

**“International Conference on Requirements and Technologies for the
Detection, Removal and Neutralization of Landmines and UXO”**

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Trends, generic conclusions, open questions

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Abstract

This paper summarizes some global viewpoints and models that emerged from the discussions during the “International Conference on Requirements and Technologies for the Detection, Removal and Neutralization of Landmines and UXO” (EUDEM2-SCOT 2003), held in Brussels, 15-18 September 2003. The following statements are elaborated in the paper:

- There is a continued strong interest of European policy makers for humanitarian demining in the framework of security and risk management.
- A revised interpretation of new controlled test and evaluation results (if confirmed by independent experiments) could boost introduction of new technologies in the field.
- There is an urgent need for new funding structures to bridge the chasm between R&D prototypes and tools in the hands of deminers.
- Significant contributions from non-demining ICT community are now being acknowledged by the end user community.
- Good progress is reported in many technology areas, including clearer definition of less useful areas.
- A paradigm shift is observed for research, development and deployment, namely from “humanitarian demining” towards “restoring local communities” and “evidence based risk management”.

1 Introduction

The EUDEM2-SCOT 2003 conference was attended by more than 250 participants from 43 countries. It has been an open forum for the discussion of the state-of-the art in humanitarian demining technology R&D and practice. New technology developments and demining systems and scenarios were confronted with view points from daily practice in demining on the field. The 114 conference contributions are published in [1], and selected papers will appear in a special issue of the “International Journal of Subsurface Sensing Technologies & Application – Cam Nguyen, Editor - Kluwer Academic”.

The goal of this paper is complementary to these publications. During the meeting we have experienced the birth of some new global insights in the domain of humanitarian demining as a whole: some are related to a paradigm shift in R&D, others are related to policy guidelines, new views on performance evaluation of novel and older technologies, and the convergence between policy views and demining practices in the field. This paper is an attempt to summarize these emerging insights and viewpoints. Some of them have triggered strong emotional reactions during the conference, many of the new ideas might have a short life time, others have the potential of forcing breakthroughs, and all of them are subject to further debate. After a few months of reflection time, we have tried to describe them coherently in a matter of fact manner.

2 Global tendencies, main topics of discussion, new view points, open questions

2.1 Interest of policy makers?

2.1.1 Perception of the achievements in R&D at the highest levels of decision making in EC

P. Busquin (Member of the European Commission, Research) has acknowledged the advances made in information management tools, integration of GIS, and incremental improvement of sensors, area reduction and international standards but he mentioned also that “*delivery of new tools and equipment to improve the search for individual mines has not met early expectations*” [2]. However, it is not clear whether the expectations of the EU programmes were realistic in view of the specific limitations of the EU R&D programmes, in particular with respect to their reliance on market forces to meet the needs of a limited demand, which in the final analysis is mostly government funded. P. Busquin referred to the complexity of the problem, the mismatch between research ideas and application requirements in the field, and the significant non-technological problems in finding the resources to turn prototypes into fully tested commercial products ready to use in the field. The latter problem was also identified previously in [3], where some ideas were put forward to bridge the gap between research and deployment (see also paragraph 2.3).

2.1.2 R&D frontiers between humanitarian and military demining are reduced

Although different goals are pursued and different practices are used in military and humanitarian demining, there is a potentially large technology sharing (Petersberg Tasks)¹. In addition to his formal speech, P. Busquin emphasized that even financial support will gradually be opened by the European Union for joint technology developments in the context of (civil) security. This may certainly help bridging the chasm between research results and deployment.

2.1.3 Confirmation of the view that humanitarian demining R&D will be treated as part of a broader field on “risk management and (civil) security”

¹ <http://www.ejil.org/journal/Vol9/No4/art5-03.html>

Humanitarian demining – although still present as a topic for R&D in framework programme 6 of the EC - is viewed as part of a global R&D framework dedicated to improved risk management [5].

2.1.4 Emphasis on the Mine Ban Convention, a political point of view

L. Carbonez (Director European Security, Ministry of Foreign Affairs – Belgium) [4] reminded the audience about the voluntary political actions of Belgium, the first country in the world that adopted in 1995 a legislation which outlawed anti-personal mines, including components, parts, and technology (see also [6]). At the international level, “the Mine Ban Convention [7] has the vocation to become a universally accepted legally binding instrument” [4]. 136 countries have become State Parties, 46 states still have to be convinced to adhere. Universality is a first objective, but impact has to be measured by factual data: e.g., stock pile destruction (60 state parties have announced that they destroyed 30 million antipersonnel mines), mine clearance figures, number of victims (approximately 15.000 to 20.000 in 2002) and victim assistance.

2.1.5 Demining put in a larger historic perspective, a military point of view

James L. Jones (General and Supreme Allied Commander Europe – NATO) has put the mine problem in a broader historical perspective. History provides the intellectual basis for the *principle of discrimination* that argues for the protection of civilians and civilian objects. Minefields are in flagrant violation of this moral principle since they continue to cause harm indiscriminately to all age classes and populations, primarily after the end of the war. Also inherent limitations in technology, geographical extent and targets have automatically provided protection to non-combatants.

The notion of *military necessity* makes the case that inadvertent harm to civilians and civilian object, though regrettable, is acceptable if a significant military gain results and there is no other way to proceed. The Ottawa Convention [8] (which bans the use, the stockpiling, the production and transport of antipersonnel Mines) and the diminishing threat of warfare with massed armies (hence the decreasing “military necessity”) are the two main reasons for optimism in the future evolution of the worldwide mine problem. “*However non-state actors see the landmine and its horrifying, indiscriminate nature as being a very useful weapon if the objective is to psychologically terrorize and influence populations and governments.*”[9].

For details on the historical facts supporting the statement of James L. Jones, we refer to [9]. Jones’ statement remained very academic, and no clear specific challenges were put on the table for scientists, despite the military experience of casualties, for example in peace keeping and humanitarian operations.

2.2 A new interpretation of controlled test and evaluation could boost introduction of new technologies in the field

2.2.1 Lab tests of established sensors show performances that are not better than “bad” research results

The impression exists that some of the techniques, adopted early for field action may have been well tried so that their implicit shortcomings are known and can be bypassed by human ingenuity, but that they were never before properly tested. This is a useful area to assess as it could lead to a better understanding of how to implement new technologies. The new technologies, however, are being properly tested and scientifically evaluated and as result never fully tried out in practice.

Amazingly low probabilities of detection in controlled test conditions were presented for three standard tools out of the toolbox of deminers, namely prodders, dogs and metal detectors in three conference presentations [1]. This was one of the first times ever, scientific analysis of the performance of standard tools was presented: C. Mueller et al. ([1], pp. 233-241) reports success rates with metal detectors beginning at about 50 % and rarely reaching above 80 %, R. Fjellanger et al. ([1], pp. 162-165) reports detection performance down to approximately 70 % based on the vapour sensing capabilities of dogs, and J. Trevelyan ([1], pp. 242-248) describes success rates with prodders down to 50%. It is certainly true that, in practice, locally adapted operational procedures, based on the contextual a priori knowledge, reduces the risks and increases the probability of detection. Strong objections were raised, concerning lack of rigor and lack of representativity of the results, against the test methodology used by Mueller et al.; the debate could not be settled. Nevertheless, the three papers on retrospective scientific analysis of well-adopted sensors remain extremely valuable – if their results are being confirmed - because they describe the objective intrinsic behaviour and limitations of sensors, when operated independently of an operational procedure based on human expertise, in controlled conditions for a variety of soils and foreign objects.

Producing these kind of figures for detection probability, for an experimental new sensor probe, resulting from an R&D project, would probably be and has often been interpreted as a failure of success. Nevertheless prodders and metal detectors have been adopted as workable instruments by the end user community, a long time ago. This leads to the conclusion that deployment of new technologies in the field should occur at an earlier stage, and time should be explicitly provided for developing appropriate procedures and contextual scenarios to complement the toolbox of instrumentation so that more and more specific situations can be covered.

On the other hand, in parallel to the development of emerging sensor technologies, the operational performance of conventional, off-the-shelf metal detectors can be enhanced, and the importance of the human factor might be reduced, by providing a sufficiently sound and detailed understanding of the detection process (e.g. electromagnetic induction, eddy current modelling,...).

2.2.2 New emerging priority: bridging the gap between user requirements/ donor specifications and exploration of technological capabilities

The evidence that we understand so little why current successful demining works (dogs, prodding, metal detectors, and machines), triggers questions like:

- What is the baseline to which new technology has to be compared?
- In the presence of urgency, isn't it appropriate to be less reluctant towards fast uptake of new technology at an earlier stage in current practice?
- User requirements have not been updated in 10 years and technology has evolved substantially. Isn't it the right time to bridge this newly developing gap, so that we can move forward and introduce some of the new technologies by associating them in the operations even if they are not a 100% effective?

The latter two points require structurally new and coordinated commitments of donors, deminers and technologists. Funding is crucial and probably requires a new paradigm.

2.3 Urgent need for new funding structures to bridge the chasm between R&D prototypes and tools in the hands of deminers

The major impediment to adoption of new technology in the field is the absence of support for bridging the gap between R&D results and fieldable systems. For a small, mainly government dependent and financially unattractive market with no explosive market increase, such a support is a prerequisite for achieving a breakthrough. Dual use developments within civil applications, common military/civilian technology development and incorporation in the broader field of security are encouraged to solve that problem but take away some of the needed focus on specific technology to solve the mine problem. A debate concerning EC co-funded RTD projects, leads to *the conclusion that no structure for support exists at this time in Europe for carrying the results of EC funded R&D projects towards fieldable systems*. The crude question is raised: Why fund research, since it is well known that "research only generates new research", if the results are not exploited?

A direct answer to such a direct question is never simple, because of the nature of fundamental research itself. Fundamental research activities often result from the spontaneous initiative of individual researchers. The latter, being concentrated on the current state-of-the-art, are probably the best "sensors" to trigger discoveries and inventions; policy makers are inevitably lagging behind and reacting only when tendencies are already visible and pursued by a larger group of R&D players. Generally speaking fundamental research leads to better understanding of open questions; it produces indirect unexpected benefits and leads to incremental understanding. Specifically for humanitarian demining, the general opinion expressed is that - as an integrated consequence of fragmented research efforts - metal detectors are better (higher sensitivity, better discriminatory power, improved tuning capabilities, ergonomic design) now than 10 years ago, safety in the demining workplace has increased, a breakthrough in acceptance of information systems has been achieved, ICT has increased communication capabilities, new information sources (satellite imagery) have been successfully used, a system like the Information Management System for Mine Action (IMSMA) [10] has introduced improved data handling and presentation. The UN International Mine Action Standards (IMAS) have

introduced standards and have for example also enforced the liability of the mine action contractors.

Bottlenecks hampering the structural funding of the transition activities between R&D results and fieldable systems in Europe are: the partitioning of DG (Directorate General) responsibilities, the strict interpretation of laws on competition, and the limited interest of donors in this area due to high budget requirements (see also paragraph 2.3.1). To deal with this situation, urgent high level political action is required.

2.3.1 Donors should be approached: spend now for much larger savings later

The reluctance of donors and their limited interest to participate in technology transfer can be explained by the high budget requirements in this area. It is a common rule of thumb that for every EURO spend in supporting research, 10 Euro is required for development, while an investment of 100 Euro is needed for turning these developments in successfully marketed products. Moreover, as stated earlier, in humanitarian demining technology we are confronted with modest market perspectives and markets created by government decisions.

A more detailed analysis is given in [3], as well as a proposal for remediation. Cost effectiveness analysis on an economic basis, as proposed by R. Keeley ([1], pp.19-26) could provide insight to support the statement: spend now (on research) for much larger savings later.

Nevertheless, technology development support as part of donor funding of MACs is a good investment for future increased efficiency of the overall demining process. This requires new contract schemes and the elaboration of novel criteria of success, and raises supplementary questions on issues like the ownership of intellectual property, etc... Also co-financing from defence budgets is suggested.

2.3.2 Large difference North America / Europe in availability of funds for fielding equipment - US army supports “market culture”

The overview of the Canadian landmine detection research and development program, presented by J. McFee ([1], pp. 9-16), and the overview of the current US Army basic research on landmine and UXO detection, presented by R.S. Harmon, illustrate the North American structural approach for the continuous cross-fertilisation of laboratory research towards applications in practice: the US Army Research office has as a mission to invest in fundamental research at universities and a parallel structure within the army for applied research is picking up the results of the fundamental research. An equivalent approach does not exist in the EU at this moment.

David Daniels raised the point of Europe lagging far behind commercially. If Europe does not start up a voluntary action in picking up the R&D results and turning them

into commercial products, US government funded technology will monopolise the market. It is in the interest of everybody that second and third source suppliers exist.

2.4 Good progress reported in many technology areas, including clearer definition of less useful areas

Progress has been made in many domains and this was covered by the conference contributions [1]. Nevertheless, P. Blagden made the statement that, except for GPR, none of the other technologies appeared to be within some years of being ready to be taken into the field for close-in detection. The general opinion at the conference is that *close-in detection of individual mines* and *area reduction* are the priority domains for demonstrating progress.

S. Ivashov's talk ([1], pp. 3-8) presented some Russian developments, revealing that in the area of mm-waves and its application to security there is a lot to be learned from Russian expertise.

It is not the purpose, however, of this chapter to give an exhaustive overview of incremental changes and new ideas in all areas, but rather to describe the general state of advancement in areas characterised by great expectations in terms of breakthroughs and focused research programmes.

2.4.1 Data fusion is not yet mature

In the area of *multisensor platforms and data fusion*, three words are essential:

- *Sharing*: information exchange certainly occurs now within the humanitarian demining community.
- *(Demonstrated) promise*: we are on the way to, but did not yet arrive – e.g. good results on learning sets are not sufficiently convincing.
- *Real time*: appropriate processing architectures are being conceived to go from simulation towards practice.

The results of data fusion, even when carried out at the level of the signals (rather than at the level of extracted features or at the decision level) at the expense of a lot of computing power, remain unsatisfactory with respect to their robustness. Sensor fusion generally is performed with sensors optimised for individual performance rather than optimum input to sensor fusion (J. MacDonald - [1] , pp. 625).

Probably the sensor fusion problems should be tackled more fundamentally, based on physical modelling and simulation of subsurface imaging. This however requires the solution of ill-posed mathematical problems (inverse solutions), which can only be regularised by mathematical constraints. The main problem resides in finding appropriate constraints that are not in violation with the real world situation. In this respect the research on *multimodal inverse problems for subsurface imaging* opens new opportunities for finding realistic cross-modality constraints based on measurements in situ, as opposed to a priori introduced constraints.

2.4.2 Airborne survey is shifting from experimental towards “production survey”

From the work presented, *a coherent framework emerges* with opportunities for improvement, both on sensors (e.g. chemical detection) and on software (e.g. integrated GIS-environments, image interpretation methods). It involves the total usage and integration of all available information over the area from small-scale to large-scale, past and present - aerial and satellite multimodal data, ground surveys, interviews and local knowledge about culture and land usage. The means to obtain all of this information are generally known, the integration and structuring schemes are emerging and being validated.

2.4.3 Significant contributions from non-demining ICT community - Decision Support/ Information Systems

Information systems are now being equipped with extra communication means and decision support systems. The primary question raised is: how to harmonise them around IMSMA? It is generally acknowledged that IMSMA has brought standardisation in the field and enforces correct documentation and reporting of mine actions. Therefore, there is a tendency to encourage add-on developments that are compatible with IMSMA that has gained wide acceptance within the deminers' community.

“Everything would have been easier if we had the JMU (James Madison University) Clearing House at the start” ([1], pp. 78-81). This statement heard from D. Radmore, a professional deminer, illustrates how initially hostile attitudes towards a technology coming from another scientific community outside the humanitarian demining field can gradually gain acceptance when developed in collaboration with end users. It was suggested that a structured knowledge base on “lessons learned from field experience” would be useful, in particular for bringing back the results and experience gained with new technologies on the field towards researchers and developers.

A small size decision support system, for local usage in Croatia was presented by N. Mladineo ([1], pp. 93-98). It illustrates how a pragmatic design made by locals for local problems can resolve discussions about priority areas if the model produces plausible outcomes. The urgency of decisions to be taken was the primary motivation to find a pragmatic non generic solution.

2.4.4 Test and evaluation standardisation is needed, but it's timeliness is questioned in the presence of a shrinking market

CEN workgroup07 [11] activities on standardisation are deemed useful and necessary, certainly for manufacturers, but the timeliness of the activities is questioned in the presence of a shrinking market. Standards should gain acceptance also by the end-users and manufacturers before getting maximal utility. Practical questions of end users should be taken into account, e.g. the appropriate foot print size at a specified depth in relation to full area coverage (Vernon Joynt). Standardisation in general could be useful as one of the elements in procurement decisions of existing tools.

2.4.5 End user needs versus technology development: scientific approaches are not yet mature

Initial steps towards a scientific approach to *economic modelling of cost-effectiveness of demining technologies* were proposed by R. Keeley ([1], pp. 19-26) as an alternative or complement to the ad hoc analyses of today. The main challenge will be the acceptance of the models and their ability to be tuned to local circumstances. One of the main identified bottlenecks is the availability and the certainty of the input information. The latter problem is related to the previously raised question: How to ensure adequate and exchangeable reporting from mine actions? Solving this question is an essential prerequisite for further development of economic models, ICT decision support systems, information systems and socio-economic impact studies that can identify priority and less useful areas for demining operations.

2.5 Paradigm shift for research, development and deployment from humanitarian demining towards restoring local communities and evidence based risk management

- At the *organizational level* in EC-FP6, *R&D on humanitarian demining* is part of “Improvement of Risk Management”. The text of the “Call for proposals” is technically oriented towards (open) system development and should be interpreted as a transcription of the global objective to achieve high level society benefits [5].
- At the *level of field actions* in practice, national governments and MACs are adapting their priorities to those of the locals: that said, avoiding famine by food supply, medical assistance and agricultural activities or restoration of water sources might come first before the removal of mines. S. Grainger ([1], pp. 56-63) presented a case study in Lebanon where urban restoration of the infrastructure started before the contracted demining organisation had the opportunity of fully removing the mine threat. In certain situations the risk of famine or socio-economic failure might either subjectively be perceived or objectively be higher than the mine threat, influencing the priority of action. Ranking of risks is implicitly made.
- At the *level of designing models and R&D*, J. Trevelyan presented a possible model of agricultural exploitation in the presence of antipersonnel mine risk ([1], pp. 32-40). The model is an initial proposal and includes mine resistant agricultural machinery development and new agricultural practice. The idea is certainly not mature yet but deserves to be taken up further.

The thinking behind the three observed evolutions converges towards a similar way to move forwards, and it calls for the investigation of a paradigm shift in research, development and deployment and donor attitude from humanitarian demining towards restoring local communities and evidence based risk management.

The fundamental question was raised if this viewpoint is compatible with the Ottawa convention [8]. In our opinion, it is: “the fencing of minefields in areas that have little impact on the socio-economic life rather than their removal” and “prioritising a

solution to the threat of famine by cultivating the land rather than to clear it” can be seen as interim solutions to solve urgent local problems causing immediate and high risk, taken up before the actual mine clearance.

The emerging new paradigm triggered also a lot of organisational questions: it requires new views on quality of results and liability defined in terms of achieving acceptable risks, which should be adopted by the donors in their contracts. Probably due to the presence of representatives from several demining companies, the difficulty of the statement of work in the contracts was raised at several occasions: e.g. the specification of quality assurance and the definition of failure. The UN requirement for humanitarian mine clearance efficiency of 99.6% [12] has now been superseded in IMAS by the introduction of land acceptance checking that primarily depends on the end use of the cleared land.

3 Conclusions and discussion

The EUDEM2-SCOT 2003 conference has brought together subsets of all players in the field of humanitarian demining. The presentations and discussions were characterised by an increasing maturity, transparency and honesty about the achievements. Views were exchanged frankly between different parts of the community, including analyses of where we have gone wrong. The main global statements of the conference can be summarized as follows:

- European policy makers have expressed a *continued strong interest in R&D* on humanitarian demining, but within a larger framework of security and risk management. R&D frontiers between humanitarian and military demining are reduced but only in certain countries. Whether this will translate to effective financial support particularly to European industry is an open question. At the *international political level*, the Mine Ban Convention has the vocation to become a universally accepted legally binding instrument. At the *military level*, “military necessity” of using landmines decreases, but non-state actors continue to use it as a very useful weapon to terrorize populations and governments.
- A new interpretation of controlled test and evaluation results could boost the introduction of new technologies in the field. Recent lab tests of established sensors show performances that are worse than performance results for new technologies emerging from research. If these test results can be confirmed, the baseline against which performance of new technologies should be evaluated needs to be more rigorously assessed and mechanisms that support faster transfer to the field should be seriously promoted.
- There is an urgent need for new funding structures to bridge the chasm between R&D prototypes and tools in the hands of deminers. No structural support exists in Europe for carrying the results of EC funded R&D projects towards fieldable systems. A large difference US/Europe is observed in availability of funds for fielding equipment: the US army supports “market culture”. Donors should be approached to spend now (on the early adoption of new technologies) for much larger savings later.
- Good progress is reported in many technology areas, including clearer definition of less useful areas. Advances in data fusion are less than expected.

Airborne survey is shifting from experimental towards production survey. Significant contributions from the non-demining ICT community are now being acknowledged by the end user community. Test and evaluation standardisation is needed, but the timeliness of the current actions is questioned in the presence of a shrinking market. While substantial progress is being realised in one of the two priority areas in humanitarian demining, namely area reduction, delivery of new tools and equipment to improve the search for individual mines has not yet met early expectations.

- A paradigm shift is observed for research, development and deployment, namely from “humanitarian demining” towards “restoring local communities” and “evidence based risk management”.

4 References

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