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Over the last twenty years, hundreds of millions of dollars have been spent on R&D for Mine Action and many say that there is not much to show for it in the field. That may be why managers in demining often have little patience with those engaged in Research and Development. Another obvious reason for impatience lies in the differing temporal perspectives held by field people and researchers. The person responsible for clearance wants a tool he can use now, tomorrow, or next week at the latest. That desire for urgent practical solutions is in obvious conflict with the need to conduct research in incremental, proven stages, developing first the technology, then its practical application.

Another difference between the field and R&D perspective is the fact that a professional researcher should think that conducting the research professionally is the goal, not the development of an end-product. Research and Development are two different things, not necessarily combined. So research often ends with publishing papers, not producing a field-ready end-product. Publishing a result that shows that a technology is not viable is really valuable – but any field people involved are likely to think that they have wasted their time if the only tangible result is paper.

These different perspectives have been exacerbated by some of those responsible for research overselling the potential of their projects. When I first got into demining

many technologies were presented as a “Silver bullet” solution but turned out to be of little or no practical value in the field. This is still happening.

HCID (2014)

Vehicle Mounted, Real-Time,
Counter Mine/IED Detection Technology

The claim:

“Our proven HCID Technology can locate and identify surface and subsurface IED/Mines from 2” up to a depth of 3 ft. with an accuracy of 99% over an area of 500m x 1000m on a “real time” basis. We can provide a field demonstration of this technology… upon request.”

The facts:

Despite the photo, their “laser vibromission” technology does not yet exist. The concept is entirely theoretical and would need years (and many millions of dollars) to prototype. Their performance claims are what they are aiming at, not what they have achieved.

If this technology is ever actually developed, the concept has severe limitations. The lasers require flat ground and a clear line of sight. The vibration means that the ground has to be hammered twice for each reading. Each laser interrogates a very small area, so dozens of lasers would be required…. This means that the hardware would be horrendously expensive and progress would still be really slow. It also suffers from a fuzzy ground/air interface so anything on or near the surface would be missed. Perhaps most important, it will not have the resolution to find smaller mines and cannot discriminate between rocks and mines so has a very high potential false alarm rate.

This is just another golf-course solution that only exists in its designer’s head, but it is being sold as “proven”. This should not surprise people who have been around in demining for a few years and have been obliged to become cynical about the claims of researchers.

Overselling happens because those conducting R&D have to be funded – and their donors often want to fund solutions. Although there is no way of knowing in advance whether a project will really deliver, the researchers have to pretend that it has a very good chance of doing so in order to get funded. Worse, to please their funding sources, they sometimes pretend it has succeeded even when it has obviously not. In this instance the researchers have a lot in common with the demining manager –

both wanting to sign off this funding cycle as a "success" so that they can get funded again. Having been a field manager for demining INGOs and the UN, I think that field people should recognise that we all have the same pressure to overstate our achievements to please donors. I am not the first to say that donors really should wise up.

As an example of research and development success, let's take hand-held dual-sensors combining a metal detector and Ground Penetrating Radar.

Sixteen years ago the first hand-held multi-sensor combining a metal detector and a Ground Penetrating Radar was under development as part of the U.S. Government's support to Humanitarian Mine Action. When I first got to handle HSTAMIDS in 2003 it had already been presented as the solution to all demining needs. Conceived as a combination of five sensing technologies[1], the researchers for each had "talked up" the potential and then became trapped in a development cycle that could not work. The technologies were too under-developed, power hungry, and LARGE to be combined in anything that could be realistically hand-held. But the idea of a hand-held multi-sensor had been sold so the project continued, dropping several technologies while swallowing vast sums[2] from the US government's R&D budget.

As many of you know, when using HSTAMIDS to search for anti-personnel mines its use relies on the metal detector in the first instance. If it does not signal, the GPR results are not used. There is real reason to doubt the GPR's ability to reliably indicate the presence of anything as small as an M14 mine, but leaving that aside the dual-technology detector cannot find any anti-personnel mine that a metal detector would not have found on its own. Despite this, an internet search still shows the claim that HSTAMIDS can detect non-metallic anti-personnel mines[3]. In theory, yes. In practice that is just another example of counter-productive and confidence-eroding oversell.

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[1] From memory, the concept then presumed "sensor fusion" using IR, GRP, MD, MMW and Ultrasound technologies (this could be inaccurate).

[2] J.Ishikawa and K. Furuta, *Anti-Personnel Landmine Detection for Humanitarian Demining*, Page 6: HSTAMIDS was developed "…at a cost of US$73 million". A table breaks down costs into Research, prototyping, demonstration and validation, engineering and manufacturing.

[3] http://www.globalsecurity.org/military/systems/ground/hstamids.htm: "… *and improved metal-detection (MD) to provide a robust probability of detection (Pd) for both large and small metallic and non-metallic anti-tank and anti-personnel mines.*

However, if we forget the oversell, it is a fact that the HSTAMID research has inspired others and GPR has advanced because of it. Today, using a multiple GPR array combined with side-scanning, it is credible to claim that a vehicle mounted system able to provide a 3D subsurface image at a useful resolution in real time could soon be available. The field man in me is impatient for this because I can see it having great value when searching for large mines and IEDs on roads.

Similar hand-held dual sensors, such as Minelab's Mineshark and Vallon's Minehound, are already available providing further evidence that the money spent on HSTAMIDS was not wasted. While they all serve a primarily military purpose today, I believe that a hand-held dual-sensor of real use in humanitarian demining will be available within the next decade.

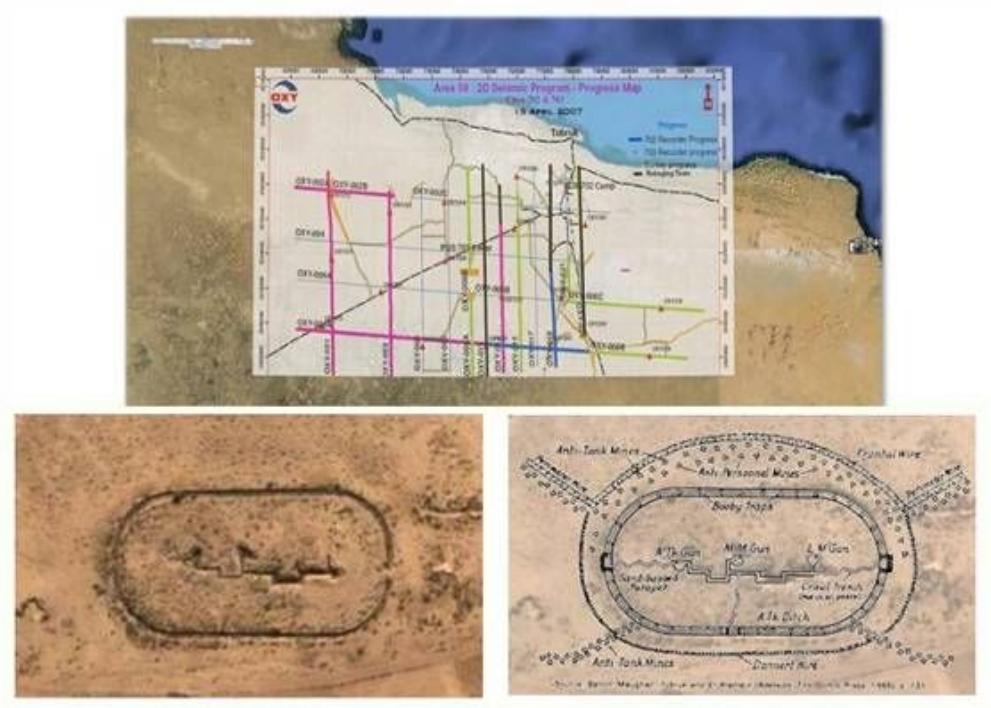
If someone can combine the best metal detector with a real-time means of sensing explosive vapour - that could change everything we do. But it is worth mentioning that such a detector would have to be responsive to increases in explosive presence in real time if it is to help us locate a source. Without that it would signal everywhere in any battle area, so tell us nothing of value. A reliable hand-held explosive sensor would be of such value in so many security scenarios that the potential market will drive the research – and humanitarian mine action can benefit incidentally.

Humanitarian demining often does benefit incidentally. An example is the Minelab F3Ci metal detector – developed for the US marines. It is switchable between static and dynamic mode – which makes pinpointing shallow metal targets easier. It is the first commercial demining detector I have seen that can discriminate between some

metal types with variations of tone – and it can also detect carbon rods. In some current demining scenarios the extra features on this detector could be really useful. So this is an example of how R&D for a military customer can benefit Humanitarian Mine Action. The demining market is so small that whenever possible researchers should aim for a bigger market to make it more likely that the development will be funded and a product can be made commercially viable.

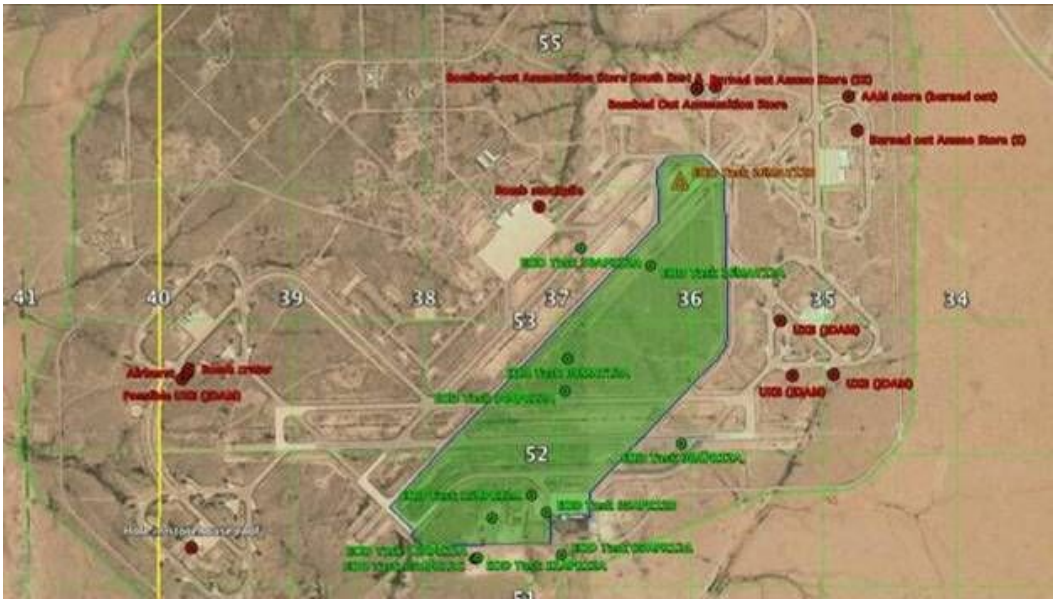
Leaving hand-held detectors aside, research into the extended use of satellite imagery, mapping and remote sensing has the potential to make our work simpler without reducing quality. On GIS, the Humanitarian Mine Action industry has become mired in IMSMA which combines limited GIS capacity with a complex management tool that is far from perfect. Most of us only use it because it's there. A few have stepped sideways and use Google Earth's GIS potential in order to be in control themselves.

It is relatively simple to overlay images in Google Earth and to control the transparency of each.



This shows an instant overlay of an oil survey map in Google earth and below, the instant overlay of an old minefield record over a google earth image showing a defensive position.

While the UN wasted time failing to introduce IMSMA in Libya, the demining groups just went ahead using Google Earth and overlays they put together themselves. A main advantage of this was that results could be shared with Nationals who did not have sophisticated computers and had no time for many months of IMSMA training.



This is a Google Earth image of Sirte airport with hazards and work areas overlaid. It was produced by an INGO and shared widely in 2012.

To be fair, the IMSMA developers probably achieved as much as anyone could have at the time. However, developing GIS alternatives that allow the user to apply their own overlays makes sense today. This will also allow users to decide the value of overlays derived from the remote sensing technologies that are becoming available.

Another technology without a long development lead-time is remote explosive sensing known as MEDDS or REST. Denel Mechem from South Africa have been doing this using filters that are scanned by dogs in a remote laboratory for a long time but, while I know it *can* work, it has a poor reputation among others. Developing refinements that allow filters to be scanned in the field would get a same-day result and greatly reduce the delays and the potential for error. Attempts to produce an electronic sensor to read the filters were tested in Croatia in 2003, but what happened next?[4] The manufacturers offer a machine they claim is as effective as a dog[5] and more cost effective, so why have I have not seen it in the field? It probably works but is not reliable, has too many false alarms or is not genuinely available for export to areas of need. Researchers and equipment producers really should state the limitations of their product *before* making extravagant claims for what it can do. More research into a really useful Remote Explosive Sensing tool seems to be needed. And so is a genuinely independent way of evaluating the claims of manufacturers.

New robots large and small have many potential uses in the ground and in the air. Their developed-world potential is high, and the spin-offs from their development should improve remote-control systems and robotic add-ons for field machines. New Camcopter designs already allow cost effective aerial survey and should be refined to carry a range of remote sensors that add value to the risk-laden process of Land Release. The risk in Land Release is not to the deminer, it is to the end user of the land when they use land that is erroneously released.

[4] The NOMADIC FIDO REST sensor tests are written up in Electronic Noses and Sensors for the Detection of Explosives, edited by J. Gardner, Jehuda Yinon, 2004, Holland: Kluwer Academic Publishers.

[5] http://www.tha.co.th/en/explosive-detection-system/29-fido-portable-explosive-detector

This picture shows a camera-carrying remotely operated helicopter conducting a post-flood survey in Bosnia last year. Still technically under development, this is already a useful tool – and I understand that CRTO and RMA Belgium organised some training for field users earlier this year.

My examples of desirable R&D need not have involved equipment at all. An area that is close to my heart is training. This is an area in which the industry leaders have done little to refine training methods to make them appropriate to the trainees, whether deminers, MRE recipients, or demining supervisors. It requires a paradigm shift in approach leading to flexible and context specific teaching packages that are informed by local research, then developed with nationals in each context.

The same need for the engagement of end-users applies to all R&D. To fully achieve any of the potential in their project, the researchers must work closely with the end-users, understanding their strengths and limitations. They must take the trouble to start from where the end-users are, not where they think they should be. This is often difficult and it can be much simpler for the researchers to contact people who speak their language and are easily available. If they do this, they will often be badly misled. They will get told what they want to hear – and sometimes told what they have effectively paid the person to say. Relying solely on unpaid advice from UNMAS or GICHD is also never enough. Often their people have the same impatience as field managers and are dismissive. Sometimes they are professional bureaucrats and know little about demining or the people conducting it.

Organisations in Croatia like the CTRO provide an excellent halfway house with events and resources that give an insight into the humanitarian demining around the world. But researchers should also get out there and spend time with the field

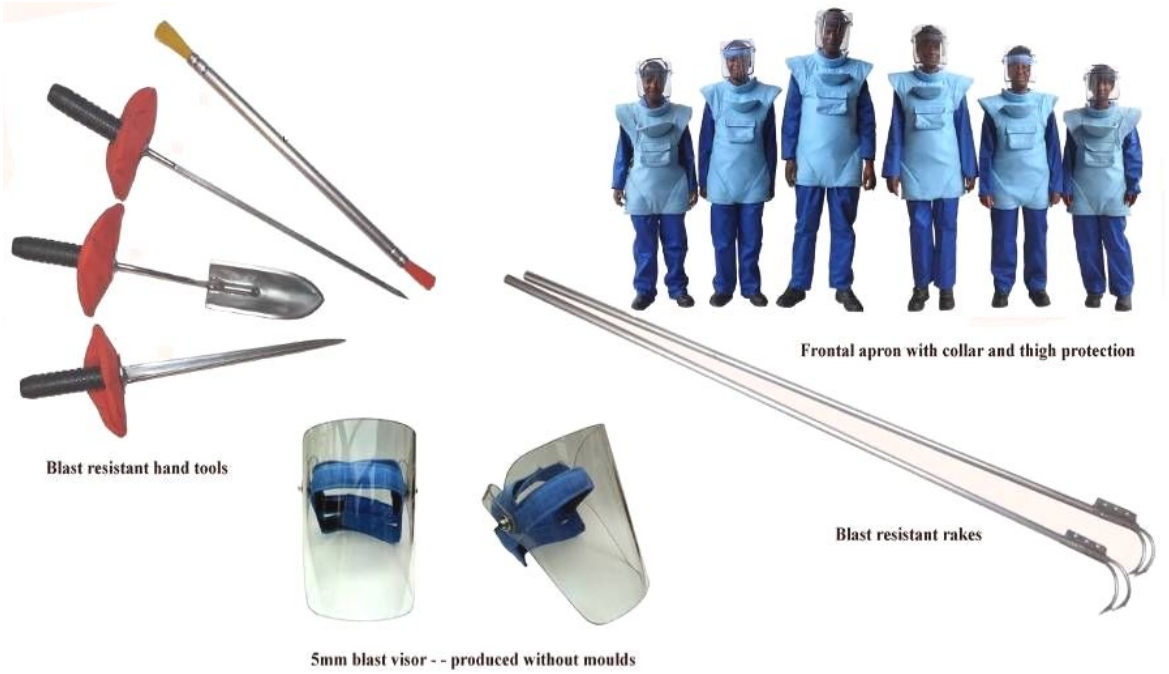
managers and the nationals in the countries they are trying to serve. Even then, success will depend on all parties being completely honest.

Honesty means that researchers should never oversell their project or claim that a useful product is just around the corner – unless it is, of course. Honesty also means that those in the field should never claim to know more than they do, or pretend that their experience makes research irrelevant. Too often, I have seen internationals working as field managers who cling to their military training and will not consider making changes to the equipment or procedures they use. Many were encouraged to believe that their training was excellent and seem to believe that any criticism of it would be some kind of betrayal. The best in the field are not like this, but those who are bear some responsibility for any shortcomings in past R&D efforts.

Meanwhile, donors and HMA industry leaders have to grow up and understand that research is worthwhile even when it may not result in a useful tool tomorrow. On the whole, Research and Development is separately funded so it does not take money from field demining.

We all know that there is no big silver bullet that will solve all problems. But there are advances to be made and Research and Development is an essential part of the Humanitarian Mine Action effort. If the industry leaders and donors would invest a little patience and politeness they might see that there really is a bandolier of small silver bullets that are either under development or just waiting to be worked on. If deminers and field managers will take time to educate the researchers, we can all help to move this industry forward, one step at a time.

I am not an academic or an engineer, so what qualifies me to have an opinion that anyone should listen to? Most of my experience has been in the field in many countries over twenty years, but I have also been involved in Research and Development. I have worked with academic groups and on my own initiative. My own efforts have not been expensive but they have led to some minor improvements in the field. My work on blast resistant tools, frontal body armour and visors is fairly well known.



My designs of blast-resistant hand-tools are widely used. My simple designs of body armour have been refined by many manufacturers and frontal body armour has become the standard. And anyone wearing a visor in demining today is likely to be wearing one designed by me and made in the oven I made for the purpose in Zimbabwe.

My visor work was initially conducted with the University of Warwick, UK, and it was a post-graduate student, Paul Sutton, who had the idea of making visors without moulds. Being practical, I saw that idea through as an independent with support from a UK medical charity and the US government.

Critically, it was not my effort that made any of my work a success. It was the sustained efforts of the manufacturer. While I have sometimes been paid to develop equipment, I have never taken any profit from its exploitation and have never controlled what happens next. Researchers with a field-ready product in mind should also have a manufacturer in mind because designing for production using available skills and resources is an essential part of product development. Teaching the

commercial partner everything you know about the technology will help them to take ownership of the product. This is essential because, whatever the product is, it will almost certainly benefit from being improved in a series of iterative refinements. If researchers do not have the means to develop their results, they have only done half the work. And if they have to give up ownership to get their ideas developed, they should.

This shows the current range of visor products offered by the manufacturer in Zimbabwe – after years of iterative development.

Taking advantage of having gained a lot of blast-testing experience, I have also worked on blast resistant wheels for at-risk vehicles. My designs have been refined at the University of Genoa in Italy for use in one of their current projects.

These are the designs I presented for comparative blast testing in Italy.

All I did was help show the researchers some crude parameters required for design success. They took ownership and improved the design dramatically. All researchers should allow for the fact that others will move their ideas forward. They should make that process simple by sharing what they know as openly and honestly as possible.



I also shared my low-tech flexible ceramic armour work. My panels can stop NATO combat rifle bullets but I had hoped to design something wearable that could reliably stop all fragments from a PROM-1 fragmentation mine. I failed because the end-product is too heavy for regular use in demining. So I published the results for everyone to use and moved on. Publishing results regardless of success is essential. Someone far cleverer than me will eventually make a lightweight armour that meets the needs in demining and my work may help to get them started, or stop them making the same mistakes.

One thing that contributed to the success of my visor, armour and tool work is that they were not new or revolutionary. They were small incremental changes to the tools and equipment already in use, or to the way they are made. Those with open minds accepted them. But some demining organisations have ignored them because to make any change would be to admit that their equipment or procedures were less than perfect in the past.

That may be why some other demining tools have not been a success. A simple excavation tool was designed by post-graduate students at MIT[6] some years ago.

[6] See it at: http://www.secdevinc.com/Excavator.htm also http://web.mit.edu/demining/

Ergonomically clever, it is easy to use accurately and without strain, so it is very popular with deminers. In hard ground this tool would be a real improvement in safety. But no one is using it today. I used it myself, got it tested in minefields and wrote a glowing report – but the developers at MIT graduated and disappeared as students do. Perhaps those organising their work should have taken more responsibility for seeing it through to field take-up?

In my view, the best example of truly revolutionary R&D that has changed demining almost everywhere has its roots in Croatia. It is the DOK-ING mini-flail.

This is one of the MV4s I had in Sri Lanka

Today a mini-flail is thought of as conventional, but it was an entirely new development in the late 90s - combining remote-control with high mobility and versatility. Like all good Research and Development, today's DOK-ING version was originally developed to meet a recognised need in the field and has since been refined iteratively. Before it was invented, the most common cause of deminer death

was the bounding fragmentation mine. A mini-flail can break or initiate these before the deminers have to go near, removing undergrowth and so making the demining process both faster and safer. But it cannot survive a tank mine blast, cannot handle wire entanglements and, like all remotely operated vehicles, can be severely restricted by unseen obstructions. Also, like all flails, it cannot destroy all mines and explosive devices – so it is not a single solution. That said, it is a really useful demining machine, helping to prepare areas and locate mine-lines. The factory also has a good reputation for providing all necessary field support and for having overcome many problems that its competitors have not – which probably explains why they have sold their products to the US army despite the US government having invested heavily in the R&D of its competitors. Small enough to be versatile and with good support, an MV-4 would be one of the small silver bullets in my bandolier almost anywhere in the world. And all research efforts could learn from its genesis – which had end-user need and commercial reality as driving forces.

For those who want something cheaper, there are alternatives such as the Pierre Trattori tractor which is smaller, highly manoeuvrable and can operate a range of tools on steep inclines. It can withstand multiple anti-personnel mine blasts under its wheels and operated by an on-board driver or by remote-control. In Europe, it is even road legal and can be driven to the worksite.

Conceived as a machine that would be cheap enough to leave behind with a community to promote use of the released land – and so promote peace-building – it has end-user needs and support for peace-building as its driving forces. Seeing demining as an integrated part of building the conditions for peace may seem obvious, but to many in demining it is a revolutionary concept. I would make daily

use of Locostra if it were in my bandolier – doing many things that a mini-flail cannot including carrying wide-area detector arrays with GPS and data logging facilities during rapid Battle Area Clearance.

Another cheap machine I would use is the ARJUN rake and vegetation remover – converted from a used backhoe.

Using converted backhoes was pioneered in Afghanistan in the 1990s where they simply added some light armouring and used the conventional excavation bucket in damaged buildings and irrigation ditches. The Indian NGO Sarvatra redesigned the tool and optimised it to both remove undergrowth and bring mines to surface. This machine increased the speed of clearance in Sri Lanka so dramatically that there were more than twenty in use at one time, some leased to other INGOs working in the country. Easy to maintain and operate, the machine also has the advantage of being readily converted back into a conventional backhoe for use in other post-conflict peace-building tasks. So Arjun is a combined demining and peace-building tool. Both machines also show the advantage of adapting existing technology rather than reinventing every part of a new machine.

The idea that there is not much to show in the field for past research efforts is wrong. From ground-compensating detectors to machines, hand-tools and PPE, people in the field benefit every day from the efforts of past Research and Development. And there are currently many new tools under development that could make our work safer and more efficient. For this to happen, we need to work together with mutual understanding, respect, honesty and above-all patience. (I admit that I have not

always met those criteria, but I try harder these days.) And then we need something truly revolutionary: we need donors and those in the field to be informed enough (and brave enough) to try something new when it is made available.

Finally, I want to mention a company that specialises in bringing technologies to market. Someone from the Brimatech company gave a presentation entitled What makes Innovation in Demining Successful in Johannesburg last year. I saw it after writing this and was impressed because they made all the points I have raised in this paper and some others.

My successful visor and armour work only took off when the manufacturer got a good website and began to market their work professionally (www.secdevinc.com) - so I consider it proven that involving marketing specialists throughout the research and development process would be a really good idea.

From a paper and presentation made at HCR CTRO 12th International Mine Action Symposium held in Biograd, Croatia in April 2015.