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CONTENTS

Quality Management VersusTime
Experience from Jordan

***Mohammed Abudalou*[1]*, Jamal Odibat*[2]**

Introduction:

Quality management (QM) is an important part of most industries. It not only focuses on the end product (in demining this is 'safe cleared land' but also the process to achieve the final product). The aim of QM in the survey and clearance of areas contaminated by mines is to provide the beneficiaries, the demining organization and the national authority with **confidence** that the land is released in accordance to the agreed standard. The aim is also to ensure safety for the operators while working, and assurance that any released land is indeed safe to use. QM is comprised of quality assurance (QA) and quality control (QC), and the intention is to achieve consistent quality throughout the entire operation.

Quality assurance (QA) is conducted by assessing that the process is being followed. Quality control (QC) is conducted by physically checking the finished product.

The purpose of QA is to confirm that management practices and operational procedures are appropriate, are being applied correctly, and will achieve the stated requirements safely and efficiently. Internal QA is conducted by the survey and clearance organizations, while external inspections are undertaken by national mine action authorities or other contracted agencies.

QA includes:

- Organizational and Operational accreditation of the clearance organization and assets
- Monitoring of survey and clearance teams during operations to ensure that the agreed procedures are followed
- Assuring that equipment is functioning properly and is being operated as per the agreed standard
- Assuring that mechanical and animal assets, if used, are performing in the way they were designed/ trained to perform and in accordance with the set standards
- Review of documentation to ensure that records are maintained as per agreement

QC relates to the inspection of a finished product, which in demining, normally involves the inspection of a proportion or taking samples (percentage) of cleared land, to validate that the work has been achieved to the agreed standard. External QC takes place when a task has been completed, and is conducted through sampling. Internal QC takes place while conducting a task. QC is only conducted on the finished product (safe cleared land) .

Where land is released by survey, a conclusion has been made that no mines were present on that land prior to the technical survey. Inspection of such land would be unlikely to unveil information about the quality of the survey while increasing costs. Inspection of land released by non-technical and technical survey may, however, form part of an initial process where the aim is to verify that a land release concept is appropriately designed.

If the Non-technical or technical survey carried out in cleared area, but not inspected by samples, so sampling inspection will applied as usual, in addition to verify the land release process.

Internal QC is conducted by survey and clearance organizations, while external inspections are undertaken by national mine action authorities or other contracted agencies. External sampling, in particular, is a costly way of ensuring quality, and should be kept to a minimum.

Credibility

Land should only be released when it is deemed safe to use, After a credible and well-documented process has been fully implemented.

When an accident happened after land is cleared, and quality management was not implemented there it deemed that credibility of the clearance Process is not sufficient to release land .

Productivity:

Effectiveness: Adequate to accomplish a purpose; producing the intended or expected result. You are effective if you follow your purpose. So the first step here is you need to find your purpose. This is essential. After that, the second step is doing the things in accordance with your purpose.

Efficiency: Performing or functioning in the best possible manner with the least waste of time and effort. After you choose to do the right things, now you should do those things in the right way.. These tools will help you do your personal finance efficiently. After choosing to do the right things, a lot of tools can help you do those things in the right way.

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Combining these two – effectiveness and efficiency – means that you *do the right things in the right way*. That’s the productivity.

Time management

The Time management is the process of planning and exercising control over the amount of time spent on specific activities, especially to increase effectiveness, efficiency or productivity. Time management may be aided by a range of skills, tools, and techniques used to manage time when accomplishing specific tasks, projects and goals complying with a due date. This contains a wide scope of activities, and these include planning, allocating, setting goals, analysis of time spent, monitoring, organizing, scheduling, and prioritizing. Initially, time management referred to just business or work activities, but eventually the term broadened to include personal activities as well. A time management system is a designed combination of processes, tools, techniques, and methods. Usually time management is a necessity in any project development as it determines the project completion time and scope.

In our study we know our purpose which is clearing the land, but does our process will lead to the expected result (which is a free land with a full credibility so we can release it to users).

The second factor does we use the manner with the least waste of time and effort , because we focusing here on time, we will study two cases, to compare the efficiency of two projects which leads to the expected result.

Jordan experience

Case 1: Jordan Valley Project:

The Jordan Valley is regarded as the main source of its food security. The nature and climate of the Jordan Valley allows Jordan to export large amounts of fruit and vegetables year-round, and has great potential for further agricultural and economic development. 266 Mine Fields (MFs) of the total Jordanian MFs were located in the Jordan Valley with a total of 95500 mines. All these MFs were cleared by Royal Engineering Corps (REC) during the period of 1993-2007. However, in the past few years most mine-related accidents in the Jordan Valley have taken place in areas that have been cleared by the REC or in areas adjacent to former minefields.

267 minefields with a total area of 12.5 million m^2 were cleared during about 10 years , with the following conditions:

1. Difficult terrain with high vegetation.
2. High temperature during summer season ,
3. Variable Working resources during that period
4. Long distances between minefields, it were distributed along 150 kms , from the Jordan riversides till the mountains .
5. Clearance was done without **quality management**.

Here we are considering the factor of QM only , and we are to differentiate between the two cases by a time percentage %.

For this case; Due to not using QM in this project , and due to accidents happened there, so the credibility was lost there.

Land there was cleared it wasn’t handed over to the end users, and with losing of credibility of clearance , NCDR could not proceed with process releasing land and handing over these lands, till a further process to take place , and to regain the credibility.

NCDR did a risk assessment which leads to start a verification and sampling project by 2009

This project still running till now, expected to finish is the end of 2014. So in this case NCDR could not release the land confidently, till verifies and samples all cleared areas again. While if Quality management were implemented there, no need for this operation, because all areas were monitored while clearance and sampled after completion

Assumptions:

Now to measure the time for clearance process and following process of sampling and verification. We assume (for this study) That: Time to clear these minefields without QM is 100%.

Facts:

1. NO handing over because no credibility of clearance
2. There is a need to Do verification and sampling project; with QM included.
3. Verification is re clearing suspected hazardous areas by taking samples about 25% of the area.
4. When any hazardous item found, there is a need to enlarge the percentage of sampled area, some times to be 75% of the area.
5. When we take an average percentage of 50 % of the area, taking into consideration planning and surveying time.
6. We need **more 60% of the clearance time**.
7. Cost of the sampling and verification is also about **60% of the clearance cost**.

Results :

After completion of sampling and verification accompanied with quality management, we could release the land confidently But with a time of 150% of the clearance time period. And 150% of it’s cost.

Case2: North Border

The Northern Border Clearance Project (NBCP) consists of 93 Mine Fields (MFs) and contains both anti-personnel & anti-tank mines. It forms a 104 km mine-belt along the northern border with a total area of 10,500,000 m^2. Under this project, the Norwegian People’s Aid (NPA) is executing the

mine clearance component and the Royal Engineering Corps (REC)'s Explosive and Ordinance Disposal Team (EODT) is responsible for destruction of fragmentation mines and other explosive ordnance identified at project area. The National Committee for Demining and Rehabilitation (NCDR) is implementing the project and carries out Quality Management (QM), reporting, Issuance of clearance certificate and liaising with the project's stakeholders.
Quality Management (QM) which comprises of QA (Quality Assurance) monitoring of the clearance process and QC (Quality Control) sampling of the cleared areas, is a legally bound component of all demining operations in Jordan as stipulated by the National Technical Standards and Guidelines (NTSG).
The project will support the NCDR Quality Management team in carrying out its duties which is an essential part of demining to release land confidently to the owners by monitoring and evaluation of land release activities and inspection of the product.

This project was accompanied with QM from the beginning,

Assumptions:

Now to measure the time for clearance process , accompanied with QM. We assume (for this study) That: Time to clear these minefields without QM is 100%.

Facts:

A. Time delay due to quality assurance during clearance operations, is very minimal.
B. After QC , For an average of 10 lots , one of them may need to be verified a gain , that mains a delay of 10% of the time.
C. Total time for clearance with QM which leads to high credibility and confidence is 110%
D. Cost for QM operations is 10% of clearance cost , this cost is a real cost percentage for the North border .

Results :

the total time to finish this project (clearance accompanied with QM) is 110% of clearance time, and the cost of is 110% of clearance cost .

Comparing the two cases

	Clearance without QM	Clearance with QM	Clearance then verification and sampling and QM
Time	100%	110%	160%
Cost	100%	110%	160%
credibility	<50%	100%	100%

From this table, comparing the results we conclude that applying quality management activities accompanied with demining operations till reaching releasing land confidently is saving time and cost (at least saving 50 % of the total project period and 50 % of the required cost).

Developing Advanced Electromagnetic Induction Methods for Landmine Detection

Davorin Ambruš[3], Darko Vasić[4], Vedran Bilas[5]

Abstract

Conventional metal detectors used in humanitarian demining feature high sensitivity to extremely low quantities of metal, but also introduce enormous false alarm rate due to their inability to discriminate between metal parts of a mine and metallic clutter. In this paper we present the current state-of-the-art in the field of advanced electromagnetic induction (EMI) methods for landmine detection. We focus on the two research topics that have the potential to significantly improve the detection of low-metal content landmines: metallic object characterisation and model-based compensation of soil effects. Also, some of the key technical issues related to the practical implementation of advanced EMI detectors are briefly discussed. At the end, the main outlines of the project DEMINED, carried out by the University of Zagreb, are presented.

1. Introduction

In the recent years, there has been numerous research efforts worldwide directed towards the development of new and improved landmine detection methods. Technologies based on various sensing modalities have been developed and tested, such as metal detectors (MD), electrical impedance tomography (EIT), ground penetrating radar (GPR), acoustical/seismic methods, electro-optical (remote sensing) techniques, nuclear quadrupole resonance (NQR) sensors, explosive vapour detection systems, smart prodders, etc. [1]. Amongst these, MD and GPR devices are still at the forefront of research and are the only ones that are currently used for close-in mine detection in the field.

The ongoing research in the scientific community in the field of landmine detection is mainly focused on the two interrelated tracks. The first one deals with improvements of existing individual technologies and devices such as MD and GPR. The second one is concerned with integration of different sensing modalities into multi-sensor systems utilizing data fusion algorithms [1].

Modern metal detectors work on a principle of low-frequency electromagnetic induction and have basically changed very little since the World War II. Their strengths and weaknesses are well-known in the humanitarian demining community, especially in terms of a trade-off between their high sensitivity and a large false alarm rate. The inability of such detectors to reliably discriminate between metal parts of a mine and harmless pieces of metallic clutter is a major problem that needs to be addressed in order to improve the overall mine detection procedure.

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2. Advanced EMI methods – state-of-the-art

There is a noticeable contrast between a modern metal detector as a rather basic induction tool and advanced induction-based tools and methods of geophysical, nondestructive testing (NDT) and security applications. Such tools normally use multiple coil arrays, complex excitation patterns, advanced signal processing and inversion algorithms in order to obtain information on shape, dimensions, position, orientation and material properties of an object under inspection [2] – [5].

Some of the interesting applications of EMI methods and their technical features that could be potentially employed for landmine detection are summarized in Table 1.

Application	Methods and tools with possible application in humanitarian demining
Geophysical measurements	- Inductive measurement of electromagnetic properties of rocks and buried objects - Devices with multi-coil configurations and multi-frequency excitations - Fast methods for solving ‘soft-field’ electromagnetic inverse problems
Nondestructive testing (NDT)	- Novel inductive and magnetic sensors and sensing configurations - Application of sensor arrays - Image reconstruction techniques
Treasure hunting	- Detectors optimized for different types of metals and with different depth profiling capabilities - Original ground compensation techniques - Detector-operator interfaces
Security systems	- Metal characterization and identification methods based on dipole inversion schemes (e.g. airport security systems) - Advanced visualization techniques

Table 1. Applications of advanced EMI methods / tools.

In general, a promising opportunity arises for a transfer of knowledge and experience from these applications in order to improve EMI methods in humanitarian demining. Such an advanced EMI mine detection would reduce the false alarm rate compared to the conventional metal detection because it would provide not only an indication of the metallic object presence but also information on its geometry and material properties.

2.1. Metallic object characterisation

Commercial metal detectors used in field operations of humanitarian demining are usually required to conform to the CWA 14747 standard [6]. The standard defines the basic technical and operational requirements for a metal detector, as well as detector-operator interface. In general, the inclusion of additional quantitative information about the buried object (in addition to the standard-defined audible signal) could potentially help the operator with a desicion in a classic „mine or clutter“ problem.
The characterisation and identification of metal objects usually implies the determination of the following properties [2]:

1. Size (i.e. the approximate volume),
2. Principal shape (i.e. is the object round, flat or elongated?),
3. Spatial orientation,
4. Position (burial depth),
5. Material properties (electrical conductivity and magnetic permeability).

In a practical sense, most of the landmines have some common features with respect to the properties mentioned above; relatively small burial depth up to 20 cm, vertically oriented firing pins of cylindrical shape, etc. The estimation of these parameters from field measurements can be obtained by using two different approaches: the pattern recognition approach or the model-based approach.

Pattern recognition approach

The most commonly used methods of metal object characterisation for landmine detection based on the pattern recognition approach are summarized in Table 2 [2] [7].

This method is based on a comparison of the measured set of data obtained from the unknown object with a respective set of data corresponding to the known object. Some classification criteria are then applied in order to characterize the object under inspection. The first step in this process is usually to perform some kind of feature extraction in order to reduce the initial data set and loosen the requirements for the pattern recognition algorithms.

Method	Features	Problems
Statistical processing of raw detector signals	- Classification methods based on support vector machines (SVM) and similar algorithms.	-Large data sets needed. -Object libraries often not available.
Method using basic features of the detector response (phase-shift / decay constant)	- Coarse estimation of object size and material type (ferromagnetic or non-ferromagnetic). - Possible alternative: classification based on a time-frequency representation of a detector signal.	-Potentially useful method for a simple discrimination of UXO, not directly applicable to low metal content landmines.
Phase-plot method	- Specific target signatures give information on object size, shape and material type. - Intuitive visualization with 2D diagrams.	-Highly orientation dependent response. -Problems with elongated ferromagnetic objects.
EMI spectroscopy	- Classification based on object’s complex spectral signatures. - Excitation spectrum typically between 30 Hz and 50 kHz.	-The same as for the phase-plot method. -Signatures not distinctive enough.
EMI imaging	- Image of the buried object produced by precise scanning over the suspected area with a known excitation field distribution.	-Low resolution. -High sensitivity to signal-to-noise ratio. -Very precise positioning of a detector needed.

Table 2. Methods of metallic object characterization based on the pattern recognition approach.

Model-based approach

State-of-the-art of the methods of inductive metallic object characterization relying on the model-based approach is given in Table 3 [8] – [10]. Simulation and evaluation of these methods is usually performed by using some numerical procedures, such as those based on the finite-element method (FEM).

Method	Features	Problems
Simple analytical models	- Models of objects of canonical shapes (spheres and cylinders) in homogenous half-space. - Useful for physical insight of the problem	- Not directly applicable to the landmine detection problem.
Induced dipole model	- Object modeled by the magnetic polarizability tensor which fully characterizes the object properties in terms of size, shape, orientation, position and material properties. - Dipole approximation enables fast inversion algorithms. - Intuitive interpretation of the tensor elements.	- Further research needed on the method applicability to discriminating low metal content landmines from metallic clutter. - Potential problem with large/composite metallic objects.
Variations of the induced dipole model	- Models based on combinations of multiple dipole elements for better characterization of complex objects (quadrupole, dumbbell dipole models, etc.)	- Further research needed, not as straightforward as simple dipole models.
Standardized excitation approach (SEA)	- Method suitable for modeling large, heterogeneous objects (such as UXOs) where internal interactions between different metal parts of an object cannot be neglected (non-dipole effects).	- Fast inversion procedures more difficult to implement (when compared to simple dipole approximation).
Simple parametric models	- Object response most commonly described by a set of poles / own frequencies.	- Orientation dependent, suitable only for very simple targets.
Empirical models	- Object response is fitted to an empirically derived model featuring only a few model parameters.	- Orientation dependent, only valid for a very limited range of objects.

Table 3. Methods of metallic object characterization relying on the model-based approach.

The aim of this approach is to reconstruct the unknown parameters of a mathematical model that relates the voltage induced in a detector coil with the geometrical and electromagnetic properties of a buried object. In other words, an inversion problem needs to be solved, which is for a general case of EMI detection non-linear and ill-posed [8]. Characterization and classification of metallic objects is then performed based on the estimated model parameters.

In comparison with the pattern recognition approach, this method can potentially provide deeper insight into the nature of the buried object since it strongly relies on the physical background of the problem. However, the model-based approach is also more difficult to implement in a practical EMI detector. To the best knowledge of authors, besides some experimental prototypes built at universities and other research institutions (mainly for UXO detection), there are still no commercial EMI landmine detectors for humanitarian demining that utilize this principle [9].

Amongst all of the model-based methods of metal characterisation mentioned above, the method based on dipole inversion seems to be the most promising candidate for implementation into next-generation metal detector devices for humanitarian demining. Although the significant research is still needed on the dipole-based modelling of landmines (and clutter), the method looks fairly straightforward to implement and is already field-proven in other applications, such as security and geophysical inspection systems [5] [8].

2.2. Model-based compensation of soil effects

Modern metal detectors used in humanitarian demining and conforming to CWA 1747 standard always employ some sort of ground compensation technique in order to minimize the effects of non-cooperative soils on metal detector performance [6]. Ground compensation is usually performed in one of the following ways (with either manual or automatic controls) [2] [11]:

1. High-pass filtering of the detector signal which aims to cancel the slowly-varying signal component corresponding to variations of soil properties.
2. Subtraction of the soil signal component by applying a simple phase correction (soil signal is used as a reference for the synchronous demodulation).
3. Compensation techniques based on frequency-differencing approach (basically a subtraction of detector responses obtained at two different frequencies).
4. Techniques based on excitation pulses of variable duration in which the responses from metal targets and magnetic ground have different signal features, making them distinguishable in time-domain.

In general, the sensitivity of a metal detector to electromagnetic properties of soil is also influenced by the sensing head, i.e. coils design. All of the existing ground compensation methods have some apparent drawbacks. These are reflected either as a decrease of the detector sensitivity or in some cases as a loss of information on target material properties [2].

New approaches to compensation of soil effects rely on developing appropriate mathematical models of soil. These models describe the spatial variation of soil electromagnetic properties (electrical conductivity and frequency-dependant magnetic permeability). If the parameters of the soil model could be estimated from the detector measurements by a fast inversion procedure, then the soil EMI response could be subtracted from the total detector response without significantly affecting the metal detection and characterisation performance.

The models of soil related to the landmine detection problem that have been reported in the literature concentrate mostly on paramagnetic soils with viscosity effects (Cole-Cole model) [11]. In general, these types of soil correspond to a worst-case scenario for commercial metal detectors. The soil is usually modelled as a half-space (with a single or multiple layers). More complex models also take into account the roughness of the soil surface using some numerical procedures (e.g. the method of auxiliary sources, MAS).

3. Advanced EMI landmine detectors – implementation challenges

When it comes to practical implementation of the next-generation EMI landmine detectors (featuring inductive metal characterisation and model-based soil compensation), there are several critical design issues that need to be specifically addressed:

1. Sensing head position and orientation tracking system with sub-centimetre accuracy. This system is essential for the implementation of inversion procedures of metal characterization.
2. Accurate and field-proven model of soil including possible specific features of a particular mine suspected area.
3. Fast inversion algorithms that can operate in a real-time manner, determined by operational procedures and requirements for the existing handheld metal detectors.
4. Operator interface that features additional information without compromising the robustness and ease of use of existing devices.

4. DEMINED project

Having in mind the limitations of existing metal detector technology and based on its expertise in electromagnetic sensors and electronic systems, the Advanced Instrumentation Group (AIG) started the project DEMINED aimed at the development of an advanced EMI detector for landmine detection[6].

6. Within the project scope, AIG is also collaborating with the research group from the University of Manchester, Sensing, Imaging and Signal Processing Group (SSIG).

The expected results of the project are proof-of-principle and experimental demonstrator of the next-generation EMI detector. The detector would have the two main features: metallic object characterization (based on dipole inversion) and model-based ground compensation (based on field-proven model of soil). A new laboratory set-up will be developed for experiments with standard test targets that simulate metal components of mines (ITOPs [6]) and metallic clutter items. Developed tools and methods would be evaluated on HCR-CTRO test sites.

First prototype of a sensing head, developed by AIG is shown in Figure 1. The sensing head consists of two transmitter coils and a single receiver coil utilizing the magnetic cavity principle. The proposed design enables laboratory experiments with different excitation sources (both continuous and pulsed) and verification of novel concepts of model-based metal and soil characterisation. The final sensing head design will be optimized with respect to multiple criteria such as metal sensitivity and overall quality of sensor data needed for inversion procedures.

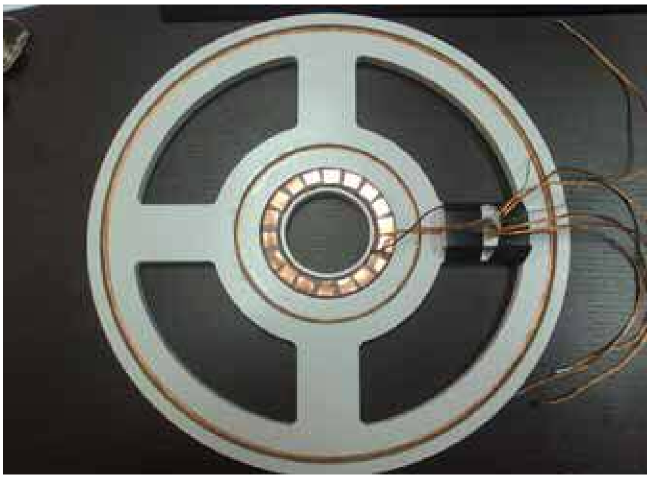

Figure 1. 1st prototype of a sensing head developed by AIG.

5. Conclusion

In order to overcome the well-known limitations of existing metal detector technology next-generation advanced EMI detectors are needed. These detectors incorporate some of the novel methods for metallic object characterisation, with a potential to significantly reduce the false alarm rate. The characterisation method based on dipole inversion is a promising candidate for practical implementation in the field. Furthermore, novel methods of ground compensation relying on field-proven models of soil could bring new possibilities in metal detector operation over non-cooperative soils. For a practical implementation of these novel concepts in humanitarian demining there are still numerous technical challenges to be resolved. DEMINED project is a small step in that direction.

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Mobile Robotic Systems: Promising Tools. Ten Years’ Experience in IARP Member’s Countries

Manuel Armada[7]

Abstract

Removal of antipersonnel landmines is a worldwide problem that requires the use of new technologies such as improved sensors and efficient mobile robots. The International Advanced Robotics Programme (IARP) has set up a Working Group HUDEM as early as 2000 focusing on the difficult problem of Humanitarian Demining. This paper presents a brief outline of some selected contributions and previous research activity in IARP Member’s Countries regarding mobile robots for humanitarian demining.

Introduction

The International Advanced Robotics Programme (IARP) is an international project initiated at the Versailles Economic Summit of 1982. All countries/members of the IARP have agreed on the general objective: ”… to foster international cooperation aiming to develop robot systems able to dispense with human exposure to difficult activities in harsh, demanding or dangerous conditions or environments. The International Advanced Robotics Programme (IARP) has set up a Working Group HUDEM as early as 2000 focusing on the difficult problem of Humanitarian Demining: “All members of the WG Hudem have agreed to foster international cooperation aiming to develop performing techniques and robotics systems speeding up the demining of infested countries.” Starting from an IARP Workshop that took place in Toulouse (France), a meeting which gave some scientists the opportunity to present their theoretical results in the domain of the outdoor applications for mobile robots, it follows the proposal of a working group HUDEM entrusted to Dr. Tom Martin (Germany) who organized a first on-site workshop in Zimbabwe. These previous workshops were systematically followed by the IARP HUDEM international workshops (2002, Vienna; 2003 Pristina; 2004 Brussels; 2005 Tokyo; 2006, Cairo; 2007, Sousse; and from 2009 on in Šibenik). Prof. Yvan Baudoin, from the Royal Military Academy (Belgium) has been the Chairman of the IARP Working Group HUDEM since 2002.

Detection and removal of antipersonnel landmines is, at the present time, a serious problem of political, economical, environmental and humanitarian dimension. There is a common interest in solving this problem and solutions are being sought in several engineering fields. Detection and removal of antipersonnel landmines in infested fields is an important worldwide problem [1]. Landmines, cluster munitions, explosive remnants of war (ERW) and improvised explosive devices (IED) are an enduring legacy of conflict. These devices can remain active for decades, they are not aware of negotiation or peace treaties and do not distinguish between soldiers and civilians. AP mines and unexploded devices (UXO) of the Second World War still exist in all the countries of Europe and North-Africa [2]. In 2010, a total of 4191 new landmine casualties were reported, 5% more than in 2009, and a total of 72 states, as well as seven disputed areas, were confirmed or suspected to be mine-affected [3]. The finest solution, but maybe not the quickest, is to apply fully automatic systems to this relevant task. However, and independently of the most recent advancements, this solution seems to be still far away from succeeding. Efficient sensors, detectors and positioning systems are, first of all, required to detect, locate and, if possible, identify the mines. Then, appropriate vehicles will be of paramount importance to carry these sensors over the infested fields keeping the human operators as far as possible for safety reasons. Fully automated systems are complex to achieve and an intermediate solution might be teleoperation and human-machine collaboration in the control loop, which is being known as collaborative control.

Any potential vehicle, in principle, can carry sensors over an infested field: wheeled, tracked and even legged vehicles can accomplish demining tasks with effectiveness. Wheeled robots are the easiest and cheapest; tracked robots are very good to move in almost all kinds of terrain; but legged robots also exhibit potential interesting advantages for this activity.

This paper presents a brief outline of some selected contributions and previous research activity in IARP Member’s Countries regarding mobile robots for humanitarian demining [5-7]. This paper summarizes the information recorded in previous IARP workshops.

Mobile robots for humanitarian demining

Several IARP workshops [50] have shown that the use of Robotics Systems could improve the safety and the clearance efficiency in humanitarian demining operations and that robotic systems may be considered as promising tools. There are three main classes of mobile robots investigated for HUDEM: wheeled, tracked and legged (also some works are known on wheeleg [26, 27, 28]. The idea of using legged

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mechanisms for humanitarian demining has been developed for, at least, the last fifteen years and some prototypes have been already tested. TITAN VIII [8], AMRU-2 [9] and RIMHO2 [10] are some more examples of walking robots used as testbeds for humanitarian demining tasks. COMET-1 is maybe the first legged robot developed on purpose for demining [11]. These four robots are based on insect configurations, but there are also different legged robot configurations, such as sliding frame systems, being tested as humanitarian demining robots [12], [13]. Next figure show some of the most relevant mobile robots for HUDEM. Conclusion

Hunter + UWB + Vallon MD

TRIDENT, Hunter, AMRU4 and AMRU5, ROBUDEM and TEODOR/MAV. The necessity of using walking robots in certain situations of the humanitarian demining where wheels and tracks cannot operate correctly has been researched by the RMA and The Free University of Brussels. The legged prototypes robots developed for carrying the detection-sensors to be tested on minefields, namely TRIDENT, AMRU4 and AMRU5. Tracked robots like HUNTER also RMA developed [5, 9, 12, 18, 23, 24 25, 31, 50].

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Department of Electronics and Information Processing VUB-ETRO-IRIS, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels; Service des Systèmes Logiques et Numériques, Université Libre de Bruxelles 50, Av. F. Roosevelt, B-1050 Bruxelles

Overview of COMET II (electrical) and final version of full autonomous COMET III (hydraulic), mine detection robot. Two kinds of mine detection six-legged walking robots developed by Chiba University [21].

Dept. of Electronics and Mechanical Engineering, Chiba University, Japan

ROBHAZ-DT, a mobile robot system with double tracks [20].

Advanced Robotics Research Center, KIST & Department of Mechanical Engineering, KAIST, Korea

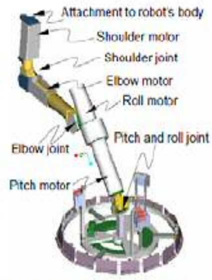
Locomotion Concept for HUDEM Robots [40].

Vienna University of Technology Division Intelligent Handling and Robotics, Vienna, Austria

Mine Hunter Vehicle: Evaluation of an array-antenna GPR system (SAR-GPR) and Evaluation of a Hand-held GPR MD sensor system (ALIS) Tohoku University [32, 51].

Tohoku University, Sendai 980-8576, JAPAN

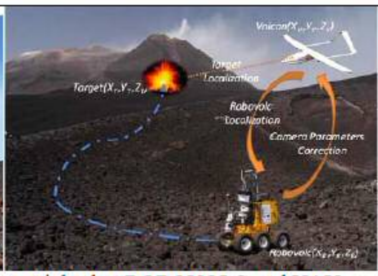




RIMHO 2 (electrical) and SILO 6, fully autonomous with 5 dof scanning arm (electrical). CSIC DYLEMA project: to develop legged prototypes to integrate relevant technologies on locomotion and sensor systems for humanitarian-demining activities.[6, 10, 14, 15, 16, 17, 22, 39, 50]

Centre for Automation and Robotics CAR (CSIC-UPM). Ctra. Campo Real, Km. 0,200- La Poveda. 28500 Arganda del Rey, Madrid, Spain.





The WHEELEG robot, ROBOVOLC system tested inside the Etna crater, Terrestrial robot ROBOVOLC and UAV VOLCAN cooperation. Heterogeneous robot cooperation for interventions in risky environments has been extensively researched by the University of Catania [26, 47]

DIEES Università degli Studi di Catania, viale A. Doria 6, 95125 Catania, Italy

Semi-Autonomous Vehicle for Mine Neutralisation [29].

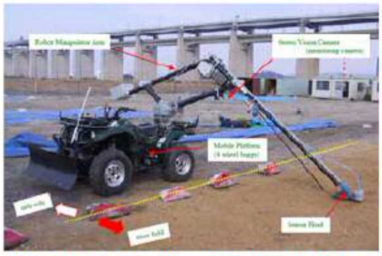
Systems Sciences Laboratory and Land Operations Division. Systems. DoD, Australia

Humanitarian Demining Robot Gryphon – An Objective Evaluation [43]

Department of Mechanical and Aerospace Engineering, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, 152-8550 Tokyo, Japan


Environment-Adaptive Antipersonnel Mine Detection System - Advanced Mine Sweeper [33].

Dept. of Micro-Nano Systems Engineering, Nagoya University; Dept. of Intelligent Interaction Technologies, University of Tsukuba; Dept. of Bioengineering and Robotics, Tohoku University; National Institute of Advanced Industrial Science and Technology (AIST); Mitsui Engineering & Shipbuilding CO., LTD



Teleoperated Buggy Vehicle and Weight Balanced Arm for Mechanization of Mine Detection and Clearance Tasks [35].

Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8552, JAPAN

Feature-Level Sensor Fusion for a Demining Robot and Autonomous demining ISR-TT
Robotics for HUDEM is extensively researched at ISR (Institute of Systems and Robotics)-UC [7, 13, 19, 30, 50]

Institute of Systems and Robotics, University of Coimbra, Polo II, 3030-290 Coimbra, Portugal

INSPECTOR robot. Cognitive Theory , and Framework for Creation of the Simulators for Inspection Robotic Systems and Semantic simulation for mobile robot operator training [44, 45, 46, 48].

Industrial Research Institute for Automation and Measurements PIAP, Warsaw, Poland; Institute of Mathematical Machines, Warsaw, Poland; Institute of Automation and Robotics, Warsaw, Poland

In-field tests of LOCOSTRA in Jordan. LOCOSTRA is deeply researched by the University of Genoa, SNAIL AID and PIERRE [43, 49]

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Conclusion

The development of Mobile Robotics Systems for Humanitarian Demining has been subject of great attention by the IARP Working Group HUDEM in the last 10 years. A summary of the main achievements regarding only mobile robots and presented at IARP Workshops has been offered. It is expected that this overview will serve as a useful tool for a better understanding of the recent developments in this demanding application. From the reviewed literature it comes out that the most used configuration employs wheels as locomotion mean [13, 19, 26, 30, 32, 33, 35, 40, 43, 44, 45, 46, 47, 48, 49, 51]. Legged robot configuration [5, 6, 7, 9, 10, 12, 14, 15, 16, 17, 21, 22, 39] is selected as second choice, maybe because their versatility. Interestingly the developments using tracked vehicles is the less selected [11, 20, 38].

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FP7 Integration Project D-Box ("Comprehensive Toolbox for Humanitarian Clearing of Large Civil Areas from Anti-Personal Landmines and Cluster Munitions")

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Abstract

The FP7 Integration Project D-BOX *("Comprehensive toolbox for humanitarian clearing of large civil areas from anti-personal landmines and cluster munitions"*) is tackling the issue of anti-personal landmines and cluster munitions through the development of innovative solutions interfaced and integrated in a comprehensive toolbox to provide stakeholders with tools, methods and procedures to improve the effectiveness of the clearing process. This "smart" toolbox can be applied for the range of demining activities (from preparation through to the elimination of the mines including communication with the public and donors) while providing operators and end users with suitable solutions, (adapted to different scenarios and conditions, cheap and "easy to use") for specific tasks during different steps of the demining process. The toolbox will encapsulate an accurate, reliable and quick information management system compliant with IMAS standards.

Introduction

The D-Box project started in 2013 in a 3-year FP7 Integration Project (*FP7research call SEC-2011.1.3-3 on "comprehensive toolbox for humanitarian clearing of large civil areas from anti-personal landmines and cluster munitions")* with 20 partners from 11 EU Member States, and a budget of ~ 10M Euros. It will integrate existing solutions for the process of clearing landmines and cluster munitions by developing a comprehensive toolbox and a roadmap for its implementation

Background

It is estimated 110 million land mines are scattered in 70 countries since 1960. With current funding corresponding to a clearance of about 500,000 mines per year and assuming no additional mines are laid, it could take a hundred years to clear them. The mines cause up to 20.000 victims p.a. and delay economic recovery. The cost of removing one antipersonnel landmine is up to €750 leading to costs of between two and eight million Euros for clearing one square kilometre. As the EU Commission and the EU Member States are donors in humanitarian demining, they have an interest to increase the efficiency of the clearing process activity.

Operational Needs and D-BOX Approach

The operational needs and priorities have been expressed by the humanitarian demining community represented by:

- Demining teams in Non-Governmental Organizations (NGO) and commercial demining companies,
- The Mines Action Centre (MAC),
- The United Nations Mine Action Service (UNMAS), and
- The Geneva International Centre for Humanitarian Demining (GICHD).

The two main priorities are:

(1) The improvement of the mapping of hazardous area, and
(2) Low cost, "easy to use" and efficient close-in detection equipment.

These priorities are confirmed by end-users involved in the D-BOX project and during discussions with the GICHD.

The D-BOX project will tackle the issue of anti-personal landmines and cluster munitions with an all-encompassing, innovative and simple approach, covering the aspects defined in the text of the call including the integration of innovative solutions, i.e. technologies and methods for (i) Mapping; (ii) Long-range localisation; (iii) Short-distance detection; (iv) Neutralisation in an open civil environment; (v) Development of protective equipment for operators and population and (vi) Training solutions for personnel and tools for mine risk population education.

The requirements will be achieved through the development of innovative, "easy to use" and low cost solutions interfaced and/or integrated in a comprehensive, distributed toolbox to provide demining stakeholders with tools, methods and procedures addressing risk management and human, ethical and legal factors (including procedures and best practices).

This "smart" toolbox will be applicable to the entire range of demining activities (from preparation of the mission until the elimination of the mines including communication to the public and donors) while providing operators and end users

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with the most suitable solutions, (adapted to different scenarios and conditions) for the specific tasks during the different steps of the demining process.
The toolbox will be enveloped by an information management system compliant with the IMAS standards. The IMS will tackle the need to have access to accurate and reliable information in a timely way by creating a link together the different stakeholders of the Demining Life Cycle.
The toolbox will benefit from past and current developments, and will link and eventually complement relevant existing information systems, procedures and databases.
To ease the use of the toolbox, D-BOX will be designed to fit the needs of mine clearing stakeholders and will be implemented via proper levels of education and training.
The D-BOX project started with an assessment of past and on-going-activities, operational needs as well as scenarios.
After the requirements for different tools are identified, a comprehensive toolbox will be established keeping the end-users strongly involved in the process.
The planned contribution includes the establishment of a comprehensive demining toolbox and the development and improvement of existing and novel tools (non exhaustive):

- Close-in detection by biosensors
- Network of sensors,
- Risk assessment tools,
- Innovative dog training methods,
- Information fusion tools.

All these parts will supported by a series of demonstrations to evaluate performances and to the establishment of a roadmap for its development and implementation.

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The Protection of Civilians from Explosive Hazards: A Comprehensive Approach

Stephan Husy[19]

Abstract

Anti-personnel mines (AP mines), cluster munitions (CM) and other explosive remnants of war (ERW) continue to affect civilians indiscriminately and impede development long after armed conflicts have ended. More than one-third of the world's countries remain contaminated by these hazards. This paper addresses how mine action has evolved since the adoption of the Anti-Personnel Mine Ban Convention (APMBC). Overall, operations on the ground have become increasingly efficient and effective, due to the introduction of new methods, techniques and tools. At the same time, the mine action sector has shifted from a focus on AP mines to a broader humanitarian disarmament approach. More and more, the protection of civilians from all kinds of explosive hazards is the challenge and aim of mine action authorities and operators.

History and context

The tenth anniversary of International Symposium on Humanitarian Demining is a great opportunity to pay tribute to Croatia's on-going efforts in promoting and disseminating mine action techniques and methods, and of course to its strong commitment to rid its beautiful country of mines and explosive remnants of war (ERW).

Both the Croatian Mine Action Centre (CROMAC) and the Geneva International Centre for Humanitarian Demining (GICHD) were established in 1998. At that time, a number of affected countries had established national mechanisms to address the landmine contamination. In addition, the Anti-personnel Mine Ban Convention (APMBC) was adopted, the United Nations Mine Action Service (UNMAS) was created, and the five pillars of mine action were defined. Demining was no longer just a military endeavour; it had become a humanitarian campaign.

Since then, considerable efforts have been invested to continually improve the effectiveness and efficiency of mine action operations. Parallel to the evolution on the ground, the normative framework has been strengthened. The comprehensive ban on anti-personnel mines, through the adoption of the APMBC, has been instrumental in drastically reducing the number of new anti-personnel mines laid, the amount of mined land and the number of victims. The Convention on Cluster Munitions (CCM) entered into force on 1st August 2010 and has gained much traction and wide support since. In addition, the Amended Protocol II on Mines, Booby-Traps and Other Devices, and Protocol V on Explosive Remnants of War within the Convention on Certain Conventional Weapons (CCW) establish general restrictions and responsibilities regarding mines, cluster munitions and ERW. The International Mine Action Standards (IMAS) provide guidance, communicate best practice, improve safety and efficiency and ensure quality and confidence in mine action. The standards are updated on a regular basis.

International and national responses to the challenges posed by conventional weapons are increasingly structured around the notion of armed violence prevention and reduction, rather than in relation to specific types of weapon. On the ground, efforts are going in a similar direction – towards the reduction of the impact of explosive weapons on civilians. Because of this, an increasing number of mine action operators are becoming involved in issues such as ammunition safety management.

Despite the great successes of the mine action sector, the GICHD has identified two major challenges for the coming years. Firstly, mine action still lacks a complete and accurate picture of the extent of the explosive hazards problem, as well as the impact it has on countries, communities and people. Secondly, there are still major shortcomings in the delivery of value for money by mine action programmes. The following chapters will highlight some of the key issues and concepts when addressing these challenges.

Strategic Planning and Transition

Delivering value for money is not only about efficiency (number of square metres cleared and number of mines/ERW collected) but also about how mine action operations improve lives in affected communities and contribute to the broader security and development priorities of the country. Findings so far indicate that mine action programmes are often not linked early and strongly enough with key security and development plans and broader international assistance activities. These include development and humanitarian work, peacekeeping, post-conflict recovery, armed violence reduction and security sector reform.

An example of the importance of linking mine action with other activities is provided by a human rights approach. Land rights in conflict and post-conflict contexts are an increasing area of concern. Conflict often stems from disputes over land and causes dramatic changes to a country's land tenure regime and administration, threatening land rights even after the conflict has ended. Secure land rights are, therefore, a

19.Geneva International Centre for Humanitarian Demining (GICHD), gichd@info.org critical issue when it comes to humanitarian response, sustainable peace-building, restorative justice and longer-term economic recovery. In mine-affected countries the situation can be even more complex, as mine/ERW contamination can make land inaccessible for decades. We have learned that, while mine action operators cannot solve land rights problems, they can be sensitive to the conflict and ensure they do no harm.

At the heart of the international mine action support is the principle that ultimate responsibility for the landmine and ERW problem rests with the State under whose jurisdiction the contamination exists. This principle has long been recognised and accepted, including in international law. Therefore, the transition from UN-managed or dependent programmes to national ownership is a crucial strategic issue. It is, however, one that the mine action sector has failed to master well so far.

The GICHD has embarked on research to increase the limited information available on transition, and will soon issue a guide on this topic, as well as on national mine action strategies. We aim to develop coherent, well-informed national mine action strategies and transition plans that facilitate the achievement of well-defined socio-economic goals.

Quality Management and Information Management

Questions of effectiveness, justification and efficiency naturally raise the profile of quality management (QM). The trends towards greater justification of mine action activity encourage a more rigorous approach to understanding and defining mine action processes. This has direct implications for the way that quality management is carried out in mine action and for the evaluations of projects and programmes.

A number of mine action organisations have formally adopted the ISO 9001 quality management system. Others are incorporating key features of such systems without pursuing formal accreditation. The adoption of recognised systems is indicative of a more demanding and sophisticated approach from operators. The GICHD is contributing to the efficient and effective work of national mine action authorities by assisting in the setup of national QM systems that will help ensure that planned results are achieved.

Setting clearly-defined results is an increasingly common feature of agreements and contracts in mine action. The evaluation of activities requires clear criteria of success, in both the results and how efficiently those results are achieved. Better measurement and evaluation requires the collection of the right data at various stages before, during and after the mine action process, as well as management of the quality of data and the analysis to turn it into useful information. Evaluations of mine action programmes typically focus on the donor concerns and, as a result, often do not produce much data that can be used by national mine action authorities to improve the management and impact of their programmes.

The fact that most evaluations are also conducted by international experts, with minimum input from nationals means that project/programme design, monitoring and evaluating expertise usually remains limited to internationals. This inhibits local ownership of the evaluation function and the development of proper accountability structures within the mine-affected country, and stunts the potential for supporting and enhancing the management function in mine action programmes.

In the past the term 'information management' was frequently misunderstood and equated with a tool (Information Management System for Mine Action - IMSMA) rather than a wider concept. An increased focus on the impact of mine action on the livelihoods of affected people brings with it the need for better communication on contamination and priorities between the mine action actors and the affected communities. It is increasingly expected that information should be gathered from all relevant groups by gender balanced teams, and sex and age disaggregated data should be collected when relevant.

In 2013 a new version of IMSMA will be released with added victim assistance data management capabilities. The new software release will provide mine action programmes the ability to store and analyse victim assistance data in broad, decentralised disability and human rights-based environments. State Parties will be better equipped to report on their continued commitment to victim assistance as required by the APMBC, CCM, and other relevant treaties.

Land Release

The 'magic bullet' for demining doesn't exist yet and it is unlikely that any fundamentally new sensor technology will become available in a near future. While less attention is paid to the development of new technologies, greater effort is dedicated to understanding how best to make effective and efficient use of existing assets.

One of the major challenges for States Parties to the APMBC in fulfilling their clearance obligations lies in the reduction of suspected hazardous areas. Often, too much land remains subject to clearance when significant areas could be released through less expensive and more rapid survey techniques. For many years, discussions have been held in the context of the APMBC and other forums on ways to overcome the challenges associated with the imprecise and overestimated identification of mined areas.

The process of land release has become enshrined in mine action through the development of three International Mine Action Standards. Land release describes a series of activities that clean up national databases, better define areas of contamination and promote efficient mine/ERW clearance - allowing land to be handed back to populations for social and economic use. Land release also encourages a greater focus on surveys and information management to support decision making.

Operational efficiency improves methods and techniques to release land in the most efficient and safest ways. It starts with the formulation and implementation of appropriate land release policies and plans, as well as a clear land classification scheme, based on type of contamination and risk assessments.

However, the land release process is not only about operations; it involves a number of legal issues such as liability. The possibility of one or more mines/ERW remaining after the handover of an area is always a risk, because an explosive item may have been missed during clearance, or suspected land may have been incorrectly released by survey. The legal issue will then be to determine who bears the legal responsibility for the damage or injury this object could cause. It is important that the government of a mine affected country develops a policy and possibly legislation that details liability aspects, including the shift of liability from the demining operator to the government when certain criteria have been fulfilled.

Another important element for legal efficiency relates to contracting. In Croatia for example, national demining activities are mainly contracted out. The challenge is often to define the end product, i.e., cleared or verified land, in terms of the exact area, quality or number of square metres. Mine action contracting should create an incentive to release land in the most cost-effective way possible.

Ammunition Safety Management

Aging, excess, and unstable stockpiles of conventional ammunition pose dual threats of accidental explosion and illicit proliferation, which could cause humanitarian disasters and destabilise individual countries or regions as a whole. There is an increasing awareness that more people are at risk of being killed or injured from unexploded and abandoned ammunition than from minefields. Poor handling and storage can result in large explosions involving tonnes of ammunition, often in populated locations.

The GICHD is developing a pro-active, consistent and low cost approach to secure and maintain stocks of ammunition, to destroy surplus ammunition and stocks which are in a hazardous condition. Future safety will be encouraged by building local capacity, sharing best practice and lessons learned, and possibly by pooling costly resources required between neighbouring countries. The ultimate aim of the GICHD is to assist states in applying good ammunition safety management practices to all their ammunition stocks and facilities, thereby reducing the potential for accidental explosions in storage areas, thus reducing the risk to the population.

Conclusion

The international treaties and processes have been successful in stigmatising the use of anti-personnel mines and cluster munitions. Such success could encourage further developments of the normative framework, protecting civilians from explosive hazards.

The mine action sector is responding positively and pragmatically to the complex and rapidly evolving environment. Shortcomings remain in regard to the clarity of the problem, as well as the capacities and performance of the actors, but the sector has demonstrated it can surmount these. The mine action sector has developed an impressive set of policies, methods and standards to deal with the challenges of mine fields, battle areas and unstable ammunition sites. It is well placed to broaden its scope and to contribute in a more general way to armed violence prevention and reduction.

Japanese Research and Development for Humanitarian Demining Technology: Review of the Last Decade Collaboration with Croatia

Jun Ishikawa[20]

Abstract

This article surveys Japanese research and development of anti-personnel landmine detection technology for humanitarian purpose, especially focusing our attention on collaboration with Croatia for the last decade. Reviewing a Japanese national project named "Research and Development of Sensing Technology, Access and Control Technology to Support Humanitarian Demining of Anti-Personnel Mines," lessons learned from our test and evaluation that were carried out from 1 February to 9 March 2006 at Benkovac test site in Croatia are described. The objective of the Croatia-Japan joint tests was to confirm performance of dual sensor systems, which use both ground penetrating radars and electromagnetic inductive sensors, i.e., metal detectors, in comparison with existing metal detectors operated by well-experienced Croatian deminers. The results showed that the dual sensor systems have a potential to discriminate landmines from metal fragments and it was found that one of the most severe problem we were facing to put those equipment in practical use was reducing operational time.

Keywords: Metal detector (MD), ground penetrating radar (GPR), dual sensor system, experimental design, explosive sensor, robotic system.

1. Introduction

Japanese research and development (R&D) of technologies that make demining work more efficiently and safer for humanitarian purpose has been fully started since March 1997 when the Tokyo Conference on Anti-Personnel Landmines had been held. In this conference, participants undertook a comprehensive discussion to strengthen international efforts on the problems of AP landmines, especially on 1) landmine clearance by the UN and other organizations, 2) development of new technology for mine detection and removal, and 3) assistance to victims. In December 1997, Mr. Keizo Obuchi, the then Minister of Foreign Affairs of Japan signed the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction (the Ottawa Convention), and the Ultimate Goal of Zero Victims has been proposed. Although detectors of landmines are regarded as a kind of weapon, on 2nd December 1997, Mr. Kanezo Muraoka, the then Chief Cabinet Secretary stated that from a viewpoint of international cooperation equipment of detection and removal of Anti-Personnel (AP) landmines for humanitarian purpose had not come under "the three principles on arms export," which is the Japanese total embargo on exports of weapons. Thus, since August 2002, humanitarian demining equipment for AP landmines has become not to be regarded as weapons in Japan, and all the arrangement to start Japanese R&D in this field has been completed [1].

2. JAPANESE R&D of anti-personnel landmine detection system

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) established the Committee of Experts on Humanitarian Demining Technology in January 2002, believing in the importance of tackling the technological development of AP landmine detection using Japanese advanced technology. Their findings were presented to MEXT in the report "Promoting R&D for Humanitarian Demining Technology [2]." Based on this report, the Japan Science and Technology Agency (JST) announced a call for proposals for R&D project of humanitarian demining technology. Out of the 82 proposals, 12 projects were selected, and the R&D project named "Research and Development of Sensing Technology, Access and Control Technology to Support Humanitarian Demining of Anti-personnel Mines" was started in October 2002.

2.1. Short-Term R&D Project

The JST project was essentially divided into short-term R&D and mid-term one. Because of the urgent need for this technology, the short-term R&D project was expected to have prototypes in field tests within three years. The goal was to develop vehicle-mounted GPR+MD fused sensor systems, the concept of which is to make no explicit alarm and to provide operators with clear subsurface images. This means that the decision-making whether or not a shadow in the image is a real AP landmine is entirely left to the operator like medical doctors can find cancer by reading CT images. The feature discriminates the systems from conventional GPR+MD dual sensors like HSTAMIDS.

In the short-term project, four sensors and three robotic vehicles had been developed. One of those is Mine Hunter Vehicle (MHV), the vehicle and manipulator part of which has been developed by a research team of Prof. Nonami, Chiba University [3]. MHV can interchangeably mount two GPR sensors in addition to a commercial-off-the-shelf MD. One

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is a stepped frequency GPR by Prof. Sato's team of Tohoku University [4] referred as MHV #1 in the following part (Fig. 1, left). The other is an impulse GPR developed by Prof. Arai's project of University of Electro-Communications [5] referred as MHV #2 in the following part (Fig. 1 right). After the GPR scanning for every a specified interval of several centimeters, migration processing, i.e., GPR tomography gives subsurface horizontal slices as shown in Fig. 2.

Fig. 1. Two GPR sensors mounted on MHV interchangeably: from left to right, stepped-frequency GPR (MHV #1) and impulse GPR (MHV #2).

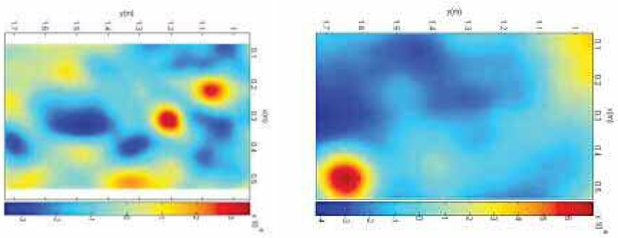

Fig. 2. Detection images from stepped-frequency GPR of MHV#1: Horizontal slices showing 2 targets at a 5cm depth (left) and a target at a 25cm depth (right).

Prof. Fukuda's group of Nagoya University had been developed an integrated sensor system with built-in stepped frequency GPR and MD [6]. The sensor system scans the ground, being carried by a low-reaction-force manipulation base that has 4 balloons on the legs to softly land the base on minefields (Fig. 3). The manipulation base is attached to the top of a boom of a crane vehicle developed by Mr. Ikegami's group of TADANO Ltd. These elements have been integrated into a detection system "Advance Mine Sweeper (AMS)," which can adapt to various geographical environments (Fig. 3) [7]. The Gryphon buggy system, which can be remotely controlled to access to minefields, had developed by Prof. Hirose's team of Tokyo Institute of Technology (Fig. 4 left) [8]. The sensor part is a dual sensor of GPR+MD "Advanced Landmine Imaging System (ALIS)," which can be also used as a hand-held detector (Fig. 4 right) [9]. ALIS has been developed by the above mentioned Prof. Sato's team and is continuing to be developed. ALIS has still continued to be tested in various field tests, for example, in Croatia [10] and in Cambodia [11].

Fig. 3. Advanced Mine Sweeper (AMS) approaching remote steep hillside.

Fig. 4. Gryphon buggy system with Advanced Landmine Imaging System (ALIS) (left) and Hand-held ALIS in 2006 (right).

2.2 Mid-Term R&D Project

The JST mid-term R&D project was on a five year schedule. The goal was to develop sensing technologies that can detect AP landmines more safely, accurately and efficiently by detecting explosive itself, the amount of which is only about 30-100 grams for AP landmines. Prof. Itozaki's group of Osaka University is developing a nuclear quadrupole resonance (NQR) detector [12], which can detect 500 grams of Hexamethylenetetramine (HMT), which is a simulant for explosive, at a distance of 30 cm from the sensor head. The NQR technology is not only for AP landmine detection but also for explosive detection to secure the public safety, for example, in the airports. Two other research teams in the project were trying to develop detectors based on the neutron analysis. Prof. Yoshikawa’s group of Kyoto University prototyped an compact Inertial-Electrostatic Confinement Fusion (IECF) device of 20cm in diameter with a titanium getter pump as the main exhaust pump to endure the vibration when it is mounted on an access vehicle [13]. Prof. Iguchi’s group of Nagoya University prototyped another type of neutron source, which is an improved Cockcroft-Walton type accelerator neutron source using a deuterium-deuterium (DD) fusion reaction. They had also developed a prototype of the multi-Compton γ camera, which estimates the coming direction of 10.8MeV γ-rays produced from nitrogen of explosive [14].

3. Croatia-Japan Joint Test and Evaluation for Short-term R&D project [19]

After domestic field tests in Sakaide, Kagawa, Japan[15][16], the prototypes had been improved to be more robust, simpler and more cost-effective, and the next step of the project had been to take field tests to evaluate these features in Croatia, which is a well-experienced country in test and evaluation for humanitarian demining equipment. In this section, evaluation results of the Croatia-Japan joint test and evaluation for anti-personnel landmine detection systems using GPR+MD dual sensors at the test site Benkovac of Croatian Mine Action Centre - Center for Testing, Development and Training (HCR-CTRO) in Croatia**.**

The objective of the test and evaluation was to confirm performance of GPR+MD dual sensor systems in comparison with existing metal detectors and to provide reliable data as a basis for future development. By using data from different equipment and techniques, the test aims at clearing differences in performance between GPR+MD dual sensors and existing MDs, especially in terms of discriminating landmines from fragments and expanding detectable range in the depth direction. Improvements in these performances are to contribute to increasing probability of detection (PD) and decreasing false alarm rate (FAR)**.**

The test was conducted from 1st February to 9th March 2006 at the test site Benkovac in Croatia. The test site is well-known to have been used in the International Test and Evaluation Programme (ITEP) project 2.1.1.2 “Reliability Model for Test and Evaluation of Metal Detectors [17]” in accordance with the CEN workshop agreement (CWA) 14747 [18]. Three types of soils are available in the Benkovac test site, that is, (a) red bauxite with neutral stones in Lane 7, (b) red bauxite in Lane 1, and (c) neutral clay in Lane 3 (see also [17] for soil characteristic details).

The above mentioned four sensor systems, MHV#1, MHV#2, Gryphon and ALIS were evaluated in the test. Through the test, influences of three factors on PD were evaluated by analysis of variance (ANOVA), that is, target type, target depth and soil type as follows:

- Target type: PMA-1A, PMA-2, ITOP I_0 and Free-formed metal fragment (Fig. 5),
- Target depth: 5.0cm, 12.5cm and 20.0cm, and
- Soil type: uncooperative and heterogeneous (Lane 7), uncooperative and homogeneous (Lane 1) and cooperative and homogeneous (Lane 3).

Due to the limitation of time for the test and the limitation of the number of landmines that can be used, it was impossible to test all the combinations of levels, *i.e.*, four levels of target type, three levels of target depths and 3 levels of soil conditions. To impartially collect unbiased data for statistical analysis under this limitation, an orthogonal experimental design based on L18 ($2^1 \times 3^7$) is used. According to the L18 array, a combination of levels in every factor was derived as shown in the horizontal axis in Fig. 6. The number of target in each level was seven. Burying targets has done from 8th to 9th December 2005 so that the targets could be left as it is for two months to fit them to the soil.

Two examinees for each system took blind tests on the three lanes, *i.e.*, Lane 1, 3 and 7. All the examinees declared detected anomalies by putting tags on the ground where the targets are considered to be buried. Confidence ratings 25, 50, 75 and 100%, were printed on the tags used in the test. The examinee declared their final decision by using 50 to 100% tags if they thought the anomaly is a target (landmine/metal fragment) and by using 25% tags if they thought it must be clutter (there is nothing). Figure 6 shows PD of five examinees for every experimental run. In this analysis, ITOP I_0 and metal fragments were treated as targets to be detected. Results in Fig. 6 were derived from data of one selected examinee from each system, who achieved higher PD than the other. The results showed that GPR+MD dual sensor systems achieved higher PD than the deminer (Deminer 1) only for deeply-buried PMA-2s in uncooperative mineralized soil (Lane 1). On the other hand, it was shown that the deminer very precisely determined the location of ITOP I_0, which was very small and had no recognizable shape by GPR. Furthermore, deminers’ work was very fast, and they took about 5 minutes for 1 m^2 search while ALIS took 30-40 minutes at that time (in 2006) and the other three vehicle-mounted systems 15-20 minutes. All the details of this test have been reported in [19].

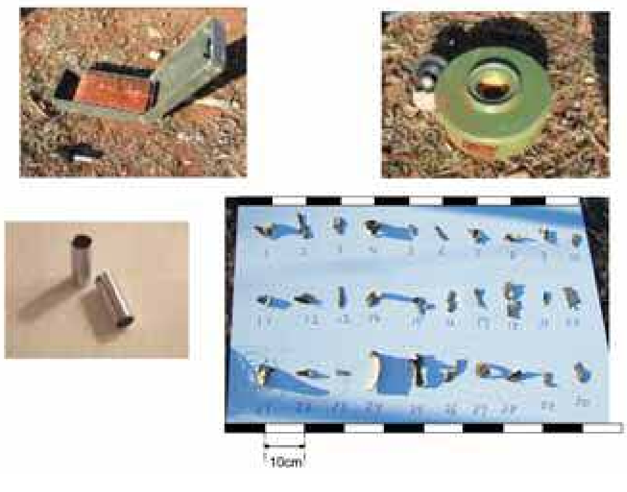

Fig. 5. PMA-1A, PMA-2, ITOP I0 and metal fragment.

4. Conclusions

Through the tests, many lessons have been learned such that PD for small targets in mineralized (uncooperative) soil can be improved by using GPR. These results were fed back to the examinees for further improvement. The project was terminated in 2007, and we have faced some difficulties regarding budget preparation. Nevertheless, R&D is still going on by their own efforts to put some promising systems into practical use.

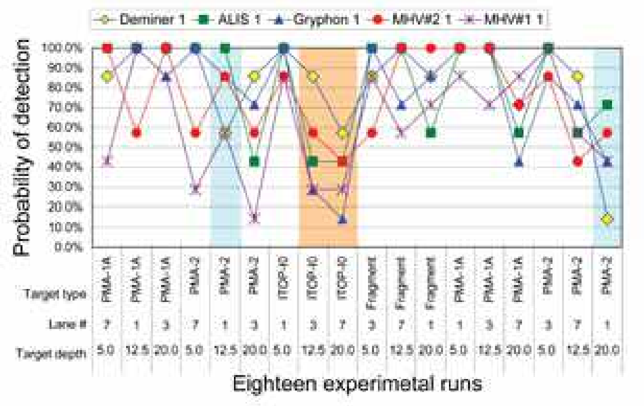

Fig. 6. Probability of detection for 18 experimental runs: one examinee from each system has been selected.

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State Parties Obligations towards the Mine Ban Treaty (MBT) and the Convention on Cluster Munitions (CCM) – Survey and Clearance

Emil Jeremić[21]

The obligations of State Parties to the MBT and CCM regarding survey and clearance of affected areas are clearly stated in both Conventions. Namely, State Parties obligations to survey, that is to record and map areas contaminated with landmines and/or cluster munitions are defined in MBT Art 5, para. 2, and CCM para. 2.a. State Parties obligations regarding clearance of contaminated areas are regulated in the MBT Article 5, para. 1, giving each State Party a ten-year deadline for clearing territory under its jurisdiction or control. Likewise, regarding the CCM, in Article 4, para.1, State Parties are given a ten-year deadline for completing clearance operations of areas under the jurisdiction or control by the State Party. Although the obligations towards State Parties are straightforward regarding survey and clearance, the solutions are not quite so. In 2004, a study of over 15 different mine-clearance programmes was carried out by the GICHD. It found that of 292 km² of cleared land suspected of containing a mine/ERW hazard, that had been physically cleared, less than 2.5 per cent of the area proved to be actually contaminated with landmines or explosive remnants of war (ERW)[2]. The main challenge is still to define the outer perimeters of minefields regarding hazard represented by landmines, and/or the "footprint" regarding hazard from unexploded cluster sub-munitions, without wasting precious human- and technical resources and at the same time adhering to relevant risk management procedures. This article argues that the best approach to cancel and release potential hazardous areas is to be found in the dynamics between non-technical survey, technical survey and clearance – interconnected in the process known as "land release".

Based on experience in southeast Europe, NPA has concluded that we should prioritize non-technical survey of areas suspected to contain landmines, cluster munitions and other explosive remnants of war, and we judge this work to be just as important as clearance operations. Non-technical survey activities confirm the potential presence or absence of landmines, cluster munitions and other ERW on given locations and provide the basis for planning of mine action activities, identifying the risk areas, preparation of demining projects, but one of the most important impacts of non-technical survey is cancellation and release of suspected hazardous areas. NPA in Bosnia and Herzegovina has in co-operation with BHMAC through non-technical survey released 163,32 km^2 formerly suspected to contain landmines and other ERW. In Serbia, NPA has in co-operation with SMAC through non-technical survey released 14,2 km^2 of formerly suspected areas.

Only through non-technical survey combined with good risk management procedures can the suspected areas effectively be reduced and controlled. The areas defined as potentially hazardous - implying probability of the presence of explosive remnants of war - cover enormous areas, and one challenge is to reduce these areas defined as "suspected" and cancelling and/or releasing non-contaminated land for productive use without using expensive clearance techniques. In Bosnia and Herzegovina, "suspected hazardous areas" cover 1,262 km^2, or around 2.5% of the total land surface area. Most of the suspected hazardous areas are reduced through non-technical survey. In 2011 non-technical survey accounted for 89% of land released in the country, whereas 11% was released through demining (technical survey and clearance). The price for demining is 80-100 times higher than for non-technical survey per square meter released. The point is, however, that non-contaminated land should be cancelled or released through non-technical survey, and not clearance.

Non-technical survey activities constitute the basis for the process of planning mine- and ERW clearance activities, task assessment and planning for community based plans, production of individual technical projects (clearance, technical survey and marking/risk education). *Efficient and effective clearance operations depend on the quality of data provided during survey, as these data generate the clearance tasks.*

Implementation of non-technical survey is a prerequisite for solving the problem of landmines as well as unexploded cluster sub-munitions in a safe, cost-efficient and timely manner.

NPA southeast Europe has developed a land release process that involves five sub-process steps, described in Figure One. The first sub-process step constitutes the Baseline, or "General Assessment" produced during the first phase of non-technical survey, in which all relevant data is entered into the database, such as GIS/bomb data, information from questionnaires on mine/ERW contamination received from relevant municipalities, records from civilian- as well as military clearance, records from clearance by commercial companies, NGOs, accident- and incident records, minefield records and depleted uranium records (where relevant). This information defines the baseline, that is, a general assessment of the situa-

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22. See http://www.gichd.org/operations/land-release/overview/

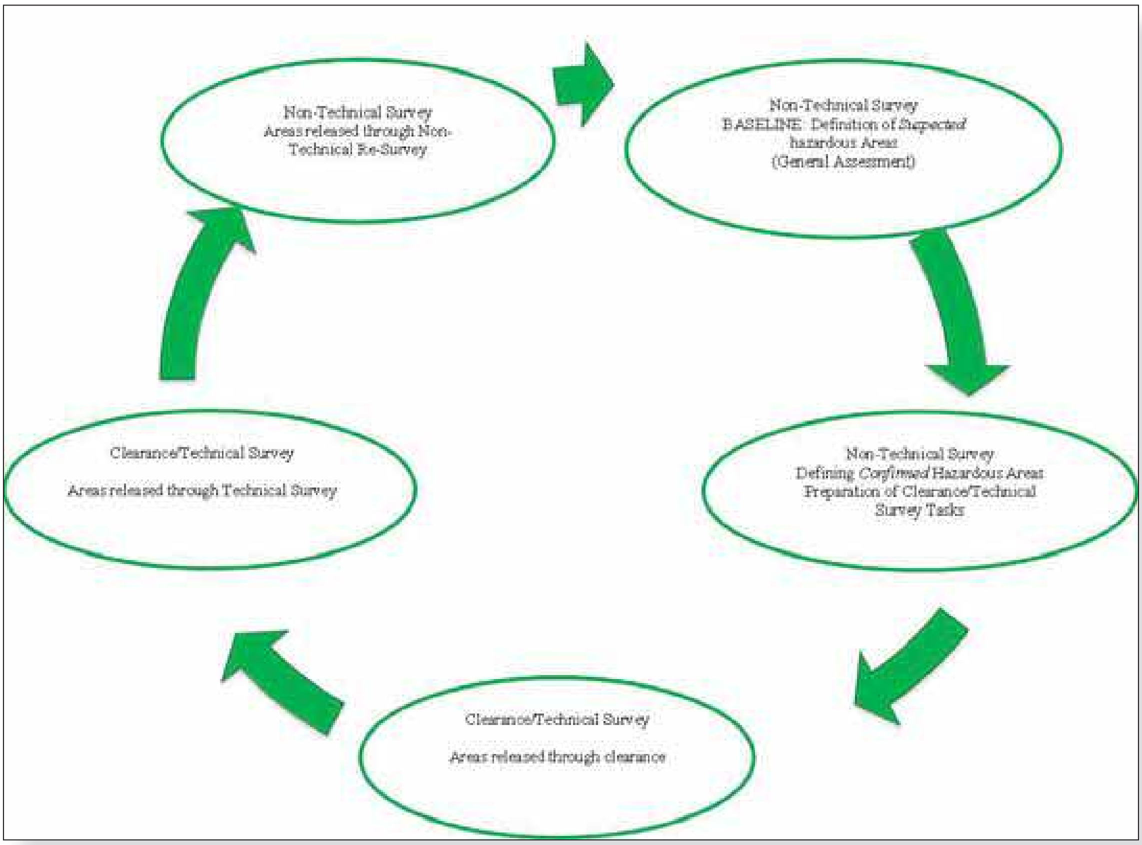
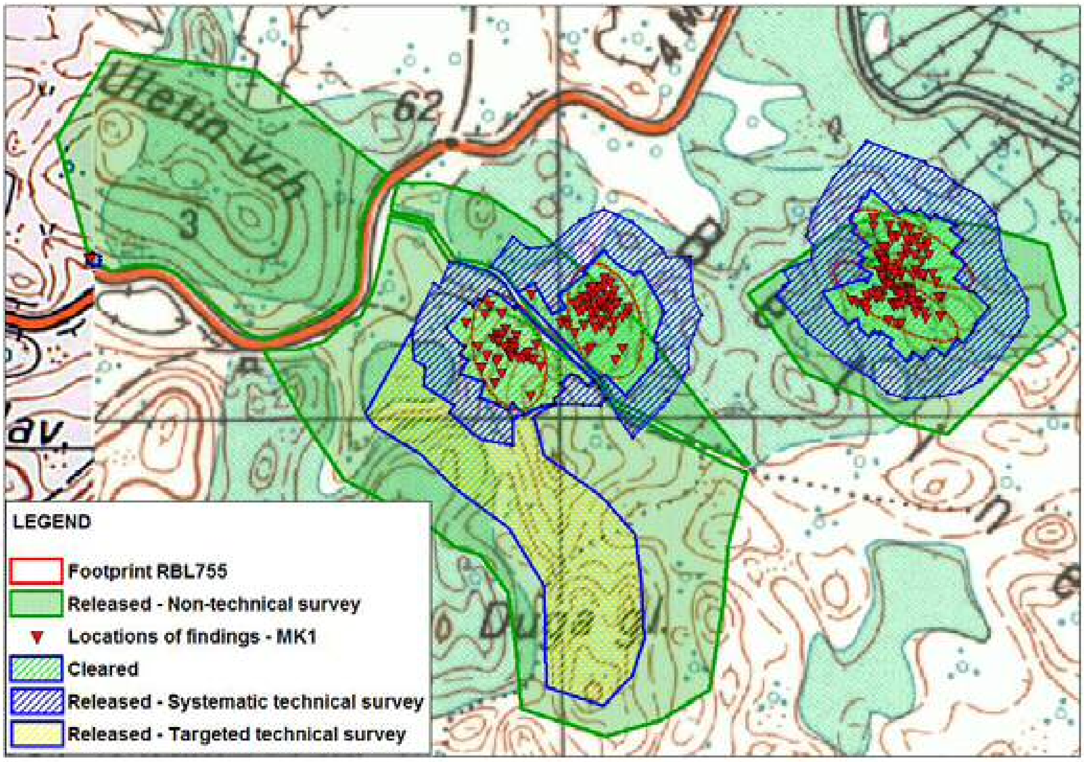


Figure One. The Land Release process.

tion related to potential contamination based on all available sources of information, before the fieldwork commences. The baseline data is typically inaccurate and gives an inflated prediction of the situation related to potential contamination by landmines and cluster munitions as it contains raw data that has not been checked against the situation on the ground through detailed field survey. However, the first sub-process step gives clear indications for the following non-technical survey, regarding what hazard can potentially be expected at what geographical locations. The second sub-process relates to fieldwork, where areas defined as “suspected hazardous” if shown clearly not to contain any ordnance/risk should be cancelled whereas areas that are confirmed to contain ordnance/risk are defined as “confirmed hazardous areas”. During this sub-process, a lot of effort is given to defining the confirmed hazardous areas as precisely as possible. During the second sub-process, technical survey/clearance tasks are defined. When such tasks are prepared, sub-process three can commence, involving technical/survey and clearance. This is the first time that machines, detectors and where possible dogs are deployed in the field, with the goal to release contaminated areas. Polygons are typically made for full clearance of minefields, or the “footprint” if the confirmed hazard relates to cluster munitions. When the polygons are cleared, the fourth sub-process can commence, in which areas in conjunction to the polygons where full-clearance was conducted are released through technical survey, evidenced through the third sub-process. The last sub-process involves non-technical re-survey, releasing the areas defined under the second sub-process step as “confirmed hazardous areas”, as the ordnance has been cleared during the third- and fourth sub-process steps. After the fifth sub-process, the problem is solved and no hazardous areas remain.

Case study, Ljubuski, Bosnia and Herzegovina

In May 1992, four pieces of BL 755 were dropped by JNA fighter planes close to the village Ljubuski in Bosnia and Herzegovina. Each of these BL-755’s containing 147 pieces of sub-munitions type Mk-1. In May 2011, during the first stage of non-technical survey, 449,040 m^2 were defined as “suspected hazardous areas”, on 14 polygons. During the second stage of non-technical survey in December 2011, 121,568 m^2 were defined as “confirmed hazardous areas”. In January 2012 NPA was tasked by the BHMAC to conduct technical survey/clearance. In April 2012, NPA conducted clearance on 63,670 m^2, detecting and disposing of 187 pieces of sub-munitions type Mk-1. During clearance operations, the task expanded out of its pre-defined borders. During May, 153,050 m^2 were released through technical survey (out of which 92,050 through “systematic” and 61,000 through “targeted” technical survey). In June 2012, 269,460 m^2 were released through non-technical re-survey and that is how the land was released at this concrete location.



Map 1. Land release at Ljubuski, Bosnia and Herzegovina.

Land release techniques		Released land		Contribution of manual clearance		Number of findings	
		m²	%	m²	%	cluster sub-munitions	other ERW
Clearance		63 670	13,10 %	63 670	100 %	187	2
Technical survey	Systematic	92 050	18,93 %	34 319	37,28 %	4	
	Targeted	61 000	12,55 %	400	0,66 %		
	Total tech. survey	**153 050**	**31,48 %**	**34 719**	**22,68 %**	**4**	
Non-technical survey		269 460	55,42 %				
Total		**486 180**	**100,00 %**	**98 389**	**20,24 %**	**191**	**2**

Table 1. Land release methods used in Ljubuski, cluster munitions.

We see from the case study presented related to tasks in Ljubuski, Bosnia and Herzegovina, that the initial general assessment or “baseline” defined the total suspected hazardous areas to 449,040 m^2. However, confirmed hazardous areas were increased during clearance operations to 486,180m^2, of which 13,10% released through full clearance, 31,48% released through technical survey and 55,42% released through non-technical survey.

Far from being a “perfect approach to land release”, the described process definitely has its weaknesses. The major weakness being the tendency to inflate the polygons and size of hazardous areas while defining “suspected hazardous areas” in the first phase of non-technical survey. A solution to this could be to introduce components of technical survey earlier in the process, such as targeted technical survey used in Bosnia and Herzegovina where manual clearance capacities are used in order to get a more exact definition of “confirmed hazardous areas”.

Further development of the processes and SOPs are needed. NPA, the Geneva International Center for Humanitarian Demining, relevant national authorities in affected countries and other operators need to work further on developing better land-release procedures to increase efficiency and release land at a higher rate than what is the case today. There lies great potential for further improvement in the dynamics between non-technical- and technical survey.

Mine Action – A Development Opportunity Well Used

Vladimir Knapp[23], Milan Bajić[24], Dinko Mikulić[25]

Abstract

According to UN estimates each year 10 000 to 15 000 innocent people, many of whom are children, are killed or severely injured by mines. As the mines in their tens of millions are mainly distributed in poor regions of Africa and Asia they pose a humanitarian and economic problems beyond the means and possibilities of afflicted countries. Removal of mines is difficult as the existing methods of demining are expensive or unable to detect mines that contain little or no metal components. To develop better and cheaper method of landmine and explosive detection has become one of major scientific challenges. Scientists in many countries have responded and are trying to solve the problem. Presented are the efforts of Croatian scientist in the period 1997-2013, initially within the Croatian Academy of Science and Art (Croatian SAA) and then within the Scientific council of Croatian Mine Action Centre (CROMAC) and the CROMAC-Centre for Testing, Development and Training Ltd. (CROMAC-CTDT).

1. Demining issue and science

According to a UN assessment, more than 30 billion US dollars would be needed to remove all the landmines using conventional technologies, since the average cost of removing one mine is approximately 300 USD. M. McDow, director of the Board on Science and Technology for International Development of the US National Academy of Sciences (NAS) and of the National Research Council (NRC) believes that: “Donor countries and international assistance agencies cannot increase the funds intended for mine clearance up to the level which would be necessary to remove millions of landmines using the available demining methods. The solution must be found in significant improvement of productivity of the existing approaches and in the development of new technologies.”

Development of new and better mine detection technologies is an urging problem posed before science and scientists. Numerous esteemed national and international scientific institutions have responded to this challenge, as well as a large number of scientist, including some renown scientists. Intensive international collaboration has been developed, which is only logical, in view of the global dimensions of the issue. In Europe, the Joint Research Centre of the European Union in Ispra has been involved in research on mine detection, as well as a whole range of national research centers. The leading European Information center is located in Geneva (Geneva International Centre for Humanitarian Demining - GICHD, www.gichd.org). In the United States, the National Academy of Sciences has been very active, and research is conducted in many national laboratories as well, eg. Oak Ridge National Laboratory and Los Alamos National Laboratory. Developmental military institutions in several countries have also given significant contribution.

Involvement of Croatian scientists

During the Homeland war, Croatian scientists became involved in finding solutions to the landmine problem. In mid 1994, they initiated discussion on the landmine problem (V. Knapp together with M. Kaplan) at the International Pugwash Movement Conference in Kolymbari, Greece, and warned about the misuse of landmines in the aggression on Croatia. In Croatia itself, scientists in leading scientific institutions, e.g. Croatian Science and Arts Academy (SAA), Ruđer Bošković Institute and several faculties, joined the efforts of solving the landmine issue, at first within the Croatian SAA. As an associate member of Croatian SAA, prof. V. Knapp invited several Croatian SAA members whose scientific activities were closely linked to development of mine detection methods to collaborate, as well as some scientists outside the Croatian SAA. The response was very encouraging, although neither financial nor material resources were available at the time. Supported by the Croatian SAA president Ivan Supek and by the president of the Croatian SAA International Relations Committee, by the end of 1996, the first organizational form was achieved in a form of a Special task force within the Croatian SAA International Relations Committee. At this stage, the Task Force was developing international contacts with institutions which were involved in development of new mine detection methods. In May of 1997, a Conference on the role of science in the development of effective methods of detection and removal of landmines was held at Croatian SAA. Introductory speeches were held by the SAA president Ivan Supek and Academy member Ivo Šlaus, giving an overview of the dimensions and nature of the problem and outlining a possible role of SAA in solving the problem. The members of the Task Force presented a scientific status and

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potential of individual mine clearance methods. Conclusions of the Conference included concrete proposed activities to be undertaken by Croatian SAA through projects, scientific contacts and encouragements.

It was during this period of time that the Task Force members gained initial insight into the mine contamination data base acquired by the UN MAC Croatia. According to the first, conservative, assessment of the UN MAC Croatia in 1997, the mine contaminated area in Croatia covered 13000 km^2 (or 23% of the land surface area including islands, of 56488 km^2), and in 1999 it was estimated to cover 6000 km^2 (or 10.6%). Such a high percentage of mine suspected area in Croatia gave additional motive to the Task Force members and gave them strong arguments to present the mine contamination problem of Croatia at scientific gatherings, and also motivated them to try to find a solution. Contacts were made with the state official authorized for demining (general S. Barić). Shortly after the Conference, new organizational possibilities of contribution of scientists in mine clearance appeared. Namely, in March 1998, the Croatian Mine Action Centre (CROMAC) was established upon the Government decision, and as early as in April, the Task Force for demining offered to collaborate with CROMAC. At a meeting held between the Task Force and CROMAC management on 7th May 1998, it was decided to rename the Croatian SAA Task Force into the CROMAC Scientific Council. The Council was inaugurated on its first session held on 10th September 1998. In the following years very useful collaboration of scientists and the new governmental institution authorized for demining was established.

After several years of existing within CROMAC, in 2003, a part of CROMAC tasked with testing and development of new methods and with training was established as a separate entity - Croatian Mine Action Centre - Centre for Testing, Development and Training (CROMAC-CTDT), and the Scientific Council was assigned to the new Centre. Thus, in organizational view, activities of Croatian scientists related to demining issues may be divided into three periods: first there were activities within Croatian SAA until 1998; from 1998 to 2004 within CROMAC and since 2003 within CROMAC-CTDT.

Activities of the CROMAC Scientific Council

After CROMAC was established in March 1998 by the decree of the Croatian Government, members of the Croatian SAA Task Force decided to join this organization, believing that their work on introduction of new demining technologies may be much more effective and efficient in collaboration with the organization which was tasked with demining, but in concrete field conditions of mine contamination, with practical human, technical and financial limitations. They were eager to learn about the criteria of field work. The CROMAC director accepted their offer, and members of the Task Force became members of the CROMAC Scientific Council, and were joined by several members appointed by the CROMAC Managing Council. From its beginnings, the Scientific Council insisted in the advisory role and in autonomy of its scientific and expert work. The members developed the Rules and Regulations of the Council and defined their goals. With relations so clearly defined, collaboration with CROMAC employees and management went smoothly, in the ambience of joint striving to contribute as much as possible to eradication of danger caused by mines. In the first years (from 1998 to 2004), the Scientific Council held its meetings at the premises of the Faculty of Electrical Engineering and Computing in Zagreb, where they were also given a room for permanent storage of documents and computers (at the Applied Physics Department).

First president of the Scientific Council was prof.dr.sc V. Knapp (1998-2001), followed by prof.dr.sc. M. Bajić (2001-2003), prof.dr.sc. N. Perić (2003-2004), dr.sc. D. Mikulić (2004 - 2005), prof.dr.sc. H. Gold (2005-2006), and prof. dr.sc. N. Kezić (2006- 2013). Connection with CROMAC, to which the Scientific Council became an advisory body, ensured a two-way information flow between scientists on one hand and CROMAC employees who had organizational, operational and field experience in demining on the other hand. Efficiency of this connection is extremely important for a meaningful work of scientists and for selection of realistic options between a wide spectre of useful ideas and useless speculations, because criteria and requirements which new technologies should meet result from actual field experience in a concrete area. First of all, they should be safer and faster, and then available as well. This collaboration was a basis for ideas on criteria in humanitarian demining defined in international organizations and their realistic survivability and applicability in view of available demining methods. Humanitarian demining requirements start with detection of mines, detection of minefields, mine suspected area reduction and danger assessment. This evolutionary process has started with humanitarian demining requirements to detect antipersonnel landmines (very small dimensions, more than 50% of which are non-metal) and minefields, with 99.6% probability and high reliability (as high as 98.1%). Later on such an unrealistic and unachievable requirement was changed in a requirement to reduce a mine suspected area if it does not contain any mines.

Members of the Croatian SAA Task Force and CROMAC Scientific Council

A group of scientists who were involved in demining issues has changed in number from the initial group formed within SAA. When the Scientific Council within CROMAC was established, some new members were appointed by CROMAC Managing Council. During its work, the Scientific Council accepted new members who wanted to contribute to solving demining issues and possessed relevant knowledge. A precondition was that they were holders of PhD title. Any person with business interest in demining has not been able to become a member.

Croatian SAA Task Force from 1997:

Academy members: H. Babić, B. Kamenar, Ž. Kućan, I. Šlaus, associated member V. Knapp, dr.sc. M. Bajić, prof. dr.sc. M. Bauer, dr.sc. K. Humski, brigadier J. Petrović.

Members of the Scientific Council after establishment, by the end of 1998:

Academy members Hrvoje Babić, dr.sc. Mile Baće, dr.sc. Milan Bajić, prof. dr.sc. Tomislav Bašić, prof.dr.sc. Mario Bauer, prof.dr.sc. Teodor Fiedler, prof.dr.sc. Marin Hraste, dr.sc. Nenad Javornik, prof.dr.sc. Stjepan Jecić, prof.dr.sc. Krešimir Jelić, ak. Boris Kamenar, prof.dr.sc. Vladimir Knapp, prof.dr.sc. Vjera Krstelj, ak. Željko Kućan, doc.dr.sc. Sven Lončarić, dr.sc. Dinko Mikulić, prof. dr.sc. Nedjeljko Perić, dr.sc. Vladimir Srb, dr.sc. Petar Strohal, ak. Ivo Šlaus, dr.sc. Branko Tomažić, dr.sc. Vladivoj Valković, prof.dr.sc. Ozren Žunec.

Active member of the Scientific Council by the end of 2012:

Antonić Davor, dr. sc. (Antonić d.o.o., davor@antonic.hr), Bajić Milan, dr.sc. (HCR- CTRO d.o.o., milan.bajic@zg.t-com.hr), Čerina Josip, dr.sc. (CROMAC, Zadar branch office, josip.cerina@ctro.hr), Fiedler Teodor, dr.sc. (teodor.fiedler@zg.t-com.hr), Gambiroža Nikola dr. sc. (CROMAC, Sisak, nikola.gambiroza@hcr.hr), Gold Hrvoje, prof. dr. sc. (Faculty of Transport and Traffic Sciences, University of Zagreb, hrvoje.gold@fpz.hr), Knapp Vladimir, prof. dr.sc. (Faculty of Electrical Engineering and Computing, University of Zagreb, vladimir.knapp@fer.hr), Koroman Vladimir, prof. dr. sc. (Brodarski Institute, Zagreb, vladimir.koroman@hrbi.hr), Krtalić Andrija, dr.sc. (Faculty of Geodesy, University of Zagreb, kandrija@gmail.com), Matika Dario, prof. dr.sc. (Institute for Research and Development of Defense Systems, dario.matika@morh.hr), Mikulić Dinko, prof. dr.sc. (VVG, dinko.mikulic@vvg.hr) , Mladineo Nenad prof. dr.sc.(Faculty of Civil Engineering, Architecture and Geodesy, Split, University of Split, nenad.mladineo@gradst.hr), Nikola Kezić, prof. dr.sc. (Faculty of Agriculture, University of Zagreb, nkezic@agr.hr), Nedeljko Perić, prof. dr. sc. (Faculty of Electrical Engineering and Computing, University of Zagreb, nedeljko.peric@fer.hr).

Ten selected works from the initial stage of activities in demining

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[A2] SuS DeM '97, 1997, *International Workshop on Sustainable Humanitarian Demining*, Zagreb. D. Antonić, co-organizer.
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[A7] D. Antonić, 1999. *Workshop on mine signature*, JRC, Ispra, ARIS, June 1999, paper by D. Antonić, member of the CROMAC's Scientific Council research team.
[A8] V. Valković, 1999. *6th International Conference on Application of Nuclear Techniques, Nuclear technology for safety, security and industrial development*, Kreta, 20. - 26. 6. 1999, paper.
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[A10] Bajić M., 1999. *Impact of mine polluted area characteristics on the suitability of the airborne multisensor mine field detection: the case of Croatia*, Proceedings, Fourth International Airborne Remote Sensing Conference and Exhibition/21st Canadian Symposium on Remote Sensing, Ottawa, Ontario, Canada, 21-24 June, 1999., pp. I779 – I786.

Participation in conferences and conferences organized by Scientific Council members and CROMAC

- Conference on the role of science in development of efficient methods of detection and removal of mines, HAZU, Zagreb, 12. 5. 1997. Conclusions and proposals of the HAZU conference.
- About new mine detection methods, Sisak, 17 November 1998.
- Mechanical demining, Sisak, 26th April 1999. The premises of the Chamber of Commerce of Sisak-Moslavina County.
- Inventory and analysis of operationally validated results related to mine action space - and airborne surveys, Workshop, Zagreb, 30.11.2005. The premises of the Faculty of Electrical Engineering and Computing, Zagreb.
- IAEA Expert Meeting RER/1005, Field Testing and Use of Pulsed Neutron Generator for Demining, Zagreb, 26-28. January 2004. Held on the premises of the Faculty of Electrical Engineering and Computing, Zagreb.

Some general conclusions, achievements and experiences from 1997-2013.

a) Contribution was made to better understanding of operational characteristics of metal detectors, to improvement of the way of breeding and testing mine detection dogs; to mechanical clearing technologies and to aerial survey of mine suspected areas.

b) Contribution was made to acquiring knowledge on the possibilities and status of new demining technologies and to the estimation of their applicability in Croatia, in local conditions (especially MEDDS and FIDO methods and a neutron based devices for mine detection).

c) In collaboration with a whole range of international organizations, Croatia was recognized as a partner which possesses scientific, expert and organizational infrastructure for application of new demining technologies, i.e. as a country where new methods and improved conventional devices can be tested and evaluated in the field, with confidence, in realistic conditions.

d) Definition of mine suspected area reduction was elaborated in 1999 and 2000 and supported with contribution from Croatia (CROMAC Scientific Council, CROMAC), and accepted as a content of humanitarian mine action. In Croatia, reduction became a significant and the most important part of reducing the mine suspected area.

f) An important role in creating conditions for testing of new methods was played by test sites the establishment of which was financed by the projects, i.e. international collaboration initiated by members of the Scientific Council (a test site for explosive vapors was established near Sisak, in Rakovo Polje, a first mine test site Benkovac was established and testing methodology was introduced which ensures statistically significant results. On the basis of initial quality, the use of this test site and others which followed (HCR-CTRO), grew into a permanent collaboration with international producers of mine action sensors.

g) Work on new methods, such as MEDDS and PELAN has shown that without one’s own finances and testing equipment, optimum results cannot be achieved. With a lot of effort invested, participation in international projects was ensured and funds raised for testing of the above methods.

h) More favourable situation was within scientific projects which were co-financed by the European Commission without commercial interests (ARC, SMART), where cutting-edge sensors and programs were acquired and multisensor airborne remote sensing system was developed, as well as methods of acquiring images, field verification and operational validation, and a team of airborne sensing operators and mine scene indicators was trained. These resources were used in the project of application of airborne remote survey (Technology Project TP-06/0007-01 Croatian Ministry of Science).

i) Extremely positive example of Scientific Council activities can be seen in mechanical demining, where a synergy of scientists was formed between the Scientific Council and experts from CROMAC, joined by an extremely capable group of development engineers from DOK-ING company. Scientific Council members, together with CROMAC and DOK-ING experts, brought mechanical demining to a global level, both in development and in application.

j) Through its contacts with international organizations, the Scientific Council has drawn attention to itself, and we can say that today it poses an added value to the Croatian demining system. For commercial organizations, results are subject to business criteria. Academic research without a direct working contact with field problems of humanitarian demining have frequently shown to be futile and slow, and sometimes even directed in the wrong direction. The Scientific Council insists on scientific and expert autonomy, but also in continuous follow-up of the problems in the field. This has been proven as a useful and successful way of involving science in the improvement of humanitarian demining.

These findings have been incorporated into CROMAC-CT-DT, which was established in 2003 when a part of CROMAC which was tasked with development of new methods and testing of demining equipment and devices became an autonomous subject.

Acknowledgements

The scientists who responded to the challenge of finding better and more efficient methods and ways to remove landmines in the past ten years, would like to express their gratitude to those institutions and persons who assisted them in their efforts. First of all, the CROMAC management, led by its directors D. Goršeta and O. Jungwirth, and CROMAC-CTDT Ltd., led by its director N. Pavković, as well as the CROMAC and CROMAC-CTDT Ltd. staff. In the early stage, these activities were linked to the Croatian Science and Arts Academy, especially to the International Relations Committee, where they were received with a lot of understanding and support. Thus we would like to thank the Croatian Science and Arts Academy. We are very grateful to the Faculty of Electrical Engineering and Computing in Zagreb, which has provided permanent work space and provided premises for workshops and meetings of the Scientific Council, meetings of international demining experts and work of project teams.

a b c

Figure 1. The representative indicators of Croatian science contribution to humanitarian mine action: a) Vladimir Knapp and nineteen co-authors in 2008., [C1], b) Milan Bajić and four co-authors in 2011., [B17], c) Dinko Mikulić in 2012., [C2].

We would like to thank the Headquarters of the Croatian Armed Forces for their support, and we would especially like to mention the support of the Croatian Air Force, which has appointed three employees for a continuous work on the projects of remote survey of minefields and enabled the use of Mi-8 and Bell-206 helicopters used in a multisensory survey of minefields from 2001 to 2004. We would like to thank DOK-ING d.o.o., a development and demining company, for its extremely valuable collaboration in testing and development of demining machines. We would like to thank prof. dr.sc. Dijana Pleština for her assistance in establishing international collaboration in the research of acoustic methods of mine detection on land and in water. In addition to the members of the Scientific Council who, in their contributions to this overview, presented their work aimed at development of new demining methods, we would like to thank the other members of the Scientific Council who have participated in its work and contributed with their knowledge and experience in certain time periods.

2. Non - technical survey of mine suspected areas based on aerial and spaceborne technology

At the first meeting of the Scientific Council of Croatian Mine Action Centre (CROMAC), director of CROMAC claimed main areas where the contribution of the science is needed and expected: a) the landmine detection b) the minefield detection, b) the mechanical demining and c) the dogs for landmine detection. In this chapter we will outline the contribution of Croatian scientist, researchers and mine action experts to b), the analysis of the mine suspected area and to assessment of the minefields. In late nineties several initial papers presented needs and requirements of Croatia, regarding the remote sensing and geographic information system technologies suitable for humanitarian mine action, e.g. [A3], [A10]. The initial concept of the multisensor survey of the minefields was developed and presented on meetings of Scientific Council of CROMAC and was good background for future scientific, research and development projects, [B1], [B2], [B3], [B4], [B5], [B6], [B7]. The intensive international cooperation resulted by development of the non-technical survey based on the aerial and the spaceborne remote sensing technology, on the methods of data fusion, the knowledge management, the multi – criteria, multi – objective analysis. From the year 2000. to 2005. /2004. have been realised Europen Commission FP6 scientific projects SMART [B1], [B2], ARC [B3], [B4] in which CROMAC's teams participated very actively. The contribution of the Croatian teams in these projects is described in [C1], [B12]. The methodology of SMART was validated operationally by CROMAC and Croatian Ministry of science, education and sports supported the development, design and building of the integrated system for aerial multisensor remote sensing of the mine suspected areas, [B5], [B14], Fig. 2, Fig. 3. This was the crucial step, while the European Commission did not support deployment the projects' results into operations.

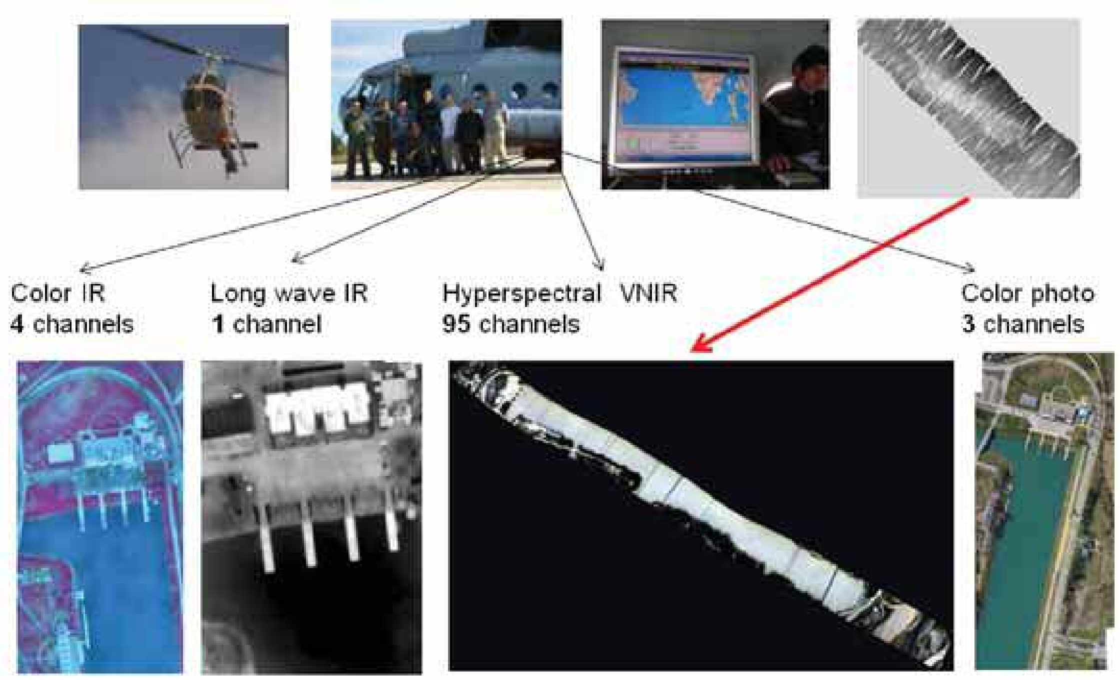


Figure 2. The airborne multisensor system which was developed by support of Croatian Ministry of Science, education and sports, [B5], [B14]. The helicopters Bell-206 and Mi-8 have been aerial platforms, which of them will be used depends on needed endurance, [B11], [B12].

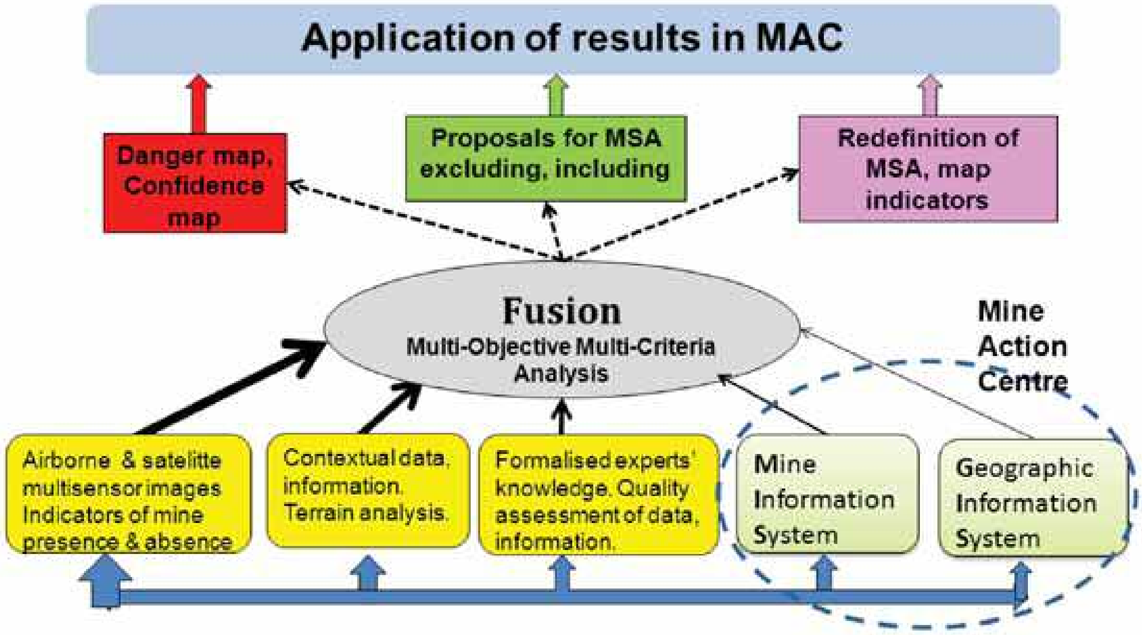
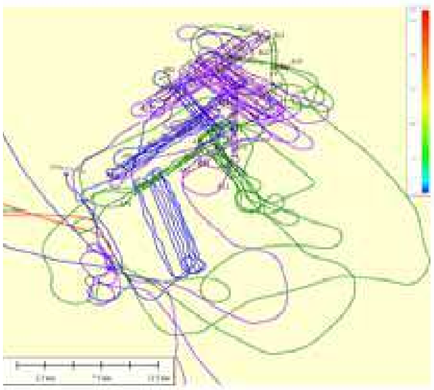


Figure 3. The advanced intelligence decision support system developed after [B5] in [B6], [B7]. Note that in Mine Action Centre (MAC) the only sources are MIS and GIS, while the presented decision support system provides evidences from additional sources and multi-criteria, multi-objective fusion.

The potentials of the developed aerial multisensor system and the processing and interpretation subsystem developed in [B5], was recognised by USA Department of State via International Trust Fund for Demining and Mine Victims Assistance[26], Ig, Slovenia. Two operational projects have been realised, first in Croatia 2007.-2009., [B6], and the second in Bosnia and Herzegovina 2009.-2011., [B7]. Example at Fig.4 shows the relief and the realised flight routes in the mountainous terrain, where the airborne remote sensing technology demonstrates its advantage in comparison to other ground based survey technologies.

Mountain Velez, near Mostar, Herzegovina .



Routes of the acquisition flights in 2010.

Figure 4. Example of the aerial remote sensing of the mine suspected area in the mountainous terrain, [B7]. The flight routes are determined by the separation lines, terrain elevation changes and the spatial resolution, needed for the reliable detection of the remains of war – indicators of mine presence.

The reliable assessment of the mine suspected area (MSA), of the mine fields, redefinition of the MSA categories is the continuous, repeatable and laborious process in the mine action, requiring collecting, processing and fusion of different kinds of the data, information and knowledge. After several cycles of the revision, nearly all available sources have been checked and the saturation appears. Only new evidences about MSA can move this process forward, the new data about indicators of mine presence, the reconstruction of the separation lines, combined in the decision support system Fig. 3 enable the significant advancement, [B15], [B16], [B17].

The application of this new technology, named the Advanced Intelligence Decision Support System (AI DSS) approved that the mine action centre (MAC) can exclude from 29,5 % to 63 % of the mine suspected area, although in the same time more than 5 % inclusion into MSA can happen. The total cost of the application of AI DSS technology is more then hundred times smaller then the cost of the conventional survey and area exclusion (reduction) technology.

The AI DSS technology described in [B15], [B16], [B17], verified in [B6], [B7], was recognised as the valuable reference and Croatian scientists, researcher and mine action experts have been invited to participate in preparation of FP7 scientific research and development project TIRAMISU, [B8]. The proposal was accepted and TIRAMISU started in the year 2012.

Due to contribution of Croatian scientits, researchers to the research and development, of the mine action practice, the evaluation of the mine action system development, is additional reference which contributed to their international reputation, [B9].

Besides the airborne survey of the mine suspected areas and the mine fields, Croatian scientist have been active in application of the honey bees as biosensors, from this activity we consider only the application of the remote sensing methods to detect density of the bees above the explosive. Analysis of thermal infrared signatures of the bees as potential biosensors for explosive detection was reported in [B10], while the image processing techniques for hybrid remote sensing using honeybees as multitude of acquisition sensors was presented in [B13]. The one task in TIRAMISU includes research and development of application of honey bees as the explosive biosensors (Sub-WP233.5).

The airborne multisensor remote sensing system, which was developed and built up in [B5], was applied with success for the hyperspectral surveillance of the ship-based oil pollution in the Adriatic Sea. This is exaplne of dual use of the developed and implemented technology.

In the frame of the TIRAMISU FP7 project participate two Croatian partners, Faculty of Geodesy University of Zagreb (FGUNIZ, modernisation of the AI DSS) and CROMAC – Centre for testing, development and training Ltd., (CTDT) Zagreb. CTDT is leading partner for the Operational validation, Work Package 510, and works on tasks Sub-WP233.4, methods and tools for the spectral imaging detection of the vegetation stress due to explosive in the landmines; wide area survey of debris of unexploded ordnance after the unplanned explosion of ammunition depot; and on Sub-WP223, CROMAC surveyors' contribution, through CTDT, [B8].

The research of the grass stress due to influence of the explosive in the buried landmines should approve or deny hypothesis that the hyper spectral analysis can detect different response of the grass inisde of the mine field and the response of the vegetation outside of the mine field. The results of this research should enable development of the tool for detection

26. In 2012. the name was changed to ITF Enhancing Human Security, in accordance with its new mission, http://www.itf-fund.si/

of the explosive presence in the ground, and/or the development of the tool for extraction of one new indicator of the mine presence and its inclusion in set of tools of the TIRAMISU-AI DSS. The test site near Benkovac (http://www.ctro.hr/eng/testing-and-certification/test-sites/benkovac/article/benkovac-test-site-25.html) contains landmines since 2001. and is an exellent object for statisticaly based research of the detecting tools. The landmines, metal debris are buried in soil inside of squares 1 x 1 m, marked by yelloow plastic sticks in the corners, Fig. 6.

In 2013. the area of test site Benkovac was shooted by the ground based hyper spectral sensor and the hyper spectral cubes have been derived. The hyper spectral images have been rectified and the measured radiance was converted into the reflectance by the simple atmospheric correction. In the 2013. the aerial hyper spectral shooting is planned, from very low altituded, at low speed, from the blimp, which provides very low vibrations in comparison to helicopters.
The last example shows that the initiative [A1] of V. Knapp from 1994. continues in 2013.

Twenty selected references

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Figure 5. The airborne image of the test site Benkovac, acquired in TIRAMISU mission of FGUNIZ and CTDT, 15/06/2013. The area of the site inside of the fence is 50 x 200 m. The bushes and hedges cover part of the test site and only part covered by grass is suitable for the research of the grass stress.

Figure 6. View of the area below the scanner. On the left side is reflectance etalon (LabSphere, Spectralon MS180-1967), on the right side is black-white marker. Yellow sticks are placed at the corners of the 1 m x 1m squares.

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3. The Challenges and Achievements of Mechanical Demining

There were a couple of stages in developing mechanical equipment for the use of humanitarian demining. During the first phase, human creativity and first-rate improvisation in manufacturing demining equipment from several demining entrepreneurs were highly expressed. In the second stage, by forming a Scientific Council of the Croatian Mine Action Centre (ZV HCR), the coordination of demining equipment development with potential manufacturers was established. Focusing on the development of demining machines, individual and serial production have taken place with several manufacturers. In the third stage, by forming the Centre for Development, Testing and Training (CRTO), the testing of machines and other equipment was established. Such coordination from the side of science strengthened the entrepreneurial activities in developing the equipment. Domestic machine production increased and, by doing so, met the requirements of demining companies.

What presented challenge to the group of scientists in mechanical demining was how to expertly and scientifically respond to the posing mine threats. First, the prototype versions of machines were produced, only to be tested in real conditions of mine suspected areas. Categories of demining machines were determined, being the light, medium and the heavy category. Through scientific research study of the ZV members in cooperation with the manufacturers, the methods and techniques for eliminating mine danger were presented. The research included as well the testing and evaluation of machines on a testing ground, such as performance, persistence and acceptability tests. The members of ZV participated in the preparation of the international standard for machine testing, CEN CWA 15044:2004/2009, which ensured the guidelines for achieving greater quality for demining machines. With the assistance of Scientific Council members, the Cerovac testing ground was formed, along with the evaluation of humanitarian demining machines and had received accreditation. All of it together resulted in compiling an original Croatian norm of HRN 1142:2010, Humanitarian Demining – Requirements for machines nad evaluating machine compatibility. A large number of scientific and expert studies from our scientists has been presented at international scientific conferences abroad and published.

Acknowledgement of the Scientific Council's activity can be seen in the field of discovering technological projects, where cooperation was realised with the Croatian Ministry of Science, Education and Sports (MZOS) and manufacturers. For instance, in cooperation with the Brodarski Institute and a manufacturer, DOK-ING, a project with machines using electrical transmission was achieved. Manufacturer's expert knowledge and acceptable risk have proved decisive for the development of demining machines.

Effect on the Economy

15 years after establishing the HCR and humanitarian demining, the problematics of mechanical demining is still a current issue. It is evaluated that another 200 square kilometers of mine contaminated area is open to mechanical machine demining. Demining machines are used as the first method of clearance. The machines are being technically enhanced so as to provide greater demining quality. Currently, 50 demining machines are being used with several companies engaged in demining, while one part of the machines and equipment is engaged in other mine-contaminated countries.

Although significant government spending and grants have been invested in humanitarian demining already, a public opinion was formed in the sense that humanitarian demining is only a huge budget consumer, however, this overwhelming positive effect inevitably translated to activating entrepreneurs and opening new job posts. The effect of demining machine development on the economy is seen in their export of 200 MV-type DOK-ING demining machines, either for humanitarian or military demining respectively. Machine production and other mechanical demining equipment is achieved. Humanitarian demining investors have indirectly become the initiators of developing a segment of the economy. In such a way mine action was used with effect on the economy.

Representable Products

The production of the MV family of DOK-ING machines implies light, medium and heavy demining machines. The machines are purchased by military formations as well, who use them in peace-keeping operations, e.g. the Croatian army, the Swedish, US or the Australian army. Despite their price, they fairly quickly yield. A light machine is capable of clearing 1500 square meters of mine-suspected area in an hour, a medium machine 5000 m^2/h, depending on the land conditions and time. Using the machines resulted in no injuries, neither deminers / pyrotechnicians. Effect of the machines is at least 10 times greater than that of manual work. Therefore, demining mechanisation clearly makes a difference in respect to manual clearance, as reflected in demining costs, productivity or deminers' safety as well.

Figure 7. Demining machines, the light machine MV-4 and the medium machine MV-10

Manufacturers' investments into the development of demining machines resulted in a springboard for development of a family of other specialised machines. In this way the machines for underground mining works were developed – chrome and platinum mines in RSA (mini dozers MVD). After this a family of firefighting machines for tough conditions was developed (Jelka).

Affirmation of Knowledge

Scientific research studies on the development of demining machines in the recent 15 years resulted in publication of a unique book (supported by GICHD). This was recognised also by a renowned foreign publisher Springer Verlag, who published the book under the title **Design of Demining Machines,** which presents the philosophy of developing special machines for humanitarian demining.

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http: //www.springer.com/engineering/
mechanical+engineering/book/978-1-4471-4503-5

The book is divided into six chapters:

1. Humanitarian Demining Techniques
2. Mechanics of Machine Demining
3. Design of Demining Machines
4. Design of Mine Protected Vehicles
5. Personal Protective Equipment
6. Test and evaluation of Demining Machines

The book is primarily aimed at the process of development and application of engineering techniques used in developing specialised machines. It’s the first book worldwide that focuses on the methods of calculation and construction of contemporary machines in humanitarian demining and which offers horizons of new development. The book will be a useful source of knowledge for engineers, researchers and leaders in the field of demining.

Apart from design and engineering innovation, this book has an educational mission as well. Knowledge provided in the book ensures fluent knowledge acquirement and shares a vision of an original approach from the author. Its mission is to provide people around the world do gain knowledge based on experience of machine development in the Republic of Croatia. Thus the book represents a significant contribution to the literature in the field of specialised vehicles.

The Mission of Mechanical Mine Clearance

Machines for humanitarian demining achieved a noted effect in neutralisation of mine threats. Demining machine manufacturers continually monitor the condition of machines and their performance. The application-development-production feedback reinforces the machines with the possibility of perfecting them. The Scientific Council of HCR-CRTO actively cooperates with academic and economic partners in the Republic of Croatia and abroad to maintain the continuity of development and production.
Research is conducted on reducing the handling risk for the machines. When controlling the demining machines by remote control, the deminers are exposed to increased tisks and threats from potential detonations and regarding that, they have to be protected from chrapnel impacts of anti antipersonnel and anti-tank mines, impulse noise and shock vibrations. The machine controllers have to be ensured with an adequate form of protection when remote-controlling the demining machines, such as the light protective gear and / or protected supporting vehicles.

The Vision of Mechanical Mine Clearance

Innovative solutions are continually being considered with the goal of developing demining machines and their production potential. The vision of mechanical mine clearance is the modernisation of machines and development of different versions of machines and equipment. The level of innovative development is to be maintained through cooperation with the partners from the economy. The projects need to stay dynamic which will entice expert and scientific research with direct application in practice. Such a vision is the projection of development achievable via a successful strategy:

• Motivation of Researchers and Engineers,
• Innovation in the Demining Technology,
• Cooperation with the Economy
• International Cooperation.

The Challenges of Developing a Robotic Machine

Various types of mine threats in low trafficability terrains, especially forest areas, indicate development of new means and technology that can eliminate mine danger without the presence of human risk. This determines the logistics of equipping for the systems of mine action as well as safety and rescue. A feasibility study on development of a robotised system for detection and neutralisation of improvised explosive devices (IED) was prepared accordingly. The tasks of reconnaissance along with terrain and object mapping are crucial for the operators and technicians to gain the ability of a multiple problem analysis. The basic purpose of a robotised machine is the substitution of EOD technicians in various life-threatening situations.

In order to fulfil rigid tactical and technical requirements, a robotised system comprises a stealth platform, changeable working tools, flail, tiller, bulldozer, control console, manipulating hand for handling complex actions and taking samples, and a mobile command centre. The study indicates that the project is both technically and economically feasible on the basis of a MV 4-tonne tracked machine with battery propulsion. Current resources and experience in developing special machines are significant for the development of a robotised system.

A remote-controlled robotic machine can be controlled by means of a mobile control unit or a stationary control board. The control board enables the operator to control the vehicle and maintain supervision over all the functions and tools at a distance of 1000 meters within the visibility area, i.e. up to 350 meters in urban areas. The operator controlling the robotised vehicle is located at a safety distance or in a command centre. The mobile control board is used in cases when the visualisation of the robotic vehicle is unavoidable.

Figure 8. Prototype development of an MV remote-controlled robotic machine

Current resources and experience are significant for the development of a robotic machine for eliminating mine and explosive devices and production in the R. of Croatia:

- DOK-ING company resources, comprising the technology of producing a base mobile platform, integration of all systems, testing, logistics, and product finalisation,
- resources of main cooperators and R&D institutions of the Republic of Croatia,
- available import resources, assemblies that are economically unjustified to develop but are integrated into the system, and mini autonomous units,
- experience of applying the mobile tracked platform on battery drive with operating devices for performing working operations,
- the company owns the most complex and expensive part of the robot technology, has the finalisation of a base platform which in fact means that they govern the product's integrity, and therefore the development perspective,
- the domestic share in producing a robotic machine is expected to be 69%, using the final price criterion,
- it is estimated that the investment will be returned when production reaches the amount of 31 units.

Conclusions

The government of the Republic of Croatia has promptly reached a high-quality decision on the system of mine action, by forming the Croatian Mine Action Centre. The market strategy of demining was determined, based on finance from the government budget, loans, public companies, government agencies, grants and assistance from foreign funds. Investments in demining, apart from clearing mine suspected areas, result in growth of the whole economy as well.

Owing to the forming of a Scientific Council, being an advisory body of the Croatian Mine Action Centre, scientists from various fields of specialisation gathered, who knew how to address the issue of eliminating mine danger. The solution was firstly to coordinate the potential manufacturers in the development and production of demining equipment. Together, in cooperation between the manufacturers and the scientific council experts, the first models were tested, followed by more complex projects. In such a manner, with an acceptable risk to the manufacturer, the technical development of special products was achieved. The scientific and expert components ensured the quality of demining through optimal methods. The established testing grounds for continual gear testing guarantee the standard and promotion of this high-quality demining model.

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Estimating the Clearance Depth Required in UXO Contaminated Areas

Michael Laneville[27]

Abstract

Clearance of unexploded ordnance (UXO) is a costly and timely endeavour. The depth of clearance assigned to an area is typically governed by the end land use and the detection limitations of the equipment being used for the search. As many projectiles can penetrate deeper than an instrument can reliably detect, one may be required to perform successive searches. After an initial search to the depth of detection of the instrument, the UXO within this horizon can be cleared and the soil removed so that the process can be repeated until the maximum depth of penetration has been cleared. While a conceptual site model may indicate what targets are being searched for, understanding their penetration depths is critical for budgets, schedules and the safety of any clearance project. As a lack of such information will result in over or under clearing, it is imperative that effort is spent to make an accurate estimate of penetration depths. Given that different soil types give rise to different penetration depths, as far as the type of UXO being searched for and the types of soil in the area can be known, one may draw conclusions about the maximum depth of penetration of the target objects. The gold and copper operation at Sepon, Lao PDR, operated by MMG LXML is in the unique position of having detailed knowledge of aircraft bombs dropped during the 60s and 70s and the geological conditions in which these UXO are being searched for. A project presently undertaken within the UXO Department at Sepon applies statistical analysis to such data along with information related to UXO recovered during fifteen years of clearance work in the area and even more throughout the county and applies prudent assumptions from research done elsewhere on UXO. The goal is to provide reasonable estimations of the number, approximate depth and lateral distribution of UXO expected to exist in a given area. Computing this information through custom made software allows the user to vary assumptions, consider alternate scenarios and conclude with approximate levels of confidence that an area will be cleared of UXO at a certain depth. Forming assumptions using actual data, performing a ground truth of the model and feeding this back can further improve its reliability.

Background

MMG LXML owns and operates a gold and copper mine in Savannakhet Province, Lao PDR, known as Sepon. Sepon is located in an area which is heavily contaminated with UXO leftover from the 60s and 70s when American Forces were in the region during the Second Indochina War. UXO clearance is thus an integral part of the cycle for all projects at Sepon, including open pit mining. Presently, the depth below natural surface to which UXO are searched for in mining pits is 12m and is known as the UXO Limit. This is based solely on the maximum penetration depth of a M117 General Purpose 750 pound bomb in dry clay [1]. Changing either the bomb or soil type has significant implications for the maximum depth of penetration. Therefore, the better these two variables can be known, the more accurate a model can be made in which to build a clearance strategy around. This project is still in progress and the main approach employed and planned for follows.

Methodology

While Laos has the unfortunate distinction of being the most heavily bombed country, per capita in the world [2], it is also in a unique position due to the existence of detailed aerial bombing records which have been provided by the US government to assist humanitarian demining operations in the region. The US bombing data contains information related to thousands of sorties; complete with the type of aircraft used, type of ordnance and payload along with coordinates, enabling this data to be managed in a geographic information system (GIS). This record however, is not perfect and problems with the data affecting confidence arise due to datum discrepancies, omitted missions and the original recording techniques used. For example, B-52 mission locations were based on release points while other sorties were based on target points. However, according to the Geneva International Centre for Humanitarian Demining (GICHD), if properly validated, analysed and utilised; there is significant potential to its use [3]. It is noted that although the UXO in Lao PDR includes land service ammunition and sub munitions, this project focuses on aerial bombs. When estimating how deep to search in mining pits, it is the aerial bombs that dictate the final clearance depth required, as their penetration is assumed to be the deepest.

As Sepon is a working mine site, there is considerable data available related to the geology of the area where UXO clearance is required. The most useful for this project is the hardness data of the material being logged during exploration and grade control work. A U.S. Army graphical bomb penetration calculator constructed from test data for bombs and small and large calibre projectiles demonstrates how different soil types affect penetration lengths for a given projectile when other factors such as striking velocity are held constant [1]. This calculator is shown in Figure 1 and uses curves specific to a particular soil type in order to obtain a value on the Y axis. This value is used in the nomograph where the maximum penetration length can be

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determined given the weight of the projectile. Using the similarity between the soil types on the graph and our own classification of soils used at Sepon, we have matched the hardness values logged to curves displayed on the graph. This gives us a starting point for considering the maximum depth of penetration into various soils found at Sepon. Equations have been derived to describe each of these curves and to solve the nomograph mathematically. There have been several other attempts to estimate the penetration depth of ordnance into soils and rock. The U.S. Army Corps of Engineers Waterways Experiment Station (WES) created a straight forward depth penetration equation which allows for a varying striking velocity, fragment weight (fragment is assumed to be a projectile) and a constant dependant on the soil type. Other approaches such as the HULL hydrocode and PENCRV3D analysis represent more rigorous approaches which require striking angle, equations of state of the ordnance and the soil as well as considerable time and expertise [11]. Given that the WES equation is conservative if one assumes a maximum striking velocity and does not require variables which are either unavailable or become additional suppositions; our own equations will be compared with those using the WES equation.

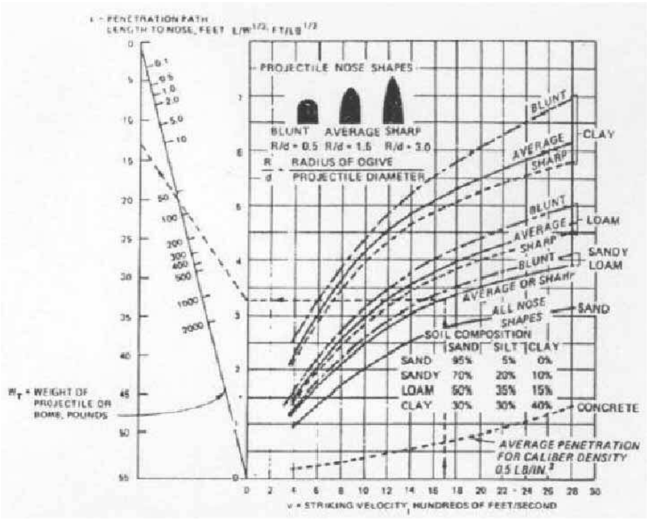

Figure 1: Projectile penetration graph, from [1]

As we are starting with the number of bombs dropped but are ultimately interested in the bombs which failed to detonate, we must apply a failure rate in order to estimate the number of UXO from each mission. During the war, B52 planes which were mainly used to bomb Laos had a payload of 30 tons of bombs, with failure rates as high as 30% [7]. This is on the high and therefore more conservative side found during research done to date and is the default value used for this study. All bomb types for each mission are directly scaled by this amount.

In order to validate the US bombing data, we have compared the locations of approximately 100 bombs found at Sepon over the last fifteen years of searching with the locations provided in the bombing data. The goal is twofold; first to see how reliable the bombing data is and second to determine how to 'spread' the bombing data radially outward based on its expected lateral distribution. For each UXO found, the distance was calculated to the closest point in the bombing data for the same type of bomb. The results were then sorted by distance, showing that 50% (Circular Error Probable or CEP) of bombs were found within 165m of the closest point in the US bombing data for the same type of bomb. It has proven difficult to take advantage of this information as the bombing accuracy of various guidance systems used throughout the war varied considerably. A simple approach would be to use one standard distribution for all missions based on the comparative analysis. A more comprehensive approach would attempt to take into account the tremendous increases in accuracy which improvements in guidance systems allowed. At the start of the conflict, American airmen primarily relied on free-fall bombs which were little different than those used during WWI [4]. Studies on the accuracy of visual and radar precision bombing after WWII concluded that the Eighth, Fifteenth and Twentieth Air Force in Great Britain all put approximately 31% of their bombs within 1000 feet (304m) of the aiming point when between 15,000 and 21,000 feet [5]. This relatively high CEP would come down considerably within a few years of the Second Indochina War. Laser-guided bombs began combat testing in mid-1967 in which 750 and 2000 pound bombs achieved a CEP of 64 (19.5m) and 9.6 (2.9m) feet respectively. By 1971, the Air Force had adapted the laser kit to 500, 1000, 2000 and 3000 pound bombs [4]; which along with the MK81 250 pound bomb, make up all of the bombs being searched for at Sepon. Indeed there is a wealth of information related to the development of guidance systems and their accuracy. This may be reasonably well managed as the bombing data also contains information on dates of missions and the types of aircraft used. Furthermore, the bombing data includes a 'Bomb Damage Assessment' (BDA) which was the crew's own observation about the mission's success. They would assign phrases such as 'Missed Target' or 'Unobserved' which could further be used to define the likely distribution of UXO remaining. Therefore, the expected lateral distribution of bombs could be set for each individual mission in the bombing data based on the date flown, the type of aircraft and BDA; and further cross checked with the record of recovered UXO. This data has been maintained in a GIS database in recent years known as the Information Management System for Mine Action (IMSMA) database, which, along with records of operators' past clearance, includes the bombing data and victim data [6]. It is noted that the sample size of 100 bombs may not be representative of the overall population, however we are not attempting to apply this model over vast areas or distances from the source data. Furthermore, the process is underway to include approximately five hundred additional UXO from IMSMA which have been recovered within the Savannakhet province in order to produce a more representative sample.

This adjusted number of UXO can now be expressed as a density (UXO/m^2) which takes into account the types of bombs dropped, failure rates and lateral distribution. We then consider the soil hardness and make an assumption of the striking velocity of the bombs; which we conservatively assume is the maximum delivery speed for each given aircraft. Using the equations referred to above, the maximum depth of penetration can now be estimated for each type of bomb in a particular soil. This may be a sufficient conclusion to reach if near 100% confidence in clearance is required and the area is geologically homogeneous.

In general, the penetration depth depends on the ordnance shape, weight, angle of impact, striking velocity, materials of construction and soil type. Penetration depth is greatest when the soils are fine grained and saturated and the angle of penetration is near vertical. Studies show that after impact, ordnance typically follows a J-shaped trajectory resulting in a decrease in penetration depth [8]. Bombs dropped from high altitude, impacting vertically and at high velocity represent a worst case scenario and according to the US Army Corp of Engineers (USACE), the actual depth of penetration for most items is much lower than the maximum depth [9]. Following depth distribution studies from the USACE based on the maximum depth previously calculated, we can obtain estimations of the number of UXO expected at various depths below natural surface. This depth distribution has been refined based on the depths of our own recovered items which allows for a feedback into our model to output increasingly accurate estimates. This approach also allows one to consider the clearance depths necessary in order to obtain a percentage of the expected UXO. This concept is particularly valuable as the dramatic decrease in UXO found approaching the maximum depth implies the enormous cost to remediate the final percentile of expected UXO.

Computer Modelling

While considering a single bombing point over homogenous ground conditions is manageable for a desktop study, taking into account the number of variables described thus far and the real world conditions of variable soil conditions demand a computer's processing power. A custom program is currently being developed to manage this data, vary assumptions and deliver outputs (see Figure 2 for a sample screen shot). Specifically, topographic data, US bombing data and geological data are the main inputs to be synthesized with the user able to control parameters such as failure rates, lateral and vertical distribution patterns and the required level of confidence. This concept of confidence is not absolute but rather directly related to the assumptions and information provided to the program. For example, if the maximum depth of penetration of a 250 pound bomb in dry clay is 8.27m, than a search to this depth will yield 100% confidence that the object will be located. Any omission of inputted data or invalid assumption will lead a corresponding increase in the margin of error associated with the level of confidence. The output includes polygons in a format compatible with standard GIS software at user-requested depth intervals which need to be searched. The program is highly visual allowing the user to study the topography and the relationship between the bombing data, geology and prescribed search depths. Crucially, this software will have the ability to consider penetration depths for multiple layer scenarios including the complex conditions modelled from the geological data. To simplify and remain conservative, all bombs will be assumed to have impacted vertically. As the present application and motivation for this project is mining activities, this software allows the user to consider multiple clearance strategies based on searching the minimum amount of material compared with a searching to common depth while maintaining or changing the 'confidence'. This is only available if the user is willing to accept less than 100% 'confidence' in the results as otherwise, the maximum depth of penetration within the area is the required search depth.

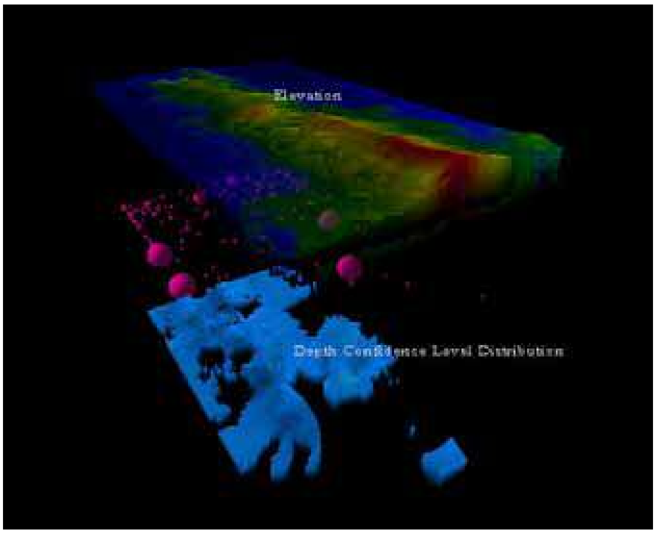

Figure 2: Computer program showing topography (upper layer), bombing data (middle layer) and areas requiring deep clearance (lower layer), from [12].

Conclusions and Going Forward

This bomb penetration depth estimator is a tool to assist with the preparation of a clearance strategy. Other sources of information such as eye witness accounts, historical records, past, present and future land use and UXO accidents must also be used to define the risk and shape the clearance strategy. In addition to serving this purpose, this program has the potential to rate the relative UXO risk of an area or identify opportunity for land release approaches. Any clearance task is a 'living project' and practically speaking, as each layer is being searched and the soil removed in order to search the subsequent layer, crucial information is being gathered about the level of contamination in the area. This should also be used to verify the model and if possible, feedback into it. The mechanism for relating fragments found during initial shallow searches to the penetration model is still being considered.

As the IMSMA database continues to advance, it is hoped that an increasing number of recovered items can be added to the analysis which goes into defining the lateral and vertical distributions of UXO. In this way, a model built on real data coupled with conservative assumptions should increase its relevance. The drawback with using the data from the IMSMA database is that clearance is typically done for a specific reason and will not be expected to be spatially random. This implies that there will a bias introduced in correlating the bombing data with recovered items and may be impossible to overcome. This project has revealed that of profound importance, is a wholesale study into the overall reliability of the bombing data and of the constituent attributes recorded. Going back to the original data sets from the

Combat Activities Asia (CACTA) and Southeast Asia Aerial Bombing Database (SEABAD) may be the logical place to start and investigate claims that some US bombing data coordinates have been assigned incorrect datum information and to have a better grasp of the limitations and opportunities which the bombing data offers [10].

The main tasks going forward are to integrate multiple layer penetration calculations and improve the lateral distribution based on the likely guidance system employed and with a larger data set. Given that there are likely to be some missions which have not been included in the bombing data, any analysis using the data must recognize this possibility. Two options presently being considered are to disregard the notion of missing data entirely and base the analysis only on the data available or to perform some type of statistical sampling to the data in an effort to recreate it. It is the goal that all of these features will be available within the final computer program.

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Regional Approach and Cooperation Towards Mine Contamination Issues in Different Regions

Dorijan Maršič[28]

The presentation gives an overview of experiences and results accomplished in the region of South East Europe in the field of humanitarian demining – and gives a highlight of regional cooperation as an important confidence-building measure, particularly in countries emerging from conflict.

The principles, level of cooperation and sharing of experience and accumulated knowledge, application of multi level methodologies learnt through the implementation of humanitarian demining activities in South East Europe were the key elements in organizing and facilitating regional approaches to mine action in Central and South East Asia and the Caucasus (yet still recognising that the primary responsibility for addressing post-conflict and disruptive challenges lies within the national authorities of the affected countries).

Promoting regional approach is one of the key dimensions of the operation of the ITF Enhancing Human Security. ITF believes regional co-operation to be vital as the countries in South-East Europe address many of the issues more efficiently as well as more cost-effectively by helping each other achieve their shared overall objective of mine-free land. Striving towards excellence, as well as exchange of experience, information and know-how is a crucial component for the attainment of this goal.

The benefits Of regional cooperation are:

- Measure against duplication of resources and efforts – financial, physical, material and human;
- Optimum use of resources (derived from the first one);
- Sharing of expertise and experience in solving unique mine problems in the field of Mine Action in whole region;
- Exchange of staff and joint projects foster experience through working in various environments;
- Regional cooperation through joint projects (clearance, capacity building, regional centres of excellence etc.) enables building a social network in the region;
- Neccessity to build on existing capacity in the region and that the strong institutions help the weak ones;
- Regional pooling of resources pays out – such as sharing of expensive technologies in region, which can reduce the cost of programs;
- The younger programs can benefit from the lessons learned and use the existing knowledge;
- Identification of Mine Action priorities, which can only be solved effectively with regional cooperation;
- Crosscutting issues addressed through Mine Action regional activities with other regional issues such as poverty, border control, environment, development etc.;
- Mine action activities on regional level contribute to confidence building.

In the text ahead I'd like to present some examples of good practice in the field of regional cooperation.

1. South-East Europe Mine Action Coordination Council (SEEMACC)

The region of South East Europe remains one of the most mine and explosive remnants of war (ERW) contaminated regions in the world. SEEMACC also represents one of the priorities on national and international level to stabilize and normalize living conditions for the affected communities.

SEEMACC vas established in 2000 and has 8 fully entitled members (AMAE (Albania), BHMAC (Bosnia and Herzegovina), CROMAC (Croatia), MAC Serbia (Serbia), RCUD (Montenegro), Protection and Rescue Directorate (Macedonia), ANAMA (Azerbaijan), and ITF Enhancing Human Security (Slovenia) and has 3 members with observer status, namely MDDC (Konjic, BIH), CTDT (Croatia), UNMIK/KPC (Kosovo).

SEEMACC was helding19 regular and 6 irregular meetings adopting documents (Strategy, Rules of Procedure, Minutes, SoPs, Newsletter), establishing Working Group, running project activities financed by various donors and its own Web page. SEEMACC was financially supported by US-DoS through ITF.

SEEMACC key guiding principles are:

- holistic approach
- neutrality
- humanity
- partnership
- compliance with the international standards
- technical expertise and professionalism
- national ownership

SEEMACC promoted objectives were exchange of experience, expertise and knowledge in relation, to Mine Action in South-East Europe, promotion of regional approach in the planning of demining programs, promotion of regional approach in relation to fundraising for Mine Action, exchange of experience, expertise and knowledge in relation, training of deminers and managing personnel and

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finally exchange of information on the testing of new technologies in demining.

SEEMACC strategic framework was to pursue the following strategic objectives to manage and/or eliminate humanitarian, socio-economic and security threats from the landmines and other explosive hazards:

Strategic Objective 1:

The SEEMACC is the focal point for dialogue and standing channel of cooperation for bilateral and multilateral cooperation initiatives in the field of Mine Action and related issues between its members, observers and partners.

Strategic Objective 2:

The SEEMACC provides a comprehensive capacity building and technical assistance program to its members, observers and partners

Strategic Objective 3:

The SEEMACC is internationally recognized expert association with its membership base expending beyond SE Europe.

2. Technical Co-operation on Explosive Hazards Reduction and Response in Central Asia

The OSCE Office in Tajikistan and the ITF Enhancing Human Security initiated effort and a system of mechanisms to support the participating States in Central Asia and Afghanistan, in addressing the concerns and challenges stemming from Explosive Hazards. Their origin can be found in the past and/or ongoing conflicts, mistreatment, abandonment and neglect as well as criminal and terrorist actions.

The term Explosive Hazards includes challenges and issues related to:

- unexploded and abandoned explosive ordnance as well as landmines,
- other excess, unsecured and unserviceable engineering munitions and ordnance and
- presence of booby traps, explosive and Improvised Explosive Devices.

Key objectives of the project:

- **Structured format for the Exchange of Experiences and Best Practices.** The focus is on bringing together technical experts and practitioners.
- **Enhancing national capacities in accordance with the international standards.** The focus is on developing know-how and expertise on individual and institutional levels.
- **Fostering dialogue through technical co-operation.** The focus is on promoting OSCE Confidence and Security Building Measures.

Mechanisms of cooperation are being implemented through annual multi-lateral workshops and conferences, bi- and multi-lateral exchange programmes, technical assistance and trainings and other bi- and multi-lateral projects.

3. Initiatives on Regional Cooperation and Confidence Building Through Mine Action in South Caucasus

The ITF initiatives taken in last few years in the South Caucasus region were as follows:

- 1st Management Training for Middle Managers of the Mine Action Program in South Caucasus, 06 December 2004 – 15 February 2005, Tbilisi, Georgia.
- Workshop on Regional Cooperation and Confidence Building through Mine Action, 5-6 October 2005, Tbilisi, Georgia.
- Regional Rehabilitation Training Program by URI Soča, Slovenia, 2008.
- 2nd Management Training for Middle Managers of the Mine Action Program in South Caucasus, 9-27 November 2009, Tbilisi, Georgia.
- South Caucasus Socio-Economic Reintegration Program for Mine Victims, 2009 -2015.
- Regional Workshop towards the Socio-Economic Reintegration of Persons with Disabilities in South Caucasus, 5-6 December 2011, Tbilisi, Georgia.

4. Regional Approach to Stockpile Reduction (RASR)

The Regional Approach to Stockpile Reduction **(RASR)** is a long-term, coordinated, regional approach to address the threats posed by excess, unstable, loosely secured or otherwise at-risk stockpiles of conventional weapons and munitions in South East Europe. **RASR's** ultimate goal is to contribute to regional security by working to prevent disastrous explosions and destabilizing diversions of stockpiled conventional weapons and ammunition.

RASR partners are:

- U.S. Department of State's Office of Weapons Removal and Abatement (PM/WRA)
- DTRA - Defense Threat Reduction Agency
- ITF Enhancing Human Security
- NATO Maintenance and Supply Agency (NAMSA)
- OSCE
- RACVIAC
- SEESAC
- Small Arms Survey
- Swiss Implementation and Verification Unit

RASR encourages affected governments to develop a pro-active, coordinated, regional approach to secure and destroy SA/LW, by building local capacity, sharing best practices and lessons learned, and pooling resources in order to maximize their efficiency. The ultimate aim of the **RASR** initiative is to prevent disastrous explosions or destabilizing diversions of conventional weapons and munitions. Ageing, excess, and unstable stockpiles of conventional weapons and munitions pose dual threat of illicit proliferation and accidental explosion, which could cause humanitarian disasters and destabilize individual countries or regions as a whole.

There are five priority issues where the **RASR** can facilitate greater coordination amongst actors involved in conventional weapons reduction:

- National and regional policy
- Infrastructure
- Training, education, and capacity building
- Sharing of information and best practices
- Standardization

RASR’s ultimate goal is to contribute to regional security by working to prevent disastrous explosions and destabilizing diversions of stockpiled conventional weapons and ammunition.

5. Regional Cooperation in Mine Action and CWD Rationale

Resources: Cooperation prevents the duplication of resources and efforts - financial, physical, material and human.

Coordination and information: Interaction facilitates the exchange of effective and efficient solutions to unique or similar landmine problems.

Social: Social networking and confidence building between counterparts in the region encourages current - as well as future - cooperation efforts.

Capacity-building: Cooperation augments institutional capacities, and if established institutions can help those with less experience and stability.

There is a Cross-cutting effect of the regional cooperation, as well: Mine Action activities can aid other regional issues, such as border security, development and commerce.

The Design Features vital to regional program successes are:

- ***Political/Strategic/Operational/Technical*** Level;
- ***Funding***;
- Strong ***country commitment*** to regional cooperation;
- The scope of ***objectives has to match*** national and regional capacities;
- ***Clear delineation and coordination of the roles*** of national and regional institutions;
- Accountable ***governance arrangements*** with the end goal of gaining country ownership;
- Planning for ***sustainability of program outcomes.***

Peer Support for Survivors of War: The Science and Practice of a Psychosocial Intervention

Kenneth Rutherford[29]***, Cameron Macauley***[30]

In the aftermath of violent conflict, many survivors suffer from intense emotional changes resulting from traumatic events they have witnessed or experienced. They are overwhelmed with grief, bitterness, horror, helplessness, anger, and the desire for revenge. For a significant number of these survivors, recurring memories and other symptoms interfere with their behavior and their ability to interact normally in society. They have a high risk of suicide, impulsive violence, drug and alcohol abuse, and long-term mental health problems.[31]

In a post-conflict environment it is often difficult to obtain counseling or psychotherapy to address these problems. War-affected communities have few health professionals and health care is often limited to basic services—or frequently, no services at all, and survivors must deal with their psychological burdens as best they can without professional care. Violent acts committed by survivors who are severely traumatized may stimulate further turmoil in communities still tense from recent conflict.

A solution to this problem is to provide basic counseling services administered by local residents who have received brief, intensive and carefully focused training on psychological rehabilitation. Experience has shown that these services are more effective if provided by trauma survivors who have attained some recovery from their own experiences. Because they know the culture and history of the community, these trained "peers" can establish a trusting relationship more effectively than health professionals from outside.[32]

When these "peer support workers" (PSWs) operate in a supervised program with ongoing logistical support and capacity-building, the results can be dramatic. Over the past two decades, a variety of these programs have been initiated in conflict-affected nations and they have inspired mutual support programs for survivors of many different kinds of trauma. Recipients of peer support are frequently inspired to help other survivors in the same way, and the psychological health of PSWs also improves while they help others.[33]

Evidence is growing that shows peer support to be an effective intervention. A study published in *The Journal of ERW and Mine Action* in 2011 found that 470 survivors of war-related violence in six countries, 56% of whom were landmine/UXO survivors, benefitted significantly from 24 months of regular peer support provided by other survivors who had been trained. All participants showed improved scores on the SF-36 psychometric test administered before, during and after the intervention period. Survivors who had sustained injuries within 24 months of the study showed the most significant improvements.[34]

An important result of peer support programs is the impetus they provide for survivors to work together. Survivor groups work on various projects to help communities recover from war, including income-generation, psychological support groups, sports and various aspects of survivor/victims' rights. Peer support programs can bring new members into these groups and teach survivors how to organize and contribute to a better, more peaceful society.

Critics of peer support warn about the dangers of retraumatization when unresolved psychological injuries are revived by exposure to another survivor's traumatic history. Selection criteria for PSWs may depend largely on the candidate's self-assessment, and PSWs who receive as little as five days' training before starting to work with survivors are not always prepared to deal with strong emotions when listening to stories of torture or violence. Indeed, the low level of training PSWs receive calls into question the therapeutic benefit of such counseling. Another possible weakness with the peer support approach is the potentially high cost of such a program, in which PSWs conduct home visits to survivors, incurring transportation and communications costs over the weeks or months invested in each beneficiary. Much of this criticism comes from psychologists and psychiatrists

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who argue that psychological trauma requires professional attention in order to prevent long-term complications such as depression or PTSD.[35]

Given this controversy, further research is needed to investigate peer support programs for survivors of war and to explore their effectiveness as therapeutic interventions. Where such information is available, therapeutic outcomes should be compared and costs examined. Both quantitative data and qualitative evaluations of program success as measured by participants and beneficiaries should be taken into account. After examining a representative sample of programs, best-practices recommendations for the design and structure of peer support programs in post-conflict settings should be made available to humanitarian agencies seeking to implement programs of this kind.[36]

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Ethics and Compliance Assessment of De-mining Operational Activities

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Abstract

This paper focuses on the ethical aspects of de-mining research and development within Framework Programme 7 (FP7) Project D-BOX (*Comprehensive toolbox for humanitarian clearing of large civil areas from anti-personal landmines and cluster munitions*); it presents the methodology and results of an ethics and compliance assessment of operational demining activities, and the underlying aspects relating to the protection of the environment, ethics and cultural differences in the field.

Introduction

The FP7 Integration Project D-BOX (*Comprehensive toolbox for humanitarian clearing of large civil areas from anti-personal landmines and cluster munitions*) addresses the development of innovative solutions integrated in a comprehensive toolbox providing tools, methods and procedures to improve the effectiveness of clearing mines.
D-BOX, asserts equal importance to the ethical aspects of de-mining as to technical aspects of tools and sensors that comprise the Toolbox. Ethical based deliverables include (i) an Ethics Aid Memoire to include an ethical impact assessment leading to an ethics behaviour protocol for de-mining operatives and managers for establishing and maintaining trusting and productive relationships; (ii) Cultural guidelines; (iii) Error prevention methodology for tools and techniques and (iv) Protocols for ethical issues.

Ethics and compliance assessment of operational activities; methodological aspects

CBRNE Ltd, (Work Package 3 Lead), applies as methodology literature reviews alongside an analysis of codes of conduct, internal compliance and a number of targeted interviews based on questionnaires. A robust filtering and analytical process underlines evidence and recommendations from the meta-evaluation process.

A research framework based on International Mine Action Standards, IMAS[39],focuses on mine action safety, occupational health, use and care of dogs, protection of the environment, relations with local communities and ethical and cultural issues. We used the Likert scale (1 to 6) for measuring levels of satisfaction, and questions to find ethical and cultural issues. Two questionnaires targeted management and operational staff. The latter in January 2013 in the Falkland Islands where 21 people (14 de-miners, 1 x ops manager, 2 x supervisors, 2 x team leaders and 2 x medics) were asked to fill in questionnaires and two were interviewed as part of that process for a period of 30 minutes each.

Results and discussion

The responders were explicitly told to reply with reference to their overall experience within the demining industry and not their present assignment. The average years spent in the industry varied between 12 and 17 years with only two de-miners having just one year's experience, the Falklands being their first deployment. Operational areas included Zimbabwe, Cyprus, Lebanon, Afghanistan, Congo, Sudan, South Africa, Mozambique, Kuwait, Croatia, Iraq, Eritrea and the Falklands.

The level of satisfaction regarding standards for safe workplace, machinery, equipment, safe-work practices, provision of Personal Protection Equipment, supervision and training, health care and emergency medical support is very high: 18 people responded with levels of satisfaction from 4 to 6 on the Likert scale (satisfied, very satisfied, totally satisfied). One unsatisfied de-miner with 1 years' experience justified his answer with the remark: "PPE cannot prevent injuries so I want total protection"; the ops manager suggested that "Prodders and trowls need improving for different terrain".

Twelve respondents were unaware of the opportunity for Safety and Occupational Health representation. All were aware of

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39 http://www.mineactionstandards.org/international-standards/imas-in-english/list-of-imas/; Paktian (2012), (Geneva International Centre for Humanitarian Demining), describe the relations between IMAS, NMAS and SOP': The IMAS are the mine action community standards endorsed by the United Nations (UN). Designed to improve safety and efficiency and promote a common and consistent approach to the conduct of mine action operations. The aim of the IMAS is to assist National Mine Action Authorities (NMAA) in the development of National Mine Action Standards (NMAS) and as a source for the development of SOPs and training material. The authors state in practice, many mine action organisations establish Standard Operational Procedures (SOPs) based on IMAS's requirements, knowing that when the SOPs are IMAS compliant they will be NMAS compliant with only moderate amendments.

the availability of Safety and Work procedure documents (*Project Health and Safety Plan/Medical Evacuation Plan/ Environmental Plan and SOPs)* via supervisors; They had all received refresher training on these subjects; one medic advised in most cases he is the chosen representative, and the operational manager said in most cases it is not a committee but one person that acts as the delegate representative. Just three of the responders were unaware of the existence of a code of conduct, but some associate the code of conduct with relationships in the chain of command.

Dogs are used on average two out of five engagements and respondents considered standards of care as consistently high.

There were three references to environmental impact: 2 intentional bush fires; one without an impact study in Zimbabwe and large excavations left un-reinstated in Afghanistan with a recommendation from one respondent that disturbed vegetation should be restored as standard practice.

Three respondents said they had been confronted with cultural, human behaviour or ethical issues during the last 5 operations: one made reference to the “racism problem - black are ill-treated”); another underlined the cultural and religious differences saying “Islamic countries, for example Lebanon, are very sensitive to their culture and religion” - *i.e. difficult countries to work in*; one de-miner remarked on the remuneration rates for long hours of work with the comment “For a de-miner to spend 9 hours (working) is too much for this type of job”.

Our research is on-going; these results are partial and have to be correlated with answers from future surveys; but they show the level of ethics and compliance in demining companies is high, the employees are satisfied with the implementation of standards and that even if not all operational staff are fully aware of codes of conduct, there are few ethical issues.

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Development of the Small Remote-controlled Platform "Micro MineWolf"

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Abstract

This paper presents the design and development of the small, compact, remote controlled platform purpose-built for landmine, IED and route clearance in ultra-rugged, hard to access environments. Based on proven MineWolf technology with a selection of detachable tools, MineWolf Systems have developed and manufactured the Micro MineWolf, a robust and versatile tool for the most demanding conditions. It has been designed to meet specific requests for a more portable and manoeuvrable platform with the same robust and reliable MineWolf technology and multi-purpose functionality. The Micro MineWolf is a platform designed for all entities in the mine action community, including the armed forces, governmental agencies (mine action centers), non-governmental organizations (NGOs) involved in the humanitarian demining, and the commercial demining companies. The Micro MineWolf is a solution comprising of a base vehicle (platform), additional add-ons and tool attachments. It is lightweight, but in the same time armoured and robust, fulfilling the requirements of endurance and survivability and ease of deployment and transportability.

Introduction

It is estimated that more than 110 million active landmines are scattered in 68 countries with an equal number stockpiled around the world waiting to be planted. Mines remain in the ground up to 75 years and pose one of the most serious humanitarian challenges facing the world today. They hinder reconstruction and development; create obstacles on the return and reconciliation process, their indiscriminate use threatens not only individuals and families, but also the peace and fabric of entire communities and nations.

To date, millions of dollars have been spent with little impact on the global scale of the issue. The struggle to remove mines and unexploded ordnance goes on, and improvements are continually sought on how to increase the safety and cost-effectiveness of mine clearance. Mine clearance efforts still rely almost exclusively on metal detectors, dogs and manual probing. Changes to tools and equipment, however, could improve useful short-term improvements. One major area of potential improvement is the use of mechanical equipment to assist in mine clearance activities.

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Scope

Nowadays more and more machines are used in humanitarian mine clearance. However, a lot of them have been designed for construction activities, or for military use; to breach a small gap in minefield, thus, minimizing casualties. These systems are generally not suitable to land clearance in a UN or peacetime humanitarian clearance environment. There is a clear need for originally designed machines to clear various types of terrain containing landmines and explosive remnants of war. The fact that mines vary in size significantly requires that any system designed needs to cover every inch of ground. Also, the personnel using the equipment must be protected for the worst case mine found in the theater. Remote control is an option that removes all risks to personnel.

The military and civilian humanitarian personnel are encountering similar threats from explosive devices, whether during or after a conflict, and that the requirement for equipment that is flexible enough to deal with the range of present explosive hazards and can prevent operator casualties is ever more paramount. In conflict situations, troops need to protect themselves against hostile fire and minefields, but more frequently have to deal with IEDs being used as weapons of war. Soldiers need equipment that will help them both to locate and remove IEDs from patrol routes, as well as free up access to larger areas still contaminated with landmines and unexploded ordnance (UXO) from the previous decades of conflict in the country.

In the peacekeeping context, in the immediate aftermath of conflict, peacekeeping forces need equipment for clearing explosive hazards for their own force protection while carrying out their mandated duties. In some theatres, they are also required to conduct small scale humanitarian demining in order to open up routes and clear contaminated areas for the distribution of aid, and the rehabilitation of the country. In these instances, clearance equipment must also be capable of clearing ground to the International Mine Action Standards (IMAS). In the emergency relief and subsequent reconstruction and development phases following a conflict, civilian agencies (governmental, non-governmental and commercial organisations) are tasked by national authorities, the United Nations or donors to conduct humanitarian demining of hazardous areas. Traditionally, these organisations have used manual deminers, mine detection dogs and big machines with flails or tillers to survey and clear large areas of land known, or suspected to be, contaminated with landmines or UXO.

In more recent years, humanitarian demining personnel have also had to deal with the threat from scatterable munitions, sophisticated IEDs and hazards from unstable ammunition storage areas, none of which can be dealt with by traditional mechanical means. This has meant an increase in the use of manual clearance procedures with the associated increase in risk to operators.

The Requirement For Machines

The increasingly diverse range of explosive hazards facing both military and humanitarian personnel can certainly be dealt with safely and efficiently by using machines. Machines are not new and have always had the advantage of reducing EOD/IED/mine clearance operator casualties compared to manual disposal. However, they can be expensive to procure and maintain, and often pose logistical challenges in the remote and environmentally challenging locations in which they are usually required. In conflict scenarios, troops require easily manoeuvrable EOD equipment that will assist rather than hinder their primary operational task. For humanitarian organisations it is often justifying the cost outlay rather than manoeuvrability that deters the use of machines over people in EOD, IED and landmine clearance, but this can be detrimental to the life expectancy of the EOD technician. The change in nature of recent conflicts and the increasing and more sophisticated use of IEDs and other weapons pose new threats to military forces and humanitarian organisations. A more progressive approach needs to be developed by using mechanical solutions if loss of life is going to be minimised in the future.

In this case it might be worth considering having one small remote platform with several tools or attachments to choose from, depending on a known threat or tactical situation. If, for example, the remote platform is armoured against small arms fire, can take the blast from detonation to the front, has a good remote range of 1 kilometre (0.6 miles) or more with suitable camera systems, then it only needs the tool to complete the operation. The tools can be almost anything already out there: small disruptors, mechanical arms and grippers, flails, tillers, rollers, dozer blades and varying types of detectors.

The Development Of The MineWolf Solution

Building on its toolbox concept and in response to the customers’ specific requests for a more portable and manoeuvrable remote controlled solution with the same robust and reliable MineWolf technology and multi-purpose functionality, in just few months of work, the MineWolf Systems engineers have developed the Micro MineWolf (MW50), by far the smallest MineWolf system to date. It has been designed to meet specific requests for a more portable and manoeuvrable vehicle with the same robust and reliable MineWolf technology and multi-purpose functionality. At just 1.2 m wide including the tiller, the Micro MineWolf is easy to manoeuvre and is small enough to operate in jungles and forests or in the built environment making it the ideal platform for supporting foot patrols in urban or remote areas. It can also operate on steep slopes of up to 45 degrees or in trenches so that clearing difficult areas can be done remotely and operator safety is not compromised. The MW50’s compact size means that it can be moved to areas which cannot usually be reached by mine clearance machines. It can be transported on the back of a 4x4 pick-up truck or on a small off-road trailer or by helicopter enabling easy access to the remotest areas.

The Micro MineWolf (MW50)

Like all MineWolf platforms, the Micro has been designed to be a workhorse, robust enough to withstand impacts from anti-personnel mines. Currently designed to be fitted with the tiller attachment it will also come with a range of other attachments as required including the robotic manipulator arm. Unlike the other MineWolf products the Micro MineWolf is rubber tracked and able to drive up to 15 km/h, which means that fitted with the appropriate tool, it should be able to clear roads and runways from cluster munitions and other explosive remnants of war.

The MW50 has been designed for use in multiple scenarios and should be of interest to military forces and humanitarian agencies as well as to internal security forces. Scenarios where the Micro MineWolf would be an invaluable tool include:

- Landmine and IED clearance in hard-to-access areas;
- Route clearance (and mule function) in support of foot patrols through jungle and forest;
- Route clearance and counter-IED in urban routes and buildings;
- Small humanitarian demining projects – including technical survey; and
- Road and runway clearance.

The Micro MineWolf in a transport mode

Conclusion

There is an obvious advantage to military and humanitarian operators of having a small remote-controlled machine in their fleet that can be fitted with different tools depending on the type of hazard faced: a tiller or flail when required to process mine contaminated land to international standards; a robotic manipulator arm to remove suspicious explosive devices; or a dozer blade and bucket to remove larger obstacles from suspected areas. A fully remote-controlled vehicle which is high-tech enough to be manipulated using camera systems yet robust enough to withstand blasts from anti-tank mines or IEDs would not be idle for long in any conflict or post-conflict environment. The Micro MineWolf multi-purpose concept offers an organisation operator safety as well as the flexibility of one machine for many tasks. MineWolf products are tested to military standards and are proven and operational in over 20 countries. The company has built its reputation on providing quality products with effective service support to keep machines operational in the toughest conditions. It expands its product portfolio in response to emerging needs in the field, and is currently developing additional attachments to its existing fleet of machines.

An investment in a small platform that can be used for a variety of tasks, can be transported easily, controlled remotely and be robust enough to deal with the impact from explosions is a value-for-money option for both military and humanitarian organisations. Although there is a strong debate going on in the mine action community on the use of the machines, their cost-effectiveness, safety, and clearance capabilities are proving the fact that machines are valuable assets that can remove landmines. Mechanical options are really not options but an economically feasible necessity.

Evaluation of Metal Detector Pinpointing Accuracy under Field Conditions

Kazunori Takahash[42]

Abstract

The pinpointing accuracy of commercial metal detectors is evaluated in this study. The evaluation is based on the results obtained from a blind test in the field and their statistical analysis. The derived accuracy can thus be considered that under field conditions. It is about ten times worse than previously evaluated pinpointing accuracy under laboratory conditions and varies depending on models. In order to identify the source of the difference in pinpointing accuracy among detector models, their sensitivity profiles and search heads are compared. As a result, smaller search heads tend to show better pinpointing accuracy. However, larger search heads may be advantageous in the productivity of operations. Therefore, oval-shaped coils and double-D configuration seems to be a good approach.

Introduction

Metal detectors are commonly used in clearance operations not only to detect landmines but also to locate them. The pinpointing accuracy has previously been evaluated only in laboratory [1]. However, most likely, the accuracy cannot achieve the level evaluated under laboratory conditions when metal detectors are used in real operations. In this study, the location performance of commercial metal detectors is statistically evaluated. The analysis is based on the pinpointing error obtained in a blind test in the field – a test campaign as a part of International Test and Evaluation Program for Humanitarian Demining (ITEP) in Germany in 2009 [2]. The test was carried out with five metal detector models from four manufacturers. The derived performance can be considered under field conditions and should be similar to that in real operations.

Pinpointing error analysis

If a target is located at (x_0, y_0) and is located at (x_0', y_0'), the pinpointing errors respectively in x- and y-direction are Δx and Δy and the total error can be defied as the distance between (x_0, y_0) and (x_0', y_0') as:

$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{\left(x_0' - x_0\right)^2 + \left(y_0' - y_0\right)^2} \qquad (1)$$

Assuming the location errors in x and y are uncorrelated and normally distributed, the location error d is characterised by a Rayleigh distribution, whose probability density function (PDF) and cumulative density function (CDF) are given as follows:

$$f(d;\sigma) = \frac{d}{\sigma^2}\exp\left(\frac{-d^2}{2\sigma^2}\right) \qquad (2)$$

$$F(d;\sigma) = 1 - \exp\left(\frac{-d^2}{2\sigma^2}\right) \qquad (3)$$

where the parameter σ is called mode.

Fig. 1 shows some histograms of location error obtained in the field test with detectors shown in Table 1. Rayleigh distributions are fitted to the histograms to model the distribution and modelled PDF and CDF are shown in blue and red curves, respectively. We can see that the blue curves are well fitted to the histograms, meaning that a Rayleigh distribution well describes the location error distribution. When a distribution is modelled, its mode and 95% percentile can be calculated and they are plotted with blue and red circles in Fig. 1, respectively. Mode σ indicates a location error that happens most frequently (i.e., the peak of a PDF), and 95th percentile indicates location errors containing 95% of detections. Moreover, modelling distribution allows us to calculate a detection rate within a certain distance. Therefore, by calculating these parameters, pinpoint accuracy of metal detectors can be evaluated. Table 2 provides mode, 95% percentile and detection rate within 5 cm radius calculated for detectors tested in the field test.

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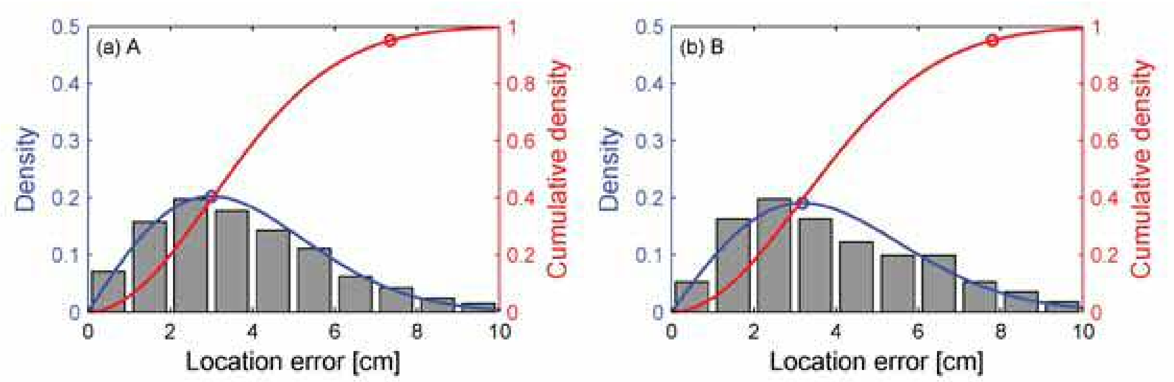

Fig 1. Location error distributions of detectors (a) A and (b) D. The blue and red curves show modelled probability density and cumulative density functions of Rayleigh distributions. The blue and red circles show mode and 95th percentile.

Detector model	Working principle	Working mode	Search head shape	Search head size	Remarks
A	Pulse	Dynamic	Oval	17 x 31 cm	Static mode while pinpointing
B	Pulse	Dynamic	Oval	14 x 33 cm	Static mode while pinpointing
C	CW	Static/dynamic	Circular (double-D)	Φ 28 cm	
D	Pulse	Static/dynamic	Circular	Φ 23 cm	
E	Pulse	Dynamic	Circular	Φ 20 cm	

Table 1 Detectors evaluated in this study.

Pinpointing accuracy and sensitivity profile

In order to understand the source of the difference in pinpointing accuracy, sensitivity profiles (also know as footprint) and the derived performance were compared. The sensitivity profiles of the detectors evaluated in the test were obtained by reanalysing the STEMD Lab test data [1]. The measured data were for various sizes of targets and they were interpolated in order to obtain profiles for a target equivalent to 10 mm 100Cr6 balls so that the different models can directly be compared. Fig. 2 shows the modelled sensitivity profiles. Note that two shapes of footprints can be obtained for the detector A in fore-aft and transverse directions because it employs oval-shaped coils. Mode and 95th percentile as pinpoint accuracy are plotted with respect to the widths of the sensitivity profiles in Fig. 3. Although there are only a few detector models evaluated in this study, it seems that the width of the sensitivity profile and pinpoint accuracy are linearly correlated, as the regression lines (dashed lines in Fig. 3) show. Note that the detector C is a double-D detector and this type of detectors employ a unique way to locate targets. Thus, the detector C is thought not to lie on the linear relation, and it was not included in the regression.

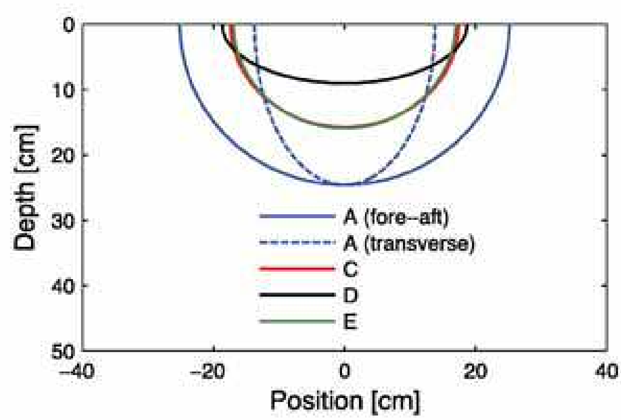

Fig. 2. Modelled sensitivity profiles for a target equivalent to 10 mm 100Cr6 ball.

Detector model	Mode [cm]	95% percentile [cm]	Detections within 5 cm radius [%]
A	2.8	6.8	80
A'	3.0	7.3	75
B	3.0	7.3	75
B'	3.6	8.9	61
C	3.4	8.4	65
C'	3.2	7.8	71
D	3.4	8.3	66
E	3.5	8.7	63

Table 2 Pinpointing accuracy of detectors evaluated in this study.
Prime indicates that the detector was operated by experienced personnel.

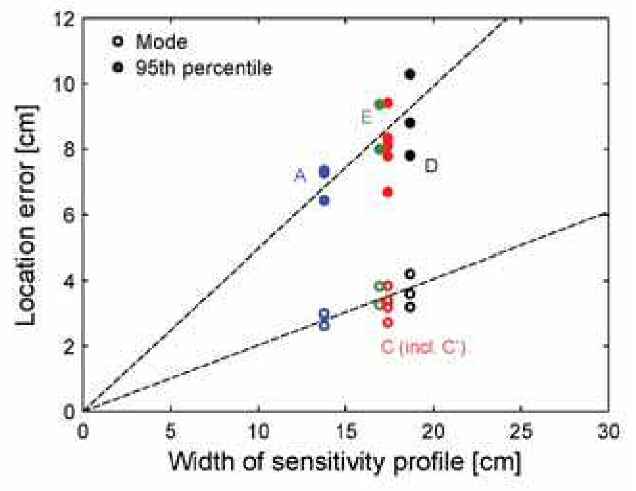

Fig. 3. Pinpoint accuracy (Mode and 95th percentile) as a function of width of sensitivity profile.

Discussion and conclusions

In this study, pinpointing accuracy of metal detectors was evaluated based on the results obtained from a field blind test. The evaluation employed statistical analysis and proposed three indications as the measures of pinpoint accuracy, namely mode, 95th percentile and detection rate within a certain radius. By analysing the data from the ITEP field test in Germany, it was shown that the obtained accuracy in the proposed way is about ten times worse than the accuracy previously evaluated under laboratory conditions. This is mainly because of the deference between locating targets buried at known and unknown locations. The analysis used in this study can quantify the pinpointing accuracy from field test data, and the accuracy evaluated in this way can be used to establish an operating procedure for safe excavation of landmines. In addition, as expected, different models of metal detectors exhibit different performance.

In order to investigate where the difference comes from, the different models were compared. The results indicated that the sources of the difference are the footprint shape (sensitivity profile) of the coils and search head design – the wider footprint a metal detector exhibits, the poorer pinpointing accuracy tends to be achieved. However, a larger footprint can be advantageous in productivity. Therefore, in order to achieve a high pinpoint accuracy without sacrificing the productivity, oval-shaped coils and double-D configuration seems to be good approaches.

The field test data used in this study, i.e., the ITEP test 2009 in Germany, include only a few models of metal detectors and a few operators for each model. Since the pinpointing accuracy probably depends on operators, difference between operators could be investigated by the proposed way to illustrate some more performances of metal detectors such as the user friendliness, and also human factors, if more operators were available.

More detailed analysis and results can be found in [3].

Acknowledgement

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Development of Land Release System – Croatian Experience

Miljenko Vahtarić[43]

Demining in Croatia started with the first liberation actions. In the period 1991-1995, removal of mines was conducted by Civil Protection, Ministry of Interior, Croatian Army and UN engineering troops. The purpose of demining was rehabilitation of terrains and facilities, vital infrastructure and military facilities. Only the manual demining method was used in demining operations. Croatian Army also used tanks (mine sweepers).

In 1995, there was a mine action centre established as part of the UN Peacekeeping Forces. In 1996, the centre became the UNMAC. In March 1996, the Government of the Republic of Croatia passed the Humanitarian Demining Act and founded the company AKD Mungos. The same year, several private demining companies were founded as well.

From 1996 until 1998, demining operations were conducted solely by the commercial company AKD Mungos established by the resolution of the Government of the Republic of Croatia. Demining was conducted by manual method, mechanical method and mine detection dogs. These were the beginnings of humanitarian demining in the Republic of Croatia. The quality assurance operations were conducted by the Ministry of Interior. Since 1998 and the establishment of the Croatian Mine Action Centre (CROMAC) until the end of 2012, over 80 companies were registered for the conduct of demining operations. 36 companies today actively participate in demining process. After the period of capacity growth from 2000 until 2008, demining capacities are now stabile while demining tools and equipment have been modernized on a regular basis ever since.

In December 1996, the Government established the Demining Committee which had an advisory role. In December 1997, the Republic of Croatia was the 12th country which ratified the Ottawa Convention. On February 19, 1999, the Government of the Republic of Croatia passed the decree on the establishment of the Croatian Mine Action Centre (CROMAC).

The idea was to integrate all mine action operations into the same institution. During the first CROMAC years, great support to CROMAC work was provided by the UN and EU through strengthening of CROMAC capacities, equipping and providing professional assistance.

Through the Administrative Board (former CROMAC Council), CROMAC is accountable to the Government of the Republic of Croatia for its work. In order to better fulfil its role i.e. establish closer contact with the mine problem, the Town of Sisak (60 km SE of the City of Zagreb) was chosen for the establishment of CROMAC head office. For the purpose of being present on the mine-affected areas on a daily basis, there were three regional offices established – in Karlovac, Osijek and Knin (later on, in Zadar).

The first estimates made by the UNMAC assumed that ¼ of the Croatian territory was potentially dangerous and spoke of the existence of 1,2 million mines.

After the analysis of minefield records and data collected, in 2001, the suspected hazardous area (SHA) was estimated to 4.500 km^2 with rough estimate of the existence of ½ million of mines spread along the estimated territory.

Out of the initial 40 employees, CROMAC has been growing in stages, especially in the period 2001-2002 when CROMAC employed 50 deminers. It was part of the process of disposal of employees of the Special Police (Ministry of Interior). In accordance with the increase of CROMAC staff, the system of technical and general survey, quality assurance and quality control operations were upgraded as well. Today, CROMAC has 144 employees.

In order to use the newly-hired human resources in a better way and ease the work of other employees in humanitarian demining, in 2003 CROMAC started with the development of Standard Operating Procedures (SOP) based on laws and by-laws which regulate the field of humanitarian demining in the Republic of Croatia, International Mine Action Standards (IMAS) and experience gained through the conduct of humanitarian demining operations.

Today, we apply Standard Operating Procedures (SOP) for the following six fields:

1. Survey of suspected hazardous area and/or facility
2. Project designing – preparation of project documentation
3. Standardization and accreditation
4. Quality assurance and quality control
5. Medical support
6. Destruction of mines and UXO

Two SOPs are currently under development:

1. Planning
2. Information system – information management

In 2003, CROMAC started the systematic survey of mine suspected towns and municipalities. After the completion of this process in 2005, for the first time, mine action experts

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no longer spoke of the estimates of suspected hazardous area (SHA) but the actual size and situation. The SHA totalled 1174 km2 and it was precisely marked on the maps distributed to the local administration and self-administration units, police, fire departments, public companies etc. The revision of general survey through application of new SOPs and experience from the previous cycle started the same year. It resulted in the additional reduction of SHA. At the end of 2007, the SHA was reduced to 997 km^2.

Due to a number of projects in which no mines were found, in 2004, CROMAC introduced new method ''mine search'' by which CROMAC investigated contamination or non-contamination of project area for which no minefield records were available to CROMAC. Without questioning the quality of operations and safety of the final beneficiary of searched area and due to a lower level of the terrain search complexity, the cost of land release was reduced up to 30% in relation to the demining method.

For the purpose of better rationalisation and more efficient land release, in 2010, CROMAC started with implementation of the new procedure – ''area reduction''. Reduction of suspected hazardous area was based on fulfilling correlated criteria of general survey and demining/mine search i.e. on a number of information collected during general surveys, mine search/demining, digitalised military maps, quality analytic preparation and analysis of completed demining operations on the part of suspected hazardous area (SHA) which is the subject of reduction.

Area reduction process was conducted through the following phases:

1. Planning of SHA reduction
2. Comprehensive analysis of Mine Information System (MIS) data

3 Reporting

4, Discussion about the Report

5. Demining for the purpose of area reduction
6. Analysis of completed demining project for the purpose of area reduction
7. Closing discussion

8.Passing the Certificate on cancellation of areas and/or facilities from the SHA

In the period 2010-2012, there were 11,7 km^2 cleared by area reduction projects. General survey conducted after area reduction resulted in cancellation of 25,6 km^2 from SHA. In three years, the SHA was reduced by area reduction for 37,3 km^2.

As a result of general and technical surveys, area reduction and demining, the SHA today is defined to 680 km^2. It extends through 12 counties and 99 towns and municipalities. It is contaminated by ca. 74.000 mines.

Quality assurance and quality control process was developed parallel to the process of survey, mine search/demining and area reduction. In the beginning, quality assurance was conducted by 6 QA officers. They had to visit each demining project twice a week. At the beginning of 2003, quality assurance operations were conducted by 9 QA officers. CROMAC also introduced the new employment position – QA monitor. In accordance with the Humanitarian Demining Act, since 2007, CROMAC introduced the category of everyday control over the quality of demining operations. QA monitors received training in conducting operations stipulated by the Act and the Rules and Regulations on the Method of Conducting Humanitarian Demining Operations. The number of QA monitors was also increased. Today, quality assurance and quality control operations are conducted by 12 QA officers and 24 monitors. In the past 10 years, over 5 km^2 were subjects of sampling during quality control procedure. Testing and certification of demining equipment and machines conducted by the Centre for Testing, Development and Training since 2003 has an important role in increasing the quality of QA and QC operations.

In 2003, CROMAC started with development of CROMAC GIP, the unique topographic database as basis for the development and monitoring of mine action activities within mine information system. Spatial data are of great importance for demining operations. Geo-information system is an ideal tool for the integration and analysis of such data. Precisely the Mine Information System (MIS) was created as an upgrade with databases. The use of digital ortophoto represented an important progress in the use of cartographic backgrounds. It made the work of field teams a lot easier and enabled faster and more precise registration of minefields and suspected hazardous areas. This resulted in reduction of time field teams spend working in the field as well as reduction of danger for the people working in the field. Donation of equipment for scanning to the CROMAC SCAN Centre made by the Government of the Kingdom of Norway in 2004 represents an immeasurable contribution to the development of the entire Mine Information System (MIS) and creating the conditions for its efficient work.

Installation of SCAN Centre enabled quality scanning of notes, sketches and maps and provided conditions for the creation of basic geospatial digital data on the positions of landmines, minefields and confrontation lines with higher accuracy. By the end of 2005 i.e. first phase of general survey, there were over 2500 military maps of different format scanned. They consisted of important information and details essential for the conduct of general survey operations for the purpose of reconstruction of the entire SHA on the entire territory of the Republic of Croatia.

In 2007, CROMAC started with the development of MISportal. It is a unique browser which enables an insight into the mine situation to all Internet users in Croatia and from around the world. MISportal brings the most up-to-date information on the SHA and positions of mine warning signs placed in the field which are being updated on a weekly basis. Currently, there are over 14.000 mine warning signs placed in the field. In that way, we ensured the widest possible access to the information on mine-contamination. This resulted in increasing the safety of the population of the Republic of Croatia and their guests.

Current SHA structure is a result of dealing with priorities crucial for the sustainable return of population. In the post-war period, the priority was to demine areas around family houses and bringing the utility infrastructure to closer to them, demining of roads, bridges, railways, transmission lines, water supply systems etc. After this first phase started demining of house yards, agricultural areas, tourist zones, roadways and routes to the tourist destinations and generally speaking, spreading the safety zone. Today, most of the SHA extends through the forests, underbrush and karst. Agricultural areas participate with 20% in the total structure of suspected hazardous area.

As a result of the above-mentioned activities and mine risk education conducted systematically throughout Croatia, CROMAC registers the reduction of a number of mine victims. Since the establishment of CROMAC in 1998 when 92 persons were involved in mine incidents, until today 314 people have been involved in mine incidents out of which 116 was killed by a landmine.

The new Humanitarian Demining Act which should be passed by the end of 2013, some of the procedures should be simplified in order to provide conditions for faster reduction of suspected hazardous area by using technical survey method. Existing area reduction method should be replaced by technical survey method. The idea is to ensure faster realization of the National Mine Action Strategy of the Republic of Croatia and fulfilling the commitments undertaken by signing the Ottawa Treaty in due time.

TIRAMISU: First Year of Designing a Toolbox for Mine Action

Yann Yvinec[44], *Yvan Baudoin*[45], *Vinciane Lacroix*[46]

Abstract

Anti-personnel landmines and unexploded ordnance (UXOs) represent an important obstacle in the transition from crisis to peace for war-affected countries. They threaten post-conflict development and welfare.

The objective of the TIRAMISU project is to provide the Mine Action community with a toolbox to assist in addressing the many issues related to Humanitarian Demining and thus promoting peace, national and regional security, conflict prevention, social and economic rehabilitation and post-conflict reconstruction.

TIRAMISU stands for Toolbox Implementation for Removal of Anti-personnel Mines, Submunitions and UXO.

The TIRAMISU toolbox is divided into several modules that cover all the different aspects of Mine Action.

A module is dedicated to Mine Action mission management. Tools in this module will help improve the planning and execution of Mine Action missions.

A module includes tools that will help the setting of priorities to suspected hazardous areas and the efficient use of the other modules in a given situation. These tools will make use of remote sensing and decision support systems.

Another module includes tools for Non-Technical Survey and Advanced General Survey, for instance by detecting indicators of probable presence of landmines/UXOs. These tools will facilitate land release.

Great efforts will be given to the design of agricultural-based platform for technical survey that would be cheap to build and easy to return to agricultural use after being use for ground preparation or demining.

A module is dedicated to Ground-based Close-in Detection. It includes tools such as advanced metal detector array, Ground Penetrating Radar array and novel chemical sensors as well as their implementation on remote controlled land platforms (UGV).

For Stand-off Detection the module includes tools to detect mines, sub-munitions or explosives at close range with remotely controlled Micro/Mini (Unmanned) Aerial Vehicles (MAV/UAV) or flying biosensors (honeybees), possibly coupled with UGV.

A module regroups tools for Disposal of Explosive Remnants of War (ERW). These tools will help protect personnel or vehicles against explosions.

The Mine Risk Education module consists of tools to assist in Mine Risk Education activities through various techniques, including theatre plays and computer games.

The Training module includes tools aiming at developing capacity building and enabling the user's uptake of the developed tools.

A last module includes standardisation documentation such as the current and in-progress or proposed CEN Workshop Agreements (CWA) [13].

In order to test the tools and to also increase the confidence of the Mine Action community in these tools, test and validation campaigns will be organised in several mine contaminated countries.

The project is supported by two boards involved in every step of the development of TIRAMISU to ensure that the tools being developed will really be useful to the Mine Action community: the End-User Board assisting in the definition of the needs and the assessment of the usefulness of the tools and the Project Advisory Board providing a scientific and independent view on the tools design and development and on any ethical issues that could arise in the course of the project.

The first objective of the first year was the delivery of the toolbox requirements and the scenarios for the validation of the tools. A second objective was to provide a more detailed description of the tools based on input from the mine action community.

Work performed and main results achieved during the first year

The main priority during the first year was the definition of the Toolbox requirements. Therefore an end-user Network and an extended PAB, consisting of key experts were established. Experts of the GICHD and members of MACs and NGOs of six countries (in Asia, Africa and Europe) were interviewed. Besides, official legal/ethical supports were obtained from the National Authorities allowing validation tests in their countries while, at the same time, validation scenario and criteria were defined. After this study the intended tools of the following modules could be described in more details and their development could start.

Advanced General Survey:

Following the advice from the PAB, the functionalities of the tools of this module and the next have been reorganised into new tools: T-REX to support the collection and management

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of expert, geospatial and contextual information at country and/or regional level; T- IMAGE consisting of methods and services related to the acquisition of satellite remote sensing images; T-MAP consisting of services for pre-processing the remote sensing images in order to prepare the images for mapping features of interest; T-PRIORITY to combine spatial analysis and multi-criteria methods to support high-level mine action management.

Non Technical Survey:
The objective of the first year was to provide detailed descriptive techniques allowing the detection and analysis of Indicators of Mine Presence (IMP) and Indicators of Mine Absence (IMA) to support Suspected Hazardous Area (SHA) reduction and assessment: two complementary tools are proposed: T-SHA will combine spatial analysis methods to support area reduction while T-AIDSS exploiting the previous tools is based on AI DSS which already led to good results in Croatia and in Bosnia and Herzegovina [19][20].

Technical Survey:
The descriptions provided for each tool (a robotized tractor [1], renewal and empowering of the technique called REST, explosives vapour detector based on polymer sensing elements, UBV and combined UGV-UAV control [3][4][5][6][7][9]) take into account the point of view of the potential end-user and gives a clear picture of the functioning, operative principles and expected performance, trying to be always as concrete as possible [10]. Furthermore, an intensive acquisition and pre-processing of airborne and ground-based hyper-spectral images of the exploded ammunition depot Padjene and the Croatian test site Benkovac allowed first conclusions on the validity of the chemical analysis of the vegetation [2]. Finally, active and passive methods of honey bees training for explosive detection were tested in Benkovac.

***Close-in-Detection**:*
Detailed specifications of six tools were given [10] and first experiments and performance evaluations were carried out: Intelligent Prodder, novel polymer based Explosives Vapor Detector [8][11], Lightweight (MD, GPR, ECS) Detecting System, Multi-channel Metal Detector, Densely sampled GPR Array and Ground penetrating imaging microwave radar.

***Safe Disposal**:*
a) *Disposal*: a preliminary study of the dynamic behaviour of granular materials used in containment devices has been done as well as an experimental set-up for future laboratory tests; an important contribution of the disposal tools focused on the neutralisation of RDX by chemical methods rather than explosive methods; preliminary designs of AP mine neutralisation systems, including ERW transportation platforms are proposed. b) *Safety or Protection*: preliminary methodologies, techniques and results related to the individual, platform (agricultural ones in particular) protection tools were conducted and experimental set-ups are operational [12].

***Training**:*
The current role of the training tools was analysed. Major advancements were reached in the design and development of a 3-D tracking (detection) system with sweep monitoring [14][15][16][17][18].
In addition the work to integrate these tools and modules into a toolbox has begun. Field tests and demonstration for the information management system were carried out.

Expected final results and their potential impact and use

The service expected to be delivered to end-users by TIRAMISU will include a service gateway that will provide end-users with a user-friendly interface (interactive Website, including Web-GIS tools) for information and access to services. The TIRAMISU Tools delivery interface will offer the possibility for the end-users to download products together with their implementation details (point of contact, descriptive sheets, costs information, training tools, etc.) and to access external information services subject to agreement with a TIRAMISU partner, such as sensors data, local assistance, ethical concerns, etc.

The main results expected from the proposed implementation are the following.

User-driven operational tools: The R&D activities will be regularly evaluated by a Scientific and Technical Advisory Board that will include renowned experts (i.e. former or current members or consultants of GICHD, UNMAS, among others); Depending on whether or not they are mature, the tools will be tried by the end-users (Mine Action Centres – MAC).
An end-to-end support service: An interactive TIRAMISU Toolbox Website will serve as a Point of Contact for each module together with the description, guidelines, provider(s), availability, etc.
A toolbox of certified tools: Each tool will be validated operationally according to existing standards; New CEN Workshop Agreements (CWA) will be developed.
Continuous updating of operational tools: Gradual implementation (and availability) of validated tools.
During the course of the project the idea of progressively setting up a European Centre of Excellence (CERAMISU) will be discussed with the Project Advisory Board (PAB) and the End-user Board (EUB). This CERAMISU would allow the mine action community to:

- Effectively use the developed tools (some of them being developed with their involvement)
- Be involved in new developments
- Be involved in CWA
- Be invited to significant events

The legal status of the CERAMISU will be defined after consulting the PAB and EUB, but in a first step it may be managed by, and hosted at, the RMA (as ITEP Secretariat was). Again, End Users interested in a TIRAMISU tool or in an integrated series of tools from several modules will be invited to subscribe to the CERAMISU when they want to introduce their particular needs/requests: their request will be addressed to the Managing board of the CERAMISU (not necessarily the same as in TIRAMISU) and solutions (services, products, integrated series of tools) will be suggested depending on their Technical Readiness Levels and according to possible related financial conditions.
Prior to any financial negotiation and in conformity with a specific CERAMISU commitment, the user may place an order for the demonstration and/or adoption of the selected tools. CERAMISU would organize the required actions with the partners responsible/owners of the selected technologies and tools.
Subsequently, the End Users can hire the toolbox components which best fit their budget and local infrastructure and peculiarities concerning successful mine action. So the End User just pays for the components of the toolbox they really need and will use, which gives a high degree of flexibility.

Acknowledgments

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Book Overview:
DESIGN OF DEMINING MACHINES

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Member of the Scientific Council of the Croatian Mine Action Centre (CROMAC)
Member of the Croatian Academy of Engineering, Department of Cybernetics

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The book ***Design of Demining Machines*** brings about the philosophy of developing specialised machines for humanitarian demining. It’s a creative result of an author involved in development of these machines. Original calculation models on which the development is based are presented, as well as the production and testing of such machines. Apart from a professional and scientific contribution, the author was to meet the publisher’s requirements. This book will find use with most of the subjects involved in the world of humanitarian demining, which is recognised also by a renowned publisher *Springer Verlag*, who have published this book into the world market.

The book is written in 211 pages, reviewed and comprises six chapters:

1. Humanitarian Demining Techniques
2. Mechanics of Machine Demining
3. Design of Demining Machines
4. Design of Mine Protected Vehicles
5. Personal Protective Equipment
6. Test and Evaluation of Demining Machines

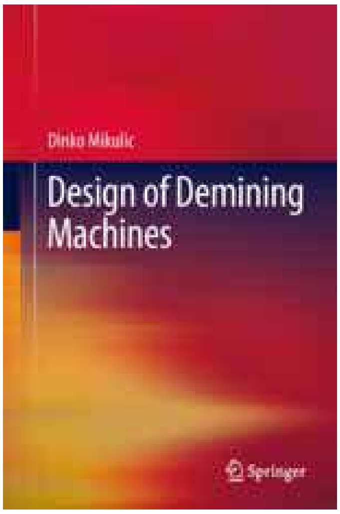
About the Author

The author has made public quite a series of scientific research work and published works, projects and publications. He has received the HATZ’s ‘Rikard Podhorsky’ award for the year 2007. Dinko Mikulić has received his PhD from the *Faculty of Mechanical Engineering and Naval Architecture* in Zagreb. He has led the development and production of specialised vehicles for the Defence Department (MoD, 1991-2005). He has taught classes on Construction Machines at the *Faculty of Mechanical Engineering and Naval Architecture*, University of Zagreb. Today he is a Head of a Study Programme at the *University of Applied Sciences Velika Gorica* and a professor for the subjects of Motor Vehicles and Construction Machines. He is the author of the following books: Construction Machines (1998), Demining Techniques (1999), Motor Vehicle Brakes (2010), Motor Vehicle Active Safety Systems (2011). He has published a significant number of professional as well as scientific articles in domestic and foreign-based journals.

Dinko Mikulić is a member of the Scientific Council of the Croatian Mine Action Centre (CROMAC), and a coordinator of machine demining. He has participated in the development of the Centre for Testing, Development and Training (CROMAC-CTDT). He is a standing councellor for the Brodarski institut d.o.o. and the entreprise DOK-ING d.o.o. that manufactures specialised machines.

The scientific and professional contribution of the book Design of Demining of Machines

The author’s scientific and professional contribution is based on setting up a methodology for development of machines specialised in activities of humanitarian demining. The testing and design calculation theory has proven in the development and production of inland demining machines of the type MV DOK-ING and export affirmation, the result of which is the elimination of mine threats by remote-controlled demining machines, bearing no risk to human lives. Except from the domestic need, the Croatian machines are being exported to developed countries where they are used for removing mine threats worldwide (US Army, SWEDEC,..), which brings about an economic effect.



Abstract

The book *Design of Demining Machines* contains theory and calculations of the machines for humanitarian demining, auxiliary means and equipment. The demining machines are used for neutralization of the buried mines, by activation or destruction. The mechanics and design of the demining machines with flails, tillers and rollers has been presented in detail. The comprehensive problems regarding design have been presented on actual examples of the developed construction and production of demining machines. The design of mine protected vehicles and personal protective equipment used in operating the demining machines have been presented as well.

The book provides a comprehensive presentation of the testing and evaluation methods of demining machines on the test range, such as the performance test, survivability test and acceptance test. Each chapter contains a large number of illustrations, offers conclusions, and provides prospects and guidelines in the development of the demining machines.

This book opens up a path towards the development of mechanisation of eliminating mine danger in the world of humanitarian demining. The presented knowledge of the machine design can provide assistance to engineers and technicians, as well as a wider circle of people who research, develop or purchase the demining machines. All the issues have been explained in a clear and simple manner.

Conclusion

The issues of humanitarian demining are a present problem in the Republic of Croatia, it is yet an equally real problem in the countries which had undergone war activities from WWII to date. It is estimated that 100 million mines remain buried or there are 100 countries in the world contaminated with mine threats.

In constant effort to eliminate mine danger, international mine action community has been developing safety, efficiency and cost-effectiveness of clearance methods. Demining machines have become necessary when conducting humanitarian demining where the mechanization of demining provides greater safety and productivity. *Design of Demining Machines* describes the development and testing of modern demining machines in humanitarian demining.

Relevant data for design of demining machines are included to explain the machinery implemented and some innovative and inspiring development solutions. Development technologies, companies and projects are discussed to provide a comprehensive estimate of the effects of various design factors and a proper selection of optimal parameters for designing the demining machines.

Covering the dynamic processes occurring in machine assemblies and their components to a broader understanding of demining machine as a whole, *Design of Demining Machines* is primarily tailored as a text for the study of the fundamentals and engineering techniques involved in the calculation and design of demining machines. It will prove a useful resource for engineers, designers, researchers and policy makers working in this field.

Apart from design and engineering innovation this book has an educational mission. The knowledge given in the book provides active learning and emanates a vision of a creative approach from the author. Its mission is to enable the people worldwide, occupied with eliminating mine threats, to gain the knowledge based on experience in developing machines in the Republic of Croatia. Therefore this book represents a significant contribution to literature in the field of specialised vehicles.

Director CROMAC-CTDT
Nikola Pavković

11th IARP WS HUDEM'2013

Data Management for the Advanced General Survey and Non-Technical Survey Tools

Didier Peeters[47], Sabine Vanhuysse[48], Eléonore Wolff[49]

1. Abstract

The Advanced General Survey (AGS) and Non-Technical Survey (NTS) tools require processing sophisticated and heavy geographical data. A system for managing spatial relational databases is being developed to optimise the storage, exchange and analysis of these data. The nature and general objectives of TIRAMISU (i.e. a toolbox for mine-action users around the world) leads to keep the general cost for users as low as possible, and hence to provide a system that is as open as possible, making it compatible and upgradeable. Therefore, we have chosen to develop the tool using an efficient open-source Spatial Relational Database Management System (Spatial RDBMS) called PostGIS. This system will operate in the background and be hidden for the regular users, but will be accessible to the power users willing to enhance the tools.

2. Introduction

The mine action activities involve a wide range of technologies of very different nature. Among them some deal with electronic data to support the practical field activities or to detect, localise and prepare to field work. Until now, different actors have developed software to achieve these tasks but often independently from the rest of the community. A well-known effort was made by the GICHD with their tool IMSMA devoted to support Mine Action Centres information management anywhere in the world. Recently studies, like the SADA study [1] funded by the ESA that ended in April 2012, pointed the need for a common data storage system for the demining actors.

In the Geographical Information Systems (GIS) particularly, there is a strong interest in sharing data between different tools to accomplish very specific tasks, but until now the GIS software used in the demining world are based on proprietary technologies depending on private companies and are rather unable to easily collaborate. The tools that are developed each have their own data storage system that is closed to any third-party enhancement.
The TIRAMISU effort consists in providing the demining community with a set of tools, "... *to bring a toolbox that will represent a step forward in mine action by being the basis for a unifying, comprehensive and* ***modular integrated solution*** *to the clearing of large areas from explosive hazards*"[50].

A "*modular integrated solution*" means first that the tools are complementary to each other and to the existing ones, and second that each tool has to be integrated with the others. We consider that data sharing is the key to achieve this goal, and for sharing data the only valuable solution is to organise the data into a common structure, which means having a database that satisfies all the features requests of the different actors.

3. The GIS database requirements

Inside TIRAMISU the remote sensing and GIS tools are:

1. T-REX, geospatial, contextual and expert information collection and management,
2. T-IMAGE, acquisition of airborne and satellite remote sensing imagery,
3. T-MAP, features of interest mapping from remote sensing imagery,
4. T-SHA, spatial analysis for supporting SHA re-delimitation,
5. T-PRIORITY spatial analysis and multi-criteria methods for supporting high-level mine action management.

These tools handle vector and raster data. Some raster data come from very-high resolution aerial or satellite images that are far too big to be processed by regular computers and will have to be entrusted to third party. They are therefore not considered here.
Beside these tools, the users in the mine-action community already use desktop GIS software, on their own operating systems and the technical solution that will be developed must take this into account.

4. Respect of the standards

One of the most useful mean to avoid the incompatibility between systems is the respect of standard technologies. It was therefore decided during the first project year to favour the use of standards. Standards are usually defined by consortia of influent actors who represent most of the users of a specific technology. Many standards are actually very commonly used like the World Wide Web protocol defined by

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50 TIRAMISU Description of Work (October 20, 2011)

the W3C consortium, others are more specific. For instance inside TIRAMISU we plan to rely on:

- OGC for Geographic data definition
- SQL for Database language
- The maXML for the regular mine action data (developed together with the GICHD)
- The web for communication protocol

Complying with the standards ensures a better life expectancy for the TIRAMISU achievements and offers an opportunity for future enhancements by other actors of the demining world.

5. The database system

For all these reasons, the choice was made to rely on the Relational Data Base Management System (RDBMS) PostgreSQL, with its geographical extension PostGIS.
PostgreSQL is a free open-source RDBMS[51] offering an undoubtedly professional steady system used all around the world in any kind of field. PostGIS adds it the ability to handle geographical data, by adding geographical data types (like points, lines, polygons and their derivatives), and hundreds of functions to process these data.
It is compatible with most operating systems (notably Windows, Linux, OS X) and can be accessed by a wide range of GIS, among which ArcGIS, GeoServer, GRASS GIS, Map Info, gvSIG, QGIS, MapServer, and many others, and of course complies with the OGC standard [2].
The initial use of the database is to support the TIRAMISU tools but it is also possible to read the stored data with the GIS systems mentioned above to produce other output.
PostgreSQL + PostGIS only require a regular PC for normal use but of course, the hardware requirements are more dependent on the data that are being processed, like for any other systems. A big aerial image, for instance, would still require a huge amount of memory once imported into PostGIS, as it would in another software. PostGIS is one of the most efficient spatial data systems but it does not work miracles.

6. Use of the database on site

The sophistication of the system will have no negative impact for the final users. All the operations will be handled by the tools developed in TIRAMISU, but the database itself will not be visible. This is similar to the use of IMSMA where the regular users are actually not aware of the data storage, organisation or retrieval, they just use IMSMA's front-end.

With our tool, instead of opening files the users will select data in a structured list searchable according to key words or the data classification, and reversely for the storing. So, concretely the TIRAMISU tools will provide the front-end of the database. The "power users" may nevertheless go beyond this and use a dedicated database front-end interface to accomplish some specific tasks like developing specific tools, by using for instance the PostGIS functions.

PostgreSQL is a multi-user system that allows to define different user types, to control the accesses, and fine-tune the access rights for each type or individual user.

Even if Postgres/PostGIS offers numerous "state-of-the-art" functionalities, the first reason for choosing it is the security provided to the GIS operations, in terms of integrity for the data, control of the processes. It also offers tasks automation and possibilities to add new tools or functions developed elsewhere.

During the last years the usual GIS have progressively evolved from file storage systems (like the shapefile) toward RDBMS solutions because of their greater robustness, their ability to handle efficiently almost limitless amount of data and their general faster performances. MS Access, which is a low end DBMS, for instance, has limited capacities in terms of database size.

A professional RDBMS such as PostgreSQL ensures also the integrity of the data in case of incident like a power failure, by reversing an operation that wouldn't have gone until its normal end. Other systems without this feature would generate data that have lost some internal consistency, meaning that an erroneous data could remain and have unexpected consequences some day.

The tools will be able to import or export their data in regular files for exchange purpose with systems different from TIRAMISU. PostGIS and PostgreSQL provide also tools for such exchanges, PostGIS can directly import shapefiles, Arc/Info, kml, geojson, and others (any OGR supported format actually, but not only).

Finally, with the SQL language and/or the PostGIS functions it is easy for GIS educated users to set up their own additional functions to execute tasks that would be needed on a regular basis.

To conclude this chapter we would like to quote an interesting reading document [3] available on internet that summarizes the advantages of the GIS RDBMS this way:

- Convenience - easy access
- Reduce redundancy - cross referencing reduces repeated data entries
- Shareable - cross organization sharing, multiple uses of data
- Flexible analysis options - multiple analysis options, expansion of analysis capability
- Standardization - controlled formats for data entry / manipulation reduce inconsistency and errors.

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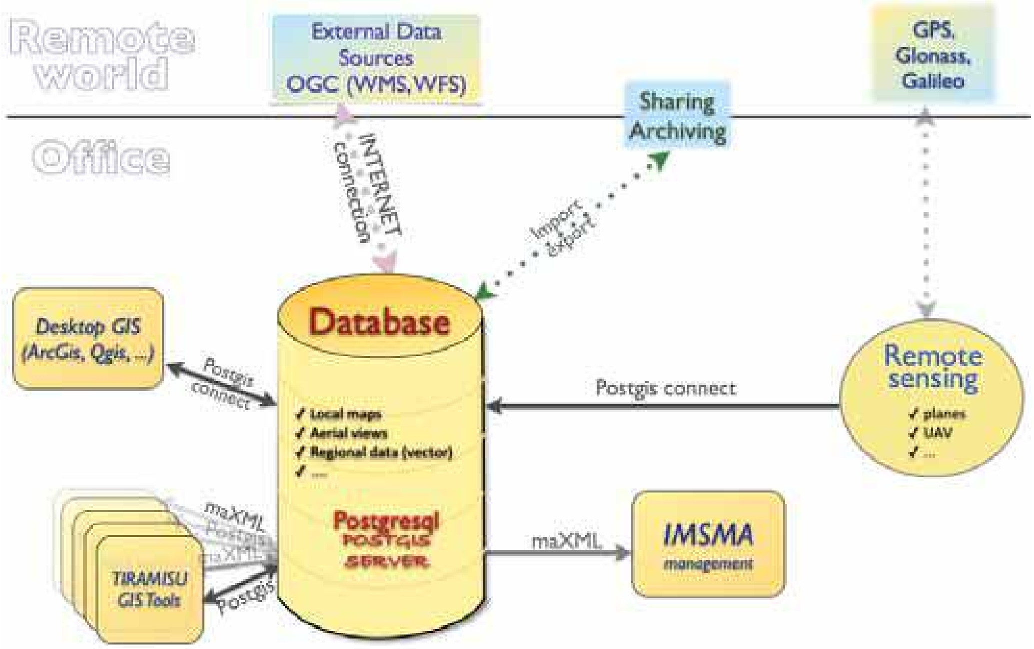

Graph 1 : Schematic view of the data flow with the database unit

Above is a graph showing the data-flow between the GIS tools with the database in the middle.
This illustrates the role of the database in the data exchanges.

7. The database during the project development

The TIRAMISU GIS teams will work simultaneously on the structure of a common database and on their respective tools. This database will be hosted on a server in a location still to be determined and be accessible by secured internet connection. So the database and the tools will be developed in synergy, ensuring a good collaboration between the partners involved. This method will act as a rehearsal for the final delivery.

8. Integration with other work packages inside TIRAMISU

We strongly believe that a centralised database system is an asset for all the software tools and that the idea should be extended to the whole TIRAMISU toolbox, but that is a question to be addressed on another level. Anyway, beside the work packages that address specifically GIS, there are other work packages that might take advantage of the database structure, like those relying on the result of the GIS operations. Unless the development of a database common to all the work packages is undertaken - which would solve this question, the GIS database will be made accessible to the partners who would need it for their own work.

A relational database should be seen like a cabinet in which it would be possible to add drawers or boxes and of which size would be dependent on its content. So it is always possible to add extensions (meaning other stuff) without any major consequences for what is already in it.

General organisation of the data

The “relational” nature of such a database has consequences on the organisation of the data inside it. Relational databases theory has pointed out rules that are real advantages when respected, and have very positive consequences on security, speed and efficiency. This is no place to explain these constraints but let us say that one major characteristic is that the data should be organised according to their nature and not according to who creates them or needs them. The data are stored in objects represented as tables that can be linked together when needed. This avoids redundancy, and hence ensures homogeneity and spares disk space. For example, considering a suspected hazardous area (SHA) identified by some GIS process should not be mixed with the administrative information related to the region in which this SHA is located. Instead there should be a table with the regional administrative information and a table with the SHA and an identification code for the region, so that when needed a synthetic report can be produced with the SHA description including the name of the region and other information. It is even possible to have this synthetic information presented in a “false” table, called a “view”, resulting from a stored SQL code that is executed automatically each time new information is inserted in one of the involved tables. This view looks like a table, it can be used by automatic processes like a table, but it is not a table. So this is a way to have the best of both worlds, on one side a rigorous data structure controlled by strong rules, and on the other side a more “user friendly” result.

9. Evolution capabilities and post-TIRAMISU perspectives

Our mission in TIRAMISU is to make tools that are useful for mine action, and hence for protecting people. After the project lifetime, mine action will keep going on, maybe endlessly. It is therefore our responsibility that the current effort could be a source of improvements and even more, a basis for further developments.

By using technologies like PostgreSQL or PostGIS, that are open, free and rely on standards, we hope that other people anywhere, will see in it an opportunity to develop their own tools, and share them with the rest of the demining community.

As mentioned above, this database system allows writing new tools, as SQL scripts, that can be shared with all the future users of the TIRAMISU GIS database. There is a huge Postgres/PostGIS community in the world very active on internet and sharing the expertise freely. Similarly there are other technologies, like for example "R"[52] that can be connected to Postgres/PostGIS to make analytical operations (statistics, reporting, …) also freely and with the same collaboration possibilities.

We see also a possibility to open our system to other existing complementary systems, like IMSMA, which could take advantage of the data stored in our database.

52 http://cran.r-project.org

Acknowledgements

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http://postgis.net/docs/manual-2.0/

The PostgreSQL official documentation :
http://www.postgresql.org/docs/

Upgrade of the Advanced intelligence decision support system for mine action in project TIRAMISU

Andrija Krtalić[53], Milan Bajić[54]

Abstract

Since the reduction of the suspected hazardous areas (SHA) is a long lasting and expensive process and considering that it requires collecting additional information from the depths of the SHA, there was a need for a new tool designed to assist the experts and managers in their decisions. To fulfil this need, the Advanced intelligence decision support system (AI DSS) was developed and operationally implemented by the Faculty of Geodesy of the University of Zagreb (FGUNIZ) and the CROMAC Centre for Testing, Development and Training Ltd. (CTDT), (They are co-owners of the AI DSS), starting from the generic methodology of SMART [EC 2001] and new developments and advancement supported by the Croatian Ministry of Science [Fiedler et al, 2008]. The AI DSS is an operational system that already was used and yielding good results in Croatia [ITF, CTDT, 2010] and it has also been used with success in Bosnia and Herzegovina [ITF, CTDT, 2011]. The objective in TIRAMISU is the advancement of the AI DSS in an operational context: a) advancement of data acquisition within the AI DSS, b) advancement of processing and interpretation of data (images, contextual data, expert and common knowledge) within the existing operative AI DSS. Research for the project TIRAMISU should result in an upgrade version of existing AI DSS, AI DSS should evolve into T-AI DSS.

1. Introduction

The aim of AI DSS is to support decision making about the SHA, respectively to enable reliable assessment of the SHA, propose areas that could be excluded from the SHA, define areas that are suspected but never have been considered as suspected, change categories, all this without deminers’ entering into the SHA. The AI DSS combines [Bajic, 2010]: a) analytic assessments and derivation from the Statements of Operational Needs about the availability and quality of the data and information in the Mine Information System (MIS) and geographic information system (GIS) of the Mine Action Centre (MAC); b) airborne multi sensor imagery acquisition and usage of satellite imagery that provide new data, information and evidences about the SHA state (the indicators of mine presence and mine absence) with high accuracy and confidence; c) the multilevel fusion and multi- criteria, multi-objective processing, interpretation and production of outputs (position of indicators of mine presence or absence, risk-weighted map, confidence of risk-weighted map, confidence of proposed reduction map and controversy map [Krtalic, 2012]).

The AI DSS, based on space borne and airborne assets, is aimed at and suitable for areas where access is not possible on the ground, where there is MIS (geographical, and contextual data), or where ground based technology is too costly. The advanced intelligence technology was developed and deployed into operations of humanitarian mine action in 2008/2009 [ITF, CTDT, 2010], [ITF, CTDT, 2011]. During these projects, certain disadvantages and limitations of the current system have been noted. Furthermore, experts in the deployment of explosives and land mine obstructions, military experts who know war history on the considered terrain and experts in mine action have to derive general and special requirements regarding the difference between available and needed information and data that should be provided through the implementation of AI DSS.

On the basis of these disadvantages, limitations and the generally defined user needs and requirements, requirements for the needed upgraded design, which should make it possible to fill the gaps between the actual functions and the parameters of AI DSS and T - AI DSS was defined and elaborated thoroughly in D220.1_v2: Non-Tehnical Survey Tool Description, TIRAMISU, 01/01/2012 [D.220.1, 2012] (one of the deliverables within project). Detailed elaboration and the beginning of the study were the objective of the first year of the project. Research should be conducted in terms of upgrading existing operating AI DSS. The gaps within the existing AI DSS should be noted and the requirements for the research defined, whose results will eliminate these gaps and improve them or just improve them. The 21 requirements, for filling the gaps, were defined and described.

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2. Requirements

The 21 requirements, for filling the gaps, were defined and described [D.220.1, 2012]

2.1. Tehnical requirements

Technical requirements were related to:

- finding suitable types of platforms for T-AI DSS,
- advancement and re-designing of airborne equipment (according to the above statement),
- stable electricity supply for the system,
- securing a stable GPS signal, without losing the connection,
- hardware and software limitation for parametric georeferencing of the hyperspectral (cubes) data.

Some of these conditions have been partially met before and in the first year of the project TIRAMISU. The aim of the research, and the need to meet technical requirements relate to increasing the robustness and stability of the AI DSS components. The robustness of airborne multi sensor imagery acquisition sub-system of existing AI DSS are increased by replacing of the existing acquisition (desktop) computer with the industrial (computer) controller, which will have the task of servicing up to two devices (rather than five, as previously). Two more industrial controllers are in the process of procurement. A desktop computer will be out of use in this way and the robustness of T-AI DSS will increase. Furthermore, the operational stability of the system for data collecting is increased by constructing and producing a new electric power supply for it. Power supply with automatic fuses / circuit breakers for switching individual equipment groups provides power from its own resources (battery power) without external converter for measuring equipment, monitors and laptops.

A study on the possibility of setting up and using the system for aerial hyperspectral data acquisition on the blimp was carried out. Smaller system for aerial data collection (due to the small payload capacity of the blimpn, figure 1a and 1b) is designed and constructed for this purpose. The study and test flights proved that airship is suitable for airborne hyperspectral survey for T-AI DSS purposes.

Hardware and software limitation of capacity and functionalities for parametric georeferencing of the hyperspectral (cubes) data [Ivelja, Bajic, 2011] are solved by purchasing and using the new version of software and stronger processor in computer with larger RAM. This technical advance has been crucial to the processing of field recordings from Padjene (exploding munitions depot) and for hyperspectral mine field assessment technology (the bio-chemical and hyperspectral analysis of the vegetation inside and outside of the minefields).
Further research is being continued in order to increase the robustness and stability of the system as planned, as well as to explore the possibility of installing the system to other types of platforms.

2.2. Methodological requirements

Methodological requirements were related to:

- developing the airborne hyper-spectral mine field assessment technology, that should be approved by research and validation,
- developing the general airborne hyperspectral survey of the area in and out the exploded ammunition storage as new functionality for T-AI DSS (for getting new indicator of mine presence (possibly),
- the interactive semi-automatic methods of the detection and extraction of the "'strong" indicators of the mine presence,
- advancement of data fusion within DSS sub-system of T-AI DSS (finding a new method),
- analytical assessment of data from MIS to obtain general and specific requirements for providing additional data of SHA,
- researching and developing of the operational calibration methods.

Air data collection was not originally planned for the first year of the project. However, additional activity: detecting the debris and UXOs resulting from explosion of ammunition depots (which was not included in the proposal but appeared as an opportunity to improve AI DSS) has changed the plan and priorities for the first year of the project. The work on this task has been a major priority for CTDT and FGUNIZ

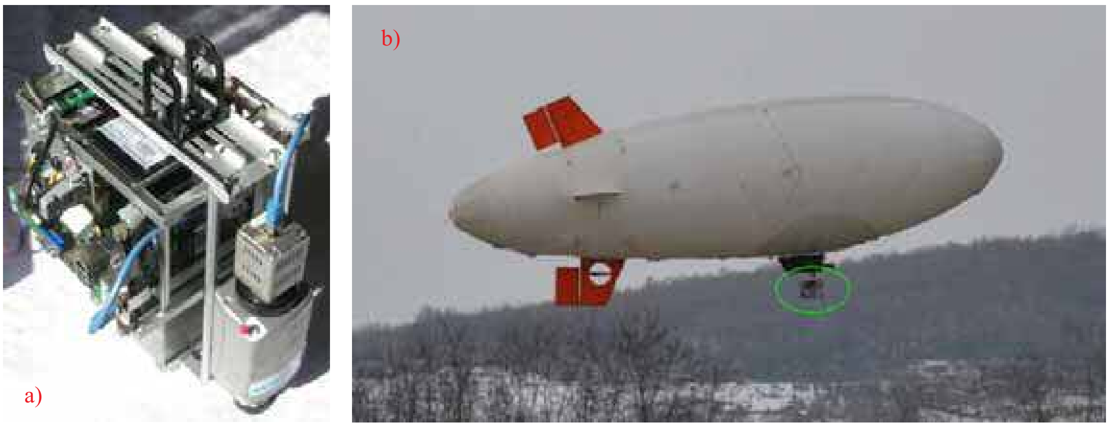

Figure 1. a) Small system for aerial hyperspectral data acquisition b) on the blimp (in green elipse).

in 2012, so the work on most methodological requirements will start in the second year of the project TIRAMISU.

In order to use multisensory system in its full potential, it is necessary to determine its limits. For that purpose, the target (figure 2.), according to ISO 12233, has been designed. Modulation transfer function (MTF) modeling through slanted-edge analysis is used. The potential of deriving MTF from slant-edge gives opportunity to use this function not only on target, but also on natural objects which have characteristics that have good definition of edge with at least 5% of slant.

Figure 2. Slant edge target and target with a pair of black and white lines of decreasing width values for MTF.

2.3. Other requirements

Other requirements were related to: advancement in the triage and the pre-processing of the acquired multisensor images, projection problems (different input data in different projections), developing of simplified version of the T-AI DSS (without the airborne multisensor acquisition and satellite images, only with MIS data), the trainings of the MAC surveyors (analytical assessment and obtaining of general and specific requirements) and the operators for the airborne multisensor acquisition.

In this sense, so far, the progress has been made in the triage of collecting images and applied on images of destroyed ammunition depot in Padjene. The new application that allows automatic geo-tagging images of MS4100 multispectral camera was used. It was not possible until then. Furthermore, training of two new operators during the airborne acquisition of multispectral images of explosion of ammunition depots was carried out.

3. Conclusion

T-AI DSS will benefit from the development of its components in TIRAMISU to fill gaps that were identified by the end-users and system operators, interpreters and user. The objectives include increasing its robustness,
decreasing the workload of the operator and improving the semi-automatic mapping of features of interest. T-AI DSS is a solution that will be proposed to the MACs worldwide for specific terrain and actions. A simplified version (without data acquisition) will also be developed that can be used in MACs for the support of the SHA assessment, reduction, re-categorizing and inclusion, only with indicators of mine presence and mine absence derived from MIS data. Services will be provided to ensure transfer of know-how and capacity building. T-AI-DSS will also focus on the problems generated by the possible explosion of ammunition depots**.**

4. Acknowledgement

These are people who have participated so far in these activities on a project TIRAMISU (for CTDT or FGUNIZ, in alphabetical order): Milan Bajic, Igor Buneta, Zlatko Candjar, Tomislav Ciceli, Dubravko Gajski, Mateo Gasparovic, Hrvoje Gold, Cedomil Gros, Tamara Ivelja, Tihomir Kicimbaci, Marko Krajnovic, Andrija Krtalic, Davor Laura, Martin Loncaric, Cedo Matic, Ivan Racetin, Luka Valozic, Dejan Vuletic.
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Land Release in Action: TIRAMISU In - Field Study of Practices in Use in Six Countries – Major Results

Emanuela Elisa Cepolina[55]

Abstract

The study is born from the need to document land release practices in use in different countries. The aims were manifold: to document current practices in order to be able to propose technologies within the context of TIRAMISU R&D work that could address current problems, be well integrated in current procedures and ultimately be useful; to understand the reasons behind critic choices (i.e. size of the area to investigate during Technical Survey and the relationships between indicators of mine presence found in an area and approaches used to target these areas); to investigate critical areas of the process and possibly propose new solutions; to try to identify what the actual role of machines is in technical survey and how they should be evaluated to be used in such roles; to highlight best practices so that can be shared among different mine action actors; and ultimately to learn more.

The study presents detailed data on Non Technical Survey (NTS) and Technical Survey (TS) practices in use in fourteen different organizations, although not all results discussed here refer to all fourteen organizations visited because it was not possible to collect the same quantity of data from all of them. The majority of the organizations visited welcome the study acknowledging a wide spread need to compare practices in use locally with the ones in use in other countries.

The study has been conceived, prepared and carried out by the author, in the context of TIRAMISU research work on the analysis of end-user's and system requirements. The author also drew the preliminary conclusions presented here.

The in-field data collection lasted from the 2nd of April to the 8th of July 2012 across six countries: Angola, Croatia, Bosnia and Herzegovina, Iraqi Kurdistan, Tajikistan and Cambodia. The complete study report is available on the project website (http://fp7-tiramisu.eu/).

1. Introduction

Considerable attention has been posed to the formulation of theoretical approaches to land release [GICHD, 2008], [GICHD, 2011], [IMAS 08.20-21-22], but little is known on the practical use of non technical and technical survey tools, the core components of land release, in the field. Only recently, a publication named "Assessment of Sudan Land Release Policy" has become available on the Geneva International Centre for Humanitarian Demining (GICHD) website [GICHD, 2011]. While the latter and the study discussed here have different aims especially because of the nature of data collected, they share some of the conclusions.

The large discrepancy between practices in use in different countries, among different organizations in the same country and more generally between practices currently in use in the field and theoretical approaches makes a comparative analysis very difficult. Anyhow, beside recording good practices in use by organizations that readers are invited to share, the study highlights common trends and some common weaknesses that might be worth addressing.

The weakness most important to address is the fact that although programmes tend to make the best out of resources they have, and their efforts should be greatly praised, a lack of a systematic approach for evaluating assets and first of all a lack of well defined outputs expected from these assets impede managing them at best. This is particularly true for mechanical technologies whose adoption is often not justified by quantitative analyses, but is rather based on perceptions, derived from someone else's experience.

A better understanding of each asset (manual deminers, mine detection animals and machines) constraints and most suitable application scenarios could help managing resources better. A new standardized way to comparative evaluate assets available for technical survey in the country should be established. Because in technical survey, a combination of assets is always used, the efficiency of the combined system should be evaluated altogether. Of course, first of all, the outputs expected from each asset should be defined and then assets tested against the expected performances.

Because cost is becoming a very important aspect behind the choice of assets, an evaluation based on criteria similar to the ones used in agriculture (like cost per area processed, $\$/m^2$) could be introduced.

The local evaluation of these technologies could also bring new ideas on the desired requirements for new technologies not currently available, helping directing budget choices in the most cost-efficient way.

Although the GICHD also already addressed the need of a tool for better planning the use of assets by publishing in May 2012 an excel based tool helping mine action programs to better plan the use of their resources [GICHD, 2012], results from this study suggest that efforts should be also invested in a preliminary stage: the definition of what tools are expected to perform and the local evaluation of their performance with respect to the requirements defined, possibly through a standardized procedure.

The need of a new CEN workshop agreement will hopefully

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be addressed by TIRAMISU project in the framework of WP630 dedicated to standardization.

2. Key findings

Rather than to draw direct comparisons between different organizations, the purpose of the study was to present a global overview of the process used to release land in different countries. Data collected were relative to the actual use of procedures and different assets; the nature of these data didn't allow making cost-efficiency comparisons between different practices, but let highlighting critical areas that might need some research investment to be improved. Sharing of good practices in use is a desired output of the study as well; it should be favoured by the presentation of data collected by questionnaires in a comparative way.

The principal findings of the study are listed hereafter.

- Every country uses different terminology, rarely in accordance with International Mine Action Standards (IMAS). The borders between Impact Survey, NTS and TS concepts shift from one organization to the other. Therefore the range of activities embedded in Impact Survey, NTS and TS phases varies according to the organization. This makes difficult to compare practices in use by different organization, which, anyway, vary greatly.
- A direct link between outputs of NTS and inputs to TS is often missing: only two organizations change TS approaches according to the output of NTS: in one case, the size of area investigated decreases as the level of risk assigned to it decreases, in the other case, the size of area investigated decreases as the level of confidence in the asset used in TS increases
- None of the organizations visited has established a systematic system for evaluating performances of the assets in use in TS aimed at assigning different levels of confidence/accuracy/reliability to them or at defining proper follow-ups, including the one that according to SOPs during TS investigates a smaller area if a more reliable asset is used.
- In practice, the only organization visited, that during TS investigates a smaller area if a more reliable asset is used, as far as the author could see, always prefers investigating the whole area[56]. Therefore, for the last organization TS differs from clearance because it implies the use of less accurate assets on the whole SHA, for all other organizations because it implies the investigation of portions of the SHA
- The criteria behind the size of the area processed during TS, when it doesn't depend on the level of threat assigned to the area by NTS, greatly vary according to the organization. In one case it depends on the number of assets used to process the area, in another case, it depends on the possibility to perform visual inspection inside the boxes, in another on the residual threat (if not all mines present in minefield record have been found).
- Although traditional demining machines, such as flails and tillers, are the ones mostly used, they might not be the best tools to be used in TS. In fact, they do not offer the type of output identified as most suitable to TS which, by stakeholders asked, in terms of capacity to collect information about contamination, is considered to be mine detection, then mine removal and then mine detonation by ground processing.
- To the question about what is the best condition in which to find mines after a machine has been used to process an area when manual deminers follow, stakeholders answered that it's better if mines are left intact; if mines are touched than it's better if they are detonated, not crushed. One organization clearly stated that "machines are not deployed with the aim of detonating mines": they are used to cut vegetation and loosen the soil (see fig.1)

Figure 1. AT mine found during TS, after a machine has been used to smooth up the soil. The machine was deployed without the aim of detonating mines.

Figure 2. Mine Protected Vehicle used for TS

56 The same result has been pointed out by the GICHD study on the assessment of Sudan land release policy; a reccomendation related tyo this finding suggested by the study is to embed "full coverage inspection" by an asset not capable to achieve a clearance result, as an alternative to tecnical survey

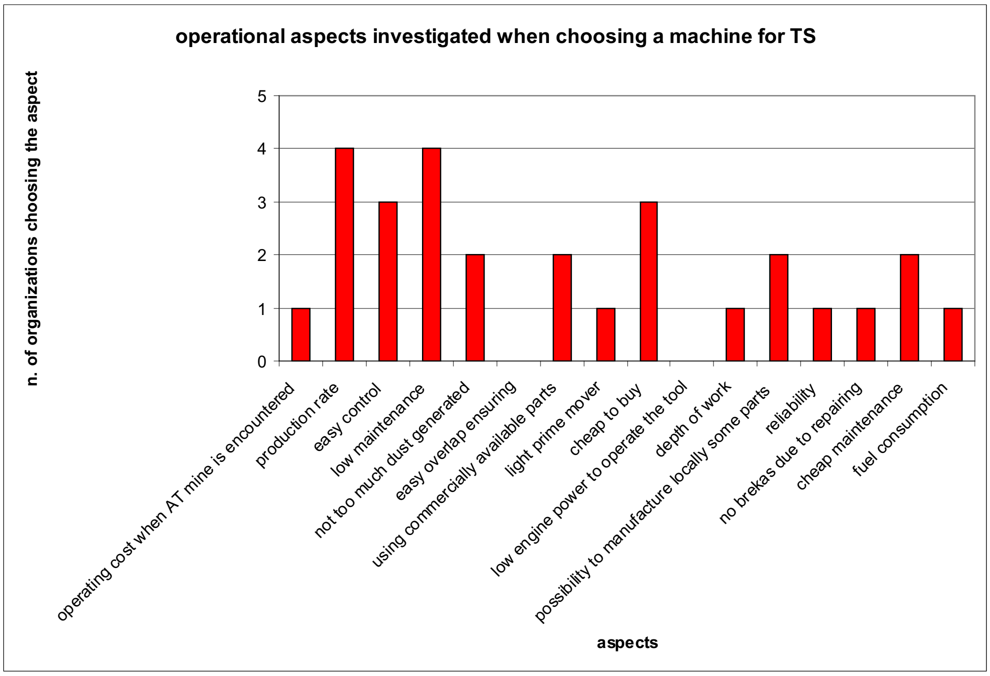

Figure 3. Operational aspects investigated when choosing a machine for TS.

- All organizations except one agree on the possibility to use in TS ground processing tools similar to the ones used by farmers when cultivating land (this consideration comes from the consideration that often areas which have been cultivated for a certain period of time without indicators of mine presence becoming known are released after NTS without further processing). Evidence suggests that this type of machines would need to be modified only to withstand AP mine explosions because the study found out that no machine is deliberately sent in areas suspected to be contaminated by AT mines, except two, of which one can only be used in case of AT mines with maximum 2kg of explosive.
- No machine is expected to detonate or crush all mines, in particular metal cased mines (during the visit to one organization out of 46 AP landmines recorded on the maps of the sites visited, in areas where mechanical ground preparation occurred, only 6 were destroyed or detonated by the machine used)
- As second or third asset, even mine protected vehicles are used to build up confidence on the fact that the area is free of explosive hazards (see fig.2)
- The study tried also to define what is the output expected from machines used in TS in terms of soil processing, finding out that machines for TS should be able to achieve a depth comprised between 10cm and 30cm, according to the organization. Only one organization defines the type of soil processing desired by defining the maximum size of soil particles that can be left over by the machine.
- The study highlighted also that life-cycle cost is becoming an important aspect of machines; in particular the cost and frequency of maintenance are among the most important aspects evaluated when choosing a new machine together with production rate and purchasing cost (see fig.3)
- A general lack of technical knowledge of machines has also been highlighted because only three organizations have chosen the machines they have and those are also the only ones that have expressed desire for new existing machines they currently don’t have. Investing in technical skills of the management staff might help investing resources in cost-efficient technologies suitable to the local context.

3. Structure of results presented in the study

Possibly, while being in the same country more entities, either mine action centres (MACs) or local or international Non Governmental Organizations (NGO), involved in land release have been visited for data collection. Within each organization, different types of interviews and questionnaires have been used targeting different types of stakeholders.

The majority of data have been collected through semi-structured interviews and questionnaires from the director of operations and planning or an equivalent figure. Other key figures interviewed were field experts or decision making persons identified by the director of operations and when possible persons in charge of quality assurance. Visits to field operations have been used for deepening the understanding of information collected. Interviews have been used to collect data on a higher scale, on a more general level. Questions allowed open answers sometimes including suggestions on the type of answers expected. Questionnaires have been used to collect detailed information in a way that allows easy comparison among different organizations.

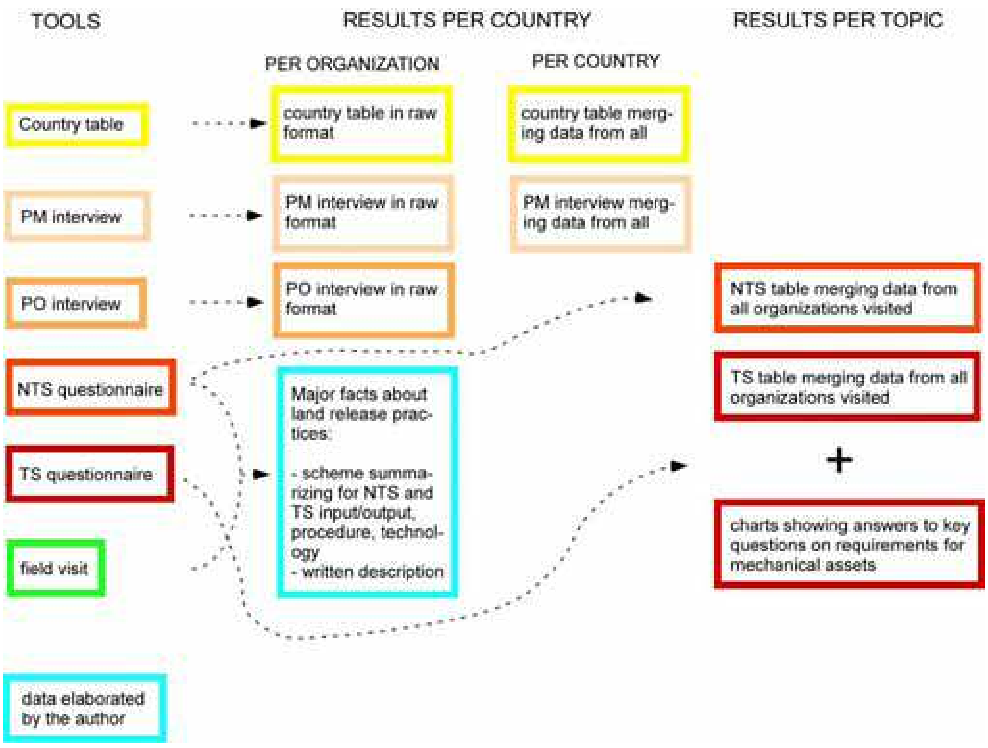

Figure 4. Analysis and presentation of data collected

The Study presents results by country and by topic. In the country section, data from all available country tables and PM interviews are merged together in two separate tables presenting general relevant facts about the country one and a general overview of the landmine problem as perceived by stakeholders interviewed, the other.

Other data collected through interviews are presented in raw format by organization. Because the study aim was not to compare and evaluate different organizations efficiency in achieving land release but to analyse the process and share good practices while highlighting weaknesses on which more research should be done, organizations are not named but referred to with numbers. To the same number doesn't always correspond the same organization.

Information acquired through questionnaires and field visits, in the country section, only contribute to the sub-section "Major facts about land release practices", elaborated by the author per each organization. Here, a scheme summing up what are inputs and outputs, what is the procedure followed and what are the technologies used in the traditional steps of land release (Impact Survey, NTS and TS) comes first a description of land release practices written following the same points per each organization. "Major facts about land release practices" section embeds all information collected per organization (see fig. 4).

Acknowledgment

The research leading to these information and results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 284747.

The author would like to thank all the people who made this study possible by spending some of their precious time with her, for their patience in answering her questions, for the interesting discussions that took place during and after work and for all what she has learnt. It's an incredible privilege to be able to visit mine affected countries with the precious support of experienced people who work there, because it allows a deeper understanding of country history and problems.

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The Multisensor and Hyper Spectral Survey of the UXO Around the Exploded Ammunition of the Land Mines Test Site Vegetation

Milan Bajić[57], Tamara Ivelja[58], Andrija Krtalić[59], Mile Tomić[60], Dejan Vuletić[61]

Abstract

The general survey of the unexploded ordnance (UXO) scattered around the ammunition depot after its unplanned explosion and the ground based measurements of the hyper spectral samples (end members) of UXO have been done in order to create initial spectral library of UXO. The methods, technique and collected data are presented and evaluated. The Johnson's criterion was used for detection, classification, recognition and identification of UXO in the airborne images (visible and near infrared wavelengths) of the surrounding of the ammunition depot. The test site near Benkovac contains 1000 landmines and 524 metal debris buried in the year 2001 in squares 1x1 m, at depths from 5 to 20 cm below the surface. The locations of 885 landmines and debris are not public and the blind tests are possible. The sparse vegetation covers some squares since the soil is meager. The hyper spectral data have been collected of the 1x1 m squares by the ground based mechanic scanner. The spectral samples of the vegetation inside and outside of the test site have been collected and total Nitrogen contents were measured.

Introduction

The research and the development of the methods and techniques of the multisensor and the hyper spectral survey of unexploded ordnance at/around the ammunition depot after its unplanned explosion are tasks in TIRAMISU, [1], [2], [3]. The example of the exploded ammunition depot Padjene (Croatia) and UXO scattered around it, was selected for the case study, Fig.1, Fig. 2. One another task is based on similar technique, this is the hyper spectral analysis of the stress of vegetation inside/around of the mine fields. The test site Benkovac, Fig. 3, (1000 landmines, since 2001) and the mine fields (Tromedja, Murgici, Siroke bare) have been selected for the case study of the vegetation stress. In the year 2012 has been done development and initial use of the ground based hyper spectral acquisition system, Fig 6a, Fig. 8b. The airborne multisensor system [4] was used for the multisensor images shooting mainly by team of FGUNIZ.

The airborne detection of the unexploded ordnance (UXO) is presented in the first chapter, the hyper spectral analysis of the UXO in the second chapter and the hyper spectral analysis of vegetation inside and outside of the test site benkovac and the minefields in the third chapters.

Figure 1. a) The ammunition storage Padjene after the unplanned explosion 13/09/2011, shown on the oblique aerial photography one month later. b) Several types of UXO collected around the exploded depot Padjene. The spectral features of fifteen UXO types have been measured by the ground based hyper spectral imaging system, Fig.6a.

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Figure 2. Typical view of the terrain around the exploded ammunition depot Padjene. The vegetation was burned- out, and six UXO targets can be reliably percieved. Ground based photography 24/10/2011 (M. Bajić).

Figure 3. Test site near Benkovac, established 2001., contains 1000 landmines (800 for statistical blind tests). Dimensions 200x50 m. Digital ortho photo of the test site Benkovac, derived from airborne images shooting 15/06/2012 in TIRAMISU mission of CTDT and FGUNIZ.

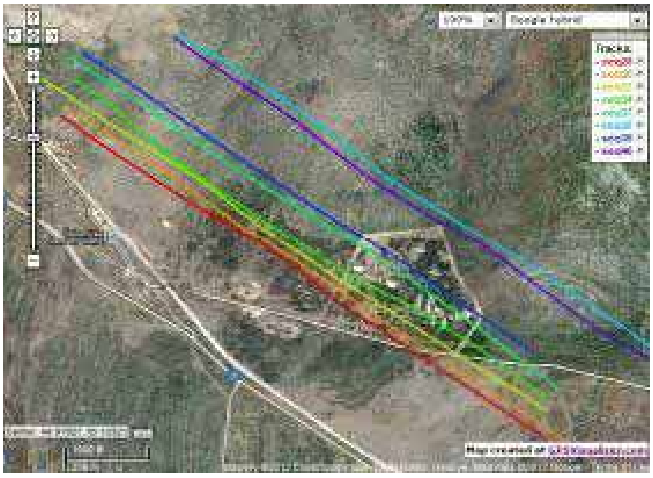

Figure 4. a) Flight routes over the ammunition depot and its vicinity (example). b) Geo tagged positions of the very high resolution airborne images collected by Nikon D90 color camera and MS-4100 multispectral camera. 11-15/06/2012, a TIRAMISU mission CTDT and FGUNIZ.

1. Airborne survey of the unexploded ordnance

The research and developmnent of the airborne survey of the unexploded ordnance at/around exploded ammunition depot started by collecting the very high resolution images in the visible (VIS), near infra red (VNIR) and the long wave infrared (LW IR) wavelengths, Fig. 4. The LW IR images collected by old Agema THV-1000 hve very poor quality and are discarded. The colour images show potential for the survey of UXO, Fig. 5.

The survey of the UXO at/around the exploded ammunition depot can be described by the probabilities of following functions: detection, classification, recognition and identification, related to the spatial resolution and the search time, in advanced [5] and historic Johnson's model [6]. The main goal of the our resesrch and development is to provide the trade-off between needed very high spatial resolution (linked to the critical dimensions of the smallest UXO) and desired coverage of a wide strip. The end user requested the detection of the UXO that has minimum diameter 40 mm and larger.

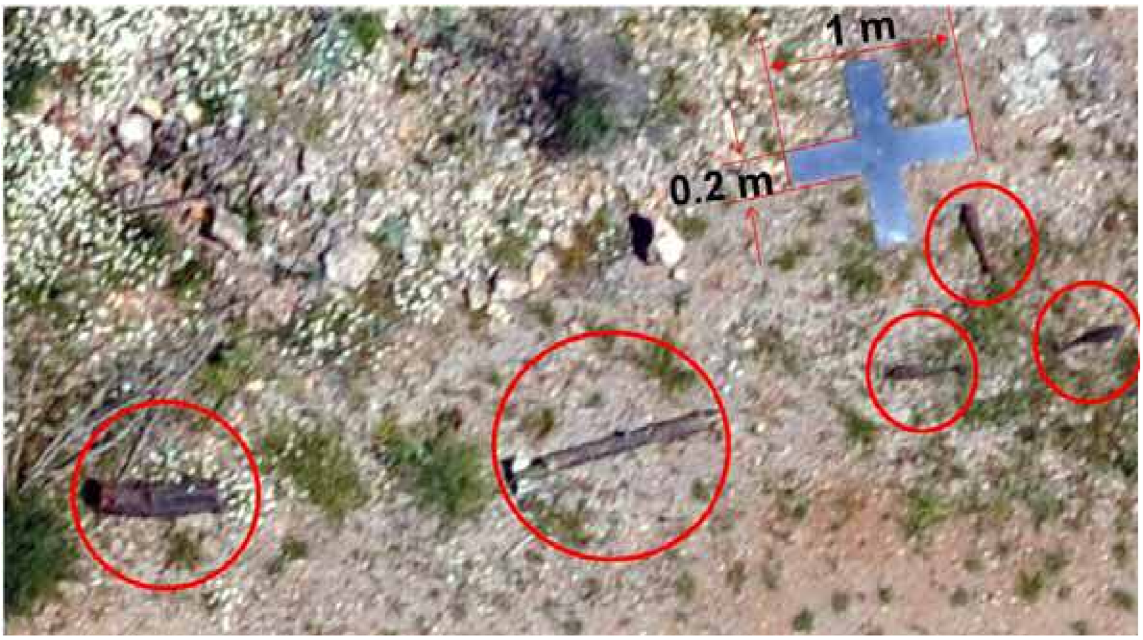

Figure 5. Example of the UXOs and calibration cross on the aerial color image acquired 13/06/2012 in TIRAMISU mission of CTDT and FGUNIZ.

The examples of UXO photography at Fig. 1b and examples of UXO at the aerial image at Fig. 5 determine the range of the requierd spatial resolution

The historic Johson’s model [5] uses only the narowest dimension of the target, while the advanced model [4] is based on the geometric mean Lc of two ortogonal minimum dimensions, Lx and Ly,

$$Lc = (LxLy)^{1/2}. \tag{1}$$

If the time of the search is not limited (here we could think on the search of the interpreter on the image), the probability $P\infty$ is determined [4, p. 427, 432] by

$$P\infty = (N/N_{50})^E/[1+(N/N_{50})^E] \tag{2}$$

where

$$E = 2.7+0.7(N/N_{50}), \tag{3}$$

N is the number of resolvable cycles (one cycle equals two resolution elements) across the target dimension,
N_{50} is the number of cycles across the target for 50% probability of survey functions, given in Tab.1.

The advanced Johnson’s model is applied in our research and development of the airborne survey of UXO as the means aimed to determine needed spatial resolution for the considered functions of the detection, classification, recognition and identification. The maximum distance (range) of the survey is not included in the development of the survey.
The concept of the airborne multisensor survey of UXO at/around exploded ammunition storage includes other approaches too: the use of multispectral images, which should enable discrimination of the vegetation, object oriented processing and interpretation, variety of enhancements, principal component analysis (PCA), independent component analysis (ICA), which should increase probability of the considered survey functions and the confidence of the mentioned tasks.

2. Hyper spectral analysis of the unexploded ordnance

The hyper spectral analysis of the unexploded ordnance (UXO) includes hyper spectral shooting from the mount by the hyper spectral scanner V9 (ImSpector, Specim), Fig. 6. The collected hyper spectral data have been processed, dark

Function of the survey	N_{50}
50% detection probability	1.5 resolution elements (0.75 cycles) per critical dimension
50% classification probability	3.0 resolution elements (1.5 cycles) per critical dimension
50% recognition probability	6.0 resolution elements (3.0 cycles) per critical dimension
50% identification probability	12.0 resolution elements (6.0 cycles) per critical dimension

Table 1. N50 for detection, classification, recognition, identification

a) b) c)

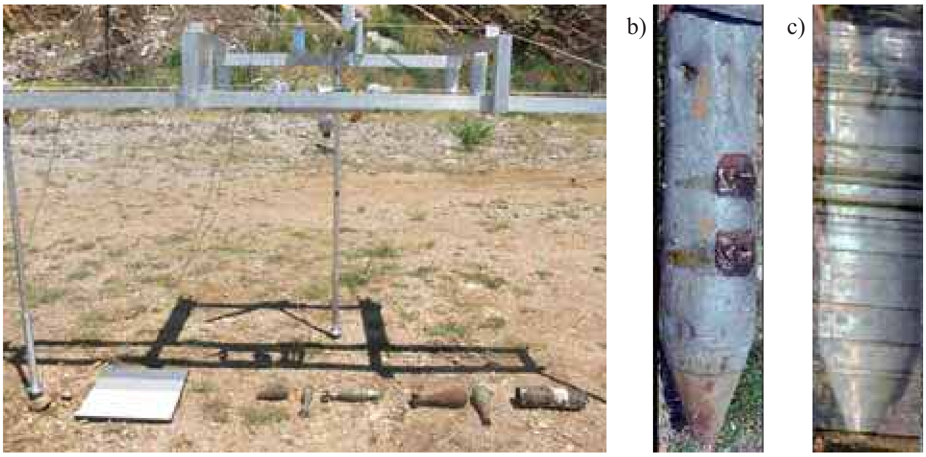

Figure 6. a) Computer controlled mount carries the hyper spectral line scanner for ground based imaging the unexploded ordnance (UXO). Height of the sensor is 1.1 m above the ground level. On the left hand side is the reflectance etalon (LabSphere, Spectralon MS180-1967). b) Aerial bomb RBK, photography. c) Hyper spectral image of bomb RBK, visualized channels: 650 nm – red, 550 nm – green, 450 nm – blue. The full width of half maximum (FWHM) of channels is 4.5 nm. The photography and the hyper spectral image do not show the same bomb.

current was compensated, and the hyper spectral cubes have been derived. While the collected data are radiance, the atmospheric correction QUAC (QUick Atmospheric Correction, ENVI) converted it into reflectance. Fifteen kinds of UXO have been used and the hyper spectral cubes are produced.

The UXO samples appear in the different conditions (intact, damaged, burned, covered by rust, original paint), orientation, but the types of soil have been similar. The set of fifteen hyper spectral cubes is the source for assessment of the spectral samples (end-members) needed for advanced hyper spectral interpretation. The example at Fig. 7, shows reflectance of the aerial bomb RBK, shown at Fig. 6b, Fig. 6c, of the soil and the small samples of green vegetation. Note that on the RBK in spectral domain dominate several different areas, in the example Fig. 7 they are named RBK grey and RBK light. Further research includes thorough analysis of the spectral characteristics of the considered fifteen UXOs.

3. Hyper spectral analysis of the vegetation inside/around the test site benkovac and the minefields

The hyper spectral analysis of the vegetation has been done inside/around the test site Benkovac, Fig. 3, and in the minefields Tromedja, Murgici, Siroke bare, Fig. 9. The Benkovac test site has 800 land mines located at unknown positions in 1628 marked squares, each has dimension 1 x 1 m, they serve for statsistical blind tests. Additional 200 land mines are located at known positions and depths, they serve for training of the sensors. The goal of the research are spectral and bio – chemical features of the grass, therefore areas covered with bushes, small trees are excluded from the analysis. Due to this fact 1121 squares of 1x1 m are considered. The consequence is that real number of the land mines available for the analysis is smaller then 800. All 1121 areas 1x1 m have beed shooted by the ground based hyper spectral imaging system Fig. 8b, while 406 hyper spectral cubes have been derived. Each hyper spectral cube has 584 x 500 pixels, 16 bits, 95 channels, from 430 nm to 900 nm. Inside of test site Bekovac are collected 171 random grass samples, and around the test site are collected 143 grass samples, Fig.8a, for analysis of Nitrogen content. Around the test site have been measured hyper spectral features of grass at locations shown at Fig. 8a. The hyper spectral measurement of grass radiance in the minefields Tromedja, Murgici, Siroke bare has been done by ground based system shown at Fig. 6a, while the whole process was more complex then in Benkovac test site. The first step was demining, deminer has to detect a landmine, remove and disarm it, take the gras which was atop of the mine and bring it to the measuring team, which was in safe area far from the mine field. At the safe location the samples of the grass from the mine field and a grass around the mine filed have been measured.

The hyper spectral measurements in 2012 of the grass of the test site Benkovac and around it, has been done in month July, when grass is dry, in its last vegetative phase. Therefore in 2013 we will do new hyper spectral measuring in the several phases of grass development, from 15/04/2013 to 15/06/2013. The ground based hyper spectral imaging is slow process and work intensive. Therefore CTDT and FGUNIZ develop a lightweight hyper spectral imaging system, controlled by WiFi, at distances larger than 1000 m, which can perform airborne mission by use of the blimp. The development has beed done, tests approved usability of the blimp based hyper spectral imaging with high spatial resolution, at low altitude (20 to 100 m), at low speed (1 m/s to 10 m/s), without interpolation of the hypere spectral image in the flight direction.

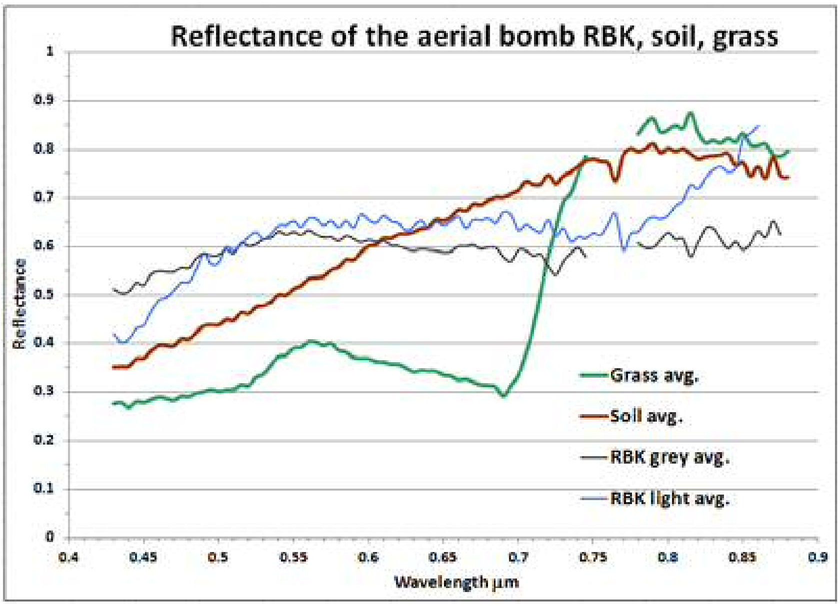

Figure 7. The average (avg.) reflectance of aerial bomb RBK grey, RBK light, soil and grass.

a)

b)

Figure 8. Hyper spectral and bio-chemical sampling the vegetation at test site Benkovac. a) Locations of the random samples of vegetation around the test site Benkovac (July 2012). b) Height of the sensor above the ground level is 3.1 m, enables to cover two squares 1x1 m and the reflectance etalon (LabSphere, Spectralon MS180-1967). The air temperatures in July have been from 30 oC to 40 oC, this coused non smooth carriage movement.

a)

b)

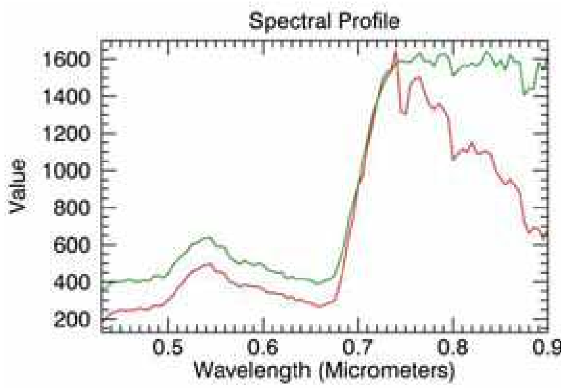

Figure 9. a) Deminer detected, removed the land mine and collected sample of grass which was atop of the mine (TIRAMISU CTDT mission, September 2012). Hyper spectral data have been acquired by system shown at Fig. 6a, in a safe area far from the mine field. b) The typical reflectance (green) of the grass collected in the minefield, atop of the land mine, obtained after the atmospheric correction by QUAC (QUick Atmospheric Correction, software ENVI) of the measured radiance (red).

Acknowledgment

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The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 284747, project TIRAMISU.

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Design and Manufacture of a Prototype for UXO Detection

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Abstract

Fourteen years ago Kosovo came out the war with about 4500 sites filled with different types of unexploded ordnances (UXOs) such are cluster bombs, anti-personnel and anti-tank mines etc., presenting a potential threat to the life of citizens. Demining started immediately and was carried by international specialized organizations and later on by Kosovo Security Force, but unfortunately the consequences were quite severe, with 115 people killed and over 450 others lightly or seriously injured, many of them remaining disabled forever.

Marking the contaminated areas, detection and clearance of UXOs are phases of a very difficult and heavy risk in the process of demining, in which the involvement of human is crucial. Therefore, it is very important minimization of human role and his replacement with technical devices.

As a result of survey on existing equipment for detection of UXOs and according to the configuration of our country, the idea for designing a prototype of a device for detection has been built and developed at the laboratories of the Faculty of Mechanical Engineering of University of Prishtina.

The phases of design, from initial idea to the design presentation including the adopted methodology of decision making at each phase, motion, detection and device’s control are described in this paper.

As a result of the design process with a clear task - to ‘eliminate’ the human role during the detection of UXOs, the prototype of a device has been constructed and named RoboDet – Robot for Detection of unexploded devices.

The test of reliability for RoboDet in improvised ‘minefield’ resulted successful and satisfactory.

1. Introduction

A number of about 4500 sites in Kosovo marked as contaminated with different UXOs in 1999, Fig.1, specialized teams of NATO forces and the Kosovo Security Force (KSF), various international and national organizations have since reduced to identified 60 high-risk and 50 suspected sites , Fig.2 after cleaning about 47 million square meters of mines. These sites still pose a serious threat to the population

Fig.1 Contaminated sites in 1999 (Source: UNMIK).

Fig.2 Contaminated sites in 2011 (Source: KSF)

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The most common methods for detection are manual or combined (using metal detectors, area excavation, dogs or mechanical equipment) and include the use of manual deminers because to date there is no fully mechanised method of ground processing that can find and remove mines and UXOs.

Having in mind all the methods and facts on contamination of the country, a prototype of a device for detection of the unexploded ordnances in marked mine fields has been designed and manufactured. The design process, from idea to prototype, and its manufacture with control system I elaborated in this paper.

2. Design process and decision making methodology

The design is a process with many questions coming up one after another, starting from problem/task introduction, design process itself and those related directly to technology or science, Fig.3. The designer needs to think, wonder and decide when solving design problems. This complex task should be put through a procedure/methodology with certain phases that can be used during all design process with needed accuracy that will bring to successful finalization of the design.

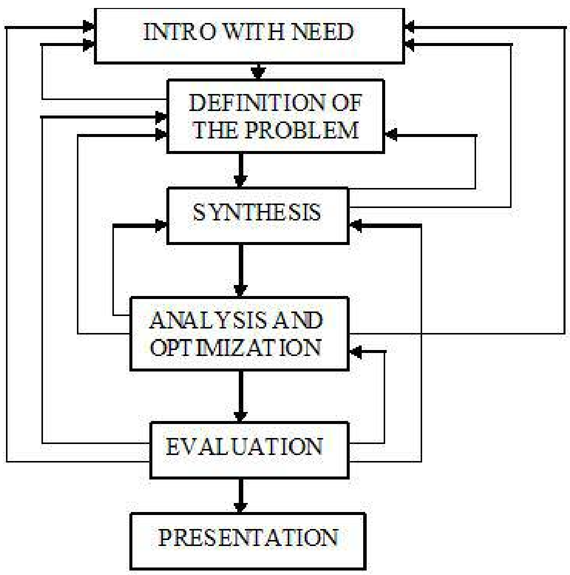

Fig. 3 Phases of a design process

The problem resolution during the design process arise a number of questions such are, [2]:

- Where and how to start?
- What is the procedure that needs to be adopted or implemented?
- Is it new or former/existing design?
- Can be followed procedure from manuals or standards?
- What is a procedure for making a new design?
- How to define design problem and set design goal?
- What are quantities and what variables – free or dependent?
- How do we set constraints?
- How each item designed looks/should look in drawings?
- What shape and structure would have a product based on a design?...

A design process presents a “challenge” for an engineer – designer/constructor, who among many tasks needs to make many decisions for getting “the best” solution.

Less “creativity” is needed if design problem is “old” or “former” design. In these cases start of design is known, only the “design procedure” needs to be followed and it easy to complete the design.

In creating the “new” design, there is no sample, no manual and no former design. The engineer – designer has to produce and decide on everything by himself. He must take into account geometry (dimensions, shape), structure (material), functionality and constraints (technical, economic, social, environmental, ethical etc.). So, the way how/what decisions are made are of most importance.

The decision concerns on:

- Carefully definition of design problem
- Searching and generating for alternatives
- Selecting the best based on evidence
- Making sure by checking that the best has been chosen

This four concerns would be adopted respectively as Task (T), Alternatives (A), Evaluation (E) and Challenge(C) and would represent the adopted methodology named TAEC and will be used on elaboration and analysis of design process, [2].

3. Design and manufacture of the device for uxo detection

3.1 Idea

Based on the above mentioned facts and statistics on mine fields and victims; noting that mostly of detection and de-mining/clearance methods involve manual deminers and are slow and dangerous, an idea to design a device which will facilitate work to specialist teams for detection has been born and would be able to [3]:

- Assist and expedite the detection of UXOs and clearance;
- Decrease the risk for users of equipment for demining;
- Contribute to making Kosovo a safer place for the life of its citizens;
- Enable farmers, growers and farmers work without fear in their pasture fields.

Therefore, the task is that through a constructive work, based on above mentioned data (on human role on demining process and equipment) to design a functional device that may have not only constructive/industrial purpose but also humanitarian.

3.2 Definition of the criteria for the design of device

Once it was decided to design a device from the idea that would be able to detect UXOs, the following criteria have been set:

- The device must have sensors/metal detectors - which will be able to detect unexploded devices (mines);
- Construction to make the move forward, backward, left and right return with a coordinated movement - at a speed less than human movement (in contaminated areas);
- Driving of the respective wheels to be independent;
- To be controlled from distance – in order that human presence be as far away from the device or from danger radius;
- To be able cross the barriers - ie detection device can move across the flat and non-flat surface;
- Links between elements of the construction to be as flexible as possible;
- Have proportionate size and weight as appropriate.

3.3 Synthesis and analysis of the design solutions

Different solutions for device to be designed have to be collected, synthesized, grouped, analyzed, modified etc. Thus some of the steps during these phases include:

- Concept solutions;
- Presentation of ideas through sketches;
- Drawing on the computer (software like AutoCad);
- Definition and design of the parts; find and supply with parts;
- Modification of existing parts and/or design of new parts;
- Assembling and simulation/testing

3.4 Decision making

It is understandable that engineer – designer must make a right decision at each phase before continuing to next one, otherwise must return back and do searching and checking for the reasons why phase solution is not the best or right one (iteration). TAEC methodology was used during all steps of design.
Following is given implementation of such methodology during some design phases of elements or tasks.

WHEELS, Fig. 4:
T - Wheels with caterpillars
A - Pulleys vs Gears
E - Smoother and reliable motion was estimated
to be making wheels with caterpillars made by chains
driven by gears than by pulleys with profiles
C - Modification of the gears and good balancing.

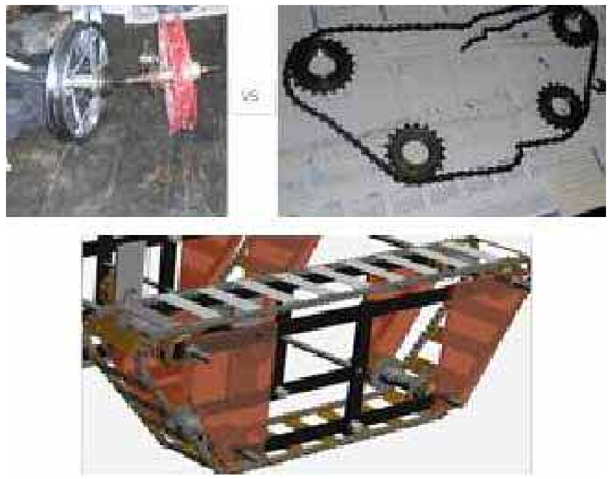

Fig. 4 Wheels

SKELETON, Fig. 5
T - Skeleton – Wheels assemble
A - Standard filleted shafts or modified filleted shaft-nut set
E - The set was evaluated to be more proper and constructively accepted because of possibility of positioning
C - Centrality and calibration

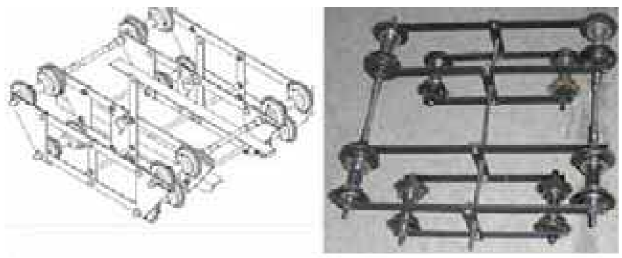

Fig. 5 Skeleton-Wheels assemble with new designed or modified elements

DEVICE MOVEMENT, Fig. 6
T - Driving of respective wheel to be independent
A - One motor with special system for motion control of wheels or two same DC motors
E – For simpler and easier design and element purchase it was decided two same DC motors
C – Speed calibration and insulation of motors

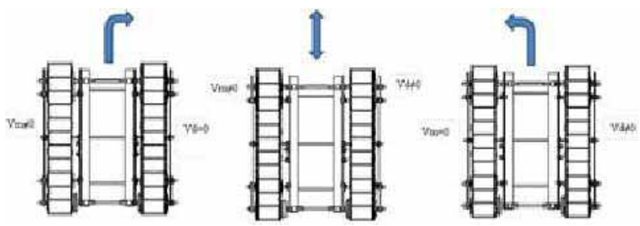

Fig. 6 Move forward, backward, right and left

REMOTE CONTROL, Fig. 7
T - Control of the device
A - Remote controlled or autonomous
E - Because of uncertainty on mine fields it is estimated that would be better human to 'guide' the device from the distance with remote controller
C – Caution for controller to be outside dangerous zone

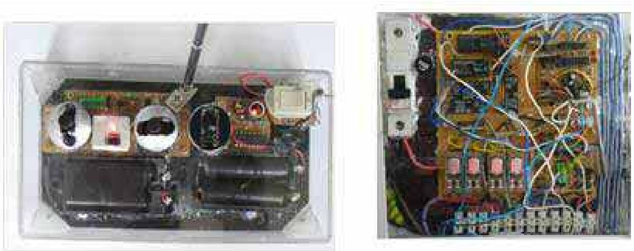

Fig. 7 Remote control system (transmitter and receiver)

3.5 From design to prototype

After clearly defined design was accepted, the needed elements were assembled constructing the prototype of device named as "RoboDet", Fig. 8., [3], containing three main parts: skeleton, moving hand and control electronics; driven by three DC motors and supplied by two batteries. The RoboDet weight of about 30 kg moves with speed of one km per hour.

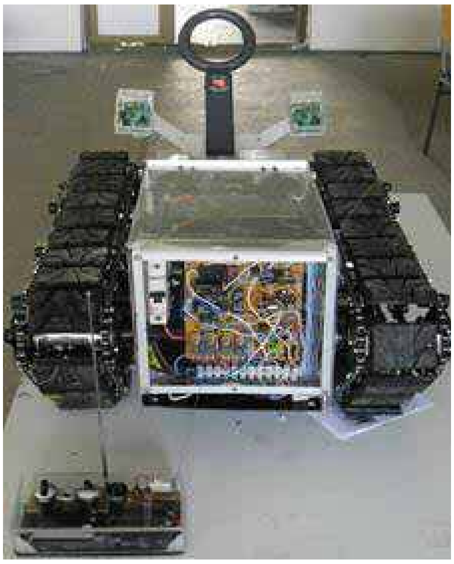

Fig. 8 RoboDet

Conclusion

Well defined idea with clear structured design process followed by dedicated decision making procedure at any step leads to a successful design task which results to a prototype. The prototype of the robot for detection of unexploded devices – RoboDet designed and manufactured at the Faculty of Mechanical Engineering laboratory in Prishtina tested in real environment with improvised 'minefield' resulted successful and satisfactory, fulfilling driving, detection and remote control criteria.

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Trailers for the Transport of Dangerous Goods Carried out within the Project TIRAMISU

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Abstract

The issue of the first part of work will be transport and storage of hazardous materials of various nature, including mines, unexploded ordnance, IEDs, ammunition and explosives. The proposed work will describe the issues related to hardware problems and the latest proposals of technical solutions related to the storage and transport of munitions. In the section on structural solutions will present information and ideas proposed recent work related to the project TIRAMISU: trailer for temporary storage and transport of explosives and munitions. In the second part of work will cover both the destruction (by trawling) hazardous materials. Paper will present information and ideas proposed recent work related to the project TIRAMISU: modular demining machine, working by pressure, connected to a remote-controlled mobile support platform - for example: tractor of PIERRE.

1. Trailer for temporary storage and transport of explosives and munitions

Currently, many kinds of explosion-containment vessels are manufactured worldwide. The weight of the explosives they can contain varies from several hundred grams to a few dozen kilograms. All these containers are mounted onto a dollies, platforms or transport trailers. Such containers are to provide protection to the persons transporting the explosive and also to those in the vicinity of the transport vehicle, should such unexpected (accidental) detonation take place. This means that the container should preclude the mine/ERW fragments, resulting from the explosion and destruction of e.g. the anti-personnel mine casing, from spreading and also properly direct the release of detonation by-product in the form of hot blast gasses. Most of the analyzed vessel constructions are characterized by unfavourable ratio of their mass to the mass of the explosive transported. In many cases the containers are relatively heavy, and the blast energy absorbing material in not very effective. Often complicated lid opening and closing mechanisms are employed, in spite of the fact that some regulations (including those in Poland) specify that the vessel no longer be used after it had contained one explosion.

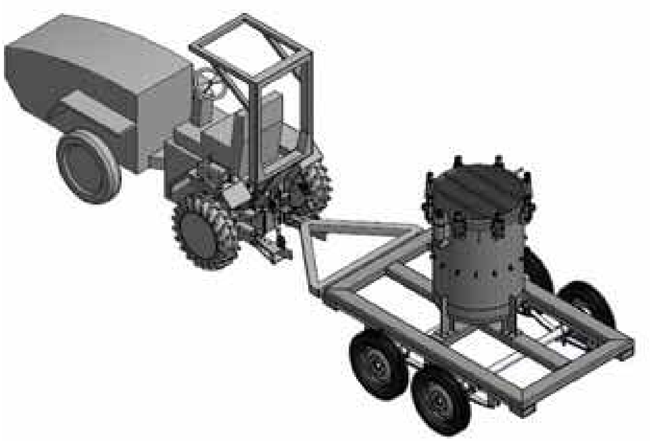

Fig.1. Trailer for temporary storage and transport of explosives and munitions – second version

This is due to the fact that a slightly damaged structure of the container (following a single explosion) may not withstand another explosion and the elaborate container constructions, especially lid lifting and lowering mechanisms (often using hydraulics) lead to unnecessary increased production costs. Furthermore, it is assumed that the structure of the vessel should direct the blast gas vertically through properly designed channels, valves and the like. This is a fully legitimate guideline, however in several types of containers the gasses are discharged horizontally, through the side walls of the vessel, and it is extremely dangerous for the persons transporting the explosive, in particular when they are to travel through urban terrain (in cities and villages).

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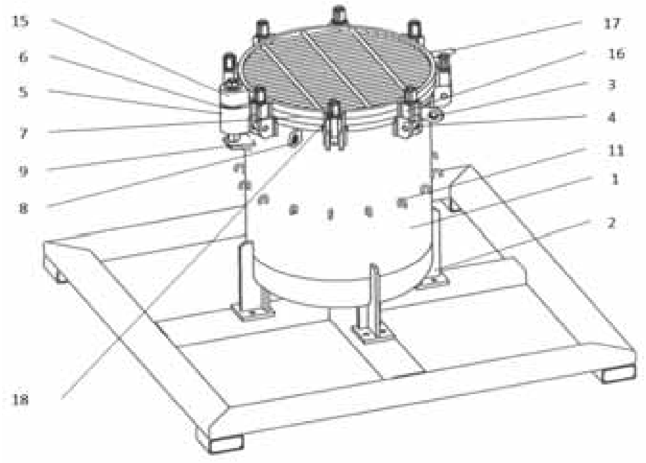

Fig.2. Blast containment vessel for temporary storage and transport of ERW (explosive remnants of war) produced by WITI
1 - body; 2 - supports; 3 - clamps; 4 - eye bolts; 5 - lower casing; 6 - rotation axis; 7 - lid; 8 - transport lugs; 9 - support; 10 - bolt; 11 - hooks; 15 - upper casing; 16 - supports; 17 - handle; 18 - nut

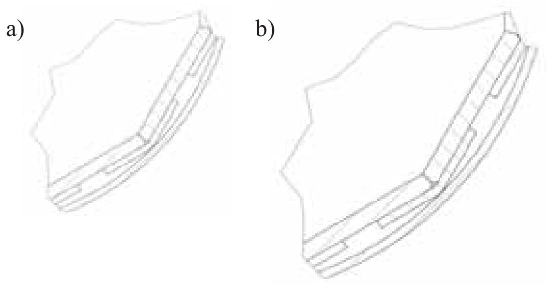

Fig.3. Blast containment vessel actuators produced by WITI:
a - safety grip, b - cross wall of the container

The body (1) of the container is a cylinder with supports (2) attached to its lower casing. The supports mount the vessel onto the transport trailer. The upper part of the body includes: clams (3) with eye bolts (4) being seated in them; lower casing (5); rotational axis (6), lids (7) and transport lugs (8). Under the lower casing (5), a support (9) is mounted upon which the (6) screw of the rotational axis (10) of the lid (7) is leaning – Fig. 2. The central part of vessels' body (1) is equipped with hooks (11) for the protective cover line. The lid (7) of the vessel comprises two rings – the lower one (12) and the upper one (13) with bars (14) placed in an alternating manner. Upper casing (15), rotational axis (6), supports (16) and a handle (17) Are attached to the cover (7). The cover (7) is held down to the body (1) with the aid of eye bolts (4) and nuts (18). Inside the vessel's body (1) (Figs. 2 and 3) there are elements which absorb blast energy: wooden boards (19) are located on the circumference of the vessel and they are conjoined with a rubber tapes (20), while a wooden floor (21) can be found in the lower region of the vessel, supporting rubber lining (22). In the mid region there is an insert (23) made of expanded polystyrene with a cavity (24) inside. This cavity is sealed with an inner lid (25) made of rubber. It is in this cavity (24) that the explosive items (26) can be stored in.

Should an unforeseen explosion occur, the blast containment vessel should preclude:

- the blast fragments from spreading directly in horizontal plane;
- 0.1 atm blast wave from propagating further then 6.5m away from the vessel.

The above assumptions will be test during a field test. 11 directional explosive charges will be prepared for the test. The number of steel bearing balls with diameter of 6 mm will amount to 2500. There will also be an explosive charge in a casing made of steal . Overall, the explosive charges combined will weigh 1.0kg.

A vital parameter to be considered when analysing the impact of pressure impulse of the hull underside is the maximal pressure value at the wavefront.

$$\Delta P2 = \varphi(k) \cdot E/L3$$

where:

- $\Delta P2$ – maximal positive pressure at the blast wave front;
- R – distance between the explosive and the walls of the containment vessel,
- E – average explosion energy per unit of mass of an explosive;
- k – vapour/gas isentropic exponent in the area affected by the blast wave;
- $\varphi(k) = 0.1038$ – for strong explosion in the air.

The model of blast-containment vessel used for the calculations is presented in Fig. 4.

Data for the calculation:

a) mass of an explosive M = 1.0 kg TNT;
b) average energy released with TNT explosion E = 4.2 • 106 J/kg.
c) L1 = 0.4 m;
d) L2 = 0.55 m;

- impact of positive pressure on the bottom of the vessel $\Delta P2$ = 2619952 N/m2;
- time of positive pressure impact on the bottom of the vessel t1 = 0.00075 s.
- impact of positive pressure on the side surface of the vessel $\Delta P2$ = 6811875 N/m2;
- time of positive pressure impact on the side surface of the vessel t1 = 0.00063 s.

The body of the vessel was manufactured out of high strength alloy steel sheet (steel grade 18G2A) whose thickness equaled g = 10mm and for this steel:

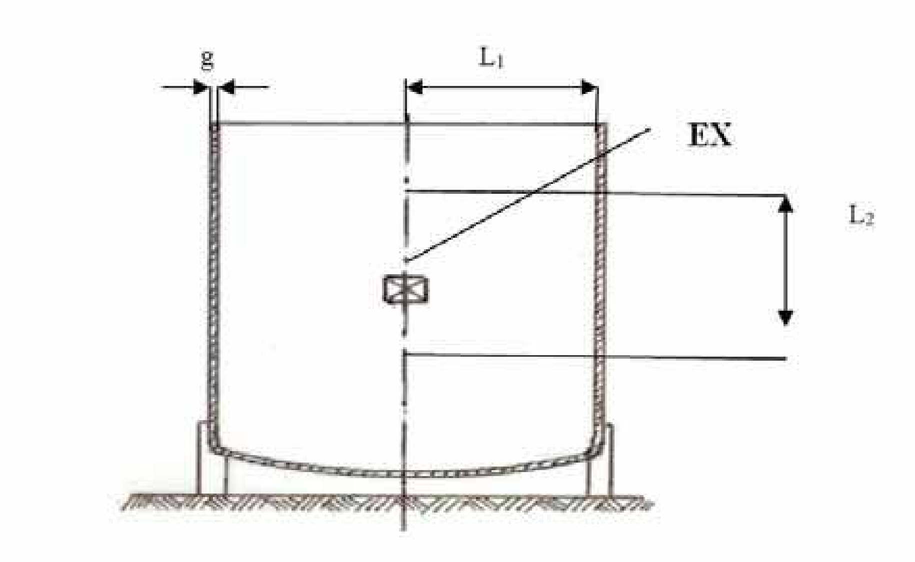

Fig.4 Schematic of a containment vessel assumed for strength calculations.

- tensile strength Rm (Rr) = 520÷640 MPa;
- admissible tensile stress kr = 260 ÷ 320 MPa
- where factor of safety x = 2.
- circumferential stress of the explosion containment vessel body σ1 max= 295.4 MPa

What can be seen here is that when σ1 max and kr are compared, it is visible that σ1 max value lies between the upper and lower limits of kr . This means that it is slightly higher than the lower limit of kr, and lower than its upper limit.
In reality circumferential stress σ1 max should be slightly lower than the ones calculated due to partial dissipation of the explosion energy by structural elements inside the vessels' body (wood, rubber, expanded polystyrene), inertia of the body (side surface) of the vessel and short time t1 of the impact of positive pressure on the bottom of the vessel ΔP2.

2. The modular demining machine

The Project is aimed at developing a state-of-the-art demining machine based on a roller principle, continuing the Polish national program, called SHIBA. The modular mine roller, will be connected to a remote-controlled mobile support platform, for example: tractor by PIERRE trattori.
Width of the device will be correlated with the dimensions of the vehicle.

The modular demining machine – Fig. 5, 6 – contains:

- protection kit (1, 2);
- mounting arrangement for vehicle (3);
- boom (4, 5);
- working tool (6).

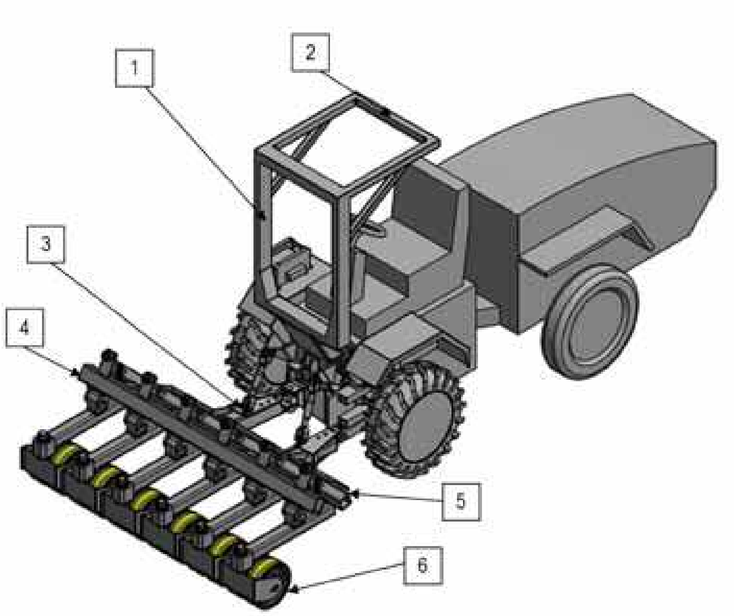

Fig.5. Light modular demining machine (mine roller) attached to a tractor – in working position

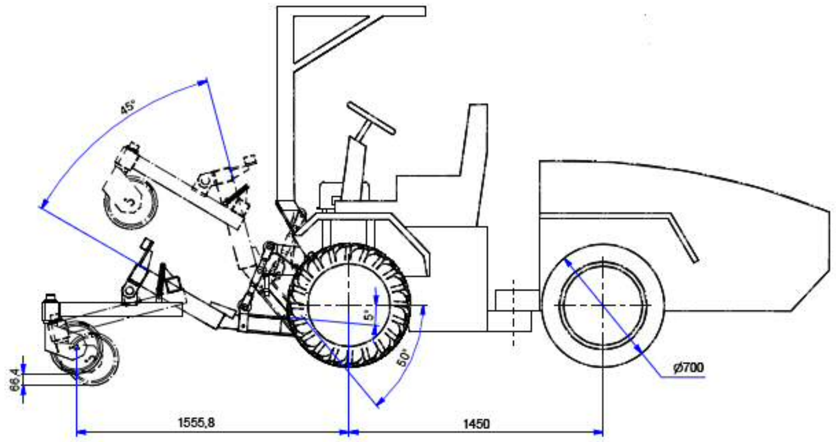

Fig.6. Diagram of a light modular demining machine with a tractor

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Semi Autonomous Mobile Robot for Mine Detection

***Arbnor Pajaziti*[68], *Ka C Cheok*[69] *and Xhevahir Bajrami*[70]**

Abstract

Detection and removal of antipersonnel landmines is a serious problem of today. There is a dire need for low-cost mobile robots for the purpose of mine detection and disposal. A de-mining mobile robot has to be cost effective compared to local labor costs. Presently commercially available mobile robots consist of mainly custom made parts. The design and manufacturing of such parts make the robots very expensive. This paper describes how careful selection of commercially available parts leads to reducing the development time and costs for a demining robot while ensuring its reliability, convenient operation and application domain. An actual example of how a low cost mine detection robot was successfully integrated within two months is outlined.

Keywords – Mobile robot, Demining, Landmine Detector.

1. Introduction

There are 40-120 million landmines all over the world today [1]. Landmines are long-term killers and active long after a war is over. According to recent estimates, landmines are killing and maiming more than 26,000 innocent civilians per year [2]. Detection and removal of antipersonnel landmines is a serious problem. Its solution requires the cooperation of various engineering fields. Due to the widespread usage of landmines, there are many diverse environments that a detection device would have to be able to work in. This paper involves designing and constructing the low-cost mobile robot that will scan a predetermined area and detect any landmines that might be present. Upon detecting a landmine the robot will mark the location where the landmine is detected.
This paper also concerns the software design that basic equipment should be control and drove. Requirements for a civilian demining mine detection mobile robot are less complicated than their military counterpart, but nevertheless must guarantee full satisfaction of these capabilities [3]:

- Detection of mines in all conditions with near 100% probability.
- Complete coverage of defined area.

In terms of coverage, mobile robot should be capable of following a defined search pattern where off line planning would be performed taking into consideration some environmental constraints. The robot should record and report position during the whole mission, negotiate difficult terrain, walk fast enough to be cost-effective, be faster than a human, while retaining high sensitivity for mine detection.

2. Mobile manipulator

A mobile manipulator, holonomic or not, is kinematically redundant – with degree R – when the degree of freedom D of its EE is strictly lower than its mobility index M. In this case, R = M − D and a.e. for a given End Effector location there is a R dimensional set of corresponding configurations [6].
Wheeled mobile robot which we will study in this paper is typical examples of mechanical systems with nonholomic constraints.
Using the Lagrange multiplier rule, the equations of motion of nonholonomically constrained systems are governed by:

$$M(q)\ddot{q}+V(q,\dot{q})+G(q)=E(q)u+B^{T}(q)\lambda_{n} \quad (1)$$

where M(q) is the n x n dimensional positive definite inertia matrix, $V(q,\dot{q})$ the n-dimensional velocity-dependent force vector, G(q) is the the gravitational force vector, u is the r-dimensional vector of actuator force/torque, E(q) is the n x r dimensional matrix mapping the actuator space into the generalized coordinate space, and _n is an m-dimensional vector of Lagrange multipliers [8].
The manipulability measure of the mobile manipulator is a method that uses the potential function included in the motion control of nonholonomic wheel mobile robot. Depending on the application we may have to consider the whole system manipulability or the robotic arm manipulability. If the user wants to keep the platform motionless to manipulate with the arm alone, it would be convenient to reach the operating site in a good configuration for the arm, from a manipulation point of view.
The control algorithm is designed by using the dynamic system of the mobile manipulator in Matlab/SimMechanics.

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The output equations are chosen to be the coordinates of the end point of the manipulator when it is at the configuration with the maximum manipulability measure.

3. Experimental platform

A. Mechanical System

The GEARS-SMP robot has been selected for the mobile platform that has 4 wheels structure, with 15 pounds payload capacity and 4.5 inches average ground clearance. A significant portion of MDBOT is built from aluminium in order to minimize weight. The use of steel was kept to a minimum, used only when the strength or ease of fabrication dictated the need for it. The electronics and batteries are placed in two boxes. Four wheels are driven by a high torques gear motors with integrated magnetic encoders. Two left motors and two right motors are controlled each side by one H-bridge. A lightweight robotic arm is attached to the mobile platform for sweeping a mine detector. Four DC motors are linked to 4 revolute joints of manipulator, allowing the mine detector to move on constrained area. The MDBOT robot is driven by 12 V NiMh batteries while the Master Module Controller is using power from onboard PC via serial port.

B. Computation Hardware

Aiming at low cost and high performance, based on Master Module Controller (involving the XIPMod expansion modules) and embedded real-time operating system, the control system is implemented and the prototype for this platform is developed [4]. The mobile platform has embedded control computer system, input/output module, sensor module, standardized drive modules and wireless communication module. Serial & CAN bus, wireless network are used to connect to embedded control computers and remote base computer.

C. Sensing Hardware

The vision system consists of the wireless camera. Its main purpose is to follow the swiped area of the robot. The camera can monitor the image for the range of 500 feet. The camera is controlled from the master computer that enables the demining person to have the view of the detected field from distance.

A GPS is controlled under a sensor module that guides the mobile robot to specific latitude, longitude and senses the angle of an incline. Infrared sensors are used on the mobile platform to measure the obstacles in surrounding environment for local navigation and obstacle avoidance. Additionally camera allows navigating the vehicle through minefield. A mine detector attached to a robotic arm performs the sweeping action for locating suspected objects. The first two axes define the movement of the robot, axes three and four operate with manipulator arm, while the commercial mine detector is attached as an end effector. The platform can be operated under autonomous operation and master-slave tele-control.

D. Landmine Detection

Many countries around the world are impacted by the past and present wars where landmines and other unexploded items remain a danger to people and the environment far beyond the conflict [5]. Landmine detector for military or humanitarian use is highly dependable and easy to set-up, however, it requires trained personnel to perform these tasks which over time it cost us many lives and money. Metal detector used is made by Garrett, which is well known in the metal detection industry, more so, it is fairly priced which makes it affordable to purchase it.

Garret metal detector has an independent power supply (6V), which is in use while the robot is sweeping (PhaseMode#4). While operating/driving the robot to its specific sweeping coordinate, metal detector is in sleep mode (not powered).

TTL switching relay which is manipulated via data acquisition. In parallel the RFI Noise Elimination switch is activated using the above data acquisition in junction with the TTL switching relay, in order to pin point the exact location and the size of the landmine. Once we sense a landmine we send out a switch signal to the mainframe, to halt the robot from moving while in parallel start Phase "Mode#3" of the robot, which entails that the robot will perform 4 sweeps while the robot maintains the exact same position. The extra sweeps are implemented to better understand the exact location, size, and depth of the landmine, as well as give the GPS receiver enough time to gather multiple coordinate samples to improve the accuracy. More importantly, the GPS coordinates are translated from the centre (CG of robot) to the location of the landmine, using other sensors as well as the pre-determined sweep path which uses specific robotic arm coordinates.

E. Lidar

Lidar is used for many applications such as: Rail traffic technology, wood-work, security/area monitoring system, distance and speed monitoring, as well as object detection. Given the fact that this device is widely used in the automotive industry for many applications such as: object detection, distance and speed monitoring, it shows that the device is durable and reliable. Hence, we decided to use lidar for object detection and possibly in the future incorporate distance and speed monitoring. The device is not fully incorporated in the existing stage, however, it is in works to fully incorporate the device in the future stages of the project. This particular Lidar is fairly priced as well as capable of sensing object in 2-D, which is an improvement when considering the older generation of Lidar, where they were able to only detect objects in 1-D. Another special feature of this particular Lidar is the capability of measuring distance and velocity of multiple objects in 3 independent measuring channels in the range of up to 10 meters, which could increase our capability of performing sensor fusion with our other sensors and increase our accuracy for object, speed, and range detection which is highly important when dealing with a project which potentially saves lives in the field.

F. Incremental Encoders

A photo electric sensor is used to simulate wheel encoders, which would help us in obtaining the distance traveled. This idea will be implemented in the upcoming phases of the mine detection robot. One of the main reasons as to why we are engaging in this approach is due to pricing of the motors with the encoders as well as the existing motors were purchased without encoders.

G. Sweep Switch

Two proximity switches are implemented as an end of travel confirmation for the robotic arm. There are a few reasons as to why we implemented this feature, such as: eliminating overdrive, position confirmation, sweep orientation status (left to right/right to left), etc. The future use of this sensor will help us in calculating the GPS coordinates of the landmine location, furthermore, it will help us in confirming that the sweep is applied throughout the whole path.

J. IR Displacement Sensor

Infrared sensor is implemented near the head of the landmine detector, in order to calculate the height of the detector with respect to the ground. The sensor will help in maintaining a constant distance to the ground, by feeding the current distance to the Matlab/Simulink. More so, once the signal (height) is implemented in the Matlab/Simulink, we can adjust the arm kinematics in order to maintain the constant height of the detector with respect to the ground.

H. Communication Network

The demining robot is steered by a 4 channel FM Radio Transmitter. The remote controlled operation identifies the existing movement of the mobile platform and paves the way for a potential future upgrade to full autonomous navigation. In order to meet the design requirements, a large number of experiments using physical, mathematical or analytical models as well as simulations were carried out. Performance of the mobile robot is being evaluated with a large number of experiments to test its motion performance, long running reliability and application in the mine field. The prototype tests have shown promising results.

4. Motion Planning Derivation

Robotic arms mounted on mobile platforms are used in both terrestrial and space applications [6-7]. The mobile platform increases the size of the robot workspace substantially enabling positioning of the manipulator for task execution. Wheeled mobile platforms are subject to non-integrable kinematic constraints. Such constraints are generally caused by one or several rolling contacts between rigid bodies, and prove the fact that the wheeled platform must move in the direction of its axis of symmetry.
The metal detector attached to manipulator is intended to detect landmines while mobile robot traverses the infected area. Therefore, in order to have complete coverage of the defined area the scanning procedure is broken into two subsystems. Subsystem 1 - mobile platform is stopped until subsystem 2 – manipulator arm is seeking fur buried mines while turning left and right covering the band equal to the wheel step rotation.

5. Simulation Results

The simulation is carried out by using MATLAB Ver.2011b. The MDBOT runs on 4 modes. First mode – the manual mode is to setup the rest position, second mode is moving the robotic arm to initial sweep position, third mode is running the robotic arm around the detected mine area, while fourth mode is runing the robotic arm to sweep and the mobile platform is moving straight forward, sequantially. Upon detecting a landmine the robot will mark the location where the landmine is detected.
The control simulation of MDBOT was visualized using the VRML environment included in the toolbox of Simulink. Figure 1 shows a diagram of the 3-D model of the vehicle. The dynamics of the motors were modeled to make the virtual robot behave the same as the real world robot, figure 2.

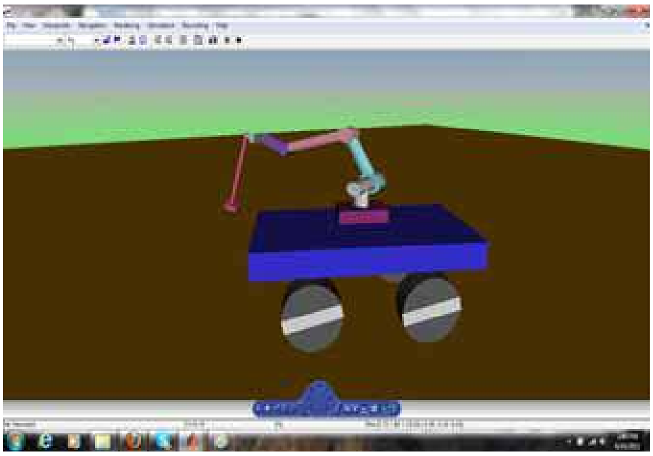

Fig. 1. VRML model of the MDBOT.

Fig. 2. MDBOT.

6. Experimental Results

The Matlab GUI shows the traveled path drawn by the blue line. The "M" labeled markers show the detected mines and the "D" labeled marker shows the current position of the robot.

To accomplish such task, GPS location is read from the GPS receiver via serial communication. $GPGGA NMEA sentence is read to obtain latitude, longitude and satellites in view. The latitude and longitude obtained are in DEG: MIN: SEC format and are converted into decimal degree for use in Google Maps. Additionally the converted latitude and longitude are logged on a local file.

A Google Maps URL is generated for loading a visual map of our current GPS location. The obtained GPS coordinates are inputted in the Google Maps URL which then loads a ".jpg" picture of our location and displayed on the GUI interface. In the URL there are other defined details such as zoom level, map type and the type of markers that point our location.

7. Conclusion

In summary, this paper reveals an approach and actual example to building a high-value low-cost mobile robot for mine detection that is able to satisfy most demands of mine detection requirements. The robotic system has been described and control architecture has been presented. Needs for such function robot is genuinely tangible in many countries affected by landmines leftover from wars. MDBOT will contribute to autonomous antipersonnel-landmine detection process.

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Autonomous Cooperation Between UAV and UGV to Improve Navigation and Environmental Monitoring in Rough Environments

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Abstract

An architecture to allow cooperation between an UGV and an UAV is proposed. The UAV can autonomously follow the UGV, by using an image processing algorithm. In this way aerial images are provided that can help trajectory planning in rough environments, via a developed webGIS platform.

1. Introduction

One of the main problems encountered during the tele-control of an UGV (Unmanned Ground Vehicle) is the limited field of view obtained by the on-board cameras and sensors. In difficult environments, such as those that can be encountered in demining operations, it can be really hard for the operator to be aware of the situation and decide the best navigation strategy.

A possible solution can be the adoption of an UAV (Unmanned Aerial Vehicle) that flying above the UGV can oversee a wider area. However in this case two operators are needed to control the two systems at the same time. A possible solution is obtained augmenting the autonomous capabilities of the involved platforms, thus minimizing the intervention of the operators.

In this paper we present the result of a strategy that makes a quadcopter UAV able to autonomously follow a ground mobile robot by means of a vision tracking algorithm. In such a way, the operator should take care of the ground vehicle only, while the quadcopter flies over the operation area. The images acquired by the UAV can be also adopted to survey the surrounding environment with the aim of building traversability maps and gather photogrammetry data.

Experimental trials have been performed at different flying heights by using a tracked UGV developed by Etnamatica srl and an Asctec Hummingbird quadrotor.

A GIS platform has been adopted to plan and monitor the UGV trajectories; moreover the gathered data are integrated within the platform to improve the representation of the information.

The cooperation between flying vehicles and robotic ground platforms is a is rapidly spreading as performing tools to be used for data gathering, search and rescue operations, civil protection and safety issues [Muscato, 2012].

In some cases, complex tasks cannot be completed by just one type of unmanned robot. [Habib, 2011] deals with different types of unmanned robots (UGV, UAV), which are employed in search, rescue, and risky intervention tasks. In particular, cooperation between UAV and UGV is a topic held in high consideration in the scientific community. [Daly, 2011], for example, develops a coordinate landing between a skid-steered UGV, used as mobile landing platform, and a quadrotor. [Brandao, 2010] deals with a decentralized control, based on artificial vision, which takes place between a helicopter and a team of UGVs. The mission to be accomplished by the helicopter consists of tracking the centroid of the ground formation. [Ippolito, 2008] exposes the Polymorphic Control Systems (PCS), providing emergency assistance and collaborative coordination between multiple systems to safely achieve the mission critical objectives. [Tanner, 2007], [Cheunga, 2008] and [Owen, 2010] develop a coordinate control between UAVs and UGVs for the purpose of tracking a dynamic target. [Grocholsky, 2006a] is another application of decentralized control, which is used in teams of UAVs and UGVs.

In some cases, an UAV is used to improve the navigation performance of an UGV. For example, tracking and state estimation of a UGV [MacArthur, 2007], [Heppner, 2013], terrain classification and path planning for the UGV [Hudjakov, 2010], or supporting the UGV navigation as in case of GPS loss [Frietsch, 2008]. [Kim, 2001] uses a coordinate control based on probabilistic approach for UAV and UGV teams employed in pursuit-evasion games. UAVs and UGVs are used for surveillance tasks in [Grocholsky, 2006b] and [Saska, 2012], for cooperative mapping in [Chaimowicz, 2005], and for detection and disposal of mines in [Zawodny, 2005].

2. The developed architecture and algorithms

A computer vision based method has been adopted to recognize and localize the position of the quadrotor by processing images coming from a camera on-board the UGV. To augment the contrast of the acquired images and to improve the recognition of the flying platforms, four strips of high-intensity LEDs have been placed at the edges of the quadrotor, under the chassis. The algorithm is based on the following steps:

a) Image acquisition and binarization by thresholding (Fig.1a).

b) White pixels extraction from the original image: this operation allows to highlight the high-density LEDs (Fig. 1b).

c) Black pixels extraction from the original image, in order to identify the chassis of the quadrotor (Fig. 1c).

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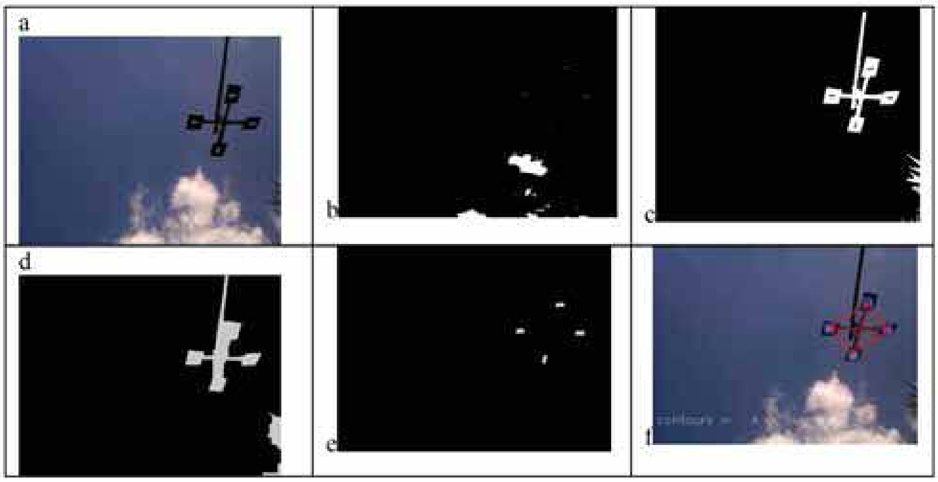

Fig. 1. Sequence of the main steps needed to localise the quadrotor in the image.

d) Erode and dilate operations to remove noise (Fig. 1d).

e) Logical AND between the obtained white image and the black one: this allows detecting the white LEDs in the four corners of the chassis of the quadrotor (Fig. 1e).

f) Geometric validation of the detected points: the pattern of the LEDs should be a square (Fig. 1f).

g) Estimation of the pose on the basis of the obtained pattern, of the quadrotor inertial data and of the UGV pose (Fig. 4).

h) Kalman techniques to filter the reconstructed pose: this allows to reduce noises caused by the surrounding environment and to improve the localization when the quadrotor is not recognized by the computer vision algorithm.

The localisation solution is adopted to compute the error signals for the control algorithm that works to maintain the flying vehicle over the UGV. Three simple PID control loops computes the commands (roll, pitch and yaw command) to be sent to the quadrotor via a wireless link.
In order to assign the path for the UGV and the UAV only free and open source GIS technologies have been adopted. In particular, the GIS platform architecture proposed is based on a spatial database, which communicates with both the GIS (Desktop and Web) and the robot. This architecture was born from the need to guarantee a unique software tool for the management of the spatial data, allowing to exploit all instruments provided by the spatial database and the characteristics available within the DMBS. With such an architecture, different kind of access policies can be integrated. For example, the administrator can access and modify the whole data, while the uses of the Desktop or WebGIS can only visualize and perform basic operations on data. Another advantage provided by the architecture designed regards the database, which is located in an "ad hoc" remote server so that the exclusive management of the hardware and software resources is guaranteed.
As desktop GIS software, we used Qgis (http://www.qgis.org/) and GRASS (http://grass.osgeo.org/), while the webGIS platform has been developed customizing Mapserver (http://mapserver.org/) and OpenLayers libraries (http://openlayers.org/). For the spatial database, we used PostGreSQL with the spatial extension PostGIS.
The architecture designed allows to digitize the paths for the robot or UAV in a GIS environment as thematic vectors on the cartographic support and to save them in the spatial database. In Fig.2 an example of the interface with some assigned waypoints is shown.

Fig. 2. Example of waypoints assigned into a map by using the webGIS platform.

3. Results and Conclusions

Testing of the architecture has been carried out by using a tracked vehicle made by ETNAMATICA S.r.l and a Hummingbird quadcopter by Ascending Technology. The tracked UGV, shown in fig. 3 with the quadcopter on-board, has two independent DC motors driven by two CAN bus based drivers. The payload of the system is about 300kg. The robot has an Xsens Mti IMU, a Leica RTK-DGPS, a SICK Laser scanner and a wireless link for telemetry and remote control. The low level control is based on a FPGA NI board and the navigation and localization algorithms are implemented by using the LabView language.

During the trials the UGV was programmed to move autonomously following a given path planned on the GIS interface. Once a difficult situation is encountered the quadcopter take-off from the UGV, the tracking algorithm is started and it begins following autonomously the UGV trajectory. In the meanwhile the aerial images are transmitted to the base station and allow replanning the UGV trajectories. Then the quadcopter lands on the UGV and the mission continues. In the actual version landing operations on the UGV are not autonomous. Fig. 4a shows the image of the quadcopter from the UGV camera with the results of the localization algorithm and the control actions superimposed as white vectors. In Fig. 4b the aerial view of the UGV from the camera on-board the quadcopter, is shown.

The system is capable to successfully track the quadcopter in a wide range of environmental conditions and lights. The altitude of the flight can be changed without compromising the tracking performance. Further work is needed to allow autonomous landing on the vehicle and to track the UGV in very low altitudes.

Acknowledgements

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Fig. 3. The adopted UGV platform with the quadcopter on-board ready to take-off.

a) b)

Fig. 4. The vision tracking system computing the position of the quadrotor (left) and the aerial view of the UGV (right).

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Tools for Protective Equipment and Protection: Protective Equipment Description and Prospect

Marc Pirlot[72], Georgios Kechagiadakis[73], Matteo Zoppi[74], Giovanna A. Naselli[75], Gianni Polentes[76]

Abstract

This paper concerns (1) the description (state-of-the-art) of protection equipment: individual protective equipment against blast and direct impacts (risks of demining tasks entrusted to human operators), platform protection (risks of highly shocks imposed to the wheels of mobile platforms, agricultural ones in particular), (2) the preliminary methodologies, techniques and results related to the intended protection tools.

1. Introduction

It is essential that all demining activities must be performed with the highest available safety measures. Therefore it is important to lay down detailed procedures, descriptions and responsibilities that are to be followed methodically. This is called "active protection" and it is the most efficient solution for reducing substantially the probability of a demining accident and its consequences. Sadly, "active protection", as efficient it can be, it is not sufficient. Even if all precautions are made, accidents will continue to happen. Thus the existence of a protective suit – "passive protection" might save lives. Current PPE are characterized by their heavy structure, their obtrusiveness of motion and their heat insulating effects. There have been reported cases of demining accidents in which the deminer had just removed (or partially removed) his visor due to overheat blurriness, only moments before the explosion [1]. Optimization of the laminated material that consists of the suit against perforation from fragments and critical overcompression of blast waves may contribute to a more lightweight and ergonomic design.

When demining operations are performed by using a vehicle to process the ground, it is assumed that such vehicle must satisfy some requirements. It is important, in fact, that in case of explosion the vehicle does not suffer relevant damage which might compromise its functioning. Since the vehicle touches the ground by its wheels, it is easy to understand that whether a blast occurs, the critical components of the vehicle are obviously the wheels. In the past, some solutions have been proposed in order to equip the vehicle with blast resistant wheels. The major contributions were provided by Vernon Joynt, who suggested to recur to high velocity of shock materials to design some components of the wheel. As it is known, the acoustic speed of a wave through a material depends on the Young modulus, the shear modulus and the density of the material: the stiffer the material (or the lower the density), the higher the velocity of propagation. Exploiting this physical concept, V. Joynt suggested to insert high velocity of shock components into the wheel, as shown in the figure below [2].

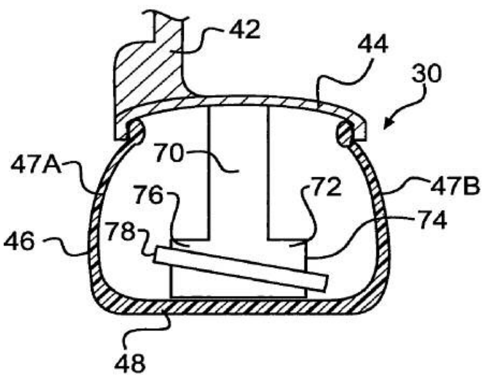

Fig. 1 - Diametrical section of the blast resistant wheel [2]

The element 78 is made of high velocity of shock material which is employed to convert the energy of the blast in kinetic energy, protecting the vehicle from the shock. Such element is supposed to hit the sidewalls of the tire, which will be destroyed. Therefore, such a wheel is not able to retain its mechanical integrity. This requirement is satisfied by another design (also proposed by Joynt, [3]), shown in fig. 2.In such design, several high acoustic speed elements (16.2) are mounted on the rim, and they are separated from each other by layers of low acoustic speed material (16.3) with low friction coefficient.

In the case presented in this paper, the vehicle used for the demining operations is a tractor, since the aim is to exploit the vehicle for agricultural activities after the mine clearance is achieved. From previous researches [4], the best solution seems to be the adoption of a blast resistant wheel composed of two parts: an outer part, made of steel, and an inner solid

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rubber tire embedded in it; such a wheel has already been used in Jordan but its general performances can be improved and the amount of energy transferred to the vehicle can be further reduced.

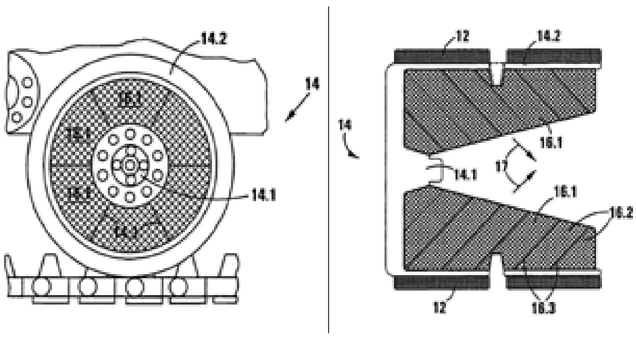

Fig. 2 - Front view (left) and
diametrical section (right) of blast resistant wheel [3]

2. Personal protective equipment and methodologies

Currently, the development of PPE is based on two fundamental standards, STANAG 2920 [5] and IMAS 10.30 [6]. The first sets the limit for the protection against perforation from fragments using standard fragment simulating projectiles (FSP) and the second provides general guidelines on the circumstances of the blast tests. While the performance of the PPE against fragments is specified in detail, the desired response to blast loading hasn't been defined explicitly. That is because of the complex phenomena occurring during an explosion, the variations between the explosions of different mines and the absence of experimentally validated injury criteria against blasts using biofidelic models [7]. There are two known basic antipersonnel mine types that pose a threat to the deminer's life, the blast mines and the fragmentation mines. The first are designed to severely injure the opponent through the destructive power of a blast wave and the second are made to eliminate the enemy by projecting an array of fragments. In reality, both types induce blast waves and project fragments [8]. Therefore it is desirable to develop PPE with the capacity of protecting against both mine lethal aspects. It is also desirable that the PPE would be lightweight, flexible with high water vapor permeability index and heat transmittance [9]. With the increment of thickness, the blast response of the PPE improves but at the same time the weight increases, the mobility hinders and the heat transmittance reduces up to a point, and then increases again as the heat transferring surface increases. The higher the number of layers of ballistic fabric, the risk of perforation from fragments is minimized but the blast response exacerbates [10]. Also, the fact that a fabric has high level of fragment impermeability that means that it will probably be impermeable to water vapor as well. Then, the only way to relieve the excess heat is by the pump effect, viz evaporate and convective heat transfer because of the forced air movement due to body movement and clothing looseness [11]. It is apparent that numerous trade-offs are required in the design of PPE.

There are two material categories that are to be used in a PPE laminated structure. The soft or hard shell, usually made of ballistic fabric or fibre reinforced polymers and the core that can be a crushable material, granular, foam or honeycomb. The shell provides protection against the fragments and the core lengthens the duration of the blast's impulse, resulting in lower peak pressure.

Five steps of selection of materials will be conducted by the form of material characterization.

I. Crushable materials under impact loading using the Split Hopkinson Pressure Bar. This will enable a quick selection of a number of different material options.

II. Crushable materials under blast loading. This will verify the desirable response under blast. The amount of energy released will be according to the scaling laws of blast waves and will be proportional to the thickness of the crushable material.

III. Ballistic impact on soft fabrics and FRP. This will be conducted according to the NATO STANAG 2920.

IV. Ballistic impact and blast tests on combinations of materials selected in previous steps. The coupling effect between the materials and the curvature effect of the laminate structure will be examined.

V. Hybrid Blast-Fragmentation tests

3. Blast resistant wheel

As learnt from previous researches, to provide the blast resistant wheel with an outer part made of steel is a good choice. The design of such part is intended to grant the continuity of the contact between the wheel and the ground, in order to make the driving comfortable also on hard ground, and, at the same time, to protect the inner part of the wheel in case of blast. The proposed design for this part of the wheel is shown in fig. 3.

Fig. 3 – Outer part of the wheel

Since the major requirement of this part is to retain its mechanical integrity whether a blast occurs, FEA simulations have been carried out to predict the damage suffered from the wheel; such simulations are intended to avoid unnecessary experimental tests, since they are expensive and time consuming.
The aim of the simulations is to evaluate the plastic deformation suffered by the steel part; in order to do this, mathematical model for plasticity and failure for the material taken into account must be provided. In this case, since the material is steel, a Johnson-Cook plasticity model and a Johnson-Cook failure model have been adopted [12]. The shockwave propagation has been modeled by recurring to shock EOS linear. To grant the reliability of the results, some preliminary simulations have been carried out on the outer part of another wheel, already tested in experimental tests; the results provided by the simulations matched those of the experiments, ensuring the validity of the setup. The simulation time has been set according to one of the empiric expressions to evaluate the duration of the positive phase of an explosion. The simulations show that the damage suffered from the outer part of the wheel is such that the wheel retains its mechanical integrity after the explosion of 240 g of TNT (as shown in fig. 4).
The inner part of the wheel may consist of a solid rubber tire embedded into the steel part. Other materials (e.g., compounds) can be exploited but the cost effectiveness must be taken into account.

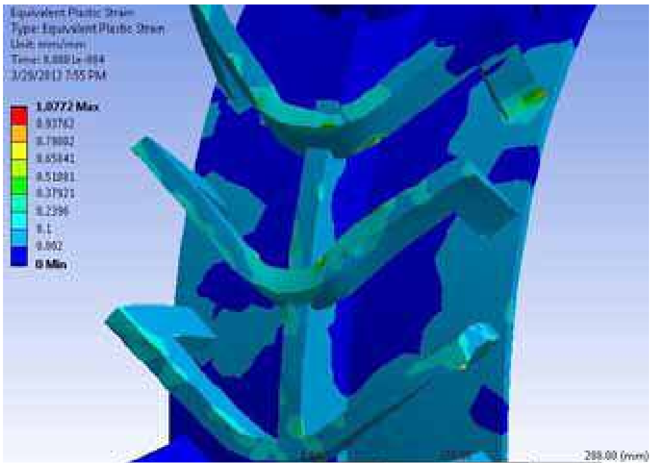

Fig. 4 – FEA simulation, plastic strain of the outer part of the wheel after a blast of 240 g of TNT (true scale)

4. Conclusions

The resulted laminated structure will be the suggested protective material for a deminer's suit and it will be able to protect the deminer from the blast effects and fragments from exploding mines.
The protection of the moving platform is achieved by recurring to blast resistant wheels, designed to retain their mechanical integrity and to reduce the amount of energy transferred to the vehicle. A wheel composed of a soft element protected by an outer steel part is designed to maintain its mechanical integrity, allowing to complete the demining operations before maintenance is strictly needed. Experimental tests will be performed to.

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A Survey on Instrumented Prodding Techniques for Landmine Recognition

S. Baglio, L. Cantelli, C. Costantino, F. Giusa, G. Muscato[77]

Abstract

Manual prodders are still widely adopted among deminers to recognize unknown buried objects. Several technological improvements are possible to improve their perception capabilities and to reduce the risk of using more force than is required to activate a mine. The paper presents a brief survey on tools that use “contact” with the mine for detection: several categorizations of the tools are based on the sensors adopted, on features analyzed and on processing techniques to classify the extracted features.

1. Introduction

Prodding is one of the most adopted techniques used by deminers to identify the cause of a signal detected via a metal detector or other systems [1].
Our group is developing an intelligent prodder within the EC project TIRAMISU. Our first activity was to investigate on the state of the art of previous research activities on this topic. Prodders are used mainly to detect the presence of a buried object that could be a mine; further efforts are needed to confirm the nature of the finding. The basic idea behind smart or instrument prodders consist in providing the tool with suitable sensing capabilities to enhance its skill in the identification of the nature of the material that is touched. A richer set of information is therefore available for the deminers to allow distinguishing between harmless buried objects, as pieces of wood or stones, and potentially dangerous objects that therefore need much more attentions and effort for the uncovering procedure.
The purpose of this paper is then to present an overview of the different methods adopted worldwide to improve a classical prodder into an automatic system capable to recognize the material in contact.
The methodologies can be classified with respect to the sensing principle adopted as ultrasonic, acoustic, piezoelectric, and piezoelectric with accelerometer. Some devices include actuators for exciting vibration on the material, while other approaches just process the vibration caused by the contact. Some approaches include a force feedback to measure or limit the contact force.
Another classification can be done on the basis of the different features extracted from the signal and the clustering strategies. Time domain or frequency domain features are usually extracted while Bayesian classifier, neural networks, fuzzy logic or K-means clustering have been proposed.
The developed prototypes have been validated using different kind of soils to simulate minefield conditions. Moreover mechanical systems have been usually adopted to guarantee the repeatability of the measurements. The classification is performed between mines, rock, wood pieces and other typical materials that can be found underground.

2. Sensing Techniques

The working methods of the devices that use contact with the material to be detected are based on prodder. A classical prodder generally is composed by a non magnetic needle (for situations where a magnetic device could activate mines) that should contact the buried material to be investigated and an ergonomic and comfortable handle, however comparative studies consider this kind of detecting instruments very unsafe for human operators, put at unnecessary risk [2]. This is why an improvement in manual mine detectors is today required and encouraged [3], [4], [5], for example including more complex sensors within the prodder. A classification of these innovative methods can be made with respect to the sensors, to the features analyzed or to the processing techniques.

Ultrasonic

A first recognition strategy is based on the use of an ultrasonic sensor incorporated into the prodder. The tip of the prodder acts both as waveguide for transmitting the ultrasonic pulse and receiving reflected energy from the contact point with the buried material. The experimental tests were carried out with different materials (stone, plastic, steel) and acquired data were divided into “training set” and “testing set” in order to train and validate the classifier [6], [7].

Acoustic

Another sensing approach is based on the use of an acoustic microphone. In this case is not needed to transmit any excitation pulse, but the microphone is employed only as sensor for registering vibrations coming from contact between the tip and the material. When the prodder tip touches the object, the vibrations generated are acquired by the microphone, and registered using a PC sound card. The acoustic microphone has been integrated in a simple prodder as sensor so that a waveguide for transmitting the pulse is unnecessary. The experiments were performed evaluating four different materials: wood, plastic, iron, and stone [8], [9]. Another example using this principle is the first version of SmartProbe™.

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However the first version of this system did not function as expected [10]. Different improved versions including force sensors as feedback elements have been developed as the Instrumented Prodder by HF Research Inc. , that provided good results [11] , However extensive tests conducted by TNO-FEL have shown that the identification is not reliable when test conditions change [12], [13].

In the patents [14] and [15] the acoustic prodder is instrumented with a force feedback mechanism.

Other researches involved the development of rotary prodders to improve penetration into the soil, or prodder equipped via a microphone to give feedback of the contact sound to the operator [16], [17], or prodder that give a sound to the operator when the force is exceeding a given threshold [18] .

Piezoelectric

An alternative solution to the problem of material recognition is represented by piezoelectric transducers. In the approach developed by the University of Catania a tactile piezoelectric sensor touches the surface of a material so it can be observed a response signal related to the physical characteristics of the stimulated material. Two different experimental prototypes have been realized, and their performances evaluated for several materials like glass, stone, wood, iron and plastic [19], [20], [21], [22]. A different approach has been proposed in [23] and [24] where the piezoelectric transducer acts only as actuator to give the buried surface a vibrational solicitation through the stick of the prodder. An accelerometer is mounted on the prodder in order to measure the specific acceleration returning from the stick and depending on some characteristics of the material (e.g. its natural frequency or stiffness). A very original solution is reported in [25]. Survey operations can be performed by two controlled hands from a location at about 2 meters. This configuration provides some advantages; the main one is that the deminer can operate outside the blast zone, with a significant increase in safety. Experiments have shown it was possible to distinguish between soft and rigid materials.

Accelerometric

Other sensing techniques are based on acceleration measurements. In [26], is described a system with multiple probes where each one is equipped with a spring and an accelerometer to directly measure vibrations deriving from contact with objects. It's possible to clear 1 m^2 in 2 min.

3. Extracted Signal Features

To obtain useful information, the signals detected from each sensor were analyzed to choose the features that better allows distinguishing between different materials.

For example in the case of ultrasonic sensor, the measured signal was analyzed in its time-domain representation and the selected features were the peaks of the time-domain signal and of its derivative [6]. A different approach was used for the features extraction of a signal detected by an acoustic sensor. First of all acquired signals were normalized by amplitude. Then, feature analysis was performed in frequency-domain representation, comparing average signal energy across different frequency windows $[f_0, f_0+\Delta f]$, where f_0 takes values from interval $[f_{min}, f_{max}-\Delta f]$ and Δf is the window width [8]. In the case of piezoelectric transducer used both as stimulating and sensing element, the signals (first acquired in time domain) were analyzed evaluating the energy rates in 4 frequency ranges in the interval [*100 Hz–3kHz*] (considering for every range the root mean square of the output as extracted feature) [21]. In the case of piezoelectric transducer with accelerometer a performance index was defined computing the square of the difference between the spectrum envelope from measured data and the reference spectrum envelope stored in advance, from a lower to an upper limit of frequency range [23], [24].

4. Features Classification Methods

The next step is represented by feature processing. The features extracted are analyzed to eliminate the redundant or unnecessary ones. Subset of features can be classified with the fitness function based on the Euclidean distance, defined as a ratio between the average distance between instances from different classes and the average distance between instances belonging to the same class. At the end the features (belonging to training set) are statistically distributed into classes, so an unknown sample is assigned to the class whose probability density function (PDF) is largest, according to Bayes classification [6], [9], [27]. A back propagation neural network is capable to set up complex borders between classes and adjust them based on known samples. In the case of ultrasonic sensor results the neural network gives better results than the Bayes classifier.

In the case of acoustic sensor sequential search algorithms were used in feature selection [8], [9], [27]. The most common are the Forward Sequential Selection (FSS) and the Backward Sequential Selection (BSS).

FSS begins with zero features, evaluates all subsets with one feature and selects the one with the best performance. Then it evaluates every subset with previously selected features and adds the feature that yield the largest fitness function, until no improvement is obtained. Instead BSS begins with all features and repeatedly removes a feature whose removal causes the least decrease of performance. These algorithms allow reducing the size of feature vector, decreasing computational time but maintaining a good level of performance.

Piezoelectric signals were processed through a fuzzy logic algorithm, calculating the average energy in 4 frequency bands [21]. A clustering analysis was performed and a collection of rules (if-then) defined. The obtained fuzzy architecture was trained by a first set of 100 patterns and tested by a second set of 100 patterns, with good results in distinguishing among different materials.

In the case of piezoelectric transducer with accelerometer recognition process was performed with a statistical approach based on analysis of variance [23], [24]. A large number of tests were carried out and compared to some reference spectrum envelopes measured in advance at different conditions. A performance index was evaluated for every reference, and results were compared, choosing as best resembling reference, the one that minimizes the performance index.

5. Conclusion

In this paper a survey on instrumented prodding techniques for landmine recognition has been presented categorizing the methods with respect to the sensors adopted, with respect to the features analyzed and to the processing techniques to classify the extracted features. A detailed comparison between the different methods in similar conditions was never performed and most of the results were conducted in laboratory conditions. Most of the work reports succesfull result that however needs a careful and objective evaluation. As a consequence a detailed analysis of the different results is not reported.

From the state of the art and several discussions made with end-users, it results that an intelligent prodder is a useful device. However actual developed instrumented prodders are not well accepted by deminers. The reasons are because these are usually expensive with respect to the reliability level reached in the recognition process.

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Lessons Learned from the Deployment of Dual Sensor ALIS for Humanitarian Demining in Cambodia

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Abstract:

ALIS is a hand-held dual sensor developed by Tohoku University, Japan since 2002. Dual sensor is a general name of sensor for humanitarian demining, which are equipped with metal detector and GPR. ALIS is only one hand-held dual sensor, which can record the sensor position with sensor signals. Therefore, the data can be processed after data acquisition, and can increase the imaging capability. ALIS has been tested in some mine affected courtiers including Afghanistan (2004), Egypt(2005), Croatia(2006-) and Cambodia(2007-). Mine fields at each country has different conditions and soil types. Therefore testes at the real mine fields are very important. ALIS has detected more than 70 AP-Mines in operation in mine fields in Cambodia since 2009.

1. Introduction

Conventional landmine detection depends on highly trained and focused human operators manually sweeping 1m2 plots with a metal detector and listening for characteristic audio signals indicating the presence of AP landmines. We are in the process of developing a high-resolution landmine scanning system which produces horizontal slices of the shallow subsurface for visualization of buried explosives and inert clutter. As many AP mines contain minimum amounts of metal, metal detectors need to be combined with a complimentary subsurface imaging sensor. Ground Penetrating Radar (GPR) is widely accepted for subsurface sensing in the fields of geology, archaeology and utility detection. The demining application requires real-time imaging results with centimetre resolution in a highly portable package. The key requirement for sharp images of the subsurface is the precise tracking of the geophysical sensor(s) during data collection. We should also notice that GPR system is a very wide band radar system, and equivalent to UWB radar, which has recently been developed for short-range high-accuracy radar. We are testing simplified but effective signal processing for imaging mines. We are currently testing a dual sensor ALIS which is a real-time sensor tracking system based on a CCD camera and image processing.

In this paper we introduce the GPR systems which we have developed for detection of buried antipersonnel mines and small size explosives. ALIS has been deployed in Cambodia since 2009 and detected more than 70 mines in mine fields, and returned more than 13ha cleaned fields to local farmers. We also report the current status of ALIS in Cambodia.

Center for Northeast Asian Studies (CNEAS), Tohoku University jointed the TIRAMISU in 2013. Based on our rich experience in the mine fields, we think we can provide a good chance to use ALIS along with other partners.

Figure 1. ALIS in operation in Cambodia

2.ALIS development

Metal detectors, which is an Electro Motive Induction sensor, has been widely used for humanitarian demining, however, in order to improve the efficiency of the demining operation, identification of buried landmines and discrimination for metal fragments by Ground Penetration Radar (GPR) is believed to be useful. Although there has been some approached to use unmanned vehicles for sensor scanning in mine fields, most of the mine fields are very small and hand-held sensors are more effective.

Due to very strong clutter from the ground surface and inhomogeneous soil to GPR, combined use of GPR with metal

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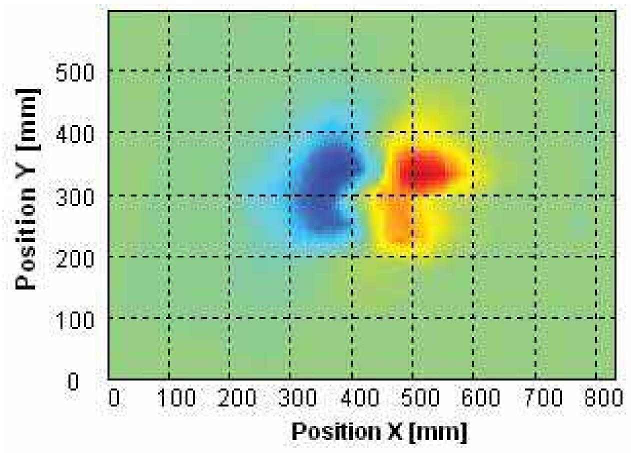
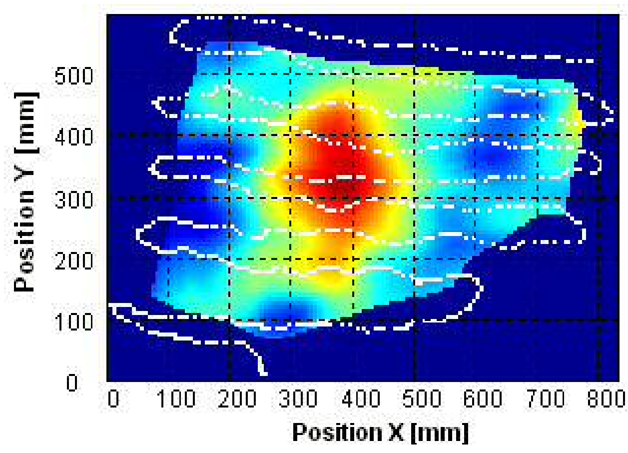


(a) Metal Detectro sugnal after interpolation.



(b) GPR Image with the locus of the sensor head.

Figure 2. ALIS visaulized images

detector is more common approach, and this kind of sensor is normally referred as "Dual sensor" in humanitarian demining. A few dual sensor systems are now available for humanitarian demining in commercial basis[1,2]. Tohoku University, Japan has been developing one of the dual sensor systems, namely, Advanced Landmine Imaging System (ALIS) since 2002. ALIS is unique in its novel technique of tracking the sensor position, even though it is scanned by hand by deminers. Then, ALIS can provide 3-D GPR image and it will help to understand the subsurface conditions much better than the conventional audio signal. It leads to the higher efficiency of detection of buried landmines. Therefore, we will also demonstrate GPR data acquisition and its processing in realistic situation in mine fields.

The raw GPR signal is strongly contaminated by clutter which is caused by soil inhomogeneity, and ALIS apply synthetic aperture radar (SAR) processing, or which is equivalent to migration, to the law GPR signal to reconstruct the subsurface image. Figure 2 shows an example of ALIS signal display. It can visualize both the metal detector signal with GPR signal in the same horizontal plane. GPR signal is 3-dimentional, and the depth slice can be changed on the display.

3. Deployment in Croatia

Systematic evaluation test of ALIS was conducted in September-October 2007 in Croatia. This test was originally planned as ITEP dual sensor test, but due to cancellation of other sensors, only ALIS was evaluated in this test. Therefore, it is not ITEP test, but ITEP send observers in this test. The test was sponsored by JST (Japan Science and Technology Agency) , and conducted by CROMAC-CTDT, and the test lanes were designed by BAM. In this test, we used ALIS-PG. We trained the operation of ALIS-PG to Croatian deminers for two weeks. It included tutorial of fundamental

(a) CROMAC test site

(b) QC operation in a mine field in Croatia, October 2007.

Figure 3. ALIS operated in Croatia in 2007-2008

principle of sensors, and signal acquisition, processing and interpretation. Then, we conducted training operations in calibration lanes. We think two-week training is sufficient, however, longer experience of operation of ALIS improves the skill of the operators.

After the evaluation test carried out in the test site of CROMAC-CTDT, we agreed with CROMAC-CTDT to start evaluation tests of ALIS-PG in mine fields in Croatia. In this test, ALIS-PG will be tested in QC(Quality Control) operation. Therefore, ALIS will not be used as a primary sensor, but will be used for a confirmation sensor. The first trial was conducted in December 2007. In the first test, ALIS was operated in the sites which were manually demined and machined demined. The soil in the manually mined are is normal, except the positions where anomaly was dug out, but in the machine demined area, soil was excavated and then it is very soft as shown in Fig. 3. In this area, many gravels were dug out and distributed in the soil. However, we found that the imaging capability of ALIS is not much affected by the soil conditions. Since this is QC test, we have low possibility to detect real buried mines in operations, we will accumulate much experience of operation of ALIS in different soil conditions, The test is planned to continue for a half year.

4. Deployment in Cambodia

After a half-year test in Croatia, where ALIS has been used in real mine fields for Quality Control, 2 sets of ALIS were introduced to Cambodia in spring 2009. The first trial of ALIS in real mine fields has started in May 2009 near Siem Reap, Cambodia.

Operation tests at real mine fields has been conducted in Cambodia with a collaboration with CMAC (Cambodian Mine Action Center) since April 2009. 2 sets of ALIS were operated by ALIS-team of CMAC and more than 80 mines were detected as of April 2013.

Figure 4. ALIS in Cambodia with detected mine.

For example during one month in July 2009, ALIS cleared 4,192 m^2 area, and detected 9 mines, which are all PMN-2 type. Metal detector detected 1,193 objects, and deminers judged 484 of them as possible mines, and 709 as metal fragments. This means, 709 points out of 1193 points (app. 60%), did not have to be prodded, and it can reduce the time of demining operation drastically. This is the most important capability of ALIS.

5. ALIS mounted on a unmanned vehicle

ALIS was also equipped on a robot of a buggy system Gryphon developed by the research group of Prof. Hirose at Tokyo institute of technology. All the same hardware and software of ALIS was used, and the data acquisition rate can be improved by the scanning by a robot arm. The ALIS mounted on a buggy uses an VNA based GPR with a Vivaldi antenna, which gives the best GPR performance. An unmanned buggy system can survey over a larger area, and improves the working efficiency compared to manual operation. The scanning of ALIS sensor by a robot hand is more stable than manual scanning, therefore we found that the quality of the GPR images acquired by this system is better than that obtained by manual scanning.

Figure 5. ALIS mounted on a buggy Gryphon (developed by Tokyo Institute Technology). A Vivaldi antenna is attached with a metal detector sensor on the robot arm. The buggy mounted ALIS uses a VNA based GPR for the best performance.

6. Conclusion

In this paper, we introduced a case study of GPR applied to humanitarian demining. A small target buried in inhomogeneous soil is a target difficult to detect by GPR, but we showed it can be achieved by combination of an advanced hardware and signal processing.

Acknowledgment

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Evaluation of a Sensory Tracking System for Hand-held Detectors in Outdoor Conditions

***Roemi Fernández*[80], *Héctor Montes*[80, 81], *Javier Sarria*[81], *Carlota Salinas*[81], *Manuel Armada*[81]**

Abstract

This paper presents the experimental results obtained throughout the outdoor testing of a sensory tracking system specifically designed as part of a training tool for improving the utilisation of hand-held detectors. The proposed system is able to acquire information in two different scenarios: when the expert's skills are studied in order to quantify some critical performance variables and when the deminers' performance is evaluated during the close-in-detection training tasks, in order to give the operator significant feedback for improving their competences. Additionally to previously studied variables such as the safety distance to advance the detector search-head on each sweep, the sweep velocity, the scan height, the inclination of the hand-held detector head with respect to the ground and the coverage area, a special emphasis related to the geo-referencing of the hand-held detector head in real-time is provided.

Introduction

Training is one of the most crucial aspects in order to improve the safety and effectiveness of the mine detection activities performed by the human operators. Training is not only required for novice operators but also when new detection technologies are introduced. For instance, the proper use of dual sensors requires more training and practice compared to metal detectors [1]. Retraining is also essential for maintaining a high level of efficiency. Deminers who do not conduct humanitarian demining operations uninterruptedly during the period of two years are obliged to attend additional training courses [2]. Some studies also indicate that the poor retention of operator skills is a common problem that endangers the success of the countermine operations and jeopardizes the personnel involved. A decline in the proportion of mine simulants detected was observed with as little as 30 days without practice. Solving this problem involves improving training to prevent or minimize such decrements from occurring, and developing intervention to restore performance to requisite levels as efficiently and as economically as possible through refresher training [3].

This paper presents a training tool intended for analysing operators' performance with the final goal of improving the use of hand-held detectors in humanitarian demining. The tool consists of a Human Machine Interface (HMI), and a hand-held detector sensory tracking system [4, 5]. The training tool can be easily adapted to be used with different kinds of hand-held detectors. The purpose of the proposed tool is twofold: (i) the study of the expert's skills by quantifying some critical performance variables, so that they can be used later on as reference values for the training tasks; and (ii) the efficiency evaluation of novice operators during the training period with hand-held detectors in order to give them feedback about important information for improving their competencies. Therefore, the proposed tool will enable the development and implementation of instructions based on the scientific analysis of the problem and the formative and summative assessment of trainees. The emphasis in this article will be put on the outdoor testing of the elements that composes the hand-held detector sensory tracking system.

Sensory tracking system

The metal detector that has been selected as hand-held detector for the experiments in this study is the VM C1 manufactured by Vallon. However, the training tool could be adapted to be utilised with other kinds of hand-held detector. The chosen device (VMC1) is able to detect mines with a very small metal content below the surface of the ground and in fresh or salt water. Its rugged search head contains the Digital Pulse Induction Sensor with integrated noise reduction features. Its shape allows easy operation in difficult and dense vegetation, rocks, shallow water and mud. This unique design provides precise pinpointing and an excellent separation between narrow placed targets without loss of detection speed. The telescopic pole consists of three tubes. The length is easily adjustable even during operation in just a few seconds so that detection work can be done in standing, kneeling or proning position [6]. For the experiments, two motion trackers (Inertial Measurement Units) are installed in the hand-held detector (see Fig. 1). One of these units is mounted in a light plastic pole located above the centre of the search head. This light plastic pole is utilised to eliminate any chance of interference of the motion tracker on the metal detector. The second motion tracker is mounted in the wand, at 540 mm from the joint that links the search head with the pole. Both motion trackers provide with a highly dynamic response, drift-free

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(a) (b)

Fig. 1. (a) Hand-held detector instrumentation. (b) Operator with hand-held detector training tool during outdoor experiments at the Centre for Automation and Robotics – CAR (CSIC-UPM).

and accurate 3D orientation (pitch, roll, and yaw), as well as kinematic data: 3D acceleration and 3D rate of turn (rate gyro). They are configured to output data from each triad of accelerometers and gyroscopes at 100 Hz. In addition, the motion tracker that is located over the search head provides GPS measurements. An active antenna is connected to this motion tracker in order to receive the satellite signals (see Fig. 1). The reduced size and weight of this antenna permits its location on the operator’s backpack.

The sensory tracking system described above will be utilized for acquiring information in two different situations: when the expert’s skills are studied in order to quantify some critical performance variables and when the efficiency of the deminers is to be evaluated during the training sessions.

Previous analysis of the expert’s hand-held detection activities shows that their techniques and strategies differ from conventionally taught operating procedures. Whereas novice operators perform detection on the basis of auditory outputs pointing out the existence of conductive materials, experts use the onset and offset of outputs that occurred during sweeping motions of the hand-held detector to create spatial patterns that they compare to learned models [7]. Experts also modify their detection techniques to adapt to environmental variations (deserts, hilly rocky terrain, lands with a wide variety of vegetation). For this reason, the projected methodology proposes the utilization of the sensory tracking system to study the experts’ skills in different environments and with different kinds of hand-held detectors. With the compiled information, some critical performance variables will be extracted, assessed, and quantified off-line, so that they can be used later on as reference values for the training sessions. The critical variables chosen preliminarily that will be analysed are the safety distance to advance the detector search-head on each sweep, the sweep velocity, the scan height, and the inclination of the hand-held detector head with respect to the ground. Principal Component Analysis (PCA) could also be used to explore the behavioural data. PCA is a well-established, standard approach for reducing the dimensionality of a large dataset, in order to identify any structure in the relationships between the variables that might otherwise be hidden. Therefore, PCA could highlight those underlying components that explain the most variance in the datasets as a whole. Cognitive engineering has proved to be a proper approach for solving applied problems in which human performance depends upon the quality of participants’ thinking and skills. Cognitive models of expert skills have been successfully adopted for training in quite different domains such as medicine (surgery and dentistry) [8], aviation [9] and landmine detection [10, 11]. Therefore, cognitive engineering will be used for translating the information acquired from the expert performance into modelling targets for unified, integrative theories of intelligence. In this way, instruction will be based on scientific knowledge rather than on personal introspection and intuitions of the training designers.

For the analysis and assessment of the trainee skills, the same set of critical variables proposed to parameterise the experts’ performance will be acquired and compared in real time with the reference training goals. In this way, the training tool will be able to evaluate the deminers' efficiency during the scanning tasks on-line and give them feedback about essential information for improving their competences. However, this evaluation can also be carried out off-line, recording the whole performance of the deminer, analysing it and finally, producing a report indicating the success of the learning process and identifying the points that should be enhanced. If the experts' skills have been studied previously, the reference training goals required for the assessment will be obtained from the results of the experts' performance. In case experts are not available for these experiences, trainee operators will be evaluated according to the reference values established in the standard procedures.

Standard procedures define some minimal requirements for the sweeping technique that should be followed in order to ensure the safety of the deminers. For the VMC1 metal detector these requirements are:

- Each sweep across the lane must overlap the previous sweep by about one-half the width of the detector head to ensure full coverage of the area being searched. Otherwise, a gap is left between sweep paths and mines can be missed. This is especially true for low-metal mines, which emit a very small electric field, often less than the width of the detector head.
- Operators' manual recommends a sweep rate of 0.2-1 m/s. However, in pinpointing mode, the detector head should be swept no faster than about 0.2 m/s.
- Height head above the ground is the most important factor. The search of the metal detector should be moved not more that 5 cm about the ground. The closer the detector head is to the ground, the deeper the electrical field is projected and the greater is the possibility to detect the mines.
- When sweeping, the search head of the detector must remain horizontal to the ground at all times. If the detection task is being carried out on an irregular surface, the search head should be kept parallel to and at a constant height from the ground, following the variations in the surface.
- To prevent interferences, the distance between different search heads should not be less than 2 meters.

Experimental results

The main goal of the experimental phase was to evaluate the effectiveness of the sensory system to track the hand-held detector during the training sessions as well as assessing the feasibility of the GPS measurements for geo-referencing the hand-held detector in real-time.

To simulate a real demining field scenario, a training lane was prepared. This lane is free from metal contamination and it is 1 m width and has a length of 10 m (see Fig. 1(b)). The sweep coverage area, obtained from the data acquired with the motion trackers located in the hand-held detector, is displayed in Fig. 2. To ensure the safety of the operator during the detection task, each sweep across the lane must overlap the previous one by about one-half the width of the detector head. This requirement is difficult to be achieved by novice operators that should keep in mind a spatial image of the last sweep motion carried out. The feedback provided by the training tool could be especially useful in this case, helping the novice operator to create the required mental patterns.

Experimental measurements obtained with the GPS of the motion tracker that is installed in the search head of the hand-held detector are shown in Fig 3. Longitude and latitude are

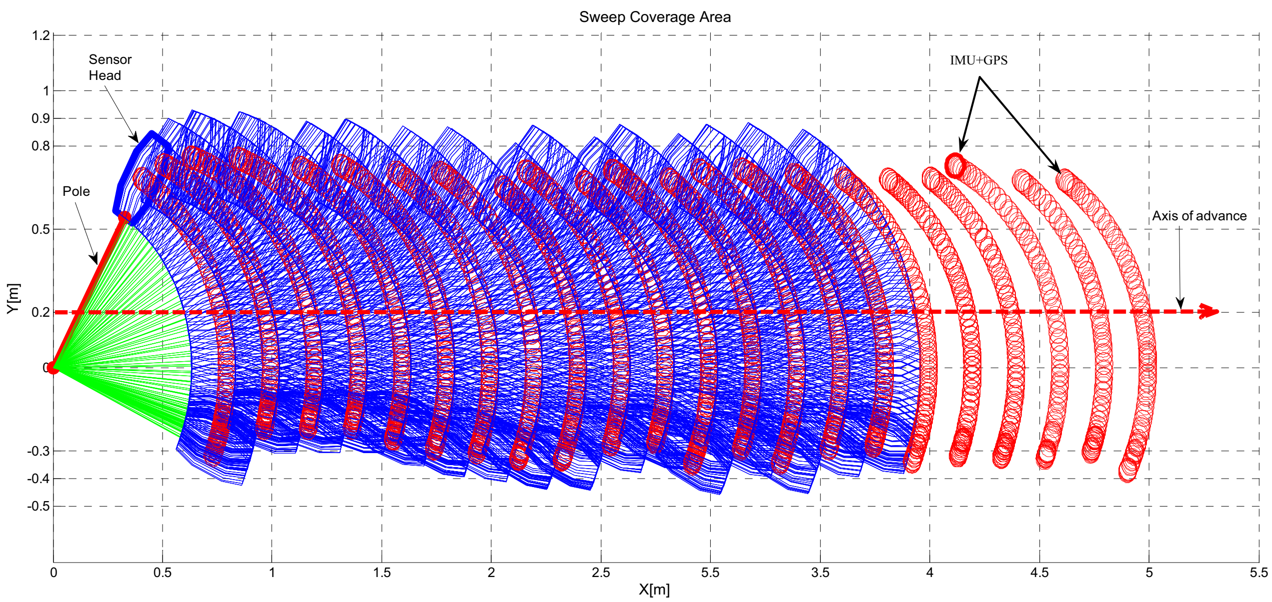

Fig. 2. Sweep coverage area reconstruction using experimental data from motion trackers.

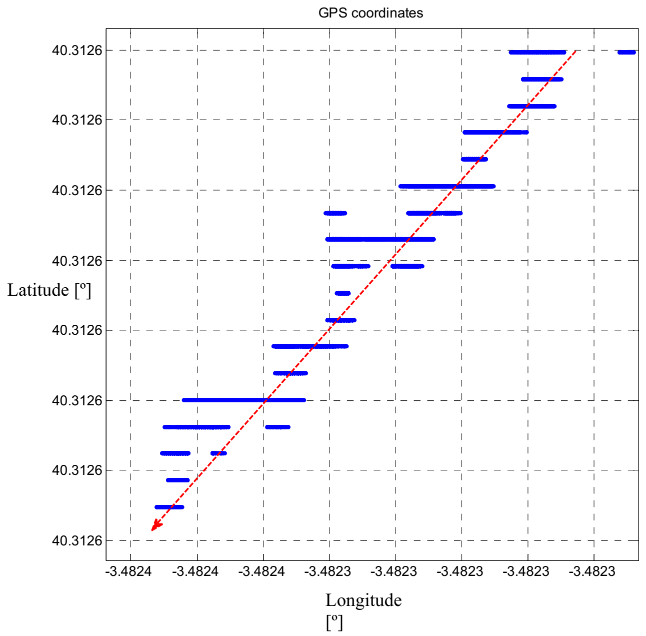

Fig. 3. GPS coordinates: Longitude and Latitude in decimal degrees. Arrow indicates motion direction.

displayed in decimal degrees. In this graph it is possible to appreciate some discontinuities during the sweeping motions, indicating that the sampling rate should be increased in next experiments in order to improve the tracking performance. Nevertheless, obtained results are very promising, showing that the geo-referencing of the hand-held detector is feasible.

Discussion and future research

In this work a sensory tracking system proposed as part of a training tool for improving the deminers’ skills during close-in detection tasks with hand-held detectors has been evaluated experimentally in outdoor conditions. Special emphasis has been placed on testing the possibilities of geo-referencing the hand-held detector head in real-time. Experimental results show that the proposed sensory system could be successfully utilised for tracking the hand-held detector during the sweeping motions. Moreover, GPS measurements are very promising for geo-referencing the hand-held detector in real-time. This last characteristic will be very useful for providing the training tool with the capability to analyse in detail the behaviour of the operators in the presence of buried (inert) landmines. In this way, spatial patterns could be created and incorporated into demining training, enhancing the detection performance and reducing the skill differences amongst participants. This is the major objective for future research.

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A State of the Art of MRE Programs from Educational Entertainment Point of View

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Abstract

The paper summarizes the results obtained during the state of the art analysis of Mine Risk Education (MRE) programs using traditional and mass media, by investigating the relationships between these media and serial dramas seen as a vehicle for diffusing educational messages in an effective and non invasive way.
Furthermore, as radio broadcast embeds both features of cost-effectiveness and widespread penetration, the paper introduces a deep analysis of educational entertainment techniques used in development activities other than mine action, such as disease prevention and family planning, and in MRE programmes, with a particular attention to radio based campaigns.
The paper finally investigates the possibility to apply educational entertainment approaches to MRE using dramatic plot (radio diffused serial drama style) embedding the key messages mostly suitable to the context.

1. MRE diffusion through media: traditional and mass media

Although a concept can be transmitted through many different channels, it is very important to identify which form of communication is the most suitable to reach the selected target audience and do diffuse the selected sort of educational messages.

There has always been a strict connection between media and development, as "media can help shape an open and more democratic society, and importantly they can also help reach more concrete goals. They can make a difference by changing stereotyped attitudes about poverty, women, marginalised groups or minorities; expressing the interests or needs of people who normally have no channel for expression; raising issues which otherwise are not in the public domain. Many programmes work with media, not just to improve media coverage but to improve the attention and quality given to development issues by the media." [Burke, 1999].

Media are commonly classified in small media (brochures, posters, cassettes, leaflets, T-shirts and other similar items), traditional or folk media (artistic means of communication transmitted from old generations, such as itinerant theater, puppets shows, etc…) and mass media (radio, television, internet and press). From an educational point of view, each of them has peculiar pros and cons, according to its target audience, its participatory potential and its cost-effectiveness. Burke [Burke, 1999] makes an exhaustive lists of the benefits and drawbacks of principal communication means. In the particular case of MRE, the choice of which media to use should be made after an extremely careful analysis of its pros and cons in relation to the context: the effective possibility to reach the poorest part of population, the likelihood to actively engage the people in a participatory way and the amount of people reached. Sometimes it could better to privilege one aspect rather than another; for instance, the fact that the poorest face the higher risks it is not always true, and the number of people potentially reached could be less important than addressing a small group which is particularly at-risk.

The traditional forms of communication, such as folk or traditional media, are a grassroots expression of the values and the lifestyles of a population and, by using local familiar languages, are embedded in people's cultural, social, and psychological thinking. Folk media are commonly used to diffuse and promote entertainment, news, messages and any kind of social exchanges, being simultaneously a mean through which a culture can be preserved and adapted [Panford et al., 2001]. Research has shown the importance of informal interpersonal contacts in persuading people to adopt or reject innovations [Hubley, 1993]: these contacts are often achieved through folk media; thus, they have been frequently used as a double-way communication mean, as performers are often themselves at-risk people (in many cases children), that have been chosen among their community and trained both to perform the shows and to diffuse the resulting key messages.

Social Circuses[84] are a good example of this sort of use of education applied to traditional media. Table 1 portrays a list of various interesting cases of Social Circus Programmes spread all around the world, some of which are aimed at diffusing MRE contents as the Afghan Mini Mobile Circus for Children (MMCC) and the Debub Nigat Circus in Ethiopia.

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83 Snail Aid – Technology for Development, Via Cabella 10/12, 16122 Genova, Italy; patfordemining@gmail.com
84 Social Circus is a developing movement aimed at using circus arts as media for diffusing social wellness and justice. Using alternative pedagogical tools and the dynamic approach of art-based education, it mainly works with marginalized or at social (or personal) risk youth.

COUNTRY	SOCIAL CIRCUS ORGANIZATION	BENEFICIARIES	
Afghanistan	"Afghan Mini Mobile Circus for Children" MMCC	orphans, handicapped, street working- and internally displaced children living in refugee camps	MRE items
Australia	"Leapin Lurp Lurps"	indigenous youth	
Bangladesh	"Creative- World Foundation"	vulnerable youth	
Brazil	"Rede circo do Mundo"	underprivileged children and youth	
Colombia	"Escuela Naciónal Circo Para Todos in Cali"	street children	
Croatia	"Daska Theater"	vulnerable youth	MRE items
Egypt	"Al Darb Al Ahmar"	children and youth in Cairo	
El Salvador	"Barefoot Angels Project"	street children out of gangs	
Ethiopia	"Debub Nigat"	children from refugee camps	MRE items
Indonesia	"Hidung Merah"	marginalized youth	
Mexico	"Creative- World Foundation"	vulnerable youth	
Netherlands	"Creative- World Foundation"	vulnerable youth	
Nigeria	"Nigeria Street Kids Project"	street children	
Tanzania	"Zip Zap Circus School"	youth at risk, children with HIV/Aids and any child who wants to learn circus	
Uganda	"Creative- World Foundation"	vulnerable youth	
U.S.A. (Illinois)	"CircEsteem"	youth from diverse racial, cultural, and economic backgrounds	
U.S.A. (Pennsylvania)	"Zany Umbrella Circus "	survivors of Hurricane Katrina in New Orleans	

Table 1 Some Social Circuses in the world

Mass media include radio, television and press: the use of a collective term to indicate all these communication means, despite their evident differences, reflects the existence of common basic features and the fact that they constitute a well-established institution, which can be considered today as much important as older institutes, such as school, politics, family, etc…[McQuail et Pace, 1992]. A significant part of people's knowledge comes from personal experience as much as from mass media. Even if they do not reflect the truth, information obtained from mass media influence audience expectations and behaviours. In this sense mass media fulfil the role of behavioural models (either positive or negative) and they offer a wide overview of real and imaginary facts that can be used to build up a personal interpretation of the world [McQuail et Pace, 1992].

As mass media can provide information not only about distant realities, but also about issues related to the local context, they are able to play a very significant role in raising awareness of mine and UXO and in diffusing safe behaviours models, but attention must be paid in deepening the messages comprehension, as there are many examples of messages diffused through mass media that, even if broadly diffused, were not deeply assimilated by beneficiaries. Moreover, even though mass media have vast diffusion and persuasion power, concerning MRE they are not always necessarily the best tool, as many people living in affected areas have not or nearly not access to them or to some of them.

2. MRE diffusion through radio

Among the mass media used in MRE, radio is today commonly considered the most effective because able to reach isolated rural communities that are unreachable by principal information channels [McQuail et Pace, 1992], and, at the same time, illiterate people as well as to educated city dwellers. Among mass media, radio reaches the widest audience: in least developed countries it is estimated that the ratio between the number of radios and the number of people is 94 radios per one thousand people [UNICEF, 2008], ten times more than the number of televisions or newspaper copies. Due to its simplicity of use, its accessibility and its cost-effectiveness, radio represents a democratic and potentially participatory mean of communication, with a high potential to be used as a development tool. Radio broadcasts are cheap to produce and receive; moreover, access to electricity from the grid is not essential, as battery powered or even power independent, such as solar or mechanical energy powered, radios can be used[85]. [CIA Fact Book, 2003] portrays a comparison between radio and television penetration around the world, showing how radio is still a very popular media also in developed countries. Radio penetration is everywhere higher than the television one, proving that an educational strategy based on radio diffusion can be the most worthy option in many different contexts. Similar outcomes are highlighted by [Jato et al., 1999], who stress the potential of radio showing the results of a study conducted in 1994 on a sample of over four thousand Tanzanian women who reported to have been exposed to campaigns for family planning achieved through different media in preceding six months. The study shows that 48.9 % of the women interviewed were exposed to campaigns through radio, and 23,4% of them received messages conveyed by a serial radio drama.
From a different point of view, radio is the modern way of delivering messages that were traditionally conveyed by oral communication. As it once was for traditional forms such as story-telling or puppet shows, radio listening is often a group activity, and is therefore a suitable mean to encourage the rising of assembly discussion after the broadcast. This is considered as an important step in the process of behavioural modification by UNICEF [UNICEF, 2008].

3. Entertainment-education

Entertainment-education (or edutainment) concerns “the process of purposely designing and implementing a media message to both entertain and educate, in order to increase audience knowledge about an educational issue, create favourable attitudes, and change over behaviour” [Singhal et Rogers, 1999]. More simply, entertainment-education is any entertainment content that is designed both to educate and to entertain the public.
Entertainment-education theory starts from the assumption that people from every country are widely exposed to entertainment through media in general and particularly mass media. The intense fruition of media messages suggests that mass media, more than other tools, can effectively modify the way how people feel, think and behave.The critical point of entertainment-education theories lies in analyzing how entertainment media such as television, radio, theatre, music and comics can be used to communicate information that effectively influences people acting.
Descending from socio-psychology and human communication theories, entertainment-education principles aim to modify social behaviours through information spreading.
The social learning theory developed by Bandura[86] [Bandura, 1977], according to which individuals change behaviour by observing role models, particularly in the mass media, is the fundamental of entertainment-education principles, whose application foresees imitation and influence as outcomes.
Although it was theorised in the last century, entertainment-education has always existed in the traditional form of parables or tales aiming to promote any social and behavioural change, both at individual and at community level [Manoff, 1985]. This remote origin allows connecting entertainment-education’s modern tools with tradition and using mass media without creating a gap between the communication mean and the audience.

Often used for information spreading in the fields of health, nutrition, agriculture and literacy, entertainment-education programmes have been used in more than two hundred actions over fifty countries in South America, Africa and Asia. The field in which they have been mostly used is reproductive health (such as HIV/AIDS prevention, family planning, gender equality) [Barker et Sabido, 2005].

4. MRE and radio serial dramas

Commonly called soap operas or telenovelas, serial dramas have the ideal structure to implement an entertainment-education strategy and have been frequently used for the purpose, due to their highly entertaining value, to the partition of the story in small episodes and to the possibility of addressing their contents to specific audiences. The long-lasting life-span of the plot and its spreading in several episodes catch public attention and allows brief pauses favouring the debates of various themes not strictly concerning the plot. Being the serial dramas regularly broadcast, spectators can afford to miss some episode without losing both the thread of narration and the key educational messages. Soap operas

85 An example of power independent radio is the Lifeline Prime Radio (http://lifelineenergy.org/prime-radio.html), firstly implemented in 2003, which features different power options, such as a solar panel, a hand crank and a DC input which can be plugged into a car battery.
86 Bandura’s Social Learning Theory asserts that people learn from one another through observation, imitation and modelling. People learn by observing others’ behaviours attitudes and by analyzing consequences of those behaviours. Human behaviour is interpreted by Bandura as a constant mutual interaction between cognitive, behavioural and environmental influences.

and serial dramas lasting for various months or even years are a really powerful sort of entertainment-education and influence safe behaviours and related social habits by:

- capturing the attention and the emotions of the audience on a continual basis;
- providing repetition and continuity, allowing audiences to identify more and more closely over time with the fictional characters, their problems, and their social environment;
- allowing time for characters to develop a change in behaviour slowly, with hesitations and setbacks that occur in real life;
- having various subplots that can introduce different issues in a logical and credible way through different characters, a key characteristic of conventional soap operas; and
- building a realistic social context that will mirror society and create multiple opportunities to present a social issue in various forms [Barker et Sabido, 2005].

As it is a very efficient vehicle for diffusing contents that combine educational and entertaining elements and due to its widespread coverage, radio has often been used to broadcast serial radio dramas, in order to entertain/educate receivers about specific topics, typically about health issues (generally HIV prevention), family planning, gender equality, agriculture, nutrition and literacy skills.

All around the world, educational-entertainment projects have been implemented for diffusing different values, both in poor and in developed countries, and among them many successful programmes are radio serial dramas. A notable and world famous example is *The Archers*, the world's longest-running soap opera, originally designed to encourage food production after the Second World War and nowadays educating about agricultural skills, that has been on air on BBC channel Radio 4 in UK for longer than sixty years. But education-entertainment projects through radio have been developed in many countries from all over the world, as displayed in Table 2.

The most noteworthy education-entertainment project spread through radio that involves (among others) MRE issues is *New Home, New Life* (NHNL), an Afghan serial drama started in 1994, initially produced by BBC and gone independent in

COUNTRY	RADIO DRAMA	FIELDS OF EDUCATION		COUNTRY	RADIO DRAMA	FIELDS OF EDUCATION	
Albania	"Rruga Me Pisha"	governance, democracy, domestic violence, land disputes, public health and drug abuse	SABIDO METHODOLOGY	Nigeria	"Gugar Goge"	reproductive health, family planning	SABIDO METHODOLOGY
Afghanistan	"New Home, New Life"	women topics, preservation of traditions, health issues, conflict resolution, mine awareness …		Papua New Guinea	"Nau Em Taim"	poverty, violence,educational barriers, land destruction, alcohol-drugs, HIV/AIDS prevention	SABIDO METHODOLOGY
Bolivia	"Wila Kasta"	sexual and reproductive health	SABIDO METHODOLOGY	Rwanda	"Urunana"	women's and youth health, family planning, HIV/AIDS, sexuality and reproductive health	SABIDO METHODOLOGY
Burundi	"Umubanyi Niwe Muryango"	peaceful coexistence, inter-ethnic dialogue and social responsibility	SABIDO METHODOLOGY	Senegal	"Ngelawu Nawet"	maternal and child health, involvement of men in family plan. and HIV/AIDS prevention	SABIDO METHODOLOGY
Cambodia	"Lotus on Muddy Lake"	reproductive health, HIV/AIDS and family planning	SABIDO METHODOLOGY	Sierra Leone	"Saliwansai"	female genital mutilation, gender-based violence and HIV prevention	SABIDO METHODOLOGY
Ethiopia	"Yeken Kignit" and "Dhimbiba"	HIV/AIDS prevention	SABIDO METHODOLOGY	South Africa	"Soul City"	HIV/AIDS prevention	
India	"Tinka Tinka Sukh"	health and evironmental issues	SABIDO METHODOLOGY	St. Lucia (Caribbean)	"Apwé Plezi"	family responsibility, family planning and HIV/AIDS prevention	
Kenya	"Tembea Na Majira"	social, health, gender, farming, governance and family issues	SABIDO METHODOLOGY	Sudan	"Ashreat al Amal"	reproductive health issues and women status	SABIDO METHODOLOGY
Malawi	"Zimachitika"	food security, nutrition, HIV/AIDS and sustainable agriculture	SABIDO METHODOLOGY	Tanzania	"Twende na Wakati"	reproductive health issues and women status	SABIDO METHODOLOGY
Mali, Côte d'Ivoire and Burkina Faso	"Cesiri Tono"	child slavery and related poverty-inducing factors	SABIDO METHODOLOGY	U.K.	"The Archers"	agricultural skills	
Mexico	"Pildoritas de la Vida Real"	sexual issues for teenagers	SABIDO METHODOLOGY	U.S.A. (Alabama)	"Body Love"	various health issues and black community problems	
Nepal	"Cut Your Coat" and "Service Brings Reward"	family planning and reproductive health	SABIDO METHODOLOGY	Vanuatu	"Famili Blong Serah"	maternal health, HIV, STDs, family planning, teaching for schools, nurses and rural health workers	SABIDO METHODOLOGY
Niger	"Gobe da Haske"	child slavery and related poverty-inducing factors	SABIDO METHODOLOGY	Vietnam	"Khat Vong Song"	HIV/AIDS prevention and discrimination against infected people	SABIDO METHODOLOGY

Table 2 A selection of radio serial drama performed around the world.

2012 as a local NGO. Through the characterization of daily lives conflicts and problems (which is an unsaid Sabido's lesson, see next paragraph), NHNL touches a wide range of themes, going from women topics to preservation of oral tradition and to mine awareness. The soap opera is broadcast three times a week; the plot is based on two different and related communities, which face every day-life problems changing and unfolding with the story development. Different situations and new matters continually arise in the story, and their solution allows the plot to evolve and offers an ideal structure for practical information integration. A survey conducted in February 1997 on the impact of the serial drama revealed that 83% of Afghan adult population listen to NHNL [UNESCO, 2000] occasionally, while 48% of adults follow the show weekly [BBC, 2012].

The deficiency of appropriate analyses of their effective impact is a common problem for educational media projects, but in the case of NHNL the substantial lack of different similar media projects in the country allows to easily evaluate the influence of the serial drama on audience beliefs and behaviours. Surveys following storylines based on specific issues are systematically conducted before and after the broadcast of episodes focusing on these particular themes. Such analysis carried out to evaluate the effectiveness of the MRE messages embedded in the storyline showed positive results, as they recorded a significant increase in audience's knowledge about landmines [Adam, 2005]. Moreover, according to a study achieved in 1997 by the UN Office for the Coordination of Humanitarian Affairs, NHNL non-listeners are twice as likely to be mine victims as listeners.

5. Miguel Sabido replicable methodology for developing entertainment-education serial dramas

Miguel Sabido, vice President for Research at Televisa (Mexican television) from 1970s to 1990s, formulated a special entertainment-education strategy for serial dramas developing: Sabido-style serial dramas are created using an empirical and reproducible approach aimed at behaviour changes obtained through mass media communication [Barker et Sabido, 2005]; the system is adaptable to get along with individual values and cultures of the particular countries or areas where it is used [Singhal et Rogers, 1999]. Putting into practice the results of theoretical and social researches, the Sabido methodology generates mass media serial dramas based on the concrete daily life of target audience, in whose stories it is easy for spectators to identify. Being based on Bandura's model of cognitive sub-processes[3], Sabido methodology is grounded on the diffusion of messages through role models: the plot is built around good characters (positive models), bad characters (negative models) and "evolving" characters, who move from negative to positive behaviours, showing during the drama their evolution path. Due to the involvement of procedures typical of evaluative research [Nariman, 1993], the development of a Sabido serial drama always starts with an assessment of the more pressing issues of the chosen context (such as health, education, economy, culture, etc…). The results of these assessments determine the choice of the positive and the negative values represented in the plot: these values will be assigned to positive and negative characters, which will personify and promote them in order to modify audience behaviour. Positive models are built in order to attract audience's identification and earn a final reward thanks to their right choices; negative models must be blamed by the same audience and get a final penalty; evolving characters have the occasion to change their mind through experiences and received suggestions: their final choices make them either positive or negative models, and they will get respectively conclusive recompense or punishment. This use of acting role models and the consequent mechanism of identification and blaming are the critical element of Sabido style's success: while entertainment-education strategies often focus in repeating messages [Barker et Sabido, 2005], Sabido's approach focuses on key role models and uses characters as a real mean for diffusing messages: the story plot descend from the role characterization and is defined by the interactions between the characters.

There are no significant cases of Sabido-style radio serial dramas in MRE literature, but the example of *Twende na Wakati* ("Let's go with the times"), a Tanzanian radio serial drama achieved as an experimental project aimed to modify listener's habits concerning HIV prevention, ideal age of marriage for women and use of family planning [Barker et Sabido, 2005], is anyway interesting due to its investigational value. Broadcast in the whole country but the capital city area since 1993, the drama was diffused in the capital only in 1995. Random sample surveys were carried out at national level before, during and after the broadcast and, thanks to experimental design of the project, it was possible to separate the effects of this soap opera from other family planning and HIV/AIDS prevention programmes implemented in the country.The study found out that *Twende na Wakati* stimulated important behavioural changes. For instance, the number of users of family planning methods recorded a rapid increase in the areas where the serial drama was broadcast and didn't change in the capital area during the two years of non-broadcasting. Then, when in 1995 the program was finally broadcast in the capital, the rate of condom use in the area suddenly increased of 16% [Barker et Sabido, 2005], while in the rest of the country recorded a 153% rise during the previous two years.

6. Conceptualization of a MRE tool based on theater/radio play

Within the context of TIRAMISU project, a modular and participatory tool to be used by a mobile team implementing MRE will be developed. This educational tool will permit the development of a MRE system based on a continuously evolving participatory theatre/radio play, which is aimed to spread MRE messages through the use of a combination of traditional media, in particular a simplified kind of itinerant theatre, and mass media, in particular radio. In the light of what presented in previous paragraphs, the project foresees using lessons learned about MRE and about entertainment-education, and creating a tool for developing educational short-time serial dramas, which will be radio broadcast and supported by local based teams travelling through the interested area.

Since a decrease in specific funding devoted to MRE has been recorded, the possibility to use or adapt the tool to integrate other development issues should make it suitable to receive attention and funding from donors other than the ones commonly supporting mine action. Thus, the research goal is the developing of a replicable tool that could be easily and quick adapted to different local contexts, without losing its educational impact and without wasting time and money in laborious re-writing. This means that the tool must fulfil the requirements of adaptability and versatility, and it has to be based on a deep analysis of the local context.

When ready, the tool will consist of a methodological kit able to guide MRE operators in identifying those context representative characters and situations that will be inserted in the plot. Through this selection it will be possible to develop a scheme whose appeal on the audience will lie in its power of real life mirroring. Thanks to this appeal the audience will gladly listen to the drama and people will identify themselves in represented characters: by this way, the MRE messages embedded in the evolving story will get to listeners' attention without assuming the form of an intrusive propaganda.

The programme structure foresees a tool organized around three relevant topics that will be focal points of the project: (1) a radio serial drama, which will be radio broadcast and simultaneously performed in front of a public through (2) itinerant theater shows, which will be followed by (3) group discussion sessions.

The drama dramatic plot will run parallel to MRE messages and will be enough captivating to appeal listeners but not so complicated to eclipse safe behaviours tips. The characters will be built on the analysis of local people daily life, through the investigations of common problems and typical behaviours and habits. Beyond "evolving" characters (see the paragraph about Sabido methodology), there will be positive figures, which listeners will have to identify in, and negative ones, which have to be blamed by spectators. Recompense and punishment will only concern safe and unsafe behaviours regarding mines and UXO matters and are not intended to judge moral beliefs or social habits: the project's intent is not interfering in communities' life style, as long as it doesn't prevent the adoption of safe behaviours.

Every drama's episode will be played in front of a public by a travelling team of trained actors that will perform the radio play in a number of different villages achieving a simplified form of itinerant theater show. The key aspect of the itinerant shows performances will be participation: live performances are mainly foreseen as means for improving the efficiency of the radio serial drama and of the group discussion sessions, and constitute the connection element between them. Audience's physical participation through a form of folk media, such as itinerant theater, is a central point of the project, as it is the mean through which MRE messages conveyed by the serial drama will be settled in beneficiaries' beliefs thanks to a more practical involvement and by linking the story broadcast to real life.

Group discussions concerning mine awareness will follow the performance of every episode and will strength the concepts conveyed in the serial drama: they represent an important tool intended to connect fictional and real mine/UXO encounters; after the group listening, these group discussion sessions will be extremely relevant due to their dual value, both as an MRE messages' integration and as a connection bridge between mine action operators and at-risk communities, aimed at developing a community liaison based project. Through these sessions it will be effectively possible to illustrate what has been done and what is planned to be done concerning MRE and demining actions and, in this way, to establish a strong communication channel between mine action NGOs and the local community. By explaining demining activities to the listeners, the audience could become not only a precious source of information but an active resource in field too.

Acknowledgments

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FP 7 TIRAMISU Integration - TIRAMISU Information Management System (T-IMS): United we stand; divided we fall…

Björn Liszka (SPINATOR, Sweden)[87]

A lot of efforts have been made to counter the mine threat. Many of these are successes in getting rid of the mines, saving time, being cost efficient and saving lives. Joining forces within the TIRAMISU consortium all these – state of the art systems – will boost the total outcome. One entity that cuts through the complete mine action process is "information".

We are convinced that it is high time to all existing "information management islands" within the mine action community and provide one tool that will give all actors throughout the complete process the possibility to gather, structure, present and distribute all relevant mine action information.

We have active co-operation with and/or support from (among others) the Geneva International Centre for Humanitarian Demining (GICHD), Belgian EOD Centre (DOVO), Canadian Defence Forces, Swedish EOD and Demining Centre (SWEDEC).

To implement the TIRAMISU Information Management System (T-IMS) – one the tools in the TIRAMISU tool-box – we use the latest development platforms, software and processes, common mine action communication language (maXML) will be further developed together with GICHD and GIS standards (OGC) will safeguard compatibility within and outside TIRAMISU.

This presentation/demonstration will show how far it's possible to bring modern technology to support the present and future mine action with information management.

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87 (SPINATOR) Sweden

Training tool for TIRAMISU Project

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Abstract

In this paper the training tool for UGV(Unmanned Ground Vehicles) operators in TIRAMISU project is introduced. The core component of the system is implemented using VORTEX simulation. This module provides an accurate physics simulation. The main goal of this research was to prepare VORTEX models of UGVs for TIRAMISU project. New research is related with the modeling of the environment based on the laser terrestrial data. The challenge was to integrate real data with a simulation, for this purpose we investigated the methods for objects classification. Major problem is related with the representation of cloud of points in rigid body simulation, for this purpose we used the triangulation. The results are satisfactory, but major work has to be done in area of visualization, therefore future work will be related with the visual effects which improve the effectiveness of proposed training tool.

Introduction and related work

When considering educational practice, simulators of specialist equipment (the operating of which constitutes basic knowledge of every trainee) are commonly used in teaching medical personnel [1], navigators and ship crews [2], operators of machines [3], and military personnel [4]. Training courses supported by the computer simulators are relatively cheap and safe, as there is a multitude of programs to simulate equipment and its operations, while maintaining the operator's interface used in the real machine. According to Edgar Dale's cone of experiences, a simulation of a real operation enables trainees to remember almost 90% of the material being taught, and proves to be much more effective than other forms of teaching. Simulation-based teaching methods are not applicable only to computer simulations, but also to drama scenarios. Using simulators and simulations (visual models) is a practice that dates back a long time, when considering broadly-defined education. Some authors would go much further, when claiming that simulations are useful and natural, and say that young predators prepare themselves for maturity and real hunting, by "playing out a real fight", similarly to a boxer practicing with his/her sparring partner [6]. Following this definition, refraining from using simulations in teaching would deprive pupils/students of a very significant element of the education system. Considering the current phase of technological advancement, it would be fake and most likely inappropriate to exclude computer simulators from the teaching process. The fact that a trainee is much more comfortable, when learning to use highly-advanced and very expensive equipment on simulators, as compared to operating a real machine, must also be taken into account. The operator has no fear of damaging the machine, by improper handling, and furthermore, they can be "alone with the simulated machine", without third parties monitoring, which has its impact on the level of the trainee's comfort and reinforces independence.

The Methodology of Teaching Adults

Developmental psychology divides adulthood into three phases of development: early adulthood: from 20 to 30-40 years of age, middle adulthood: from 30-40 to 50-60 years of age, late adulthood: above 55-60 years of age. In the first period, i.e. early adulthood, the capability to acquire and use knowledge is at the highest level. People develop relative thinking and the ability to comprehend and balance the opposites, which greatly facilitates the understanding of others. We use our creative thinking, systematic approach to problem-solving, and the ability of rapid adaptation[7]. Middle adulthood: it is characterized by stable levels of the majority of intellectual capabilities. The vast knowledge of life and collected experiences result in great wisdom, which is understood as the capability to make accurate judgments about the issues related to important problems in life. The only thing that slows down as we grow older is the speed of processing information, which may result from the fact that we relate the problems being solved to the entire abundance of collected knowledge. Our memory will also deteriorate, if not trained enough. When teaching people at this age, one must focus on perfecting the already acquired knowledge and skills[7]. Late adulthood: it is the time of developing integration and harmony between the logical-rational and the intuitive-emotional spheres. The crystallized intelligence (social intelligence) connected with life experience remains on a stable level or even increases, but the fluid intelligence (determined by biology) responsible for the processing of information and acquiring new skills is slowly reduced. It is only with people seriously sick or near death that we observe a significant decrease in their intellectual capacity. Teachers must make note of the fact that people advanced in age are very effective students, if they can control the tempo of their own learning[7]. In conclusion, when considering the differences in learning between the young and the elderly, one can assume the following: The elderly are much less effective in processing information, but better in expert knowledge (professional knowledge), and similarly competent in less complex tasks, when compared to young learners[7]. Assuming that operators-to-be are people in their early and middle adulthood, and their abilities to acquire knowledge and learn skills are very high, all that must be provided is motivation and comfort of education when learning to operate robots. The operating of robots is much more a part of the sphere of skills, than the sphere of knowledge, and as such, it serves the purpose of learning the right habits of responding to stimuli, transmitted visually and acoustically, through monitors (view from cameras) and loudspeakers (sound from microphones and sounds of working machinery). Thus, the most important element in learning to operate robots is exercises, and it is highly recommended to use simulators (training simulators) in practical drills, at least in the initial phase of training.

Creating model of the environment based on real terrestrial data

The model of the environment is generated form 3D point clouds gathered by a laser scanning system[10]. It consists of two parts: graphical/physics model based on VORTEX engine and reasoning tool based on QSTRR(Qualitative Spatio-Temporal Representation and Reasoning) framework[8]. The models are used concurrently during the scenario execution. Graphical VORTEX model is created by turning the 3D point clouds into triangle meshes. Semantic model is generated based on the same data during a semi-automatic process that can be divided into four steps: 1) data preparation, 2) conceptualization, 3) segmentation, 4) generation of qualitative representation of the environment. During the first step the data are matched and filtered. A normal vector is calculated for each point of the 3D point clouds. The preprocessed 3D point clouds are then used for conceptualization. Each point is given a label. In current version of the tool, labels attached are: ground, building wall, vegetation and unknown. In this process we concentrate on larger, primary objects of the scene(buildings, trees etc.) Smaller objects are left as unknown for later segmentation. The three main assumptions we make about the environment are: 1) ground can be approximated by a most dense horizontal plain. This assumption has minor drawbacks, but allows for fast separation of different 3D point cloud areas, 2) building wall points have normal vectors pointing in the same direction and are mostly a vertical plain, 3) trees and large vegetation have a uniform distribution of normal vectors directions.

The detection algorithm is based on those three assumptions. First a histogram of density of points in the vertical plain is calculated. Only points whose normal vectors are also vertical are used. After that the RANSAC [9] method is used to find the most populous plain in the most densely populated cell. Points that lay in distance D to this plain are labeled as ground. The D value was chosen to be 30 cm, which is a large, but acceptable considering the scale of the objects that are being detected. Remaining data points are assigned to cells of a horizontal grid. Each cell holds point from a 2x2 m area. In each cell points are grouped by directions of their normal vectors. Points are considered to be in the same group if their normal vector don’t wary by more than 12 degrees. The groups are later classified into three bins: dominating(>30% of all bin points), large(>20% of all bin points), small(<20% of all bin points). Based on this classification cells are classified to: potential building(at least one dominating group), vegetation(no dominating and large groups, at least 10 groups). The potential building cells are additionally verified by using RANSAC method to match a plain to the points in the cell. If at least 50% of points are near the found plain and their normal vectors are roughly in the same direction as the plain the cell is considered building wall. All cells that do not meet the building or vegetation constrains are labeled unknown. The last step of the classification is correction. The cell labels are corrected by analyzing their neighborhood for example: if a building is surrounded by unknown cells it is considered false positive and labeled unknown(it is unlikely that a 2x2 m building is in the scan). The third step is segmentation. Labeled point cloud is segmented into regions. Segmentation is done by and adaptation of region growing approach. The points are considered to be of the same segment if they are in 15cm distance to any point of the segment and the label of the point is the same as the label of the segment. The results of conceptualization and of the segmentation are shown in figure 1. In the last step creates a description of all detected objects. The description can then be interpreted into the QSTRR framework to create a bounding box representation of the semantic model. This model can then be used to simulate and catch events in the virtual environment.

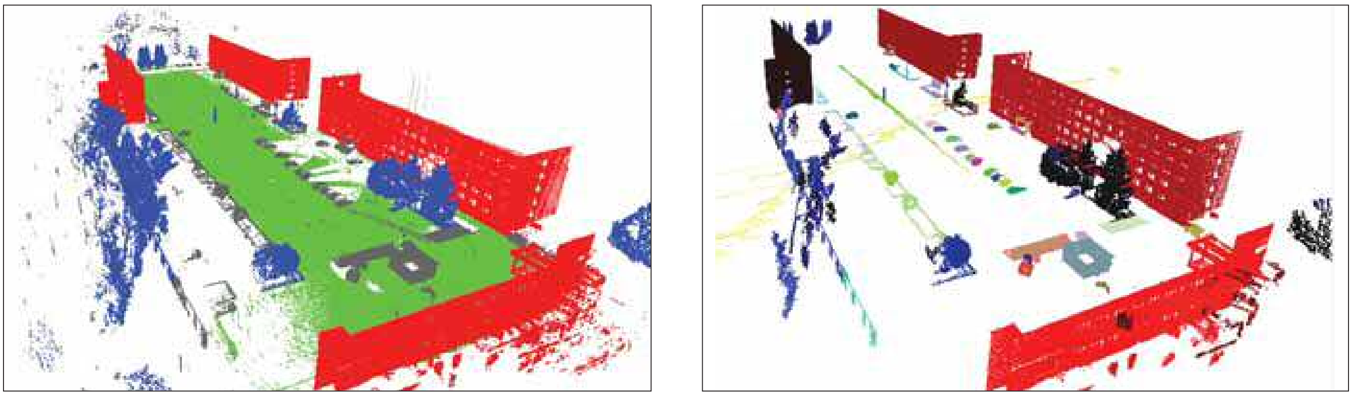

Figure 1. Left: semantic labeling: red-buildings, green-grounds, blue-vegetation. Right: segmented data.

Simulation of physics using VORTEX

For collision sensing and animation Vortex uses a simplified models consisting of basic shapes: boxes, cylinders and spheres. Combining these shapes allows to build a model covering all the space, where a graphic model of the vehicle will be loaded. Then it is necessary to set the mass and material parameters for each part. By default center of mass is set in the geometry center, but it can be adjusted, to match the actual part properties. After that, the first part of preparing the simulation is completed. The simplified model will be use in all the further calculations. For complex models it may be very time-consuming, but it is necessary to do it carefully, to achieve proper results of collision detection and dynamics calculations. The next step is getting the model ready for moving. All the parts must be connected with proper constraints. Vortex library covers a great amount of basic and complex constrains typically used in mechanisms, such as ball-and-socket constraint, hinge, prismatic, car wheel and others. All the constraints may be modified, by adding some individual limits, for example an angular limits of movement for hinge constraint. Depending on the model requirements, the constraints may be free to move or locked. The locked one may be than controlled e.g. by appropriate engine. To increase the reality, the breaking force for each constraint may be set.

Engines are the last part, that need to be added to a model in order to move it. Vortex also covers a wide range of parts typically used in vehicles like wheels, tracks etc. It allows to create an simulation which includes as sophisticated elements as the gear changing in the vehicle. At this stage the model is ready for the simulation. However for an aesthetic and reality reasons some graphics should be added. To do it we have used an Open flight (*.flt) models of the vehicles. For our purposes the very important property of .flt models is the tree structure, that corresponds to the model parts. It allows to load the graphic model to the simulation and then separate the moving parts. The simplified models of the vehicle parts are linked to their graphic representation. However all the simulation's calculations are being proceed for the simplified model, during the simulation(fig. 2). That areas, that will possibly take part in the collision detection. is why it is so important to match the model and its graphic representation very accurately. For terrain representation Vortex needs another 3D model to be loaded. Then all the forces and collision interaction between the vehicle and terrain may be calculated. We have developed a whole new system of data acquisition from the real environment. The raw data in the form of point cloud is filtered and processed to achieve a simplified triangulated shape. Then an appropriate texture is added and a model is exported to a file suitable for Vortex engine(fig. 3).

Results

In presented work we have integrated the CAD models of the vehicles with an appropriate exporter, to match the graphic representation and simulation with the exact size and shape of the vehicles. We have also developed a model of PackBot

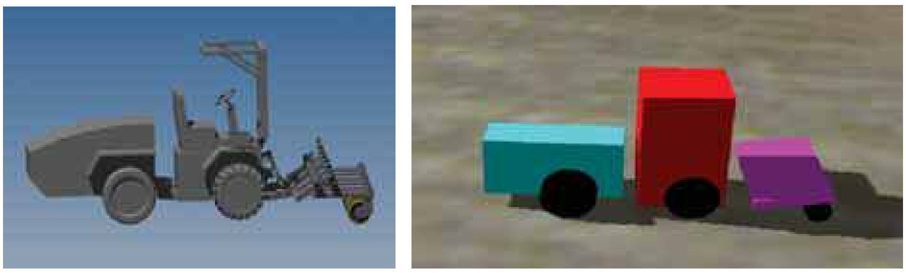

Figure 2. CAD model of vehicle LOCOSTRA and its collision geometry model in VORTEX.

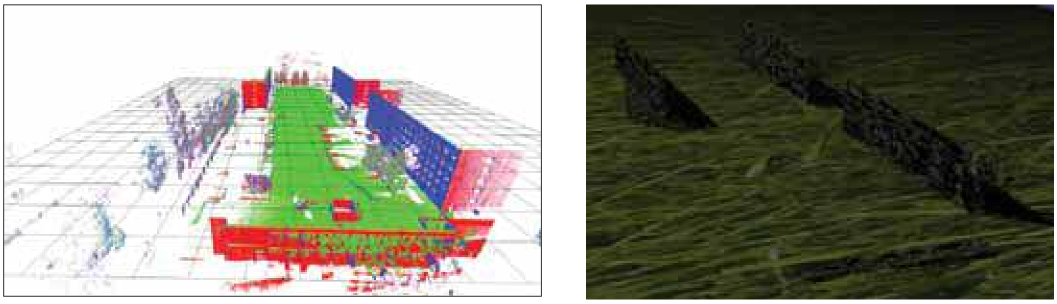

Figure 3. 3D scan input data and ready terrain model in VORTEX.

Figure 4. PackBot and some possible camera views.

robot simulation(fig. 4). In the system we have provided the possibility to change the viewport of the camera, so that the operator could control the vehicles from different positions. First one is the view from behind and above the robot, as it could be seen by the observer walking after the teleoperated robot. Next one is the viewpoint of the supporting robot following the main vehicle. Another acts as the cameras mounted on the robot. We have also provided the possibility of adding new viewpoints to the simulation and possibility to load, directly or after conversion, third part terrain models, for example from the Trimble 3D Warehouse database.

Acknowledgments

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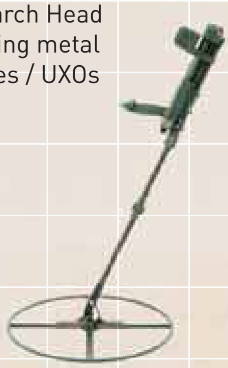
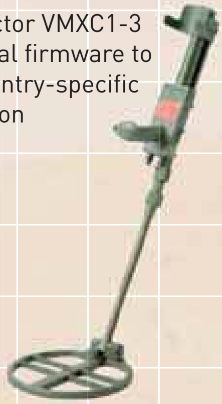
MINE & UXO DETECTION

Metal Detector VMH3CS
with pinpointing feature

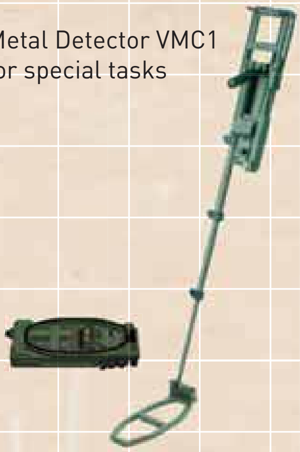
60-cm-Search Head
for deep lying metal
cased mines / UXOs



UXO Detector VMXC1-3
with special firmware to
detect country-specific
submunition



Metal Detector VMC1
for special tasks



Dual-Sensor-Detector VMR3
GPR and metal detector to
detect metal and metal-free
objects

Vallon GmbH has been a manufacturer of mine detectors for more than 40 years. The own R&D division develops hand-held mine detectors, hand-held bomb locators, vehicle mounted multi sensor detection systems, navigation tools for the field work, and powerful software for automatic evaluation of the detector data and following identification of UXOs.

Vallon GmbH's engineers and technicians work closely with the users in order to integrate their requirements into the equipment.

Additional tools for EOD and demining are offered by Vallon's subsidiary company Force Ware GmbH. For more information please visit www.forceware.de.

Customized Vehicle-Mounted Detection Systems,
for example VMV8

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10-20cm **Armor plates of 10 to 20 mm thickness**
All exposed MV-4 parts are supported with special Swedish HARDOX 400 armor plates

1X **1 person to operate**
Only 1 person is needed to fully independently operate MV-4

AVERAGE **30 cm average cleaning depth**
Flail hammers enable cutting through dense vegetation and digging 30 cm into soil

Fast learning curve
Most people can learn within a period of several hours how to operate the system

5,3T overall vehicle weight
5.31 metric tons (dry weight)
5.56 metric tons (with fuel & lubricants)

2X **Field crew**
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MV-4 THE WORLD'S LEADING DEMINING MACHINE

VF-100 demining machine

DEMINING MACHINES

By Istrazivac Ltd.

VF-100 DEMINING MACHINE

Istrazivac produces the VF-100 demining machine, which is based on an AHWI GmbH RT-400 chassis (undercarriage). Though the AHWI GmbH RT-400 is a land-clearing and forestry machine and not suitable for demining and mine-clearance applications, the VF-100 machine it has been completely redesigned, modified and certified for such tasks.

Controlled from its protected cabin, the VF-100 heavy demining machine has been designed for the most difficult terrain, conditions and high temperatures and also offers the possibility of remote control.

In this modified version of the AHWI GmbH RT-400, the existing cabin, which was not suitable for demining applications, has been removed and replaced with a completely new Istrazivac-built cabin in a different position to ensure maximum safety for the machine operator. The new cabin has level II ballistic protection against mine splinters, noises and vibrations. Windshield, windows and all other surfaces are made from several levels of ballistic glass to prevent internal splinter penetration. An emergency exit has been included on top of the cabin.

The whole machine is protected with an additional armour shield constructed by Istrazivac experts using Hardox 450 boards.

Istrazivac has therefore built and can supply a completely new working tool, with a range of tillers and flails available depending on terrain type and the buyer's needs. Unlike the AHWI GmbH RT-400, the new machine also offers a high-quality remote control system.

The VF-100 has been tested and certified by the Croatian Mine Action Center (CROMAC) Center for Testing and Research, and meets all requirements for use in humanitarian demining activities, passing tests on all anti-tank and anti-personnel mines.

Technical characteristics:

Length with caterpillar	4825 mm
Length with work tool	6630 mm
Weight with work tool	18660 kg
Work tool weight	4000 kg
Engine type	Deutz
Engine power	300 kw (408 Hp)
Engine capacity	11906 ccm
Work tools	Tiller or flail
Tool manufacturer	Istrazivac, Ltd.
Machine protection	Ballistic glass, Hardox boards
Transport speed	Up to 6 km/h
Working speed	Up to 1.5 km/h
Anticipated processing of ground depth	Up to 35 cm
Working tools cycling direction	Forward
Machine management	Cabin + Remote Control
Remote control distance	Up to 200 m

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