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2. 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, delivered by artillery, rocket, mortar, or 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"
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-analyzing technologies such as artificial olfactory systems which analyze air particles for trace elements of explosive vapors.
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. (*Hidden Killers*, 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 Defense
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 Organizations (IOs)	Organizations with a global charter and influence such as the United Nations and International Committee of the Red Cross.
JRC	Joint Research Center of the European Commission
JUXOCO	Joint Unexploded Coordination 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. (*Hidden Killers*, 1994)
LWIR	Long Wave IR
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 organizations, and non-governmental organizations to train local populations to deal with landmines until mines can be permanently removed. The program minimizes 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 Defense
Multi-sensor Mine Detector	Detection using combinations of technologies such as magnetic, infrared, microwave, chemical, radar and biosensor detectors to correlate their respective accuracies into a more accurate detection.
MWIR	Medium Wave IR
Non-governmental Organizations (NGOs)	Transnational organization of private citizens that maintains a consultative status with the Economic and Social Council of the United Nations. Non-governmental organizations 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-neutralizing, or command-neutralizing 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 ($C_5H_8N_4O_{12}$) is one of the strongest known high explosives. It is primarily used in booster and bursting charges of small caliber ammunition, and in upper charges of detonators in some land mines 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, $C_3H_6N_6O_6$) Hexogen, or Cyclonite, RDX is considered one of the most powerful and brisant of the 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 categorized 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 ($C_7H_5N_3O_6$)
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 from particles of the medium traversed.

ANNEX 1. EXISTING INFORMATION SOURCES AND DATABASES EXPLOITED AS "STARTING POINTS"

- *Internet*: list of links and databases:
  - DeTeC (http://diwww.epfl.ch/lami/detec/minelinks.html);
  - MgM Foundation Web site (http://www.mgm.org/);
  - Lawrence Livermore National Lab's "Who's Who" (http://www.llnl.gov/landmine/landmine_whos_who.html);
  - HDIC Demining Organisation Directory (http://www.hdic.jmu.edu/hdic/exchange/database/);
  - CARE (http://www.care.org/newscenter/landmines/ngoland.html);
  - JMU Humanitarian Demining Information Center (http://www.hdic.jmu.edu/hdic/exchange/ngo/).

- *Internal lists* of persons and organisations active in humanitarian demining, accumulated in previous projects, and other lists:
  - Internal EPFL;
  - Internal VUB (also in relation with ongoing projects);
  - US State Department "Hidden Killer'98" report (http://www.state.gov/www/global/arms/rpt_9809_demine_toc.html)

- *EU financed projects*, in the research as well as the clearance area:
  - List of projects and contact points: projects from DGIII(ESPRIT)/DGXIII: http://www.cordis.lu/esprit/src/hphdhome.htm
  - For technology projects from DGVIII, Mr. Cervone / DGVIII;
  - ARIS Network of Excellence (NoE) on Humanitarian Demining (http://www.at.sai.jrc.it/aris/);
  - DGIA, DGIB - Mr. Cervone;
  - DGVIII: airborne minefield detection.

- List of participants to well known conferences in the domain:
  - JRC workshops;
  - Edinburgh 96-98 (EUREL International Conference on The Detection of Abandoned Landmines);
  - Other (ex. conferences on mechanical demining in Germany & Toulouse).

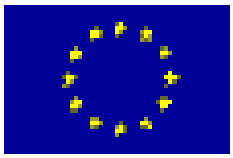
- Literature on the subject (survey papers for example).

ANNEX 2. LIST OF RECEIVED DOCUMENTS, PUBLICITY BROCHURES, AND OTHER INFORMATION SOURCES

(1) Andrews A.M., George V., Altshuler T.W. & Mulqueen M. Results of the Countermine Task Force Mine Detection Technology Demonstration at Fort A.P. Hill, Virginia, March 18-22, 1996
(2) Rotondo F., Altshuler T.W., Rosen E., Dion-Schwarz C & Ayers E. Report on the Advanced Technology Demonstration (ATD) of the Vehicular Mounted Mine Detection (VMMD) Systems at Aberdeen, Maryland, and Socorro, New Mexico, Virginia, 1998
(3) JUXOCO (Joint Unexploded Ordnance Coordination Office). Hand Held Metallic Mine Detector Performance Baselining Collection Plan, Fort A.P. Hill, Virginia, 1998
(4) Tantum S.L. & Collins L.M. Detection and identification of mines using signals from Wichmann/BRTRC Antenna: a preliminary report, Duke University.
(5) Carin L. & Baum C.E. Wideband Time- and Frequency-Domain EMI: Phenomenology and Signal Processing, Duke University
(6) Khadr N., Barrow B.J., Bell T.H. & Nelson H.H. Target Shape Classification using Electromagnetic Induction Sensor Data, Arlington.
(7) Kaczkowski P.J. Pulsed Electromagnetic Induction (PEMI) for UXO Discrimination in JPG Phase IV – Preliminary Results, University of Washington.
(8) Arcone S.A., Delaney A.J., Sellmann P.V. & O'Neill K. UXO detection at Jefferson Proving Ground Using Ground-Penetrating Radar, UXO Forum '98, Anaheim, California, 1998
(9) Wichmann G. Research and Development on the Field of Mine Detection, 1996
(10) DFID Background Briefing. Humanitarian mine action, a progress report, February 1999
(11) Andrews A.M., Altshuler T.W., Rosen E.M. & Porter L.J. Performance in December 1996 Hand-Held Landmine Detection Tests at APG, Coleman Research Corp. (CRC), GDE Systems, Inc. (GDE), and AN/PSS-12, IDA, March 1996
(12) Carin L., Geng N. & McClure M. Ultra-Wideband Synthetic Aperture Radar for Mine Field Detection, Duke University, Durham
(13) Arnsfelt A.B., PL Brake. Innovative environmental inventions.
(14) Hydrema Publicity Brochure on Mine Clearing Vehicles
(15) Vallon Publicity Brochure on MDs
(16) CAT Publicity Brochure on Multisensor Mine Detecting System
(17) Zanzi L, Moscon A & Valle S. Processing Strategies for the Application of the GPR Technology to Humanitarian Demining, Milano, Italy
(18) DEMEX Publicity Brochure on Environment Dynamics Recovery
(19) Naz P., Bobin L., Christnacher F & Parmentier G. Détection acoustique et sismique d'objets enfouis, ISL
(20) SODERN Publicity Brochure on Neutronics
(21) Universität Tübingen Publicity Brochure
(22) IUT Publicity Brochure on Ion Mobility Spectrometry
(23) FGAN Publicity Brochure on Research Fields and organisation
(24) TZN Publicity Brochure on Mobile Mine Detection and Clearance Device
(25) ABC Publicity Brochure
(26) LETI Publicity Brochure on Magnometer Technologies
(27) CEA-LETI Publicity Brochure on X-Technologies
(28) Cacciabue P.C. (ed.). Human Factors Research Activities, Annual Report 1998, JRC, Ispra, 1998
(29) SATIMO Publicity Brochure on Electromagnetic Field Measurement Systems
(30) AA Publicity Brochure on Leben Ohne Minen: Der Ottawa Vertrag- Eine Herausförderung für die Zukunft.
(31) AA Report on Humanitarian Mine Action, 1998
(32) Busch OTL. Humanitäres Minenräumen in Afghanistan, Bonn, June 1999
(33) Padova University Publicity Brochure on the Explodet Project 1998 Progress Report
(34) Bach P, Le Tourneur P., Poumarède B & Brette M. Detection of Abandoned Land Mines Using Neutron Interrogation. International Conference Edinburgh, UK 1996.
(35) Bach P., Ma J.L, Froment D. a J.C. Jaureguy. Chemical Weapons detection by fast neutron activation analysis techniques.
(36) Vettèse F., Asselineau B, Dhermain J, Antonot B & Bach P. Neutron activation analysis techniques to identify arsenic in chemical weapons, Sweden, June 1995.
(37) SODERN Publicity Brochure on Mines detector using neutron interrogation
(38) General Engineering Anchor Group Publicity Brochure on GIS for demining
(39) ABC Publicity Brochure on Humanitarian Demining
(40) BICAT Publicity Brochure on Recycling of Demolition Debris with Hidden Explosives

(41) Aardvark Publicity Brochure on Mechanical Minefield Clearance System
(42) Hydrema Publicity Brochure on Mine Clearing Vehicle
(43) Handicap International-MAG-NPA. Publicity Brochure "Portfolio of Mine Related Projects 1998
(44) Busch OTL Slides on Close-in Detection & Remote Sensing System
(45) AA Humanitarian Mine Action Equipment Catalogue 1998-1999
(46) NPA Brochure: Mines, the Silent Killers
(47) Hundskolan Publicity Brochure
(48) Hundskolan Video
(49) Celsius Mine-Guzzler Video
(50) Celsius Publicity Brochure on Mine Guzzler & Technical Description
(51) Ixtrem Publicity Brochure on Electromagnetic Detectors
(52) DLR print out CD-rom
(53) TNO year report 1998
(54) Vallon Publicity Brochure on Metal Mine Detectors
(55) Aardvark Beating the land mine video
(56) Hydrema Publicity Brochure on Toolbox Concept
(57) AA slides on Toolbox approach
(58) ICRC Overview 1998
(59) Schiebel Publicity Brochure on All Terrain Mine Detector
(60) HOM2000 Publicity Brochure

ANNEX 3. QUESTIONNAIRE FOR THE SURVEY



EUDEM Research Survey

Questionnaire for a survey: EU-project on DEMINING organisations

PART I: Identification Data (required unless otherwise specified)

Organisation Name: «Institute» - «Dept»

Organisation Type (please cross out and/or complete):

- ❑ Industrial SME (<250 pers.)
- ❑ Large Industry
- ❑ Research Centre
- ❑ Academia
- ❑ Defence
- ❑ Other Governmental
- ❑ NGO
- ❑ International Organisation
- ❑ Other, please specify: ……..

Contact Person, «Title» «First_name» «Family_Name»,
Function within Organisation: ……

Address (Street, no., Postal Code, City, Country):
«Address_1»
«Address_2»
«city»
«Country»

Telephone/Fax no. T«Tel» F: «Fax».

E-mail (if available): «Email»

Address of the Web site(s) (if available): «Homepage»

Affiliation or Branches in other Countries (if applicable) to be listed below:

Total no. of Staff Members working in the entire Organisation:

No. of Staff Members in activities directly related with Demining:

Involvement in Demining (please cross out and/or complete):

- ❑ Mine Awareness
- ❑ Victim Assistance
- ❑ Survey/Mapping
- ❑ Detection
- ❑ Clearance/Destruction
- ❑ Other, please specify:…….

Type of Involvement (please cross out and/or complete):

- ❑ Consultancy
- ❑ Education/Training
- ❑ Equipment Manufacturing
- ❑ Demining Campaigner/Organiser
- ❑ Other, please specify:…….

PART II: Structural data on the organisation type:

Products/services/research topics (if any) offered/handled by your organisation:

Please list **five** keywords to summarise your activities:

- …….. -…….. - ……

- …….. -……..

Current activities, described in an abstract of not more than 10 lines:

Financial support sources (if any) actually involved in these activities:

Specific technologies currently being used or considered for the future:

Solutions which have been used in the past, but have been discarded, and why:

PART III: Background data on the organisations' partners and more specific information:

Partners (if any) involved in current (C) or past (P) activities:

Comments (C) or needs (N) that you would like to share with us:

Please list references***** on your activities (articles, brochures, books with results, activity reports, yearbooks, …) which you judge to be relevant:

Are you interested/willing to have further contacts and/or visits?

- ❑ Yes
- ❑ No

*****Please send us a copy of your reference material together with the completed questionnaire or by separate mail to the following address:

Karin De Bruyn
EUDEM Survey Project-Vrije Universiteit Brussels
ETRO Dept., Fac. of Applied Sciences
Pleinlaan 2
B-1050 Brussels, BELGIUM

ANNEX 4. CHRONOLOGICAL OVERVIEW OF INTERVIEWS CARRIED OUT

During EUDEM 49 main players, active in several aspects of demining/mine action, were personally visited in 10 European countries. The following visits and interviews were carried out in chronological order:

Organisation	Full Name	Place	Country	Date
IDS	Ingegneria dei Sistemi	Pisa	Italy	14/1/1999
JRC	EC Joint Research Centre	Ispra, Varese	Italy	15/2/1999
Politecnico di Milano		Milano	Italy	16/2/1999
INFN	Istituto Nazionale di Fisica Nucleare	Padova	Italy	16/2/1999
ABC	Appalti Bonifiche Costruzioni	Firenze	Italy	17/2/1999
Marconi SpA	(now Marconi Communications)	Genova	Italy	18/2/1999
ICRC	Intnl. Committee of the Red Cross	Genève	Switzerland	3/3/1999
GICHD	Geneva Intl Centre for Hum. Demining	Bern & Genève	Switzerland	15/3&3/6/1999
Alain Priou	**[contribution by e-mail]**	Univ. X Nanterre, Paris	France	18/3/1999
DGA	Délégation Générale pour l'Armement	St. Cloud, Paris	France	23/3/1999
Handicap International		Lyon	France	23/3/1999
ONERA		Toulouse	France	24/3/1999
SATIMO		Courtabœuf, Paris	France	24/3/1999
ISL	Institut de Saint-Louis	Saint-Louis	France	24/3/1999
CEA-LETI		Grenoble	France	25/3/1999
EPPRA		Palaiseau, Paris	France	26/3/1999
SODERN		Limeil-Brevannes, Paris	France	26/3/1999
MoD	UK Ministry of Defence	London	United Kingdom	30/3/1999
DERA	Defence Research & Evaluation Agency	Chertsey	United Kingdom	30/3/1999
HALO Trust		Glasgow	United Kingdom	31/3/1999
BGT	Bodenseewerk Gerätetechnick	Ueberlingen	Germany	21/4/1999
Vallon GmbH		Eningen	Germany	22/4/1999
Universität Tübingen		Tübingen	Germany	22/4/1999
Institut Dr. Förster		Reutlingen	Germany	23/4/1999
FGAN/FOM	Research Establishment for Applied Science	Tübingen	Germany	23/4/1999
TZN		Unterlüss	Germany	3/5/1999
IUT	Institut für Umwelttechnologien	Berlin	Germany	4/5/1999
DEMEX	(Consulting Engineers)	Copenhagen	Denmark	5/5/1999
A/S Hydrema		Støvring, Aalborg	Denmark	5/5/1999
DTU	Technical University of Denmark	Lyngby	Denmark	6/5/1999
Ole Nymann, CAT		(Lyngby, see above)	Denmark	6/5/1999
FOA	Swedish Defence Research Est.	Linköping	Sweden	10/5/1999
Biosensor Applications AB		Oerebro	Sweden	11/5/1999
Bofors AB		Karlskoga	Sweden	11/5/1999
Celsius Tech		Järfälla, Stockholm	Sweden	12/5/1999
Landmacht	Dutch Ministry of Defence	Den Haag	The Netherlands	18/5/1999
TNO	Netherlands Organization for Applied Scientific Research	Den Haag	The Netherlands	18/5/1999
NPA	Norwegian People's Aid	Oslo	Norway	20/5/1999
Swedish Armed Forces Dog Training Center		Stockholm	Sweden	20/5/1999
Humanity Dog		Kramfors	Sweden	21/5/1999
UN MAAP and CROMAC	UN Mine Action Assistance Programme, CROatian MAC	Zagreb	Croatia	24/5/1999
MECHEM operations		Gospic, Licki Osik	Croatia	25/5-26/5/1999
A.B.C.D. operations		Slavonski Brod	Croatia	27/5/1999

Tamar operations area	[ops had not yet started]	Kusonje	Croatia	27/5/1999
CROMAC Scientif Council		Zagreb	Croatia	28/5/1999
King's College London	**[written contribution]**	London	United Kingdom	5/1999
JRC	EC Joint Research Centre	Ispra, Varese	Italy	14/6-16/6/1999
German Federal Foreign Office		Bonn	Germany	25/6/1999
DLR	Deutsches Zentrum für Luft- und Raumfahrt	München	Germany	25/6/1999

ANNEX 5. THE CASE-STUDY DONE IN THE US

The study was carried out by John Brooks, on behalf of the EUDEM project.

1. Introduction.

This report summarizes the results of a series of telephone and personal contacts made with US Government and industry representative in various areas of unexploded ordnance (UXO) and land mine detection and remediation. **0** at the end of this report lists the names and affiliations of all key personnel contacted. The goals of the 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). US Army-funded programs were investigated; the many US Navy programs were not, due to the general nature of humanitarian or post-conflict demining. All information herein is current as of 01 March 1999.

1.1. Approach

The approach to the survey was two-fold; telephone contact and personal contact. Every effort was made to contact the program manager for each on-going technology development effort. In general, they were responsive to my inquiries, but declined to provide specifics of any signal processing. In almost all cases, they referred me to the Government Contracting Officer's Technical Representative (COTR) at Ft. Belvoir.

Upon contacting each individual, I explained my relationship to the EUDEM; in addition, I informed each individual that all information provided by them could be used in published documents; thus, any proprietary or confidential information was to be excluded. However, within this report, I have at times made judgements of sensor configurations and performance based on deriving or extrapolating from personal observations of equipment. This is particularly the case with the GDE version of the HSTAMIDS, where I have made inferences of system configuration based on personally handling the device, and discussions with US Government personnel.

On 24 and 25 February 1999, I met with representatives of the US Night Vision Electronic Sensors Directorate (NVESD) and the Joint Unexploded Ordnance Coordination Office (JUXOCO). NVESD is the designated US Government office of responsibility for all Army countermine programs, including humanitarian demining programs. JUXOCO was established to provide a coordination function for all Department of Defense (DoD) UXO programs; it serves as a repository of data collected at US test facilities such as Ft. A.P. Hill, Aberdeen Proving Ground and the Jefferson Proving Ground (JPG). All test data involving UXO and mine detection/clearance is linked to the JUXOCO web site, http://www.uxocoe.org/index2.htm. JUXOCO is also referred to as the Joint UXO Center of Excellence, abbreviated JUXOCOE. In this report, JUXOCO, UXOCOE, UXOCO and JUXOCOE may be used interchangeably.

1.2. Previous Surveys and Workshops

JUXOCOE held a series of workshops to investigate various technical approaches to detecting UXO. Due to the volume of information, the links to those workshops are provided.

General: http://www.uxocoe.org/index2.htm
Aided Target Recognition:
http://www.denix.osd.mil/denix/Public/News/UXOCOE/Documents/Atr/atr1.html#Technology%20Limitations
Other Technologies: http://www.denix.osd.mil/denix/Public/News/UXOCOE/Documents/Other/other1.html
Magnetometry: http://www.denix.osd.mil/denix/Public/News/UXOCOE/Documents/Magnetometry/mag2.html

1.3. Comments on Military vs. Humanitarian Design

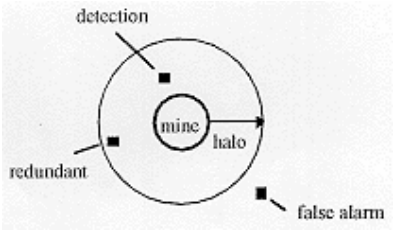
Because the vast majority of funding for US demining technology is derived from the US Department of Defense (DoD), it is therefore necessary to understand the extent to which the design of such systems is based on military operational doctrine compared to humanitarian, or post-conflict doctrine. This influence is manifested in two ways; the requirement, stated by US Government program managers, to locate the mine "in real time" and also the fact that all developmental devices are tested by military engineers using military practices. The first requirement results in a development path that does not permit the exploitation of several processing methods which, for example, generate an image of the target following the scanning of an area of interest. The current prototype models (CRC, GDE) Hand-Held STAnd-off Mine Detection System (HSTAMIDS) are scanned over an area of interest and the possible presence of a mine is indicated by a simple audio tone at the time the sensor is passed over the mine; thus, only the received energy and possibly the duration (an indication of physical size of the target) are used as classification features. The practice of military personnel testing the devices leads to designs which may not be ergonomically suited to indigenous deminers in such places as Cambodia and Angola;

acceptance of the devices by those deminers and the corresponding Non-Governmental Organizations (NGOs) is thus problematical.

1.4. Comments on Performance Measures

As a framework for the discussion in the following sections, it is instructive to assess the way in which field tests in the US have been conducted and evaluated. In particular, whether a contractor "wins" or "loses" a competition is based almost entirely on how that contractor scores in the area of "probability of detection (P_d)" and "probability of false alarm (P_{fa})" and the resulting receiver operating characteristic (ROC) curves. Three specific reports are of note (Andrews, et.al.(1), Rotonso, et. al.(2), Draft JUXOCO Report (3)). Each report has different criteria for measuring P_d and P_{fa}, so it is not possible to compare various systems from one report to the other, nor is there any firm "standard" measure of performance.

The first report describes a series of tests conducted in March 1996 of both vehicular and hand-held demining systems. The vehicular systems were represented by Geo-Centers, SAIC, IAI Elta and GDE Systems. In this report, a valid target is declared if it is detected anywhere within the bounds of the mine, and also 0.5 m outside the mine boundary; in other words, the mine is surrounded by a "halo" which is 0.5 m larger than the mine itself (Hand-held systems were evaluated with a 0.15m halo):

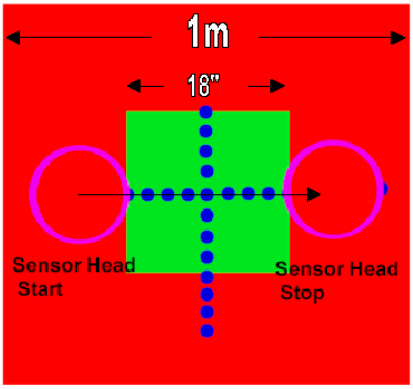


Thus, any signal that exceeds some threshold within this large ring is considered to be a valid mine detection. Additional detections within the halo are considered to be redundant. The second report describes a series of tests conducted at Aberdeen and Soccoro sites two years later than the first report. The systems in this report are from CRC, GDE, EG&G, GeoCenters and Computing Devices of Canada. In the second report, *the halo is extended to 1.0m*. This automatically increases the chance that a "detection" will be declared a mine (and thus ensuring a higher "score" for the device,) even though it may have been produced by a non-mine object.

In both the above reports, the ROC is generated by assuming Gaussian statistics for both clutter and mean-shifted Gaussian for target + clutter. This seems to imply that the mean clutter is statistically different from the target; this is not the case in practice. Perhaps a better measure of performance under the Gaussian assumption would be a test of variance, or an assumption of Rayleigh-Rice statistics common to radar signal processing practice.

The third report is a draft test plan for the HSTAMIDS tests. In this report, the test area of size 49m x 20m is divided into 980 squares, each 1 m in length. 880 squares contain various clutter targets, and 100 squares contain mine targets. The center of each grid square is scanned once vertically and once horizontally as shown in the following figure, extracted from the test plan:

Fig. 6 Data Collection Template and Sensor Head Positioning Technique



This methodology permits a more consistent measure of assessing detector performance. It should be noted, however, that this test approach still involves the use of a single scan in any one direction over the target. No images are created. The results of this test methodology was used by Duke University to assert "100% Correct" classification of a number of minimum-metal APLs with the Wichmann/BRTRC antenna (4).

The above discussion points out the need to develop a consistent method, and a mathematically sound procedure for assessing and comparing system performance; it also indicates that reports of a certain system achieving a specific level for P_d and P_{fa} needs to be accompanied with a clear explanation of the methods used to determine the reported performance.

1.5. Summary of Technology Issues

Radar (GPR)

For this 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.

Although no specific information was obtained regarding signal processing methods and algorithms due to company proprietary considerations, a review of applicable published literature and discussions with US Government personnel revealed that, in general, the features used for classification are rather simple, including the statistical mean and variance of the returned signals under the assumption of a Gaussian distribution for noise. This may explain the poor performance of the HSTAMIDS candidates to date. The US requirement for HSTAMIDS is a probability of detection, Pd, of a mine to be 0.80 (see Section 1.1 ###); the "halo" for handheld system tests is 15cm); the best performance with trained contractor personnel was 0.70, and the average performance using military personnel was only 0.30 for min-metal APL. Such performance has led to an 18-month extension of the HSTAMIDS program.

Electromagnetic Induction (EMI)

EMI has been used with some success for the detection of buried metallic UXO and mines (5) One EMI system which has been used in these tests is the Geophex GEM-3 (8). The GEM-3 is a prototype wide-band frequency-domain EMI sensor. The GEM-3 uses a pair of concentric, circular coils to transmit a continuous, wideband, digital electromagnetic waveform. The resulting field induces a secondary current in the earth as well as in any buried objects. The set of two transmitter coils has been designed so that they create a zone of magnetic cavity at the center of the two coils. A third receiving coil is placed within the magnetic cavity so that it senses only the weak secondary field returned from the earth and buried objects.

Infrared (IR)

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. He program has been realigned to study other options; the program is now called the Light Airborne Mine Detector (LAMD), according to NVESD and JUXOCOE personnel. No specific information regarding the failure has been made available at the time of this report.

2. Vendor Specifics

2.1. HSTAMIDS

The Government Contracting Officer's Technical Representative (COTR) is Mr. Mark Locke, 703-704-2418, mlocke@nvl.army.mil.

The HSTAMIDS program consists of working prototypes from Coleman Research Corp. (CRC) and GDE Systems. When controlled tests were conducted at Yuma Proving Ground, both "expert operators" (contractor personnel) and military operators used the systems. The expert operators managed to achieve a probability of detection (Pd) of about 0.70, whereas the military operators achieved only about 0.30 Pd. The objective goal for HSTAMIDS is to achieve a Pd of 0.80, so the HSTAMIDS program has been extended for 18 months, with additional tests to be conducted in march-April 2000.

A detailed summary of additional tests of the two HSTAMIDS competitors in Dec. 96 is attached (9), and is also available at http://www.denix.osd.mil/denix/Public/News/UXOCOE/Documents/Ida/ida1.html.

The following, extracted from the report, summarizes the performance of the two systems:

"The two contractor systems exhibited similar performance to the AN/PSS-12 for AT/Metal, AP/Metal, and AP/LowMetal. For AT/LowMetal and AT/NonMetal, both systems outperformed the AN/PSS-12. Finally, the CRC system exhibited a slight statistically significant improvement over the AN/PSS-12 for AP/NM, whereas the GDE system did not exhibit a statistically significant increase in performance, as determined from the upper limits on the confidence intervals calculated using a binomial detection process. The following summarizes the results:

	GDE			*CRC*			*AN/PSS-12*		
Mine Type	*FAR* (m^{-2})	P_d	*SNR*	*FAR* (m^{-2})	P_d	*SNR*	*FAR* (m^{-2})	P_d	*SNR*
AT/M	0.50	0.97	8.3	0.67	1.00		0.56	1.00	
AP/M	0.50	0.97	9.2	0.67	0.93	7.9	0.56	0.97	9.1
AT/LM	0.50	0.90	6.7	0.67	0.97	7.9	0.56	0.67	3.5
AP/LM	0.50	0.66	5.1	0.67	0.69	4.9	0.56	0.67	5.0
AT/NM	0.50	0.91	6.9	0.67	0.89	6.1	0.56	0.34	-1.7
AP/NM	0.50	0.32	1.1	0.67	0.46	2.4	0.56	0.20	-1.9

- "Both the GDE and CRC systems provide increased capability over the AN/PSS-12. This is particularly true with regard to the detection of AT/LM, AT/NM, and potentially for AP/NM mines. Regardless of the improved performance of the contractor systems relative to the AN/PSS-12, *both performed poorly when attempting to detect AP/LM and very poorly when attempting to detect AP/NM mines*. (emphasis added by JWB)

- "Detection of NM mines by the AN/PSS-12 -- which does not have the capability to detect nonmetallic objects -- indicates that visual cues may have influenced the test results.

- "Probabilities of detection in the current test are somewhat lower than have been achieved by the same systems in previous tests. This may be attributable to operation of the equipment by soldiers rather than contractor personnel; it may also be due to differing clutter environments, target populations, and natural geology. "

Neither of the HSTAMIDS devices produce any type of image. In operation, the sensor is scanned by hand and an audio and visual indication alert the operator to the presence of an anomaly; the radar sensors can be considered to be adjuncts to the MD sensor in both cases.

GDE:
Program Manager : Mr. Bob Penninger, 619-675-2605

Mr. Penninger declined to provide any details of the GDE version of HSTAMIDS, other than to volunteer that the modulation scheme is a stepped frequency approach. NVESD has a working prototype of the GDE HSTAMIDS; a physical inspection of the GDE device reveals that the antenna assembly is probably of a patch design. There are two painted rings on the top of the antenna assembly, and an oval-shaped drawing; each figure is offset to denote the locations of the metal detector loop, a wide-band RF antenna and possibly a narrow-band, high-frequency RF antenna. According to NVESD personnel, the fact that the three sensors are not coaxial, the possible detection of a target can lead to confusion in target registration. The higher frequency antenna is probably designed to permit better discrimination of small targets. The hand-held sensor is augmented with a helmet-mounted IR camera, as is the CRC model.

CRC:
Program Manager: Dr. Bill Steinway, Bill_Steinway@mail.crc.com

The CRC version of HSTAMIDS is a stepped-frequency GPR operating (according to contractor-provided information) in 128 discrete frequencies from ca. 900 MHz to ca. 2750 MHz; a single scan through these frequencies is called a "frequency packet" and 78 packets are transmitted per second. Thus, each frequency dwell has a nominal 100 microsecond duration, with a nominal 14 MHz frequency separation. The current version has 2 receive and 2 transmit antennas; however, the newest version for evaluation will have a single transmit antenna and 2 receive antennas.

2.2. GSTAMIDS:
GSTAMIDS is now undergoing proposal evaluation for EMD (PE 6.4) so all discussions about the current program are prohibited until after 01 April 1999. Government Contracting Officer Technical Representative (COTR) for preceding program is Peter Howard, 703-704-2636, phoward@invel.army.mil. Test reports on previous GSTAMIDS devices are referenced in (6) and (7), and the following comments are derived from those reports.
Although not explicitly a part of the GSTAMIDS program, the Boom-SAR (10) has been used to outline minefields. The reference indicates reasonably good agreement between simulation and experiment.

EG&G:
POC: Jory Cafferky, 505-998-0677, caffej@egginc.com, http://www.eoir.com/uxo/eg&g.htm

The August 1997 EG&G data collection was performed to test the ability of the EG&G VMMD Radar System to locate buried mines. The EG&G radar system is comprised of nine transmitter/receiver pairs each 35cm apart, 1 foot off the ground, and pointed at a 45 degree angle with respect to the ground.

Geo-Centers, Inc.
POC: Thomas Gorman, 617-964-7070, tomgorman@tech.geo-centers.com,

Geo-Centers GSTAMIDS consists of a vehicle-mounted GPR and IR sensors. The forward looking IR sensor consists of a 3-5 mm Amberview camera that provides a 14 bit, 256 by 256 pixel, video image every 2 seconds. The GPR system is mounted 50 cm. above the ground. The 80 cm. wide multi-antenna (four transmit, four receive) ground-penetrating radar array, termed a Focused Array Radar (FAR), focuses and sweeps energy into the ground to detect buried objects. This GPR operates in a frequency range of 700-1,300 MHz. The focused GPR array is described at http://www-dsed.llnl.gov/documents/em/sdndarpa96/sdndarpa96.html, "LLNL DARPA Mine Detection Field Experiment using RF."

2.3. BRTRC/Wichmann

Fred Clodfelter, 703-205-1535, fclodfel@brtrc.com, http://www.brtrc.com/:, described briefly a cooperative agreement between BRTRC and Guenter Wichmann whereas BRTRC builds a GPR using the Wichmann antenna. The antenna is claimed to minimize ground clutter and is the key component; the antenna has an upper frequency of ca. 5 GHz. And employs a simple pulse.

Subsequent to the visit to JUXOCO, a report dated 1996, entitled "Research and Development on the Field of Mine Detection" by Guenter Wichmann, DTIC AD AD-A325 260, available from the Defense technical Information Service (DTIC), http://www.dtic.mil/dtic/ This report describes an antenna design which is capable of transmitting a sub-100ps pulse with little reflection, at the cost of very high attenuation and low output power of 10mW.

Prof. Leslie Collins, Duke University, 919-660-5260, lcollins@ee.duke.edu, performed a study of the BRTRC/Wichmann radar data set and claims "100% Correct Identification"[VIII] of a number of APLs, including PMA-3, M-14 and VS-50. This research was supported by JUXOCOE. The briefing is included in this report[4]. A telecon with Prof. Collins on 01 March 1999 indicated that she used a very small data sample, so the results and claims are not conclusive. The analysis of the data followed in part the Generalized Likelihood Ratio Test (GLRT). The BRTRC/Wichmann antenna is a ca. 0.5m linear array of eight transmit/receive antennas sample the surface about every 10cm.

2.4. ASTAMIDS:
According to Mr. Locke of NVESD and Dr. Altshuler of DARPA, the ASTAMIDS program failed to pass the previous milestone and the program has been returned to the tech base, i.e., back to R&D (PE 6.2). The system failed due to the inability of the IR sensor to reliably detect mines at a distance. The program has now been renamed the Light AirBorne Mine Detector (LAMD).

2.5. Acoustic/Laser Device
Prof. James Sabatier, 601-232-5404, sabatier@olemiss.eduu, has a news release at http://www.olemiss.edu/news/newsdesk/story438.html which also claims "100% Correct Identification" of a number of APL and ATL at Ft. A.P. Hill tests in 1998. He explained to me that the system works by scanning a

laser beam across a suspect area while exciting seismic waves over the area. The laser is claimed to be able to permit the detection of the mines. Works poorly in vegetated environments.

2.6. DARPA Dogsnose/NQR Program

Details of the DARPA chemical detection and nuclear quadrupole resonance (NQR) programs are described at http://www.darpa.mil/dso/rd/Applied/UXO/index.html No additional comments are offered here.

3. Conclusion

The US Army demining technology program is maturing, with some erratic programmatic behavior 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; however, the enthusiasm for continuing is encouraging, as the US clearly recognizes the need for a solution to the mine detection problem. 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.

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4. References

[1] A. Andrews, *et. al., Results of the Countermine Task Force Mine Detection Technology Demonstration at [For] A.P. Hill, Virginia, March 18-22, 1996*, IDA Report P-3192, July 1996

[2] F. Rotondo, *et. al., Report on the Advanced Technology Demonstration (ATD) of the Vehicular-Mounted Mine Detection (VMMD) Systems at Aberdeen Maryland and Soccoro, New Mexico*, IDA Report D-2203, October 1998

[3] Draft UXOCO Report, *Handheld Metallic Mine Detector Performance Baselining Collection Plan, Fort AP Hill, Virginia*, May 1998 to November 1998

[4] S. L. Tatum, L. M. Collins,"Detection and Identification of Mines Using Signals From the Wichmann/BRTRC Antenna: A Preliminary Report," undatae briefing

[5] L. Carin, C. Baum, *Wideband Time and Frequency-Domain EMI: Phenomenology and Signal Processing*, Undated

[6] N. Khadr, H. Nelson, *Target Shape Classification Using Elecgtromagnetic Induction Sensor Data*, Undated

[7] P. Kaczkowski, *Pulsed Electromagnetic Induction (EMI) For UXO Discrimination in JPG Phase IV-Preliminary Results*, Undated

[8] L. Collins, P. Gao, " Statistical Signal Processing for Demining: Experimental Validation Progress Report I: Signatures of Land Mines in Soil and in Air: Are They Different? What are the Characteristics of the Sensor Noise?," Duke University, August 1998

[9] A. Andrews, *et. al., Performance in December 1996 Hand-Held Landmine Detection Tests at APG, Coleman Research, Corp. (CRC), GDE Systems, Inc. (GDE), and AN/PSS-12*, March 1998, IDA Report (Unk)

[10] L. Carin *et. al., Ultra-Wideband Synthetic Aperture Radar for Mine Field Detection, Undated*

ANNEX 6. SOME LINKS TO GENERAL AND MORE TECHNICAL INFORMATION ON HUMANITARIAN DEMINING

This information is complementary to the one already provided in Annex 1: Existing information sources and databases. Please check in particular the pages at http://diwww.epfl.ch/lami/detec/mine10links.html, http://diwww.epfl.ch/lami/detec/mine10links.html and http://etro.vub.ac.be/~eudem/eudemlinks.html

- A Summary of Land Mine WWW Pages: page with a load of links.
- Australian Specialist Dog Sections
- Canadian International Demining Center
- Canadian International Demining Center - bilder
- Countermine Solutions (Canadian Defence R&D)
- Countermine solutions: Very interesting, clear and down to earth overview of the long Canadian experience in the field of "Countermine" Information, Detection, Neutralization and Protection
- Danish Demining Research Forum
- DARPA DogsNose (Chemical Signatures, Trace Explosive Detection): DARPA's 3 year, 25 M$ program, on the detection of landmines via their chemical signatures, inspired by the dogs' remarkable capabilities (http://web-ext2.darpa.mil/DSO/solicitations/index.html). See also the impressive Knowledge Warehouse (bibliography on the vapor detection of landmines), and the "older" database at http://eagle.sysplan.com/Info/LandMine/index.html
- DefenseLINK News: HUMANITARIAN DEMINING ON THE INTERNET
- Demining in Cambodia
- Demining Project, Information Search Strategy
- Demining Research at UWA (University of Western Australia, James Trevelyan): Excellent site on incremental, "down to earth" research projects (short term practical improvements), photograph gallery, Australian links (http://www.mech.uwa.edu.au/jpt/demining/Default.html).
- DeTeC - Demining Technology Center in Lausanne: This page contains a LOT of links on other sites, but also to all the technical ones by the producing companies. Situated at the Demining Technology Centre - frequently updated: http://diwww.epfl.ch/lami/detec/mine10links.html:
- DHA-Online - Uganda - Demining Information
- E.S.R.I. (ArcInfo)
- FHF´s Hemsida: The Swedish military doghandler's association presents itself.
- Gazette - special Phototour in Bosnia
- Geneva International Centre for Humanitarian Demining: Information Management System for Mine Action; annual meetings for mine action managers and other stake-holders; training courses for mine action managers and information technology specialists; Technical studies (staff: 12-15 from the beginning of 1999) (http://www.gichd.ch/).
- GTD: A Spanish Company, EUREKA ANGEL project
- Guartel Ltd.: Maunfacturer of Metal Detectors.
- Guides | Landmines (OneWorld):Excellent source of information on the landmine problem (http://www.oneworld.org/guides/landmines/front.html).
- Handicap International
- HDIC Demining Category Pages
- Heartlands Group Ltd.: A UK-based Company
- Hemvärnshundar: Home Guard Norra Hälsingland presents itself in Swedish.
- http://www.mech.uwa.edu.au/jpt/demining/minefields
- http://etro.vub.ac.be/~eudem/eudemlinks.html: some links established in regard to the EUDEM project
- http://etro.vub.ac.be/minedet: ETRO/VUB web site on the research activities related to demining
- Humanitarian demining
- Humanitarian Demining Equipment Catalog MEDDS K-9 Detection: Humanitarian Demining Catalog - Mine Detection Dogs

- Humanitarian Demining Equipment Catalog, Free-leach K-9 Detection: Humanitarian Demining Catalog - Mine Detection Dogs free-leash search.
- Humanitarian Demining K-9 Program: Humanitarian Demining K-9 Program
- Humanitarian Demining Technology Development Programme (The Development Technology Unit (DTU) - Univ. of Warwick): Excellent effort, especially in the field of humanitarian land-mine clearance and the design of demining equipment and protective clothing for production in poor countries (http://www.eng.warwick.ac.uk/dtu/mines/)
- Humanitarian Demining: Esprit evaluates R&D proposals, plus other news
- Infinia: A Croatian Mine Clearance Vehicle Design (BAD LINK)
- International Campaign to Ban Landmines Winner of the 1997 Nobel Prize in Peace
- International Red Cross on humanitarian demining: web site of the international Red Cross
- Internet Petition to Ban Landmines in Memory of Diana
- IS Robotics: Counter mine and reconnaissance projects.
- Jan Bildtgårds hemsida: Swedish Policedogs site in english.
- JMU Humanitarian Demining Information Center Pages: HDIC at James Madison University: Center of Excellence in information collection, analysis, processing and dissemination (http://www.hdic.jmu.edu/hdic/demining.htm).
- K9 - Police Dog Homepage: The original Canadian site
- K9 - US Polishund hemsida: Swedish version of a good canadian site. Good own links.
- Kurd Web Minelinks
- Land Mine Awareness Education: Lots of information and practical descriptions as well as reports on Mine Awareness
- Landmine Ban Treaty Agreed in Oslo - Norway
- Landmines - NGO Committee on Disarmament: Info on international efforts to control and eliminate landmines (http://www.igc.apc.org/disarm/landmine.html).
- Landmines - the hidden enemy
- Landmines explosions-photogallery
- LANDMINES: Support to EC Humanitarian Demining R & D
- Landmines: What is Schools Demining Schools
- LANDMINES:EC Humanitarian Demining Web Site)
- Lawrence Livermore National Labs: Impulse Radar
- Linkpage: Peace & Security: Several links on land mines as well as other armed conflict pages
- Mark Daltons Summary of Land Mine WWW pages: Another "loads of links" page Menschen Gegen Minen: MGM, a large humanitarian group, with lots of links. The Humanitarian Foundation of People against Landmines. Addresses, links, online forum and much more.
- Midas Data Systems: Orbis, the Minefield Data Administration System
- Mine map over Sarajevo
- Minerats: Anti-personnel mine clearance robots.
- Mines and Minefields - Defining the Problem (Univ. of Western Australia)
- MineWeb Home Page
- MINWARA - The Mine Warfare Association
- Nordiska Polishundsidor: Police dog and Policedog handlers sites from all nordic countries.
- Norwegian People's Aid: Mines: The Silent Killers: The Landmine Problem and NPA's humanitarian demining concept/activity. One of the leading NGOs in Humanitarian Demining (http://www.npaid.no/mines/).
- OAO Robotics: Various teleoperated designs
- Oneworld: Contains photographs, video clips, and soundtracks
- Operation Landmine (from the Operation USA NGO): Focus on conversion of advanced American technology to the detection and destruction of AP landmines (overview of detection technologies etc.)
- (http://www.opusa.org/opland/index.html)
- Operation USA K-9
- Oxfam
- Peace and disarmament: Land mines - Canadian Forces College
- Pictures from Bosnien
- Pictures from Zagreb
- Princess Diana, 1961-1997

- (Review) C&EN 970310 - LAND MINES: Horrors Begging for Solutions: Excellent review article on (chemical) detection methods. Interviews, glossary (http://pubs.acs.org/hotartcl/cenear/970310/land.html).
- Ronco Consulting Corp.: International Demining Consultants
- Safe-Lane:Live coverage of the Treaty Signing Conference in Ottawa December 2-4 as well as other information on the issue - this site also contains a nice thematically sorted link page.
- Schiebel: An Austrian mine clearance company
- Second International Conference on the Detection of Abandoned Land Mines: By Institution of Electrical Engineers
- The Cambodian Mine Action Centre: Cambodia's National Humanitarian Demining Organization.
- The International Campaign to Ban Landmines
- The Mines Advisory Group: One of the leading NGOs in Humanitarian Demining, with activities in North Iraq, Cambodia, Angola and Laos (others planned) (http://www.oneworld.org/mag/).
- The MineWeb: U.S. State Dept. Info on Bosnia.
- The Warchild Landmine Programme
- Trondheim Politi's tjenstehundklubb: Trondheims Policedogs presents itself in Swedish.
- U.S. Navy: Various designs for robotic countermining vehicles.
- UN information about Mine detection dogs
- United Nations Demining Database: Conference information, world reports, some links, UN Mine Action Policy, Points of Contact, Demining Programmes, Casualties and Incidents Reports from around the world, Landmines Magazine, International Mine Clearance Standards (http://www.un.org/Depts/Landmine/).
- United Nations Institute for Disarmament Research
- United Nations Landmine Conference, Geneva
- United Nations on humanitarian demining
- United States Army: Extensive list of available and prospective technologies.
- University of Alberta: A mechanical means of land mine detection.
- University of Florida: X-ray backscatter
- University of Western Australia: Many Different Projects
- UXB International: An American UXO Disposal Company
- UXOCOE (Unexploded Ordnance Center of Excellence): Aims: to build a cooperative multinational effort to share expertise, data and test sites; to build and maintain a UXO detection and clearance database; to standardize target UXO (including land mines); establish benchmarks, metrics, milestones and deliverables. Work your way especially towards the huge SIGNATURE DATABASE and a number of interesting documents (http://www.denix.osd.mil/denix/Public/News/UXOCOE/uxocoe.html).

Vietnam Veterans of America Foundation: International humanitarian, advocacy, and educational organization dedicated to assisting the victims of war. Played pivotal role in international campaign to ban landmines (http://www.vvaf.org/). Excellent Landmine Library - Resource List at http://www.vvaf.org/library/resource_list.html.

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ANNEX 8. FACE TO FACE INTERVIEWS IN CHRONOLOGICAL ORDER

ANNEX 9.