustful of the possibilities for reliable detection and «fear for their legs». Technical documentation was in English so I translated, studied and «tested» the metal detector on a daily basis.

I think the key moment happened in the settlement of Žitnić, Dalmatia where we parked the vehicle next to the road on a «safe» surface area and started demining the railway line. Prior to the entrance to the mined area I checked the metal detector in front of the vehicle and found a TMA-5 mine and by further inspection three PMA-2 mines.

After that, deminers' attitude towards metal detectors changed significantly.

The team leader entrusted me to carry out training with other members of the team and after achieving certain results the training extended to other teams. Documentation and experience were ceded to the Special police that was, at that time, still engaged in humanitarian demining.

At that time, I was intensively involved in testing Vallon ML 1620B which is now considered as outdated technology. It is important to know that by proper operation and adjustment of metal detector it is possible to accomplish a lot. That is how I managed to compensate the railway track, and in Škabrnja, Dalmatia, (where the soil is extremely mineralized) I had no problems detecting the fragments below the wire placed on the ground (length of ca. 10 mm).

Later on, the AKD Mungos procured some more Vallon metal detectors, but of the C series.

Vallon is currently the most popular metal detector in Croatia. I have certain information that most companies are phasing in the VMH-3. I personally do not consider it to be the best one, but deminers have developed a certain habit especially considering the fact that a large number of deminers and the majority of work site leaders and quality assurance officers actually come from the AKD Mungos.

I think the companies producing or selling metal detectors should be more engaged in becoming more familiar with performances of each model and by proper and consistent usage it is always possible to reach the maximum.

For comparison, the instructions for use of Vallon ML 1620B was a thick book where the work in different situations with metal detector was described and a lot could be learnt from it, while the instructions for Vallon VMH-3 consist of

only a few pages. The fact is that this part should be included in deminer's training since one can not know everything about every model. This is why I think that manufacturers should give detailed instructions.

3. TEST FIELD CONSTRUCTION

3.1. Layout and elaboration of the test field

The test field or test line (field for set up of the metal detector) is necessary for set-up of a metal detector to the soil conditions, and for the set-up to required depth and specific target.

This is why it is necessary to place the position of the test field in close proximity of the work site or at the entry to the work site. A few test fields are necessary at bigger work sites due to different soil conditions (mineralization, density, humidity etc.)

The test field should be at least 1 x 2m or bigger if more targets are placed. After this, the field should be searched and cleared of all metal parts. The test field is cleared of metal parts when no metal detector that is used at the work site detects any metal

It is recommended to start with less sensitive metal detectors, and then to continue with more sensitive ones. It is very easy to determine detector's sensitivity (next chapter) at the work site. In any case, it is good to know the performances of individual metal detectors in order to organize operations at the work site.

First part of the test field is intended for set-up of metal detectors to the soil conditions, and the other one to required depth and specific target. In the other half the manufacturer's tester is buried to the required depth of 20 cm. The position is marked with a wooden stick.

3.2. Comparative testing of metal detectors with aluminum foil

Testing of metal detectors is decreed by standard CWA 14747 : 2003, and when this testing is concluded we can use the data at the work site.

However, if we want to conduct a simple comparative test of metal detectors, we can conduct it very quickly. This way of testing was presented at a GICHD Workshop by Mr. Hendrik Ehlers, MgM Angola.

The procedure is to take aluminum foil (it can be chocolate foil), cut in half, from one half we make a ball, and the other half we continue to

cut and make more balls. At our trials we ended up with 11 balls, and each ball was $\frac{1}{2}$ size of the previous one.

All balls should be buried at the same depth, in our case 10 cm at 0.5 m distance.

Then we carry out set-up of the metal detector to the soil conditions and we begin with the detection of the balls, starting from the biggest one to the smallest.

In our tests we used 5 types of metal detectors, of which 1 detected 10 balls, one 9 balls, two 8 balls and one 7 balls.

We can not name the types of metal detectors, since this test is not scientific, and depends on soil conditions, but it can be a significant indicator to the work site manager, for planning the use of metal detectors at each individual work site.

3.3. Testing of metal detector sensitivity in relation to capacity of the batteries

All manufacturers claim that the sensitivity of their devices is not affected by decrease of batteries' capacity, and that batteries do not have to be replaced until the devices does not signal so.

We carried out a simple test in the field. We used 5 metal detectors like in the previous test. We prepared new batteries, batteries that had been used for 2 and 4 hours, respectively.

All five devices were tested during previous test with balls. The results were identical for all metal detectors using all 3 sets of batteries.

We conclude that the capacity of batteries does not affect the sensitivity of the metal detector.

4. SET UP OF METAL DETECTORS

Set up of metal detectors prior to their use at the work site is a precondition for safe and proper work. The basic rule while setting up a metal detector is to follow the Instructions for use written by the manufacturer. The set-up described in this part is a minimum precondition which must be met prior to starting a work.

We have conducted parallel set-ups in different conditions. One was conducted in Eastern Slavonia on non-mineralized soil, and the other on the island of Vis, on mineralized soil. The basic purpose, except for the whole set-up procedure, was to establish a possibility of detection at a required depth.

4.1. Metal detector general condition and appearance check

While assembling a metal detector we inspect the joints, cables, screws and other parts. We check for any physical damage on the metal detector. Special attention is given to the area where the batteries are inserted, to proper function and proper insertion of batteries. After this inspection, we proceed with checking the functionality and set-up of the detector.

4.2. Metal detector proper operation check, in-air test

Inspection of proper work is conducted in accordance with instructions provided by the manufacturer. The testing is normally conducted in air because the air is the ideal non-magnetic environment. A deminer conducting the test must not wear metal objects on his hands – rings or bracelets, etc. The test is conducted using the tester provided by the manufacturer. With some metal detectors the tester is moved toward the sensor head from the front end and with others from the rear end. The purpose is to establish if the detector works properly and to establish the distance from which the metal detector detects the tester. In this case the tester was detected at 30 cm, which means that the detector works properly.

4.3. Set-up according to soil conditions

This set-up is also conducted in accordance with instructions provided by the manufacturer, but deminer's experience is also very important.

On the basis of experience and knowledge of designing a test field, the work site leader decides on conducting a set-up of metal detectors according to soil conditions, i.e. decides whether quick compensation or full compensation will be performed. One should bear in mind that after conducting compensation possibility of detection is decreased, that is to say, detector's sensitivity should be increased.

In this case, in Slavonia, set-up was conducted without compensation, while on the island of Vis full compensation was conducted due to high mineral content of the soil.

4.4. Set-up to a specific target and required depth

This is the most important part of the set-up procedure, it enables safer work. Nevertheless, I have observed that it is not used regularly in

clearance operations. This set-up enables to establish if the metal detector is able to detect what deminers are looking for, at a required depth.

For this set-up most instructors suggest to use real mines because when a deminer detects a real mine, he will gain confidence for work in a minefield. In Croatia it is forbidden to carry mines with you and we cannot wait for one to be found at the work site. The tester provided with the detector is a good replacement for a mine.

Please note that in addition to the performance of the metal detector, we also check the ability of a deminer to use it in a proper way. In addition to the metal detector sensitivity, the speed of moving the sensor head for pinpointing the target is also established.

In any case, this set-up should be conducted by every deminer prior to entering a mine field.

In Slavonia, Vallon VMH-3 detected the tester with sensitivity 10/12, while on the island of Vis, the tester was detected with 11/12 sensitivity.

The difference of sensitivity which is lost through compensation in this case is minor, and it is usually much greater. This is because the soil in Slavonia was very humid during the set-up. Humidity strongly influences electromagnetic conductivity of soil, thus influencing the metal detector as well. This again shows the importance of daily set-up of the metal detector to soil conditions.

4.5. Check-up of metal detectors during operation

After conducting the above set-ups, deminer starts working in a mine field. The majority of metal detectors give the confidence tone which we usually call "the OK signal". If the signal stops or a continuous tone is heard, the work is ceased because the metal detector does not function properly or, in most cases, the batteries are low. Regardless of the "OK signal", and especially for metal detectors which do not produce it, it is recommended to check proper functioning from time to time, by moving the sensor head toward visible metal pieces on the surface, to the working tools or shoes.

4.6. Readjustment in changed conditions

By these conditions we primarily mean soil, humidity and temperature conditions. It is not likely that during a five-hour work a deminer will move so much from the test field that soil conditions will change. In a 5 hour period humidity will sig-

nificantly change only if it rains, and deminers do not work while it rains. Temperature difference which would require readjustment of metal detectors is 10 °C which is possible in Croatia.

If any of these changes occur, the entire set-up procedure should be repeated.

Nevertheless, one of the most important things is that set-up should be conducted each time a metal detector is turned off and turned on again. During their break, after two and a half hour's work, deminers turn their metal detectors off so that the continuous period of work is two to two and a half hours, and it is not likely that work conditions will change significantly.

4.7. Check up of metal detectors after work

After work the metal detector is disassembled, we inspect it for mechanical damage, we take the batteries out and we clean the detector of possible dirt and humidity. After that the metal detector is packed and it is ready to be used next day.

5. CONCLUSION

The most important conclusion is that we have been able to detect the tester at 20 cm deep in two different soil conditions. The question is how fast we can work with the selected sensitivity. Then there is a question of how often AP mines are found at this depth and can they be detonated if we step on them.

This is why in practical, everyday work, one cannot conduct two or more set-ups for various depths in order to speed up the work and eliminate the quantity of metal in the first run, i.e. the first run can be set-up to lower depth and the second to 20 cm.

In this way we can achieve working speed, meet safety conditions and achieve absolute clearance up to the required depth.

The next thing is everyday set-up which must be conducted because of demining companies and deminers, and not because of mine clearance records, QA officers and monitors.

Work site leaders and deminers should recognize the necessity of conducting the entire set-up process, and demining companies should regulate the set-up procedures for metal detectors they possess in their SOPs. I believe that this should be regulated by SOPs and not by the Law or Rules and Regulations, but it is obvious that it had to be regulated this way, since I have not seen it in the SOPs.

Preliminary Evaluation Results of Trials for Japanese GPR-EMI Dual Sensor Systems at Benkovac Test Site in Croatia

Jun Ishikawa⁹, Mitsuru Kiyota⁹, Nikola Pavković¹⁰, Katsuhisa Furuta¹¹

ABSTRACT

This article presents an experimental design and preliminary evaluation results of trials that were carried out from 1 February to 9 March 2006 at Benkovac test site in Croatia. The objective of the Croatia-Japan joint trials is to confirm performance of dual sensor systems, which use both ground penetrating radar (GPR) and electromagnetic inductive (EMI) sensor, in comparison with existing EMI sensors, i.e., metal detectors (MDs) and to provide reliable data as a basis for future work. Increasing probability of detection (PD) and decreasing false alarm rate (FAR) will contribute to improve working efficiency in humanitarian demining. Therefore, by analyzing the data from which general principles can be established on the relative value of the different technologies, the trials aim at evaluating differences in performance between dual sensors and MDs, especially in terms of discrimination of landmines from metal fragments and extension of detectable range in the depth direction. Devices to be evaluated here are four prototypes of anti-personnel landmine detection systems developed under a project of the Japan Science and Technology Agency (JST), the supervising authority of which is the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The prototypes that provide operators with subsurface images make no explicit alarm and final decision whether or not a shadow in the image is a real landmine is left to the operator. This is similar to the way that medical doctors find cancer by reading CT images. Since operators' pre-knowledge of the locations of buried targets significantly influences the test results in these kinds of systems, three test lanes have been designed to be suitable for blind tests. The results showed that the dual sensor systems have a potential to discriminate landmines from metal fragments and that reducing operation time is the most important problem to be solved for practical use.

INTRODUCTION

Japanese Research teams from universities and industries, which are funded by the Japan Science and Technology Agency (JST), have been developed the GPR+EMI dual sensor systems since October 2002 under the program of "Research and Development of Sensing Technology, Access and Control Technology to Support Humanitarian Demining of Anti-personnel Mines." To evaluate the prototypes, a series of trials were carried out from 8 February to 11 March 2005 in Sakaide City, Japan[1][2]. The concept of the developed systems is to make no explicit alarm and to dedicate itself to provide operators with clear subsurface images (Fig. 1). Therefore, decision-making using the subsurface images is entirely left to operators' subjectivity. Since operators' pre-knowledge of the locations of buried targets significantly influences the detection results for these kinds of systems, all the test lanes in Japan were designed to be suitable for blind tests. Evaluation results of the trial showed that probability of detection for targets in deeper levels than 10 cm can be improved by combining GPR with an EMI sensor.

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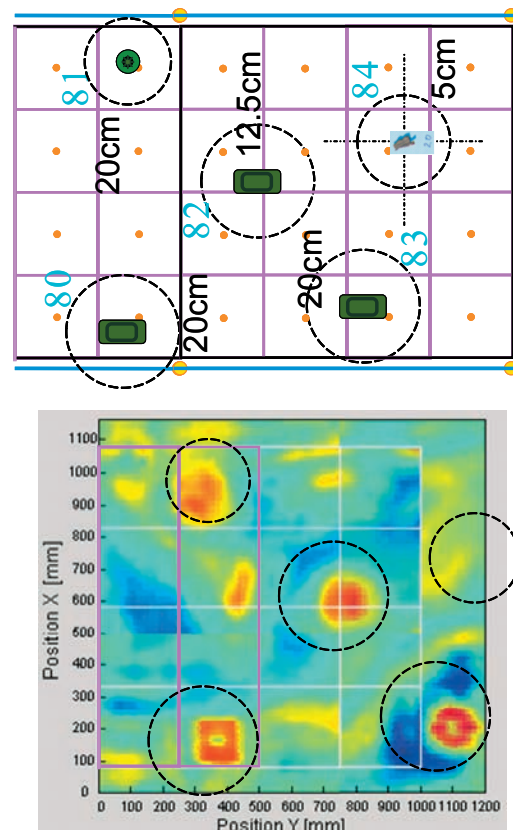


Fig. 1. Examples of detection image acquired by a stepped-frequency SAR-GPR[3] mounted on MHV[4] during the Croatia trials. The left figure shows locations of targets with depth (one PMA-2s, three PMA-A1s and one metal fragment) and the right image is a wrapped image composed of several slices of different depth.

After the trials in Japan, the prototypes have been improved to be more robust, simple and cost-effective, and the next step of the project has been to take field tests to evaluate these features in Croatia, which is a well-experienced country in test and evaluation for humanitarian demining equipment. This article shows preliminary results of the Croatia-Japan joint test and evaluation for anti-personnel landmine detection systems using GPR+EMI dual sensors at the test site Benkovac of Croatian Mine Action Centre - Center for Testing, Development and Training (HCR-CTRO) in Croatia.

TEST AND EVALUATION PLAN

The objective of the test and evaluation is to confirm performance of GPR+EMI dual sensor systems in comparison with existing metal detectors (MDs) and to provide reliable data as a basis for future work. By using the data from which general principles can be established on the relative value of different equipment and techniques, the trial aims at clearing differences of performance between dual sensors and MDs, especially in terms of discriminating landmines from fragments and expanding detectable range in the depth direction. Improvement of the performance will contribute to increasing probability of detection (PD) and decreasing false alarm rate (FAR).

Test site Benkovac

The trials were conducted from 1 February to 9 March 2006 at the test site Benkovac in Croatia. The test site is well-known to have been used in the International Test and Evaluation Programme (ITEP) project 2.1.1.2 “Reliability Model for Test and Evaluation of Metal Detectors[5]” in accordance with the CEN workshop agreement (CWA) 14747[6]. Three types of soils available in

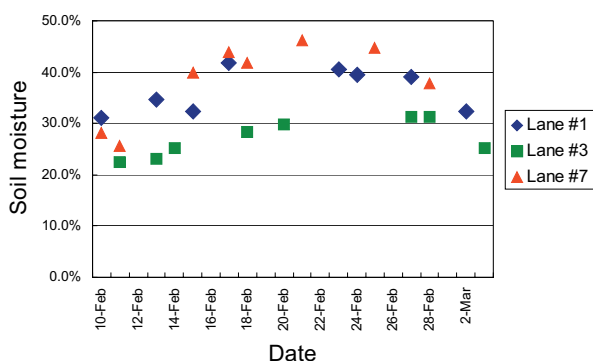


Fig. 2. Soil moisture measurements through trials.

the Benkovac test site, that is, (a) red bauxite with neutral stones in lane #7, (b) red bauxite in lane #1, and (c) neutral clay in lane #3[5]. In the later half of the trials, the weather was harsh, raining and snowing. Measurements of the soil moisture sometimes reached more than 40% (Fig. 2).

Four devices to be evaluated

Four sensor systems were evaluated in the trials. One of those is Mine Hunter Vehicle (MHV), the vehicle and manipulator part of which have been developed by a research team of Prof. Nonami, Chiba University[4]. MHV can interchangeably mount 2 GPR sensors in addition to a commercial-off-the-shelf MD. One is a stepped frequency SAR-GPR developed by Prof. Sato's team of Tohoku University[3] referred as **MHV#1** in the following part (Fig. 3, left). Stepped frequency radar determines distance to a target by constructing a synthetic range profile, which is a time domain approximation derived from the frequency response of a combination of stepped frequency signals via inverse fast Fourier transform (IFFT). The major advantage of stepped frequency methods is that the spectrum bandwidth can be easily tuned to set the parameters to be optimum according to environment conditions such as soil moisture. The other is an impulse GPR, LAMДАР-III, developed by Prof. Arai's project of University of Electro-Communications[7] referred as **MHV#2** in the following part (Fig. 3, right). This kind of GPR operates by transmitting a very narrow pulse of electromagnetic wave (less than 1 nanosecond), the advantage of which is that the measurement time required to generate one range profile is very short.



Fig. 3. MHV#1 (left) and MHV#2 (right).

The 3rd system to be evaluated is **Gryphon** (Fig. 4, left), which can be remotely controlled to access to minefields. The robotic buggy has been developed by Prof. Hirose's team of Tokyo Institute of Technology[8]. The manipulator that is mounted on the buggy has been designed so as to cancel reaction force induced by sensor scanning. The sensor part of Gryphon is a GPR+EMI dual sensor named Advanced Landmine Imaging System (**ALIS**), which can be also used as a hand-held detector[9]. ALIS has been developed by the above mentioned Prof. Sato's team and took a field trial in Afghanistan in December 2004. The hand-held type ALIS is the 4th system to be tested here (Fig. 4, right).



Fig. 4. Gryphon (left) and ALIS (right).

Experimental design

Through the trials, influences of 3 factors on probability of detection (PD) are evaluated by analysis of variance (ANOVA), that is, target types that consist of landmines and metal fragments, target depth and soil types as follows:

- Target type: PMA-1A, PMA-2, ITOP I0 and Free-formed metal fragment (Fig. 5),
- Target depth: 5.0cm, 12.5cm and 20.0cm, and
- Soil type: uncooperative and heterogeneous (Lane #7), uncooperative and homogeneous (Lane #1) and cooperative and homogeneous (Lane #3).



Fig. 5. PMA-1A, PMA-2, ITOP I₀ and metal fragment.

Due to the limitation of time for the trials and the number of landmines that can be used, it is impossible to test all the combinations of levels (4 levels of target type, 3 levels of target depths and 3 levels of soil conditions). To impartially collect unbiased data for statistical analysis under this limitation, an orthogonal experimental design based on $L_{18}(2^1 \times 3^7)$ is used. According to the L_{18} array, a combination of levels in every factor is derived as listed in Table 1. The number of target in each level is 7. Burying targets has done on 8-9 December 2005 so that the targets could be left as it is for 2 months.

Table 1. Combination results of levels of each factor via $L_{18}(2^1 \times 3^7)$ experimental design.

No.	Target type	Target depth	Lane # (Soil type)
1	PMA-1A	5.0cm	7
2	PMA-1A	12.5cm	1
3	PMA-1A	20.0cm	3
4	PMA-2	5.0cm	7
5	PMA-2	12.5cm	1
6	PMA-2	20.0cm	3
7	ITOP-I0	5.0cm	1
8	ITOP-I0	12.5cm	3
9	ITOP-I0	20.0cm	7
10	Fragment	5.0cm	3
11	Fragment	12.5cm	7
12	Fragment	20.0cm	1
13	PMA-1A	5.0cm	1
14	PMA-1A	12.5cm	3
15	PMA-1A	20.0cm	7
16	PMA-2	5.0cm	3
17	PMA-2	12.5cm	7
18	PMA-2	20.0cm	1

EXPERIMENTAL RESULTS

Trial procedures

Two testees of each system took blind tests of 3 lanes, i.e., #1, #3 and #7. All the testees declared detected anomalies by putting tags on the

ground where the targets are considered to be buried. As described in Table 2, the tags show confidence rating of the testee and the final decision whether the declared anomaly is a target (landmine/fragment) or clutter.

To compare the performance of GPR+EMI dual sensors with that of existing MDs, a benchmarking was conducted by two Croatian deminers, who do not know the target positions. The design of the experiment, the training of deminers and the monitoring has been organized by the Federal Institute for Materials Research and Testing (BAM). The deminers claimed that they cannot distinguish a metal fragment from a landmine only based on the audio signal of the MD. Therefore, only two levels of confidence were used in this trial. When the deminers heard an audio signal, they marked its location with 100% confidence if they would investigate that location with a prodder. If they would not investigate it, believing it comes from the soil or other source of noise, they marked the location with 25% confidence.

Preliminary results

This section shows some preliminary results because statistical analysis is still in progress. Figure 6 shows probability of detection (PD) of 5 testees for 18 experimental runs, where ITOP I_0 and metal fragments treated as targets intended to be detected. One testee from each system, who attained higher PD than the other, has been chosen. GPR+EMI systems attained higher PD than a deminer (Deminer 1) for deeply-buried PMA-2 in mineralized uncooperative soil. On the other hand, the deminer can very precisely determine the location of ITOP I_0 , which is very small and has no recognizable shape by GPR.

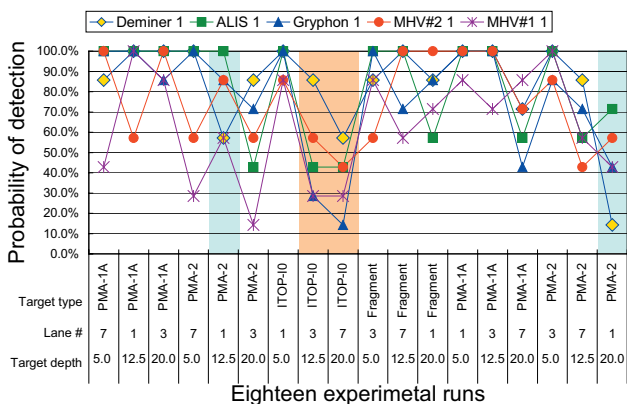


Fig. 6. PD for 18 experimental runs: one testee from each system has been selected.

A testee of ALIS (ALIS 1) attained 81.7% of average PD, which matches those of two deminers, who attained 84.0% and 81.0%. Figure 7 shows average PD for each level of factor. The detail should be discussed after ANOVA, but superiority of ALIS to deminers was observed in the levels of PMA-2 and Lane #1 (uncooperative and homogeneous soil). On the other hand, ALIS took 30-40min. for 1m² detection while deminers took about 5min., the other 3 vehicle-mounted systems 15-20min.. Regarding false alarm ratio, a deminer (Deminer 1) was 0.9 times/m² and that of a testee of ALIS (ALIS 1) was 2.2 times/m².

Although the data that have been analyzed by the colored tags explained in Table 2 were omitted due to the limitation of space, GPR+EMI sensors showed a possibility of discrimination of landmines from metal fragments.

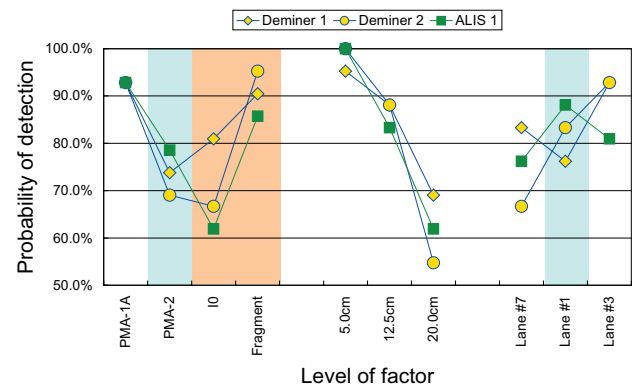


Fig. 7. Average PD for each level of factors.

CONCLUSIONS

Through the trials, many lessons have been learned such that PD for small targets in mineralized (uncooperative) soil can be improved by using GPR. These results were fed back to the testees for further improvement. The next step is to put one or two promising system(s) into practical field trials that will be conducted by a third party after the modification.

ACKNOWLEDGEMENTS

The authors would like to thank all the project members especially for the trial participants from Tohoku University, Chiba University, Tokyo Institute of Technology, University of Electro-Communications, Fuji Heavy Industries Ltd., TAU GIKEN Co. Ltd..

The authors also would like to thank Dr. Christina Müller and her colleagues of the Federal Institute for Materials Research and Testing (BAM) for their comments in statistical analysis and coordination of blind-tests by deminers.









Definition of confidence rating	I'm 100% sure that there is nothing here.	It seems that there might be something here.	I'm almost sure that there is something here.	I would classify the detected object as an intended target.	I confidently classify the detected object as an intended target.
Final decision	I declare that it is a clutter.		I declare that it is a landmine.		
Confidence rating and tag color	N/A				
Final decision	I declare that it is a clutter.		I declare that it is a fragment.		
Confidence rating and tag color	N/A				

Table 2. Definition of confidence rating and tag that indicates declared location.

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Personal Protective Equipment for Use in Humanitarian Demining - Standardised Test and Evaluation Methodologies -

Kaj Hörberg¹²

Abstract

Most of the Personal Protective Equipments today are tested by using the NATO STANAG 2920 test methodology. This test standard reflects the threat that military personnel and police forces are exposed for.

No recognised standard test replicating the blast effects of 240g TNT exists, and it is recognised that the NATO STANAG 2920 fragmentation test does "not realistically replicate mine effects". For these reasons, it is not possible for an equipment purchaser to be confident that the equipment they buy will perform appropriately against the threat(s) they anticipate.

By forming a group of users, manufacturer and other experts and follow the procedure for CEN Workshop Agreement it is possible to agree on vital criteria to be tested and appropriate testing methodology (ies). The aim is, within one year time, to have such a document, a CEN Workshop Agreement, specifying threats in HMA and how to test equipment against those threats.

The beneficiaries of this process will be field operators, manufacturers, researchers and developers within the global HMA community. The results of this work should ensure that, for the first time, there is a baseline standard against which to judge the performance of PPE for HMA.

Background



Despite the hard work that already has been done the hazardous work to clear land from mines and other Explosive Remnants of War (ERW) will continue for many years. The use of different mechanically devices have become more common. Still, most of the work is done manually and a lot of people are exposed for risks, risks that could be reduced by use of proper Personal Protective Equipment (PPE).

There is a huge variety of different models of PPE available on the market. The level of protection that any PPE gives is usually specified by the manufacturer. When the Program Manager for a Humanitarian Mine Action (HMA) project has to select the PPE equipment which is most suitable for his task there are two problems that

will make it difficult to make a good choice.

Even if the mine threat is well known there is very little information available what kind and level of impact the Deminer will be exposed for if an accident will occur.

The other problem is that the most commonly used test methodology is the NATO STANAG 2920 which is designed for ballistic protection against projectiles. The threats in Humanitarian Demining are different and a test made with that standard will not give the needed information to the user. The lack of an agreed test methodology to test the performance of protective equipment against the threats common in the HMA environment makes it difficult for the manufacturer to design the best possible equipment and it is also almost impossible for the user to choose the most suitable equipment.

Standards

To create a standard in accordance with the Committee for European Standardization (CEN) procedure would be a several year long and very expensive process. The need of having a quicker way of formalising available knowledge that could be accepted by most of the actors has been recognised by CEN.

The solution is the **CEN Workshop Agreement (CWA)**. The CWA methodology, which is quite new, has been used before in the HMA community and there are three CWA available, Test of Demining Machines, Test of Metal Detectors and Competency Standards for Personnel.

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Objectives of the CEN Workshop Agreement on testing and evaluation of PPE for HMA

The two main objectives of this CEN WS are to agree on well defined specifications for:

- vital criteria to be tested;
- appropriate testing methodology(ies);

This will be achieved by establishing specifications for reliably replicable simulated threats and specifications for determining the mechanical suitability of finished PPE products. To make the test result easy to understand and to compare results from other test specifications for recording the results of tests in a uniform manner is required. Finally, a determination of the ergonomic criteria and constraints required by the HMA end-users has to be done.

The following, as a minimum, shall be presented to the Workshop for consideration:

- defining a limited range of threat types that can be protected against;
- agreeing on means of simulating each threat type in a reliably replicable manner;
- agreeing on sample sizes and their presentation to the threat during tests of materials;
- determining how to test for the effects of use-context on equipment performance (temperature, humidity and moisture content);
- determining the reliability of mechanical aspects of the equipment (fastenings, etc) that may impact on safety; and
- determining the minimum equipment required to conduct tests;
- agreeing on specifications for the conduct of tests and the recording of results;
- determining appropriate scales to facilitate the comparison of results.
- agreeing on the range of ergonomic requirements of PPE for the varied purposes for which it is used in HMA.

The beneficiaries of this process will be field operators, manufacturers, researchers and developers within the global HMA community. The results of this work should ensure that, for the first time, there is a baseline standard against which to judge the performance of PPE for HMA. This will reduce the incidence of severe injury and death during HMA activity, which in turn will reduce the stresses placed on medical and social systems by those with severe disabilities. A further advantage is that more of the trained individuals who suffer accidents will remain active, meaning that their training and experience are not lost to the HMA community.

Organisation

The workshop will be co-chaired by two specialists in HMA PPE issues:

Mr Kaj Hörberg, SIS, Kaj.horberg@telia.com, responsible for administration and organisation

Mr Tim Lardner, GICHD, T.Lardner@gichd.ch, responsible for technical coordination.

The Secretariat will be provided by Swedish Standard Institute (SIS)

Mr Rolf Thesslin, rolf.thesslin@sis.se

CEN Advisor: CEN Management Centre Ms Gaïd Le Gall CMC gaid.legall@cenorm.be

Workshop participants

The participant in a workshop is the guaranty for a high quality of the work, and to make the result, the CEN Workshop Agreement, widely accepted. The following groups of people are in particular invited to contribute to this CEN WS. They are users of PPE in HMA, manufacturers of PPE, institutions/agencies which perform tests on related equipment, and specialists in IMAS and standardisation.

Action plan

This CEN workshop will formally start with a Kick-Off Meeting to be held at the CEN building in Brussels June 2006. The meeting will decide on the Business Plan and appoint a co-chair, a Secretariat and a National Standardisation Body to provide professional standardisation expertise. The first Technical CEN WS meeting will be held in September 2006, where progress towards agreement will be presented and areas requiring further work discussed.

The Second CEN WS meeting is scheduled to take place in October/November 2006. The Chairman will seek consensus in each meeting (consensus meaning "no major opposition" as opposed to "unanimity").

A third CEN WS meeting will be arranged, if necessary in January/February 2007 to discuss and adopt the final CWA.

The objective is to have the CEN Workshop Agreement finalised before the end of June 2007.

On approval of the CWA it will be sent to GICHD for presentation to the IMAS Review Board and consideration for inclusion into IMAS.

Mine and UXO Detection in Russia

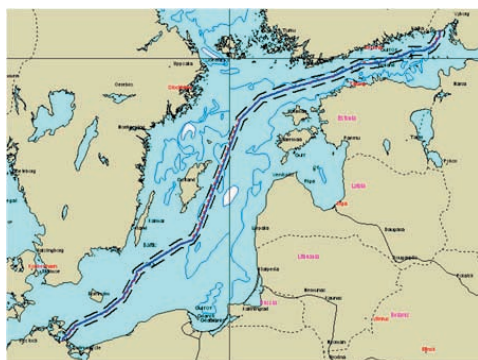
Konstantin Fateev¹³

Abstract

1. Growing market for UXO clearance problem; UXO clearance as a special type of demining activities;
2. Emercom-Demining experience in performing territory UXO clearance operations;
3. Modification of approaches towards the risk assessment system when performing territory UXO clearance operations;
4. Particularities of detector's use;
5. Particularities of PPE use;
6. Necessity to develop IMAS adjustments with respect to territory UXO clearance operations' performance;
7. Proposals to consolidate efforts in elaborating underwater demining and UXO clearance standards.

Growing market for UXO clearance problem. UXO complete clearance as a special type of demining activities:

Recently, because of developing of various product pipelines' construction and its infrastructure, UXO complete clearance market is also progressing. A number of current construction sites are situated within the areas that used to be the arena of serious battles during the 2nd World War, with no minefields planted.



1



2

1. North-European gas line:
 - water part length - 1200 km
 - survey strip width - 100 m
 - total area to be surveyed - 120.000.000 m²
 - land part length - 218 km (areas of serious battles)
 - survey strip width - 60 m
 - total area to be surveyed - 13.080.000 m²
2. "Altay" pipeline system:
 - land part length - 1.218 km (areas of serious battles)
 - survey strip width - 60 m
 - total area to be surveyed - 73.080.000 m²

Therefore, UXO complete clearance of the territory becomes at this stage a **separate type of humanitarian demining operations** in Russia and in other countries. That is because of its area dimensions, clearance depth's augmentation (generally up to 3 meters), variety of types of UXO found (artillery missiles, mortar bombs, aerial bombs etc, guaranteed absence of land mines) and other factors.

In our opinion, this market will be subject to further growth:

- with further operations' performance to liquidate mine hazard in various regions;
- with building up favorable economical and investment environment within the areas that used to be the arena of serious battles during the 2nd World War, using various types of armament, and this refers not only to Russia.

According to specificity of UXO complete clearance operations' performance within the areas of serious battles during the 2nd World War, and basing on the IMAS principles, "Emercom-Demining" has fulfilled the following tasks:

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UXO complete clearance operations of Bolshoi Tjuters Island

- developed SOP, which would reflect the specificity of such operations;
- modified the ways to risk assessment system when performing UXO complete clearance operations;
- developed the detectors` and locators` use procedure;
- modified IMAS recommendations to PPE use.

Emercom-Demining experience in performing territory UXO complete clearance operations

“Emercom-Demining” performed 11 UXO complete clearance Contracts both on land and water area within the regions of serious battles. In this period 16.700.000 m² was investigated, 17.684 of various UXO found, also found 48.000 ammunitions of less than 14,5 mm caliber, 138.500 signals of other ferromagnetic objects was processed.

year	area	cleared area	UXO quantity	Number of signals
1996	Bryansk area	1.214.000 m ²	468	1.850
1997	Voronezh area	3.755.000 m ²	8.540	35.000
1997	Smolensk area	793.000 m ²	329	1.500
1998	Voronezh area	306.000 m ²	697	2.500
1999	Chechen Republic	1.890.000m ²	2.983	9.780
2000	Chechen Republic	2.200.000 m ²	3.254	10.100
2003	Sakhalin area ¹⁴	4.690.000 m ²	37	1.179
2004	Sakhalin area *			
2004	Sakhalin area	400.000 m ²	157	7.200
2005	Sakhalin area	938.000 m ²	75	6.850
2005	Bolshoi Tjuters Island	510.000 m ²	1.324	62.500

¹⁴ water area operations

Average territory UXO complete clearance speed of 1 operator within the areas of serious conflicts was 120-125 m² per shift.

UXO location depth – from 40 cm to 2,5 m.

Modification of approaches towards the risk assessment system when performing territory UXO complete clearance operations

Basic task of UXO complete clearance risk assessment is the analysis and estimation of all factors affecting:

- the safety of territory UXO complete clearance operations` performance;
- the safety of personnel and local population;
- the safety of neighborhood objects and facilities; and also providing information for developing and approval of strategic and operational planning of territory UXO complete clearance operations.

Risks connected with territory UXO complete clearance operations (with the guaranteed absence of the land mine problem) are seriously different from such risks during humanitarian demining operations. At the same time it does not mean that performance of territory UXO complete clearance operations is easier than humanitarian demining.

“Emercom-Demining” operational practice demonstrates that it is rather intensive work and sometimes a lot more time and labour-consuming than demining, due to extreme ferromagnetic contamination of the sites.



1.

1. "Sakhalin 2" project
2. "Bolshoi Tjuters" project



2.

- signals density 4,2 signals per 1 m²
- signals density 2,7 signals per 1 m²

Taking in account that battle actions took part more than 60 years ago, there are a number of factors that influence the risk assessment and are subject to individual assessment in each particular situation:

- insufficiency or lack of archive documents;
- inability to practically find UXO types and concentration;
- necessity of personnel high qualification;
- serious change of relief of terrain etc.

Particularities of detector's use

When performing territory UXO complete clearance operations "Emercom-Demining" uses 2 types of equipment: metal detectors and depth locators. According to our experience, UXO found are situated at the depth of 40 cm or lower. Accordingly, metal detectors are generally used only to locate ferromagnetic "rubbish", located at the surface or at a small depth. After territory inspection by metal detectors the territory is inspected by depth locators. When detecting an object special technique is used to define its dimensions and location depth.

Particularities of PPE use

IMAS stipulates the use of PPE always when personnel are within the dangerous area. Taking in account that UXO complete clearance provides large amount of work to be performed on various depths and also to dig out the located objects, "Emercom-Demining" specialists per-

form searching without PPE. PPE is used only to identify the UXO found.

Necessity to develop IMAS adjustments with respect to territory UXO complete clearance operations performance.

Based on the abovementioned facts, in our opinion, there is the necessity to develop IMAS adjustments. They will consider the specificity of risks and particularities of UXO complete clearance's performance within the territory initially free from mines. In particular, they should include:

- Modification of approaches towards the risk assessment system;
- Particularities of detector's use;
- Particularities of PPE use;
- Particularities of further earthmoving techniques use.

As a rule, UXO complete clearance is performed within the framework of investment-constructional projects, commercial by its nature. 100% following IMAS when performing such kind of operations makes territory clearance unacceptably expensive.

In the absence of such adjustments the problem of "cheap" ways of clearance, when even the simple quality and safety requirements are not satisfied just to minimize the expenses, arises more and more frequently. In its explanation the managers of these campaigns declare the impossibility to use "pure" IMAS to perform such kind of operations.

Proposals to consolidate efforts in elaborating underwater demining standards.

In 2003 and 2004 “Emercom-Demining” performed underwater demining operations within the framework of “Sakhalin 2” project. In the year 2006 “Emercom-Demining” received invitation to participate in the similar work in the context of North-European gas line UXO investigation.

To perform operations under the “Sakhalin 2” contract “Emercom-Demining” elaborated SOPs

for magnetometric and diving UXO investigation of the water area, and individual Procedure for UXO disposal at the point of detection.

IMAS principles were used to elaborate these documents. “Emercom-Demining” and “Montenegrin Regional Center for Underwater Demining” which also possess its SOPs to perform this operations, exchanged its documentation and signed an agreement to collaborate in the field of mutual development of SOPs for underwater demining.

“Emercom-Demining” proposes to all organizations concerned to participate in this work.



1.

1. “Sakhalin 2” project
2. “Sakhalin 2” project



2.

- UXO found
- underwater demining team

Dog - Handler Interaction

Marijan Miklobušec¹⁵

INTRODUCTION

While taking the dog for a walk, have we ever noticed its way of communicating and behaviour towards the environment the dog was in, the way it reacted to a certain situation? Was the dog looking back at his handler or owner while running through the park?

Was he coming closer to them looking for protection or support in form of patting on the back or words of encouragement like "Well done, boy"? Was it having its hackles up in the air due to being scared or testing the strength with another dog. These are all indicators of our dog's socialization, its character built, temperament, psychological stability etc.

We, as observers, get a clear picture of our dog that we can or cannot modify.

The most important type of interaction is communication. Communication itself can be:

- verbal
- nonverbal

Verbal communication is communication with words, but also includes speech rate and rhythm, intensity and colour of the voice as well as accent and articulateness.

The dog as subordinate in dog-handler relation does not understand the meaning of words but understands the segments stated above and acts accordingly. Particular speech rate and rhythm remind the dog of a learned skill and action it needs to perform in order to be the leader of the pack, that is, to be commended by the handler concentrating on the intensity and colour of his voice. The dog raises and wags its tail to demonstrate its respect for the handler. When the dog is working inside mine suspected area searching for stated ordnance, the position of its tail shows its current psychological status. If the tail is raised and goes left-right, it means the dog is happy to be doing the task assigned. If the tail is placed between its hind legs, it means the dog works under pressure and is not motivated.

The position of ears determines the psychological status. Ears in backward position are the symbol of nervousness.

Nonverbal communication reflects itself in:

- handler's face expression
- orientation and movements while standing or walking
- body language
- taking the spatial distance

Handler's behaviour has the character of a message by which the dog is given certain instructions. The dog as the message recipient responds to those instructions by the form of his behaviour i.e. performs the task set and in this way becomes involved in the interaction process. The dog can take the message received as a request or an order and react accordingly.

PERSONALITY

Personality is represented by the group of features structured in a specific way for each dog what gives the particular dog the mark of psychological individualism. During personality interpretation, it is crucial to pay special attention to the FEATURES the mode of reacting depends on. Personality features differ depending on whether they appear frequently or on specific occasions. If we closely examine dog's behaviour while being in the pack where the hierarchy is very well-known or when the dog finds itself in a completely unknown situation, its personality features become obvious very quickly.

Behaviour in a pack reflects the HABITS ACQUIRED and in the unknown situations the PERSONALITY.

Each dog as an individual has its own personality which reflects itself though its behaviour in dog's living environment in which the handler is respected as the pack leader. Groups of personality features united according to specific criteria are TEMPERAMENT and CHARACTER.

TEMPERAMENT is an individual's typical way of reacting. It is mostly determined by hereditary factors – genetics. The temperament can be determined by external factors – climate where the dog is living. In warmer climates, dogs are more temperamental and thinner while dogs in colder climates are calmer, slower and more massively built.

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The dog as domesticated animal starts to express its EMOTIONS and they are manifested in form of the following reactions: wagging the tail, barking, jumping around and hawling. When dogs-hunters bring the prey to the pack, female dogs and puppies express their EMOTIONS in form of above-mentioned reactions. If we examine the behaviour of puppies in the litter more closely, we can see that the puppy, that's pulling its mom's teat in a way that it eventually becomes painful for her, is being warned by growling and pushed aside. It responds by wailing and starts withdrawing. The dog looks forward to his handler as a pack leader and expresses its joy in form of jumping around, barking and establishment of physical contact by rubbing against handler's leg. All these reactions are the form of emotional experience. We can state the fact that the temperament reflects itself in an intensity of emotional experience.

Types of temperament

- Choleric – strong emotions changing rapidly and stormily. Impulsive in its reactions, restless.
- Sanguine – medium expressed emotions changing rapidly. The dog is sociable and responsive.
- Phlegmatic – weak emotions. The dog is careful, peace-loving and reliable. The weakness of this typology is impossibility to classify the dogs into CLEAR TYPES.

CHARACTER

While the character is determined by biological factors, the CHARACTER is gained during socialization and is, in its greatest part, result of breeding and training. The character is a name for the group of features manifested in a relation of a dog towards the handler, pack i.e. the environment. Dogs' behaviour can dynamically vary. Sometimes the extreme behaviour appears and it is usually provoked.

TRAINING

Training represents the possibility of change in performing certain tasks and it is determined by exercises.

The only way of training the dogs is learning by conditioning. There are two types of conditioning:

- Classical conditioning
- Operant conditioning

Classical conditioning – the theory founder is Pavlov who studied production of saliva in dogs. Upon research, he came to the following conclusions. When the dog produces the saliva to a direct smell and taste of food, it is a non-conditioned reaction to a non-conditioned stimulus. If the dog is taught to be given food always at the same time, the dog will produce the saliva each time it hears the person bringing the food.

Operant conditioning – compared to the classical conditioning where there is a reflex response of the body to the stimulus, at operative conditioning there is an active response of the body to the stimulus. Here, the LAW OF EFFECT becomes important. As per this Law, there is a larger possibility for certain behaviour to appear if it will result in positive consequences. The kind of behaviour that leads to negative consequences is being avoided.

Important substantiations

Positive – food or cuddling

Negative – pain

Training the dogs with positive substantiations gives excellent results and achieves an excellent dog-handler communication.

THE POWER OF PLAY

In the 80-ies of 20th century, the plays of tugging the toys with a dog were considered as the ones that increase the aggressiveness and should be avoided. Some individuals still think the same. The popularity of "agility course" and others was gradually growing and many dogs started enjoying the play with their owners and their favourite toy.

Energetic dogs enjoy such plays so they think of it as of some kind of reward. When training the dogs for more "serious" activities such as in case of detection dogs, various toys are used which motivate the dog to use maximum of its capabilities. The dog will be more motivated and ready to learn if he knows that there is a play with his handler waiting for him at the end of training. The problem starts when the dog does not want to leave the toy. In order to avoid negative consequences of the play it is important to give the dog an order "leave it" and something to eat as the award. When it leaves the toy, you take it. The key of this play is to offer the dog the toy again by saying the order "take it". By repeating "leave it" and "take it" the dog will learn that leaving the toy is a completely normal thing.

How to start the play

The toy is never put to dog's mouth by force. He will probably refuse to take it at first.

First few days, you play with the toy yourself in the presence of the dog. After that, put the toy away. After seven days, give the dog the toy but only for a little while and gradually increase that period. Then comes the period when the dog is eager to play with the toy.

The power of play has many sides. After some time, the dog will start enjoying the company of a handler. Interaction is the purpose of that relation.

TRAINING PROCESS

If we agree that the basic precondition for training of dogs is their active participation in the conditioning process, then we should agree with the claim that the basic task of the handler is to make this thing possible.

Planned method of conditioning

- running around in handler's presence
- running around using various means (balls, etc.)
- obedience exercises
- work in the training box

According to that, the training should, among other things, give the answer to two questions.

First question is how to transform certain number of information existing in physical training to functional entireties.

Second, how to transform more or less information possessed by the handler that could help in realizing the goal and tasks to the training process. Evidently, the training process is an extremely important handler's activity especially considering the fact that he is completely autonomous in selection of time and place of work, methods but also in dosing, distribution and control of susceptibility to encumbrment. To conclude, the handler decides what, how, how much and why working with the dog. There is no doubt that the successfulness of the above-mentioned process will be equal to the level of preparation, organization and realization of training.

Realization of goals and tasks of the training process depends among other things on their preparation and organization. Namely, training process should be organized and conducted so that its participants can feel it. Dogs need to

experience the training process and they will, if they get the stimuli – possibility for giving physical and psychological vent to their instincts i.e. discharge represented by physiological and psychological encumbrment.

Will that be achieved during each conditioning, only periodically or never depends a great deal on numerous factors. Since the origin of the factors influencing more or less the organization of training process can vary, due to their more successful detection, it should establish the following; the existence of:

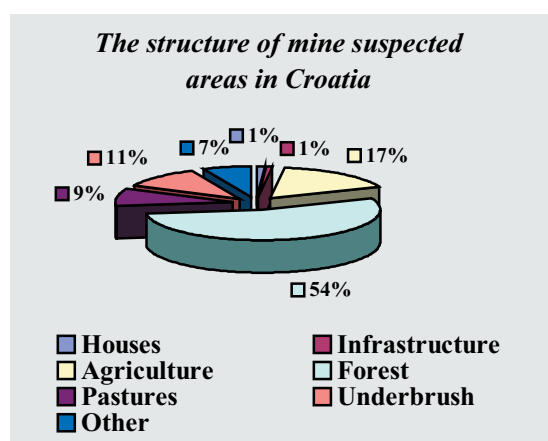
- external factors
- internal factors

External factors are out of our reach and directly influence the training process. Internal factors are under our control and can influence the training process unless we remove them. That practically means that during the preparation, each handler should respect the concrete working conditions to the maximum. It is my belief that success in training process depends a lot more on material working conditions than expert and methodological competence.

Technical Requirements and Standards for Safe and Efficient Use of Dogs and Handlers in Detection of Mines, UXOs and Fragments – Experience in the Republic of Croatia

Mirko Ivanušić¹⁶, Davor Laura¹⁸, Željko Šarić¹⁷

Summary



Extremely big mine suspected area in the Republic of Croatia covers in its greatest part the forests, pastures, agricultural areas and karst. The information on 1 147 km² of mine suspected areas out of which only one third is actually mine contaminated speaks in favour of dog-handler usage in mine search operations with the purpose of simpler, faster and more cost-effective work. However, there is always the matter of safety, efficiency and creating the preconditions for their usage.

In their paper, the authors will present experiences up to the present, development of normative acts and test modes, test site characteristics and usage of MDDs in accordance with valid rules and regulations. Special attention will be paid to all technical requirements in the process of approaching to testing itself, method of monitoring, conditioning and regular training, extremely important quality assurance activities, adequate test site preparation, daily test prior to the commencement of works as well as the estimate of initial dog-handler status, monitoring and verification of efficiency through prescribed forms.

Mine suspected areas of the Republic of Croatia

This paper does not interpret nor explains a number of important factors referring to the selection of dogs and all genetic predispositions, training methods, aspects and needs of health and hygiene, adequate transport and accommodation, building trust in dog-handler relation as well as number of non-mentioned but important factors since these topics have partially been covered and agreed in cooperation with other authors in preparation of the international symposium «Humanitarian Demining 2006».

Introduction – Brief Historical Overview of Development in the Republic of Croatia, Comparative Information and Experience Up to Now

Mine search in the Republic of Croatia using dogs and handlers was first initiated by the UN. It financed the teams according to their own established methodology. State owned company AKD-Mungos, for the first time in the Republic of Croatia, starts using MDDs in mine clearance projects financed through the World Bank Loan based on the Contract with the American company RONCO Co.

Dog and handler obtained bigger importance and role when CROMAC, upon its establishment in 1998, took the legal commitment of performing quality control over mine clearance operations mostly due to limited capacities for the QC operations.

The UN dogs i.e. the ones of the company MECHEM from South African Republic known for its high quality system of training and usage were used at the beginning.

At the very beginning, the Governments of foreign countries used to finance the UN's support program to CROMAC in the segments of control and overall build up and capacity development. In the framework of the Scientific Council as well as engagement of its employees, CROMAC was active in a number of important workshops and

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assemblies trying to gather positive experiences in MDD usage from all over the world. Leading authorities were visiting CROMAC and setting the guidelines for team usage and competence verification mode.

Development of demining companies in the period 1999-2000 and especially in the period to come, resulted in procurement of dogs and creating the teams for area inspection after mechanical mine clearance i.e. as a second method. Procurement of dogs and training were based on different system of values of different training and dog breeding centres mostly of the foreign countries.

In that period, demining companies in the Republic of Croatia were trying to upgrade their own methodology by creating Standard Operating Procedures (SOPs) mandatory for test and accreditation process. The results of CROMAC's QA and QC Department from that period undoubtedly confirm questionable values of certain breeding centres and teams.

There was a need for the establishment of our own test site for MDD testing and verification.

With the assistance of the representatives of UN, Scientific Council and members of the first committee for verification and trainability assessment of dogs and handlers, the first test site was built in Sisak on the area called Jodno. We may well say that the overall upgrade of CROMAC

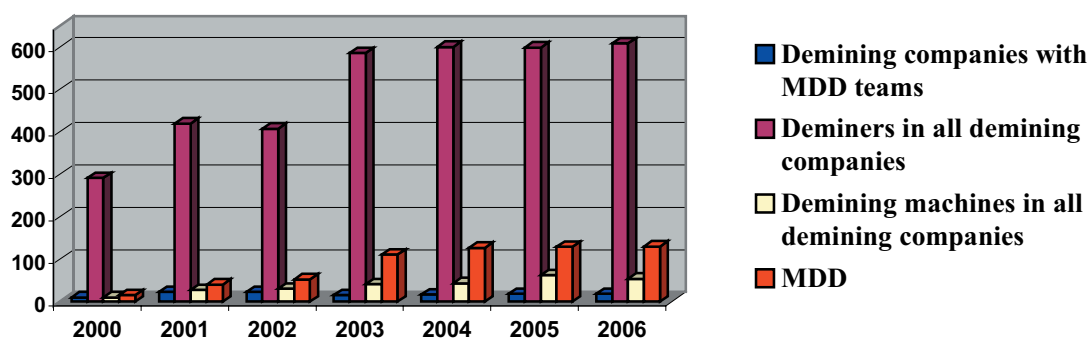


in terms of testing, assessment issuance, building new test sites, closer connection with the QA and QC Dept. and test and accreditation process establishment starts from that very moment and finally results in special chapter of the «Rules and Regulations on Methods of Demining» and its modifications.

Humanitarian demining as well as wider usage of MDDs has relatively short development period. MDDs have been used for 15 years now and their usage has the tendency of continuous development as in the sphere of capacity increase so in the sphere of standard operating procedures development.

Year	2000	2001	2002	2003	2004	2005	2006
Demining companies with MDD teams	10	23	23	15	17	18	18
Deminers in all demining companies	292	420	408	586	601	599	609
Demining machines in all demining companies	10	27	30	41	43	62	54
MDD	15	40	52	111	127	129	130

Development of the capacities



Sphere and Forms of Dog-Handler Usage - Experience Up to the Present

Many countries today use the dogs in different mine clearance operations (mine action) and in the framework of different methods allowed. MDDs are mostly used:

- In reduction of mine suspected area by defining minefield boundaries primarily in the low risk areas,
- As the first method during mine search combined with other manual detection methods,
- During the MSA search from the safe access lanes on the area of differently marked and defined minefields,
- As the second method in mine clearance projects, mostly on mechanically treated areas after some period of soil stabilisation,
- During mine search of devastated buildings with significant quantity of metal, along with removal of rubble in layers,
- Mine search of railway infrastructure as well as other firm surfaces along the macadam, asphalt, stony and concrete systems, areas with significant quantity of metal: water supply systems, gas pipelines etc.
- Sample search during the final quality control over mine clearance operations
- Inspection of the safe access lane in case of urgent need for approaching the mine victim

These are, of course, modern forms of usage from which it can be seen that the liberalization of dog usage in many countries is at different levels in the same way as the acceptable risk limit in different countries in relation to mine action activities and accepted methods. It is important to point out that at least 2 dogs are used for all forms of mine search which enter the test site one after the other.

Laws, By-laws and Normative Regulations in the Republic of Croatia Related to Dog-Handler Usage

Law on Humanitarian Demining (National Gazette, 153/05) is the basic legal act which regulates and defines the mine action in the Republic of Croatia. Until today, it suffered several changes and modifications. The one still effective was passed in December 2005 and entered into force on January 1, 2006.



Second important legal act which regulates this matter is Rules and Regulations on Methods of Demining which also suffered several changes. Document from October 2005 (NG. 79/00, 87/02, 94/02, 149/02, 138/03 and 123/05) is currently effective.

Besides defining the procedures related to dog-handler usage, the Enclosure 1 contains the Program of Trainability and Dog-Handler Evaluation.

For the purpose of easier understanding, here we bring the key terms and guidelines related to dogs and handlers in mine search and mine clearance process:

- Dog handler is a person directing the dog towards terrain search and giving orders during mine search. It must be accredited for conducting mine clearance or supporting mine clearance operations by the relevant Ministry (Article 2)
- When mine search operations are conducted by using mine detection dogs, prior to the beginning of works, demining team leader is obliged to:
 - Hold the meeting with handlers and define the individual tasks
 - Temporarily send the handler who declared himself to be incapable of performing his daily task or the same was established by the demining team leader off the site
 - Directly assign the handlers to the work site
 - Determine the conditions for the work with MDDs by using anemometer (Article 15)
 - Monitor the work of the handler during work site search and continuously monitor the conditions for the work of MDDs (Article 16)

- Enter the meteorological characteristics such as soil temperature on the surface, air temperature at the height of 1 m, speed and direction of the wind to the record from the paragraph 1 of the Article 17
- Except number of duties of the work site leader, the Article 22 defines the one of keeping the record on dog conditioning.
- Supporting staff can enter the work site where mine clearance or technical survey operations are conducted if they carry out handler's or machine operator's work.

In addition to 8 commitments defined by the Article 28, the ninth has also been defined - prior to the commencement of mine clearance i.e. mine search operations, the authorised legal entity is obliged to carry out marking of the test site to make it ready for the work of mine detection dogs.

When work site search is carried out by using mine detection dogs, a part of the work site is marked with stakes having their tops painted in red and monochromous red tape or red flags with no inscription. Visible stake top has to be painted in red in length of 10cm. Stakes are placed along the search direction at the distance of 1m on both sides and are longitudinally connected with red tape at a height of 50cm (Article 33).

- If mine search is carried out using mine detection dogs, only the dogs and handlers whose trainability is verified and evaluated can be used. Verification of trainability and evaluation of handlers and mine detection dogs are carried out by the Croatian Mine Action Centre. Method of trainability verification and evaluation of handlers and mine detection dogs is carried out as per program prescribed in the Enclosure 1 which is published with the Rules and Regulations and makes its integral part. (Article 39a).
- When the terrain is searched by MDDs, the handler who gives the dog certain instructions has to be a deminer or a supporting worker. If supporting worker is performing handler's work, deminer should be present during the work. The area where the dog managed to detect mines and UXOs must also be searched by the deminer. When the work site is searched by MDDs, the same part of the work site must be searched by two different dogs.

- Mine search by using MDDs is conducted according to the SOP verified and approved by the authorised legal entity in marked boxes with the distances of 0,5m between them in order to search the entire box. Mine detection dogs can be used:
 - As the second method after the manual detection,
 - As the second method after mechanical demining, if the soil was mechanically treated up to the depth determined by the project,
 - For the rubble search during the removal of layers,
 - During quality control over mine clearance operations.
- Work site search by using MDDs can be conducted only under the conditions prescribed for MDD testing in the Enclosure 1 of the Rules and Regulations (Article 42)
- Authorized legal entity is obliged to keep the dogs in good working condition during the period for which the assessment was issued. This is proved by weekly plan of dog conditioning. It contains: place, time, method and participants of dog conditioning. Verification of conditioning can be executed by the authorised representative of the Croatian Mine Action Centre. If the authorised representative, during the period while the assessment is still valid, 3 times misses to condition the dogs, he will no longer be allowed to use the dogs until they are tested and evaluated all over again. Authorised legal entities are obliged to define the method of keeping the dogs in good working condition by its SOP. (Article 42 a).
- Complete work site clearance can be achieved by using the combination of demining machine usage and mine detection dogs. (Article 43)
- Deminers and supporting staff performing the work of handlers need to wear personal protective equipment which consists of flak jacket with protection for groins and helmet with a visor. (Article 59)
- During the work site search by MDDs, the distance between handlers needs to be at least 50m. Distance between the handler and closest deminer needs to be at least 25m. (Article 61)
- If mine search activities are conducted by MDDs, authorised legal entity is obliged to search working lanes 1m wide, each 10m horizontally and vertically i.e. using the grid

system – manual mine detection and search the fields formed by MDDs. (Article 66f)

- If during mine search by MDDs the dog detects UXO or its fragments, the authorised legal entity is obliged to inspect the area in radius of 20m from detected UXO and its fragments using the manual method.

The above-mentioned 25 articles are exclusively related to the part from the Rules and Regulations referring to dogs and handlers.

It is important to point out that the Law on Humanitarian Demining and the Rules and Regulations on Methods of Demining passed in 2005 enabled the usage of dogs and handlers as an independent method in mine search projects (low risk areas or areas where mine and UXO existence or non-existence should be established up to the depth determined by the project following the prescribed rules referring to the preparation of the field and action lanes).

Three basic prerequisites elaborated so far: size and structure of mine suspected area, developed and sufficient capacities as well as legal and normative regulations indicate the need and necessity for wider usage of dog-handler teams.

Fourth extremely important link refers to the quality of teams, what is in close connection with the technical requirements and regulations prescribing test and accreditation.

The ultimate goal is that after testing and accreditation issuance for dog and handler for certain limited period, all other links and factors in monitoring and control meet the high standards of legal regulations i.e. detection of all mines, UXOs and their fragments up to the depth determined by the project.

We should strive for liberalization of dog-handler team usage under the condition of complete safety while performing the works and constantly improve all stated preconditions accordingly.



The Program of Trainability Verification and Dog-Handler Team Evaluation



Testing on the Pridraga test site in 2002.

Development of companies in the period 1999 to 2000 resulted in not only the strong expansion but also the procurement of machines and dogs. Later on, that number kept growing what can also be seen from the following data:

2000 - 10 companies - 15 dogs
 2001 - 23 companies - 40 dogs
 2002 - 23 companies - 52 dogs
 2003 - 15 companies - 111 dogs
 2004 - 17 companies - 127 dogs
 2005 - 18 companies - 130 dogs

The Enclosure 1 of the Rules and Regulations on Methods of Demining in 12 chapters defines:

- The holder of trainability verification and evaluation of dogs and handlers – the holder is CROMAC and the director appointed 5 member committee consisting of from CROMAC and CROMAC-CTDT Ltd. staff.
- The term «dog-handler team» consists of one handler and two dogs the most, trained to properly detect all mines and UXOs on specially prepared sites during mine search process.
- General information on the dog and handler
- Test application procedure
- Documentation in the test process
- Test Committee
- Basic elements of dog-handler trainability verification
- Test methods and quality control
- Criteria for the establishment of quality of dog-handler team
- The assessment of the dog and handler
- Other regulations among which – giving up testing or its interruption, possibility for repeating the test, decision on accreditation validity suspension, test site appearance and supporting forms.

Test Sites

Test site Rakovo Polje - Sisak was set up in November 2001. Configuration and soil composition are typical for the continental part of the Republic of Croatia. 41 test fields have been formed after geodetical terrain measurement with fields 10 x 10 m out of which each fourth field is empty. 51 piece of UXO with no fuse or the same was modified and some parts of UXO are buried at known depths. All types of mines known in the Republic of Croatia and worldwide are buried on the test site area. Surrounding area provides the possibility for warming up and acclimatisation and, inside the test site, one field provides the possibility of remotivation in well-known UXO pattern.

Test site Škabrnja – municipality of Škabrnja was set up in January 2003 with 72 fields and 150 mines buried. Other characteristics are similar to the ones in Rakovo Polje and the difference is in climatic and soil conditions typical for the southern part of the Republic of Croatia.

Preparations for setting up new test site Cеровac in Karlovac County are currently underway. It will be watched over and entrance to the site will be controlled. It is planned to establish 80 test fields and use all the experience gained so far. The test site should, in all four boxes formed and assigned per one dog, provide the same conditions in relation to the number and type of mines, UXOs and their fragments.

Test Results



Due to repeated tests, the total of 237 tests was executed in 2004. 50% of tested dogs and handlers were positively evaluated at first try, 38% in second and 12% in third, repeated try. Positive accreditation for the period of one year was given to only two dogs, 22 dogs were accredited for the period of 9 months and the biggest number

i.e. 103 dogs to only 6 months according to the point list given in the Enclosure 1 of the Rules and Regulations on Methods of Demining.

The total of 222 tests was executed in 2005. 46% of teams were judged favourably at the first try, 39% in the second and 15% in the third try. As compared to 2004, it can be seen that there were no qualitative breakthroughs. Test results from 2004 and 2005 indicate the systematic need for improvement of quality at all system levels.

SOP 03.01 - Standardization and Accreditation - Assessment of Mine Search and Demining Results

This standard operating procedure defines the efficiency estimates of mine search and mine clearance operations in different mine, soil, vegetation and climatic conditions with different work methods. It is enacted on the basis of measurements and experience up to now.

This SOP clearly defines the situation and limiting factors when dog-handler team usage is unallowable:

- In cases of higher intensity explosions on project areas in radius 20 m from the explosion epicentre,
- In cases of chemical and similar contamination (oil, herbicides) or waste dumps when there is significant impact on detection concentration and safety,
- When the work site is not properly marked with safe action lanes,
- When the team does not meet required readiness in terms of condition and motivation for systematic work,
- When the air temperature is lower than 0°C,
- When the air temperature is higher than +25°C and direct insolation is present,
- When the wind speed is bigger than 25 km/h, i.e. 7m/sec,
- When the soil is extremely moist, muddy or swampy,
- When the vegetation is higher than 1 m, thick and disturbs the work of a dog i.e. when the area was not properly prepared for the efficient and quality work of the dog, that is, when the vegetation was not properly removed by mechanical method,
- On the frozen ground or the ground covered in snow,
- In case of a rain or a fog.
- In case of dog illness or unfavourable physiological processes

SOP also prescribes other important conditions for the work with dogs:

- Marked boxes can be of different sizes: 50x10, 4x25, 10x10,
- If there was a fire on the area previously treated by demining machines prior to the commencement of work, work with MDDs is allowed only two days after the mechanical soil treatment,
- In case of intensive rainy period and project area washing out as well as favourable conditions of the soil treated by demining machines, the work with MDDs can start 2 days upon mechanical soil treatment at the earliest.

From all the above-mentioned we can see that it is extremely important to control such situations with the purpose of achieving good results and detections from demining team leader, QA Officer and QC Monitor. Besides the large number of limiting factors, world's experience show that even in cases of training related to the scent units i.e. explosives (TNT, DNT etc.) there are situations when dogs do not detect UXOs containing the explosive TNT which is most frequently used. Research and our indicators show that this is actually the UXO which is more or less hermetically sealed, what was completely evident from several cases in 2005. It should definitely bear in mind that MDDs are trained to recognize «the complete bouquet» related to all scents of «military arsenal». Other factors that should be taken into account are the projects and execution projects on different terrains where the researches undoubtedly showed different evaporations and infiltration to the soil in relation to the soil consisting of clay, silt and sand as well as the impact of moistness and temperature on spreading of the explosive particles to the surrounding soil. It is proven that the soil temperature of 26°C is the most suitable for spreading of the explosive particles to the environment. We will continue by focusing on technical requirements and regulations prescribing the test process and quality of teams.

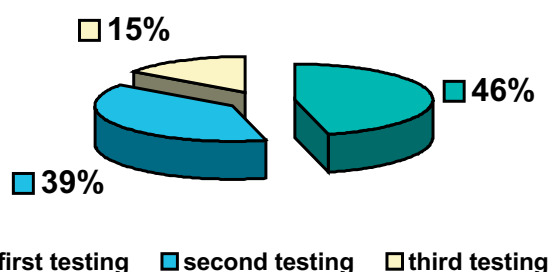
No	Working procedures description	Proscribed number of points
1	Assessment of level of handler's knowledge-written exam	0-5
	Obedience exercises	
2	Walking by handler's leg on leash	0-5
3	Walking by handler's leg without leash	0-5
4	Stops, while walking	0-5
5	Abort of the dog	0-5
6	Moving in front of the handler	0-5

7	Resting dog	0-5
8	Modes to let a dog enter the test field	0-5
9	Evaluation of systematic searching method in accordance to the training method	0-10
10	Handler's rapport with the dog	0-5
11	Safety of the dog while detecting mines	0-10
12	Reliability of dog's findings and handlers interpretations	0-10
13	Distance between an indication and a buried mine	0-5
14	Number of wrong indications	0-5
15	Evaluation of found and indicated UXO fragments	0-5
16	Level of motivation to search	0-5
17	Level of focus intensity during search	0-5
	Evaluation of overall work quality and behaviour of handler-dog team, total number of points=100	

The enclosed table explains the point system according to which for the total number of points the assessment for work in humanitarian demining operations is issued for the period of 6, 9 or 12 months. Important precondition is the one that dogs detect all buried mines in the boxes assigned. Maximum number of points is 100. Our practice up to now has shown that the average number of points is 62 what indicates inadequate quality of work and need for quality control and monitoring during conditioning and upon testing which should be carried out by the committee and CROMAC's QA Officers and QC Monitors.

Latest information from the monitoring companies in Bosnia and Herzegovina indicate MDD-teams' quality drop and the situation is the same in the world.

Percentage of those that have passed the testing in 2005



To conclude, several subjects are responsible for the total quality and they should be closely connected. These are:

1. Accreditation

In this procedure, it is important to point out the following:

- Handler needs to have a certificate or other type of proof that he passed the test in schools involved in training and dog breeding which should be compliant with conditions prescribed by the Rules and Regulations.

2. Rules and Regulations

- The company needs to submit the documents (index card, pedigree) from which the origin, breeding, socialization process and training, type of explosive and other things the dog was trained for, basic elements of mine search method, medical card or chart as well as clear identification marks (tattooed number, micro-chip) can be seen.
- The company needs to submit the SOP or a part of the SOP referring to the overall work, methods, conditioning i.e. all that is today mostly comprised in the effective SOPs of the companies and, in the major part, complied with national and international standards.
- In cases when the company possesses a large number of dogs, it is required to appoint the person having the certificate confirming the person to be a dog trainer.
- The company needs to have its own test sites for training, conditioning, internal testing or have a lease contract confirming the lease of the adequate space.
- It is required to present all the forms on conditioning with place, time, results as well as indicators on the achievements so far in demining projects in the country and abroad (references).

Normative regulations need to clearly prescribe the possibilities and method of usage, effects, all limiting factors, all the forms, method of monitoring, define the appearance and other factors relevant for the quality of the test site and provide all the subjects with the same conditions similar to the ones in the actual conditions. It should also appoint the expert committee, prescribe the appearance of the index card or the form to be filled in by the Committee and serves to the company, QA Officer and QC Monitor for getting the completely clear picture while estimating the performance of the team at evaluation of execution projects as well as monitoring and quality control over mine search and mine clearance projects.

3. Testing

It is required to create high quality and equal terms of testing, increase the number of points for acquiring the time limit of usage, perform the control upon testing by field survey for the purpose of getting an insight into the status of companies' test sites and prescribed forms of daily, weekly and monthly conditioning and verification.

4. Monitoring and Quality Control

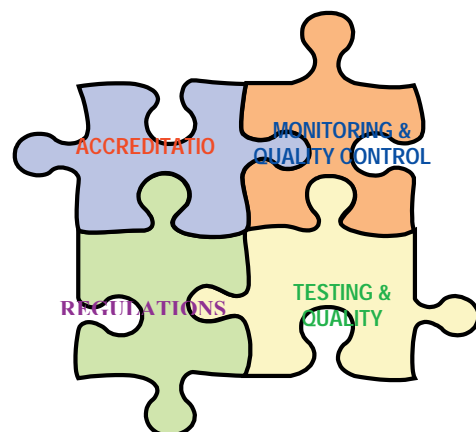


Permanent monitoring and quality control as well as education of QA Officers and QC Monitors is necessary.

This is only a part of basic measures which should in the forthcoming period result in quality increase and consequently, wider and safer usage of dog-handler teams in humanitarian demining.

Dog and handler have undoubtedly built a high level of trust and that process keeps continuing. Of course, in mine clearance, it is more complex that in cases of some other activities involving the dogs, for example; having a dog as a pet.

Significant characteristics in safe and efficient usage of dog handlers and MDDs in humanitarian demining



Development of Japanese Dual Sensor Systems for Landmine Detection

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Abstract:

In this paper, we introduce the development and evaluation tests of dual sensor systems conducted under the project of JST (Japan Science and Technology Agency) for humanitarian demining. At first, we introduce the projects, and the role of dual sensors. Then, we introduce the development of dual sensor systems including SAR-GPR and ALIS and others. SAR-GPR is a vehicle mounted system, which employs an array antenna for advanced signal processing for better subsurface imaging. This system combined with synthetic aperture radar algorithm, can suppress clutter and can image buried objects in strongly inhomogeneous material. ALIS is a hand-held system, we can record the metal detector and GPR signal with the sensor position information. Therefore, signal processing for 2-D signal image is possible. For GPR signal, we can apply migration algorithm, which drastically reduce the clutter and we can obtain 3-D image of the buried targets. These systems were evaluated in Croatia, in February 2006.

1. INTRODUCTION

In order to improve the operation efficiency of landmine detection by metal detectors, the concept of dual sensors has been employed and some systems have been developed. However, due to the difference of the characteristics of metal detector and GPR, there is no fixed methodology of characterizing dual sensors and no dual sensors have been deployed in the real humanitarian demining fields. JST (Japan Science and Technology agency) have conducted the development of humanitarian demining machine, which include unmanned vehicle and landmine detection sensors. Two robots and three sensors were tested in February 2006 by CROAMC and ITEP at the test site of Benkovac

2. DUAL SENSOR

EMI sensor (Metal detector: MD) has been successfully used for humanitarian demining for many years. It is compact and light weight, and easy to use after training. It is widely accepted by local deminers. Current metal detectors can detect most of the low-metal AP mines, but the most serious problem of metal detector is its false alarm due to metal fragments. In order to detect very small amount of metal used in AP-mines, most metal detectors are sensitive to also to a small metal fragments. However, it increases the false alarm rate and reduces the efficiency of

the demining operation.

GPR (Ground Penetrating Radar) can detect and image of buried metallic and non-metallic objects. And GPR can image the shape of buried landmines, and this feature can be used for discrimination of landmines from other metal fragments. The combined sensor of metal detector and GPR is normally called as a dual sensor, in humanitarian demining. This principle works quite well under ideal conditions, i.e., dry and homogeneous soli condition, but it was found it has so much difficulties in real world.

There have been a few projects to develop dual sensors for humanitarian demining in the world, however, no system has been deployed in the real demining operation so far. In the following sections, we introduce dual sensor systems developed under the project conducted by JST.

3. SAR-GPR

SAR-GPR is a sensor system composed of a GPR and a metal detector for landmine detection. The GPR employs an array antenna for advanced signal processing to achieve better subsurface imaging. This system, combined with Synthetic Aperture Radar (SAR) algorithms, can suppress clutter and can image buried objects in strongly inhomogeneous material. SAR-GPR is a stepped frequency radar system, whose RF (radiofrequency) component is a newly developed compact vector network analyzer. The size of the system is 30cm x 30cm x 30cm, composed of 6 Viv-

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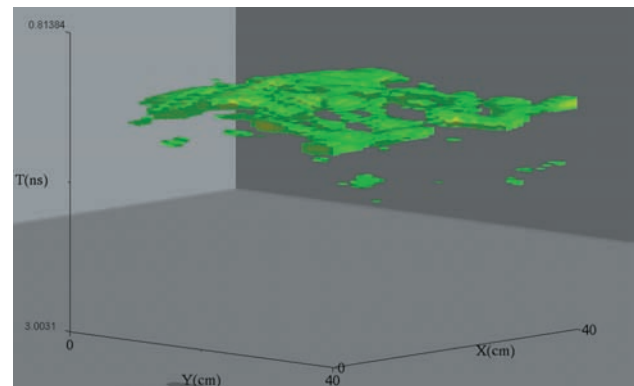
aldi antennas and 3 vector network analyzers. The weight of the system is about 20kg, and it can be mounted on a robotic arm on a small unmanned vehicle such as the MHV. SAR-GPR also employs the combination of metal detector and GPR. However, imaging by GPR is very difficult in strongly inhomogeneous material due to strong clutter. We propose therefore to use a Synthetic Aperture Radar (SAR) approach to solve this problem, and have developed a SAR-GPR equipment to be mounted on a robot arm on MHV manufactured by Fuji Heavy Industry. SAR-GPR antennas are scanned mechanically near the ground surface and acquire the radar data. Actually, an array antenna composed of 6 elements is employed, in order to suppress the ground clutter. The data is then processed for subsurface imaging.



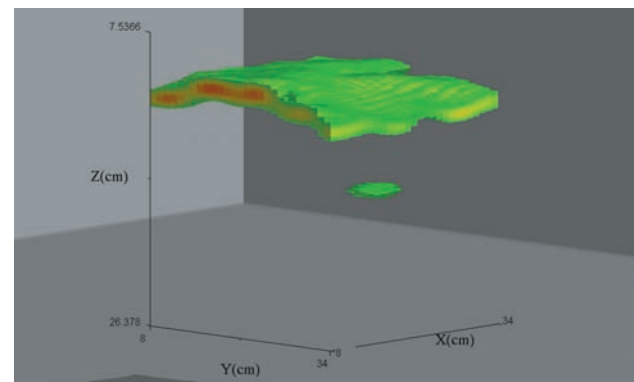
Fig.1 SAR-GPR mounted on MHV

In order to achieve the optimum SAR-GPR performance, we believe that an i) adaptive selection of the operating frequencies is quite important, and that ii) antenna mismatch causes serious problems in GPR. Most of the conventional GPR systems employ impulse radar, because it is compact and data acquisition is fast. However, most of the impulse radar system have disadvantages such as signal instability, especially time drift and jitter, strong impedance mismatch to a coaxial cable, which causes serious ringing, and fixed operating frequency range. An alternative is represented by the use of systems such as vector network analyzers, synchronized transmitter-receiver measurement equipment composed of a synthesizer and a coherent receiver. They enable quite flexible selection of operation frequencies, and stable data acquisition. We have therefore chosen to equip the SAR-GPR with 3 sets of vector network analyzer operating in the

100MHz-4GHz frequency range. The optimal operational range can actually be selected as a function of the soil conditions.



(a) Raw GPR profile



(b) Processed GPR profile after CMP stacking and migration.

Fig.2 3D reconstructed image of GPR acquired by SAR-GPR

Thanks to the very strong signal processing with rich datasets acquired by an array antenna, SAR-GPR image can reduce the effect of clutter drastically. Fig.2 shows an example of the raw data acquired by SAR-GPR and the 3D image after signal processing by the SAR-GPR algorithm. LAMDAR-III

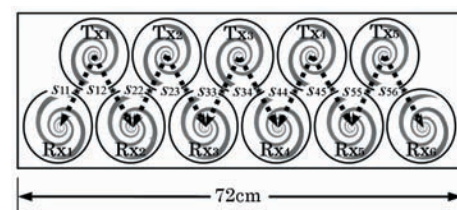


Fig.3 LAMDAR-III Antenna configuration

LAMDAR-III is an array type impulse GPR system developed by the research group of Prof. Arai of University of Electric Communication, Tokyo, Japan. LAMDAR-III can be also mounted on MHV. This GPR consist of five Transmitting and six Receiving antennas arranged in an array with the circuit designed to work for the detection of different targets like, landmine, Metal fragment, UXO, rocks, etc. The transmitting and receiving antenna used in the GPR are Spiral Antennas. The Radar transmits the pulse signal of approximately 150 ps. The reflection of this pulse signal from the soil and from the various targets inside the soils can be used to determine its position in the underground area. The data acquired from the reflection is processed using SAR (Synthetic Aperture Algorithm) for the 3-D display and the target can be seen visually. The GPR dimension is 75 X 30 X 40 cm and its weighs about 27 kgs. The system can be used in a High Speed Scanning with the High-resolution signal analysis.

4. ALIS

ALIS (Advanced Landmine Detection System) is a hand-held dual sensor for Anti-Personnel landmine detection, which can visualize the MD and GPR signals for the benefit of deminers. The visualized metal detector signal image provides direct information about the location of metallic objects, and then GPR gives the radar image of the buried objects, which can be used to detect landmines. The visualization system increases the reliability of operation. The locus (position in space) of the sensor head scanned by the deminer can also be recorded in real time. This record can be used for the quality control of the operation, and also for the training of operators. The sensor signals from the metal detector and GPR are stored in a PC, which provides both detection and sensor position information. The entire system is controlled by a PC which is carried inside a backpack worn by the deminer. The deminer monitors the metal detector signal displayed on a hand-held display or PDA and scans the ALIS sensor as shown in Fig.1. The same image which the deminer is looking at is transmitted by wireless LAN to a handheld PC display, allowing several operators to monitor the operation as well. For the normal operation of ALIS, one operator who scans the sensor and another operator who controls and monitors the sensor signals are needed.



Fig.4 ALIS

The scanning by ALIS follows exactly the same procedure as for the normal hand-held metal detector. A deminer stands at the front of the boundary of a safe zone, and scans an area of about 1 m by 1 m. Continuous scanning is recommended, even if the deminer detects an anomalous signal from the metal detector. One set of data acquisition by ALIS takes several minutes, which is almost equivalent to the time required for normal scanning operation of a conventional MD.

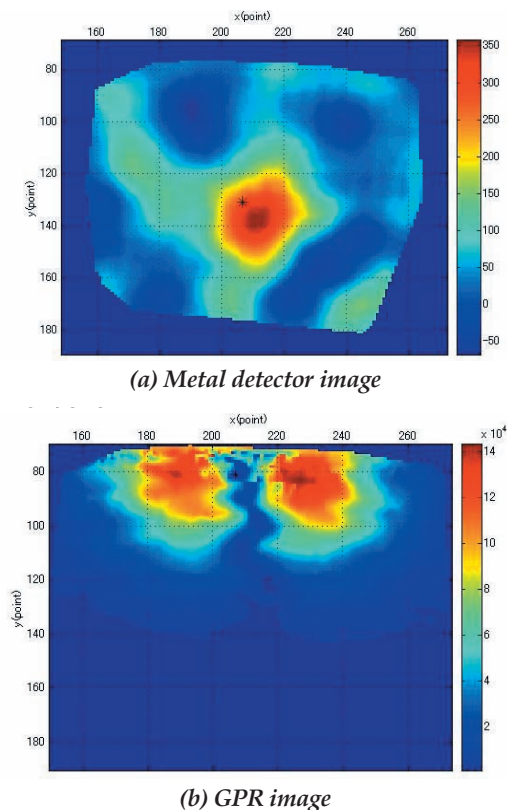


Fig.6 Typical ALIS output image of buried AP landmine. (PMN-2, 10cm depth)

After scanning the area, the acquired data sets are processed using the same PC mentioned above. First, all the acquired data sets are transformed to a regular grid of points. An interpolation algorithm is used for this process. The full processing does usually require one to a few minutes until all the data sets are displayed. Subsequently, ALIS provides a horizontal (plan) visual image of the metal detector signal (Fig. 6(a), and 3-D GPR information. The 3-D GPR information is however usually too detailed and cluttered for interpretation on site, so that the displays of horizontal time slices (C-scans) of the GPR signal (Fig. 6(b)) is preferred instead. In our experience the detection of buried landmines with the horizontal time slice image is the most reliable.



Fig.5 ALIS mounted on Gryphon

Another unique feature of ALIS is its compatibility with conventional landmine detection operations, as it requires minimum modification of the operational procedures. The ALIS is an add-on system that can be attached to an existing commercial metal detector (e.g., CEIA MIL-D1). The performance of the metal detector is not altered by adding the ALIS system: the operator still hears the audio tone signal from the metal detector, and can detect anomalies using its own experience. ALIS is a sensor unit and can be mounted on a robot arm. Currently, we test ALIS on Gryphon, which is a buggy system with a robot arm, which is developed by Tokyo Institute of Technology.

5. EVALUATION TEST IN CROATIA

Evaluation test of the sensors developed under the humanitarian demining project of JST was conducted in February 2006, by CROAMC and ITEP at the test site of Benkovac, Croatia.

The weather condition was sometimes rainy, and even snowy. Even under these conditions, the developed sensors could detect and image buried landmines.

6. CONCLUSION

We summarized the dual sensor systems developed under the humanitarian demining project of JST. The initial stage of development was over, and we are planning a long-term evaluation of some of the sensors including ALIS.

ACKNOWLEDGEMENTS

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Technical Requirements and Compatibility Assessment of Demining Machines and Metal Detectors Used for Demining Operations

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Based on enacted Law on Demining (National Gazette no. 153 dated 28 December 2005) and previously acquired opinion of the authorized institution, Croatian Standards Institute – Technical Humanitarian Demining Committee, CROMAC passed the regulation on technical requirements and test procedures (compatibility assessment) for the equipment, devices and machines designed for humanitarian demining operations.

Technical regulations for establishment of technical requirements and procedures for determination of compatibility of machines and metal detectors used in humanitarian demining with stated requirements are described in the paper.

It is defined by Standard Operating Procedures that neither one demining machine nor metal detector can be used for humanitarian demining operations in the Republic of Croatia unless they are consistent with prescribed technical requirements.

Their consistence has to be defined by following the prescribed procedure. Verification of characteristics is carried out once a year for all the machines and metal detectors on specially prepared polygons: «Cerovac», «Benkovac» and/or «Škabrnja».

Key words: technical requirements and compatibility assessment, demining machines, metal detectors, standardization

1 Introduction

Humanitarian demining operations are often conducted in very difficult and specific conditions which involve a lot of risk and danger for people's lives and health. Those characteristics in particular direct the constructors and manufacturers to the specific technical requirements the machines, equipment and devices should meet. On one hand, demining machines are required to demine as much surface area as possible in the shortest period possible i.e. to reach required performance and on the other hand, the requirement of the quality of soil treatment set simply has to be met along with the safe neutralization of mines or their destruction by demolishing or detonating, as well as machine operator's safety. Beside adequate sensitivity, reliable detection is also required from metal detectors – precision of location definition, that is, maximum capability of providing reliable signals of detection without any false signals.

Ca. 30 legal entities and one non-governmental organization authorized for conducting demining operations in the Republic of Croatia are engaged in technical survey and demining operations. The analysis of existing capacities and their correlation established that demining machines have the most important portion in the total efficiency and they participate with 55 km² (50 demining machines). All other capacities (610 deminers, 680 metal detectors and 125 MDDs) are subordinated to area inspection after the machines.

Only the unengaged capacities will be used for primary manual detection of the area where the use of demining machines was not possible.

In the last couple of years there has been a significant quantitative and qualitative capacity increase of authorized legal entities where the portion of demining machines in technical survey and demining as first method makes up ca. 85% of the total area as well as increased scope of quality control and metal detector usage. Due to all these facts it is necessary to pass technical requirements for the machines and metal detectors. In the technical regulation, technical requirements would be described directly or they would refer to the standard, technical specification or usage instruction. Technical regulation would also prescribe assessment procedures of compliance with technical requirements. All the above-mentioned would be in line with IMAS and other relevant national and international standards, agreements, regulations and requirements (ISO, HRN, CEN etc.). Law on Demining (National Gazette no. 153 dated 28 December 2005) provides CROMAC with possibility to pass the regulation on technical requirements and test procedures (compliance assessment) of equipment, devices and machines designed for humanitarian demining operations. Standard Operating Procedures define that neither one demining machine nor metal detector can be used for humanitarian demining operations in the Republic of Croatia unless they are compliant with prescribed technical requirements. Their compliance has to be defined following the prescribed procedure.

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2 Technical requirements and compliance assessment of demining machines and metal detectors used in humanitarian demining operations

The following elements are established by prescribing technical requirements and assessment procedure of compliance with prescribed requirements:

- Technical requirements that machines, equipment and devices used in humanitarian demining operations should meet,
- Rights and liabilities of legal and actual entities which put the machines, equipment and devices on the market and/or in use,
- Assessment procedures of compliance with technical requirements,
- Rights and liabilities of the authorities conducting the compliance assessment of demining machines, equipment and devices with technical requirements,
- Documents that should be available for CROMAC prior to putting the machines, equipment and devices in use (compliance assessment issuance, accreditation procedure),
- Mode of marking the machines, equipment and devices used in humanitarian demining operations. The machines, equipment and devices used in humanitarian demining operations will be allowed to be used only if they are compliant with prescribed technical requirements, if their compliance is established as per prescribed procedure and also if they are marked in accordance with rules and regulations. The purpose of the enactment of technical requirements and compliance assessment procedures is:
 - Safety,
 - Protection of people's lives and health and
 - Environment protection.

Technical requirements and competence assessment procedures will be based on the Agreement reached at the CEN Workshops CWA 115044:2004 and CWA 14747:2003.

1.1 General Requirements

2.1.1 General Requirements for Demining Machines

Demining machines are the machines which mechanically treat mined area, remove the vegetation (by cutting and/or grinding), dig up mines and disable them by activating and/or demolish-

ing up to the depth in the soil determined by demining or mine search project.

General requirements to be put in front of demining machines are:

- Demining of minefields (antipersonnel mines (AP), antitank mines (AT) and mixed minefields) in different soil conditions.
- Removal of remnants of mines, explosive and ammunition which could pose the potential threat.
- The machine should neutralize mines or destroy them by demolishing or detonating. Upper part of the tool (diggers, flails) should be resistant to wear and tear, mine explosions, roots and stones and the teeth of the tool i.e. flail easily replaceable.
- Each machine should have technological speed adjusted for the soil treatment and coordinated with required depth (5-10-20 cm, depending on the soil category).
- The quality of soil clearance should comply with the requirements prescribed by the SOP.
- Machine operator's safety: remote control or protected cabin. The machine crew should be protected from the stroke of the fragments of AP and AT mines, impulse noise and high-impact vibrations.
- Protected with the shield from all sides, especially in cases of sudden explosion from the front and below the machine.
- Machine staying power and maintenance simplicity.

2.1.2 General Requirements for Metal Detectors

Despite the fact that metal detectors – devices using the electromagnetic induction principle for metal detection – are used for over 60 years, there are no universal technical specifications for their work and usage in humanitarian demining operations or assessment of their compliance with prescribed technical requirements.

The Agreement reached at the CEN Workshop CWA 14747 represents high achievement in definition of test and evaluation criteria of the machines used in humanitarian demining. The Agreement sets the guidelines, principles and procedures for test (compliance assessment) and evaluation of metal detectors. It is thorough and comprehensive so that all the users can choose adequate parts of the Agreement for their own needs.

General requirements to be put in front of metal detectors used in humanitarian demining are as follows:

- Sensitivity (measure of its capability of mine and UXO detection) measured as maximum height from the detector's head to the test target on which detector can detect that target or sensitivity presented as minimal target (in terms of size, form and material) which can be detected at certain height above the target.
- Sensitivity drift (sensitivity regulated in a way not to decline regardless of working conditions, low battery, operation of constant quality level in presence of electromagnetic disturbances etc.)
- Possibility of soil impact compensation (reduction or elimination of detection signal which appears in magnetized soil while, at the same time, detector keeps its capability of metal detection).
- Positive detection signal needs to be repeatable under the same conditions and should not be discontinuous.
- Warning and alarming systems. Detection signalizer must enable signalisation of detection with a characteristic sound.
- Detection reliability - precision of location definition (maximum capability of providing reliable signals of detection without any false signals).

2.2 Operative Requirements

Operative requirements are connected with specific performances of the particular type of the machine, equipment and devices, their staying power and acceptability. Specified performances have to be a part of documentation submitted by the machine or metal detector manufacturers or users during the submission of request for compliance assessment test and/or accreditation of authorized legal or actual entity for conducting demining operations in the Republic of Croatia.

2.2.1 Operative Requirements for the Machines Used in Humanitarian Demining Operations

In the supporting documentation, demining machine manufacturer and/or user needs to ensure the information stated in the point 8 of the Agreement reached at the CEN Workshop CWA 15044: 2004. Except specifications enclosed and performances presented, CROMAC will pre-

scribe the following technical requirements and verification of compliance of the same:

- Machine classification in view of the weight, management mode and working tool.
- Definition of machine categories in accordance with efficiency requirements in specific conditions of usage.
- Requirements for performances for each category in view of the machine mass:
 - capability of the machine to demine (i.e. capability to detonate or destroy) the mines at various depths and soil types,
 - capability of vegetation clearance,
 - machine staying power,
 - placement of digging tools which define the characteristic of soil treatment density,
 - machine operator's safety
- Requirements for machine reliability and maintenance simplicity.

2.3 Machine Classification and Compliance Assessment

Machine classification is executed according to demining machine purpose, in view of the machine mass and machine management mode. In cases when direct and remote machine control is possible, compliance assessment is carried out only for the classification demining machine was tested in. Technical requirements are defined for each classification separately. Compliance assessment is conducted according to CEN Agreement CWA 15044:2004 and scheme presented in Figure 1.

2.4 Operative Requirements for Metal Detectors

In the supporting documentation, metal detector manufacturer and/or user needs to ensure the information given in the Annex C of the Agreement reached at CEN Workshop CWA 14747. Except specifications enclosed and performances presented, CROMAC will prescribe the following technical requirements and verification of compliance of the same:

- Maximum detection height
- Repeatability of sensitivity on set-up
- Sensitivity drift
- Capability of detection for specific targets
- Minimum detectable target depending on the depth
- Target locating accuracy
- Differentiation of adjoining targets
- Detection reliability

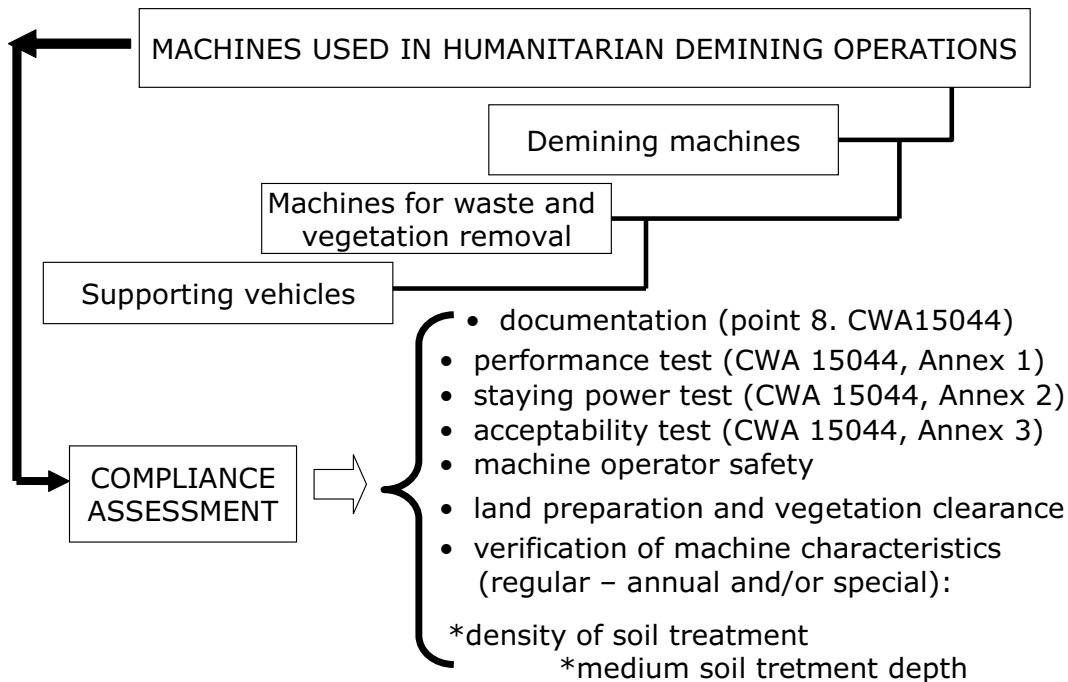


Figure 1 Diagram of the relation between requirements for the machines and compliance assessment procedure in CROMAC

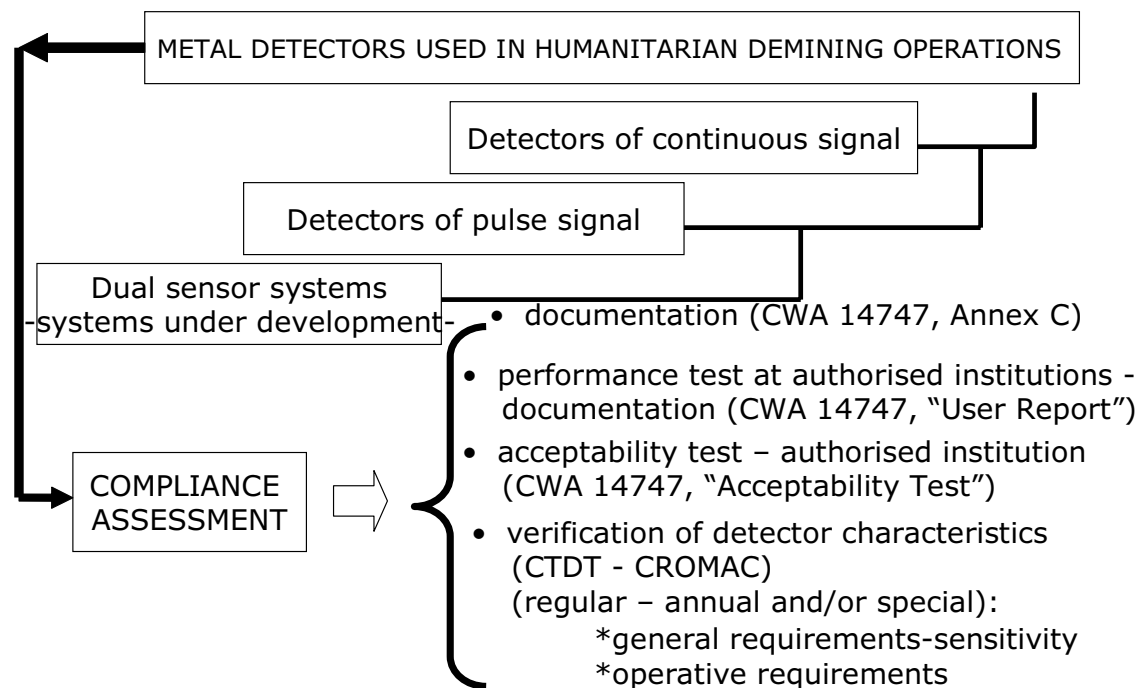


Figure 2 Diagram of the relation between the requirements for metal detectors and compliance assessment procedure in CROMAC

2.4.1 Classification of Metal Detectors and Compliance Assessment

Classification of metal detectors could be performed according to work principle i.e. technology used: detectors of continuous signal, pulse signal detectors and dual-sensor system detectors. Technical requirements will be defined for each classification separately. Compliance assessment is conducted according to CEN Agreement CWA 14747 and scheme presented in Figure 2.

2.5 Compliance Assessment

Compliance assessment of the machines and metal detectors used in humanitarian demining operations implies each action referring to direct or indirect establishment of whether the «products» (in this paper «products» means machines and metal detectors) measure up to the adequate

technical requirements. As per Law on technical requirements for products and compliance assessment (National Gazette, 158/03) products can be “put on the market” i.e. can be used only if they are compliant with prescribed technical requirements and marked in accordance with rules and regulations. Considering the fact that the humanitarian demining operations are defined by special law, CROMAC is authorized for implementation and monitoring of compliance assessment procedure in accordance with the international standards and accepted agreements (CWA 15044, CWA 14747 etc.)

Figures 3, 4, 5 and 6 present the diagrams of compliance assessment procedure proposed in CROMAC for the machines used in humanitarian demining operations. Figures 7, 8, 9 and 10 present the diagrams of compliance assessment procedure proposed in CROMAC for metal detectors used in humanitarian demining operations in the Republic of Croatia.

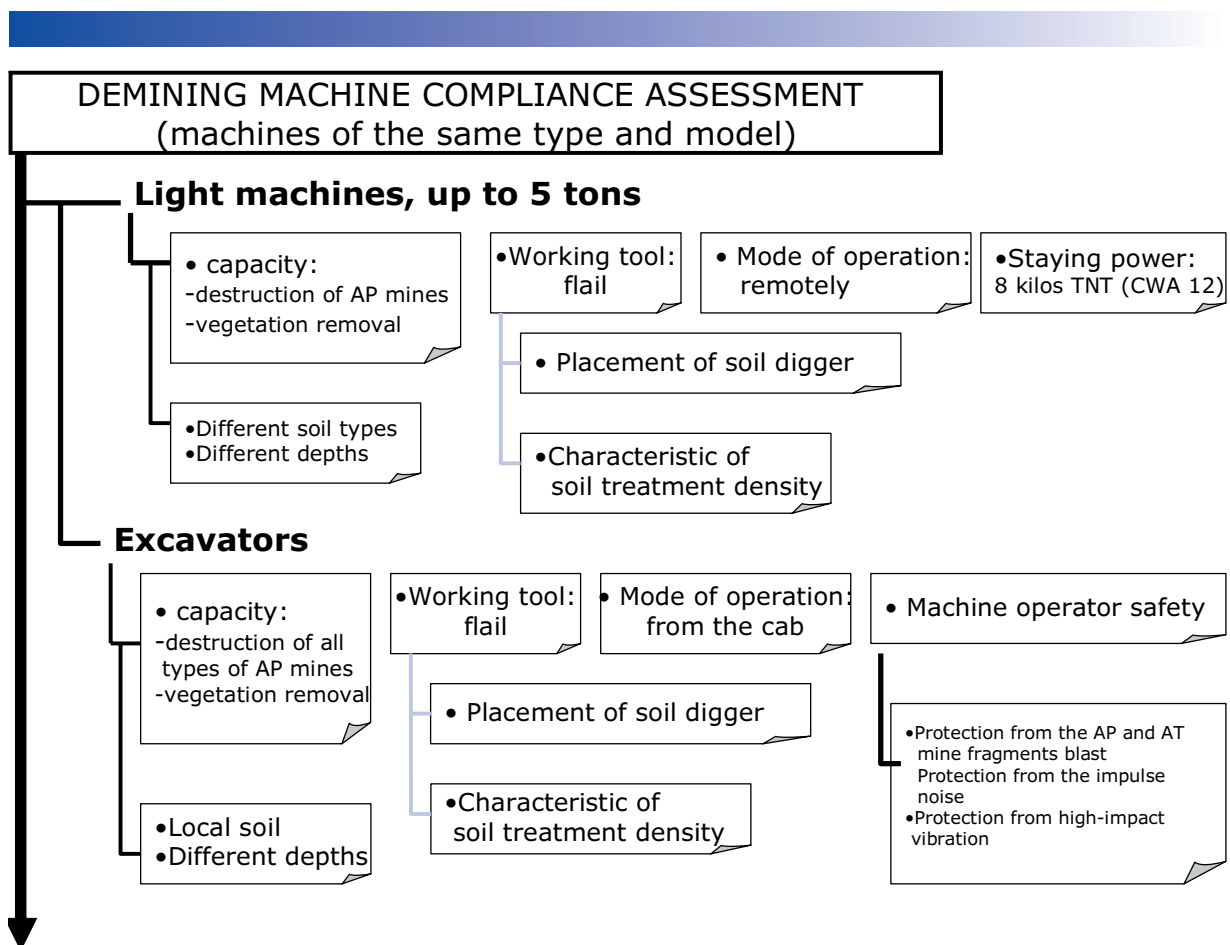


Figure 3 Diagram of the compliance assessment procedure for light machines and excavators with fail

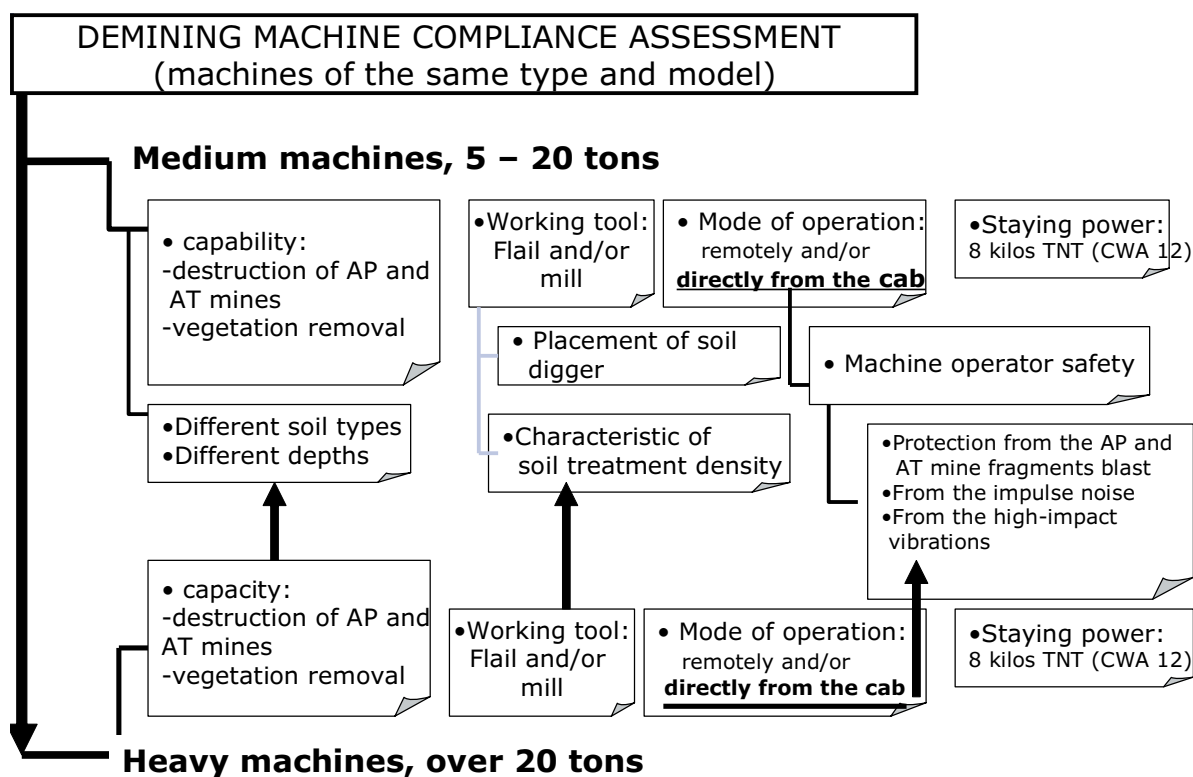


Figure 4 Diagram of the compliance assessment procedure for medium and heavy machines

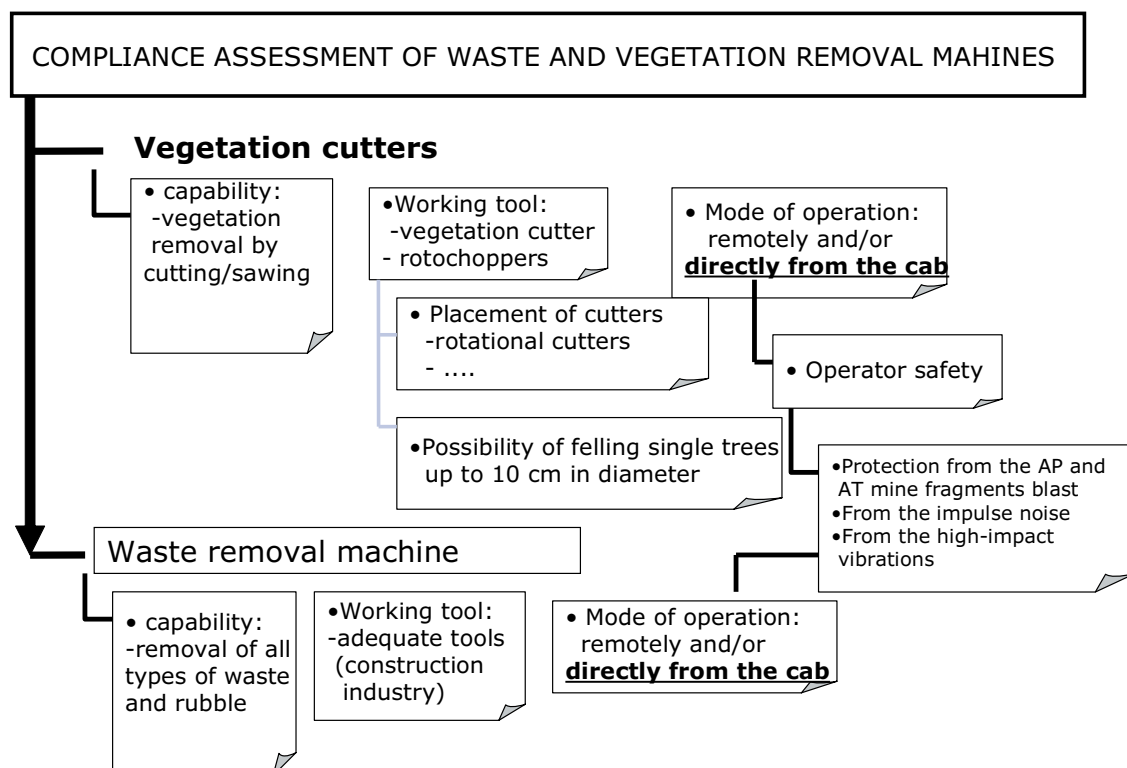


Figure 5 Diagram of the compliance assessment procedure for vegetation cutters and waste removal machines

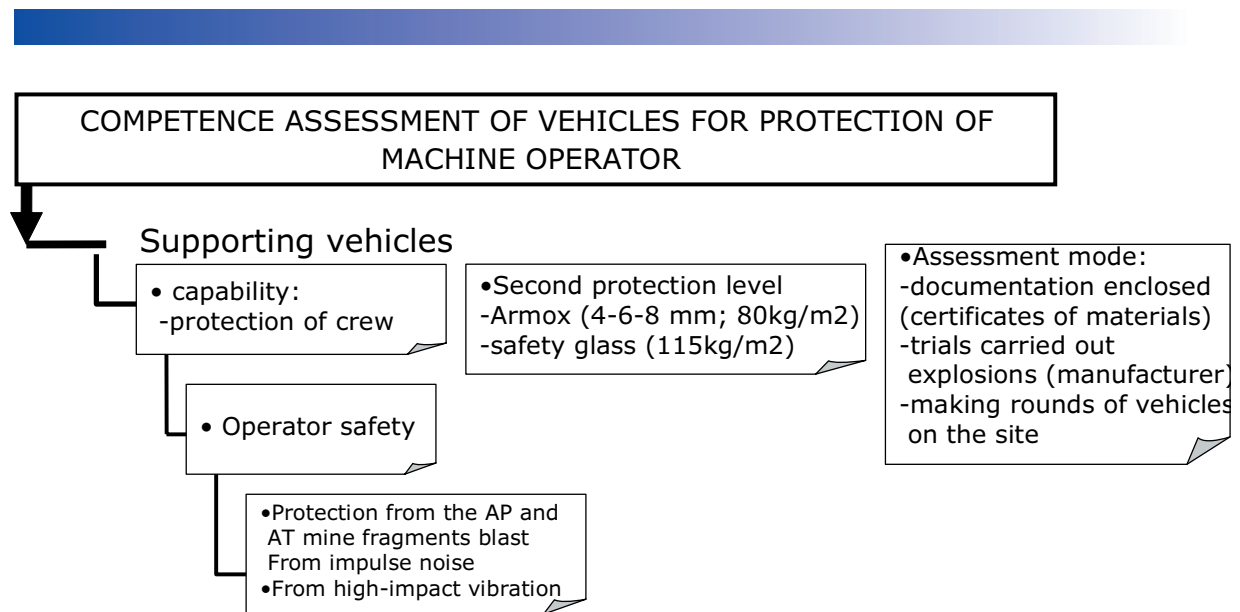


Figure 6 Diagram of compliance assessment procedure for supporting vehicles

2.3.2 Compliance Assessment for Metal Detectors Used in Humanitarian Demining Operations

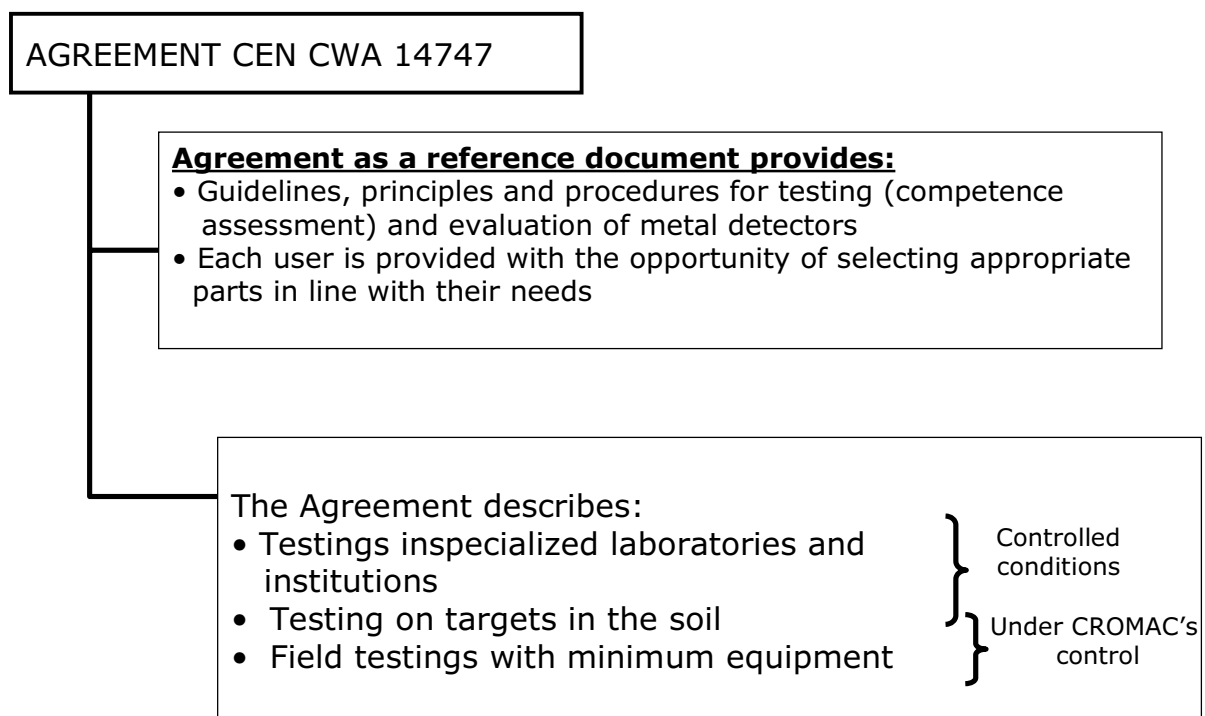


Figure 7 Scheme of metal detector compliance assessment procedure

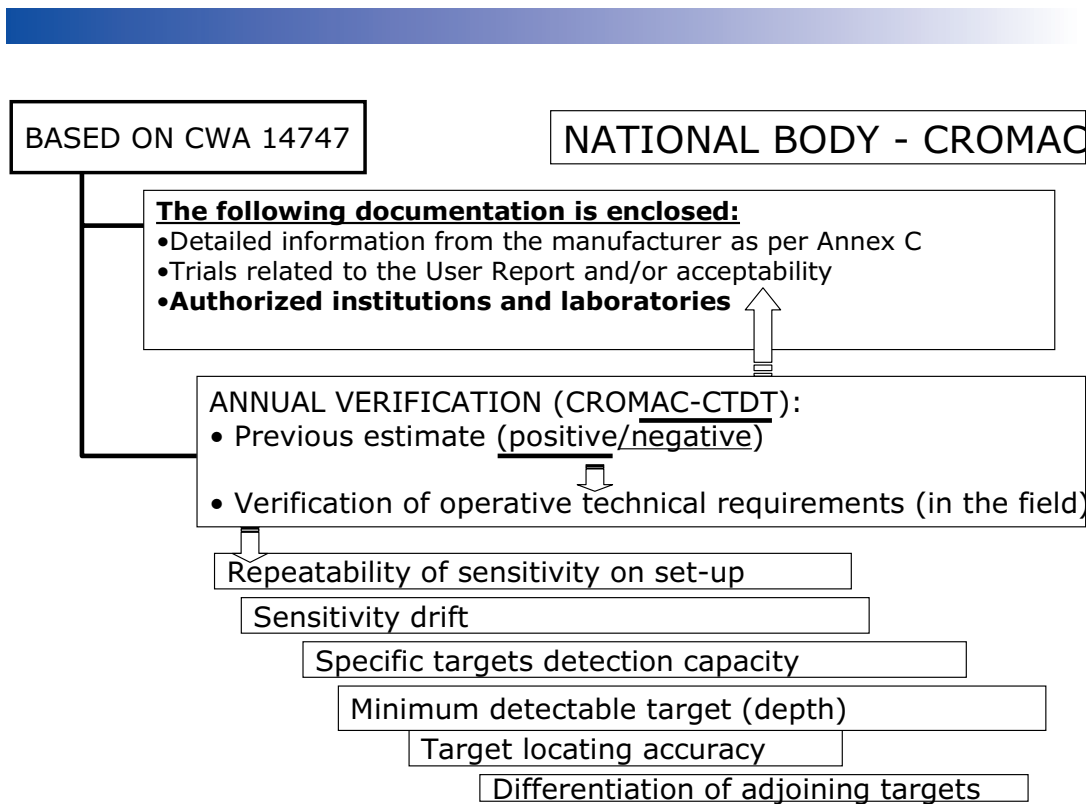


Figure 8 Diagram of compliance assessment relation among the authorized institutions, laboratories and annual verification procedure in CROMAC

In consideration of the fact that based on the Law on humanitarian demining only certified equipment with certificate confirming its compliance can be used, all accredited companies authorized for conducting humanitarian demining are obliged to enclose the above-mentioned certificate on the occasion of each accreditation extension. Based on CEN Agreement CWA 14747 as per diagram presented in Figure 8, all metal detector users will enclose the documentation with complete information according to the Annex C to the Agreement and certificate on compliance (tests linked with User Report and/or acceptability as per CWA 14747) issued by the authorised institution/laboratory.

Annual verification for metal detectors of the same type and model would be carried out under CROMAC's control and it would include:

- Previous estimate
- Verification of certain operative technical characteristics in the field

Visual survey, completeness and basic measurement of sensitivity in the air (calibration) would be used for previous estimate. Negative previous estimate would result in returning metal detector to authorized institutions/laboratories.

Positive previous estimate would result in continuation of defined operative characteristics verification.

The following operative characteristics would be verified on the annual basis:

1. Repeatability of sensitivity on set-up - determination of variations of maximum detection heights with the purpose of detecting any kind of repeatability fault.
2. Sensitivity drift - determination of detector's detection capacity modification during certain period of usage.
3. Detection capability for specific methods - determination of maximum detection height in the air for any target for metal detector and certain sensitivity.
4. Minimum detectable target - detectable depending on the depth. Detection capability by targets buried at various depths should be established.
5. Target locating accuracy. It is the accuracy by which detector can locate the position of hidden target.
6. Differentiation of adjoining targets - minimum distance between the targets on which they can be differentiated is measured.

3 CONCLUSIONS

The machines, equipment and devices used in humanitarian demining operations will be able to be put to use only if they are compliant with prescribed technical requirements, if their compliance is established according to prescribed procedure and if they are marked in accordance with rules and regulations.

Technical requirements and compliance assessment procedures of the machines and metal detectors used in humanitarian demining operations are based on the Agreement reached at the CEN Workshop CWA 14747; 2003.

General and operative technical requirements and compliance assessment procedures of the same have been proposed.

The purpose of passing technical requirements and competence assessment procedures is pri-

marily: the safety, protection of people's lives and health and environment protection.

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Use of bees in explosive devices detection

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Introduction

In addition to production of food and pollination, bees have recently been used for assessment of environment quality. Extensive research of residue in bees products as indication of polluted environment has been conducted (Barišić 1999, 1992, Kezić 1997). In nature bees orient themselves by the sun (Von Frisch 1993), but for finding food bees rely on a very sensitive sense of smell. They search for food in a distance of up to 3 km, but first they collect food closer to the beehive. If they start with certain food, they remain faithful to that food and odor as long as they can find it, regardless of the fact that new, more abundant food source appears. Bees are fully adapted to vegetarian diet. Nectar and honey dew are energy food, while pollen is a source of proteins, vitamins and minerals. They collect liquid food and take it to the bee hive in a honey bladder. Pollen sticks to the hairs which cover the bee's body. A beehive contains a very large colony of bees. There are around 10 000 bees in a kilogram, and a developed colony may weight five kilograms, and even more. Searching for food, bees fly around a beehive evenly. Each bee leaves the beehive 12 or more times a day. Knowing the biology, way of nutrition and behavior, it is possible to control bees for the purpose of keeping their movement on a specific area, or for the purpose of directing them to search for food we have trained them to search for. By placing sources of additional food, it is possible to direct bees to fly in the area of interest. If we have thought bees to consume certain food, i.e. the food having a certain odor, for a following day or two bees will relentlessly search for that odor. Due to these characteristics of bees, intensive research has been conducted in recent years of the possibility to use bees in confirming the existence of explosive

or in detecting location where the explosive odor exists.

Research with bees has developed in two separate directions, i.e. passive and active methods of mine detection have been researched.

Passive method:

On their hairs bees bring to the beehive substances which exist in the area they fly in. After the bee comes back to the beehive, these substances are released into the beehive. In this way explosive particles are also brought into the beehive. Electrostatic charge of the bee hairs also helps in collecting explosive particles (Bromenshenk 2003).

Research has been conducted at a mine test site in Benkovac. There are 1000 mines there on the area of 1 hectare. Mines have been buried for more than 5 years. A colony of bees was brought from the area free of mines and was set up at the mine test site where it stayed for a month prior to the beginning of the experiment. Research was conducted in October 2005. Air samples were collected from the beehive by pumping of 1 liter of air per minute through a Tenax tube (Figure 1).

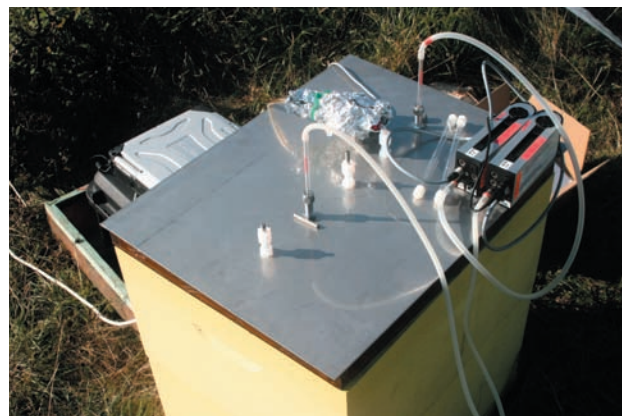


Figure 1. Air sampling through Tenax tubes from the beehive placed at the mine test site in Benkovac in 2005

Duration of sample taking was one hour. The same quantity of a check-up air sample was taken in the immediate vicinity of the beehive. An artificial (electronic) nose was also connected to the beehive for 3 days (Figure 2.).

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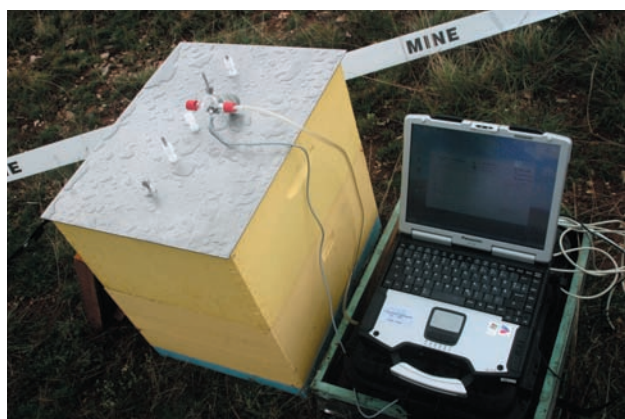


Figure 2. Electronic nose connected to the beehive placed at the mine test site in Benkovac in 2005

The flow of air from the beehive through the electronic nose was continuous in the quantity of 1 l per minute. The first day of the experiment it was raining. The rain stopped the next day, but conditions for bees to fly out of the beehive were unfavorable. The third day was sunny and suitable for bees to fly out of the beehive. Measuring results are given in Graph 1.

In check-up samples existence of TNT particles or traces of other explosives characteristic of mines buried at the test site were not found. Taking the air samples from the beehive placed at the test site, existence of particles of 2,3 DNT ranging from 3.95 to 48.59 ng in the volume of 12 liters (Table 1) was determined.

In samples taken at 8:00 a.m. when the bees started rummaging, 3.45 ng were determined, and at 4.00 p.m. when they came back, 48.59 ng of 2,3 DNT were determined. DNT quantity in the period when bees did not fly (rain, morning) is significantly lower.

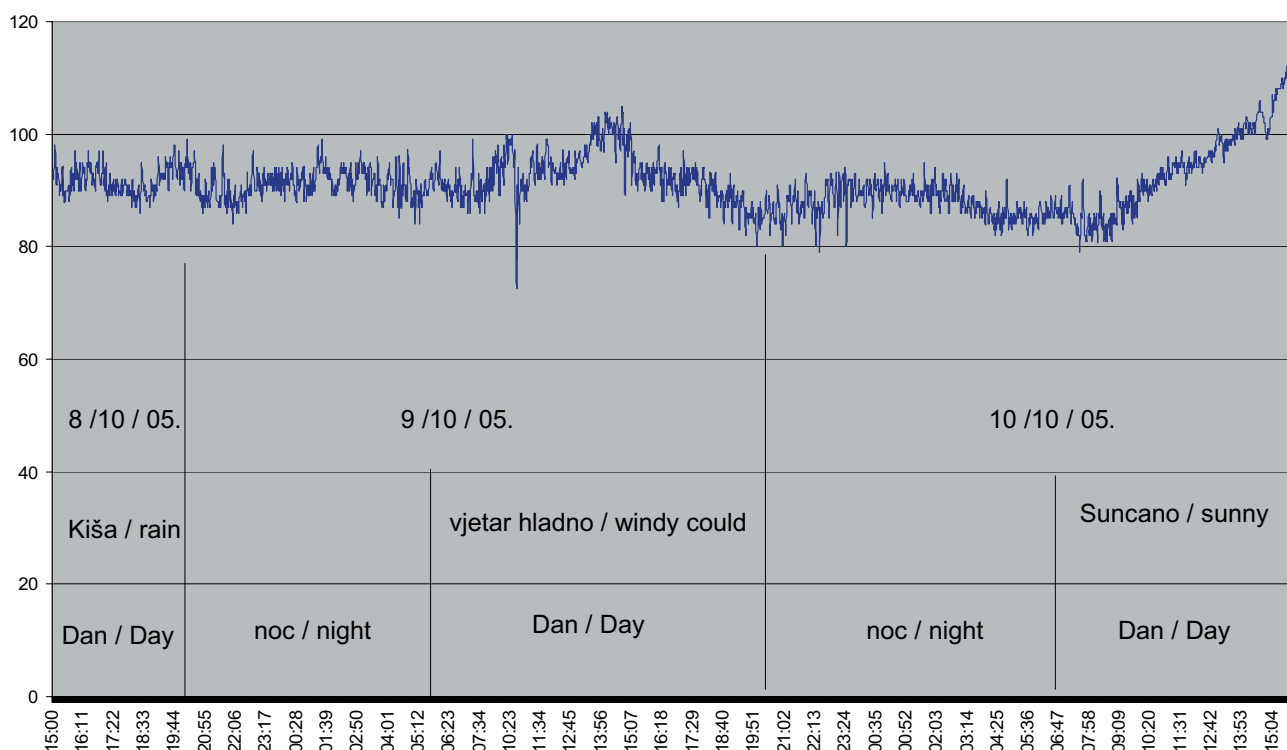
Table 1. Concentration of 2,3 DNT and 246 TNT explosives found in 12 L of air from the beehive placed at the Benkovac test site in 2005.

Weather	Date	Start time	2,3 DNT	2,4,6 TNT
Rain	9.10.2005	9,30	5,48	n.d.
Not rain	9.10.2005	17,45	11,64	n.d.
Sun	10.10.2005	9,15	3,95	n.d.
Sun	10.10.2005	16,00	48,95	n.d.

By connecting an electronic nose, change in concentration of DNT in the beehive on the third day, when bees started rummaging, was determined (graph 1).

Active method

When collecting nectar, bees orient themselves by the learnt specific odor of the food source. They remain consistent in gathering nectar connected to one type of odor as long as they can find the food with the same odor. Adjusting to a new odor, and also to a new food source,



Graph 1. Detection of emission of substances from the beehive by an electronic nose

takes one to two days. For the purpose of pollinating cultivated plants and fruit trees which are less attractive to bees, training is conducted. With the training we direct bees to the plants we want to pollinate. The program of training bees to the TNT odor is based on the experience in pollinating plants by using bees. Since TNT has a very discrete odor, training of bees is more complex. Bee colonies which were trained had been formed only one day before we started with conditioning, mainly from old bees on a new honey-comb, and a mother bee was added. Glass feeders were designed for training (Figure 3). TNT was added beneath the soil in the feeders where food was offered.



Figure 3. Feeder for training of bees

Bees also memorize the shape of the food source. During the training identical feeders were placed which contained no food or TNT (check-up). First two days after formation, colonies have settled and oriented in space. At the beginning, the feeders were placed in front of the beehive so that bees would be able to find the food. After they have found the food, the feeders were placed away from the beehives and check-up feeders were added, so that they would learn to differentiate between the feeders with odor and those without odor (Figure 4).



Figure 4. Layout of feeders and check-ups in front of beehives

In the next two days we changed and/or replaced the positions of feeders with food and check-up feeders. After the bees were accustomed to find the food in the location of the TNT odor, we moved the colony to the test site. Bees are interested in the TNT odor for one or two days, when new food must be offered, or a new colony prepared. For tracking the movement of bees in the area, i.e. to track the swarms of bees on locations of buried mines, a tracking system has been developed with a camera which takes images in infra red area (Bajić 2004). Further research of bees training will be focused on influence of concentration of TNT in feeders, i.e. on speed and intensity of conditioning.

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Conclusions from the Workshop Held in Geneva in February 2006.

Noel Mulliner²⁷

This is the third Symposium I have attended and I am very pleased to have been asked to speak after the opening ceremonies. The first Symposium concentrated on the most impressive achievements of CROMAC and justifiably promoted the part played by machines in their operations. The second Symposium built on this foundation and addressed a more international approach as well as an interesting practical demonstration of various flail capabilities. Both meetings made excellent use of the outdoor demonstration area and proved the saying that "seeing is believing". I therefore have every confidence that this Symposium will live up to expectations and be as informative and interesting as the other two.

I should start by sincerely thanking our hosts for not only inviting us all to this series of Symposia but also for the unique opportunity they offer to discuss and demonstrate so many different aspects of the application of technology in mine action today.

We are gathering today very soon after the first International day of Mine Awareness and Assistance in Mine Action (4 April 2006) and just before the next round of Intercessional Meetings of the Ottawa Convention. Both events are relevant to mine action at this point in the life of the AP Mine Ban Convention - a time for assessment and review. There were many events planned around the world for the International Day but the message was clearly "we have achieved a great deal and we can complete in years/decades instead of hundreds of years." I would like to add a few comments in relation to this message specifically directed to mine action related technology, as well as reporting, in general terms, on a Technical Workshop held in Geneva in February.

Over the years I have tried to understand the conflicting statements and dynamics around mine action technology, its application and its availability. Much is talked about technology, but not always by people who understand all the issues. Hence there is often confusion, misunderstandings and unreal expectations. The

silver bullet is not coming our way and yet we frequently talk in terms such as "What we really need is....". When, perhaps what we mean is that a particular technology would be very useful in some locations, some of the time, and when it is useful, that we need a lot of it to finish the task quickly and then we don't care what happens to it. Our needs are often specific, and not globally applicable, they are wanted for a finite period and they may also be satisfied by mechanical solutions, which then have social consequences of reduced employment for those who need it etc. etc. It is a complex business but it does not make a lot of economic sense to donors, manufacturers and inventors who continue to be confused as to what it is we need.

There are also economic and social factors to be considered and political influence, national legislation and restrictions differ from country to country. Therefore no simple technical solution or requirement is ever applicable to everyone. Add brand loyalty to all this and it is extremely hard to standardize and so we are inevitably left with a range of different situations requiring different equipment with different capabilities for varying periods of time. The coordination of this at the programme level is hard but at the international level is much more complicated.

A further dilemma has been the inability to answer developers and would-be inventors, manufacturers etc. who seek advice about what we want, and how many of them, are needed for mine action. How big is the market?

To try to answer some of these questions and listen to requests UNMAS and GICHD held a technical workshop earlier this year, in Geneva in order to gather information from a broad cross section of qualified field operators. Fifteen country programmes were represented along with 6 NGOs and 4 commercial companies, collectively representing some 8000 metal detectors. The Workshop was a development of a project funded by the Canadians and was aimed at identifying some of the real and basic needs of demining operations and programmes. It was a very interesting meeting and was a representative gathering of technically minded personnel. I regret that it was not open to everyone but the

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findings are available to all.

Without going into great detail of the many findings and conclusions, which I have to admit were significant in number but not dramatic in their originality, I would like to offer my own personal conclusions.

At the Workshop it became apparent to me that there were three different interest groups in the stakeholders of technology and mine action. Landowners and communities want technology to bring clearance of their land faster but they have no way of articulating what is needed. Demining organisations and operators, the second group, while obviously concerned over the safety of their employees, are not all specifically interested in efficiency (unless they are commercial companies) as, perhaps controversially, they are keen to continue operations and their employment in this field. This group actually raised no significant new requirements at the Workshop. (Interestingly, this difference between commercial and non-commercial operators may well be more significant in the introduction of dual sensor detectors when they become available. Commercially, dual sensors will allow more work to be done, faster, and hence more contracts and more income, whereas for non-commercial operators their introduction will be at the expense of long term operations and provide competition for limited funds.)

Finally, there is the group of donors, without whom very little can effectively be done. It should surely be in their interest to reduce the cost of demining and to achieve results as soon as possible. At the Workshop it was announced that the annual output for one programme had been effectively doubled by the introduction of just 14 brush cutters by a single donor. Think for a moment what this means. In one year they achieved what would have taken two years simply because they had 14 brush cutters. They have saved one year of operational costs. What could they have done with 21 or 28 brush cutters? The cost of these machines must be a fraction of the cost of annual operations and so can be easily recovered in the short to medium term. Brush cutters are simple, existing technology, but the application of them in the right place at the right time has produced very impressive results. This would suggest that donors can, therefore, perhaps take a more decisive role in the application of technology – obviously with direct and local consultation to ensure the end user can cope. This process introduces a different approach to the question of technol-

ogy – rather than waiting for programmes and operators to tell industry what they need, which they sometimes have difficulty in articulating for a number of reasons not least of which are time and the fact that many do not seem to know what else is possibly available, it should be possible, with the experience that is available to day, for donors to provide what is necessary to do the job and to encourage change and innovation. I can hear great groans from some who remember the days when ill advised equipment was dispatched to support programmes simply because a donor wanted to be seen to be providing it or promoting it. Well this is not what I am suggesting. While I have heard comment from some field based personnel that no-one ever visits them to give technical advice but most just come to see what is happening or criticize what has happened, I believe that, correctly coordinated, it should be possible for donors to sponsor technical visits to provide themselves with information as to how best to spend their money as well as providing advice to programmes on how best to tackle their problems. I believe the community contains sufficient experience to provide this service and it is not too late. I believe there is scope for further discussion in this area. Can we double the annual output of any other programmes simply the sponsorship of more equipment

Returning now to the theme of the International Day and achievements; you/we, the demining community, have been picking up mines for nearly 17, yes, 17 years now and so we should be pretty good at it and we most certainly should have achieved a great deal. We should also have come to terms with what works and what does not in various situations. This is true and I think we are good at it, and we have achieved a great deal, and we do know what works and what does not. I also believe that we are talking in years to reach a nationally sustainable and acceptable situation in very many places in the world. And yet, we continue to hear talk of the huge problem ahead and the need for new technologies to solve it. How can this be, or is the problem also of availability and visionary application rather than a need for more new ideas?

In many countries we should by now have addressed the high priority areas, as well as the areas that were originally medium priority but were lifted to high priority when the original high priority areas were cleared! So, what are we left with today, what is the problem? In very general terms, I think we are faced with

the more physically difficult areas to reach and clear (the wooded areas here in Croatia are examples) and huge areas that are suspected to be hazardous but probably do not actually contain any/many landmines or UXO, (an issue for data audit and survey). There can be few formal mine fields left to clear.

We **have** developed good equipment to locate landmines with metal content (the vast majority) and we have presumably removed a lot of mines as a result. We also know a lot about other equipments and processes and, even though a great deal is talked about criticizing much of their use, land is being handed back having been processed by these equipments or a combination of flails, dogs, tillers etc. To deal with the difficult areas like forests, underwater dangers and shifting sands etc. we may need some new specialist equipment and methods but these will certainly be on a limited basis and not generally applicable everywhere. To deal with the confirmation that areas do not actually contain any dangers also requires specialist equipment but this requirement was identified way back in 2002 by a GICHD study into Global Operational Needs, and has still not been adequately resolved. So what are the **apparent** needs of today for the demining community? More money- yes, more of what has proved successful so far - yes, some specialist equipments – yes, and a way to quantify the risk of suspect areas and release them quickly back to the communities. The point I am trying to make today is that maybe we do not need much new technology. We have most of what we need to finish this job already but we do need to have more of what works, and to have them in the right place and the right time, and this is more a logistical and resource problem than a technical problem. One could go so far as to say that there is really no time left to develop new technologies and have them deployed to the field for effective use. This is another reason to make better use of what we have got today and this would include the need to understand and manage risk better and show more common understanding of basic common sense.

Let me end by highlighting just a few of the requirements identified at the Workshop.

- Improvement in the comfort and protection of the deminer was a very high concern and a greater dialogue must be maintained between manufacturer and users of PPE.
- Continued testing and sharing of more trial results for the dual sensor detectors was en-

dorsed but operators really do need to consider how they will take these new detectors on board, if at all.

- There remains a gap in the ability to conduct surveys that can quickly reduce and release areas or prove that roads are clear. While this may never be totally satisfied the use of the humble honey bee remains a tantalising potential possibility! The application of sensible risk analysis is also necessary but physical action will still be required to convince local communities.
- We really do need to know more about how best to use the REST system, or at least whether it works, and more about the effectiveness of dogs.
- The use of integrated teams in the clearance process is very effective.
- There still appears to be a role for rollers –especially in the proving of cleared, cancelled or released areas.
- Alternatives to explosives remain just that but are too expensive currently to buy. If donors, however, provide them they would be welcome in many areas.
- There is a need for better communication of technology information – news about what works, where and how. Equally records of mechanical performance must be kept, to build up the ability to explain performance and cost. Technology meetings are still required and appreciated.
- Innovation, initiative and delegated powers of authority can produce simple but effective solutions to problems. Equally a slavish adherence to SOPs which are inflexible and out of date produces highly detrimental results to output and morale.

This symposium will give us the opportunity to see and discuss several issues related to the use of technology and machines in demining. It will again offer the opportunity to see how others are doing it and what is available. I therefore urge you to take away contacts and ideas and try to fit existing technology and procedures that you see here into your own programmes and operations today. If you are responsible for a programme or operation, and if you can select your equivalent of the “14 brush cutters” from this Symposium, you will be much better able to request and persuade donor support and resolve your problem in short years not decades.

Thank you.

Detection of Explosives in Landmines by Nuclear Quadrupole Resonance (NQR)

T. Apih²⁸, A. Gregorovič²⁸, R. Blinc²⁸, J. Seliger^{28, 29}, J. Lužnik³⁰, Z. Trontelj^{28, 29}

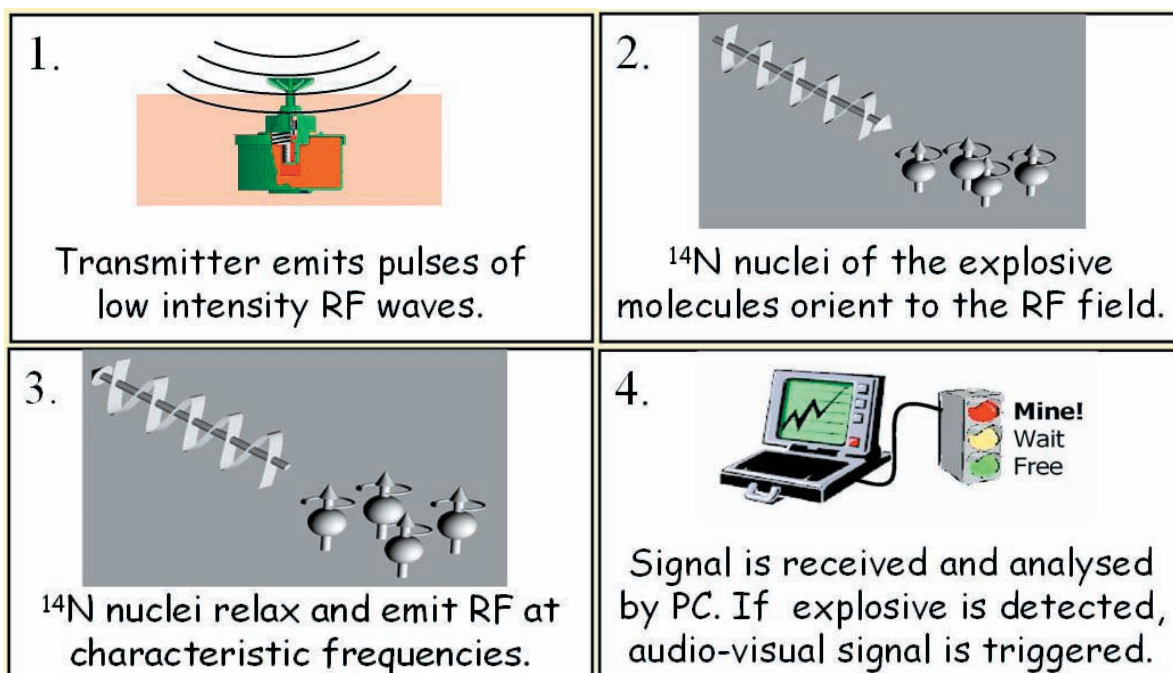
Abstract

Nitrogen ^{14}N nuclear quadrupole resonance (NQR) is a molecular compound specific spectroscopic method. It's potential in method for remote detection of nitrogen-bearing explosives, which gives some hope of speeding up the lengthy demining process of abandoned minefields. In comparison with other mine detectors, such as metal detectors and ground penetrating radar, the advantage is that NQR detector does not produce false alarms due to shrapnel and other metallic clutter. The NQR detection does not depend on metal content or landmine shape, since it detects the presence of nitrogen in explosives explosive directly. Also, due to chemical sensitivity, NQR is not affected by presence of other nitrogen compounds, such as fertilizers. NQR is able to detect all main explosives used in landmines, such as RDX, HMX, PETN and TNT. Unfortunately, the ^{14}N NQR frequencies of TNT explosive all lie in a very low frequency region (below 1 MHz), which reduces the sensitivity of the method and makes pure NQR detection of TNT very difficult. Slovenian research groups at IMFM and JSI concentrate their work on developing polarization techniques to improve the sensitivity of NQR to detect TNT. Two techniques are being used: ^1H - ^{14}N nuclear quadrupole double resonance (NQDR) and polarization enhanced ^{14}N NQR (PE-NQR).

Introduction

Nitrogen ^{14}N NQR represents a promising method for remote detection of explosives in land mines, as the main explosives used in land mines (TNT, RDX, HMX, PETN, ...) all contain nitrogen. The main advantage is that the method

is molecular compound specific, i.e. it does not depend on any feature of a mine (such as metal content), but it detects the presence of explosives directly. Even the presence of other nitrogen bearing compounds (i.e. fertilizers in the soil) will not influence the detection, due to much different resonance frequencies.



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Since radio-frequency electromagnetic waves do not penetrate metal, NQR will not detect explosive in metal-cased mines. This, however, is not a serious drawback of the method, since NQR detector can work also in the "metal detector" mode where it detect metal by it's influence on the on the NQR probe tuning.

The main disadvantage of the NQR method is its low sensitivity, which is roughly proportional to square of the ^{14}N NQR frequency in the given molecular compound. The method works well for RDX where the NQR frequencies lie in the range between 3 and 5 MHz. Unfortunately, NQR frequencies of TNT, which is the dominant explosive for land mines, all lie below 0.9 MHz. Therefore, the NQR signal may be too weak to detect in a reasonable measuring time and some sort of enhancement of the signal will be needed for practical application of the method.

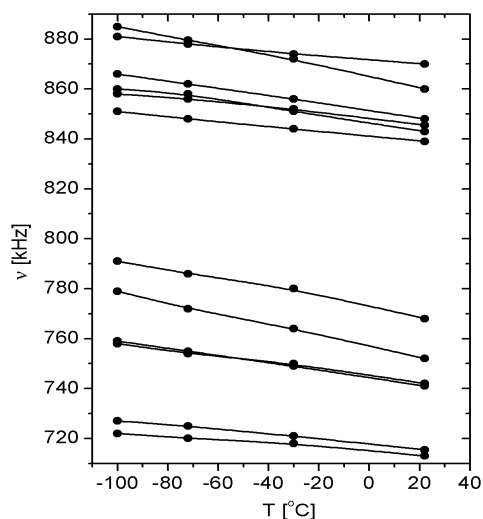


Fig. 1 Temperature dependence of the ν and ν_{+} ^{14}N quadrupole resonance frequencies in TNT.

Table 1 NQR frequencies of the six nonequivalent nitrogen nuclei of military grade TNT at room temperature. The seventh line is probably due to impurities in the sample.

	ν_0 (kHz)	ν (kHz)	ν_{+} (kHz)
1	160	712	872
2	92.5	769	861.5
3	110.5	742.5	853
4	132	718	850
5	92	755	847
6	95	742	837
7	~0	~807	~807

1. ^1H - ^{14}N quadrupole double resonance (NQDR)

The ^{14}N NQR signal to noise factor can be enhanced in the laboratory by the use of the proton-nitrogen nuclear quadrupole double resonance (NQDR) technique with magnetic field cycling. Here the weak ^{14}N NQR is not detected directly, but rather indirectly by its influence on much stronger and easier to detect proton (^1H) nuclear NMR signal. Here the proton nuclear magnetic resonance (NMR) signal is measured in a high magnetic field. In the experiment, the proton NMR system is coupled to the nitrogen NQR system by the use of magnetic field cycling and rf magnetic field irradiation. When the systems get in resonance, the energy flow (polarization transfer) between the systems reduces the observed proton signal, enabling an indirect detection of the ^{14}N NQR signal.

Various implementations of the basic experiment were tried, achieving a signal to noise increase by a factor 30 with respect to standard direct ^{14}N NQR for military grade TNT.

The sensitivity of NQDR technique can be further increased by making the energy flow between the two sub systems more efficient. This is achieved in the "NQDR with multiple level crossing" experiment, where proton NMR levels and nitrogen NQR levels cross several times in between the "rf irradiation" period.

Nuclear quadrupole double resonance techniques, described above, enable fast and efficient determination of ^{14}N NQR parameters on *sub-gram* samples of the explosives, including TNT. However, the need for highly homogeneous magnetic field for the detection of protons and the expected masking of the sample signal by 'environmental' protons make this technique impractical for the out of the laboratory use.

2. Polarization enhanced NQR (PE-NQR)

In polarization enhanced NQR (PE-NQR) experiment, the pure NQR signal in zero magnetic field is enhanced by transferring nuclear polarization from previously polarized ^1H nuclei.

In the experiment, a strong magnetic field is initially applied to the sample. It is important that there is no need for the magnetic field to be homogeneous, as it is used only to polarize protons and not to detect the proton NMR signal. In the second stage of the experiment, magnetic field is reduced (either by turning off the electromagnet or by re-

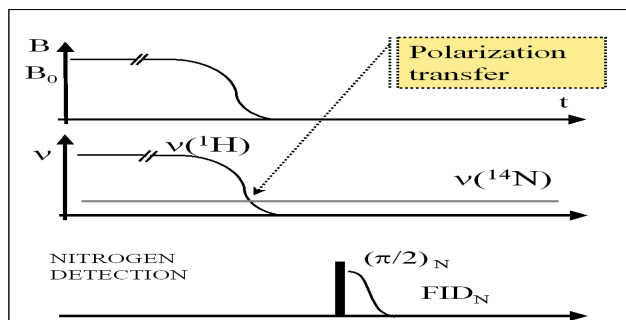


Fig. 2 PE-NQR experiment scheme. External magnetic field polarizes the proton nuclear subsystem. After magnetic field is reduced to zero and ^{14}N NQR and ^1H NMR levels splittings cross, (enhanced) ^{14}N NQR signal is detected in zero magnetic field.

moving the permanent magnet). During this adiabatic demagnetization, the proton NMR splitting is reduced and eventually equalized to the small ^{14}N NQR splitting, causing an energy flow from the 'hot' nitrogen NQR system to the 'cold' proton NMR system. Consequently, the nitrogen NQR system is 'cooled' (polarized), and ^{14}N NQR signal, detected by standard NQR detection techniques immediately following the magnetic field removal. In our laboratory experiments, an approximate enhancement factor of 10 was obtained for TNT detection, which allows for a "single scan" detection.

3. Summary and Conclusions

Advantages of NQR detection:

- nondestructive detection
- selective detection of explosives
- reduced number of false alarms
- improvement of electronics makes equipment more affordable every year

Disadvantages:

- nonmature technique
- larger energy requirement than metal detector
- can detect explosives only close to receiver coil, rf interference
- low sensitivity for TNT

Indirect detection of ^{14}N NQR signal by NQDR enables signal to noise factor enhancement of about 30 in the laboratory conditions. However, experimental requirements make the method impractical for the use in the field.

PE-NQR in an inhomogeneous magnetic field has been successfully tested on TNT. An enhancement factor of about 10 was obtained, which enabled a single scan detection of 50g TNT sample. Evaluation of the method for the remote detection of TNT is currently underway.

Acknowledgment

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Samplings in Humanitarian Demining

Tomislav Ban³¹

Summary:

The paper presents HRN ISO 2859-1 standard «Sampling procedures for inspection by attributes».

Sampling plans are indexed according to acceptable quality level (AQL) for lot-by-lot inspection.

Implementation of standard refers to «Sampling for inspection and control of soil treatment depth during demining machine usage» and «Sampling for inspection and control of surface area demined and searched by metal detector».

This way of sampling and standard implementation is used in order to avoid subjectivity of persons performing stated activities and establish safety mechanisms for final beneficiaries.

The paper will elaborate basic elements of the standard and its implementation in humanitarian demining.

An important segment of all activities carried out is their documenting and keeping records of stated activities.

Key words: HRN ISO 2859-1 standard, lot, level of inspection, incorrectness, non-conformity, acceptance terms

1. Introduction

The sphere of humanitarian demining in the Republic of Croatia is defined by Law and Book of Rules and Regulations.

The Law on Humanitarian Demining published in the National Gazette (Narodne Novine, 153/05) is a result of several years' work, created as rich in practice and based on use of IMAS within the boundaries of applicable and for sampling by using ISO 2859-1 standard, Sampling by Attributes.

The Law defines humanitarian demining operations, persons involved in performing the operations, means and mode of operations execution and liability for conducting the same. The Book of Rules and Regulation should follow the Law and is currently under development with transitional period of one year as defined by law.

Beside laws, rules and regulations, IMAS standards are also used for preparation of Standard Operating Procedures (SOPs) of the Croatian Mine Action Centre as documents that set the guidelines. ISO 2859-1 standard is used for sampling during mine search and mine clearance operations (Figure 1).

The use of standard is based on statistic analyses and sampling plans are indexed as per acceptable quality level AQL for lot-by-lot inspection. The use of standard is followed by laws and by-laws in the process of sampling in humanitarian demining and has the purpose of reaching higher quality of operations carried out, avoid subjectivity of individuals while making decisions about whether something was well or badly done.

2.1. Application Sphere

Elements of standard used while preparing SOPs for samplings should prevent various approaches to performance of the same as well as prescribe clear instructions how something should be done, which documents to make etc. When performing quality assurance, the standard is applied to:

- Sampling for inspection and control of soil treatment depth during demining machine usage
- Sampling for inspection and control of the area demined and searched by metal detector

The standard sets the guidelines for implementation of quality assurance of searched and/or demined area by applying sampling plans indexed as per acceptable quality level (AQL) for lot-by-

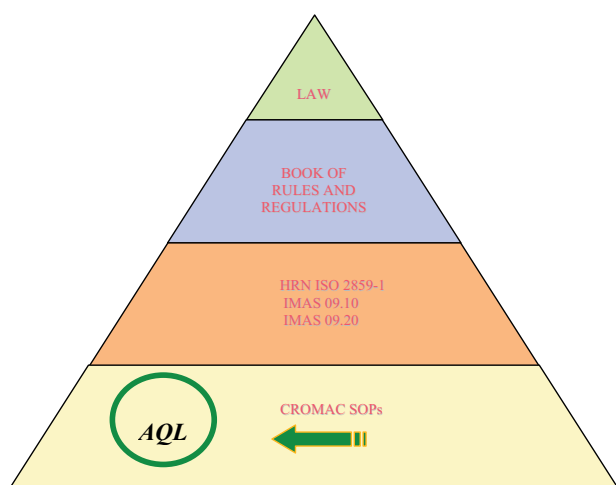


Figure 1

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lot inspection of searched or demined area.

It is applied for soil treatment depth measurement during demining machine usage and quality assurance.

Elements of standard used during the production of SOPs for samplings should disable different approaches to performance of quality assurance operations, prescribe clear instructions for conducting the operations and documenting.

Besides, transition rules with regard to sampling results achieved are integral elements of standard. It is defined that each company starts with regular inspection and with regard to the results achieved, quality i.e. non-quality of work, becomes the subject of tightened or reduced inspection. The process continues all the way to redoing the accreditation process if standards are frequently not met.

2.2. General Requirements and Acceptable Quality Level (AQL)

Quality assurance is an important part of humanitarian demining management process whose purpose is to verify the quality of mine search and mine clearance operations and establish required quality level according to Book of Rules and Regulations on Methods of Demining and in line with contractual liabilities.

Term “acceptable quality level – AQL” used in ISO 2859-1, HRN ISO 2859-1 refers to the objective mathematical probability of reaching required medium soil treatment depth during mine search.

The AQL is the mark for non-conforming items percentage value that will, by sampling scheme that should be used, be most frequently accepted. When mine search projects are concerned, the AQL represents reaching required level that makes the border value of acceptable mine search average. Sampling plans are prepared in a way that the acceptance probability for denoted AQL value for the AQL given depends on the sample size.

Efficiency and value of quality assurance by sampling for the purpose of checking requires mine search to be “complete and controlled”. “Complete” process implies that every entity to be surveyed includes the land treated/searched under the same conditions (daily treated area), in the same way, using the same tool.

In order to avoid excessive rejection of daily searched area, average of soil treatment depth is expected to be lower than AQL or equal to that

value.

Acceptable quality level (AQL) to be used is defined by the contract or mine search and/or mine clearance project.

2.3. Sampling for Inspection and Control of Soil Treatment Depth during Demining Machine Usage

Sampling for inspection and control of soil treatment depth during demining machine usage is defined by Standard Operating Procedure CROMAC SOP 04.02 and prescribed by Article 71, paragraph 9 of the Book of Rules and Regulations on Methods of Demining.

2.3.1. Demining Machines

Results of demining machine testing currently being carried out according to demining machine test program that is the enclosure 2 of the Book of Rules and Regulations are precondition for the application of SOP 04.02.

Demining machines represent great assistance in conducting mine search and mine clearance operations since they use working tool – flail or mill – to remove the vegetation that represents, besides mines, the greatest limiting factor during the operations execution. They use their working tool to treat the soil and create the preconditions for easier work of deminers.

Authorised legal entities in the Republic of Croatia own 54 demining machines:

- 7 heavy (figure 2),
- 8 medium (figure 3),
- 22 light (figure 4) and
- 12 excavators



Figure 2

All the machines used in the humanitarian demining process are tested in regard to:

- protection and safety
- effect on ERW
- capacity m²/h and
- soil treatment depth



Figure 3

Based on test results, the machine is awarded usability assessment and used in humanitarian demining process.

Besides testing, regular annual verification of every machine is carried out with the purpose of establishment of changes arisen.

Test results i.e. the quality of machines' work is important for the establishment of confidence level and is related to the application of standard (table 1).

Consequently, confidence level in relation to the machine type is defined with regard to the soil conditions.



Figure 4

Table 1

No.	Soil conditions	Level of confidence/machine type		
		Small degree	Normal degree	Large degree
		Light machine	Medium machine	Heavy machine
1	Favourable soil conditions (SC1)	91%	95%	99%
2	Aggravated soil conditions (SC2)	81%	85%	89%
3	Heavy soil conditions (SC3)	71%	75%	79%

Confidence level is defined based on impact of working tool on mine clearance and vegetation. Light demining machines such as MV-4, Božena-3 and 4 and similar have low level of confidence ranging from 71 to 91% of efficiency.

Medium demining machines such as RM-KA, Samson, Hydrema, MV-10 and similar have medium level of confidence ranging from 75 to 95% of efficiency.

Heavy demining machines such as Rhino, Scanjack, Mine Wolf, MV-20 and Oracle have large level of confidence ranging from 79 to 99% of efficiency.

Besides defining three levels of confidence (I, II and III) as per machine type, two levels of inspection have also been defined – general and special (table 2).

Table 2

No.	INSPECTION LEVEL	LEVEL OF CONFIDENCE/MACHINE TYPE			
		LIGHT M.	MEDIUM M.	HEAVY M.	
1.	GENERAL LEVEL	III	II	I	
2.	SPECIAL LEVEL	S-4	S-3	S-2	S-1

General inspection level is always applied at the beginning of work i.e. during sampling when demining machine starts the work upon testing or on certain area when there is still not enough experience in working with the machine in such soil conditions. Special level is applied when, upon initial samplings carried out, the machine reaches good results i.e. average soil treatment depth is continuously bigger than the one determined by the project.

2.3.2. Quantification of Measurement Results

Measurement results in regard to measured values of mechanically treated soil are quantified as irregularities i.e. non-conformity.

IRREGULARITY: Deviation from quality attributes (projected soil treatment depth) whose result is that searched mine suspected areas do not meet the requirements arising from project design or contract.

NON-CONFORMITY: Deviation from quality attributes whose result is that mechanically treated mine suspected areas do not meet certain requirements.

Non-conformity class A – Single measured soil treatment depth is smaller than 12 cm in the first soil category and smaller than 6 cm in the second and third category.

Non-conformity class B – Single measured soil

treatment depth is smaller than 17 cm and bigger than 12 cm in the first soil category. In the second and third category, it is smaller than 8 cm and bigger than 6 cm.

Non-conformity class C – Single measured soil treatment depth is smaller than 20 cm and bigger than 17 cm in the first soil category. In the second and third category, it is smaller than 10 cm and bigger than 8 cm.

Conditions for lot acceptance i.e. rejection will be elaborated more precisely through the example that follows.

2.3.3. Sampling Procedure

2.3.3.1. Lot Size Definition

Lot is a sum of treated MSA items (m²) – daily or weekly mechanically treated area out of which the sample should be taken and inspected in order to establish conformity with acceptability criteria.

Daily or weekly treatment (search) of MSA using demining machine as an independent method is

formed into the recognizable lot, sub-lot or some other appropriate form. Each lot has to be treated under approximately the same conditions (the same soil and climatic conditions, same machine type and working tool).

2.3.3.2. Determination of Confidence Level

After that, one should read off confidence level from table 2 according to machine type.

As already emphasized, general inspection level is taken for initial inspections and if it is successful, transition to special levels can be executed.

2.3.3.3. Determination of Sample Size and Number of Measurements in the Sample

Upon determination of inspection level and confidence level sample size and number of measurements in the sample are read off.

For example: Confidence level for medium machine is II and for the lot of 3.250 m² one should read off the code letter D first. After that, other values in the line 4 of the table 3 should be read off. Sample size is 100 m² and it is required to execute 15 measurements in every sample.

Table 3- Sample Size Code Letters

No.	Lot size (m ²)	Sample area (m ²)	No. of depth measurements	Special levels of inspection				General levels of inspection		
				S-1	S-2	S-3	S-4	I	II	III
1	200-500	50	10	A	A	A	A	A	B	C
2	501-1-200	50	10	A	A	B	B	B	C	D
3	1-201-3200	50	10	B	B	C	C	C	D	E
4	3 201-5 000	100	15	B	C	C	D	D	D	E
5	5 001-8 000	100	15	C	C	D	D	D	E	F
6	8 001-15 000	100	15	C	D	D	E	E	F	F
7	15 001-35 001	200	20	D	E	E	E	E	F	G
8	35 001-150 000	200	20	D	E	E	F	F	G	H
9	150 001 and over	200	20	E	E	F	F	G	H	J

Table 4

Supplement C1 : Table 4-A - One-time sampling plans for the normal inspection																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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2.3.3.4. Determination of the Number of Samples

With values given in the table 3, we begin with one-time sampling plan (table 4).

We should always start with regular inspection. In respect to the acceptable quality level in the column 1 we should find the code letter (D) previously read off. Then, we read off the number of samples in the lot in the next column and that is 5.

2.3.3.5. Sampling Plan

There are a number of alternative sampling methodologies impossible to be applied. Certain parts of treated soil that should be inspected will be selected using random sampling method.

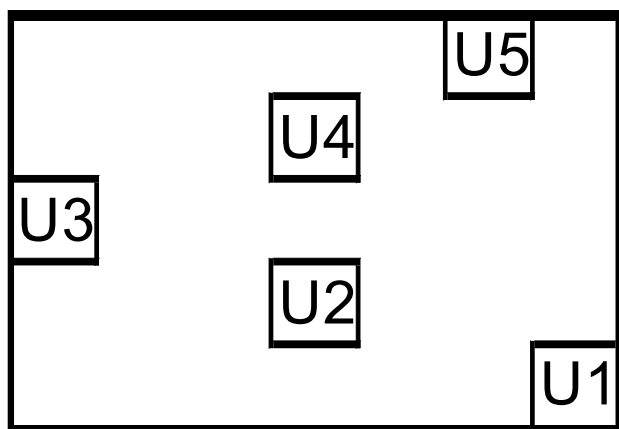


Table 5

Positions of measurement in the sample are selected in a way to cover the entire sample area. After that, according to sample size, one should determine the combination from Appendix D (D2, D2-1 and D 2-2).

2.3.3.6. Scheme of Movement inside the Sample

When all the parameters relevant for sampling are fulfilled, it is required to select the scheme of movement inside the sample. Selection is performed as per prepared plans i.e. the same represents the mode/way of moving inside the sample and sampling or measurement spot.

Distance in the sample is measured in steps as per enclosed scheme of movement inside the sample and, in principle, in the centre of the sample itself but can also be measured in any part of sample m^2 . Soil is dug up with a small shovel up to the hard base. (Figure 5) Then, a hand scale is placed in the middle (Figure 6) and depth measurement performed (Figure 7).

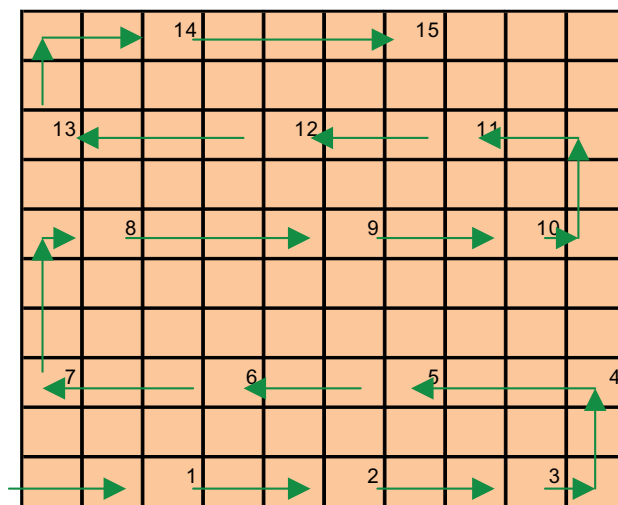


Figure 5



Figure 6



Figure 7

Measurement results for each sample are entered into prescribed forms and finally summed for the entire lot; in this case 5 samples.

2.3.7. Quality Level Acceptability Criteria

ACCEPTANCE CONDITIONS	I cat.	II and III cat.	ACCEPTABILITY LEVEL	
	depth 20 cm	depth 10 cm	ACCEPT (Ac)	REJECT (Re)
			Xsr>20 cm Xsr>10 cm	
IRREGULARITY	Deviation from quality - not satisfying conditions			
NON-CONFORMITY A	>12	>6	0	1
NON-CONFORMITY B	<17>12	<8>6	2	3
NON-CONFORMITY C	<20>17	<10>8	3	4

“The entity” will be considered as “quality treated/ searched” only if the average value of measured samples is equal or bigger than the projected value. If any entity sample comprises one or more average measured depths, smaller than the projected, that will make “critical non-conformity” (non-acceptance/non-allowed defect) and the entity comprising this sample will not pass the final inspection/quality control.

Searched soil can contain single non-conformities classified into three groups: A, B and C. Such cases would indicate possible «defect» and create critical fault (defect) again.

Terms for acceptance or non-acceptance of all non-conformity categories are given in the table. Upon execution of all measurements, registration and interpretation of results, lot is accepted or rejected.

For example: the lot is rejected (Re) if one measured value for the first soil category is smaller than 12 cm or if three measured values are between 12 and 17 cm or 4 measured values between 17 and 20 cm. The lot is accepted if measurement results match the ones stated in the table 6, with meeting the condition that medium depth is equal or bigger than 20 cm.

If stated conditions are not met in only one of the samples, the entire lot is returned for mechanical treatment all over again.

2.4. Sampling for Inspection and Control of the Area Demined and Searched by Metal Detector

Sampling for inspection and control of the area demined and searched by metal detector is defined by Standard Operating Procedure

CROMAC SOP 04.03 and prescribed by Article 73, paragraph 5 of Rules and Regulations on Methods of Demining.

2.4.1. Mine Detection Dogs

The results of MDD testings are preconditions for use of SOP 04.03. Testings are carried out according to program for demining machine testing given as the Enclosure 1 to the Rules and Regulations.

Accredited legal entities in the Republic of Croatia dispose of 126 mine detection dogs.

All MDDs (figure 8) used in humanitarian demining process are tested. In line with test results, they are awarded usability assessment of a dog-handler team for the period determined according to score points.



Figure 8

Besides, when speaking of use of below-mentioned SOP, it is also important to set some facts on metal detectors (figure 9) used in humanitarian demining process. They have to pass regular annual verification and each deminer should have certificate of competence for work with metal detector issued.



Figure 9

Metal detectors represent basic means of deminer's work. Deminer should reach complete work site clearance by using metal detector.

2.4.2. Quantification of Measurement Results

Measurement results are quantified as irregularity i.e. non-conformity.

IRREGULARITY – detection of mines, UXOs and fragments with explosive substances.

NON-CONFORMITY – deviation from quality attributes whose result is that area inspected by metal detector or MDDs does not meet certain requirements

- non-conformity class A – singly detected and identified mine and/or UXO metal fragment with length L or diameter D bigger than 10 cm.
- non-conformity class B – singly detected and identified mine and/or UXO metal fragment with length L or diameter D from 5 to 10 cm.
- non-conformity class C – singly detected and identified mine and/or UXO metal fragment with length L or diameter D from 3 to 5 cm.

2.4.3. Sampling Procedure

Sampling procedure, lot size definition, number of samples etc. is identical to depth measurement procedure at demining machine usage. During sampling by metal detector it is required to search the entire selected m².

All detections in control samples are dug up (figures 10, 11 and 12) and results of the length of detected fragments, that is, mines, UXOs and/or fragments registered.



Figure 10

Every non-detected mine and UXO metal fragment is examined in a way that its length i.e. diameter is measured and the result entered into the form.

When mines/UXOs or fragments containing explosive substances are detected, such ordnance SHOULD NOT be moved and work site leader and QA Officer must be informed. Detection is registered/type, depth, position and photographs of ordnance taken. Quality Control on the lot is suspended.

2.4.4. Conditions for Acceptance - Rejection

During quality assurance and control of the area searched by MDDs, mine and/or UXO metal fragments found should contain at least 3 grams of explosive substance to be considered as non-conforming.

This relates to metal fragments (shrapnel): warheads, hand grenades, rifle grenades, gun grenades, shells, AP mines, fuses and so on.

Such found metal mine and/or UXO fragments with traces of explosive substance will be considered as non-conformities of certain class.



Figure 11



Figure 12

Table 7

ACCEPTANCE CONDITIONS			
IRREGULARITY	Mines/UXOs containing explosive substance		
	ACCEPTABILITY LEVEL		
	Mine and UXO metal fragments	ACCEPT (Ac) (pcs)	REJECT (Re) (pcs)
NON-CONFORMITY A	< 10 cm	0	1
NON-CONFORMITY B	from 5 to 10 cm	1	2
NON-CONFORMITY C	from 3 to 5 cm	2	3

3. CONCLUSION

Detailed description of procedures intended to minimize subjective trust including human factors such as perception, assessment and opinion.

When speaking of depth objects (mines and UXOs) should be found at, some issues are raised: which is the optimal depth for work with metal detector considering its limitations? Is depth of 20 cm a delusion?

Which are the limitations of MDDs i.e. what is that they can not detect?

Beside limitations that people and means of work definitely have, the important factor of quality is continuous training and practice for the purpose of minimizing the existing limitations. Carrying out continuous control and sampling of searched and demined areas will create people's trust in quality and safety of demined area.

Application of Advanced Methods in Clearance Projects of Rivers and Wet Areas from Unexploded Ordnances (UXOS)

Toša Ninkov³², Sasa Vukadinović³³, Dragoljub Cvetković³⁴,

One of essential exploration tasks relating to Clearance Projects of rivers and other wet areas included search operations of areas and identifications of locations with remaining unexploded ordnances (UXOs).

In this paper the word UXOs shall have the meaning of aircraft bombs and other projectiles of great ferrous magnetic weight, differing from generally accepted glossary term in demining operations that UXOs also denote such items as cluster bombs, artillery ammunition, hand grenades and shells and alike. For this reason, the word UXO will be replaced by the word projectile in further text.

Due to unknown features of searched projectiles, the non-destructive (non-invasive) geophysical methods have been applied and these range among the methods of non-contact/remote sensing detection. Search and test operations called for application of multiple complementary methods. The task was made even more complex because the riverbank area and the river flow have been included into the areas of planned search activities. The search activities of the riverbanks and river flow for presence of UXOs were conducted by application of geodetic surveying and geophysical methods, which have yielded high quality results both in terrestrial and marine investigations.

The advanced GPS (Global Positioning System) and GIS (Geographic Information System) technologies were used to generate adequate layouts for analysis of suspected UXOs locations and to ensure precise navigation of vessels with magnetometer equipment fitted for search operations of selected territory sections and for accurate positioning of detected projectiles.

Key words: Global Positioning System (GPS), Geographic Information System (GIS), Geomagnetic measurements, Digital Terrain Model (DTM), UXO (Unexploded Ordnance).

Introduction

In the 2002-2005 period the expert team of PMC Engineering associates (the GPS team, Geomagnetic Institute of Serbia and the EOD team) carried out the surveys and geomagnetic measurements at the locations of the destroyed bridges of the Danube and the Sava Rivers and their riverbanks in the total area of 4.500.000 m². It was possible by application of the said geophysical test methods to determine the zones wherein "high-amplitude" anomalies of the total intensity of geomagnetic field (F components) were recorded. Intensive anomalies of geomagnetic field indicated occurrence of the sources at "low" depths, in the zones of riverbanks and the river water flow thus they could be correlated to the presence of projectiles [1-7].

The advanced technologies of Global Positioning System (GPS) and Geographical Information System (GIS) were applied for the purpose of providing the quality databases for analysis of possible projectile locations, for precise navigation of vessels equipped with magnetometers used for search of selected territories and for accurate positioning of detected projectiles. The GPS technology and equipment facilitated pre-

cise geo-referenced positioning and display of all relevant area entities and phenomena, which were demonstrated on the existing and newly made topographic maps. The GIS technology with the modules for digital topography was applied for putting together the complex graphic and alphanumeric databases of all georeferenced values and phenomena including their describing and alphanumeric attributes [8-12].

The geo-referenced coordinates of critical zones, which indicated intensive and dominant anomalies of the total intensity of geomagnetic field were accurately determined on the basis of analysis and interpretation of geophysical (geomagnetic and geo-radar) test results obtained from the locations of destroyed bridges of Novi Sad (Sloboda, Žeželj and Petrovaradin Bridges), near Beška and Ostružnica, and in the Danube and Sava water flows. The critical zones with recorded anomalies of high intensity geomagnetic field could be correlated to the occurrence of the objects having heterogeneous contents (metal objects, blocks of reinforced concrete structures, metal pipes, wire-ropes, projectiles and others).

Methods of geophysical tests

The methods of geomagnetic measurements and terrain surveys were applied to the locations of the destroyed bridges and the river flow

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with their riverbanks for the purpose of detecting the characteristic anomalies of the total intensity of geomagnetic field. In the process of measuring the changes of the total intensity of geomagnetic field along assigned trajectories, the daily variations of geomagnetic field were continuously measured at the previously determined base stations. The base stations were set up in magnetically quiet homogenous area. The daily variations of the total intensity of geomagnetic field recorded in the base station were compared, each day, with the daily variations of geomagnetic field recorded in Geomagnetic Observatory of Geomagnetic Institute in Grocka (Belgrade).

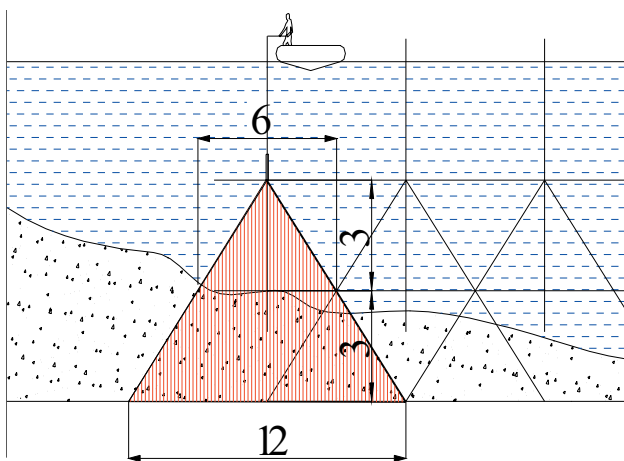


Figure 1 Schematic display of the mode of measuring with geophysical methods

Geomagnetic measurements of the river water flow were carried out along the projected and precisely geo-referenced trajectories. The GPS station recorded the coordinates of the trajectories along which the vessel was traveling with the instruments and equipment. The referenced coordinates of the GPS system (time and distance per X and Y directions) were recorded when measurements of the total intensity of determined point of trajectory took place at fixed intervals (at each 5 seconds).

Results of geomagnetic measurements at the locations of the destroyed bridges of the Danube River

Measurements of the total intensity of geomagnetic field were carried out with the GSM-10 proton-magnetometer of high precision ranging up to ± 0.25 nT, namely with the level of measurement up to 20000-100000 nT and the range of measurement up to ± 2000 nT (nanoTesla /

nT/ is the unit to express the total intensity of geomagnetic field). The GSM-10 instrument and the GPS mobile station were placed into the dinghy (Figure 1), which was headed by the GPS station to the trajectory along which it was traveling. While traveling along the trajectories, the instrument was sampling the values of the total intensity of geomagnetic field at each 5 seconds together with synchronized recordings of the dinghy positions in geo-referenced coordinates of the GPS station (Figure 2).

The results of detailed geomagnetic measurements relating to the changes of the total intensity of geomagnetic field at the locations of destroyed bridges of the Danube River, carried out per described methodology were produced in the form of the data base containing:

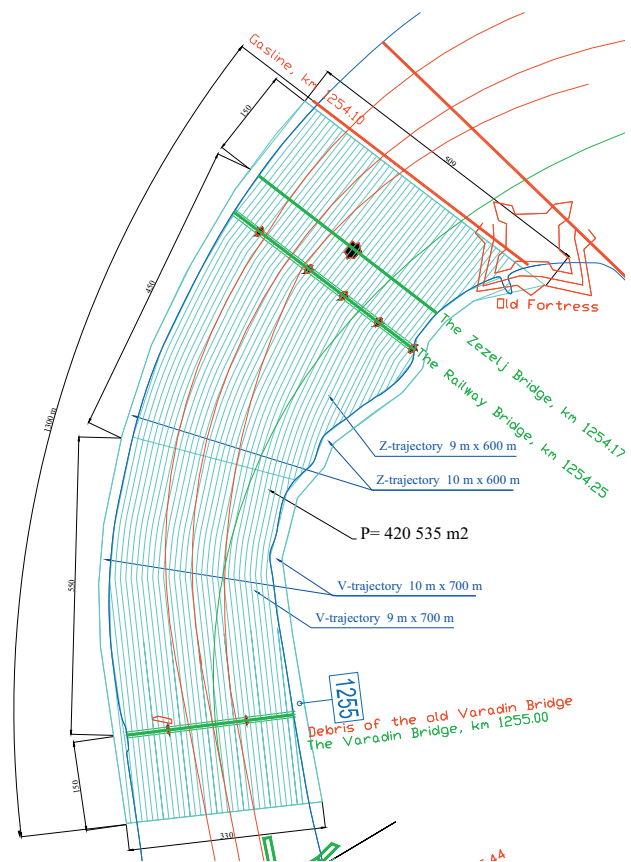


Figure 2 Trajectories along which the measurements of the total intensity of geomagnetic field were carried out

- Date of measurement;
- Hour, minute, second, commencement of geomagnetic measurement (per UT time);
- Recorded F component value of the geomagnetic field with the sampling step of 5 seconds;
- Geo-referenced coordinates of the point where intensity of the F component was measured.

The geomagnetic results of the total intensity of the tested locations were defined in the area-time coordinates, i.e. in an adequately precise geo-referenced coordinate system. These could be plotted in diagrams indicating the distribution of anomalies of the total intensity of geomagnetic field, namely in 2D or 3D diagrams. Figure 3 has shown the area of search with referenced points and trajectories that served for measuring of the total intensity of geomagnetic field.

The measurements of the total geomagnetic field intensity were carried out at the location of destroyed *Sloboda* Bridge and technical survey of terrain was carried out at the left bank of the Danube River (the Strand beach) with geo-radar equipment. Points of measurements per geo-

magnetic profiles were distant for 2 m from each other. The base station was set up in the local park, at the left bank of the Danube River some 150 m far from undestroyed platform of the *Sloboda* Bridge. Geomagnetic measurements started on 05.03. 2002 and the records of the daily variations of the total intensity of geomagnetic field (F components) covering the riverbank zone and the Danube River water flow took place continuously until 28.04.2002. The measurement results of the total intensity of geomagnetic field in the zone of the Danube riverbank, of the Danube water flow and at the locations of destroyed bridges were compared with the daily variations both in the base station and in Geomagnetic Observatory of Grocka.

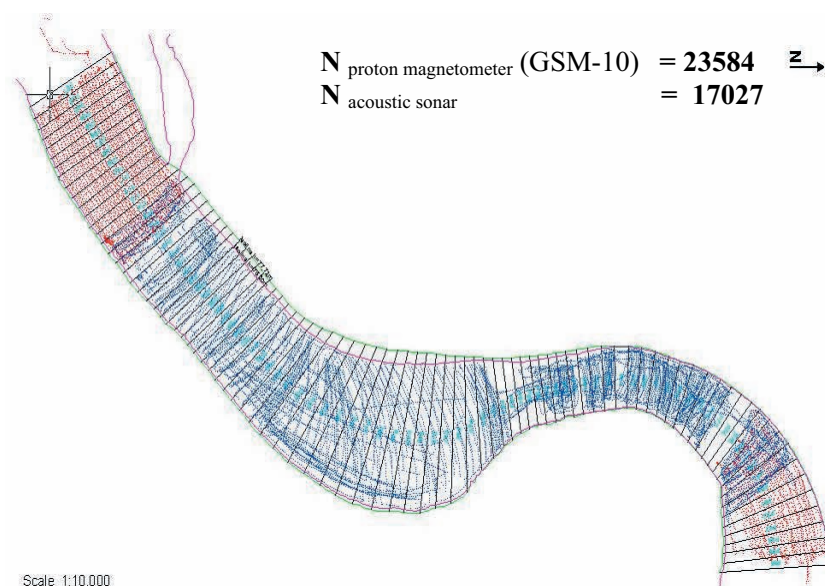


Figure 3 Zone of search with marked measuring points that served as the basis for measuring of the total intensity of geomagnetic field with acoustic sonar

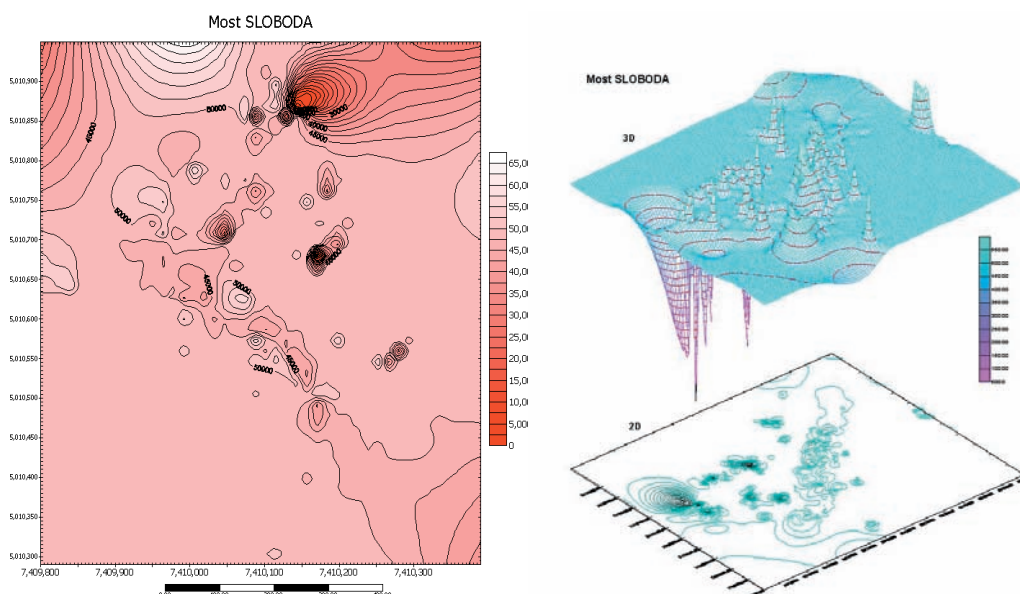


Figure 4 Anomalies of geomagnetic field (2D and 3D photo) in the Zone of Sloboda Bridge, Novi Sad

Characteristic and dominant zones of anomalies could be distinguished from distribution of the changes in the total intensity of geomagnetic field at the locations of destroyed bridges. They pointed toward presence of the objects of variegated dimensions and diversified magnetic features (magnetic susceptibility, intensity of magnetization, physical and chemical features of materials) in the water flow and in the riverbed. Anomalies of elongated shape with recorded lower or higher values than the average daily variations at the base station could be associated to big platform blocks of the *Sloboda* Bridge, embedded in the riverbed to some extent and protruding the water level to a certain degree. Anomalies of nearly circular form or of irregular ellipse shape indicated the objects, which could be of nearly spherical or cylindrical shape (Figure 4).

The measurement results of the F component of geomagnetic field in anomalous zones were compared with the results of search operations conducted with metal detector MD-2 Ferex and with the survey results of the riverbed obtained from acoustic sonar.

The zones of dominant anomalies indicating the changes in the total intensity of geomagnetic field and the findings of metal detector, which produced positive results (the anomalous value of the field intensity is in correlation with intensive echoes of metal detector) were marked as the primary critical zones. Figure 5 has shown critical zones of *Petrovaradin* and *Žeželj Bridges* with detected UXOs.

Anomalous zones, which did not produce positive results during search operations with metal detector, were marked as secondary zones. These were probably the areas accommodating the objects (whose impact on the intensity of geomagnetic field was detected), which penetrated to deepening depths, i.e. those going beyond the project task determined for detailed search of embedded projectiles.

The analyzed structure of detected anomalies of geomagnetic field in marked critical zones was properly interpreted. The recorded values of the total intensity of geomagnetic field were marked per profiles along the X and Z axis of geo-referenced coordinate system. These diagrams have shown the area configuration of measured anomalies. It was possible, on the basis of obtained parameters, which have related to dimensions of geomagnetic field anomaly, to design the depths of the objects, which caused the changes of field intensity in critical zones.

Measuring of riverbed profile and data processing

Measuring of transversal profiles was carried out with the calibrated system composed of 2 GPS equipment, acoustic sonar and *Laptop* computer configured with *Hydropro* software. One of GPS equipment (the base) was put over one of the control network points of the project. Operation of both GPS equipment was synchronized by *Trim-talk* radio equipment. The second GPS equipment (paired with acoustic sonar) was able to determine, via its TCS1 controller and the second radio equipment, its position with 2-3 cm of accuracy per time increment or passed route determined beforehand. In the same moment, the acoustic sonar measured the depth of water, in synchronized manner, and such recorded data were added to the point coordinate of the profile, i.e. in the point where antenna was mounted in the vessel. Position and height of antenna mounted in the vessel had to be taken into consideration when computing the depths. The best solution was accomplished when the GPS antenna was positioned in the axis over the vertical holder of acoustic sonar probe. Control of vessel travel along designed trajectories (parallel with distance of 10 m) was monitored on *Laptop* display and therefore it was possible to define with precision any deviation from the direction of determined profile. When required, the correction of any trajectory was possible. If deviation was too great, the profile survey

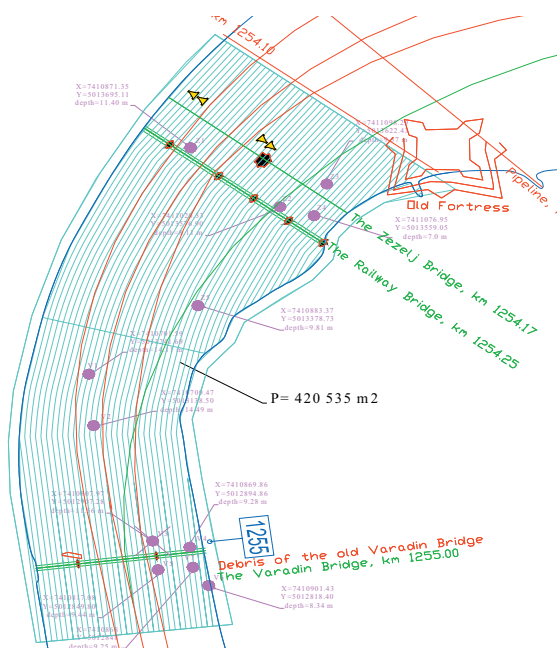


Figure 5 Suspected UXOs locations in the zone of Petrovaradin and Žeželj Bridges

had to be repeated. The survey of all designed profiles was carried out by application of the said procedure. Density of the points that served for survey operations (one point at each 10 m of traveled route) was also controlled via computer display. When measurement operations were conducted during presence of turbulent waves of the Danube River, produced measurement results had to be eliminated due to wave impact upon the values of measured depths for the purpose of ensuring the accuracy in depth determination. Processing of measuring data was carried out in two stages. The first stage of data processing was done with HydroPro program package, and the second one with the software for digital topography and GIS *ArcInfo/ArcView*.

The first stage included primary processing and control of data integration, i.e. the data measured by GPS and acoustic sonar. In the processing phase, the data of detailed point coordinates were automatically integrated into the State coordinate system (measured by GPS on the basis of Real Time Kinematics (RTK) method) including corresponding values (data) on measured depths. The control process had to prove that each measured point was provided with its recorded coordinate, supported by measured depth. If such process requirement was not met, then respective point had to be eliminated from the base of measured data. If measurement process was performed during turbulent waves of the Danube River, the corrective values for each measured point had to be computed and

their effect eliminated from the measuring results. All measuring results were conveyed to the Excel program database wherein final coordinates and levels of detailed riverbed points were computed. The second stage of numerical processing was carried out with the GIS program package of *ArcInfo/ArcView* and relevant 3 D *Analyst* module for 3D digital topography (Figure 6). Utilizing the capabilities of the said software program packages, the DTM was generated out of collected data of area coordinates with detailed points based on the triangular principle. Such DTM showed the best possible local min and max of terrain level, and therefore the formed model was the best possible approximation of real conditions (Figure 7).

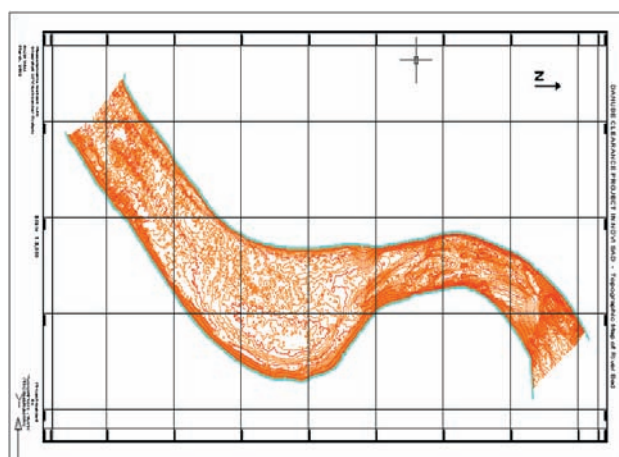


Figure 6 Iso lines of the Danube riverbed from Sloboda up to Žeželj Bridges

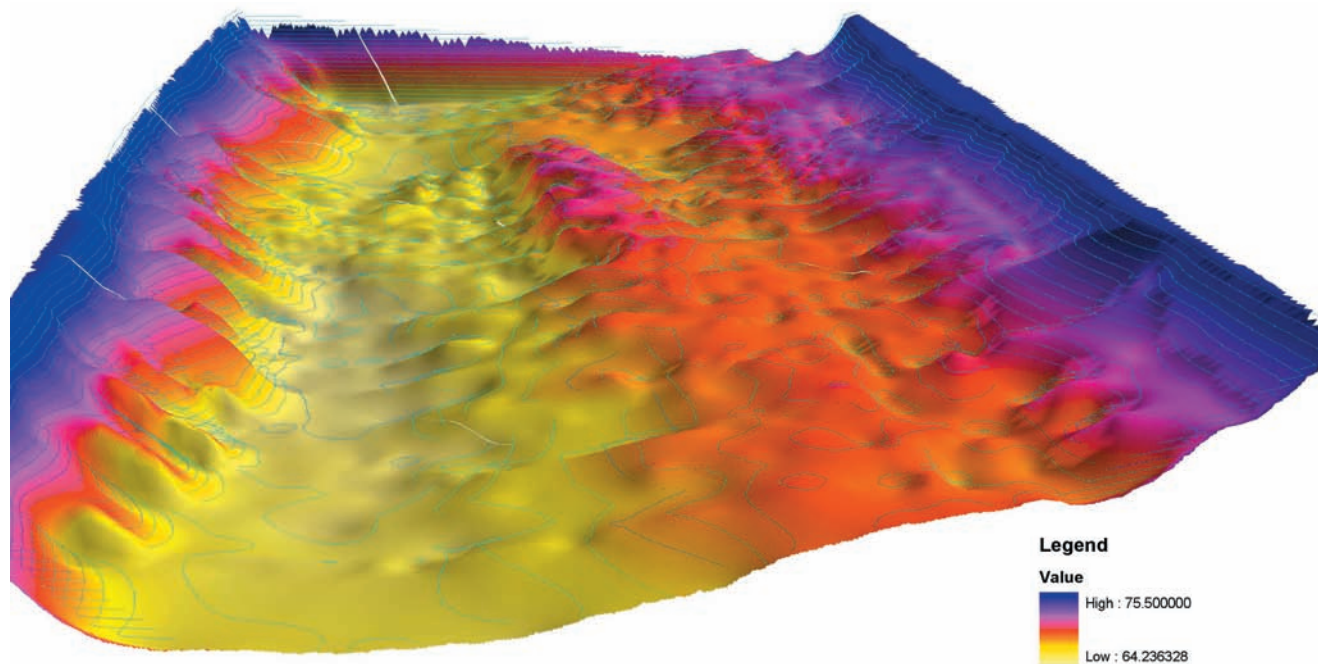


Figure 7 3D display of distorted topography of the Danube riverbed caused by erosion effects of water triggered by the Danube current in the zone of destroyed Sloboda Bridge

The formed DTM served as the basis for automatic generating of iso lines with equi distances of 0.5 m or of those having any other value.

Conclusion

The procedure of projectiles detection at the locations of the River Bridges was carried out with the advanced measurement and survey geophysical methods of the GPS system. The interpretation of complex geophysical and survey tests enabled splitting up of the zones with projectiles. The structure of geomagnetic field anomalies (Figures 4) designated the anomalies, which originated from concrete blocks and metal structures of the destroyed bridges. The anomalies of elongated shape (blocks of irregular dimensions) corresponded to the debris of the destroyed Zezelj Bridge. It was in the riverbed and some of its parts protruded above the river level. The anomalies of irregular circular and elliptic shape stood for complex effects of the piers and metal structures of the Railway Bridge.

The measurement results of the F component of geomagnetic field in the anomalous zones were compared with the search results obtained from metal detector MD-2 Ferex and the survey results of the riverbed provided from acoustic so-

nar. That was the way to determine accurately the geo referenced coordinates of anomalous zones by complex analysis of all search results. The zones of dominant anomalies, which indicated the changes in the total intensity of geomagnetic field and the findings of metal detector, which produced positive echoes (the anomalous value of the field intensity is in correlation with the intensive echo of metal detector), were marked as primary critical zones. The anomalous zones, which did not produce positive echoes during search operations with the metal detector, were marked as the secondary zones. These were, most probably, the zones where the object (whose effect upon the intensity of geomagnetic field was detected) was far deeper than the depth defined by the project task for detailed search of projectiles. These parameters of distribution of recorded changes in the total intensity of geomagnetic field have enabled the selection of 47 critical zones in total, indicating the characteristic anomalies of geomagnetic field. They became the zones of detailed investigation and search operations of the riverbed with metal detector MD-2 Ferex. Figure 8 shows the 3D diagram made on the basis of measurements with the metal detector prior to and after removal of projectiles.

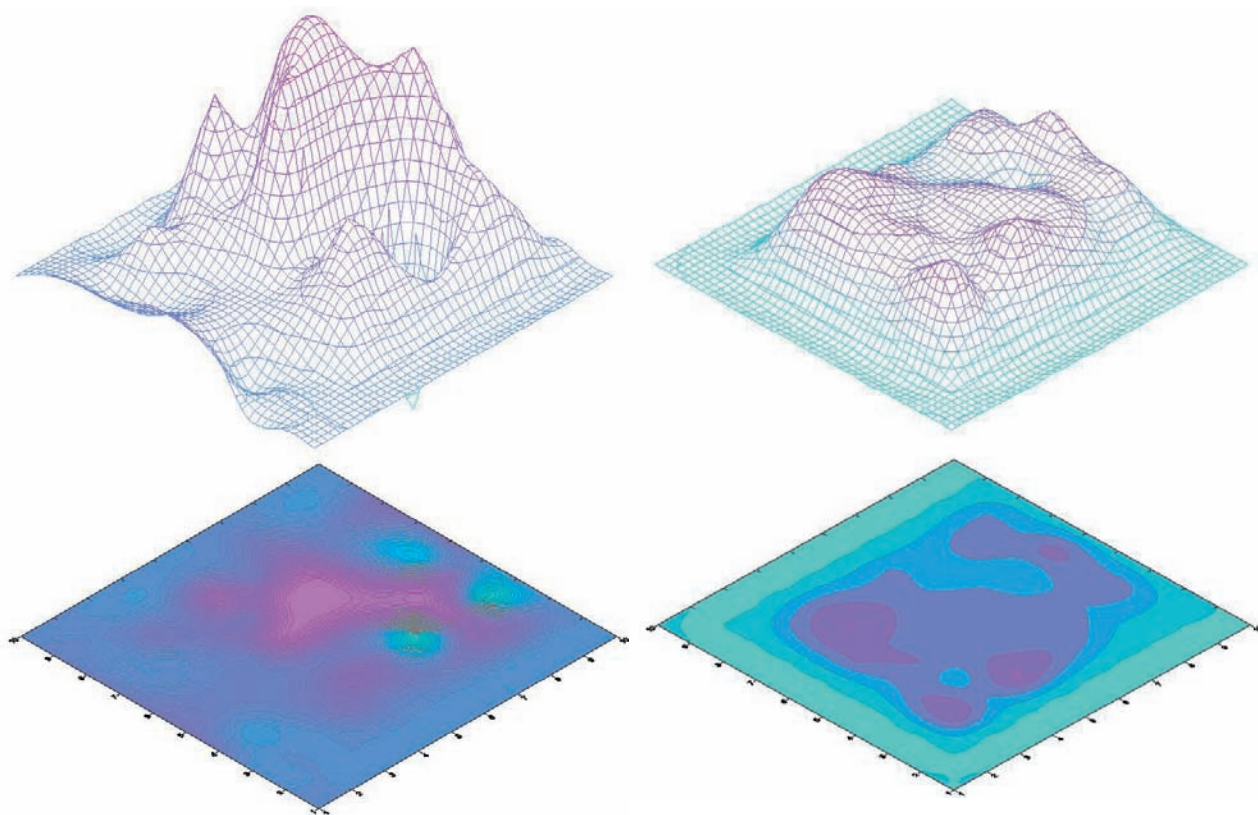
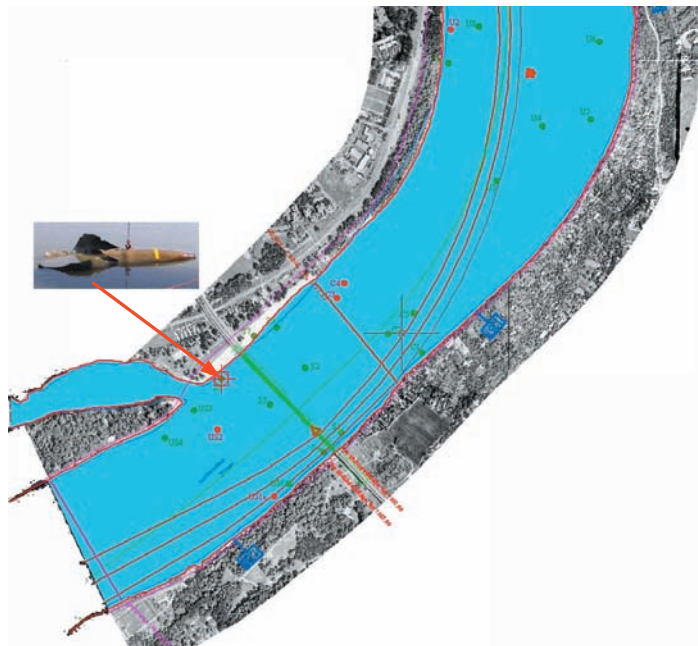
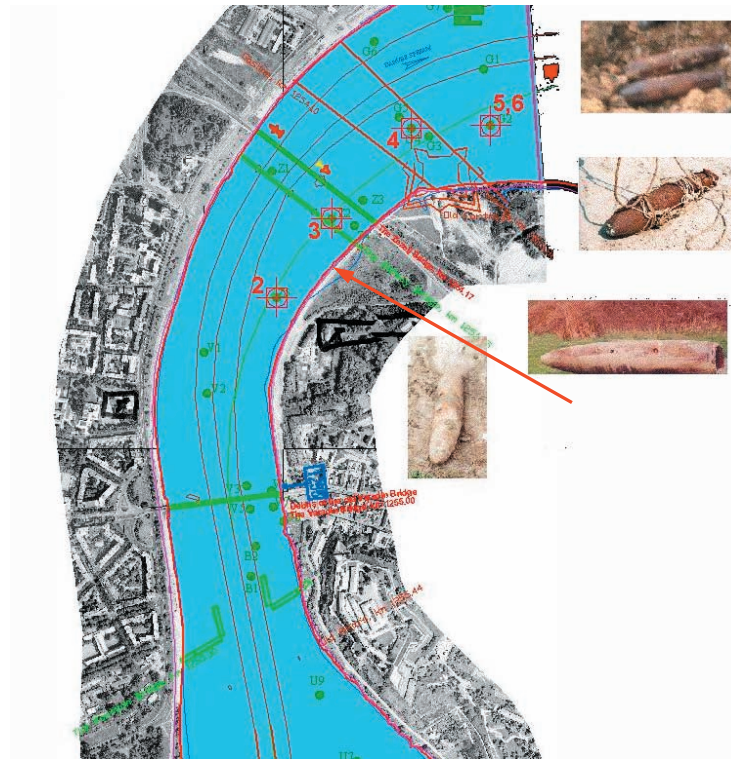


Figure 8 MD-2 diagram prior to and after projectile removal from one of the critical points

The operations of the EOD divers were conducted in the most unfavorable conditions due to:

- maximum water level of the Danube River in the period of Project implementation
- water temperature, which was rather low, i.e. + 5°C
- high velocity of watercourse current
- water turbulences, which were extremely powerful (caused by destroyed bridge structures)
- visibility at the riverbed, which was highly poor (10 – 20 cm).

Six (6) projectiles were removed from the river bed during the first stage of operations. Their locations and views have been shown in Figure 11. The first three (3) projectiles were the aircraft bombs Mk 82 and Mk 84 of the NATO bombardments in 1999. Other three projectiles originated from the World War II (Figure 9).



1

Figure 9 Locations of the Danube river near Novi Sad with detected projectiles

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Capacity Exploitability of Croatian Mine Action Firms

Vedrana Miličić³⁵

In a period following the year 2000, many Croatian mine action firms have been working on increasing human resources (increased number of pyrotechnics), technical and mechanical equipment (considerable increase in mine clearance machinery). A number of search dogs for mine detection has also been increased, so today, with the total of their capacities, these firms are capable of clearing vast territories. It all results from considerable investments these firms made in relation to equipment, but also professional trainings.

The year 2000 is here taken as a starting point, when the Republic of Croatia started considering the mine problem in a more comprehensive way. The existing capacities were at that time insufficient for mine clearance procedures that were to take place.

On the other hand, at present, 5 years later, the capacities of the Croatian firms are not exploited.

This presentation is to raise awareness of the existence of disproportion between mine contaminated environment and capacity under-utilization of the Croatian mine action firms, considering mine contamination of the Croatian territory as a disaster.

MINE CONTAMINATION OF THE CROATIAN TERRITORY IS A DISASTER

A disaster represents a significant disruption in functioning of a community because it causes human losses, material and environmental damages that overcome the abilities of the affected community preventing it to solve the problem by using its own resources.

Consequences of the ravages of war are also considered to be disasters.

What makes us entitled to consider the mine contamination of the territory of the Republic of Croatia a disaster, among other things, is:

- the 2000 estimate according to which, on 4500 km² of a mine suspected area covering 14 counties, there are 1.000.000 mines.
- the end of 2004 estimate according to which, on 1174 km² of a mine suspected territory, there are, with reference to the minutes, 246 000 mines. Mine suspected area spreads over 12 counties (57% of all counties in the Republic of Croatia), 121 cities or districts (22,16% of all cities or districts in the Republic of Croatia), and 1.112.793 inhabitants (25% of all inhabitants of the Republic of Croatia) face the consequences of mine contamination on daily basis.
- Ever-present consequences of mine contamination:
 - Cases of death and injuries (medical and psychological traumas, social and economic problems)
 - Interruption of usual way of life

- Economical losses (economically potential areas are being unused, farmlands are being unused, forests are not being exploited)
- Developmental disturbance of economy and society
- Unusable infrastructure
- Loss of primary means of support
- Sociological and psychological consequences of the inhabitants in mine suspected areas
- Depressing feeling of lack of freedom of movement
- Security and ecological consequences

RESPONSE TO DISASTERS AND ITS EFFECTS

The Republic of Croatia responded to mine contamination by creating legal and organizational assumptions for applying counter-mine actions. It also made a commitment to destroy mines on its territory until 2010 defining in that way a period of time needed to get things back to normal in mine contaminated areas. ("Disaster relief" determines all the activities being undertaken during disaster itself and during the period of disaster relief because of faster normalization of life in the affected areas. – "Protection and Rescue Law")

At the same time, defining its budget as a basic means for financing de-mining activities (Means for the realization of de-mining activities are provided for in the national budget of the Republic of Croatia and in other resources – "Humanitarian De-mining Law"), the Republic of Croatia accepted the costs of disaster relief which, at a rough 2000 estimate, came to 9,52 billions of kunas. (table 1)

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Table 1. Activity plan and estimate of needed resources for the period 2000 – 2010

Time	Mine suspected areas – km ²	Areas to be surveyed – area reduction – km ²	Areas to be de-mined	Necessary means for a survey and de-mining in billions of kunas
2000-2004	2100	1850	250	3,87
2005-2010	2400	2050	350	5,65
Total:	4500	3900	600	9,52

Table 2. Used up means and de-mined area in the period 1998 – September, 2004

Financial resources	Used up means in billions of kunas	De-mined area in km ²
Croatian national budget	885,0	178,0
World bank loans	202,8	
Public firms and other corporations	251,9	
Donations - foreign 88% - national 12%	217,3	
Total:	1 557,0	

Table 3. Total capacities of the licensed Croatian mine action firms

	2000.	2004.	Capacity increase in percentage
Number of registered licensed mine action firms	17	49	288%
Pirotechnics	450	610	135%
De-mining machines	9	45	500%
Metal detectors	250	677	271%
Mine detection dogs	18	136	755%
Total capacities of croatian mine action firms in km ² per year	20	75	375%

Table 4. Activity plan and estimate of the necessary means for the period 2005 – 2010

Year	Mine suspected areas – km ²	Areas to be surveyed – area reduction – km ²	Planned for de-mining	Necessary means in billions of kunas
2005			50,0	550,0
2006			75,0	750,0
2007			75,0	700,0
2008			75,0	700,0
2009			70,0	650,0
2010			40,0	380,0
Total:	1174,0	789,0	385,0	3 730,0

Table 5 Comparison between 2000 and 2004 (areas to be de-mined and necessary means)

Time	2000 estimate of an area to be de-mined in km ²	De-mined; 2004 estimate in km ²	3/2 (%)	2000 estimate of necessary means in billions of kunas	Used up means; 2004 estimate in billions of kunas	6/5 (%)
1	2	3	4	5	6	7
2000.-2004.	250	155	62 %	3,87	1,27	33%
2005.-2010.	350	385	110 %	5,65	3,73	66%
Total:	600	540	90 %	9,52	5,00	53%

De-mining activities started to be attended to on commercial basis and thus formed the environment for creating new de-mining companies. By the end of the year 2004, a recapitulation of the previously performed de-mining activities could already be done and our capabilities for closing the chapter of de-mining activities could be estimated.

According to the afore-mentioned data, it is necessary to emphasize:

- Having accomplished a number of counter-mine activities and having used suitable new methods of evaluation in the previous periods (2000-2004), a mine suspected area has been considerably reduced (from 4500 km² to 1174 km²). On the other hand, 38% of areas less than planned have been de-mined (95 km² less), and a balance has been postponed to the upcoming period (2005-2010).
- In a previous period (2000-2004), according

to the 2000 estimate, 33% of estimated means were spent. For the following period (2004-2010), according to the 2004 estimate, 66% of all means is necessary to be used out of the 2000 estimate. A total of necessary means for de-mining, if we add up the used up means in the previous period and estimated means for the following period, would be 53% out of the means estimated in 2000. (table 5)

In contrast to the reduced de-mining realization, and contrary to the reduction in investing in de-mining activities, in a period from 2000 to 2004, total capacity of Croatian mine action firms has increased which can be seen in an increase from 20 km² to 75 km² of de-mined areas per year, which means 375% (table 3). This is the period in which the Croatian de-mining firms have increased their capacities in terms of human resources (increased number of pyrotechnics), technical and mechanical equipment (a considerably increase in de-mining machinery). A number of search dogs for mine detection has also been increased, and it all results from considerable investments these firms made in relation to equipment, but also professional trainings.

Taking into consideration that the national budget, in the last three years (2004, 2005, and 2006), has provided only approx. 150 millions of kunas for the de-mining activities and comparing that with the necessary means: approx. 700 – 750 millions of kunas per year (table 4.), even with the funds coming from other resources, we can evaluate that only up to 50% of the planned activities would be realized.

We have to emphasize that the capacities of the Croatian mine action firms are such that they are capable of bringing to realization even 100% of the planned activities, that is, to de-mine the territory of the Republic of Croatia until 2010.

CONSEQUENCES OF THE ACTION

The results are:

- time for the de-mining of the Republic of Croatia will be prolonged for at least five years and things in the contaminated areas will be brought back to normal, at earliest, 2015,
- a number of de-mining firms will give up de-mining work which will cause, among other things, loss of primary means of support for the pyrotechnics and the rest of the employees, loss of the originally invested means in

acquisition of machinery and equipment and miners' education. No new firms will be created because of the impossibility to work successfully. Total capacities will be reduced.

Taking the year 2000 as a starting point, when the Republic of Croatia started considering the mine problem in a more comprehensive way, we might say that the existing capacities were at that time insufficient for de-mining procedures that were to take place. On the other hand, at present, 5 years later, the capacities of the Croatian firms are not being exploited.

What is clearly noticeable is the existence of disproportion between the assumed commitment and declared interest of the Republic of Croatia in de-mining on its territory until 2010 and its realization:

- the means being set aside from the national budget, even with the funds from other resources, are insufficient to realize a de-mining plan until 2010. Funds set aside for de-mining in the last three years make 0,20% of the budget itself, and the necessary setting aside should be 0,70%.

It is also important to point out that the participation of the counties, cities and districts in de-mining process is not obligatory. It means that the counties, cities and districts are entitled to estimate on their own how much to be involved and how many funds to set aside for the de-mining activities. Unfortunately, this usually leads to the lack of their involvement and eventually makes them passive bystanders instead of active responders.

An interesting legal study might give the answer to what would time prolongation in the de-mining process mean for the Republic of Croatia in terms of finances. However, it may easily be concluded that the total costs would be much higher and they would include:

- expenses of the de-mining agency and parts of the civil services involved in de-mining activities as well as the expenses of mine action firms (fixed expenses which are independent of the amount of work),
- training expenses of new pyrotechnics
- economical losses due to the under-utilized areas which are economically potential, under-utilized agricultural areas, non exploited forests
- additional expenses for forest clearance before the de-mining work
- expenses of the health care (physical and psychological) of the victims

- expenses due to the effect of the mine problem on tourism and other economic branches in or out of mine suspected areas
- expenses caused by the inability or reduced ability to intervene properly in cases of forest fires, chemical accidents, water pollution, etc.

CONCLUSION

Instead of a formal conclusion this attempt to raise awareness of the existence of disproportion between mine contaminated environment and capacity under-utilization of the Republic of Croatia might be brought to an end as follows:

“Those who act as decision makers and neglect a relationship between disaster and development are working against the community they are supposed to serve.”

Remark:

The author of this text leaves the possibility that some of the data is not entirely correct, but it doesn't affect the true image and set up relations we would like to demonstrate.



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OPREMA ZA DEMINIRANJE

SAMSON THE WORLD'S MOST MODERN MINE CLEARING MACHINE FROM SLOVENIA



Accredited representative (exclusive representative for Croatia, Serbia and Montenegro, Bosnia and Hercegovina, Macedonia and South Korea) is a demining firm L.M.B.S. d.o.o. from Zagreb, Croatia, I. Šibla bb, phone number: +38516686677 or +38516686704). Number of certificate ISO 9001:2000 is below: n*184617

Samson is a modern mine clearing machine with rotating flails for clearing placed or buried personnel and antitank mines

Great mobility - **Samson** can drive on the road or off-road with a speed of up to 25 km/h. The vehicle may be easily transported with an ordinary truck.

Efficient Mine Clearing - **Samson** clears a 2.5 m wide track on any terrain. The machine may be controlled manually or automatically. During automatic control the latest computer control technology is used for the hydrostatic drives, while manual control is electro hydraulic with the help of a joystick.

The entire machine may be also remotely controlled.

Greatest safety - The rotor housing is made of armored steel and offers optimum protection against explosion and mine fragments. The driver cabin is also made of armored steel and all windows are made of special bulletproof glass. The driver's safety is thus fully ensured.

Construction - The chassis of the machine is constructed of two frames coupled with a joint. This joint allows lateral flexure and oscillating of the frames. This ensures optimal maneuverability and adaptation to the terrain. The front and back wheels drive in the same track.

Drive - hydrostatically driven vehicle and flails, computer-controlled, load-regulated diesel motor and drive.

Braking system - braking through hydrostatic drive, hydraulically activated service brake, spring storage parking brake, electrohydraulic deactivating.

Technical Data

Motor : DEUTZ - BF6M 1013 FC212 kW
at 2300 rpm , 1050 Nm at1400 rpm

Total length of vehicle..... 7,8 m

Length for transportation..... 9.4 m

Width during operation..... 3,4 m

Width for transportation..... 2,3 m

Total height of vehicle 2,9 m

Width across the wheels 2,3 m

Total weight of vehicle with filled tires..... 9800 kg

Capacity1200 - 2600 m²/h

Mine clearing width 2530 mm

Flail rotation speed 0 - 880 rpm

Depth of penetration..... > 23 cm/1566m²/h

Driving speed 0 - 25 km/h

Working speed 0 -3,0 km/h

MINE CLEARING MACHINE “SAMSON” IMPORTANT FACTS :

To get better understanding of our mine clearing machine “SAMSON”, we would like to point out few important fixtures to be take in consideration while comparing it with others:

1. low weight

2. safe and comfortable working place with air-condition and seat with air springs

3. Drive

SAMSON- has build in unic computer steering hydrostatic drive which:

- Prevent overloading of mechanical parts of the vehicle, rotor and diesel engine
- Control the engine and optimize it's work to achieve minimum fuel consumption
- Enable power of the engine to be divided between rotor and vehicle automatically with respect to required power for the rotor by reducing the speed of the vehicle
- Prevent unexploded mines to be left behind with automatic steering system of the speed of the vehicle and rotor revolution.
- With this steering system, we are able to achieve the same or better effect with one engine in comparison to other machines with two engines (separate engine for vehicle and separate engine for rotor).

4. Explosion blast compensation

Joint construction of chassis enable “SAMSON” to achieve optimal maneuverability and adaptation to the terrain.

SAMSON has build in three systems for compensation of explosion blast on the flails system:

- mechanical system that enables flails system to be lifted 1,2 m without effecting the power of the chassis.
- hydraulic system with hydraulic accumulator
- hydraulic relief valve

5. Air-filtration

Air-filtration system with ejector build in exhaust pipe, eliminates 95% of solid particles from the air before filtering itself, which gives “SAMSON ” great advantage when working in desert conditions.

An important advantage is the possibility to increase the universal applicability of the machine, since it may be equipped with several optional devices, such as:

- an additional rotor of 900 mm width on a crane-arm of 8.6 m in length, that allows cleaning and mine clearing of inaccessible terrains.



Transport position



SAMSON 300 on the test ...

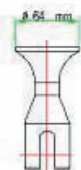
SAMSON - Cabin and control desk



... also with anti tanks mines

Samson 200 (300) – rotor

Shape of flail
(mass = 1 kg)



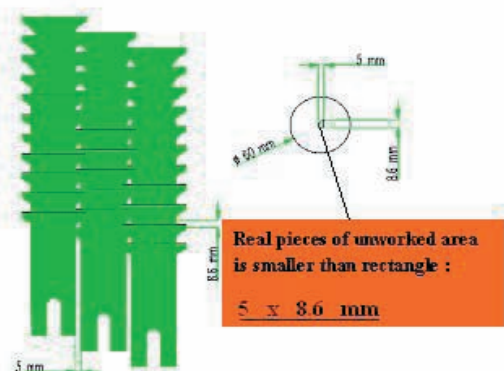
Mesh strokes of flails

Consideration is real shape of flail

Detail "N" of the mesh :
covering area with flails
strokes, by consideration
of real shape of the flail.

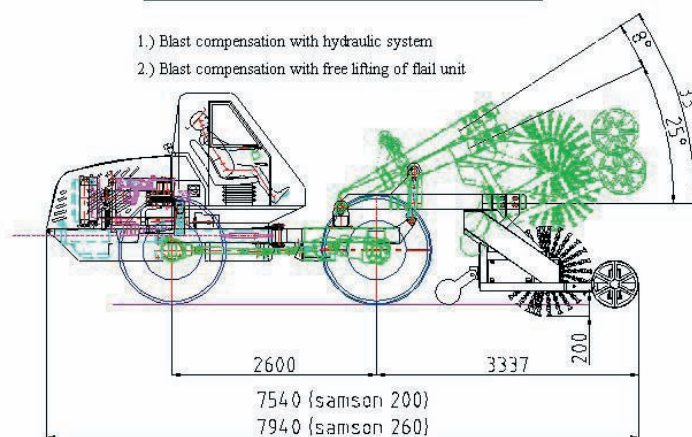
Vehicle speed : 0.8 km/h

Revolution of rotor : 800 rpm

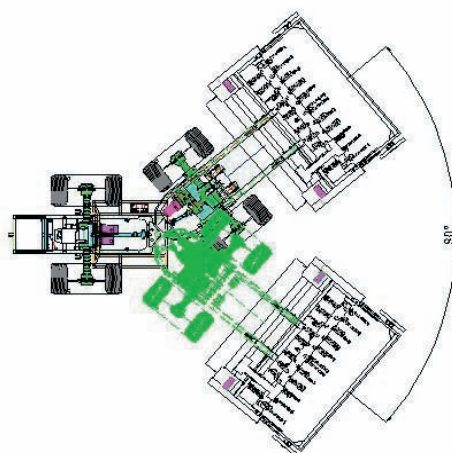


Compensation of mine explosion

- 1.) Blast compensation with hydraulic system
- 2.) Blast compensation with free lifting of flail unit



Swing of flail unit +/- 40°





Let The Operator Decide What Detector To Use

STEMD Report 2005 -

“The exceptional behaviour of the Minelab detectors is due their soil compensation and also because of the design philosophy adopted, which is to optimise for equal performance in all conditions....”

The metal detection technology selected for use in the world's first operational dual sensor mine detector - HSTAMIDS



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BOZENA 5

MIDI MINE CLEARANCE SYSTEM

Effective clearance width 2880 mm

Even in the most challenging terrains and in the most confined spaces, where size and weight makes a difference, BOZENA liquidates both Anti-Personnel and Anti-Tank mines and takes confident steps forward with **WAY**.



AT MINES 9 kg / 19,8 lb of TNT



NCAGE 1001M
NATO CODIFICATION



VARIETY OF ATTACHMENTS TO BE USED INSTEAD OF THE FLAIL HEAD





**CENTAR ZA TESTIRANJE,
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With its testing capacity (test sites and equipment) and highly professional staff, the Center offers the following services:

- testing of demining machines
- testing of mine detection dogs
- testing of metal detectors
- training and issuing certificates for the use of metal detectors
- testing of demining methodologies, technologies and equipment
- training of work site managers, demining teams and monitoring personnel
- organizing workshops, conferences and other gatherings on the subject of mine action
- preparation for introducing quality management in demining companies as per ISO 9001:2000
- lease of test sites
- implementation of research and development projects in the field of mine action
- field testing and evaluation of technologies used for mine contaminated area detection and mine suspected area reduction
- scientific and professional cooperation with national and international institutions.