HUMANITARIAN DEMINING
RESEARCH AND TECHNOLOGICAL DEVELOPMENT FUNDED BY
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Luxembourg: Office for Official Publications of the European Communities, 2003

ISBN 92-894-5942-5

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Printed in Belgium
PRINTED ON WHITE CHLORINE-FREE PAPER
We are pleased to present this brochure which summarises the actions funded by the European Commission in support of research and development of new technologies for humanitarian Mine Action.

Significant technical advances have been made in recent years in humanitarian demining, yet some of the most important of these have not received the publicity they merit. This brochure highlights a few of the successes which have come from European Commission funded, and co-funded, research and technological development. This work has been supported with a total of over €55 million from the European Commission since 1994. We are proud that the European Commission has played such an important role in supporting new technologies that make the painstaking process of clearing antipersonnel mines, and other explosive items, faster, safer and more cost effective. In addition to the new equipment already used by mine clearance organisations, we highlight a number of key technologies which have reached the point where they are ready for exploitation.

This brochure also outlines the most important issues which must be addressed if advanced technologies are to fulfil their considerable potential in this humanitarian task. We fully endorse the need for action to facilitate the production of new demining tools and equipment, and to promote the utilisation of these new technologies in the field. Clearing the world of mines is a moral imperative which demands the application of the best technical resources if the goal of a world free from anti-personnel mines is to be achieved in the lifetime of those most affected.

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Research into and Technological Development of new technologies (RTD) has already made an important contribution to the complex process of humanitarian demining.

Significant impact has been reported through such actions as:

• Developing advanced information-management tools for planning and monitoring the progress of mine clearance projects.

• Supporting demining operations by:
  - implementing geographical information systems linked to the survey of mine affected countries;
  - providing managers of mine clearance projects with ortho-photo maps, images collected from a low flying platform such as an airship or a helicopter; or where collecting such airborne data is not possible, high resolution, geo-referenced satellite images.

• Developing a new generation of metal detectors which significantly improve deminers’ ability to locate minimum metal mines, especially when they are buried in difficult mineralised soils.

• Developing new tools which complement metal detectors in the search for landmines, in particular ground penetrating radar which has reached the point of being ready for field-testing. GPR may soon improve demining speed by reducing the significant amount of time wasted digging up scrap metal found by metal detectors when looking for mines.

• Researching alternative methods to detect the explosives contained in abandoned landmines: for example the use of giant rats.

• Establishing international standards for test and evaluation of demining equipment and methods, which have already influenced field practice.

• Researching and implementing new tools which support the vital task of area reduction. By reducing a large “suspected area” to the small area that actually contains mines or unexploded ordnance, very significant savings of cost and time can be made.

However, even though RTD has had a measurable impact on the overall process of mine clearance, it must be recognised that the delivery to deminers of new tools and equipment to improve the search for individual mines has not met early expectations. Reasons for this include:

• The considerable complexity of the mine clearance problem as a process to which risk assessment and management tools need to be applied.

• The poor initial appreciation by some researchers of how to apply advanced technologies in the field in poor countries.

• Some significant non-technological problems in finding the resources needed to turn prototype mine clearance equipment into fully tested commercial products ready to use in the field.

It is also clear that some of the successes which have been achieved have apparently gone unnoticed.

In summary, the RTD efforts supported by the European Commission (EC) together with those supported by European Union (EU) Member States have reached a significant level of maturity, but there remains a need to implement these new technologies in Mine Action projects in the field.

**It is now time to establish a joint strategy between the RTD actors (technologists), Mine Action donors and field practitioners (deminers) in order to secure the effective deployment and use of new technologies which have already been developed.**
The EU institutions (principally the Parliament, Council and Commission) have in recent years taken a series of actions to oppose the production and use of Anti-Personnel Landmines (APL), and to support humanitarian Mine Action. One of the first was in May 1995 and called, principally, for a strengthening of the 1980 United Nations “treaty on certain conventional weapons”. Subsequently, the collective position of the EC and the EU institutions has been developed and reinforced, and support has been given for humanitarian demining operations, victim assistance and the development of new technologies for landmine clearance. The Parliament first adopted in 1996 a specific budget line for the work against Anti-Personnel Landmines.

In 1999 the Ottawa Convention on anti-personnel landmines came into force (“the mine ban treaty”), strongly supported by the EU Institutions and most Member States. Obligations for states ratifying the treaty include:

- Destruction of all stock-piled mines within 4 years (Article 4)
- Clearance of APL mined areas within 10 years (Article 5.1)
- Identification, marking and fencing of mined areas as soon as possible (Article 5.2)

In July 2001, the Council and the Parliament adopted a regulation to further reinforce the EU response to anti-personnel landmines. This regulation lays the foundations for the current integrated and focussed European APL policy. The financial and legislative efforts were enhanced with the adoption in 2002 of a multi-annual strategy (2002–2004), with a budget of around 17 M€ per year, managed by the European Commission’s Cooperation Office (EuropeAid). The specific APL budget line is used to co-finance actions of mine clearance, mine awareness, landmine impact surveys and victim assistance, as well as RTD and standardisation actions.

From 1992 to 2002 the EC spent about 200 M€ on Mine Action, and Member States spent a comparable amount on bilateral actions. Research and development of new technologies for humanitarian demining has been supported by the Commission through the Framework Programmes for research. At the same time the Commission’s Joint Research Centre supported these projects through efforts mainly focussed on test and evaluation.

A selection of these projects is presented in the “Success Stories” highlighted in this brochure.

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1 The APL regulation consists of two regulations, the first covering developing countries (Regulation (EC) 1724/2001, OJ L 234, 1.9.2001, p. 1), and the second, third countries other than developing countries (Regulation (EC) 1725/2001, OJ L 234, 1.9.2001, p. 6).

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SOME SUCCESS STORIES

IMPROVED METAL DETECTORS

Metal detectors have to be able to detect the tiny amounts of metal in minimum metal mines - this becomes very difficult when the mines are buried in soils with a high mineral content that produces false alarms. The EC co-funded the PICE project (FP4) and Schiebel used the project to bring to market the ATMD™, a new metal detector which has become a commercial success. Key reasons for Schiebel’s success include:

- The development of ATMD™ was based on long experience with metal detectors for demining
- The incremental change to the new model was straightforward for both the manufacturer and, crucially, for deminers.
- Intensive testing and evaluation were done during the PICE project, including phases of redesign based on field test results.
A number of Directorates General and Offices of the European Commission participate in Mine Action:

<table>
<thead>
<tr>
<th>Directorate-General for External Relations (DG RELEX)</th>
<th>Overall responsibility for EC Mine Action policy</th>
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<tbody>
<tr>
<td>EuropeAid Co-operation Office (also known as AIDCO)</td>
<td>Management of Mine Action projects, including funding of some research and development actions. Collaboration with DG RELEX for the definition of priorities of Mine Action.</td>
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<tr>
<td>European Community Humanitarian Aid Office (ECHO)</td>
<td>Management of emergency humanitarian Mine Action</td>
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<tr>
<td>Directorate-General Joint Research Centre (DG JRC)</td>
<td>Participation in Mine Action research projects, especially test and evaluation of equipment, and development of standards. Represents the EC on demining international technical organisations.</td>
</tr>
<tr>
<td>Directorate-General for the Information Society (DG INFSO)</td>
<td>Responsible for Mine Action technology research in the 4th, 5th and 6th Framework Programmes for RTD.</td>
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<tr>
<td>Directorate-General for Research (DG RTD)</td>
<td>Participation in some Mine Action research</td>
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<tr>
<td>Directorate-General for Development (DG DEV)</td>
<td>Participation in some Mine Action research</td>
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Ground penetrating radar (GPR) is at last reaching maturity for humanitarian demining; several dual-sensor (GPR and metal detector) mine detectors are currently ready for field trials. FP4 project DEMINE successfully developed a novel “radar-on-a-chip” technology for humanitarian demining and other uses. This advanced technology offers significant improvements in cost, power consumption and reliability, as well as advancing the “state of the art” in radar hardware performance.

The DEMINE radar system has been taken up by a FP5 project, DEMAND, and has also formed the basis for the GPR of one of the nationally funded mine detectors which is now ready for field trials.
The objective of Mine Action is defined in the International Mine Action Standards as: reducing the risk from landmines to a level where people can live safely, in which economic, social and health development can occur free from the constraints imposed by landmine contamination, and in which the victims’ needs can be addressed.

Mine Action comprises a number of complementary groups of activities including:

- mine risk education.
- humanitarian demining, i.e.
  - mine and UXO survey,
  - mapping, marking,
  - clearance of explosive items when necessary.
- stockpile destruction

In addition to supporting operational mine clearance projects, the European Commission decided in the mid 1990s to launch RTD actions aimed at making mine clearance faster, safer and more cost-effective. Several individual EU Member States also sponsored RTD projects related to mine clearance, however the Commission initiative focussed exclusively on humanitarian mine clearance and aimed to avoid, as much as possible, unnecessary duplication of national programmes.

In the early and mid 1990s it was generally accepted by the international community of researchers that the key to clearing abandoned landmines was to improve “mine detection”. New sensors were researched, and data fusion was proposed as a way to combine the output of more than one individual sensor. Research priorities in the European Commission’s Fourth Framework Programme (1994-98) reflected this approach.

In just a few years humanitarian demining has advanced rapidly and, in general, understanding of which technologies are likely to lead to the greatest improvements in demining has also evolved. The Fifth Framework Programme (1998-2002) saw the introduction of research on area reduction. Still in progress, this work is showing considerable promise. Technologies to enhance area reduction, and the use of Information Technology for improved management of Mine Action, are now considered to be two of the key applications for the most significant improvement to humanitarian demining efficiency and cost effectiveness.

The potential of airborne remote sensing in to detect mined areas by looking for “minefield indicators” was demonstrated by a pilot project co-funded by the EC Directorate General for Development. Four test areas in Mozambique were used: each one represented a different type of landscape with variations in relief, vegetation type and density, climate, soil type, etc as well as different conflict histories. Optical, infra red and microwave sensors were used and subsequent image analysis identified minefield indicators such as:

- linear features, like roads and paths that designate safe passages;
- periodically placed minefield indicators, like poles and sticks;
- differences in vegetation & land use.

The success of this pilot project encouraged the EC to fund further work on area reduction technologies.

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2 An example of the potential savings that can be made by improved Area Reduction is the case of Croatia. Initially 13,000 sq km of land were regarded as possibly contaminated by mines/UXO. Area reduction techniques have now made it possible to safely declare most of this land free from contamination. The remaining area, which will have to be painstakingly cleared, has been reduced to 1,700 sq km, saving an estimated 17,000 M€ in demining costs.
THE EVOLUTION OF TECHNOLOGY RESEARCH PRIORITIES IN HUMANITARIAN DEMINING

THE RAPIDLY CHANGING ROLE OF HUMANITARIAN DEMINING RTD

<table>
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<tr>
<th>Early to Mid 1990s View of HD Research</th>
<th>More Recent View Five to Ten Years Later</th>
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<tbody>
<tr>
<td>Aim: to develop a universal mine detector suitable for many different environmental situations.</td>
<td>Aim: to develop a range of tools, each one suitable for just a few scenarios.</td>
</tr>
<tr>
<td>Mine Detection is the key.</td>
<td>An overall “systems approach” to Mine Action is the key. Improvements to: surveying, area reduction, mapping, programme management, mine risk education, etc., may result in larger gains in overall efficiency than new detectors.</td>
</tr>
<tr>
<td>Clearing all mines will take hundreds of years.</td>
<td>Significant progress has already been made in some heavily mined countries, but much work is still to be done. It is recognised that low priority mined areas may need different approaches to Risk Management.</td>
</tr>
<tr>
<td>The focus was on completely new technologies for mine detection.</td>
<td>Incremental improvements to established humanitarian demining technologies and methods may give better results sooner.</td>
</tr>
<tr>
<td>Technical experts will help deminers by designing new tools for them.</td>
<td>Deminers and researchers will work together on solving the problems, the key to success is combining field expertise with technological research.</td>
</tr>
<tr>
<td>Research was often primarily focussed on technical objectives.</td>
<td>Cost effectiveness, within the socio-economic context of the region of use, is the top priority.</td>
</tr>
<tr>
<td>Performance benchmarks were primarily based on laboratory performance and test-lanes; there were no agreed international standards.</td>
<td>Test &amp; evaluation of the suitability of the equipment to specific post-conflict scenarios (environment, threat, logistics, etc.) are based on international standards. More emphasis is given to “near-realistic” testing.</td>
</tr>
</tbody>
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SOME SUCCESS STORIES

GEOGRAPHICAL INFORMATION SYSTEMS FOR MINE ACTION IN SOUTH EASTERN EUROPE

The project “Geographic Information System (GIS) for Mine Action in South Eastern Europe” was initiated to strengthen the GIS and mapping resources available in the region, and to work towards harmonising methods and data. The main aims were to:

- Improve the availability of verified, validated, objective and precise geographic information for Mine Action programmes.
- Facilitate regional co-operation in Mine Action through effective and continuous sharing of information, by developing common criteria and improving interoperability.

The project was successfully implemented by the International Trust Fund under the scientific supervision of the Joint Research Centre and jointly funded by the EuropeAid and the US Department of State.
FOURTH FRAMEWORK PROGRAMME (1994-98)

The focus of co-funded Research and Technological Development for Humanitarian Demining in the Fourth Framework Programme –FP4– (1994-1998) was to bring to the field better mine detectors by improving existing technologies already used for other purposes. Particular attention was given to the use of multi-sensor systems with data fusion of the sensor outputs in order to reduce the false alarm rate of metal detectors.

A total of four FP4 projects proposed hand-held mine detectors, and three proposed vehicle mounted systems. Work was also done to establish test facilities and targets (surrogate mines): this investment was made recognising that objective and independent testing of equipment is essential in order to assure that new tools will be accepted by demining organisations.

FP4 projects were used to construct or improve test sites in France, Bosnia and Angola, and also contributed to a comprehensive test facility at the EC Joint Research Centre (JRC) at Ispra in Italy, which was principally funded by the JRC itself and by a special grant from the Secretary General.

The JRC also participated in five FP4 projects and provided independent support to several others.

To support researchers, information services were put in place for the emerging demining technology research community.

Proposals to develop complete multi-sensor mine detection systems and to bring them to market within two years were over-ambitious, particularly in the case of hand-held equipment where size, weight and power requirements all pose very serious engineering challenges. Even if these systems did not achieve the anticipated results, they led to the development of significantly improved metal detectors, an important outcome.

A SUMMARY OF EC FUNDED HUMANITARIAN DEMINING RESEARCH AND TECHNOLOGICAL DEVELOPMENT

The Joint Research Centre at Ispra has built Test and Evaluation facilities for testing sensors, prototype multisensor systems, and commercially available equipment for humanitarian demining. Users include five EC co-funded Framework Programme projects, and also testing programmes for metal detectors; GPR, infrared, magnetic and acoustic sensors; surrogate mines; and soil property instruments. Measurements freely available on the JRC’s website provide a database for researchers working on advanced detection techniques. The JRC also responds to specific technical requests, e.g. investigating the detectability of the PROM-1 bounding fragmentation mine at the request of the Bosnia-Herzegovina Mine Action Centre. JRC activity is currently focussed on the standardised test and evaluation of metal detectors. With experience gained at Ispra and from the International Pilot Project for Technical Co-operation, the JRC has led the development of a new CEN Workshop Agreement in this area (see overleaf).

The Fifth Framework Programme - FP5 - (1998-2002) reflected the change in priorities regarding humanitarian demining technologies and made use of lessons learned during FP4. Improvements to area reduction were emphasised, and research and development of novel sensor systems which showed promise was proposed. Further support to the research community was initiated, based on the success of the earlier actions.

The Directorate General for the Information Society was responsible for the administration of Mine Action technology research within the Information Society Technologies programme of FP5.

RTD is advancing in technologies for area reduction, including observation at different infra-red and optical frequencies from skylifts, autonomous aerial vehicles and satellites. These data are processed using advanced information technologies in research projects which aim to enhance the work of human interpreters and to partially automate the process.

Another key technology for area reduction is the use of explosive vapour detection systems. FP5 budget has been used to support the development of advanced vapour detection technology based on immunoassay methods, and is supporting the integration of this technology into a multi-sensor mine detector system.

SOME SUCCESS STORIES

A MULTI-SENSOR DATA FUSION MINE DETECTOR

In the LOTUS project, PipeHawk - a specialist in ground penetrating radar to locate buried pipes - joined metal detector manufacturer Foerster, and TNO research laboratories who developed the real-time data fusion of the radar, infra-red camera and metal detector. The humanitarian deminers of DEMIRA added field experience to the consortium. In 2002 this FP4 project gave the first public demonstration in Europe of real-time data fusion mine detection, in a former minefield in Bosnia.

Under the right conditions an advanced detector vehicle is so much faster than manual demining that perhaps just ten are needed to meet the demand world-wide. Financing the cost of product development and testing, probably "several million euro", from a total sale of just ten units is simply not feasible, so technical success has not been matched by commercial results.
OTHER RESEARCH ACTIVITIES

EUROPEAN COMMISSION’S COOPERATION OFFICE (EUROPAID):
Several humanitarian demining research projects have been co-funded or managed by EuropeAid, including:

- Detection of landmines using rats.
- Improvement of information and mapping systems in south eastern Europe, under the technical supervision of JRC.
- Development of standards for use in Test and Evaluation of demining equipment, with the technical participation of JRC.
- Preparation for the destruction of the Ukraine APL stockpiles of 6 million PFM-1 mines, in cooperation with DG Research³.

DIRECTORATE GENERAL JOINT RESEARCH CENTRE (DG JRC):
Since 1994, the JRC has undertaken actions related to Test and Evaluation (T&E) of demining equipment, under its institutional programme and also for third parties:

- Creates and maintains indoor and outdoor test facilities for the assessment of sensors and monitoring of environmental conditions.
- Supports and conducts T&E campaigns of detection equipment, in collaboration with international organisations (United Nations, Geneva International Centre for Humanitarian Demining, Non Governmental Organisations, as well as Mine Action Centres and manufacturers).
- Develops standards for T&E of metal detectors co-funded by EuropeAid.
- Represents, since 2000, the European Commission in the International Test & Evaluation Programme (ITEP) for humanitarian demining and hosts its Secretariat.
- Creates and maintains T&E information databases (mine signatures) and associated websites (ARIS network: Action for Research and Information Support).

DIRECTORATE GENERAL FOR DEVELOPMENT (DG DEV):
In 1998 DG DEV co-funded an international project investigating airborne minefield detection. Real-world testing was done in mined areas in Mozambique and the results formed an essential pre-cursor to the area reduction research in FP5.

DIRECTORATE GENERAL RESEARCH (DG RTD):
DG Research is supporting technically, a trial project together with EuropeAid³. The project is researching ways to safely dispose of the Ukrainian stockpiles of PFM-1 mines. This project is conducted through the Science and Technology Centre in Ukraine and is financed through funds made available by the TACIS programme, administered by DG RELEX.

³ A trial project to prepare for the destruction of the 6 million PFM-1 mines stockpiled in Ukraine was launched in 2003; the first phase has assessed the safety and environmental risks of handling and transporting the mines, the second phase will research the best technologies for their destruction.

SOME SUCCESS STORIES

STANDARDISED TESTING OF METAL DETECTORS

Objective and independent test & evaluation is needed to assess and predict the performance of existing and new demining equipment, and this requires internationally agreed test standards. In a project co-funded by EuropeAid and chaired by the JRC, the European Standardisation Committee (CEN) produced a Workshop Agreement on metal detectors. The first “CEN Workshop Agreement” (CWA 14747:2003) was published in June 2003; it gives principles, guidelines and procedures for metal detector testing. The CEN initiated a new process to establish standards for mechanical mine clearance.

The agreements will be used by the Geneva International Centre for Humanitarian Demining to write Technical Notes, and then by the United Nations Mine Action Service to draft International Mine Action Standards. These standards will be freely available and will be important reference documents for the Mine Action community.
RESIDUAL EXPLOSIVE SCENT TRACING: GIANT RATS

APOPO is a Belgian research organisation which is developing a new and different mine detection technology using giant pouched rats. The idea of using rats for the detection of landmines may answer the need for a cheap and efficient mine detector tool able to detect the explosive inside both metal and plastic landmines.

In the future these “biosensors” may be used either to sniff out and indicate the position of the individual mines, or to sniff for explosive residue in filters brought back after air sampling in suspect areas. Initially a Belgian funded project, the transition phase from research to implementation, including test and validation, capacity building and development of operational procedures is now co-funded by the EC through EuropeAid.

The take-up of new demining equipment is in many cases limited by the very high costs of:

• turning a laboratory prototype into rugged and reliable equipment suitable for use in harsh conditions and
• testing and verifying new equipment to a standard that allows deminers to have confidence in it for this safety-critical application.

The world-wide market for humanitarian demining equipment is small and fragmented, and is often considered to be about 20 M€ per year. New mine detection systems can expect to account for only a part of this total, so it is not commercially viable to spend several million euro on the engineering and testing required to launch a new product. Two detailed reports by Directorates General of the Commission have already addressed this issue 4. Further reports also support this view 5.

There appears to be wide agreement that the return on investment is too small to make such development work attractive commercially, and ways must be found to financially support the introduction of new technologies for mine clearance. The large companies which initially participated in the development of new humanitarian demining technologies have gradually withdrawn, and small and medium enterprises are emphasizing their inability to continue without an adequate return on their investment. The critical points appear to be first, the transition from the RTD phase to the production of commercial prototypes and subsequent mass production, and secondly, the introduction of the equipment into the field. These efforts are beyond the mandate of RTD and it is important to find new means to field successful research results. Donors have a key role to play - without their approval and direct support Mine Action projects cannot change their working methods or undertake the necessary large scale testing of new equipment. In the long term the introduction of better tools and equipment should increase efficiency and thus offer donors substantial savings. So, in implementing new technologies in the field, donors and end users have key roles to play, as well as technologists.


5 For example the study prepared for the Canadian Government “Assessment of the International Market for Humanitarian Demining Equipment and Technology” by GPC International, Canada - January 2002.
A recognised problem in technology research for Mine Action has been making relevant information readily accessible to researchers. The ARIS and EUDEM networks in FP4, and now the EUDEM2 network in FP5 (www.eudem.info) have successfully addressed the needs of demining technology researchers. ARIS had over 230 registered members who were regularly informed about relevant issues. EUDEM2 averages nearly 2000 accesses from different users each month.