Remote Explosive Scent Training: Genuine or a Paper Tiger?

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Remote Explosive Scent Training: Genuine or a Paper Tiger?

This article briefly discusses many of the research challenges presented by the Remote Explosive Scent Training (REST) concept. These challenges were reviewed at a recent workshop (8–12 February 2003), hosted by APOPO at the Sokoine University of Agriculture in Tanzania, and attended by all current players involved in developing or using REST for demining purposes.

by Håvard Bach and Ian McLean, GICHD

Introduction

REST is the process of taking scent from a source for remote analysis. The scent is obtained by using a pump to draw air containing scent or particles from the soil surface through an absorbent filter. Filters are analysed using specially trained sniffer dogs or rats, or potentially any other natural or artificial odour-sensing system.

The REST concept was originally conceived and developed in South Africa.¹ First used to detect explosives, weapons and drugs in contained units—cars, containers, houses—the system was adapted by Mechem, a South African demining company, for detecting landmines and UXO. Originally known as the Mechem Explosives and Drugs Detection System (MEDDS), it has since been given many names, although the official name in the demining arena today is REST.

Mechem used REST extensively in southern Africa from 1990 to 1996. Although not fully tested and verified, REST was used to search for landmines on roads and routes in Mozambique and Angola and along power lines in Mozambique. At least some of those routes had been inadequately cleared using manual techniques. REST proved to be fast and efficient, eliminating vast areas of road much more quickly and cheaply than any other known technology. Justification of its efficacy included finding anti-vehicle mines in previously cleared areas.² At least some of these projects were funded by the United Nations, suggesting considerable faith in the capability of the system at the time.

In the mid-1990s, the humanitarian demining industry was rapidly evolving and there was a strong push towards increasing the speed and efficiency of global demining. It is thus surprising that a field-tested system that apparently offered both of these objectives remained isolated and essentially unknown in southern Africa. Despite its potential, REST cannot yet claim to have a significant impact on the global demining process. On the contrary, it is fair to say that it has almost slipped into disuse, as at the time of writing it is not being used operationally anywhere in the world. In early 2003, just four organisations had capacity for mine detection using REST. Two of these are research centres and have never undertaken operational demining, although they may do so in the future. Of the other two, Mechem is using its REST capacity to support a research contract, and Norwegian Peoples Aid (NPA) is rebuilding its capacity after the program had difficulties in 2002.

The Geneva International Centre for Humanitarian Demining (GICHD) runs a multi-faceted program of research and operational support aimed at improving the overall quality of mine detection
Mine Detection Dogs

An animal is a complex detector that responds to a variety of substances (whether in a filter or elsewhere), some of which the trainer may be unaware of. A recent example: Mechem dogs trained on "pure" TNT responded to DNT at very low concentrations. Some relevant research had been undertaken years previously by Mechem, but that information was inadequate, poorly documented or unavailable. The key incentive was the great potential of REST for area reduction. Implementation of search has involved identification of the central elements of REST, which are:

- The sampling technique
- The sampling equipment and filters
- Sample and transportation of filter cartridges
- Training of the detector
- Methods to ensure reliability in the final analysis process

Animal and Artificial Detection—Pros and Cons

It is easy to ignore the sampling process, but the role of the REST is critical. A great potential for the improved mode of operation is that the two technologies can work together. This is being tested by Mechem, and the results show that theREST is critical. The filter system is used to improve the quality of the sample and to ensure that the sample is representative of the environment. The filter system is used to improve the quality of the sample and to ensure that the sample is representative of the environment. The filter system is used to improve the quality of the sample and to ensure that the sample is representative of the environment. The filter system is used to improve the quality of the sample and to ensure that the sample is representative of the environment.
units are cleaner and quieter, but the disadvantages are likely to restrict their use for operational demining. If the sampling unit is mounted on a vehicle, then the vehicle compressor (which supplies power to the air brakes) could be used to power the pump. This option has been used in the past by Mechem for some applications.

There have been suggestions that under at least some conditions, a pump is unnecessary. Wind action and convection could bring enough molecules to the filter for detection to be successful if the filter is placed in the field for some period. A development of this possibility, a passive sampler, was demonstrated by IVEA at the REST workshop. The principle remains unproven, but tests will continue.

**Suction Pressure and Sampling Technique**

Mechem originally decided to use a pumping rate of 60 liters/minute, based on the concept of entrapping all the air from a car in a short amount of time so that the car could be used for explosives. Although this suction rate apparently gives effective filter samples (using the Mechem filter), higher or lower suction rates could give even better samples. Higher sampling rates allow the vacuum operator to move at a quicker pace, and/or change filters more frequently. Possible disadvantages are blow-through of target molecules (molecules passing through the filter without being trapped), and clogging in dusty environments. Lower sampling rates will likely have the opposite effects. Certainly, there is a need to optimise the relationship between sampling vacuum, sampling rate, and filter efficacy (which may vary with filter design) and the advantages of collecting dust.

Work with free-running dogs shows that a dog can miss mines if its nose is too far away from the mine during the search. It appears that under at least some conditions, the detectable plume of scent over a mine is small and localised. Mine detection using REST may therefore require that all ground be covered by the vacuum operator in much the same way as the nose of a field search dog covers all of the ground. Apart from the obvious safety implications of such a requirement for the sampling personnel, using artificial odours in different conditions can be used in different conditions or in different ways to optimise the sampling process. These issues need further research.

**Sampling Conditions**

It is known that variability in environmental conditions affects detectability of mines for animal sensing systems working in the field. It is sensible to assume that the known environmental effects on direct animal detection will similarly affect filter detection. Research undertaken for the GICHID by NOKSH in Bosnia (using dogs) supports this contention, with lower humidity at the time of sampling producing higher probabilities of detection. APOPO has similarly found that lower humidity gives better detection (using rats). One possibility is that sampling during dry conditions facilitates a higher rate of collection of dust particles, which has a greater impact on the quality of the sample than collection of air.

Surprisingly, preliminary analysis of the Bosnia data set did not show any effect of temperature on detection probability, apart from decreasing detection probabilities at ambient temperatures below about 15°C at the time of sampling.

The analysis is not yet complete and more research is planned.

**Geotization**

The possibility that vegetation in the sampling area affects the quality of the filter sample has been much debated. However, in Mechem’s field experience, there are indications that vegetation has a positive effect. Vegetation potentially acts as a reservoir for explosive molecules, which are attached to leaves (particularly on the underside where they are protected from the sun). The vegetation may filter wind-blown molecules out of the air, or molecules could be taken up through the roots and deposited on the leaves during transpiration. Wind-blown pollen may also carry explosive traces. More research is needed to totally understand the importance of vegetation as a reservoir of target molecules. The results could significantly alter the way sampling is undertaken in the future.

**The Analysis Process**

The analysis process involves two central components—a training program for the detector and a testing concept. Both of these processes vary among the four organisations currently training REST detectors. NPA originally developed principles developed by Mechem, but has recently modified its approach to the system developed by NOKSH. Unfortunately, to date, the only one of these training and operational concepts that has been formally documented in a way that is accessible to the demining community in the NOKSH program. At the time of writing, REST dogs were about to be accredited in the United Kingdom (although not for mine detection), but again no documentation of the training program or use concept for those dogs is available. Thus, understanding of the use of animals for REST detection is improving, but this knowledge is not generally being formally documented in an accessible way. Only limited elements on training issues can be made here.

**Training Issues**

Animals are good detectors, but they require careful tuning and calibration. Having produced the detector, maintenance of its skill is of high priority. Attention to details of its operational use, including internal QC to monitor its daily reliability. Small mistakes during training or testing could introduce "clues" that tune the animal onto different scents. The word clue deserves further explanation. In this context, a clue means an aid that the animal uses to focus on target filters. A clue can be a scent, the lack of scent, an unconscious signal from the handler or simply a non-random placement of filters in an analysis array.

Once a clue is found, the handler can use it to guide the animal and avoid false indications. Clearly, the testing procedure must be rigorously designed to eliminate any possibility of clues. Independent laboratory analysis (using artificial detection procedures) can also support clue identification.

An alternative mistake is that positive filters are neglected (dismissed) by the animal. Such mistakes may be because odour availability on the filter is below the sensory threshold of the animal, because of factors affecting the sampling process (see above), or because the detector is not working to peak performance (a training problem).

**CONTROLLING THE ANALYSIS ENVIRONMENT**

Animal analysis was initially an outdoor affair. Both Mechem and NPA now use indoor analysis facilities, which give much greater control over the environment in which testing is undertaken. Humidity and temperature are key factors affecting vapour availability. As research on vapour detection progresses, experiments with manipulated indoor climates may help to optimise detection using REST technology.

Pre-heating of filters is likely to increase the release of the target scent from the filter and thus aid detection. Manipulating humidity in the filter or in the room might also improve detection, although it is still unclear what the optimal humidity levels should be. A combination of the two factors could have a major impact on detection probabilities and should be further investigated.

**REST for Area Reduction**

Two test areas (in Angola and Tanzania) have been funded under GICHID sponsorship to facilitate investigation of area reduction applications. A similar test field has been prepared for similar purposes in Croatia. The two African test fields have the same general layout. To prevent cross-contamination between boxes with landmines, the minimum distance between mines is 35 metres. Testing is currently being undertaken in both locations to determine the potential of REST for area reduction.

Size and shape of the plume put up by a mine are the central issues being addressed using these test fields. Large plumes (or plumes that increase in size over time) mean that REST sampling may have to be rather course-grained (each filter
Environmental factors during sampling
- Continue sampling in test fields under different environmental conditions to determine the full environmental effects on detection.
- Investigate whether some filter options may work better under certain conditions than others.
- Investigate the effect of vegetation.
- Investigate the leakage (flow) rate from landmines and use this information to determine the potential for vapour detection.

Training
- Document and compare training test results to determine optimised training solutions.

Analysis – environment
- Determine the effect artificial modification of temperature and humidity in the analysis environment has on detection.
- Examine all aspects of the environment to identify potential clues that may jeopardise the analysis process.

Analysis – testing
- Identify procedures to provide effective internal controls on the detection process.
- Further develop and test filter handling procedures to ensure optimal testing.

Table 1: Areas needing further research before REST can be considered proven.

**Filter**
- Optimise the filter to allow highest adsorption during sampling.
- Optimise the filter to allow highest desorption during analysis.
- Develop a filter that can be analysed both chemically and by animals.
- For some applications, make the filter able to tolerate long-term storage without significant quality reduction.
- Investigate the relationship between vacuum flow rate and quality of the sample.
- Conduct filter testing to determine how fast of a exchange frequency will affect the quality of the sample.

**Sampling machine**
- For some applications, develop a low-weight battery-driven sampling machine with long operational time and easy charging.

**Sampling technique**
- Undertake tests to determine the most reliable sampling technique(s).
- Develop a new sampling concept for area reduction that will ensure quality sampling and high safety for the operators.

Table 2: Alternative routes to establishing a REST analysis capacity supporting demining operations.

**Advantages**
- No need for demining organisations to develop costly and difficult analysis capabilities.
- Quicker response time (need only to establish sampling teams initially).
- Higher cost effectiveness.

**Disadvantages**
- Logistical burden in transporting filter cartridges (internationally).
- Demining organisation has little/no control of the analysis process.
- No global analysis concept in place.

**Centralised analysis**
- Full control of the analysis process.
- No dependency of other organisations.
- Less filter transport requirements.

**Decentralised analysis**
- Requires high skills and a more complex demining process.
- Likely to result in limited use of REST worldwide.
- High initial costs.
- Time-consuming process of developing capacity.
- No system for external QA in place.

Table 3: Issues for future consideration if REST is to be established on a broad or global scale.

**Who should undertake the analyses?**
There are currently four organisations involved in analysis of REST filters for humanitarian demining: NPA-Angola, NOKSH-Norway, APOPO Tanzania and Meschem-South Africa. Preliminary arrangements could be made with these four organisations. There may be more organisations with an interest in becoming centralised REST analysis providers.

**Who will test and accredit these organisations?**
There is a need to ensure that the same standards are followed by all organisations involved in REST. A much simplified analysis could be accredited on a regular basis. Criteria for the accreditation process will be required. An impartial accrediting body must be identified.

**How can the demining community be assured of a high-quality analysis process?**
A QA system of the analysis process will be required. This could be a responsibility of an objective independent institution. Alternative QA measures could be to develop a system to cross-check filters between centres and compare the results.

**The Future of REST**
The future of REST relies on proving the technology and facilitating its use. The latter is potentially difficult in an industry based on free market principles. Humanitarian mine action differs from most established industries in being small, artificial and donor driven. Realistically, demining organisations can continue operating without using REST, even if the system proves more efficient than other methods. So REST must become a proven alternative before demining organisations will consider using it. However, even once proven, it is not realistic to expect that many demining organisations will establish the required analysis capacity, due to the time and investment involved. It is more realistic to consider if demining organisations have access to a centralised analysis facility, the far easier sampling could then begin. The barriers to potential routes to follow if REST is to gain ground in demining. Each has pros and cons (Table 2).

**How can the analysis centres be assured of a high-quality sampling process?**
International procedures for quality sampling will be required. QA of the sampling undertaken by demining organisations is another area that needs to be addressed. There may not have to be a need for analysis centres to perform QA on the sampling as long as there are recognised QA mechanisms in place.

**How should a global logistics system be developed?**
It is not too difficult to send filters overseas today. There should be agreement regarding packing, transport and shipping of filter boxes during transportation. Analysis centres should solve their own problems in receiving the filter boxes in their respective countries.

**How to reach a consensus regarding the pricing and timing of analysis?**
There must be a general understanding within the group of analysts on issues such as costs and time. The logistics, the analysis and the QC requirements.

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Conclusion

There are currently four organisations with an analysis capacity for REST in place today: three in Africa and one in Europe. Among them, they currently have a total of 30 individual detectors (12 rats, 18 dogs)—an impressively small capacity considering the potential of the REST concept and its historical precedence. Although some of these organisations could potentially expand their capacity, the limited number of detectors available today severely restricts the further development of REST in the near future. Of these four organisations, one is strictly commercial, one is a broadly focussed humanitarian aid organisation and two are research agencies. To at least some extent, all depend on sponsorship money for their operations, and humanitarian aid sponsors do not usually support research. Thus, maintenance of even this limited REST capacity could depend on a requirement to use the detectors operationally, further limiting their availability for research. Given the comments above, use to support demining operations could even be regarded as premature.

The Tanzania workshop was not in a position to make a formal list of recommendations, but it strongly supported the principle that REST will not be implemented on a broad scale unless it is firmly founded on quality research. Not only is there still no properly structured research and development program in place, but some of the few organisations with functioning detectors are working on shoestring budgets and are in danger of being closed down irreversibly. Clearly, if REST is to be further developed, the industry needs to get behind it and support it at all levels, including explaining its value to the sponsors.

On a more positive note, these four organisations could be encouraged to establish a coordinated analysis capacity, supporting the required research in the short to medium term, and then moving on to supporting demining operations. A few companies are using REST for other purposes, such as Chilpport in the United Kingdom who is implementing REST at docks and airports, hotels and cargo storage sheds under the name Vapour Odour Detection System (VODS). Such companies may also be interested in analysing filters from minefields, and/or supporting research on further development of the REST concept. Most importantly, the expertise currently available for training REST detectors must be nurtured if REST is to have any chance of showing its true potential.

REST remains a paper tiger, caged by inadequate investment, poor development and secrecy among the few organisations with relevant expertise. The key to the door of the cage is effective research, properly undertaken and properly resourced. The Tanzania workshop was a valuable preliminary step towards building that key. The next challenge is to feed the tiger, giving it the energy to escape.

*All photos courtesy of the authors.

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