

5. SMALL SCALE ANALYSIS OF ONGOING GOVERNMENT FUNDED R&D PROJECTS IN THE US

The current paragraph is the summary of a report made by John Brooks, on behalf of the EUDEM project. It is mainly centred towards military R&D projects with some focus on humanitarian demining.

The goals of the US survey were to determine the current state-of-the-art of US military and humanitarian demining technologies related to the detection and classification of anti-personnel land mines (APLs). The US Army-funded programs were investigated; the many US Navy programs were not. It is interesting to note that a co-ordination office, JUXOCO, was established to provide co-ordination for all Department of Defense (DoD) UXO programs; it serves as a *repository of data collected at US test facilities*. All test data involving UXO and mine detection/clearance is linked to the JUXOCO web site, <http://www.uxocoe.org/index2.htm>.

For the EUDEM survey, three US *GPR programs* were reviewed; the Ground-based STAnd-off Mine Detection System (**GSTAMIDS**), the Hand-held STAnd-off Mine Detection System (**HSTAMIDS**), and a developmental short-pulse hand-held GPR designated as the BRTRC/Wichmann radar. In general, the tendency to employ stepped-frequency modulation is consistent between the three main programs; the BRTRC/Wichmann radar uses a more conventional short-pulse modulation, albeit a very wideband pulse, ca. 5 GHz.

EMI (ElectroMagnetic Induction) has been used with some success for the detection of buried metallic UXO and mines. The principle is based on transmission of a wideband electromagnetic waveform. The resulting field induces a secondary current in the earth as well as in any buried objects. A receiving coil senses only the weak secondary field returned from the earth and buried objects.

The US requirement for **HSTAMIDS** is a probability of detection, Pd, of a mine to be 0.80 (i.e. a clearly military oriented specification; Annex 5 explains how this Pd is defined); the best performance with trained contractor personnel was 0.70, and the average performance using military personnel was only 0.30. Such performance has led to an 18-month extension of the HSTAMIDS program. Two systems of different vendors are briefly analysed in Annex 5

The Airborne STAnd-off Mine Detection System (**ASTAMIDS**) was a program developed to locate minefields, and used an IR sensor as the primary queuing sensor. **ASTAMIDS** failed to meet US Government specifications due to the poor performance of the IR sensor. The program has been realigned to study other options; the program is now called the Light Airborne Mine Detector (**LAMD**). No specific information regarding the failure has been made available at the time of the report.

As a conclusion, one can say the US Army demining technology program is maturing, with some erratic programmatic behaviour due to lack of clear success of any single or group of technologies. The 18 month delay in **HSTAMIDS** and the restructuring of **ASTAMIDS** are clear evidence of this. The progress of **GSTAMIDS** is promising. The lack of a consistent methodology for performance evaluation and system comparison leads to a "floating baseline" for competing systems to meet (see Annexe 5).

6. CONCLUSIONS AND DISCUSSIONS

To guide the reader through the conclusions, we have classified them in 3 categories: *Policy* (related to organisational and co-ordination aspects), *Practice* (related to currently used demining technology and procedures), *Technology* (related to R& D for new technologies, specification of equipment and testing).

6.1. Policy

– EQUIPMENT PROCUREMENT (AGENCY):

Several NGOs have stressed the need for new technology to speed-up current demining procedures, but they are often reluctant to invest in it, since (i) every particular local circumstance requires specific logistics, campaign organisation and equipment, (ii) as a consequence not all existing equipment is continuously in use, and (iii) the investment in equipment maintenance is too high. In this respect the concept of a supranational Equipment Procurement Agency, acquiring, organising and maintaining a *central pool of equipment* (technical toolbox), which could be called upon by the deminers following e.g. a leasing formula, could indeed form the basis of a solution to meet the market requirements. Work on setting up such an Agency is currently ongoing, with discussions involving (at least) the JRC in Ispra and the Geneva International Centre for Humanitarian Demining at the European level. The same concept should also be valid for currently available but expensive equipment (e.g. machines and dogs).

– MINE CLEARANCE FUNDING:

Although it is recognised that the EU should play a coordinating role in mine action programs, there is a generalised criticism by the *NGO end users* of the current EU way of working. Main recommendations for better operational functioning include *shortening the delay in funding, reducing the amount of bureaucratic procedures and limiting the fragmentation in too many EU divisions* with *insufficient coordination*. It should be generally accepted that mine clearance needs a continuous security of funding, because it is a long-term process, and not a short-time emergency action.

– PUBLIC INTEREST:

Public interest changes quickly, leading to inefficient usage of funds. This has caused the shift of campaigns from Bosnia, where the mine problem still persists, towards for example, Kosovo. Working NGOs had to change their policy at several other occasions, simply because they depend on the demands of their donors. Although the public interest, highly influenced by the mass media, has placed the mine issues lower on the problem agenda, compared to other international issues, the international community should not forget its responsibility.

– INFORMATION SHARING:

Apart from the normal protections of industrial property rights, we have found *many government-funded projects for humanitarian demining purposes, which are not releasing any of their results in the public domain*. This is a major impediment to progress, historically resulting from the early military involvement in the domain. Many classified NATO reports for example could bring a breakthrough in the development of new technology, the assessment of usefulness of certain techniques and the standardisation of testing protocols. Seeing Humanitarian demining as an urgent problem (see the signed Ottawa treaty), the release of this information should be a major and priority topic for the political agenda. *Information sharing between publicly funded military- and civilian projects should be a bi-directional process.*

– EUDEM DATABASE:

The EUDEM database is an attempt to give *an overview of the European offer within the field of humanitarian demining*. Its goals can only be realised if updates and the possibility for new entries are guaranteed on a continuous basis. Under these conditions, it could serve as a common data repository and a practical search tool for all actors in the demining sector, simplifying contacts and *favouring joint efforts to solve a joint commitment*. Maintaining the availability of the EUDEM data base requires a (small-scale) effort, continued over a number of years. More generally speaking, a lot of information sources on humanitarian demining can be consulted via the internet, but most of them are repeating the same things, and many of them are unreliable with respect to the information content and should be interpreted with care. This is of course a basic characteristic of the internet, but nevertheless we think that a reliable information dispatcher (e.g. JRC) could be beneficial to structure the fragmented information, to guarantee its reliability or at least mention its origin.

6.2. Practice

– INCREMENTAL IMPROVEMENTS TO CURRENT FIELD PROCEDURES:

At several occasions during the EUDEM survey, the importance of continuous developments was stressed to improve several pieces of equipment (e.g. protection items, more effective prodding and excavation tools, or vegetation cutting equipment) that, far from being spectacular, can make a difference in the field and bring *real short term added-value*.

– MINE DOG PROGRAMS:

Although the use of dogs is rather far from being a perfect science, well-run dog programs have apparently managed to convince more than one sceptic deminer. The use of dogs is therefore nowadays generally approved by most humanitarian demining organisations for area verification and minefield delineation purposes (area reduction), which allow important time gains compared to manual clearance operations, and quality control after mine clearance activities. Detection of minimum metal mines is possible and particularly appreciated. Individual mine detection during clearance operations is somewhat more controversial. In general mine dog programs seem to be expanding.

Heavily discussed issues are the lack of coherent and universal testing protocols for dogs and sufficient local training for the dog and its new handler. There seems to be little agreement on a Standard Operating Procedure (SOP). A number of studies are also underway to establish what dogs actually detect and how.

– MECHANICAL SYSTEMS:

An evolution is observed from *mechanical demining* towards *mechanically assisted demining* adaptable to local circumstances. Concerning the mine clearing vehicles in particular, one can say that the machines have usually to be *backed-up* by some manual method. These systems are employed for mine verification and area reduction tasks, as well as clearance of actual minefields. Large mechanical systems do require substantial investments (machine costs, logistics, and maintenance), and can actually only be employed on a fraction of the total mined areas. *Environmental effects have not always been sufficiently studied.* Several *specialized pieces of equipment* are also being used, for example to *clear vegetation* and tripwires, to accelerate manual clearance or the use of dogs.

– HUMANITARIAN VERSUS MILITARY OBJECTIVES:

It is important to understand the extent to which the design of mine detection and minefield delineation technology is based on military operational doctrine, compared to humanitarian or post-conflict requirements. *For the latter the needs of real time operation and testing following military practice are not so relevant.* Hence objectives as *acceptance* and *ergonomy* adapted to usage by indigenous deminers and NGOs, as well as *increased performance in sensitivity at a reasonable False Alarm Rate* should be emphasized.

6.3. Technology

– INPUT FROM OTHER DOMAINS:

It is well recognised how *military procedures and technology* have influenced, through a relatively long process of adaptation, the field of humanitarian demining, but *other domains are also providing new insights*, like non destructive testing, signal/image processing, remote sensing, Geographic Information Systems, medical imaging, etc. These other domains were included in our study, containing the list of actors claiming to develop new technological applications, but admitting not to be active yet in humanitarian demining. In our opinion, it is useful to closely monitor these developments, so that specific humanitarian demining tests can be carried out once the technology has reached maturity in other application domains.

– EXISTING VS. NEW TECHNOLOGIES:

Several end-users and national demining campaign sponsors brought up that less emphasis should be put on development of new technologies. The *"improvement of existing technology will resolve the problem faster"*, so that the political commitments of a mine free world within 10 years could be achieved. This (perfectly understandable) attitude towards new technologies is also observed in other professions (e.g. health care and medicine), where fast and critical decisions need to be made. It can partly be explained by a preference to use an imperfect technique whose limitations are well-known as compared to a new technique with better performances that is not fully trusted yet.

It is recognised, on the other hand, that the progress made with present techniques will not enable the 'current people in the field' to meet the Ottawa requirements. *Faster and safer technologies* are badly needed. The discussion on this issue is ongoing, and the many visions do not always coincide.

Following the same line of discussion, one should not forget that in the framework of the Ottawa convention every mine has to be identified as a 'real potential killer'. In practice however, when priority areas are defined and the *remediation strategy is adapted to the urgency* (e.g. fencing instead of clearance) only a fraction of the millions of mines spread out over the world are causing an immediate threat. Adapting the remediation strategy to locally defined priorities was mentioned by many government agencies. The need for *complete solutions, taking into account all economical, rebuilding, psychological, cultural and environmental aspects* was stressed by many NGOs – *Mine Action is indeed not only about demining.*

– **(GLOBAL) R&D TRENDS:**

Much of the R&D effort for humanitarian demining has indeed gone towards the **detection of individual mines** (usually close-in techniques mainly for blast mines rather than stand-off techniques for fragmentation or bounding mines). Two approaches seem to be followed, (i) either the combination of different sensors in one unit (*a multi-sensor system*), more performing but at the same time more complex and difficult to characterise, and (ii) the *combination of a detection sensor* (usually the metal detector) *with a confirmation sensor* such as NQR or neutron based techniques for bulk explosive detection, or sometimes the GPR.

Some research is also currently underway on **wide area confirmation methods**, for example airborne minefield delineation or explosive vapour/trace detection (e.g. biosensors) to complement or replace dogs, in order to save precious time by concentrating on areas which really need to be demined. The amount of such research is nevertheless rather small in the civil sector, compared to the importance of the subject, and compared to the effort put into other sensors (most notably GPR). This might change in the near future, especially concerning the detection of explosives.

The use of sensors for **specialised applications** (e.g. *Quality Assurance* in some scenarios) has probably not yet received sufficient attention (see comments in the GPR and metal detection sections, 4.2.6 and 4.1.3).

Evolution should be governed by the following set of keywords (NPA): "*Safer, Faster and Cheaper*".

– **SENSOR TECHNOLOGY MATURITY:**

A summarising view on the maturity of mine detection technologies is undoubtedly subjective and open for criticism. Taking into account that (i) we have to rely on indirect evidence due to the absence of well established definitions of equipment performance, (ii) most of the results of independent performance tests are not publicly available, (iii) we have not conducted performance tests ourselves, and (iv) we do not share the practical experience of deminers working in the field, we nevertheless think that *Table 2 in 4.4 is useful in fixing the large tendencies in technology maturity and equipment cost.*

Ground Penetrating Radar is undoubtedly the most popular sensing principle for R&D in humanitarian demining. The new developments in metal detection try to extend target detection towards target depth, volume, and shape estimation as well as imaging. Microwave radiometers could be complementary to GPR for imaging and detection of buried mines at shallow depths. IR sensors will probably always require a physical reasoning from the operator to yield good results. Image sequence analysis is a good candidate for boosting up IR imaging performances for the detection of man-made targets. The techniques mentioned above rely on the detection of an *indirect* parameter or pattern (e.g. temperature difference, dielectric constant, reflection coefficient..) from which subsequently the presence of a mine is inferred. Direct detection of explosives and/or analysis of its composition are achieved by bulk and vapor trace detectors. The latter are perceived as potentially important developments.

– **DETECTION AND NEUTRALISATION (AN INTEGRATED APPROACH):**

In the surveyed research programs, a tendency is observed to *combine the detection and neutralisation phases of demining.* It is clear that this is motivated by the urge to speed-up the process. In this area, compound vehicular platforms are being developed for detection, marking and neutralisation. Particular to humanitarian demining, real time operation is a less stringent requirement than for military applications.

– **INFORMATION TECHNOLOGY:**

Geographic Information Systems (GIS) are recognised as useful tools for managing, planning, monitoring and designing solutions concerning global infrastructure and environmental issues. For demining only, it is often perceived as being too complex to put into practice. Nevertheless at several occasions, situations were encountered where the transmission of information between different demining organisations, working in the same geographic area, caused uncertainty about the work already carried out and lead to duplicated efforts. *Supranational incentives and co-ordination could avoid the reluctance to share information, help in simplifying the user interface and standardising products. Low cost and commercially available technology for localisation* (e.g. differential GPS, Glonass, and other forthcoming satellite networks), used

in conjunction with GIS and wireless communication could provide objective and easily collectable data on minefield areas. Training, education and demonstrations could achieve promotion for the wide spread usage of these technologies. The know-how, if not available already, is certainly not too complex to acquire. Adequate *maps* (cartography) are also badly needed in a number of circumstances.

– **NEW CONCEPTS FOR USING ANIMALS AND PLANTS:**

At the conceptual level, some attempts to introduce really new technologies in the field of humanitarian demining have been noticed (e.g. extension of the detection by animals to other types of animals than solely dogs - cockroaches, rats, fluorescent wasps, plants that change colour when they come into contact with explosive molecules). These imply a complete change of attitudes and ways of working. The more conservative end users are reluctant to even consider these new concepts.

– **AIRBORNE MINEFIELD DETECTION / REMOTE SENSING:**

The role of *remote sensing vs. ground based methods* has not yet been fully identified. For airborne minefield detection on realistic surfaces (100 up to 1000 km²), ***terabytes²⁰ of digital data have to be analysed.*** Setting-up a measurement campaign is a complex and expensive operation. Although for civilian applications on-board processing might not be a primary requirement, even off-line analysis requires huge computing facilities. The development of remote sensing systems has been primarily done in the military context, results are often not publicly available, and it is unlikely that these systems will be operational for civilian applications in the near future. Several platforms have been tested, like airships, aircrafts, drones, and helicopters. The *privileged sensors* are the *optical* and the *IR imager*, although *UWB-SAR* seems to yield promising results for the future. On certain soil types and non-densely vegetated areas the airborne minefield delineation results are reported to be successful (e.g. deserts). In our opinion, ***aerial photographs might be useful, as pictorial information for end users*** to help understand the structure of the local terrain. ***Change detection by analysis of satellite data*** is ongoing and could be attractive as a supplementary exploitation of commercial satellite image dissemination.

– **SIGNAL AND IMAGE PROCESSING**

During the EUDEM survey, it became obvious that it is much easier to gather information about the physical properties and principles of demining equipment, than about the signal processing architecture inside the equipment. Almost no precise information could be obtained about the actual algorithms for clutter rejection, feature extraction, and classification. ***In this area there is clearly an important task for universities and research centres publishing in the public domain.*** Several levels of data fusion have been defined in 4.3.1. No concluding results could be found, at this stage. Besides continuation of the data fusion efforts, also further developments on pushing the full single sensor systems (physical set-up combined with appropriate signal processing) towards their intrinsic physical detection limits.

– **SIGNATURE DATABASE:**

Due to the accepted high clearance rate (99.6 %) required for civilian applications, equipment evaluation and detection algorithms should inevitably be tested on an independent (i.e., different from the learning set used for designing the algorithms) and large data-set. Moreover it appears that the signal processing is highly dependent on the particular sensor implementation and the measurement conditions. This means that *local detection circumstances* (e.g. environmental factors such as humidity, soil type, vegetation, temperature), *data acquisition protocol* (e.g. sensor height, scanning type,...) and *object related parameters* (e.g. mine type, depth, orientation) have to be taken into account. At this moment, only fragmented pieces of information exist (e.g. MACADAM, EPFL, VUB,...). ***To build a useful signature database is a major enterprise requiring a well-defined methodology and sufficient funding.*** A supranational initiative is recommended, which is currently being prepared under the co-ordination of the JRC.

– **TESTING AND EVALUATION:**

The implementation of ***specifications for testing protocols*** is again a supranational mission. The existence of several *ad hoc* protocols is a well-known fact after this survey, but they remain proprietary information, which is inaccessible for the research community. Annex 5 points out for example that probability of detection and probability of false alarm are useless specifications without at least a clear explanation of the methods used to determine the performance.

In order to test or to compare new technologies that are in the phase of development or have been developed, a possibility should exist to ***gain confidence by application on the field.***

²⁰ 1 Terabyte = 10¹² bytes = 1000 Gigabytes (one CD-ROM contains about 0.65 Gigabytes).

The establishment of a joint working group, focussing on the development of testing methodologies and the design of standards for sensor and system assessment, is currently ongoing. At the European side, the existing CADMOS²¹ workgroup, promoted by JRC, acts as the core group. The demining community would appreciate dissemination of the current status and intermediate results. Work is also being done at international level to set up *an international network of test, evaluation and certification centres*.

– **USER REQUIREMENTS / EQUIPMENT CERTIFICATION:**

The problem of defining precise requirements, i.e. of some authority(ies) clearly stating what is required for which type of application – especially concerning sensors – and how to measure it, has been raised by several industrial companies. Ongoing efforts to come up with *Statements of Operational Requirements* (SOR), sort of catalogue of end user needs (“wish lists”), and related *Statements of Equipment Requirements* (SER) (the technical specifications for equipment to address the users’ needs) are certainly a step in the right direction. These are likely to be country dependent, but a standardisation effort will be made. Work is ongoing, in Europe, at JRC and the Geneva International Centre.

This information, perhaps together with examples of how demining is actually carried out (e.g. taken from the end users’ Standard Operation Procedures, or SOP), should according to us reach all interested parties in a timely and precise manner. This could be for example in the form of a newsletter, or a simple reference to an updated Web page. Tightly coupled to this is a demand, expressed by some, for *certification of equipment* developed by industry and R&D centres to ensure conformity with the user needs and suitability for the application in question²².

The current report is a summary of the state of the art in the EU related to humanitarian demining technology, products and practice. Sometimes the conclusions reflect personal opinions of the authors, and some of them had to be simplified leaving out nuances in order to make their message clear. For detailed information and the origin of the individual conclusions, the reader is referred to the substantial amount of information coming from different sources in the Annexes of the report.

²¹ Committee of Advisors: Detection of Mines based on Operational Standards.

²² This point is obviously related to the question of who is responsible in case of system error or failure.

7. LIST OF ANNEXES

Annex 1: Existing information sources and databases exploited as “starting points”

Annex 2: List of received documents

Annex 3: Questionnaire for the survey

Annex 4: Chronological Overview of interviews carried out

Annex 5: The case study done in the US

Annex 6: Some links to General Information and more Technical Information on Humanitarian Demining, alphabetically sorted

Annex 7: Co-ordinates of the organisations that were contacted for the survey

Annex 8: Face to face interviews in chronological order.

Annex 9: EUDEM data base listing

8. GLOSSARY

Sources:

<http://www.hdic.jmu.edu/hdic/category/>

<http://www.demining.brtrc.com/policy/publicpolicy/intragny/summary.htm>

Term	Definition
Anti-personnel Landmine (APL)	The term "anti-personnel landmine" means any munition placed under, on, or near the ground or other surface area, either placed by humans, or delivered by artillery, rocket, mortar, any similar means, or dropped from an aircraft and which is designed, constructed or adapted to be detonated or exploded by the presence, proximity, or contact of a person. The term "anti-personnel landmine" does not include command detonated Claymore munitions. (Leahy Amendment, signed into law February 12, 1996, "Moratorium on Use of Antipersonnel Landmines," section 583)
AP Mine Sifter	A drum that picks up the contaminated soil, closes and rotates until all loose soil falls out. The remaining debris can be visually inspected.
ARIS network	A European Network of Excellence on “Action for Research and Information Support in Civilian Demining”, co-ordinated by JRC
Biochemical Neutralization	Some organisms feed on certain elements of explosive chemicals, thus rendering them inert, and therefore could theoretically be used in demining.
Biosensor	Animals (dogs, pigs, rats) can be used as biosensors but the term can also refer to other new artificial vapour-analysing technologies such as artificial olfactory systems which analyse air particles for trace elements of explosive vapours.
Bounding Mine	A fragmentation anti-personnel mine that employs a primary charge to elevate the mine to a predetermined height before the main charge is initiated. Set off by either trip wire or pressure and, unlike blast and simple fragmentation mines, is designed to kill rather than maim. Sometimes nicknamed "bouncing Betty."
Check Clearing	When little or nothing is known about the mine situation in a given area, the area has to be check-cleared to establish whether it is mined and warrants a full fledged mine clearing operation.
Clutter	Interfering echo's in a radar signal caused by reflection from objects other than the target
Command-destructing Mine	A mine that can be detonated by a remotely delivered command.
Countermine	Military operations concerned primarily with rapid breaching of mined barriers rather than mine clearing through the use of ploughs, rollers, flails, etc., and not concerned with area clearance.
Demining	The complete removal of all landmines from an area in order to safeguard the civilian population. (<i>Hidden Killers</i> , 1994)
Demining Debt	Used to describe the phenomena occurring when the uncleared landmines proliferate at a rate faster than adequate funds and technologies allow for as a rate of clearance.
DoD	Department of Defence
Earth Tiller	Horizontal steel beam mounted with teeth tilling the soil up to a depth up to 50 cm, whilst travelling, detonating or disrupting mines

Electromagnetic Induction (EMI)	The process by which a current flowing through a primary coil produces a secondary current in a conductive medium
Environmental Restoration	The process of cleaning up areas that have experienced military action or armed conflict eliminating munitions, explosives, and harmful by-products to restore the area to peaceful civilian pursuits.
EOD	Explosive Ordnance Disposal
False Alarm Rate	The rate of alarms generated by other phenomena than the target objects which have to be detected
Flail	Rotary flail devices are typically composed of cylindrical drum structures housing a collection of chains on a horizontal bar which, hitting and milling the ground to detonate the mines or break them apart
FNA	Fast Neutron Analysis is based on the interaction of fast neutrons with the nuclei of interest. During this process the high energy neutrons put elements in an excited, short lived state, in particular Carbon, Nitrogen and Oxygen of explosives and soils, by hitting their nuclei. The nuclei return to their initial state by emitting gamma radiation, whose energy distribution is chemically characteristic of each nucleus. By characterising the outgoing gamma rays it is possible to calculate the elemental proportions – how much of each element (C, N, O) is present with respect to the others – in order to determine the type of substance under analysis
Fragmentation Mine	An antipersonnel mine laying above the ground and usually employing either a packing of fragments, steel balls, or pellets, or a segmented outer casing which is dispersed by the force of the explosion and becomes the primary cause of injury to the victim.
GIS	Geographic Information System
GPS	Global Positioning System
GPR	Ground Penetrating Radar
Horizontal Action Mine	Mine designed to produce a destructive effect to one or more targets in a variable direction approximately parallel to the ground. Also called an aim controlled-effect mine (ACEM).
Humanitarian Demining	The safe, effective, and cost efficient clearance of landmines from land and littoral areas in order that life can return to normal.
IMS	Ion Mobility Spectrometer
Indiscriminate Effect	Problems posed by landmines even when the combatants make a good faith effort to distinguish between military targets and civilians; because of the inherent time lag between the laying of mines and their explosion, mines often present an indiscriminate danger far into the future.
Infrared (IR) technology	Technology based on electromagnetic waves in the infrared spectral region, lying outside the visible spectrum at its red end
International Organisations (IOs)	Organisations with a global charter and influence such as the United Nations and International Committee of the Red Cross.
JRC	Joint Research Centre of the European Commission
JUXOCO	Joint Unexploded Co-ordination Office, the US government office responsible for all army counter mine programmes, including humanitarian demining programmes
Landmine	Any munitions designed and manufactured to be detonated after it has been laid by the presence, proximity, or contact of a person or vehicle. (<i>Hidden Killers</i> , 1994)
LWIR	Long Wave IR (8-12µm)
MD	Detector to detect metallic objects
Mine Action	In principle, includes more than mine clearing and mine awareness campaigns and is designed to mitigate the effects of landmines prior to the beginning of clearance operations.
Mine Action Center (MAC)	A host nation structure for carrying out mine awareness campaigns, conduct reconnaissance, collects and centralizes mine data
Mine Awareness Training	A program to assist host nation governments, international organisations, and non-governmental organisations to train local populations to deal with landmines until mines can be permanently removed. The program minimises the danger of uncleared mines by training host nationals in mine detection, identification, marking, avoidance, reporting, mapping, rudimentary extrication, and first aid skills.
Minefield Density	The average number of landmines detected per square meter of minefield or the number of mines in a known "pattern."

Mine Protected Vehicle (MPV)	Vehicles designed to be protected against AP and AT mines.
Microwave	A comparatively short electromagnetic wave, typical wave lengths between 1 cm-1 m
Millimeter wave	Frequency between 50-180 GHz, i.e. wavelength between 6 mm-1.7 mm respectively
MoD	Ministry of Defence
Multi-sensor Mine Detector	Detection using combinations of technologies such as magnetic, infrared, microwave, chemical, radar and biosensor detectors to correlate their respective accuracy's into a more accurate detection.
MWIR	Medium Wave IR (3-5µm)
Non-governmental Organisations (NGOs)	Transnational organisation of private citizens that maintains a consultative status with the Economic and Social Council of the United Nations. Non-governmental organisations may be professional associations, foundations, multinational businesses, or simply groups with a common interest in humanitarian assistance activities (development and relief).
Non-reconstitutable Mine	A self-deactivating, self-neutralising, or command-neutralising mine that cannot be reactivated by means available outside its manufacturing plant or comparable facility.
NMR	Nuclear Magnetic Resonance: the magnetic resonance of an atomic nucleus
NQR	Nuclear Quadrupole Resonance: an electromagnetic resonance screening technique for the detection of explosives in bulk form, relying upon the resonant response of certain nuclei possessing electric quadrupole moments
PETN	Pentaerythritol tetranitrate (C ₅ H ₈ N ₄ O ₁₂) is one of the strongest known high explosives. It is primarily used in booster and bursting charges of small calibre ammunition, and in upper charges of detonators in some landmines and shells.
Probing	See prodding
Prodding	Location of individual mines by prodding the ground with a thin rod or blade inserted at an angle every 4-5 cm (i.e., 400-600 prodding actions every square meter).
RDX	(Cyclotrimethylenetrinitramine, C ₃ H ₆ N ₆ O ₆) Hexogen, or Cyclonite, RDX is considered one of the most powerful military high explosives. Sometimes used in mines together with TNT (Composition-B).
R&D	Research & Development
ROC	Receiver Operating Characteristics
Safety Distance	Distance to be maintained at all times between deminers; usually 50 meters between teams and 5 meters between members of the same team.
Self-deactivating Mine	A mine that automatically renders itself inoperable by means of exhaustion of a component of the mine that is essential to the operation of the mine.
Self-destructing Mine	A mine that automatically destroys itself by means of an incorporated mechanism.
Self-eliminating Mine	A mine that is self-destructing, self-deactivating, and cannot be reconstructed..
Self-neutralizing Mine	A mine that automatically renders itself inoperable by means of an incorporated mechanism.
SAR	Synthetic Aperture Radar
SER	Statements of Equipment Requirements
SOP	Standard Operating Procedure
SOR	Statements of Operational Requirements
Sub-Surface Clearance	Mine clearance is categorised by depth; in this case, the ground has to be searched for mines to a depth of 200mm, the layer where antipersonnel mines are found.
TNA	Thermal Neutron Analysis: features high sensitivity to nitrogen concentration and low cost. On the other hand it is relatively slow, and is usually not employed in a real-time mode, like conventional metal detector for example, but used as a confirmatory device targeted at the verification of suspected spots.
TNT	(2,4,6-) Trinitrotoluene (also Trotyl), most common explosive in landmines (C ₇ H ₅ N ₃ O ₆)
UWB	Ultra-wideband radar
Unexploded Ordnance (UXO)	Any mass-produced explosive munitions that have failed to function fully as designed.

Vegetation Cutter	Machine designed for clearing vegetation and tripwires as a precursor to accelerated manual clearance
Wheel Shovel	Wheel Shovel (e.g. HALO Trust in Afghanistan) based systems for digging up mines that will be manually cleared afterwards, for the excavation and inspection of (urban) rubble, also for roads (road grader). A mesh basket is fitted over the shovel, which then shakes out the rubble; large ordnance and mines will remain held by the mesh in the bucket.
X-ray back scatter	The scattering of X-ray radiation in a direction opposite to that of the incident radiation, due to reflection on particles of the medium traversed.