Ain Shams
(PEDD)

Vol. 1.March, 2010, pp.1-16

EGYPT LANDMINE PROBLEM: HISTORY, FACTS, CONSTRAINTS AND DEMINING TECHNIQUES

Said M. Megahed*, Hussein F.M. Ali+ and Ahmed H. Hussein+

*** Professor, + Graduate Students, Mechanical Design & Production Engineering Department, Faculty of Engineering - Cairo University, Giza 12613 – Egypt,**
smegahed@cu.edu.eg, huss_ali77@yahoo.com, ahmed_noran@msn.com

ARTICLE HISTORY
Received: 10/1/2010
Accepted: 15/2/2010

ABSTRACT

Egypt is contaminated with Landmines, UneXploded Ordnances (UXO), and Explosive Remnants of War (ERW) which are normally buried under deep layers of sand and mud from World War II. Most of the battles took place in the area between the Quattara Depression and Alamein at the Mediterranean Coast. Other affected areas lie around the city of Marsa Matruh and at Sallum near the Libyan border. In addition, ERW from armed conflicts between Egypt and Israel in 1956, 1967, and 1973 remains to be cleared, especially in the eastern areas (Sinai Peninsula and Red Sea Coast). No reliable figures for the extent of contamination exist. The joint Egypt/UNDP project document of November 2006 referred to 2,680 km^2 of contaminated area, which is almost four times the estimated contaminated area in Afghanistan. Similarly, the number of landmines, UXO and ERW that remain to be cleared can be little more than speculation. The Egyptian army has estimated that 16.7 million explosive items have still to be found, including both antipersonnel landmines (APL) and anti-tank landmines (ATL) and much larger quantities of UXO. This problem has a serious impact on Egypt National Income.

This paper presents the scope of Egypt landmine problem and its available official data as a first step to select the most suitable techniques for safe detection and removal of such landmines. It also addresses some landmine research topics: area reduction techniques, sensors design, detection and removal equipment. The paper is organized in the following main sections:

- Scope of Egypt Landmine Problem
- Egypt Landmine Monitoring Reports
- Survey of Demining Techniques
- NSF Landmine Research
- International Funded Landmine Projects

Keywords
Egypt Landmine Monitoring Report, Demining, Detection, Clearance, Sensors, , Robots

1. INTRODUCTION

Landmines represent a serious danger in a number of regions of the whole world. Many Landmine fields are known, mapped and mostly even fenced-in. Other Landmines, however, no information exist so that they pose the greatest threat. The problem of Landmines at these regions has a serious effect on their national incomes and on the safety of personal living in such regions.

According to the Civil Right Organization, "a Landmine is some object placed on or under the ground or any surface, conceived for exploding by the simple fact of the presence, the proximity or the contact of a person or a vehicle". There are more than 100 countries affected by Landmines, UXO and/or ERW. Approximately 20 countries are heavily-affected, including Angola, Afghanistan, Croatia, Egypt, and Cambodia. More than 12 countries produce Landmines, including Cuba, Egypt, Singapore, and Vietnam; and almost 20 countries or rebel groups use Landmines, including some countries that produce them. As estimated 45-50 million Landmines infest at least 12 million km^2 of land around the world. These Landmines:

- kill or maim a reported 10,000 people annually;
- create millions of refugees and internally displaced persons;
- prevent hundreds of thousands of square kilometers of agricultural land being used;
- deny thousands of kilometers of roads for travel;
- create food scarcities, causing malnutrition and starvation;
- interrupt health care, increasing sickness and disease;
- inflict long-term psychological trauma on Landmine survivors;
- hinder economic development;
- undermine political stability.

Table 1 lists the most important areas around the world infected with Landmines, UXO and/or ERW with their field type.

Table 1: Estimated Number of Landmines in the Most Infested Countries

Country / region	#Landmines (Million)	Field type (NA= Not available)
Egypt	22	Sandy desert
Angola	10-15	NA
Afghanistan	9-10	Dry, desert, rocky, clay, vegetation, Residential
Cambodia	8-10	Vegetation
Kuwait	5-10	Sandy desert
Yugoslavia	6	NA (without Kosovo)
Bosnia & Sarajevo	NA	Vegetation wild among ruined houses
Lebanon	NA	Rocky high ground
Mozambique	2	NA
Somalia	1	NA
Latin America	0.3-1	NA
Croatia	NA	Vegetation, residential/ industrial, machinery.
Iraq	NA	Semi-arid region
Other countries	6.7-33	NA
Total	70-110	

2. SCOPE OF EGYPT LANDMINE PROBLEM

The Egyptian government cites a figure of 22 million Landmines: 16.7 million affect 268,000 hectares (km^2) in the western desert area and 5.1 million affect 20,000 hectares (km^2) in the eastern areas. Other Egyptian officials have stated that: Only 20-25% of these Landmines are really Landmines, the remainder being other types of UXO and ERW. In the next paragraphs, the available information of Egypt Landmine problem is outlined as follows:

- Egypt Landmine Maps and Time Effect
- Egypt Socio-Economic Effects

- Egypt Landmines Clearance Efforts
- Egypt Landmine Monitoring Reports

2.1 Egypt Landmines Maps, Types and Time Effect:

There are different and inaccurate maps for the Landmines in Egypt as indicated in Figures 1 and 2 with the Maps of Alamein area drawn from memory indicative only of Landmine field records. These Maps are partly misleading because of the limited accuracy of those records. UXO and some Landmines lie scattered across entire area so that the entire area has to be cleared. Table 2 gives the types of landmines used in World War II and Israeli-Egypt (Is-Eg) conflicts.

Table 2: Types of Landmines in Egypt

World War II	Is-Eg Conflicts
British: MK5, MK7 **German:** Rieglmine 43, S mines, Tellermine 35, 42, 43 **Italian:** B-2, V-3.	**Israelian:** MOTAPM (Mines Other Than Anti-Personnel Mines) **Egyptian:** M71, TM46, T79 , TS50, MOTAPM
There is also a wide variety of ERW in the infested land of Egypt including air dropped bombs	

The time has many unpredictable effects on landmines characteristics especially under sand contaminations. The age of much of these Landmines is up to 66 years. Much of Landmines, UXO and ERW are covered by thick deposits of mud or sand so that conventional detection techniques are often of little value. The military analysts said that storms have increased the depth at which many land mines are buried by eight meters, thus ruling out the use of normal mine-detection methods. The trigger mechanisms on many of the weapons have corroded. Mines that were intended to be set off by the hefty bulk of a tank may be detonated by weight of a baby. Some mines may explode by themselves. All surveys and researches state that the mines status is totally unpredictable especially under sand contaminations.

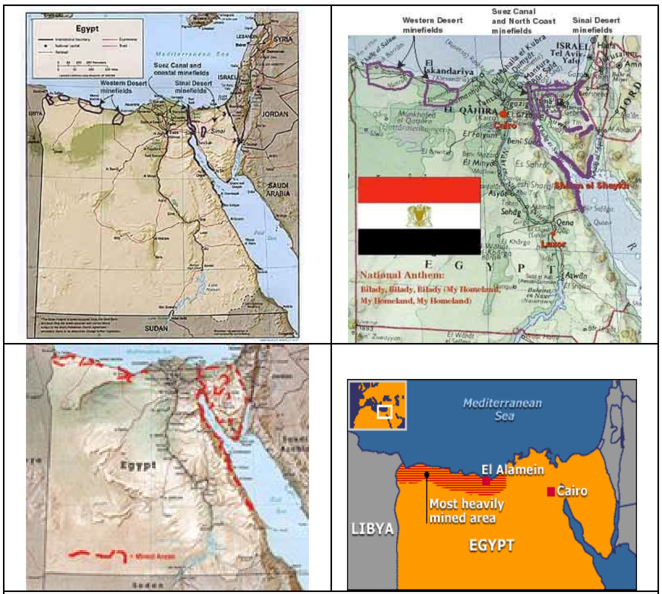


Fig. 1: Egypt Landmines Distribution Maps

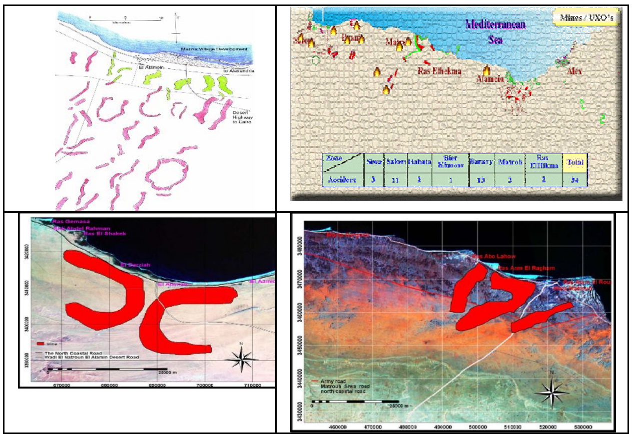


Fig. 2: Alamein Landmines Affected Areas

Maps Data Sources

- North Western Coast Soil Survey and Reports: FAO 1970.
- Land Master Pla: Euro consult-pacer Consultants (LMP, 1986).
- The Geology of Egypt. EGPC 1988.
- Topographic Maps 1: 100,000: Department of Survey and Mines. EGSA 1970.
- Landsat ETM+ of 5 scenes of year 2001 (P178 R039, P179 R038, P179 R039, P180 R038, and P180 R039) and Mosaic Landsat TM of zone 35 year, 1990
- Water Science Department, Alexandria University.

2.2 Egypt Socio-Economic Effects

There is no national mechanism to record victims of ERW and MOTAPM. Table 3 presents the reported mine/ERW causalities as reported in the Egypt Landmine Monitoring

Reports for the period 1999-2009 (www.icbl.org).

Table 3: Estimated and reported number of Mine/ERW causalities till 2009

Year	Causality		
	Total	Killed	Injured
Till 1999	8313*	696*	7617*
2000	12	NA	12
2001	11	NA	11
2002	18	5	13
2003	14	NA	14
2004	10	NA	10
2005	16	6	10
2006	22	9	13
2007	25	8	17
2008	40	14	26
2009	22	13	9
Total	8503	751	7752

* Estimated by the Egyptian Official Authorities and Egypt Landmine Monitoring report of the year 1999

The impact of contamination is said to be significant in many Egyptian activities. Landmines, UXO, ERW and MOTAPM prevented the irrigation of land that could have been used for agriculture in affected areas as well the establishment of new communities in the northern coast area. In addition, ERW and MOTAPM have hindered tourist projects on the northern coast and delayed oil and gas extraction from reserves estimated at 4.8 billion barrels of oil and 13.4 trillion cubic feet of gas in the western desert. New kinds of tourism, such as safari and eco-tourism, can encroach on affected areas, increasing the risk of incidents. It is necessary to warn people of potential hazards, but there is a fear of discouraging travel to the country.

The mine/ERW causalities include men, women, boys, girls, children under the age of 18, civilian and military people. Among 50 accidents cases: (16 accidents were reported at suspected areas (32%) and 34 accidents were reported outside the infected areas (68%)). An Egyptian Non-Governmental Organization (NGO) gathered data on ERW and landmine casualties reported similar data.

According to Egypt Landmine monitoring Report 2009 (www.icbl.org), there were 40 new mine/ERW casualties recorded in Egypt in eight governorates from 11 incidents in 2008. Casualties included 28 men, one woman (injured), 11 boys (7 killed and 4 injured), and no girls. ERW caused 33 of the casualties, landmines caused 6, and an unknown device caused one casualty. 3 incidents involving 4 casualties occurred in Matruh Governorate, where the Ministry of International Cooperation (MIC) and UNDP mine action program operates. The other incidents occurred outside the area covered by the mine action project, including 2 incidents in Ismailia, and one incident in each of Albihira, Al Suez, Alqaliobia, Alexandria, North Sinai, and Alsharqia governorates. 2 incidents causing 5 casualties occurred while people were trying to illegally cross the Egypt-Libya border. The vast majority of casualties occurred during activities relating to the scrap metal trade (29 casualties). Other activities at the time of incident included playing with ERW (3), playing/recreation (3), travel (3), agriculture (1), and fishing/hunting (1). Except for the two incidents that occurred at the Egypt-Libya border, none of the casualties witnessed any danger signs or had received risk education, despite some living in or near to mine/ERW-affected areas.

Casualties continued in 2009, with 9 boys (8 killed and 1 injured) and the 13 men (5 killed and 8 injured). Activities at the time of the incidents included agriculture (4), fishing/hunting (4), travel (3), playing with ERW (3), playing/recreation (3), and providing security (1); the activities of 4 casualties were unknown. In May 2009, a police officer was injured when he handled a landmine while working at the Egypt-Israel border.

The MIC with UNDP and the local NGO Peace Gardens, conducted a mine/ERW survivor survey from January to May 2008, on the North West Coast (primarily in Matruh governorate). The primary objective of the survey was to verify existing information on survivors collected by the Office of the Governor of Matruh and the Governorate Social Solidarity

Department. Interviews were also conducted to identify previously unknown survivors in cooperation with local authorities. It is estimated that some 80–90% of mine/ERW-affected communities were covered by the survey.

The survey identified 645 mine survivors living on the North West Coast, 94% of them were males and 3% children. It should be noted the survey recorded the age of the person at the time of the survey, not when the mine/ERW incident occurred. Among the injured, 48% suffered upper body injuries, 37% lower body injuries, and 15% other injuries. The number of people injured annually from 2002 to 2004 was found to be 18, but by 2007 the number had decreased to three.

The number of mine/ERW survivors recorded in the survey was considerably lower than the estimate of 8,000 mine/ERW casualties which, according to UNDP is "understood to relate to casualties in the whole country." It should be noted that the Peace Gardens survey included only those injured and those who still lived on the North West Coast at time of survey. A number of survivors particularly from Bedouin communities are assumed to have moved from the area since they were injured by mines/ERW. As a result, the survey does not capture all those injured by mines/ERW in the survey area. The survey did not include military casualties from mines/ERW. The Ministry of Defense estimated that about 700 people, soldiers and civilians, have been killed in mine explosions since 1945.

Landmine Monitor recorded at least 190 mine/ERW casualties (55 killed and 135 injured) in Egypt between 1999 and 2008.

2.3 Egypt Landmines Clearance Efforts

Since 1946, according to the Egyptian Official Authorities, 7 million mines have been cleared from the western desert in the past 15 years and 3 million from the Sinai desert. That leaves at least 20 million others. Egypt has set the year 2017 as the target for finally ridding its sands of land mines, but it is anxious not to left alone in paying for and carrying out this huge task.

The fact that over the years many reference points and landmarks have disappeared by rain and sandstorms added to the complexity of drawing a comprehensive picture of the Landmine situation. The complete marking and fencing of huge areas in the western desert is not considered feasible by the Egyptian Military due to climatic conditions, sandstorms and scrap traders. Next are some other official acts:

- The Government of Egypt has established the National Committee for the Northwest Coast Development and Demining Programs aiming to propose and implement regional developmental programs for the Northwest Coast and its desert back areas up to the year 2017
- Clearance activities severely hampered by having only limited maps, sketches and minefield records. Maps and data sources that have been provided by Germany, Italy and Britain have proven to be inaccurate or incomplete
- All Demining work is handled by a division of the Ministry of Defense in Cairo the Egyptian Military Engineering Organization **(EMEO)**.
- Until recently, all aspects of minefields and Demining are classified. However, the Egyptian government is now pursuing a more open policy, recognizing that information is needed to help secure assistance.

A summary of the 2008 and 2009 Egypt Landmines Monitoring Reports are presented in **Appendix A**. These reports include: Mine Ban Treaty status, Stockpile, Contamination, Estimated area of contamination, Demining progress, Mine/ERW casualties, Casualty analysis, Availability of services, Mine action funding, and Key Development in the years 2008 and 2009. The detailed reports can be found on the website: www.icbl.org.

4. SURVEY OF DEMINING TECHNIQUES

There are two main demining categories: Military and Humanitarian Demining. In the military demining, a military force prepares a safe corridor for the troops to move through. Some losses are accepted as an expected part of the conflict. Therefore a flail machine with an 80% clearance success can be used. This sort of clearance operation is not suited to humanitarian demining. In the humanitarian demining, the entire land area must be cleared free of mines to be productive. The United Nations has specified a mine clearance standard of 99.6% for humanitarian Demining. Currently the only way to achieve this is with manual demining methods. The main humanitarian demining technical problems are given in **Appendix B** and next are some details about the used Demining techniques.

4.1 Area Reduction Techniques

Demining is the action of removing landmines, booby traps and UXO from an area; those are normally hidden and most often buried and distributed over wide areas. However, not all the wide areas are contaminated. For optimum application of demining; contaminated regions should be detected first, then it is possible to utilize uncontaminated areas for economic and human activities, while contaminated regions are treated for clearance. The process of locating region of interest (ROI) to exclude uncontaminated areas is called Minefield Area Reduction. This technique may be useful to declare the minefields existing inside larger unrecognized area to minimize the overall cost dramatically. Therefore, it is usual to use sensors in two levels; wide view to locate ROI, and detailed view to locate the specific mines. Generally, the reduction is conducted on the basis of collecting more reliable information on the extent of the hazardous area. Clearance data gathered by the GICHD from 15 countries suggests that of suspect areas cleared, less than 3% actually contained mines or other ordnance. The effective area reduction is the phase of demining where the greatest increases in efficiency can be made. Many varied prerequisites have to be observed, such as soil and type of topology, as well as type of contamination. Figure 3 presents the different known area reduction techniques: Mechanical Rollers, Sampling and Imaging. Next are some details about these techniques.

Mechanical Roller: is normally mounted on the front of a minefield intrusive prime mover such as the Minefield Tractor or an armored loading shovel. It is then pushed through the minefield. The roller works by detonating any near-surface or surface pressure-activated mines. It is designed to withstand APL mine blasts only.

Sampling Technique: is a remote explosive sent tracing **(REST).** The sent may be obtained using a pump to draw air containing scent or particles from the soil surface through an absorbent filter. Trained snuffers dogs or rats, or potentially any other natural or artificial odour sensing system may be used for analyzing this sample. **REST** is originally known as the MECHEM Explosives and Drugs Detection System (**MEDDS**).

Imaging Technique: Images taken by Satellite, Balloons or Helicopters may be used to reduce the expected area to be cleared in the next demining phase.

Fig. 3: Area reduction Techniques

4.2 Landmine Detection Techniques

In addition to metal detectors, biological detection (Fig.4 and Fig. 5) is in use to locate Landmines such as:

- Bacterial sensing of soil
- Transgenic plants for sensing of explosive compounds
- Detection using dogs, rates, bees, rodents, mongoose, and other animals.

Modern anti-personnel mines used today are: relatively small, about 3-20 inches in diameter, made of plastic with very few metal parts and hard to detect. Many companies are currently working in field to test their innovative mine-detection methods such as:

- Supersensitive ground-penetrating radar,
- Infrared emission,
- Thermal neutron activation,
- Energetic photon detection
- Detection by practical applications of certain types of polyurethane foam
- Nuclear Detectors

Next are some details about these types of detection techniques.

Metal Detectors (MD): The operator (human) uses handheld sensors (probe, metal detector, magnometer … etc) and investigates the surface of the required field. Any little mistake can cost his life. False alarm is the main disadvantage of metal detectors. They cannot detect landmines with very low metal content. These metal detectors can be used with non-manual detection techniques.

Bacterial Sensing of Soil: This technique is promising for large areas and provides a tool for direct detection of explosive compounds. The bacteria would be spread over an area from an airborne plate form and would subsequently become luminescent in the presence of explosive compounds in the surface of the soil. The area could be then passively, or actively, observed with an airborne hyper spectral camera. The problems identified with this system have limited its development; since the bacteria need to be activated on site in large quantities, and sophisticated large-area dissemination equipment need to be available. More importantly, once spread over an area of interest the bacteria sense only a thin layer of soil near the surface, where explosive concentration may be quite low. Bacteria are also subject to environmental conditions which may hinder their growth, such as undesirable temperature and UV light.

Fig. 4: Biological detection techniques

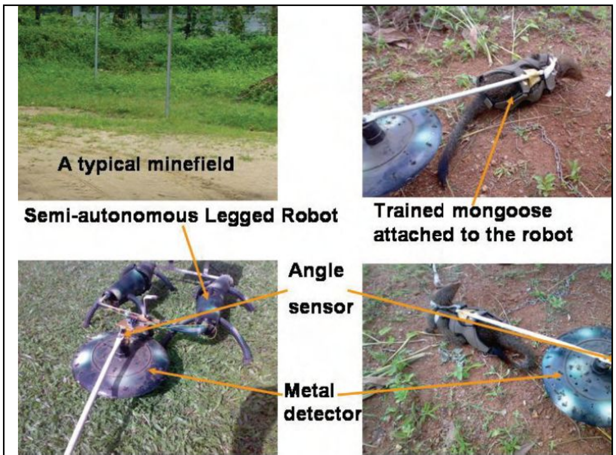


Fig. 5: Biological detection techniques

Plants Landmine Detection: Landmines release nitrous oxide that turn these plants turn red. The best studied is the specie mustard Arabidopsis thaliana which has been genetically manipulated for this purpose. However, nitrous oxide can also be released by denitrifying bacteria, resulting in the risk of false positives. Researchers are addressing this problem by making the plant less sensitive. In theory, these plants could either be sown from aircraft or by people walking through demined corridors in minefields. No studies have yet been conducted with actual landmines, though successful studies have been done in greenhouse environment.

Bacteria Landmine Detection: Scientists have genetically engineered a strain of bacteria to fluoresce under ultraviolet light in the presence of TNT. In tests, the bacteria successfully detected mines when sprayed over simulated minefields in successfully located mines. This method has been found to produce relatively quick results, and could be used over different terrain. Even small amounts of TNT are detected but there are some false positives near plants and water drainage.

Polyurethane Foam Detection: Foam material is being tested on beaches or other battlefields as a sort of "cushion" to keep mines from exploding. When ground troops or vehicles move over them, or in the event that the mines do detonate, as a pressure-wave "absorber", foam will shield troops from destructive effects of explosion.

Nuclear Detection: The concept of detecting explosives through elemental analysis by neutrons to detect nitrogen has been proposed. Majority of explosives are nitrogen rich. The focus has mainly been directed at airport security and hostile trucks although its use for landmine detection has been suggested.

4.3 Landmine Clearance Techniques

Demining clearance operations can be achieved using: Manual Methods, Mine clearance machines, Ground preparation machines, Remotely Operated Vehicles (ROV) and Mine Protected Vehicles (MPV). Next are some Examples (see **Appendix C**):

- **Tele-operated Machines:** Light-Flail, Remotely Operated Vehicles (Kentree Limited), Pookie, Vehicle Mounted Detection System (VMDS), and Improved Landmine Remote Detection Vehicle (IL-RDV)
- **Multi Functional Tele-operated:** Robots, Articulated Modular Robotic Mine Scanner (Engineering Service Inc. (ESI)), Enhanced Tele-Operated Ordnance Disposal System (ETODS), (OAO Corporation, Robotics Division), TEMPEST. (Development Technology Workshop (DTW), The Armored Combat Engineer Robot (ACER) MSEA Robotics, Modular Robotic Control System (MRCS) for Mine Detection
- **Demining Service Robots:** Three Wheels Dervish Robot (University of Edinburgh/ UK), Spiral Terrain Autonomous Robot (STAR) (Lawrence Livermore National Laboratory (LLNL), MILmine, FETCH II, Finder, PEMEX-BE (PErsonal Mine EXplorer) (EPFL/Switzerland), Shrimp Robot (EPFL/Switzerland), AMRU and Tridem (I and II) (Belgium HUDEM), WHEELEG (University of CATANIA, Italy), COMET I, II and III: Six legged Robot (Chiba University Japan), Buggy and Legged Robots (TIT in Japan), Mine Hunter Vehicle (MHV), Fuji Heavy Industries (FHI), ARES Wheeled Robot Int. Robot System) (TITAN-IX & Buggy system mounted ALIS), PEACE: An Excavation-Type Demining Robot, Two interchangeable Radar sensor modules and <u>Unmanned Aerial Vehicles (UAV)</u>.
- <u>**New Robotic Systems (lizard, warm):**</u> Virtual mock-ups of smart crawling robots for landmine localization in thick vegetation using REST and Robotic modules for steering and peristaltic trust

5. NSF LANDMINE RESEARCH

Research related to Sensors: Recent advances in sensor research have yielded important innovative applications to national security, healthcare, environmental safety, and energy resource management:

(a) Develop new sensor arrays to increase Landmine location/detection capabilities, accurately locate UXO to improve removal activities, and improve data merging solution
(b) Use of sensor data in control and decision making, particularly in relation to the prediction and detection of explosives and related threats,

(c) Detection of explosives and related threats, including improvised explosive devices (IEDs).

Research Related To Prediction: New fundamental research will enable to the recognition of explosives and other threats earlier than current technologies allow, identify and isolate a threat at or before the point of device assembly and placement. Research towards this goal might include:

(a) Algorithms and sensor systems to predict the possible assembly and placement of explosive devices.
(b) Recognition of emplacement patterns, behavioral pattern recognition from video and other innovative sensing systems.
(c) Human intelligence and social network analysis of terrorist networks
(d) Analysis of communications, and knowledge-management systems.

Research Related To Detection: Sensitivity and fine resolution of sensors is important for the detection of explosive devices, since the earlier a threat can be identified, the easier is addressed. Once an explosive device is in place, its rapid detection accelerates its standoff identification and localization. To distinguish real threats in an environment with minimal or no false alarms, signal processing, data fusion, and autonomous system technologies are in use.

6. INTERNATIONAL FUNDED LANDMINE PROJECTS

Many organizations are working on Landmine field Area Reduction to develop their own techniques. Two examples of Governmental and commercial organizations are presented here. The 1st project (http://www.arc.vub.ac.be/) is carried out by 7 European organizations and partially funded by the European Commission. The parties are: CROMAC (Croatian Mine Action Center), Croatia, FOI (SDRA: Swedish Defense Research Agency), Sweden, GEOSPACE Satellitenbilddaten GmbH, Austria, GTD (Ingenieria de Sistemas y Software Industrial), Spain, IMEC (Ineruniversity MicroElectronic Center), Belgium, Schiebel GmbH, Austria and TNO (Netherland's Organization for Applied Scientific Research), Netherlands. The 2nd project (www.mineclearing.com) is carried out by Mine Clearing Company Corp

7. COMMENTS AND CONCLUSIONS

The exploration, localization, mapping, and removal of Landmines in infested areas are complicated problems. Many questions are still raised about the most efficient technique for Landmines detection and removal as well about the most efficient sensor(s). The answers of these questions will be useful to develop safer, faster and cost effective Anti-Personal and Anti-Tank Landmines (APL & ATL) clearance. This will save human lives and will have a very positive impact on the Egyptian National Income.

This paper presents the scope of Egypt Landmine problem and its available official data as a first step to select the most suitable techniques for safe detection and removal of such landmines. The paper also addresses some Landmine research topics: Area reduction techniques, sensors, and detection and removal equipment. One of the possible solution to this problem is the use of a multi-function remotely operated robot equipped with metal detectors (MD), ground penetration radar (GPR) and/or radioactive or foam materials for localizing, marking and clearance of landmines.

ACKNOWLEDGMENTS

This paper has been supported by the Egyptian Science and Technology Development Fund Program STDF through the research project: "Remotely Operated Robots with Application to Landmines Removal in Egypt", Grant # 465.

REFERENCES AND BIBLIOGRAPHY

1- www.sis.gov.eg,
  a. Statement of Egypt, First Review Conference, Nairobi, 2 December 2004.

   b. Statement of Egypt, Seventh Meeting of States Parties, Geneva, 22 September 2006.
   c. Statement of Egypt, "Explanation of Vote on Resolution on the Ottawa APLM Convention, L.6," First Committee of the UN General Assembly, New York, 30 October 2008.
   d. State Information Service, Government of Egypt, "Egypt Yearbook 2008," undated, p. 294.

2- Government of Egypt/UNDP,
   a. "Support to the Northwest Coast Development Plan and Mine Action," Project document, Cairo, November 2006, p. 5.
   b. , "Support to the North West Coast Development Plan and Mine Action," Project Document, Cairo, November 2006, pp. 1–2.

3- Egypt Landmine Monitor Report
   a. http://www.icbl.org/lm/2004/egypt.html, p. 957, p. 959
   b. http://www.icbl.org/lm/2005/egypt.html, pp. 699–700
   c. http://www.icbl.org/lm/2006/egypt.html, p. 881
   d. http://www.icbl.org/lm/2007/egypt.html, pp. 818-819
   e. http://www.icbl.org/lm/2008/egypt.html, pp. 828-829

4- www.unddp-mic.org,
   a. Executive Secretariat, "Opening of Matruh Office," 1 January 2009
   b. Executive Secretariat, "Mine Clearance Project," Technical report, Cairo, June 2009, pp. 18-20.
   c. Executive Secretariat for Mine Clearance and Development of the NWC, "Meeting with HE. Mr. Rene Wilson, New Zealand Ambassador," 28 December 2008,

5- UNDP,
   a. "Mine Action on Mine Awareness Day: The Government of Egypt and UNDP sign a project document that promises to eradicate all mines from Egyptian soil," Press release, Cairo, 4 April 2008.
   b. "Mine Detectors to Celebrate Mine Awareness Day," Press release, Cairo, 22 April 2008
   c. National Committee for Landmine Clearance and North West Coast Development/Ministry of Planning, "The North West Coast and Inland Desert Project (NWCID), Vision for development," undated, p. 37.

6- U.S. Department of State,
   a. "Fact Sheet", Washington, DC, 2 July 2003
   b. "2008 Country Reports on Human Rights Practices: Egypt," Washington, DC, 25 February 2009.

7- Mine Action Support Group,
   a. "MASG Newsletter October 2008–February2009," Washington, DC, 28 February 2009, p. 12.
   b. "MASG Newsletter 1 January 2008–30 April 2008," Washington, DC, 28 February 2009.

8- Emails from:
   a. Ayman Sorour, Protection, 24 July 2009
   b. Ulrich Tietze, 25 July 2009
   c. Hagar Mostafa, Media and Mine Risk Education Officer, Executive Secretariat, 29 July 2009
   d. Hala Nour, Monitoring and Coordination Officer, Executive Secretariat, 8 August 2009.
   e. Hala Nour, in email forwarded by Ambassador Fathy El Shazly, Executive Secretariat, 30 August 2009.
   f. Reuben McCarthy, UNDP, 31 August 2009.
   g. Rania Hedeya, UNDP, 31 August 2009.
   h. Rania Hedeya, UNDP, 31 August 2009. Executive Secretariat, contained in email from Reuben McCarthy, Conflict Prevention and Recovery Specialist, Sub-Regional Office for Eastern and Southern Africa, UNDP, 31 August 2009.

9- Ibid.

10- Telephone interview with Hagar Mostafa, Executive Secretariat, 20 August 2009.

11- Ulrich Tietze, Chief Technical Advisor, "Demining for Development Mine Action in the North West Coast of Egypt," UNDP,

International Conference on the Impact of Landmines and Development, Tripoli, Libya, 3–4 November 2008.
12- Vivian Salama, “Egypt launches Demining program with eye toward development,” Daily Star, 7 April 2006;
13- Ayman Sorour, Director, “Protection and Mine Action and Human Rights Foundation for Mine Victims in Egypt,” Cairo, 24 July 2009.
14- Human Rights Watch and Landmine Action, Banning Cluster Munitions: Government Policy and Practice, Mines Action Canada, May 2009, pp. 197–199.
15- “Weapons and contraband tunnels found in Egypt’s Sinai,” Agency France-Presse, 18 July 2008.
16- “A campaign to raise awareness and rehabilitation,” al-Ahram (newspaper), issue 44428/132, 27 July 2008.
17- “The social development fund funds micro-projects for people with special needs,” Al-Wafd (newspaper), 4 May 2008;
18- “Simple micro projects loans for people with special needs,” Al-Gomhuria (newspaper), 2 May 2008.
19- “Half ton of explosives seized in border city with Gaza strip,” Almasry Alyoum (daily newspaper), Cairo, 22 August 2008.
20- “Egypt receive Demining equipment from China,” Africa Press Agency, 9 February 2009.
21- Germany Article 7 Report, Form J, submitted 27 April 2009
22- New Zealand Article 7 Report, Form J, submitted 30 April 2009.
23- www.irinnews.org, “Unexploded mines block development in northwest,” IRIN (Cairo), 31 January 2008.
24- www.ismailia1928.com, “Al-Gaafary calls for dismissal of Abul Naga after failing in mine clearance,” Muslim Brotherhood in Ismailia, 25 March 2009.
25- www.imra.org.il, “Israel praises Egypt for counter-terror ops,” Independent Media Review and Analysis, 17 May 2009.
26- http://www.mmc.gov.eg/ “Egyptian Armed Force”
27- United Nations Mine Action Service (UNMAS), “Mechanical Demining”, Draft 1st edition, 2006
28- ”How do Dogs Detect Landmines? A Review of Research Results”, GICHD: Geneva International Centre for Humanitarian Demining, Geneva, 2002.
29- “Remote Explosive Scent Tracing Genuine or a Paper Tiger”, GICHD: Geneva International Centre for Humanitarian Demining, Geneva, 2003
30- “Mine Detection Dogs: Training, Operations and Odour Detection”, GICHD: Geneva International Centre for Humanitarian Demining, Geneva, 2003
31- “A Study of Mechanical Application in Demining” GICHD: Geneva International Centre for Humanitarian Demining, Geneva, May 2004.
32- “Mechanical Demining Equipment Catalogue 2008”, GICHD: Geneva International Centre for Humanitarian Demining, Geneva, January 2008.
33- “Detectors and Personal Protective Equipment Catalogue 2009”, GICHD: Geneva International Centre for Humanitarian Demining; Geneva, January 2009.
34- ”Guide for the use of mine detection dogs”, United Nations Mine Action Service, 2005.
35- “Remote Explosive Scent Tracing (REST)”, United Nations Mine Action Service, 2005.
36- ”Explosive remnants of war and mines other than anti-personnel mines” Landmine Action, Action group Landmine.de, Mines Action Canada, 2005.
37- Trevelyan J., “Robots and Landmines”, Proceedings of International Symposium of Robotics Research, Zushi, Japan, October 1997.
38- http://www.mech.uwa.edu.au/jpt/de-mining/countries/minefields.html, “Demining Research at university of Western Australia”
39- “Landmine Action and German Initiative to Ban Landmines - Alternative anti-personnel mines the next generations”, 2001.
40- Yvan Baudoin, “Humanitarian Demining: Sensors Systems: Mechanical and Robotic System”, after2002

41- Emanuela Elisa Cepolina, “Progetto di un dispositivo per la localizzazione di mine anti-uomo”, M.Sc. Thesis 2002.
42- Maki K. Habib, “Service Robots and Humanitarian Demining - Mobile Robots Towards New Applications,”, ISBN 3-86611-314-5, Edited by Aleksandar Lazinica, pp. 784, ARS/P IV, Germany, December 2006.
43- Maki Habib (Editor), Humanitarian Demining, Technical Education and Publishing, February 2008.
44- Keller C., "Landmine detection methods comparison", Brescia University, Jan 2008. http://www.ing.unibs.it/~arl/projects/detmeth.htm
45- http://www.greatcore.com/de-mining-comparison.htm, Greatcore inc.
46- “ MDD_odour_detect_Goeth.pdf ”
47- “IMAS_9.43_2_Draft2.pdf”
48- “MDD_ch2_part2.pdf”
49- “Section1: Flail systems Light flail” MDE_Cat_2006_Section_1_Light_flail.pdf

Appendix A
Egypt Landmine Monitoring Reports (2008 & 2009) (www.icbl.org)

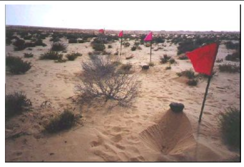
	2008	2009
Mine Ban Treaty Status	Not a State Party	Not a State Party
Production, Transfer and Stockpile	Unknown, but thought to be substantial	Egypt has stated that it stopped production of antipersonnel mines in 1988 and export in 1984
Contamination	Antipersonnel and anti-vehicle mines, UXO	Antipersonnel and anti-vehicle mines, UXO and ERW
Estimated area of Contamination	2,680km², to be significantly reduced by technical survey	2,680km², to be significantly reduced by technical survey
Demining progress	None	The “Support to the North West Coast Development Plan and Mine Action Project” between Egypt and UNDP was signed in November 2006 and, following an extension, was due to run until December 2009
Mine/ERW casualties	Total: 25 (2006: 22) Mines: 10 (2006: 8) ERW: 14 (2006: 8) Unknown: 1 (2006: 6)	Total: 40 (2007: 25) Mines: 6 (2007: 10) ERW: 33 (2007: 14) Unknown: 1 (2007: 1)
Casualty analysis	Killed: 8 (2006: 9) Injured: 17 (2006: 13)	Killed: 14 (2007: 8) Injured: 26 (2007: 17)
Risk Education capacity	Inadequate	Risk Education was included in the joint UNDP/Egypt project signed in November 2006, yet little has been implemented. In July 2008, the Chair of the State Information Service stated that a three-month Risk Education campaign in Matruh, Alexandria, Suez, Al-Arish, northern and southern Sinai, and Ismailia governorates would take place, but no activities had taken place as of July 2009
Availability of services	Unchanged-inadequate	Unchanged—inadequate
Mine action funding	$500,000 (2006: none)	$918,244 (2007: $500,000)
Key developments	In mid-August 2008, it was announced that Demining would begin before the end of the month.	From 7 February 2009 until 31 July 2009, Demining operations were reported to have cleared 210,214 items of UXO and 13720 mines from 14474 acres (58.6 km²). It is not possible to verify these figures, which seem high given the available resources

Appendix B

Difficulties in Humanitarian Demining

(All photos Prof. J. Trevelyan)

Complications and Description	
1- Landmines locations are usually unknown: because they are very cheap, it is easy to build weapons, so they have been largely used in different types of conflict, by military or civilians.	
2- Landmines are often discovered by accidents: Associations like the Red Cross when they have to provide support for mine victims.	
4- Maps indicating the locations are useful in few cases: as demining operations do not start until years after the minefield was laid and during this time the conditions of the affected lands can drastically change.	
5- Mines that have been in place for years: Can be corroded, waterlogged or impregnated with mud or dirt, and then behave quite unpredictably.	
6- Floods and heavy rains: may cause mines to move from the original place to another or to move deeper into the ground.	
7- Mines placed near buildings: may lie deep under fallen rubble with more mines laid on top	
8- Stakes supporting fragmentation mines: may fall over and may rot, leaving the fragmentation mines half buried lying on their sides.	
9- Tripwires may run through: the branches of the scrub may pull the pins from the fragmentation mine as the branches sway in the wind.	
10- The vegetation grown in many years after the landmines were laid: an obstacle to demining operations.	

	
border between Croatia and Republika Serbska within (present and 8 years later)	
11- Type of terrain: Plenty of metal fragments represent an obstacle for the use of metal detector. Uneven rocky terrains add complications to the mine removing operation.	 Photo: MCPA, Afghanistan
13- Mines buried in a sandy desert: can easy move deeper when the wind blows the sand.	 Western Desert, near Al Alamein
14- Mine age implies high sensitivity of mines: In Western Desert and Sinai Peninsula, age of most of the explosive materials is up to 65 years. (high sensitivity)	
15- The climate is extremely unpleasant for deminers: Temperatures upto 55° C are common. The conditions are either dusty and sandy or muddy (salty mud and swamps) along the coast: sometimes both. The muddy areas and marshes are particularly difficult to deal with as it is often impossible to stand in the mud.	
16- Mines status are not expected as well: Array of mines as those German mines in the World War II. Waiting for press in order to be activated. Already pressed under certain weight of contaminations and waiting for release in order to be activated.	

Appendix C
Demining Machines and Robots

(a) Armtrac 25. (Armtrac Ltd., United Kingdom)

(b) Bozena 4 (WAY Industry J.S. Co, Slovak Republic)

(c) Mini-flail. (US Department of Defense)

(d) Diana 44T (Hontstav S.R.O., Slovak Republic)

(e) Minecat 140. (Norwegian Demining Consortium)

(f) The MV-4. (DOK-ING d.o.o., Croatia)

1- Light-Flail

(a) The wheeled Hobo.

(b) The wheeled Hobo.

(c) the tracked Hobot.

(d) The Brat.

(e) Thrasher.

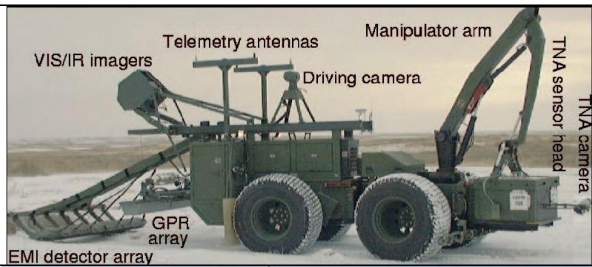
2- ROV

1st phase

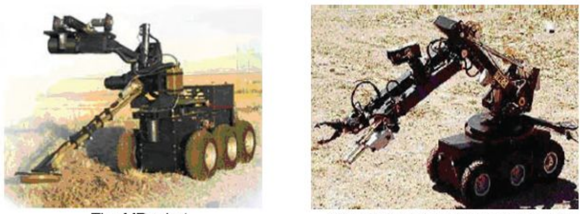
2nd phase

3- Pookie

4- VMDS



5- IL-RDV



The MR robot

MR robot with another arm module

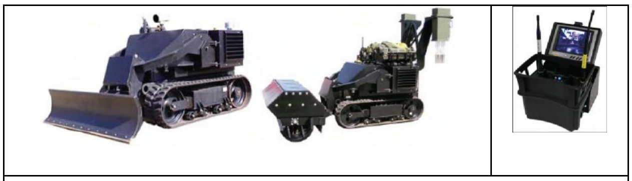
Laser/US imaging sensor

Mine Detector Head

6- AMM Scanner

7- ETODS

8- TEMPEST

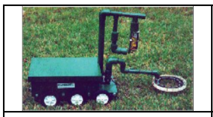


9- ACER (MSEA Robotics)

10- MRCS

11- Three Wheels Dervish Robot

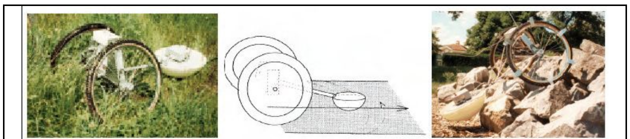
12- STAR



13- MIL mine

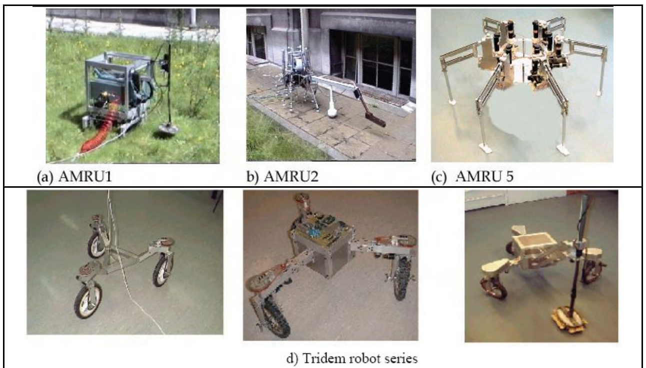
14- FETCH II

15- Finder

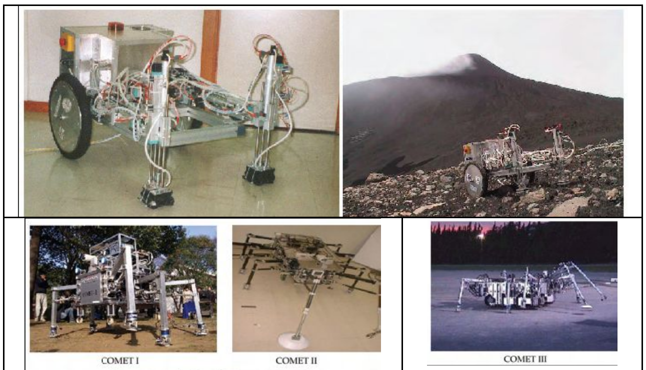


16- PEMEX-BE

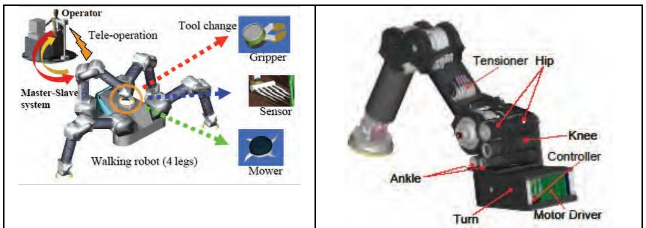
17- Shrimp Robot



18- AMRU | 19-Tridem-I | 20-Tridem-II



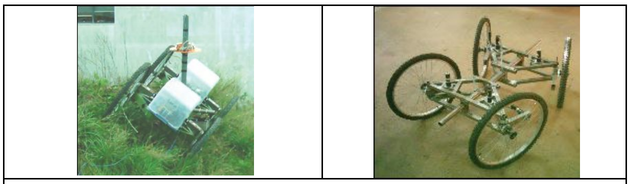
21- WHEELEG, COMET I, II and III & Six Legged Robots



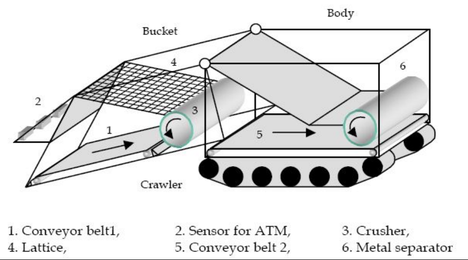
22-a Buggy and Legged Robots

22-b Buggy and Legged Robots

23- MHV

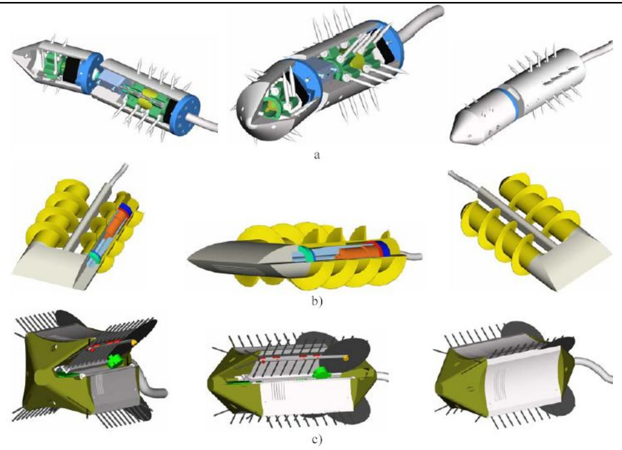


24- ARES Wheeled Robot

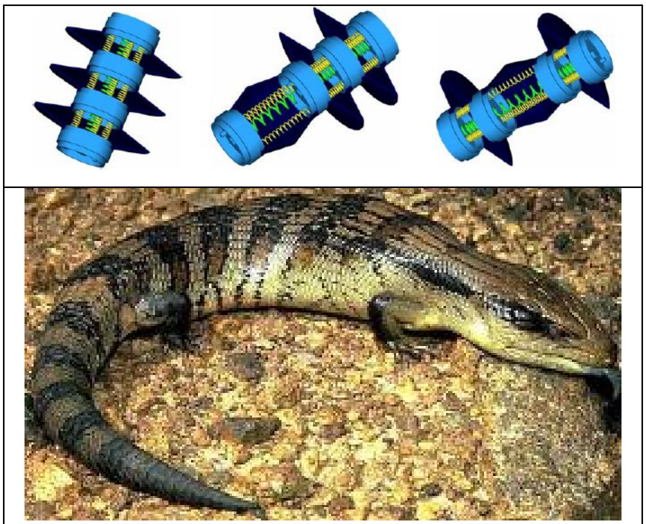


25- PEACE

26- UAV



27- Virtual Smart Crawling Robots



28- Robotic modules for steering and peristaltic trust