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Education of Population and Target Groups About Mine Threat in the Republic of Croatia

Đurđa Adlešić¹, Dražen Šimunović²

Contents:

Program of mine threat information – experiences thus far, Educating and informing the population on mine action in the Republic of Croatia; means and methods, Basic characteristics of suspected hazardous area (SHA), risky and correct behaviours, The usage of CROMAC MIS web portal with aim to educate the population, Education of target groups



1. Program of mine threat information – experiences thus far

Basic aims of information and education of population about mine threat are as follows: warn the population and target groups of the mine and ERW threat, prevent fatalities, wounding and material damage, point out the appropriate and safe behaviour inside the SHA, increase the level of knowledge pertaining to mines and ERW, and finally, to raise public awareness of the mine threat.

Activities for preparation of education are: application of all pedagogical methods and means of informing and education, application of adopted information in real conditions, creation and realization of the yearly plan of information and education for population by CROMAC in accordance with demining projects in subject areas, coordination of activities, work with target groups (hunters, fire-fighters, forest workers...)

Implementers of mine risk education are: Croatian Mine Action Centre (CROMAC), “Croatia without Mines” – Trust Fund for Humanitarian Demining of Croatia,, Ministry of Interior, Croatian Red Cross, Croatian Hunter’s Association, NGOs, others

Participants of MRE are: local population in areas contaminated by mines and ERW, school children, farmers, hunters and fishermen, forest workers, hikers, fire-fighters, municipal, city and other council members, other target groups directly or indirectly exposed to mine and ERW threat.

Experiences to date about informing and educating the population about mine threat:

All counties, towns and municipalities in the Republic of Croatia affected by mine problem have already been included into previous mine risk education activities and



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informing about mine problem.

Over 1 million people have been informed via the TV and radio shows, theatrical performances, visits to the threatened areas, promotional materials etc.

Informing and education of population regarding the mine threat is being implemented on a daily basis in accordance with the annual plan and as necessary.

For this activity, CROMAC spends about half a million HRK per year from the budgetary funds. “Croatia without Mines” – Trust Fund for Humanitarian Demining of Croatia also participates in financing mine risk education (MRE) projects for target groups.

Informational and educational activities in the recent years: “NE, NE MI–NE” – Theatre Daska, Sisak

Less arms – less tragedies, Ministry of Interior, BEMBO – a play, a movie and a picture book “The endangered world”, 4 April - International Day of Mine Awareness and Assistance in Mine Action, April – Month of Protection against Mines, Project – Education of Farmers, Project – Education of Hunters

The reduction in number of accidents and victims in the past is a result of work and preventive measures taken by CROMAC, “CWM” Trust Fund, Ministry of Interior and other stakeholders in informing and education of population.

2. Educating and informing the population on mine action in the Republic of Croatia; means and methods

Methods of informing and educating about mine threat: VERBAL METHODS (oral presentation, discussions, interviews, Q & A...), VISUAL METHODS (pictures, maps, drawings, movies, plays, TV shows, picture books....) and PRACTICAL METHODS (presentation of educational materials, equipment and devices, presentation

of work with detector, simulation of mine field with school mines in the field....)

3. Basic characteristics of SHA, Risky and correct behaviour

Initial MSA in Croatia in 1996 totalled 13.000 km². Estimated number of mines was 1 000 000. In line with data available in CROMAC MIS, current mine situation in Croatia is as follows: 12 mine contaminated counties, 88 contaminated towns and municipalities, 610 km² of SHA, 70.567 mines left.

Most threatened counties in Croatia according to the mine field records and type of mines

No.	County	Minefields	Type and number of mines		
		TOTAL	ATM	APM	Total
1	Sisak-Moslavina	148	350	15.848	16.198
2	Lika-Senj	408	3092	11.500	14.592
3	Osijek-Baranja	284	8.277	5.522	13.799
	TOTAL	840	11.719	32.870	44.589

According to data from CROMAC MIS web portal from 30 September 2013, there was 1821 mine field record with 70 567 mines (16 532 AT mines and 54 035 AP mines)

This is not the final number. The real number is unknown and can only be estimated.

Risky behaviour in the vicinity of SHA: **curiosity, wish for adventure, economic necessity and touristic curiosity.**

Correct behaviour

- ☐ Do not explore unknown areas.
- ☐ Do not try to remove mines and ERW – leave demining to the experts.
- ☐ Do not collect mines and ERW
- ☐ Do not approach mines and ERW
- ☐ Never risk by entering dangerous areas and do not explore military installations and equipment
- ☐ Before traveling, collect the information about threats in the area
- ☐ Pay attention to the mine threat signs and marcations

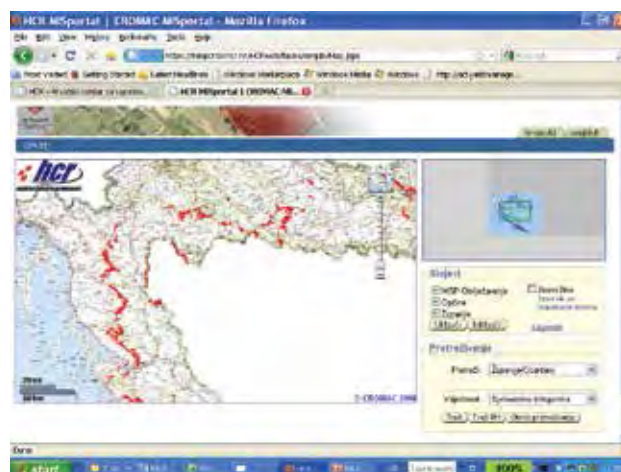


PROCEDURE IN THE DANGEROUS AREA

If you see a mine or an ERW, you are probably in a dangerous area and should adhere to the following instructions;

- ☐ Stay in place, do not walk further or move.
- ☐ Do not panic and keep your composure.
- ☐ Think well before taking any action.
- ☐ Do not attempt to exit the dangerous area.
- ☐ Warn others that you are in a dangerous area.
- ☐ Call or cry for help.
- ☐ Wait for someone to come along.

4. The usage of CROMAC MIS web portal with aim to educate the population



Information on mine situation is on CROMAC web page at www.hcr.hr. Access to CROMAC MIS web portal can be: public and/or authorised access to information/registration in Croatian or English language. Following the instructions, visitors of CROMAC MIS web portal may obtain information on SHA situation and marking of a selected county, town, municipality etc.

Authorised access provides the same information as public access but also provides additional access to presentations up to scale 1: 2 000 and more precise information on CROMAC mine action-related activities.

5. Education of target groups

Besides CROMAC, mine risk education (MRE) activities are also implemented by “Croatia without Mines” – Trust Fund for Humanitarian Demining of Croatia. The Trust Fund is founded on March 10, 1999 by Croatian Mine Action Centre (CROMAC) for the purpose of promotion of the mine problem in the Republic of Croatia and raising funds for demining from donors, domestic and foreign legal entities, institutions, associations and individuals.

Three basic tasks of the “Croatia without Mines” – Trust Fund for Humanitarian Demining of Croatia: accumulation of funds for humanitarian demining, mine risk education (MRE) and mine victim assistance (MVA). **Supervision over the execution of tasks is under the Supervisory Board; Supervisory Board consists of 7 members elected for a 4 year mandate. The work of the Trust Fund is managed by the director.**

Mine threat education

The “Croatia without Mines” – Trust Fund for Humanitarian Demining of Croatia in co-operation with CROMAC implements mine risk education activities (MRE) involving specific target groups (hunters, farmers, fire-fighters...)

The aim of education is to inform target groups about safe and appropriate behaviour in vicinity of SHA and fully prevent any casualties.

The project of mine risk education (MRE) for farmers is conducted by CROMAC and “Croatia without Mines” Trust Fund in co-operation with the Croatian Red Cross

(CRC), and Special Police Associations of the Homeland War.

In cooperation with Croatian Hunter’s Association the education of their members is implemented in order to familiarize them with risks related to mines and ERW.

A number of public and distinguished figures support the work of the Trust Fund. Some of them are: the President of the Republic of Croatia, Ivo Josipović, Ph.D., President of the Republic of Croatia (2000-2010) Stjepan Mesić, former prime ministers of the Government of the Republic of Croatia, ministers, distinguished individuals (Franjo Gregurić, Ph.D., Mate Granić, Ph.D., Đuro Dečak), American actress Angelina Jolie, Davor Šuker Croatian footballer and current president of Croatian Football Federation, Croatian actor Rade Šerbedžija etc.

In connection with mine risk education (MRE) projects, the “Croatia without Mines” – Trust Fund for Humanitarian Demining of Croatia established the co-operation with the AMAN Trust Fund in Libya, participated in preparation of mine risk education (MRE) projects in Bosnia and Herzegovina and co-operation with Croatian diaspora.



Priority-Setting in Mine Action

Mikael Bold³

Introduction

Priority-setting in mine action entails a set of processes and decisions that determine what should receive the most resources. These are known as ‘big P’ prioritisation, and cover, for example, which geographic areas of a country are most in need, which programme components and which operators. Then, given how resources have been allocated, ‘small p’ prioritisation is the name given to what should be done first, e.g. impacted communities, survey and clearance tasks. The main aim of priority-setting is to make sure we are delivering the most value for money.

Prioritisation involves; (1) deciding what should receive



priority and (2) ensuring adequate resources actually get to the selected priorities. If both are not done, the priority-setting system is not complete and will not deliver the most value for money.

In decisions involving the allocation of scarce resources, such as prioritisation, everything is interrelated. Priority-setting needs to be understood as a system. In donor-dependent mine action programmes, the government budgeting system is not used to allocate international resources to where these are most needed. This creates huge problems – even if ‘small p’ priorities are set well, the ‘big P’ priorities will be wrong and the overall system will not deliver value for money.

Good priority-setting normally entails both technical and political issues. Political decisions need to be based on open communication among key stakeholders to identify gaps in the system. In turn, good priority-setting facilitates coordinated action to address those gaps.

Key Challenges

We need to set priorities because there are never enough resources (people, money, assets, time) to accomplish all that needs to be done. In the case of mine action, for example, we might seek “a world free of the threat of landmines and explosive remnants of war (ERW), where individuals and communities live in a safe environment conducive to development, and where the needs of mine and ERW victims are met and they are fully integrated into their societies”. However, this will take far more resources than are currently available, and many years. So, we need to determine what should receive the most resources, and what needs to be addressed first.

Because assigning resources to one alternative means they are unavailable for others, prioritisation must be viewed as a system of interconnected decisions. Commonly, the greatest weakness in priority-setting for mine action is not regarding mechanisms already in place but those, which are missing. The solution lies mainly in the national capitals of mine/ERW- affected countries and the mine action donors. Decisions made – or left unmade – in the capitals have a huge impact on the quantity and type of resources available for prioritisation later and, therefore, the overall performance of national mine action programmes.

A systems approach is needed to tie together priorities emerging from strategic planning. These should consist of long term processes, operations planning (annual), and task planning (short term).

Different Decision Scales And Durations

In mine action, discussions concerning priority-setting have often focused on task priorities, e.g. which hazardous areas will be demined first, which communities will receive risk education (RE) this year, etc. However, there is a broader range of prioritisation decisions that mine action managers should make. Some of these involve the commitment of large shares of the total resources available.

For example, decisions on ‘big P’ prioritisation need to be taken. These involve large-scale decisions about how to allocate resources among different areas of the country

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and among the different mine action ‘pillars’ - demining, risk education, victim assistance, stockpile destruction and advocacy.

Priorities differ substantially in terms of the time it takes to achieve them. For example, the decision to make road verification and clearance a priority in a post-conflict period may imply investments in specialised assets that will be occupied on this task for years. Because of these variations in the scale and duration of decisions, different types of priority-setting decisions are often grouped into broad categories, such as:

Strategic – large scale decisions that commit resources over an extended period of time to advance broad objectives (often termed strategic goals or aims)

Operational – decisions of varying importance that commit resources, typically for a year or less, to specific projects, areas of the country or pillars etc, in order to implement the strategy

Task – decisions to commit specific resources to certain tasks at a specific time, for example, which minefield is to be cleared, which community is to receive risk education, etc.

Information Challenges

Priority-setting aims to increase the ratio of benefits to costs. Although this will clearly require information on both costs and the likely benefits, information may be difficult and costly to obtain. This will particularly be the case in the early days of a mine action programme – post-conflict or after other emergency situations. Often there is little reliable data about even the most basic of things; such as the extent of mine/ERW contamination, the location and number of refugees and internally displaced persons, when they will return, and to where.

Because of this lack of information, mine action managers are forced to make uninformed decisions, which often prove incorrect and cost time, money and even lives, despite the very best intentions. During the early days of a mine action programme when good data is scarce, mistakes are unavoidable. The success of a mine action programme over time depends largely on the appropriate decision makers having more and better information at the right time.

Changing Contexts

Complications can arise when the broader operating

environment, or context, of a mine action programme changes; often rapidly and dramatically.

Mines and ERW stem from conflict. Mine/ERW-contaminated countries evolve from conflict to an immediate post-conflict period, then into a phase of reconstruction, and finally, into a more traditional period of development.

These broad changes lead in turn to: population movement, changes in the pattern and intensity of mine/ERW impacts, significant adjustments in the pattern of donor assistance and how such assistance is delivered, and a growth in the government’s capacity to implement investments and deliver public services.

In parallel, the mine action programme collects more data and becomes better informed over time.

Mine action priorities need to change in step with significant changes that take place. Priorities appropriate in the immediate post-conflict period are almost certain to be different to the reconstruction or development phases.

In addition, the mechanisms for setting priorities should evolve, to incorporate the additional information available and, as government capacities grow, to allow greater national ownership.

If mine action priority-setting systems do not adapt over time to the broader environment as it naturally evolves, gaps will emerge and widen, and value for money will fall.

Ground vehicle based system for hyper spectral measurement of minefields

Milan Bajić⁴, Marko Krajnović⁵, Anna Brook⁶, Tamara Ivelja⁷

Abstract: The airborne and space borne hyper spectral remote sensing is new challenge for the application in humanitarian mine action. The basic knowledge and the understanding of the demands, needs and requirements to this technology in the domain of humanitarian mine action starts from the available knowledge in the agriculture, forestry, ecology, land use, land cover, military surveillance and reconnaissance etc. The research of the basic behavior of hyper spectral features, potentially relevant for the humanitarian mine action, was conducted on several minefields using the ground vehicle based system. The development of the ground vehicle based system started in 2012, its advancement continued in 2013 and 2014, in the frame of EU FP7 project TIRAMISU. The experience collected during research phase led to development of the model of a ground vehicle based hyper spectral remote sensing system which can be applied for technical survey.

Introduction

The behavior of the grassy vegetation if exposed to the fertilizing is known and researched in several domains, in agriculture, in botany, in ecology among others. In EU FP7 project TIRAMISU is foreseen thorough research of this phenomenon with aim to develop, test, evaluate and operationally validate a tool (method, technology, equipment, procedure, recommendation) which should be applied in Technical – Survey or/and in Non-Technical Survey [1]. The research was foreseen in several phases, results of each phase have been selected as a milestones for decision about further steps. At each milestone two options were possible: to stop research/development or to continue and modify certain parts for next phase. The initial assumption were that reflectance spectra and the bio - chemical analysis in the laboratory of total content of Nitrogen can detect the difference of grassy vegetation in the considered case. The research in 2012 showed that analysis of total Nitrogen content by bio-chemical analysis

is not suitable for this purpose. Therefore we focused attention on spectral analysis of the grassy vegetation in the reference area and in area contaminated by landmines (test area), Fig.1. Also UXO samples have been analyzed [2], [3].



Figure 1. Test area (minefield) in red polygon, reference area between red and blue polygons.

The reference (training) area shall have the same features as the test (minefield) area, it shall also be abandoned, free of contamination by landmines, UXO, explosive, agricultural fertilizers. If this condition is satisfied can be applied spatial change detection of grassy vegetation features of reference and test areas, based on simultaneously collected hyper spectral data, developed and verified by tests and evaluation in 2013 (the airborne and ground based systems).

System for collecting the hyper spectral data by ground vehicle based sensor

The crucial part of the research was collecting of hyper spectral data in the mine fields, data pre-processing, processing, quality evaluation, correction, atmospheric calibration, interpretation. The hyper spectral imaging on the minefield was performed with a spatial resolution 1 x 7 mm and provides hyper spectral cubes of the vegetation and soil above 885 landmines, 524 metal debris at different depths, 544 empty squares (1 m x 1 m). The collecting of hyper spectral data was done by the hyper spectral line scanner, installed on mechanical sliding carriage, controlled by micro - processor, its set – up can be done by PC, Fig.2.

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⁶ Anna Brook, PhD, Prof., University of Haifa, Israel, abrook@geo.haifa.ac.il

⁷ Tamara Ivelja, Mag. Ing. Geoinformatics, Faculty of Geodesy University of Zagreb, EU FP7 project TIRAMISU, tamara.

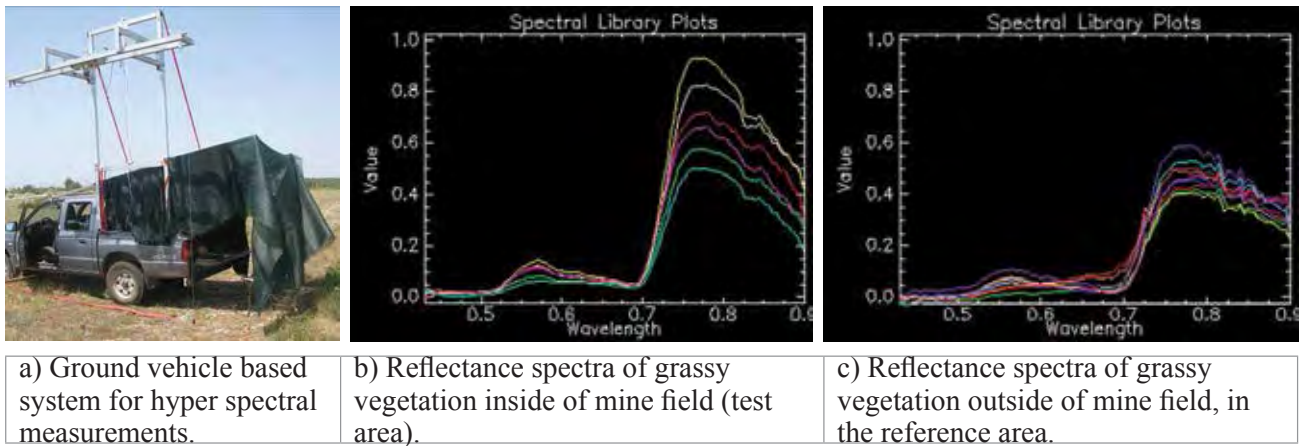


Figure 2. The ground vehicle based hyper spectral sensor was used for nadir collecting of the data.

The hyper spectral line scanner collects data from 430 to 900 nm in 95 channels. By described system were collected and processed 190 hyper spectral reflectance cubes, each correspond to area of 2 x 1 m in the test area and the set of 25 hyper spectral reflectance cubes of grassy vegetation response in the reference area. The difference of the reflectance spectra of the grassy vegetation in the mine field, Fig.2b and of grassy vegetation in the reference area, Fig. 2c, is the part of the milestone after second project's year. Second part of this milestone was affirmative conclusion about the suitability of the ground based measuring system. It was tested in several modes, at several areas and targets (four different minefields, unexploded ordnance at exploded ammunition depot) in 2012 and 2013.

Side looking oblique hyper spectral data collecting

The reliable use of the data collecting system from Fig.2 and the suggestion²⁵ at the end 2013 initiated analysis of the possibility to develop side looking, oblique collecting of the hyper spectral data. The preliminary analysis was done in first days of 2014, mathematical model of the side looking geometry was derived, the mechanical system was designed and made. The geometry of the side looking collecting the hyper spectral data is defined at Fig.3.

The influence of the height of the grassy vegetation on the looking angle b was analyzed, on hyper spectral cubes from minefield Fig.1. This analysis shows²⁶ that looking angle from 10° to 70° can be used, Fig. 4.

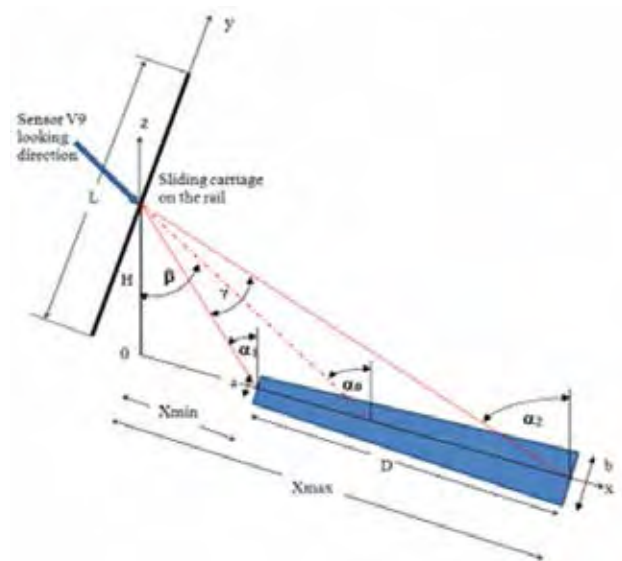


Figure 3. Geometry of one snapshot. The hyperspectral sensor V9 at height H above ground, looks at angle b (measured from axis z) very narrow trapezium which has length D , sides a and b , $a < b$, $a \ll D$, $b \ll D$. Trapezium is oriented in direction of x axis.

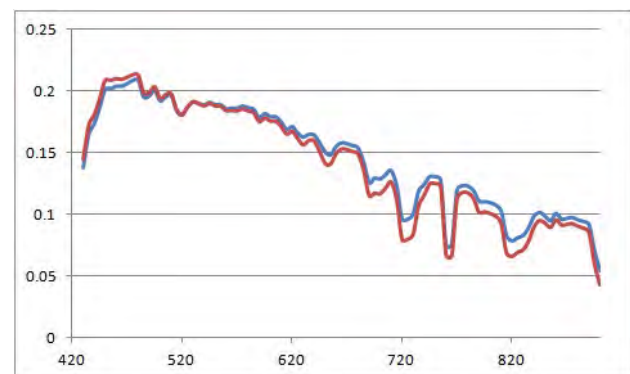


Figure 4. Two radiance spectra simulated for ground side-looking system using data of grassy vegetation measured in the minefield Fig. 1, in 2013, red – looking angle $b = 10^\circ$, blue – looking angle $b = 70^\circ$.

⁸ Telephone communication with Mr. Čedo Matić, leader of the Survey and planning department in CROMAC. cedo.matic@hcr.hr

⁹ Anna Brook, E-mail 27.03.2014.

The system was tested and basic operational data are determined, the testing and evaluation of the system is under way, Fig. 5.

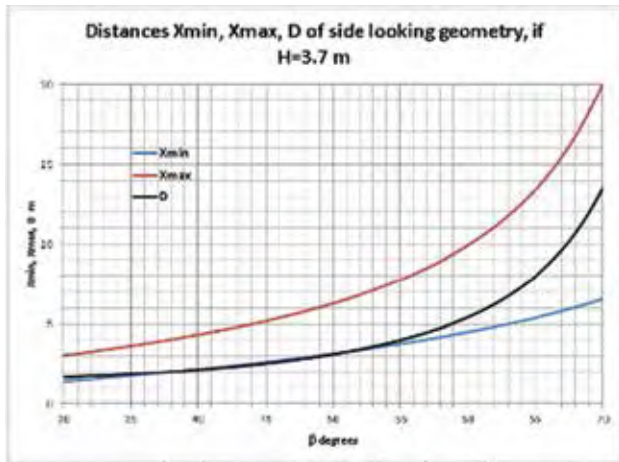


Figure 5. Distances X_{min} , D , X_{max} of the area of one snapshot.

Sensor is installed on the carriage which moves on the rail (length $L = 4$ m) at height $H = 3.7$ m above the ground surface, Fig. 3. The number of positions where carriage with sensor shall stop for data collecting is $N = L/a$.

Conclusion

Ground vehicle based tool is less complex than the airborne: raw data images need only to be rearranged into a hyper spectral cube, there is no need for parametric geocoding, simple radiometry calibration with Spectralon provides data which are reliable and stable, atmospheric correction is simple. Data have very high spatial resolution, measuring system is robust, although the capacity is determined by speed of carriage movement and speed of vehicle movement from location to location.

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Aerial Remote Sensing Area Reduction

Avi Buzaglo Yoresh¹⁰, Eva Peled¹¹

Abstract

Geomine technology focuses on reducing suspect hazardous areas (SHA) based on the spectral identification and characterisation of the vegetation of the SHA. According to UN estimates, approximately 80 % of all land designated a SHA is in fact free from landmines. Identifying areas that are free from mines is the underlying concept of the Geomine tool.

TNT (Trinitrotoluene) is the most commonly used explosive in military and industrial applications. It is used in landmines, bombs, shells, grenades and many other explosive devices. The technology relies on this fact. TNT consists of nitrogen, and when ERW are buried in the ground, they release small amounts of nitrogen which is then absorbed into the ground and metabolised by the surrounding vegetation. Under certain conditions, still to be fully investigated, this extra amount of nitrogen could produce changes in the vegetation spectral response. If these changes are detectable and can be directly and unequivocally attributed to TNT contamination, then high-resolution hyper spectral remote sensing could be considered a suitable technique for supporting SHA's reduction.

Introduction

According to UN estimates, approximately 80% of all land designated as SHA is in fact free from ERW/landmines. Identifying areas that are free from ERW/mines is the underlying concept of the Geomine tool – an Israeli company that for the past 6 years, has been developing Aerial Remote Sensing solutions for demining. The technology focuses on reducing SHA based on (1) the spectral identification and (2) characterisation of the vegetation of the SHA.

The technology relies on the fact that TNT is the most commonly used explosive in military and industrial applications. It is used in landmines, bombs, shells, grenades and many other explosive devices. TNT consists of nitrogen, and when ERW/mines are buried in the ground, they release small amounts of nitrogen which are then absorbed into the ground and metabolised by the surrounding vegetation. Under certain conditions, this extra amount of nitrogen may produce changes in the vegetation spectral response. These changes are detectable and can possibly be attributed directly to TNT contamination.

The research

Between the years 2007 and 2013 Geomine has surveyed a total of 226 million m² out of which 100 million m² in Malanje, Dundo and Aldeia Nova in Angola, 120 million m² in Wittstock Germany and 6 million m² in the Golan Heights Israel. The vegetation on the various sites differs between areas with very little vegetation, moorland with dense vegetation, and forest areas with uneven ground. In each location, airborne Hyperspectral campaigns were executed to estimate the probability for detection of buried ERW/mines using cameras such as AISA-Dual, and HyMap with an investigated spectral range from VNIR to SWIR i.e. from 380 to 2500 Nm.

Over 100 million pixels were verified, 54 chemical analyses of the ground and vegetation surrounding the ERW/mines were performed and 34 chemical analyses of the ground and vegetation outside of minefields were performed. This allowed the development of seven different detection algorithms which are the result of the research to be described in this paper.

A Geographic Information System (GIS), integrated with Hyperspectral imagery and classifications layers including advanced applications allowed for fusion of measured image data, a priori information (ground truth) and geographic information to be used for planning of demining activities and as working support during operational process. Validation in controlled environment and real minefields allowed the suggested method to achieve effective results.

The research phases, in each country, included the following:

1. Information gathering phase – collection and storage of data in GIS: (a) available information about the SHA from the general survey data, (b) available maps, (c) general area evaluation (terrain, vegetated area and temporal change detection).

2. Examination and planning phase – this phase determines the site conditions (spectral ground truth data and spectral models), possible extent of the minefield and allow us to develop a plan for the airborne survey. Several aspects are considered: the environment (weather, vegetation etc.) and the SHA (evidence of mines, possible infiltration routes, or available minefield sketch in case of planned and maintained field).

3. SHA survey phase – The Hyperspectral sensors (HyMap and AISA-Dual) acquire images by the defined search pattern using the Google Earth interface. Repetitive pattern flights as well as different flight heights are planned for spectral and multiscale image data analysis. All the acquired images and the corresponding metadata (flight path, Flight height, sensor parameters, recorded image position) are then stored into the GIS for further processing.

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4. Interpretation phase – Upon completion of the survey, the spectral interpretation and data fusion starts. The end product is the mapping of the SHA specifically the identification of areas that are free of ERW/mines. The additional result is a quantitative classification evaluating chemical properties of contaminated vegetation based on spectral models developed in the laboratory.

Research 1: Golan Heights Israel – 2007-2009 – 6 million square meters

Research 2: Malanje, Dundo, Angola - 2009 – 100 million m²

Research 3: Wittstock Germany – 2012-2013 – 120 million square meters

In 2013 the Geneva International Centre for Humanitarian Demining (GICHD) participated as the lead observer in the Geomine demonstration test in Wittstock, Germany.

The demonstration was carried out in Wittstock, Germany.

Two kinds of areas were pointed out by Geomine – those which were found to be clear/uncontaminated according to Geomine (GROUP A), and those which were found to have a high probability of contamination (GROUP B).

Out of the total area of 120 km², 89 per cent of the area was indicated by Geomine as clear of ERW/mines and 11 per cent as contaminated.

The indications were investigated by Sensys. The investigation of the area indicated by Geomine as clear found full accuracy between the Geomine findings and Sensys verification, i.e., locations that were indicated by Geomine as clear/uncontaminated were confirmed to be 100 per cent clear/uncontaminated.

Conclusions

The new procedure, based on airborne and space-borne platforms and the optimized set of Hyper-, multi-, and digital high resolution sensors including Digital Terrain Model (DTM) allow a repetitive and fast survey for area reduction, increase the flexibility and adaptation to several scenarios, and above all reduce the risk. An enhanced GIS, resulting in a 4-Level information and decision system based on satellite and airborne data, aerial photography, ground investigation, GPS measurements and Level-1 survey gathered information, was developed. The Expert System (ExS) developed based on the existing GIS program provide additional information from external sources and the results of the suggested system presented as a complete project. The multiplicity of experimental areas all over the globe clearly demonstrates the robustness of the developed methodology. The ExS method has a full potential to provide a useful addition to existing procedures and technology to solve the mine problem as currently exists in many mine infected countries. The use of airborne sensors

allows flexible approach in flight altitude and patterns. The presented experiments of different campaigns, sensors and locations are undertaken to prove and optimize the method to true suspected mined areas. The results of ExS were validated based on conventional minefields, the detection was provided by NPA in Angola, the Ministry of Defense in Israel and by Sensys in Germany. The total accuracy of the presented method is very high (up to 99.9%) that provides a robust, generic and fast tool for area reduction using remote sensing technique.

Geomine would like to thank **Prof. Alan Mathews** from The Hebrew University in Jerusalem, **Prof. Eyal Ben Dor** from Tel Aviv University, **Dr. Ittai Gavrieli & Dr. Faina Gelman** from The Geological Institute of Israel and **Mr. Peter Cocks** from Hyvista Corporation in Australia. Thank you all for the support, assistance and good ideas all along the way. We also thank the GICHD for its support and its efforts with going ahead with the demonstration test.

The Role of Demining in International Development Cooperation and the Impact on Sustainable Development

Iva Jantolek¹²

ABSTRACT

Humanitarian mine clearance aims to clear land so that civilians can return to their homes and their everyday routines without the threat of landmines and other unexploded remnants of war (ERW), which include unexploded ordnances and abandoned explosive ordnances. This implies that all the mines and ERW affecting the areas where ordinary people live must be cleared, and their safety in those areas that have been cleared must be guaranteed. Very often landmines are long-forgotten remnants of conflicts long past and yet they retain their ability to destroy lives and livelihoods in areas that are still struggling to recover. Eliminating this threat is essential for further development which is why the Republic of Croatia, as a young donor country, maintains projects devoted to neutralizing mine fields, providing mine-risk education, and assistance to victims in many areas of the world where landmines continue to be a dangerous threat, which is recognized as a specific Croatian niche. The experience gained during the transitional period for Croatia represents its comparative advantage which is successfully being transferred to the countries in the need.

INTRODUCTION

The link between demining and development goes both ways. While demining can enhance development opportunities, a lack of development support can also limit the impact of demining. The two are intrinsically linked. By recognizing the link between mine action and development, the Republic of Croatia embarked upon an integrated approach towards mine action programs within its' international development cooperation projects.

Croatia has gained substantial experience in transforming itself along the path of peace, reconciliation, development, cooperation and European and Euro-Atlantic integration over the last twenty years. Given the specific experience gained during the Homeland War, humanitarian demining is considered to be one of the top Croatian export products. Croatia expertise and products (for example, patented

remote controlled vehicles and precision mechanics) are competitive in Europe and around the globe.

Providing development assistance and humanitarian aid in the sector of humanitarian demining for Croatia implies strengthening the national capacities in the field where a comparative advantage of Croatian experts have attained experience in wartime and post-war conditions, can be shared with others in need. The Republic of Croatia has identified mine actions as one of Croatia's export products, and this product has helped the Ministry of Foreign and European Affairs to initiate the implementation of several projects through education, training and accreditation of experts in developing countries.

INTEGRATING MINE ACTION WITH DEVELOPMENT PROGRAMMES

Integrating mine action with other development programmes implies building a sustainable economic community. The concept of integrated mine action acknowledges the fact that landmines are not the only threat facing communities. Poor water supply and sanitation, diseases, land-grabbing and other poverty-related problems often create a much greater barrier to developing country's rehabilitation and development. These factors are even more particularly relevant to the most disenfranchised members of society who are often landless and live in squalors. For this reason, integrated mine action strives to expand beyond reducing poverty through mine clearance, mine risk education and assistance to survivors. It aims to facilitate community ownership and empowerment, not only by clearing the mines, but by providing appropriate resources for resettlement on cleared land, including supporting infrastructure, strengthening agriculture, introducing alternative food security, supply of water and sanitation, and providing victim assistance and legal support structures.

National governments are responsible for and should be in control of National Mine Action Programmes, except in extreme cases where no functioning government exists, or in countries in or emerging from conflict. A nationally owned mine action programme requires that the state demonstrates political, financial and technical ownership. This is done by adopting legislation and national standards

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governing mine action, mobilizing national and, where required, external resources to sustain the programme. It should develop clear and achievable mine action plans which are aligned with national, sub national and sector development priorities. Furthermore, it is vital that international organizations and NGOs also support the government in this regard.

While difficult to quantify, the developmental impacts of mine action include safe roads, improved access and provision of health care, education and other social services, as well as safe access and productive use of land intended for resettlement/housing, agriculture, grazing and forest land. Indirect developmental impacts include: fewer deaths and injuries; increased availability of labour, skills and knowledge as a result of fewer accidents; improved sense of security; safe access to land, infrastructure, markets and social services; improved income levels, living standards and funds available for other economic investments; and a reduced burden placed on the health care system.

Landmines and other unexploded remnants of war often affect lives and livelihoods long after a conflict has ended. Linking mine action and development is about ensuring mine action promotes socio-economic development and reduces poverty. This concept is particularly relevant where landmine contamination impedes post-conflict reconstruction and development. Linking mine actions and development requires the integration of mine action in development policy and programming. It also encourages effective coordination between mine action and development actors at all levels (community, sub national, national and international).

The international community has come to recognise that demining with development is the way forward. We can group the motives for integration in three broad categories: equity, efficiency and sustainability.

1. Equity

Improve equity nationwide: individuals living in a mine area are disadvantaged compared to individuals living in area cleared of mines as the former do not have safe access to agricultural land, to water, health centre, etc. Making demining a national development objective reduces socio-economic inequalities by improving the standard of living of vulnerable individuals and communities and thus improves overall equity. Making demining a development

objective at community level also increases equity as civil society organizations will address the needs of the most vulnerable families first.

2. Efficiency

Efficient resource allocation and priority setting at national level is very crucial. Lands that have potential for sustained economic output (e.g. farmland, roads, ponds) are prioritized for mine clearance over land that has little economic potential. The purpose of demining is one of socio-economic development, rather than one of humanitarian aid. Mostly, mines are being cleared with a development purpose rather than for humanitarian.

3. Sustainability

And last but not the least, it is important to ensure sustainability of impact. Mine clearing alone is insufficient to sustain improved standards of living. Families need secured land rights, access to water, schooling and health. A community that was successfully organized around demining activities can sustain its mobilization to build community infrastructure (Sustain community dynamics). To sustain development activities, NGOs should build the capacity of local institutions and give them crucial support (Sustain local support). Furthermore, activities that ensure sustainability and development of the society can be benefited by increased support of a donors (Sustain donor support).

The focus of the integrated mine approach of the Republic of Croatia is to provide training, education and accreditation workshops to other national authorities in order to educate those involved with the current land contamination. These activities consist of support in policy guidance and implementation, inter-institutional coordination and support in the mine action sector as well as promotion of the strengthening institutional mechanisms for transparent and objective collaboration between all levels: national, municipalities and civil society. Most of the technical assistance provided by Croatian experts is focused on training and preparing for the procedure of proposing and adopting normative legal acts regulating mine action. The assistance focuses on the proposals for standardized measures, methods, procedures, tools, equipment, location of sites, and databases.

MINE ACTION AS A SPECIFIC CROATIAN NICHE FROM WAR-TIME AND POST-WAR CIRCUMSTANCES

Croatia has developed humanitarian demining capacities after the recent war Homeland War (physical demining, equipment, know-how, and rehabilitation of mine victims) which has been recognised as a comparative advantage in Europe and worldwide. The system was positively influenced by the EU during the accession process.

In the past few years, by sharing the experience of specific wartime and post-war circumstances, Croatia as a new donor country has been recognized as a donor with this specific post-conflict niche. Croatia has developed strong humanitarian demining capacities after the recent war Homeland War (1991-1995) because of the remaining mine risk which was constantly present, threatening the civil security of the country. The Republic of Croatia is one of 59 countries in the world facing a mine problem. In the period of 1991-2012 there were 1,964 people affected by mines in Croatia, out of which 508 people died (mostly individual cases). By the signing of the Ottawa Convention (1997), Croatia was recognized as one of the leading world humanitarian demining countries.

As a result of the institutionalization of the Croatian mine action expertise, the Croatian Mine Action Centre (CROMAC) was established by the Government in 1998 as the national agency responsible for the coordination of mine action activities in Croatia. The recently established Government Office for Demining functions as a political coordinating body that monitors CROMAC activities, contributes to mine awareness raising and further development of the mine action system etc. CROMAC develops proposals for the National Mine Action Plan and Humanitarian Demining Plans, coordinates mine risk education activities and activities related to mine victims assistance, gathers and processes mine suspected areas data and marks mine suspected areas, performs demine control inspection etc. The government encouraged activities of the CROMAC's Centre for Testing, Development and Training and the Trust Fund for Humanitarian Demining of Croatia. Within governmental support, CROMAC has co-founded the Cluster for Humanitarian Demining Operations Abroad and the South Eastern Europe Mine Action Coordination Council – SEEMACC (CROMAC, n.d. b).

Croatia's demining capacities include physical demining, equipment, know-how, and assistance to rehabilitation

of mine victims. Based on its experience, Croatia is ranked among the best performing and the most admired world demining systems with good technical resources and highly educated human potentials. Mine clearance capacities in Croatia include complete equipment of 32 demining companies that are authorized to perform demining activities (primarily Mungos and DOK-ING, but also others), over 600 equipped deminers and the same number of metal detectors, a number of demining machines and mine detection dogs. Special attention is given to education and informing citizens about the risk of mines, where the Croatian Red Cross also plays an important role in raising awareness and informing endangered populations.

The demining activities in Croatia and abroad are mostly financed through the state budget and Croatian public enterprises (on average some 60 percent of total costs) and private companies while the remaining sources are obtained from foreign and domestic donors. A great deal of progress has been made in dealing with the mine action that Croatia was faced with during the recent war and in the post-war period. Croatia has developed humanitarian demining capacities (physical demining, equipment, know-how, and rehabilitation of mine victims) which became its comparative strength in Europe and around the globe.

DEMINING AS PART OF CROATIAN DEVELOPMENT ASSISTANCE

Through its integrated mine action programme within the development assistance policy, the Republic of Croatia ensures safe land is made accessible to the landless poor for resettlement and for family farming. It helps to create permanent land titling for demined land and allocate it to landless people by building legal framework awareness and understanding.

Columbia

The Ministry of Foreign and European Affairs of the Republic of Croatia, throughout its development assistance projects in 2011 encouraged the implementation of the mine actions projects together with other Croatian competent authorities and partners from CROMAC's Centre for Testing, Development and Training. In 2011 a pilot project for the training of Colombian experts in the establishment of a legal framework in Columbia

was implemented which is recognised as an “in kind” contribution to the Organization of American States (OAS). The project included the establishment of a legislative framework and national strategic guidelines in partner state, and assistance in setting up the necessary procedures for the operation of the institutions involved in mine clearing.

Because of its success and due to the identified need in partner countries, some of the mine action projects continued in 2013. After the process of assisting in systematization of existing data and experience on the mine problem in Colombia and according to the identified needs of Colombia, further support was provided by Croatia including the following: accreditation and certification of equipment used in demining operations (metal detectors, demining machines, protective gear, mine detection dogs), training on demining, guaranteeing and monitoring the quality of demining operations; assistance with the organisation of a quality system for the management of overall demining activities; assistance with the drafting of legislation and standard operating procedures.

The Ministry of Foreign and European Affairs of the Republic of Croatia also financed the third phase of the implementation of this project, which encompassed the Training of supervisors and supervisors for quality in mine action which will be based on the education of fifteen (15) participants. As part of the training standardized measures, methods, procedures, tools and equipment used in humanitarian demining was proposed. Furthermore, as part of the this third phase, the Republic of Croatia is donated 15 complete sets of demining wear for the participants to the Ministry of Defence exclusively made by Croatian companies. The demining wear is compliant to the highest international standards.

Libya

Furthermore, as a high-priority project of early post-conflict recovery of Libya, at the end of 2011, the project of establishing the state of the environment, with a focus on mine action programs and education about the dangers of landmines, was conducted in coordination with the Joint Mine Action Coordination Team Libya (JMACT). Specifically, with respect to Libya, more focus was directed to activities in the exchange of experiences between civil society organizations which addressed the needs of the most vulnerable families first, as poverty is

putting most vulnerable people at risk of mine incidents. To sustain development activities regarding mine actions, the Republic of Croatia supported the NGO sector which built the capacity of local institutions²⁵.

Jordan

According to the request by the National Mine Action Center in Jordan a technical assistance project was done by CROMAC's Centre for Testing, Development and Training. The project included the organization and examination of the first degree course of the Explosive Ordnance Disposal (EOD) in Jordan and on the basis of the success (the students who passed the course), the implementation of the second phase of the project - the organization of the training for EOD II was done in Croatia. The project opened space for training workers for the implementation of the next phase of the project which include education and examinations in the third and fourth level of EOD that would potentially identify experts in the field of demining from that part of the world. The project also raises the possibility of opening a regional centre for training in mine clearance in the country of the Southern Mediterranean and the Middle East, and for which the Jordanian side expressed its interest the last year's conference on demining held in Šibenik. This would open further possibilities for Croatia's accession to the Jordanian and the wider Arab market, particularly in the area of mine action.

Serbia

In closer cooperation with Mine Action Centre of Serbia, Ministry of Defence and Ministry of Interior of the Republic of Serbia an EOD level 1 and 2 was successfully done by CROMAC's Centre for Testing, Development and Training was done in 2013 and was funded by the Ministry of Foreign and European Affairs of the Republic of Croatia through development cooperation. The project is a contribution to the development of relations between Croatia and Serbia and an expression of efforts to strengthen security and the general progress in the region of Southeast Europe. The project also sends a message that the Republic of Croatia is taking a leading role in stabilizing and development of the region of Southeast

²⁵ Mine-affected communities are often doubly disadvantaged because NGOs and other development actors are unable or unwilling to visit them. They desperately need help in catching up and rebuilding their social capital and livelihoods.

Europe, and thus fulfils its mission of a leader in this area. In Serbia, there is a great need for additional training and development of employees in jobs of removing and disposing of unexploded ordnances, particularly in cluster munitions, as well as the need for underwater demining.

There are several principles that guide the design and implementation of Croatia's integrated demining programmes. It consists of support to local systems and authorities which involve officials' at all relevant levels of the project and building the capacity of local authorities to assist them to improve the process of demining for community development. Community participation is an important part when it comes to the point of organizing joint planning sessions before the commencement of projects. This includes building trust between the national level authorities and NGOs. Community empowerment is crucial in the sense of enabling communities to initiate development requests themselves. The most important part of mine action assistance is education and raising the awareness of development workers and communities about the realities of mine action. And last but not less important is to adjust to the need of the specific community.

CONCLUSION

Mine action programmes find themselves responding to many different needs. Humanitarian mine action is focused on saving lives and limbs, providing a rapid and flexible response to hazards, and often based on clear priorities set by international organisations (rather than government). It is not exclusive to humanitarian emergencies that is, it can take place alongside mine action which is in support of development. Mine action for internal security is largely focused on supporting the operational mandates of national and international forces to restore internal security. Mine action for reconstruction is focused on rebuilding key infrastructure and often based on clear priorities set by international organisations (rather than the government). Mine action for development is focused on supporting new investments and based on more varied demands from a range of diverse groups. Government ownership in this process is crucial! Mine action, in particular mine clearance, is expensive compared to other development investments. However, it is a sound investment given the benefits derived in the form of improved community safety, development opportunities and enhanced sustainability of development investments. Bilateral and multilateral donors increasingly recognise

that mine contamination is a development issue in many mine-affected countries and development partners are funding to implement integrated mine action and development programmes.

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Solving the Problem of Cluster Munitions on the Territory of the Republic of Serbia

Branislav Jovanović¹⁴

Abstract

As result of conflict from Balkan wars till air raids in 1999, Serbia affected with big diversity risk from mine and ERW on her territory. Exactly definition of SHA and CHA is one of main task of Serbian MAC together with QA/QC. Method of definition SHA and CHA on minefield is already developed in the region and acceptable on problems in Serbia, but problem with cluster munitions (CM) and other ERW are specific and SMAC must developed some modification of already know approach. Because density and high risk SMAC put priority on area with unexploded cluster munitions. After preliminary date from NPA Survey (2008) Serbia start clearance activity with 30.7 mil sqm in 16 municipality, in this moment Serbia have 6,5 mil sqm SHA in 7 municipality. SMAC focus with challenge how to find right tool for cost effective approach for definition of SHA/CHA. Article focus on experience of SMAC and some thoughts of how to solve the problem of definition CHA/SHA.

Introduction

As result of conflict from Balkan wars till air raids in 1999, Serbia affected with big diversity risk from mine and ERW on her territory. SMAC define problem in several group of risk:

1. AP/AT Mine (minefield and group of mines)
2. Unexploded cluster munitions (CM)
3. Other ERW (UXO and AXO without CM)
4. UW ERW (underwater clearance)

At the moment Republic of Serbia faced with problem of 6.0 million sqm SHA of unexploded CM, 2 million sqm SHA and 1.3 million sqm of CHA of group of mines, more of 12 location UW ERW (mainly from 1999 raids) and more of 150 suspicion location with Air Drop Weapons (ADW) mainly from 1999 raids. Very often risk on same location is multilayer. Solving one problem in upper layer of the ground is not guaranty that risk don't exist in lower layers. Certificate of clearance according some criteria are

necessary but some time gives a false sense of security to the local population, because of that SMAC put lot of effort to educate local community in this sense.

In period from establish till now most clearance operations supported by international community and donors mainly via ITF Enhancing Human Security (ITF) or independently. Main donors in Republic of Serbia are EU, USA, Russian federation, Kingdom of Norway, Czech Republic, Republic of Ireland and Kingdom of Spain.

Problem of unexploded cluster bombs in Republic of Serbia

SMAC from beginning recognized unexploded CM like one of main priority. In first years focus on high risk location without general approach. This method was due to a very small number of employees just 6 employee. From the first project main challenge was definitions borders of SHA/CHA and appropriate QA/QC. In period 2007/2008 Norwegian People Aid (NPA) conduct General Survey with result of 30.7 mil sqm of SHA in 16 municipality. What is even more important, this project define base line for unexploded cluster munitions. From early begging, finding correct foot print was main challenge.

Problem of definition right footprint and CHA

1. Characteristic of weapons (number of sub-munitions, construction etc)
2. Tactic and moment of use (altitude, direction of attack, weather in the moment of attack, multiple attack on the target)
3. Morphology of ground (mud, rock, send, etc)
4. Geographic specification (Relief, river, lake etc)
5. Emergency Surface clearance operations (without useful report)
6. Weather (Rain, snow, sun)
7. Subjectivity eyewitness

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Figure 1. Process approach-2008/2012

Main challenge in this approach are definition right project area with great falls. SMAC and NPA together analyze result of clearance (2008-2013), it has been concluded that NTS and clearance only, do not enable optimal use of available resources.

Only 20-30% from total clear area are really finding unexploded cluster munitions.

NPA developed the SOP for technical survey, which were adopted by SMAC. This SOP base on clearance result in Republic of Serbia. Main goal how to better use existing capacity.

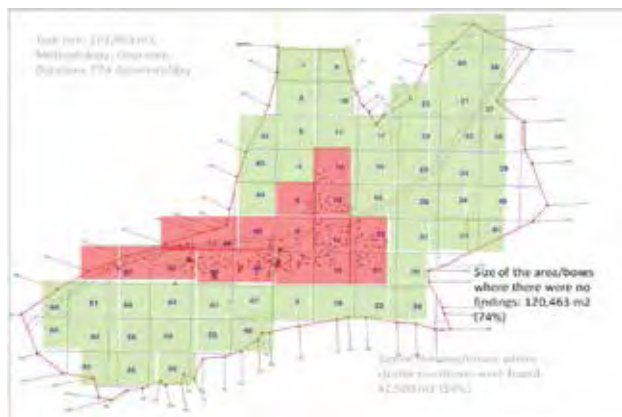


Figure 2 . NPA -SOP for technical survey²⁵

Some of the risks in the previous approaches:

1. Possible “fly over” (due weather situation in the moment of attack)

2. Multifaceted (multilayer) risk
3. Morphology of ground (mud, rock, sand, etc)
4. Geographic specification
5. Subjective fails of surveyor

SMAC on some BAC project face with problem of multifaceted risk. SMAC according available information assess risk and developed projects. Due clearance operation demining organization find ERW was from WWII (German SD50 and SD250 bomb) on great depth (around 1m). This problem is pointed out to suspect that in some cases it may also occur multilayer risk on same location.

Quality assurance and Quality control

SMAC following definitions of IMAS recommendations of QA/QC:

Quality Assurance (QA), part of QM focused on providing confidence that quality requirements will be fulfilled.

Quality Control (QC), part of QM focused on fulfilling quality requirements.

SMAC recognize following process:

- **Internal Quality Control:** Sampling of cleared areas, performed on a daily basis within the internal staff.
- **External Quality Control:** Sampling conducted during an external quality assurance visit by an SMAC QC team. Every time recorded in form of report.
- **Post-clearance Inspection:** Sampling by an external body once, a site has been completed, during final inspection of SMAC team

Presence IQC officers on daily bases is very important for QA/QC and show good result due operations of clearance. IQC officer on every day perform QC on minimum 5% of cleared area.

Some reflection on future direction of reduction SHA/CHA

Because of all risk in definition of SHA/CHA and in same project possible multilayer risk SMAC developing one more optional tool for better definitions SHA/CHA- *Technical Survey with non intrusive survey system.*

²⁵ Vanja Sikirica NPA Serbia Programme Manager, Presentation “NPA SERBIA Cluster Munitions Problem”, NPA regional workshop, October 2013.



Figure 3. Preliminary process approach

Non intrusive system is used for the detection of buried ferrous objects and explosive ordnance contamination. Systems are also available to generate high resolution, sub-surface data, which may be used to interpret underground conditions for the location of possible areas of archaeological interest or burial/disposal pits. This system can enabled maximum reduction, just on area with anomalies depended of depth of the object.

SMAC team perform test close to SHA “Sjenica” airport (without entering in SHA). SMAC team during the test use Sensys SBL-10 with DLM 98 data logger, data analysis was performed with MAGNETO®

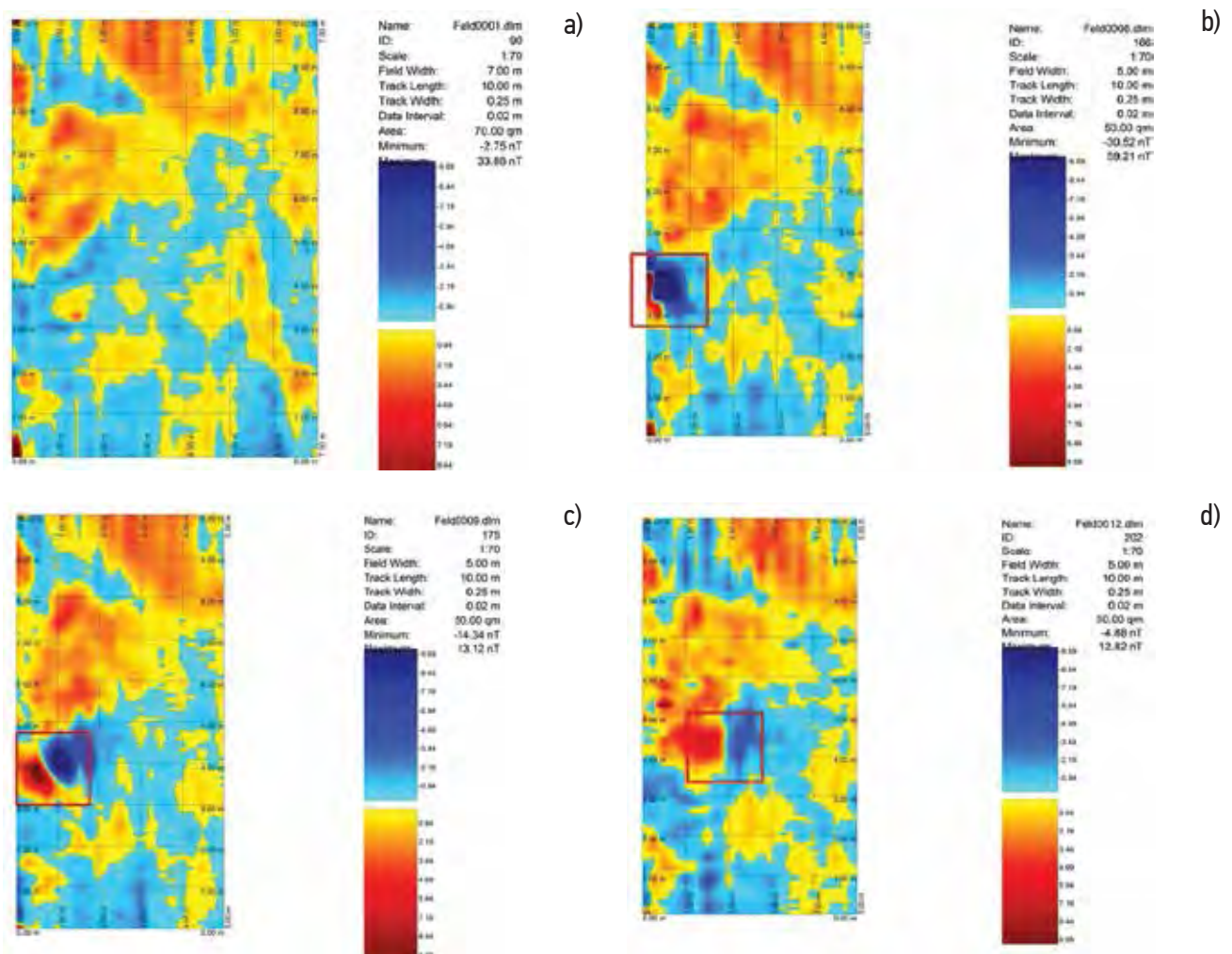


Figure 4 a) start field with normal ground noise; b) metal object weight 240gr on 25cm depth; c) metal object weight on 240gr on 50cm; d) metal object weight 240gr on 75 cm

Result show possibility to discover ferromagnetic object mass of 240gr min on 75 cm. Also one of advantage of this approach are date interpretations possible to QA/QC from RAW to final date.

This method is possible to use in post-clearance inspection and in some special case increase QC on 100% without significant increasing capacity of QC team.

Of course method have some limitations:

- highly magnetized ground
- significant concentration of metal crap
- railway track
- urban area
- etc

This process approach are still in preliminary phase, and at this moment is not enough tested, but we think it has the potential for further research. In period 2014-2015 SMAC plan is to test this approach in SHA just in area with very low and low risk.

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A New Concept in Defining Risk Area and Land Release

Branislav Krljaš¹⁶

Bosnia and Herzegovina is a country with the most negative consequences of the breakup of the former Yugoslavia and the war in the four-year period. The problem of mines is one of the key problems whose impact blocks a range of social and life processes.

History of the war is quite complex and that confirms the fact that in the war were involved six belligerents in different time periods. Mines and explosive devices were massively used on almost the entire territory of Bosnia and Herzegovina. During the war, confrontation lines were often moved without any written documents or operational maps.

After the war, mass migration of the population were going on and all of that together contributed to the fact that the original documents and reliable informants become unavailable.

Common to all the above, as well as general social processes in BiH, is the confidence building that will provide the quality of decisions made. This is exactly what was crucial in defining the new concept that tries to develop a new approach in defining suspected hazard areas and land release of such areas: to make a decision based on reliable and verified information.

In the previous period, Bosnia and Herzegovina and BHMAL made a maximum effort to clear the country of mines and to reduce the mine risk to the lowest possible level.

Around 7,000 of registered mine victims, 47 killed deminers and 69 deminers with minor and serious injuries, and effects achieved through mine action that does not follow the set objectives were clear signal that some changes are necessary in approach and solving the problem of defining and land release of suspected hazard areas.

The new concept is based primarily on the large experience of previously implemented projects in Bosnia and Herzegovina, the evaluation of its own procedures but also the experience of operational staff of BHMAL.

Objectives set:

- GENERAL - contribution to the fulfillment of Bosnia and Herzegovina obligations regarding the Ottawa Convention and the establishment of a permanent strategic progress of mine action in Bosnia and Herzegovina, and

- SPECIFIC - Reduction of suspected hazard area in Bosnia and Herzegovina which will allow the return of the population in cleared areas, increase the safety of the residents from mines and unexploded ordnance (UXO) and reduce the number of mine victims thus creating the prerequisites for sustainable socio-economic development in the cleared areas.

Implementation of the new concept and the project has been enabled by support of the European Union through the IPA program of support to BiH which provided funding for BHMAL.

The project is being implemented in the region of the four regional offices of BHMAL, while the other four offices also went through a process of training and they are indirectly involved in the project.

In preparing the implementation, there were processed 21 suspected hazard areas in 70 communities and 23 municipalities.

Implementation of the project is divided into four phases.

In the first phase, the key decision was the selection of SHAs (suspected hazard areas) and a detailed analysis of available information. A new approach to analytical and graphical data processing primarily aims to provide a high-quality evidence to make decisions to follow and relaxes the decision-making process. The primary task of the analytical and graphical data processing is interconnection of mine indicators by place, time, participants, causes and consequences.

In the second phase, it is planned mine survey that primarily aims to verify and confirm the results of analytical data processing and provide more reliable information for SHAs, which are integrated into already adopted system. The result of the second phase is the decision on the selection of project objectives and the development of operational plans which together make a study of SHAs.

The third phase involves the operations, monitoring,

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quality control and verification. At this phase, BHMAL will engage its most experienced and most professional operational staff.

In the fourth phase, it will be carried out detailed evaluation of the project based on input and output parameters. Results of the evaluation will be crucial for the process of amending the existing and defining new procedures as well as for the second revision of the Mine Action Strategy in Bosnia and Herzegovina.

Results of the first phase are quite encouraging. The initial request for surveying of 100 km² of SHAs seemed too optimistic since BHMAL has a number of other constant

obligations of the tasks. The plan is not only fulfilled but exceeded for 6.08 km². Very brave decisions were made in evaluating the possible reduction of SHAs and it was to 64.16 %. The evaluation was made based on the analysis and connecting more than 2,739 of mine records with 291 projects of General Survey, with 208 of realized mine actions, with 46 reports on mine accidents and incidents and 116 estimated reliable informants.

In the final outcome, BHMAL expects from this project to become a milestone for the accelerated process of land release in Bosnia and Herzegovina and for making that land available to its final users and citizens of Bosnia and Herzegovina.

Plans and Activities Related to Obligations of the States Parties to the Convention on Cluster Munitions - Norwegian People's Aid and Regional Cooperation in Southeast Europe

Darvin Lisica¹⁷

Introduction

Releasing land contaminated by cluster munition remnants, as well as destruction of stockpiles of cluster munitions, are challenges most countries in Southeast Europe are faced with. The obligations of the States Parties to the Convention on Cluster Munitions (CCM) regarding survey and clearance of affected areas are clearly stated in the CCM.

The States Parties have eight years to finalize the destruction of all cluster munitions held by each State Party, according to CCM, Art. 3. Also, the States Parties have an obligation to survey, and that includes recording and mapping data of areas contaminated with cluster munitions as defined in the CCM para. 2.a. The States Parties obligations regarding clearance of contaminated areas are regulated in the CCM, Article 4, para.1, where the States 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 the States Parties are straightforward regarding survey and clearance, the solutions are not quite so. NPA has conducted three country-wide nontechnical surveys in Southeast Europe, in co-operation with relevant authorities in Serbia (2008), Bosnia and Herzegovina (2011) and Montenegro (2013). During non-technical survey, contaminated areas are mapped and a baseline is established for the reduction and release of contaminated areas for safe and productive use. Non-technical survey activities thus 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 for clearance, technical survey and marking/risk education. Efficient and effective clearance operations depend on the quality of data provided during survey.

Norwegian People's Aid efforts related to implementation of the Convention on Cluster Munition Remnants in Southeast Europe

Serbia. Since November 2007 the Norwegian People's Aid is implementing non-technical survey of areas suspected to be contaminated with unexploded cluster sub-munitions in the Republic of Serbia, in cooperation with the Serbian Mine Action Center. NPA started in December 2010, a three year project to clear all unexploded cluster sub-munitions from the municipalities of Bujanovac, Preševo and Kuršumlija. To date, NPA has cleared 2.5 km² and disposed of 859 pieces of unexploded cluster sub-munitions of the types BL 755 MKI and BLU 97A/B. In addition 706 other pieces of explosive remnants of war have been found and disposed of. Through non-technical survey a total of 2.4 km² has been released in municipalities of Bujanovac, Preševo and Kuršumlija.

Bosnia and Herzegovina. In the period of January - June 2011 the Norwegian People's Aid completed first phase of the non-technical survey of areas contaminated with cluster munition remnants (identification of suspected areas), in coordination with BHMAC. In 2012, NPA started with technical survey and cluster clearance of cluster contaminated areas in affected communities in Bosnia and Herzegovina. Until the end of June 2013 NPA released a total of 1.32 km² of cluster contaminated areas through technical survey and cluster clearance activities, and 1.98 km² through non-technical survey activities in 17 affected communities in Bosnia and Herzegovina. During operations NPA found and destroyed 536 pcs of unexploded sub-munitions type KB-1 from cluster munition R-262 rockets Orkan M87 and Mk-1 from cluster munition BL 755.

Montenegro. In mid-2012, the Norwegian People's Aid started a “Completion Initiative” related to cluster munitions problem in Montenegro. The Norwegian People's Aid and the Regional Centre for Divers Training and Underwater Demining completed the first phase of the non-technical survey in May 2013, creating a baseline for land release of suspected hazardous areas. In the period of December 2012-May 2013, NPA implemented capacity building of RCUD non-technical survey capacities. In the period of

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2nd December – 13th December 2013, NPA implemented capacity building of RCUD for quality monitoring.

Macedonia. NPA completed destruction of the stockpiles of cluster munitions in Macedonia by the end of October 2013, in co-operation with Macedonian Ministry of Defence.

Messages from Regional workshop on how to solve the problem of cluster munition remnants and stockpiles in Southeast Europe

A Regional workshop on how to solve the problem of cluster munition remnants and stockpiles in Southeast Europe, organized by the Norwegian People's Aid (NPA), was held in the period from 8th to 10th October 2013. The workshop was dedicated to the experiences of the countries of Southeast Europe and the Norwegian People's Aid in fulfilling the obligations under Convention on Cluster Munitions (CCM) with a focus on survey and release of contaminated areas, and on stockpile destruction. Participants of the Workshop were:

1. Representatives of national authorities responsible for mine action: Demining Commission in Bosnia and Herzegovina, Bosnia and Herzegovina Mine Action Centre (BHMIC), Regional Centre for Underwater Demining from Montenegro (RCUD), Croatian Mine Action Centre (CROMAC) and Kosovo Mine Action Centre (KMAC);
2. Representatives of organizations involved in mine action: Geneva International Centre for Humanitarian Demining (GICHD); Centre for Testing, Development and Training from Croatia (HCR-CTRO), Mine Detection Dog Centre in Bosnia and Herzegovina (MDDC) and Demining Battalion of the Armed Forces of Bosnia and Herzegovina;
3. Representatives of international organizations and embassies: United Nations Development Programme, Embassy of the Kingdom of Norway in Bosnia and Herzegovina, Embassy of Switzerland, Embassy of the Federal Republic of Germany, Embassy of the United States of America, Embassy of Canada in Hungary and Embassy of Belgium in Serbia;
4. Representatives of NPA: Regional office for South-East Europe; Mine Action Programme in Serbia, Mine Action Programme in Bosnia and Herzegovina and Global Training Centre for Mine Detection Dogs (NPA GTC).

Generally, the workshop participants agreed to continue with the exchange of experiences related to non-technical

survey, technical survey and clearance in Southeast Europe. During the three-day Workshop, eight thematic sessions were held and visits were organized to the Norwegian People's Aid Global Training Center. Through discussions during the sessions, a series of conclusions were reached of political, strategic and operational nature, grouped by subject and presented below:

1. The fulfilment of the provisions of the Convention on Cluster Munitions

- 1.1. The Norwegian People's Aid in cooperation with Bosnia and Herzegovina launched an initiative to finally resolve the problem of cluster munitions remnants in Bosnia and Herzegovina in the period of 2012-2015. The measures taken will contribute significantly to Bosnia and Herzegovina to become free from cluster munitions well before the deadline specified by the Convention on Cluster Munitions. This initiative and the practice should be followed by other countries in southeast Europe.
- 1.2. The Norwegian People's Aid in cooperation with the Regional Center for Underwater Demining launched an initiative to finally resolve the problem of cluster munitions in Montenegro in 2014. The results of non-technical survey show that Montenegro can become free from cluster munitions much well before the dates specified in the Convention on Cluster Munitions.
- 1.3. It is recommended that the Mine Action Centre Kosovo publishes, as soon as possible, the Mine Action Strategy and the modus of its implementation. It should be a starting point for communication with organizations and donors who could help Kosovo to complete the resolution of the problem of cluster munitions contamination. Kosovo should be a part of an initiative to finally resolve the problem of cluster munitions in Southeast Europe.
- 1.4. The remaining area contaminated with cluster munitions is of limited size and Croatia could become part of the initiative to finally solve the problem of cluster munitions remnants well before the deadline stipulated in the Convention on Cluster Munitions. A part of this initiative should be the destruction of cluster munitions under the jurisdiction of the Croatian Ministry of Defence.

2. The concept of land release applied to areas contaminated with cluster munitions remnants

- 2.1. Integrated process of non-technical survey, technical survey and clearance, which is applied in Bosnia and Herzegovina, has proven to be effective for land release of areas contaminated with cluster munitions remnants.
- 2.2. In Serbia, conducting of technical survey is regulated by the Decree of the Government of Serbia from August 2013, however, it has not been performed still. It should be recommended to Serbia to conduct technical survey as soon as possible, i.e., to introduce an integrated process of land release which includes non-technical survey, technical survey and clearance. This will allow more efficient use of available human and technical resources, and the process of returning land to safe use will be accelerated by the much lower financial resources and greater confidence in the quality of operational performance.
- 2.3. Adoption of national procedures for non-technical survey, technical survey, mine clearance and battle area clearance in order to return the land to be used safely in Serbia would facilitate planning, management, implementation and processes of control of mine action to relevant agencies and contractors.
- 2.4. The Norwegian People's Aid has developed standard operational procedures for release of areas contaminated with cluster munitions in Montenegro.
- 2.5. Development and improvement of standard operational procedures for land release contaminated with cluster munitions remnants, including the transfer of knowledge and experience in non-technical survey, technical survey and clearance of the area, in which the Croatian Mine Action Centre and Norwegian People's Aid may establish cooperation. This cooperation can enable more efficient fulfilment of Croatian obligations undertaken by the Convention on Cluster Munitions.
- 2.6. Given the nature of the problem with cluster munitions, that is significantly different from the problem which pose anti-personnel mines, we should reconsider the prohibition of entry into the suspicious area during the non-technical survey

and moving of contractors for technical survey and clearance within the boundaries of the task. The current prohibition restricts data collection and risk assessment.

3. Capacity building

- 3.1. The Norwegian People's Aid, in cooperation with Bosnia and Herzegovina Mine Action Centre, conducted a series of training for technical survey and clearance of sites contaminated with cluster munitions remnants, both governmental as well as non-governmental organizations in Bosnia and Herzegovina, it is necessary to continue with the involvement of other organizations in the process of technical survey and clearance
- 3.2. The Norwegian People's Aid should continue to support the Demining Battalion of the Armed Forces of Bosnia and Herzegovina, especially in professional training and equipping for activities of land release of the land contaminated with cluster munitions remnants.
- 3.3. Montenegro does not have its own resources for technical survey and clearance. It is necessary to inform possible donors about the size of the problem and the possibilities for its efficient and short-term resolution.
- 3.4. The Norwegian People's Aid in Southeast Europe has management, human and material resources for the operations for releasing of areas contaminated with cluster munitions in Montenegro.

4. Targeted technical survey

- 4.1. Targeted technical survey should allow for the identification of hazardous areas through the collection of additional data that will confirm or reject the suspicions of contamination of areas with cluster munitions. It is an activity that will enable a more efficient process of land release.
- 4.2. Simultaneously, necessary changes should be considered in processes of non-technical survey, technical survey and systematic technical survey and clearance, which are necessary for efficient incorporation of targeted technical survey into land release system.
- 4.3. It is necessary to undertake activities on the development of methods and procedures for the

application of targeted technical survey and to begin, as soon as possible, the application of this method in the process of land release contaminated areas.

- 4.4. Targeted technical survey should be introduced to identify the fingerprints of suspect areas, when it is not possible to identify evidence point through non-technical survey.
- 4.5. In the process of sampling for final confirmation of the quality of technically surveyed and cleared surfaces, targeted sampling and random sampling should equally apply.
- 4.6. Technical survey at least 50m around the cleared area effectively defines the boundaries of fingerprint.
- 4.7. It is necessary to accelerate the development of the process and standard operational procedures for targeted technical survey, so that targeted technical survey should enter into operative use no later than 2015.

5. Use of dogs in targeted technical survey

- 5.1. NPA has special detection dogs, which are currently preparing to work on a pilot project of targeted technical survey in Bosnia and Herzegovina. Similar pilot projects should be done in other affected Southeast Europe countries.
- 5.2. The intention of The People's Aid is to encourage the standardization of the use of dogs in targeted technical survey. Therefore it is necessary to include the Geneva International Centre for Humanitarian Demining and the Bosnia and Herzegovina Mine Action centre in order to standardize the process.
- 5.3. The NPA practice in other countries, and training with dogs in the Global Training Center for training dogs for explosives detection, confirmed the efficient use of dogs for detection of non-exploded cluster submunitions. The operational use of dogs in technical survey and clearance of areas contaminated with cluster munitions remnants in Southeast Europe should accelerate.

6. Hazard identification from cluster munition remnants

- 6.1. On clearance projects on which the Norwegian People's Aid worked in Serbia, the area for clearance after last discovery is 100 meters. Usually it was 50 meters, and it is recommended to use 50 meters also in Serbia.
- 6.2. It was determined that there is a great difference in size between the confirmed hazardous areas on which clearance tasks are designed for and cleared areas on which cluster munitions were really found. This is another confirmation of the necessity to introduce technical survey in Serbia.
- 6.3. BHMAC introduced the concept of evidence points that defines through non-technical survey, resulting in a higher efficiency of the process of technical survey and clearance.
- 6.4. If we fail to collect information on “direct evidence” or “evidence point” in the phase of non-technical survey, a lot more resources than necessary are consumed in the technical treatment of hazardous areas.
- 6.5. Request for identification of evidence points, respectively, immediate evidence of the existence of non-exploded cluster sub-munitions was proved as correct. It helped to improve the definition of confirmed hazardous areas for technical survey and clearance.

7. Cluster munitions stockpiles destruction

- 7.1. The cluster munitions stockpiles destruction remains a priority of initiative to finally solve the problem of cluster munitions remnants in Southeast Europe. It is not time consuming as clearance of areas contaminated with cluster munition remnants, but requires significant resources for cluster munitions stockpiles destruction.
- 7.2. The problem of stockpile destruction should be promoted on the level of regional cooperation, particularly through regional mechanisms for disarmament and destruction of surplus weapons.
- 7.3. The partnership between ministries of defence and non-governmental organizations on projects of destruction such as “SHADOW” (Self-Help Ammunition Destruction Options Worldwide),

an NPA project which provides expert assistance to poor countries that need support in destroying their stockpiles. SHADOW enables efficiency and transparency, in compliance with environmental, safety and other standards. Financial participation of affected countries in destruction of cluster munitions stockpiles is desirable, thus ensuring additional support from donors.

The main objectives of the Workshop had been achieved, expertise had been shared and the potential for future collaborations, coordination and cooperation between the Norwegian People's Aid and Mine Action Centres in the region had been discussed and explored. The Workshop thematically covered the latest developments in the implementation of the Convention on Cluster Munitions and gave the opportunity to Southeast Europe countries to present their achievement and exchange experiences regarding the fulfilment of obligations under the Convention on Cluster Munitions.

Southeast Europe free from cluster munitions through regional co-operation

National authorities have shown political initiative as well as their will to meet the obligations from the CCM in Southeast Europe. This political will, as well as initiative, should be transformed to strategies aiming at releasing contaminated land and destroying stockpiles of cluster munitions.

Two countries in Southeast Europe: Croatia (State Party of CCM) and Serbia (not State Party of CCM) have not finalized the destruction of all cluster munitions stockpiles according to CCM, Art. 3.

Bosnia and Herzegovina, Croatia, Montenegro, Kosovo and Serbia still have obligations regarding clearance of contaminated areas as regulated in the CCM, Article 4. This problem could be solved in efficient way through the process entitled the “Completion Initiative“, thus enabling the States Parties and non States Parties to fulfil clearance obligations under Article 4 of the CCM.

The aim should be no less than a region free from cluster munitions. This initiative will improve the security of citizens and increase the level of trust between the countries in the region. However, to achieve this goal, we must ensure that experience in the field of survey and clearance is shared between the countries, so that the

problem can be solved within a reasonable time-frame and at a reasonable cost.

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White Paper: TIRAMISU Information management system. 1.0

*Björn Liska*¹⁸



Toolbox Implementation for Removal
of Anti-personnel Mines, Submunitions and Uxo



White Paper

The mine action community needs integrated tools and standards

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Project Acronym	TIRAMISU
Project title	Toolbox Implementation for Removal of Anti-Personnel Mines, Submunitions and UXO
Funding Scheme	Collaborative Project
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Project Coordinator	Royal Military Academy (RMA)
Date of Paper	March 23, 2014
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Dissemination Level	PU

1) This information is further elucidated in section 1.4

* Please indicate the dissemination level using one of the following codes:

PU = Public,

PP = Restricted to other programme participants (including the Commission Services).

RE = Restricted to a group specified by the consortium (including the Commission Services).

CO = Confidential, only for members of the consortium (including the Commission Services).

Dissemination list:

Participants of the 11th HUDEM symposium – Zadar (Croatia)

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1. SCOPE

1.1 Identification

This document is a written compilation of the presentation made by members of the TIRAMISU Integration Work Package 522. It describes the main arguments for why the mine action community needs integrated tools and standards where one example is the **TIRAMISU Information Management System (T-IMS)**, a field data collection tool developed within the TIRAMISU consortium.

1.2 Time and place for the presentation

This is the second time that T-IMS is presented at the HUDEM symposium.

Place: Zadar (Croatia)

Event: 11th HUDEM Symposium

Date: April 23-25, 2014

1.3 Abstract

The mine action community needs integrated tools and standards

Mines and unexploded ordnance all over the world are still taking its toll as lifelong suffering or death. It strikes blindly and effect innocent civilians.

The European Union has, by the Project TIRAMISU, taken on the task to boost clearing of the deadly legacy left in countries plagued by war. One (cost-) effective and safe solution is the TIRAMISU Information Management System (T-IMS). It combines easy-to-use computer software and some of the standards developed by Geneva International Centre for Humanitarian Demining (GICHD). It will also fully integrate with the TIRAMISU Repository Service (TRS), also presented during the conference. T-IMS is mature for demonstrations now and fully operational late 2015.

1.4 White Paper produced by

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2. PRESENTATION



Brief presenter biography

Björn was until year 2000 colonel in the Swedish Armed Forces and Project Manager for the "original"/military version of today's system. Björn is overall responsible for integration within the TIRAMISU Project where T-IMS is one part of the deliveries.

AGENDA



1. Standards
2. Integration
3. Information Management
4. TIRAMISU Info. Mngmnt System
5. What is it good for...?



The agenda speaks for itself.



1. STANDARDS



What is “standards” ...?

- What was the first “things” to be standardised?
- Mass, length, time, temperature, energy, light, pressure
- So “natural” we don’t even think of them as standards
- Position, communication, substances, production, quality
- Definition of “standards”:



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“Standards” is explained on slide 3 - 5.

1. STANDARDS



Definition of “standards”

A standard is a **norm** that applies to **all aspects of one thing**. Standards are **documented knowledge** from **prominent players** in the industry, business and society. Standards are everything from toys, helmets, envelope sizes and surgical implants to environmental and quality management systems for businesses and organisations.

Standards are aimed to **improved safety**, **increased trade**, **reduced costs**, **improved working conditions** and environmental and consumer protection.



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1. STANDARDS



Great Boston fire 1872



Fire hydrant couplings were not standardised



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The Great Boston Fire of 1872 ranks as one of the most costly fire-related property losses in USA history.

One of the major causes to the disaster was:

The Mayor of Boston called in help from nearby cities but of no use – **fire hydrant couplings were not standardized.**

2. INTEGRATION



Definition of “integration”...?

Compilation of **different** parts to get a more complex **whole**.



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Rather simple explanation of a complex activity. “Integration” is explained on slide 6 - 7.



2. INTEGRATION



What would we like to integrate...?

- Positions (with or without maps)
- Ordnance data
- Satellite and aerial imagery
- Reports
- Communication

~~• Sensor signals~~

...but then again “yes”!

Our Project is developing an integration Demonstrator named **TIRAMISU Repository Service (TRS)**. Presented later...



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The integration of Humanitarian demining information should not that complex. See slide above. Sensor signals are not integrated in T-IMS but will be a part of TRS integration.

3. INFORMATION MANAGEMENT



Definition of “information management”

The **collection and management** of information from **one or more sources** and the **distribution** of that information to **one or more audiences**.

This sometimes involves those who have a stake in, or a right to that information. Management means the organisation of and control over the planning, structure and organisation, controlling, processing, evaluating and reporting of information activities in order to meet client objectives and to enable corporate functions in the delivery of information.



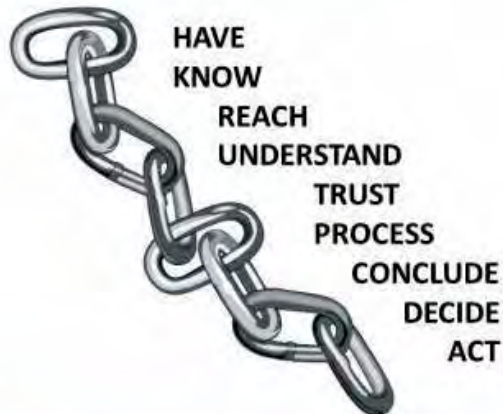
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8

“Information management” is explained on slide 8 - 9.



3. INFORMATION MANAGEMENT



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“Information economy” is how well one can manage the whole chain of information, from **having** the information to be able to **act** on it. If one part is missing in the chain, the information management will sooner or later not work.

AGENDA



1. Standards
2. Integration
3. Information Management
4. TIRAMISU Info Mngmnt System
5. What is it good for...?



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Now “Standards”, “Integration” and “Information Management” will be joined in T-IMS.



4. T-IMS



T-IMS will handle...

- maXML (communication standard by GICHD)
- CORD (ordnance database by GICHD and SPINATOR)
- Standardised interface for use of “any” GIS-engine
- Standardised positioning (OGC compliant)
- “Map symbols” for Mine Action
- Non-Technical Survey, Technical Survey and Clearance
- Comm. interface with TIRAMISU Repository Service (TRS)
- Any digital attachment (photo, video, doc etc.)



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These are the most important standards that T-IMS will handle.

4. T-IMS “SCENARIO”



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Slide 12 - 17 describe one (simplified) scenario where T-IMS would support the Mine Action community from “A - Z”.

TIRAMISU Information Management System (T-IMS) supports all Field Data Collection within the scope of Humanitarian Demining, from Non-Technical Survey to Clearance operations.

T-IMS may (as shown on this picture) be used to define areas for tasking Non-Technical Survey Teams.

4. T-IMS “SCENARIO”



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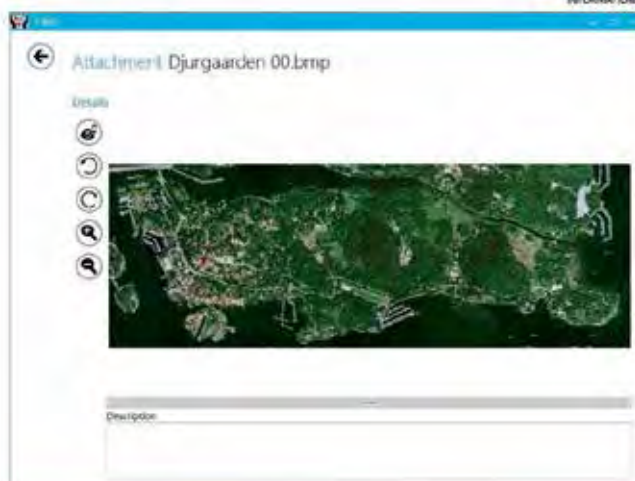
13

T-IMS has built in report forms and can carry any digital attachment.

This T-IMS report is a “response” from a remote sensing unit that was tasked to make high-resolution photos over an area where defence positions where suspected etc.

The map shows the area that was supposed to be photographed.

4. T-IMS “SCENARIO”



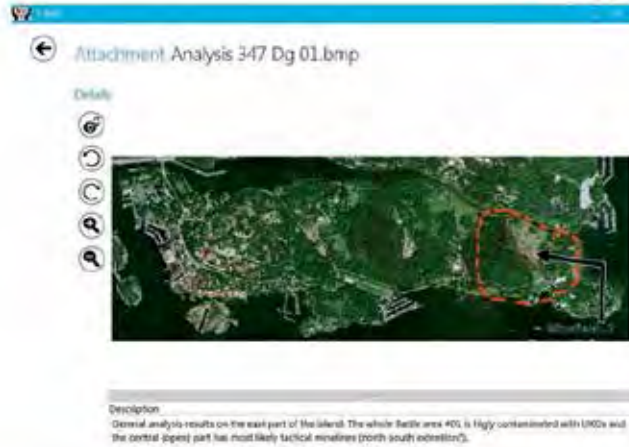
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The report mentioned above carried a 350 MB photo, here shown as an attachment in T-IMS.



4. T-IMS “SCENARIO”



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The aerial photo was analysed by specialists. They could clearly identify evidence that there were combat activities around some previously suspected defence positions.

These findings are marked by the analysis group on a copy of the aerial photo that they analysed.

The same T-IMS report carried a 14 page document (standard Word for Windows doc) that, in detail, described what could be found within “Battle Area#01” (document not presented here).

4. T-IMS “SCENARIO”



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Based on the analysis report a close-in detection unit was sent to the area.

After 14 days of work this is what they came up with.

All geo-objects are generated from the T-IMS ordnance database and all objects are positioned and registered with a max. error of one metre.



4. T-IMS “SCENARIO”



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It is important to understand that many areas will be contaminated/affected as the one reported on slide 16. Still... looking on the initial area, the examined are (- the red box) is only a fragment of the Non-Technical Survey mission. This give a hint regarding how much effort/manpower, time and data is needed to fulfil a complete mission (the map on slide 17 is only approx. 18 km from north to south).

5. WHAT IS IT GOOD FOR...?



- Gather as many Mine Action de facto-/standards as possible
- Support the field operator from day one
- Integrated with TRS – large amount of data over long time
- Direct communication with IMSMA (...any maXML system)
- Is (very) easy to use...

Welcome to a hands-on demo
at the TIRAMISU booth...!

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The last slide summarizes the most important advantages with T-IMS. The system is so mature that it will be demonstrated by letting people, interested in the system, test/handle the system themselves.

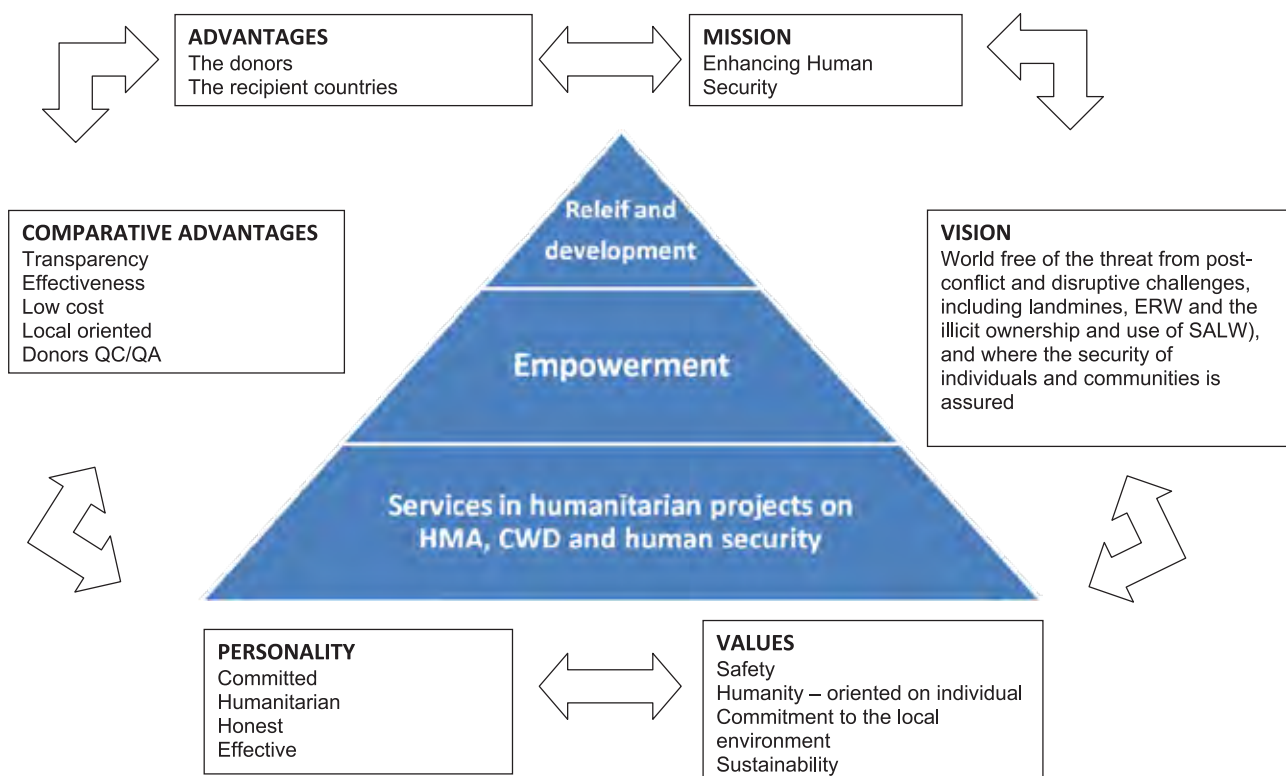
The Transition From Humanitarian Demining To Human Security Projects – Threat Or Opportunity

Dorijan Maršić¹⁹

The beginning of humanitarian mine action programs in South Eastern Europe (SEE) more than fifteen years ago was groundbreaking in its own way and was instigated with the right approach by all humanitarian action stakeholders: mine-contaminated states, international and nongovernmental organizations, donor community, academia, private entrepreneurship, local communities and other actors. Since then, outstanding results have been accomplished: exceptional mine action programs and national and regional capabilities established, expertise, standing operating procedures and standards developed and the most important as the final result: millions of square meters of mine suspected land released, communities saved from the threat of explosive remnants of war, thousands of survivors rehabilitated, hundreds of different MRE and MRE programs developed and attended by hundreds of thousands of members of local communities.

The situation after 15 years of intensive execution of humanitarian mine action programs caused several effects:

- Countries declared mine safe or with minimum suspected areas
- The decrease of number of high impacted population with mine affected areas
- Development of capabilities from the technical and human point of view
- Lack of funding from the national budgets
- Decreased interest from the international and local donor community to fund HMA projects stressing due to new emerging world crisis



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Most of the governments but nongovernmental and commercial organizations, as well, found themselves in a position with surpluses of their capabilities whether that be well trained personnel or equipment without the possibility to engage them locally. Some of them strategically predicted this perspective and tried to find opportunities out of the original country or region. An example of systematically organized approach to expand out of the national boundaries in the region is the Cluster for Humanitarian demining Ltd. Established by Croatia, as they claim “to express our readiness for possible business-technical co-operation in organisation, conducting and monitoring in the field of mine action system”. On the other hand especially local commercial companies merged or even ceased to work cause of the lack of business opportunity and strong competition. Some international organizations declared their exit strategies and announced the end of operations. A number of organizations started new programs in the field of HMA in other countries or in other fields of work out of HMA.

This process is not limited on demining organizations only, but is faced by other organizations working in the field of mine victims assistance, risk education and risk awareness. Finding a solution to preserve this accumulated knowledge and resources should be a priority for national authorities.

The transition in a brother human security sector

Since the end of the Cold War, armed conflicts have increasingly taken place within, and not between, states. National security remains important, but in a world where war between states is becoming rare, the concept of human security is gaining importance. For some proponents of human security, the term is limited to threats from violence; for others the term is used to address a broader range of threats including hunger, disease, natural disasters and other disruptive challenges affecting individuals and communities. This strategy has adopted the broader concept of human security. Some countries have been strong supporters of policies, organizations, programs and international initiatives which strengthen human security (for example the Human Security Network). By definition, mine action, the control of Small Arms/Light Weapons (SALW) and other post-conflict work contribute to the goals of human security.

This need of addressing a broader range of global post-conflict and disruptive challenges which threaten the security of individuals and communities can be one of the main reasons with a proper vision, mission and goals these organizations can be expanded to areas beyond humanitarian demining such as conventional weapons destruction (CWD) projects and projects aimed at reduction of threats to human security. But this of course cannot be reached automatically and overnight but with a strategic vision, meticulous planning process, reeducation and reorganization.

The case of ITF – Enhancing Human Security (ITF)

As national authorities in SE Europe became more able to address their mine problem unaided, and as the socio-economic impact from landmines and unexploded ordnance (UXO) became less acute, there has been a reduced need for ITF assistance within the region. Indeed, this reduced assistance demonstrates the success of the ITF, mine-affected states, international organizations, donors, implementing organizations and civil society working together to achieve a common goal of substantially reducing the socio-economic impact of landmines and UXO in SEE.

ITF perceived a growing need to address other post-conflict and disruptive challenges, to support Security Sector Reform (SSR) and Disarmament, Demobilization and Reintegration (DDR) programs, and to combat violence and terrorism from the illicit ownership and use of SALW.

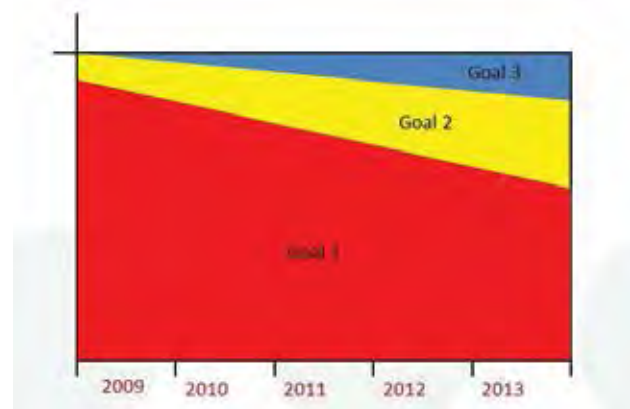


Chart 2: The distribution of implemented funds by strategic goal

By the adoption of the new strategy in 2009 ITF planned that there a decrease of funds dedicated to mine action (Strategic Goal 1) and the growth of funding for projects in CWD (Strategic Goal 2) and developing pilot projects on disruptive challenges towards human security. The Chart 1 shows that ITF has retained the average yearly funding. Nevertheless, the Chart 2 also shows that the distribution of the funds implemented for respective strategic goals changed in last four years. The decrease of funding implemented for HMA is a result of the completed missions in some countries in SEE (Albania, Macedonia, Montenegro) and lower interest for the donor community to fund HMA project in the region (Croatia, Serbia, Kosovo and BiH) due to new international focuses.

The comparison is showing that in the period from 2010-2013 ITF raised \$74,24 millions of which \$16,9 million have been implemented for the 2nd strategic goal and \$4.7 million for the 3rd strategic goal.

The transition to Conventional Weapons Destruction Programs

The transition of national stakeholders to new strategic goals can develop new expertise especially on trainings covering wide range of topics in consistent with UN International Ammunition Technical Guidelines (IATG), International Mine Action Standards (IMAS), national and international military standards, OSCE Handbook of Best Practice on Conventional Ammunition covering topics as Physical Security and Stockpile Management (PSSM) and non intentional (ammunition storage) explosive sites, post Unplanned Explosions at Munitions Sites (UEMS) cleaning operation of the area contaminated by UXO, warheads, ammunition engineering, demilitarization, standardization in accordance to NATO standards, ammunition maintenance marking and identification, risk assessment of ammunition operations, information system for ammunition management system, ammunition storage – operations and safety, international standards related to ammunition storage, ammunition surveillance tests and propellants stability, ammunition transportation etc. . A strong involvement of respective ministries for defense and arm forces is needed to develop such cooperation and transition.

There is a need of risk awareness and risk education or even victims assistance programs for the local population effected by UEMS which can be performed by organizations dedicated previously only for mine related issues (the case of Gerdec UEMS case in Albania).

Programs on Disruptive Challenges Towards Human Security

Local mine action dedicated organizations can contribute to increase human security through realizing joint strategies of protection – crafting institutions that protect and advance human security – and empowerment – using the experience and knowledge form their work in humanitarian mine action. This would create programs helping people to be able to act on their own behalf thus reducing threats, promoting human rights and active citizenship, social inclusion, health and wellbeing of vulnerable groups (disabled, children, and women), building of community resilience, and armed violence reduction and prevention projects, promoting supportive national and regional programs that enhance individual, community and national capacities and thereby ensure the sustainability of actions.

Towards an Acousto-Ultrasonic Landmine Detector

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Abstract

Close-in detection of buried and obscured landmines presents significant technical challenges. Current clearance efforts rely heavily on metal detection technology while more sophisticated GPR systems are slowly maturing and coming to market. A third method (acoustic or seismic) detection, which works on the basis that all landmines are manmade and therefore acoustically compliant objects. This means that they exhibit a resonance phenomenon in contrast with earth and clutter. Since the mechanical properties of mines are largely independent of the metal content or the electromagnetic properties of the soil, this method is adding an extra dimension to the minesweepers toolbox. This paper describes the mechanism behind acoustic landmine detection, illustrates the available vibration detection technologies and expands on the development of a simple, cost efficient and practical implementation using an ultrasonic detection method.

Keywords- acousto-ultrasonic detector, landmine, mine, acoustic, seismic, ultrasonic, ultrasound

Introduction

In spite of the advancement of technology it remains that the primary platform of close-in landmine detection is the metal detector (MD). In recent decades landmine construction has advanced to a stage where mines are either very low metal mines with only a metallic detonator spring, or even metal free landmines. Using metal detector technology to detect very low metal mines requires a very high resolution apparatus. In turn such apparatus detects every metal fragment, hence giving a high false alarm rate. Metal free landmines are invisible to MD technology. Ground penetrating radar (GPR) provides an excellent complement to MD and enables the detection of plastic/wooden landmines by identifying discontinuities in dielectric materials. However GPR is a complex solution, with extensive signal processing requirements and is only slowly becoming practical for use in the field [1]. Furthermore there are demining scenarios where GPR technology fails. Wet saline soil for example is completely opaque to electromagnetic waves.

Emerging systems combining GPR and MD technologies show promising results[2]. It is clear that MD and GPR are the forefront technologies. Nevertheless further solutions, using mutually exclusive detection mechanisms, are required to increase detection probability and reduce false alarm. Other innovative detection solutions being developed include electrical impedance tomography, X-ray backscattering, nuclear quadrupole resonance, chemical vapour detectors, hyperspectral methods and acoustic/seismic detection [3]. While each of these methods shows promises they are all still falling short of practical implementation in the field.

ACOUSTIC / SEISMIC LANDMINE DETECTION

While landmine construction material varies, there are mechanical properties which are shared. A landmine is an explosive container, most often a cylinder oriented in the vertical direction. The smooth flat surfaces of the landmine, and the regular shape make it an acoustically compliant object. That is to say it exhibits elastic properties under vibrations and at certain frequencies and conditions will resonate. The acoustic/seismic detection method works by exciting an acoustic wave directed towards the ground. Upon coupling to the ground a seismic wave in the vertical direction is created and this wave will excite the acoustically compliant object to a far greater extent than other objects (eg non-smooth, non-uniform clutter). A simple diagram of this method is shown in Figure 1 with a first order mechanical model of buried mine behavior under these conditions.

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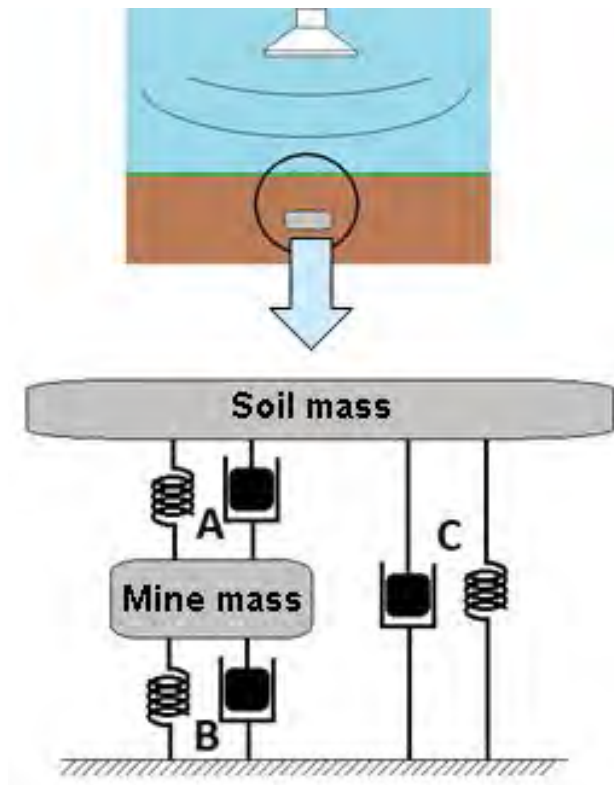


Fig. 1. Acoustic landmine detection mechanism and simplified mechanical model where A, B & C represent the elasticity and damping of the soil; above the mine, below the mine, and soil itself.

This first order model shows that if the mine is vibrating in a different way than the surrounding soil, this vibration will be manifested as a movement on the soil surface. Furthermore, there will be certain frequencies at which the mass/spring system will resonate. This phenomenon has been well studied, [4], and results show that AT landmines resonate from 200 – 400 Hz and smaller AP landmines resonate from 250 – 520 Hz in different soils and at different depths. In addition to the first order model there are second order non-linear effects arising from the mine's own elasticity and discontinuity between the vibrating mine and soil, which stimulate additional resonances at higher frequencies and further enhance the detection probability. It is clear that the principles of detection are mutually exclusive from the principles of MD and GPR technologies. The three methods are compared below in Table 1, illustrating that a fusion of all three would make for an excellent detection system.

Table 1. Comparison of MD, GPR and Acoustic Methods

	Detection method		
	<i>Metal Detector</i>	<i>GPR</i>	<i>Acoustic</i>
Basis	Inductive coupling	Dielectric properties	Mechanical Properties
Detects	Metal fragments	Material dielectric boundaries	Compliant (resonant) objects
Complexity	Very simple	Complex	Simple
Depth	~1m	~25cm	~15cm
Imaging	Poor	Good	Some
Dry soil	Minor effect	Works well	Does not work
Wet Soil	Minor effect	Does not work	Works well

VIBRATION DETECTION TECHNIQUES

While the acoustic properties of landmines are well described in the literature [4], no consensus has been reached on the best detection method of surface level vibrations. A number of soil surface vibration detection methods are here described. This leads to the selection of the ultrasonic detection method developed in this paper.

Previous work, [5] indicates that the vibration detection target required to identify resonating buried landmines is in the order of 1 μ m.

Contact (accelerometer) Vibrometer, [6]: The simplest and cheapest method for measuring soil vibration is to place an accelerometer on the ground surface. This technique raises a very obvious flaw in that deploying contact sensors to a

mine field presents unacceptable risk to the deminer and the equipment.

Laser Doppler Vibrometer, [7]: A laser beam illuminates the ground surface and vibration is measured from the Doppler shift of the reflected light. This method provides excellent accuracy, and surface vibration measurement down to 1 nm has been demonstrated. The complexity of the measurement results in a large and expensive apparatus, especially when expanded to an array as required for a practical detection system. Also the laser is limited by the line of sight to the vibrating surface and it is also very sensitive to vegetation and surface level clutter.

Radar Doppler Vibrometer, [8]: Based on a similar effect as LDV, RDV uses electromagnetic waves, as opposed to light waves, to detect vibration. The radar systems require high frequency and low phase noise meaning that cost and complexity reaches unacceptable levels. The scan rate of RDV systems is painfully slow and further development is required to make them practical.

ULTRASONIC VIBRATION DETECTION

In a similar fashion as for LDV and RDV the measurement of vibration ultimately requires the measurement of the phase difference between the excitation and the reflected signals. Considering the wavelength of laser light (600 – 700 nm) and the wavelength of electromagnetic waves for radars in air (suppose 10 GHz = 3 cm), and that both of these waves propagate at 300 million m/s, it is clear that both cases need extremely high bandwidth and accurate signal processing. Ultrasonic waves propagate slowly i.e. at 340 m/s, the speed of sound. Coupled with a low excitation frequency, from 20kHz, the ultrasonic vibration detection method results in much simpler signal processing. As ultrasonic transducers are very cheap, in the range of 1\$, several orders less than lasers or radars. Therefore smaller, cheaper and lower power measurement systems can be developed.

Until recently the limiting factor in the accuracy of ultrasonic measurements was the quality of the transducers themselves. However, recent advancements in the development of MEMS ultrasonic transducers and in particular pMUT/cMUT (piezo/capacitive micromachined ultrasonic transducers) bring promises of significant increase in accuracy and minimum vibration range that can be detected. For these initial experiments off the shelf, Futurlec US1240 40 kHz piezoelectric transducers were used giving an acoustic wavelength of 8.4 mm.

Two measurement methods were considered as shown in Figure 2. The first method (a), applies an ultrasonic resonance cavity where the distance between the transducer and the surface is fixed at a multiple of the wavelength. A standing wave is created and the cavity is said to be in resonance (i.e. the impedance is minimum since the transmitted and reflected waves subtract at the transducer). As the vibration surface moves back and forth the waves seen at the transducer are no longer perfectly in phase. The resonance condition is therefore broken and the cavity impedance increases sharply. Consequently the surface movement is correlated directly to the cavity impedance, which is simply measured using a bridge amplifier circuit. The second method (b), uses two ultrasonic transducers; one as transmitter and a second as receiver. The transmitted ultrasonic wave is reflected by the surface to the receiver. In this case surface movement is represented directly in the wave path travelled between transmitter and receiver. Therefore the movement is represented in the phase difference between transmitted and reflected signals.

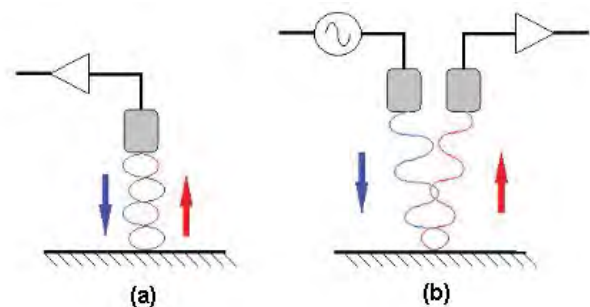


Fig. 2. Vibration detection using (a) ultrasonic resonance cavity and (b) transmission & reflection of ultrasound.

The ultrasonic resonance cavity gives the advantage of high accuracy and low noise with minimal signal processing required at the cost of a limited standoff distance to approximately 10 wavelengths (~8.5cm) and a need for high transducer positional accuracy. The second, transmission and reflection topology enables a greater standoff and reduced need for transducer positional accuracy at the cost of higher noise and more complex phase demodulation signal processing. The dominant sources of this noise are temperature and humidity variations with air turbulence, which have inherently low frequency.

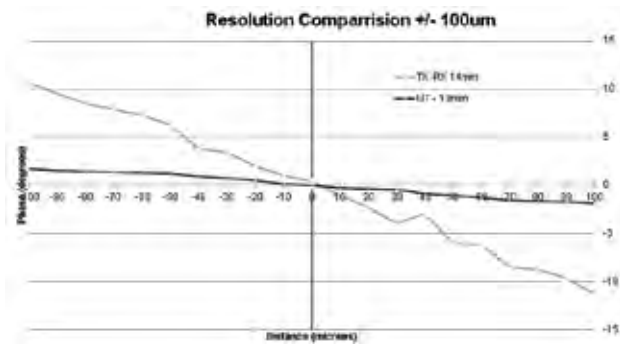


Fig. 3. Comparison of Ultrasonic Resonance Cavity (UT) and Transmission/Reflection (TX-RX) methods over a range of 200 μm

A comparison of the two methods described is shown in Figure 3. A similar standoff distance of 13 mm and 14 mm is used for the cavity and TX-RX methods respectively. In this case the distance to be measured is controlled by fixing the transducers to a micrometre apparatus and moving them in steps of 10 μm over a range of 200 μm . Examining first the cavity result it is clear that the result is highly linear and low noise. However the signal level is quite low, giving a resolution of 0.018° of phase per micron. Looking at the TX-RX result shows that the measured distance colligates directly to the ultrasonic wavelength at approximately 0.1° of phase. However the impact of low frequency noise is also much stronger in this case.

Current development is focused on increasing the standoff distance to practical levels (above 20 cm). Various circuits for phase demodulation are being tested; a phase locked loop (PLL) demodulator, and IQ demodulator and an EXOR signal subtraction technique. Recent tests have demonstrated the measurement of a displacement of 1 micron in the frequency range 200 – 520 Hz.

ACOUSTO-ULTRASONIC LANDMINE DETECTOR

The envisaged system, illustrated in Figure 4., will use an acoustic source to couple seismic waves into the ground. These waves will propagate through the soil and cause the buried acoustically compliant objects such as landmines to resonate of, as described previously.

The surface level vibration will be detected using ultrasonic transducers as described in this paper. For practical reasons the transmitter receiver topology will be used. To enhance

detection probability and increase scanning speed the ultrasonic transducer element will be expanded to an array. This array will allow the use of multiple ultrasonic wave paths for differential measurements enabling the simple removal of noise. Furthermore the array will allow ultrasonic beam forming giving additional accuracy and control in the measurement.

pMUT and cMUT transducers, currently being fabricated in house, are expected to give an improved performance by a factor of 10. The fabrication process also give the possibility of designing arrays with accurately controlled element spacing in the order of wavelength. Therefore a highly accurate ultrasonic measurement system will be presented for the final solution.

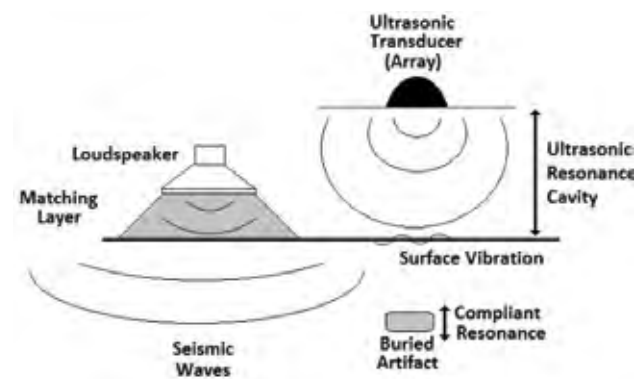


Fig. 4. Landmine detection using acoustic actuation of resonance and ultrasonic detection of vibration.

CONCLUSION

The work of this paper highlighted the potential of an ultrasonic vibration detection solution in acoustic landmine detection. This method presents a cost efficient solution, which enables deployment in the field. The work of the authors, within the D-BOX project, aims toward a laboratory demonstration of the detection of buried landmines in a number of scenarios where MD and GPR technologies are unable to confirm the presence of a landmine. The acousto-ultrasonic detection tool is expected to provide a complement to MD and GPR methods, hence increasing the probability of landmine detection while decreasing the probability of false alarms.

ACKNOWLEDGMENT

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Liability and Confidence in Mine Action

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The operations concept change - strategical shift in Bosnia and Herzegovina Mine Action Program

Mine action program in Bosnia and Herzegovina is one of the mature programs in the world. For more than 17 years every day are being made enormous efforts to eliminate the risk of mines remained from the war. When making decisions relevant to this long-term process, it is very important to look back to the history and review important dates and lessons learned that should guide further actions in order to improve the whole process in all of its elements.

In 1996 the problem was huge and it was not known the scope of the problem in general. There were over 70 mine victims per month, so with the help of the international community it started so called phase of emergency demining. This period was marked by the presence of the World Bank, UNHCR, UN agencies and some foreign companies. Immediately after the war, we urgently started to remove the risk from the most affected and populated locations such as towns, villages, roads and other similar places. It is a period of two years when the work was conducted by the principle of large-scale intervention without much preparation. There were mostly cleared locations of 500 000 m², but considering that those were locations with very frequent use and subject to return of population, it was a very reasonable decision. Simultaneously, the international community launched the development of national capacities which will be seen later as one of the most important decisions.

Strategical shift was done in 1999 when mine action structure was changed and when the state took responsibility over to national authorities. At that time it could already be seen the development of technical procedures which are greatly influenced by large scientific projects and coordination conducted at the level of the international community through the Geneva International Centre for Humanitarian Demining (GICHD).

During this period, funding has pretty stabilized. With much more knowledge through non-technical methods it was made large reduction of suspected hazard area which, from the initial 4200 km² from 1999, was reduced to 2765 km² by adopting the first Mine Action Strategy in 2002 as significant result. At the same time, it also involved the operational activities with technical methods so the risk was generally and drastically reduced right in this period.

Technical methods, analysis and studies on mine impact have been developed, so as early as 2004 the Landmine Impact Study was produced. That completely changed attitude towards priorities assessment and also reduced the total suspected hazard area through non-technical methods.

Next comes the first Strategy review deadline which was planned by the Ottawa Convention, where already was continuously developing a non-technical method of general survey, general assessment, updates, studies about the landmine impact on population and all of that very clearly led to a large further reduction of the risk.

Extension of deadline has been achieved in 2009 and a new strategy was adopted (Bosnia and Herzegovina without mines by 2019).

Trend of the development of non-technical methods also continues as well as continuous conducting of technical methods operations.

In 2012 was made the first revision of Mine Action Strategy 2009-2019 and the revision has adopted certain conclusions that with the existing concept and level of financing will not be possible to complete the job by the 2019 as planned. The financial audit report clearly shows that each year from 2009 to 2012 was regularly lack about 30 million KM, mainly for technical methods that resulted in a large shortfall in the plan. Due to lack of funds, in each type of operation the plan simply was not fulfilled proportionally to the lack of funds which has led to a situation when you need to make a strategical shift.

To exit from this situation there were two scenarios - the first was to find additional 80 million KM per year and the second was to ask for extension of time to fulfill the obligations under the Ottawa Convention. Neither one was realistic so the only solution was to restart the concept change.

The strategy itself has predicted developmental research projects so a lot of work was done in cooperation with various organizations in the air survey by helicopters, satellites, unmanned air vehicles with various types of sophisticated equipment. It was procured and updated orthophoto image through a census of population conducted in 2013 with the extraordinary scale of 1 : 1000 for the entire Bosnia and Herzegovina. Much experience has been acquired in cooperation with the European Space Agency, which has enabled us to cooperate with few European consortiums dealing with the use of satellite imagery. All these experiences have indicated that the non-technical methods can still be improved. Thus, the critical moment occurred when we dropped from these

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two scenarios, and since we can not make it up for the time or money that is not provided, we started the concept change.

Confidence

Changing the concept has a very important segment. Whenever something drastic changes in any profession, in habits, in daily activities of hundreds or even thousands of people who are dealing with a risky job, it is very important to come up with the concept and then develop proper procedures in order to create the environment of confidence for those people who will deal with it. From this it follows that the confidence is very important in the process of changing the concept. Confidence in employees, inspectors, deminers, management, confidence in the procedures will ensure the safe operation and use of these procedures. And when you see the professional dimension of easiness of operation without fear, then it has been transferred to the people and the government and the donors. These are essential issue for each program and especially for such programs where the profession is concerned with risk management. Statistics on mine victims reminds us of it and it is unfortunately still present, thus causing additional fear for all employees in demining.

Here we come to another important topic on which we want to talk and that is liability. Liability is directly related to the general environment, the liability is related to any individual, institution, state and government so we will also look back and see what was going on in Bosnia and Herzegovina from 1998.

Liability

The one criminal procedure and 22 civil court procedures have commenced in the past. The criminal procedure lasted for two years when the director of the Federal MAC and head of the Civil Protection of Novo Sarajevo municipality were accused for the mine accident. The process has been very frustrating but at the end the court made the reasonable decision and released them of all charges. It is interesting to say here that the entire international demining community thoroughly monitored this process because it really was a precedent in the judiciary and in our profession, and luckily it did not repeat afterwards. Next followed 14 civil court procedures with largely negative judgments whether it was an accident in the cleared or in the marked area, unmarked, surveyed or unknown minefield. In any case, BHMACH was getting all negative judgments with very unpleasant classifications such as : they missed or ignored to do it, they did not do it and they should have done it etc. so it was quite insulting for all those engaged in this kind of job.

However, the court is court, so there was no other way but to do one general campaign on education of judges

and prosecutors. In this case the support from GICHD was very important and besides their support, they have also provided training at the end of 2013 for judges and prosecutors in Bosnia and Herzegovina.

After this training where they clearly explained all the specifics of this profession, a significant change have happened in judgments where the courts in Bosnia and Herzegovina have started to respect documentation and procedures that BHMACH implements. After this, four judgements have been made let's say in favor of BHMACH – while 4 judgements are running. It is important to say that the release of fear, when being in this job through these events that we just mentioned, was really helpful for the employees.

Therefore, education of judges and prosecutors has been achieved and this year the additional training on this topic will also be held in Mostar.

The achieved goal was that the employees cleared up the importance of administrative actions, monitoring and recording of all operational activities in accordance with procedures. Another achievement is related to the judges and their understanding the specifics of mine action and work of BHMACH. This can be considered as an important moment that needs to support conceptual change and strategical shift which are in fact the essence of the current needs of this matter that we work on. In addition to the development of operational procedures and the concept change, it is very important here to give support through the confidence in profession and confidence and safety in liability.

So here are the answers : Are we doing the right job? – Yes; Are we doing that job in a right way? – Yes; but monitoring the situation in our field and changes in the rules are still necessary.

The concept change and strategical shift will happen this year through the implementation of the IPA 2011 Land Release project with support from the European Union and it is a topic that my colleague will show in the operative part.

In this part it will be clearly identified with how much courage changes are being made and that is really necessary, from the beginning and during the development of procedures, training and project to always talk to and to encourage all employees dealing with this job that they can be safe and that they can do their job easy and without fear and to have confidence in it and to know that the liability is solved exactly through the professional development of this work.

Training of EOD Staff: Thoughts and Suggestions

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ABSTRACT

Based on a ten-year experience in the field of training for EOD staff, HCR-CTRO d.o.o. discusses suggestions and guidelines for solving the observed faults related to the topic of EOD training. The necessity of prescribing the minimum standards in the field of training is observed, i.e. the need to standardize the training in the international level in a more clear and firmer way, in relation to conditions of organisation and implementation, as well as to the system of revision and control of implementation of training courses. In this way, through opening a wider public debate among the interested international community, the goal is to enhance the quality and primarily the safety of the staff involved in clearance of contaminated areas, through standardization procedures and through identifying the minimum of knowledge and skills of the trainees. The issue is double fold, and is presented as a need for a full implementation of documents which govern the field of EOD training, namely IMAS 09.30 and CWA 15464:2005, by introducing a control system, as well as for necessary upgrading of the documents, which is of utmost importance in view of quality and safety.

The intention of this short Paper is to draw attention of a wider mine action community to inappropriate/insufficient regulations in the field of training and improving the skills of the staff involved in EOD tasks. The starting point is a ten-year experience of the Croatian Mine Action Centre - Centre for Testing, Development and Training (HCR-CTRO)²³ in the field of testing, research and development, and especially in the field of education - qualifying and improving skills of mine clearance staff. During our activities of organizing and implementing of improvement of professional skills of the EOD staff, as well as on other professional training courses that we have conducted, we have noticed certain

shortcomings of international documents²⁴ that define this field and have direct influence on the quality, safety and efficiency of performing clearance activities. Having this in mind, on the basis of our experience, we would like to draw attention to some of the problems we have noticed in the course of training the EOD staff, and we would also like to open a wider public debate on the stated issues with interested colleagues from the mine action community.

Considering the EOD issues from the **regional point of view**, we would like to point out that a major part of Southeast Europe has been suffering from consequences of both world wars, and, unfortunately, the consequences of the warring activities from the recent past. A part of the territory was hit by a NATO armed intervention in the last decade of the past century, thus the danger of UXO in the countries of the region is higher than in other countries. Unfortunately, as high a number as **120 countries in the world** face the problem of UXO contamination, and every new conflict brings about new problems and dangers. UXO items are pose a **long-term potential danger**, even decades after the end of warring activities, sometimes in very unusual places, such as: ports, beaches, parks, areas of demolished buildings.

In view of the above stated, education of EOD staff is one of the issues which require high priority among demining activities in general. The need for qualifying and improving the skills of EOD staff is a continuous one. The EOD training is a professional training in modular form, which involves professional knowledge, skills and competencies that should be acquired by the EOD staff, depending on the training level, and in line with international regulations, represented with two key documents: *International Mine Action Standards - IMAS 09.30* and *CEN Workshop Agreement - CWA 15464:2005 – Humanitarian Mine Action - EOD Competency Standards* (5 parts). These documents organize the EOD training as a modular (Level 1-4) education of the staff involved in activities of detection, identification, rendering safe, recovery and final disposal of unexploded ordnance outside or inside suspected hazardous areas or buildings.

The IMAS 09.30 states that the aim of the standard is „to provide specifications and guidance for the management

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²³ HCR-CTRO d.o.o. was established in 2003 with the aim of encouraging, assisting and developing field tests and evaluation of mine and UXO detection technologies, and of performing systematic tests, examination and development of mine action. HCR-CTRO d.o.o. is a limited liability company founded by the Croatian Mine Action Centre. Web page: www.ctro.hr

²⁴ IMAS 09.30 and CWA 15464:2005 – Humanitarian Mine Action – EOD Competency Standards (5 parts).

of EOD as part of mine action. It covers general principles and management responsibilities for EOD“. Within the above stated, EOD operations involve *the detection, identification, field evaluation, render safe, recovery and disposal of explosive ordnance*.

CWA 15464:2005 is another document which regulates the training of EOD staff, i.e. it provides *guidance on the competencies needed for EOD levels 1, 2 and 3 when dealing with conventional munitions disposal as part of EOD in mine action operations*.

In order to conduct EOD procedures in a safe and efficient way, experts are needed which are qualified and trained for EOD disposal. This implies an accurate assessment of the risks of UXO and development of safe and effective capability of removing and disabling UXO. In this sense, there are many problems and ambiguities within international standards, which at the same time pose a wide space for improving the performance, efficiency and quality of EOD activities.

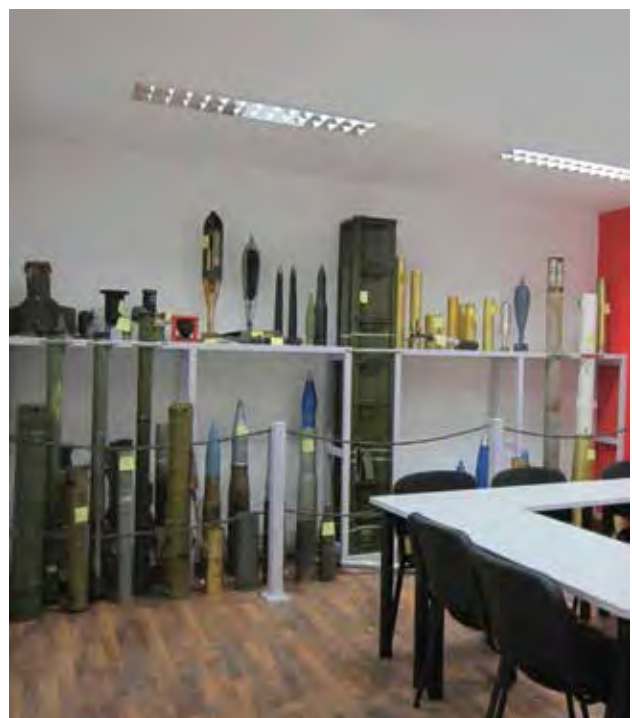
The basic problem is that the stated documents do not identify explicitly a type of authority that can qualify for conducting the training of UXO staff. In this sense, it is necessary to **clearly stipulate the conditions which should be met by a legal person wishing to conduct EOD training and other professional training courses.** Ultimately, every subject that conducts training **should be accredited** for training operations by a national and/or international authority whose activities of accrediting organizations to perform training have yet to be prescribed. In the accreditation process, this authority will proceed according to **clearly defined rules**. Such rules would mean the creation of **common minimum standards** to be met by a legal entity in the implementation of the training of EOD staff.

With this in mind, we propose **to clearly define competencies of the lecturers who conduct theoretical classes and of those who run demonstrations in training programs.** These competencies by all means should include the necessary pedagogical competences, as well as appropriate experience in clearance of contaminated areas. It is also necessary to determine the precise minimum of knowledge for the EOD staff depending on the level of training. So **it is necessary to prescribe the general content of the curriculum, as well as the minimum length of training depending on the level.** Furthermore, it is necessary to explicitly state and standardize preconditions for admission to EOD training

programs and other specialized training programs. For example, candidates without a basic deminers course should not undertake the EOD training, since this training is an upgrading of basic education with specialist knowledge and skills.

It should be noted that in both key international documents which explicitly define the training of EOD staff, there is a problem of **imprecise and unclear identification of competencies and skills of trainees by levels**, i.e. during the training for disposal of individual UXO items or groups of UXO items by levels. Implementation of the final examination of the trainees should be prescribed by a minimum standard of knowledge and skills that will be tested, as well as by the way in which the examination will be conducted.

From the above stated it is clear that there is a need for **stronger standardization in the field of training of staff involved in clearance of contaminated areas, and for creating minimum standards** that are required to perform this training. Uncertainties should be clarified and some issues should be regulated unambiguously, such as the question of **who can conduct the training, who supervises the organization that conducts the training, what are the conditions for entering in a specific training, what is the minimum duration of the training, what are the qualifications and pedagogical training of the lecturers, the training conditions (classroom , demonstration site).**





Pictures 1 and 2: Up to date classroom (HCR-CTRO)

In this sense, the international mine action community should intervene and act to raise the quality of training, in order to enhance safety of persons involved in performing these activities. The existing EOD modular training program, as regulated by international documents **does not provide sufficient systematic, technical and technological, organizational and other solutions** that, within appropriate mine action strategy, would give optimum results. Therefore, we would like to point out that in this way, there is a huge and unacceptable space for imbalance and disharmony in delivering quality training in different legal entities. The discrepancies are so huge, that what we consider a reasonable minimum standards in terms of content and skills of the candidates and their tutors and of organizing the training and conditions in which the training is implemented, often are not met adequately.

Reputation of HCR-CTRO, gained both in international and domestic communities²⁵, and individual examples of other companies that conduct training in accordance with international documents, are by no means sufficient to guarantee the general safety, quality and efficiency in the removal and disposal of UXO. Our vast experience in international training, especially in upgrading existing EOD qualifications, shows that an agreement should be reached urgently on minimum standards and knowledge

²⁵ HCR-CTRO has conducted numerous training courses for trainees from the region of Southeast Europe (Croatia, Serbia, Monte Negro, Macedonia, Bosnia and Herzegovina), and for a wider international community, e.g. Jordan and Colombia. In addition, a series of training courses was implemented for Iraq, Russian Federation and countries of Central Asia. In 2013 alone, we have organized and implemented training courses for EOD Level 1 and 2 for the Norwegian People's Aid from Bosnia and Herzegovina, EOD Level 1 and 2 for NCDR Jordan, EOD Level 2 for Iraqi Directorate for Mine Action, as well as training courses on the topic of Marking of Mine and ERW Hazards and on Non-technical Survey; training course on Management in Demining for a Russian company Emercom and EOD Level 2 in the Republic of Serbia.

within the international mine action community, in order that all service providers provide high quality services, with the aim to raise safety of EOD staff. Although there are isolated examples of successful and high-quality training courses that provide successful training, such examples have yet to become a general rule in the training of EOD staff. **Therefore, we believe that it is necessary to revise and more clearly define the standards in the field of training, in order to achieve more uniform** transfer of basic theoretical and especially practical knowledge and skills to the trainees.





Pictures 3, 4 and 5: Up to date practical training (HCR-CTRO training site)

Verification of training providers should be conducted by an authorized international body, as well as the audit of the training courses conducted, according to clearly defined criteria. Knowledge and skills acquired from training programs regulated in such a way will significantly raise the professional theoretical and especially practical level of proficiency of trainees and assist them in finding the best solutions in solving the problems of UXO. Therefore, the safety in performing everyday tasks related to UXO and the overall quality of the work will be raised to a much higher level.

Since individual parts of IMAS are revised every three years, we suggest to start a public discussion related to problems in education of mine action staff, perceived on the basis of our own experience. We would primarily like to call upon UNMAS, which is responsible for issuing and maintenance of the IMAS within the UN, and upon the Geneva International Centre for Humanitarian Demining, which manages the development and the review of the IMAS.

Finally, the problem of unexploded ordnance is one of the most important problems in mine action and

a serious threat to any community. Nevertheless the issues of education of demining staff has not been discussed in detail to date, in view of safer, better and more efficient detection, removal and disposal of UXO. Having this in mind, we have pointed to some of the problems encountered during the training courses, which require urgent resolving, agreement and consensus of a broader mine action community. It is necessary to revise and define more clearly the standards in the field of training and devise a system of audit and control of the implementation of the training in accordance with the highest andragogical standards.

References:

International Mine Action Standards (IMAS) 09.30

European Committee for Standardization Workshop Agreement (CWA) 15464:2005

www.ctro.hr

The Role of Mine Action in Integrating Victim Assistance into Broader Frameworks

Juan Carlos Ruan²⁶

Abstract

Victim assistance requires a long-term perspective, and involves a set of actors with lead responsibilities that are different from actors who lead with respect to other aspects of mine action.

Nevertheless, mine action structures have an important role to play in promoting and supporting the application of the principles embodied in the main instruments of international humanitarian law and in keeping with the United Nations' policy on victim assistance.

This publication aims to explain the particular role that mine action structures can play by providing five key examples of mine action in integrating victim assistance into broader frameworks. It is hoped that by documenting examples of good practice, national mine action authorities, United Nations advisors and partner governments will benefit from enhanced understanding regarding the types of interventions that are most appropriate and have the greatest impact. This is particularly important as concerns the sustainability of efforts beyond the end of humanitarian demining programmes.

This publication was prepared by the Anti-Personnel Mine Ban Convention Implementation Support Unit thanks to support provided by Australia and the European Union.

Assisting the victims of landmines and other explosive remnants of war is a central feature of the Anti-Personnel Mine Ban Convention, Protocol V to the Convention on Certain Conventional Weapons, and the Convention on Cluster Munitions. As such, it has been clear since the late 1990s that all that is involved in *victim assistance* is an integral aspect of *mine action*. According to the United Nations, victim assistance is one of “five complementary groups of activities” which “aim to reduce the social, economic and environmental impact of landmines and (other) explosive remnants of war.”²⁷

Delivering on the promise of mine action and that of relevant international legal instruments, which speak to a

commitment to “end the suffering” caused by landmines or other explosive remnants of war, means clearly understanding one’s end goals and distinguishing various actors’ responsibilities in the achievement of these goals. The end state with respect to some aspects of mine action is straight-forward, particularly for those states which have acceded to the Anti-Personnel Mine Ban Convention or the Convention on Cluster Munitions. For those that have, the end state as concerns *humanitarian demining* is the return of all areas, which were originally considered dangerous due to the presence or suspected presence of mines or cluster munitions remnants, to a condition that would permit normal human activity to take place. In addition, for those States which have accepted these international legal instruments, the end state as concerns *stockpile destruction* is the elimination of all stockpiled anti-personnel mines or cluster munitions.

The end point as concerns victim assistance is not defined. However, for individuals who have been killed or who have suffered physical or psychological injury, economic loss, social marginalisation or substantial impairment of the realisation of their rights caused by the use of mines, cluster munitions or other explosive ordnance, the end point, while not specified by conventional weapons treaties, is logical and can be derived from international human rights law. That is, the mission of victim assistance is the full and effective participation of landmine and other explosive remnants of war victims in society on an equal basis to others.

A human rights-based approach to victim assistance has been recognised by the States Parties to the Anti-Personnel Mine Ban Convention, Protocol V to the Convention on Certain Conventional Weapons, and the Convention on Cluster Munitions. Using a human rights-based approach to define the mission of victim assistance makes two things abundantly clear regarding the task and who has responsibility for what.

- Achieving the mission implied by victim assistance means having a long-term perspective. Even in the most developed countries, realising the full and effective participation of all individuals, including mine victims, in society on an equal basis to others, is a long term task. Consequently, the timeline for what is understood as victim assistance goes

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²⁷ United Nations Mine Action Standards 01.10, Second Edition, Amended 8 June 2013, paragraph 4.

beyond the time-lines for other “complementary groups of activities” that the United Nations defines as comprising mine action, such as humanitarian demining and stockpile destruction.

- Realising the full and effective participation of all individuals, including mine victims, in society on an equal basis to others means integrating victim assistance into broader contexts. The States Parties to various international conventional weapons instruments have, for some time, understood this point, recording that victim assistance should be integrated into national policies, plans and legal frameworks related to issues such as disability, health, rehabilitation, social services, education, employment, human rights, gender, development and poverty reduction. Consequently, the set of actors with responsibilities for victim assistance, including those with lead responsibility, is different than is the case with other aspects of mine action, such as humanitarian demining and stockpile destruction.

Understanding what is unique and different about victim assistance relative to other efforts undertaken to end the suffering caused by mines and other explosive remnants of war is important in developing and implementing good public policy. Good public policy is that which efficiently and effectively overcomes particular challenges and does so in a just and inclusive manner. Good public policy in the pursuit of the full and effective participation of mine and other explosive remnants of war victims in society on an equal basis to others means paying due regard to sustainability and an appropriate assignment of responsibilities.

Sustainability is important because the mission of victim assistance implies a long-term perspective. The assignment of responsibilities is important because of the broader contexts within which victim assistance finds itself. This is particularly the case, although certainly not exclusively so, with respect to disability and the rights of those living with disabilities. As United Nations Human Rights Chief, Navi Pillay has stated, “when survivors of mines and other explosive devices acquire a disability, they fall under the scope of the Convention on the Rights of Persons with Disabilities.”²⁸

²⁸ Opening remarks, Ms. Navi Pillay, United Nations High Commissioner for Human Rights, 12th Meeting of the States Parties to the Anti-Personnel Mine Ban Convention, Geneva, Monday, 3 December 2012.

The disability rights context is only one of the broader frameworks within which victim assistance should be integrated. These include healthcare, rehabilitation, social services, education, and employment. Each of these frameworks has its own set of state institutions, which normally have existed for decades, such as ministries of health, education and social affairs. This is in contrast to humanitarian demining, which only matured as a field of practice in the 1990s and 2000s. New structures, such as mine action authorities and mine action centres, have been required to take lead responsibility for humanitarian demining. In contrast, doing all that is required with respect to victim assistance, which again should find itself integrated into broader frameworks, does not require the establishment of new structures or entities.

Lead responsibilities for victim assistance, depending upon the types of activities to be undertaken and goals to be achieved, should rest in entities such as a ministry of social affairs, a ministry of health, a ministry of labour, a ministry of education, a national disability council or a national human rights body. The 2003 United Nations’ sectorial policy on victim assistance has recognised this point, highlighting that “mine action centres are not designed to take the lead role in victim assistance, nor do they have the mandate, expertise or required resources.”²⁹ This is also alluded to in the United Nations’ International Mine Action Standards, which suggest that victim assistance is more likely to be managed by organisations other than national mine action authorities or mine action centres with “the scope of victim assistance covering victims of other incidents as well as mine accidents.”³⁰

While national mine action structures are not the appropriate entities to take the lead in the care, rehabilitation and reintegration of a State’s population, they do have a supporting role to play in assisting the victims. The United Nations’ 2003 policy on the scope of action of mine action centres in victim assistance, while highlighting that “mine action centres are not designed to take the lead,” suggests that mine action centres/authorities can contribute to assisting the victims. These mine action entities can assist in a number of ways:

- Mine action entities can **raise awareness** within the machinery of government of the important promise states have made to mine and other explosive

²⁹ Sectorial policy: The scope of action of mine action centres and organizations in victim assistance, Mine Action and effective coordination: the United Nations’ policy, UNMAS, May 2003.

³⁰ Annex D, Guide for the Establishment of a Mine Action Programme, IMAS 02.10, First Edition, 01 August 2007, (Amended 3, June 2013), 18.

remnants of war survivors through accession to the Anti-Personnel Mine Ban Convention, Protocol V to the Convention on Certain Conventional Weapons, and the Convention on Cluster Munitions and how this promise is understood.

- With awareness having been raised, a mine action structure can **support or initiate an inter-ministerial process** to address the needs and guarantee the rights of victims and survivors in the broader context of a State's responses as concerns disability and development. This broader approach as relates to disability is reflected in the *Strategy of the United Nations on Mine Action 2013-2018*.³¹
- Mine action programmes can further leverage international interest in assisting the victims of mines and other explosive remnants of war to **advocate** for advances that should benefit a broader community of those whom have been injured and / or are living with disabilities. This could include supporting accession to and implementation of the Convention on the Rights of Persons with Disabilities.
- International interest in the landmine cause could be used by mine action programmes to **mobilise resources** to benefit not only landmine and other explosive remnants of war victims and survivors but also the broader community of women, girls, boys and men who live with disabilities.
- Mine action programmes can **promote effective coordination** between landmine survivors and their representative organisations, those interested in assisting them, and those state entities with lead responsibility for health care, social services and disability.
- Age- and sex-disaggregated **data on mine and other explosive remnants of war casualties** collected by a national mine action programme should be fed into broader national injury surveillance and disability information systems.

Several mine action programmes and related structures and institutions are doing valuable work in relation to assisting victims and survivors. However, mine action programmes and structures are intended to exist only for a fixed period of time whereas the need to address the

needs and guarantee the rights of survivors will last for their lifetimes. Efforts to clear landmines are already complete, or soon will be, in several States Parties to the Anti-Personnel Mine Ban Convention reporting responsibility for significant numbers of survivors, including Albania, Burundi, El Salvador, Guinea Bissau, Jordan, Mozambique, Nicaragua, and Uganda.

Given the place of mine action programmes and national authorities with respect to victim assistance and the importance of this matter as concerns sustainability of efforts, a great deal can be learned from those that have demonstrated good practice. By documenting examples of good practice, ultimately victims of mines and other explosive remnants of war – as well as other individuals who are injured and / or who are living with disabilities – should benefit if the lessons learned can be replicated elsewhere. National mine action authorities, United Nations advisors and partner governments should also benefit from enhanced understanding regarding the types of interventions that are most appropriate and have the greatest impact.

Finally, it should be recalled that while most responsibilities a ministry of health, a national demining programme, a non-governmental organization or an international donor may have are different, all actors involved share the responsibility of ensuring the effective participation and inclusion of survivors and other persons with disabilities. Survivors and other persons with disabilities have a unique perspective on their own situation and needs. They can and should be constructive partners in all victim assistance and broader disability efforts. The principle of participation and inclusion is well understood in the context of the Anti-Personnel Mine Ban Convention, Protocol V to the Convention on Certain Conventional Weapons and the Convention on Cluster Munitions, with parties to each heeding the message of “nothing about us without us.” The participation of persons with disabilities, including landmine and other explosive remnants of war survivors, in all aspects of planning, coordination, implementation, monitoring and evaluation of activities that affect their lives is essential.

Author

The Implementation Support Unit is the secretariat to the 1997 Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction. The Implementation

³¹ The Strategy of the United Nations on Mine Action 2013-2018, United Nations, March 2013, 14.

Support Unit is mandated to support the States Parties to the Convention, in particular by doing the following:

- Providing support to all States Parties through support to the Convention's implementation machinery and office holders,
- Providing support to individual States Parties, including by providing advice and technical support on implementation and universalization
- Communicating and providing information about the Convention,
- Keeping records of formal and informal meetings under the Convention, and
- Liaising and coordinating with relevant international organisations that participate in the work of the Convention.

The ISU is directly accountable to the States Parties while being hosted by the Geneva International Centre for Humanitarian Demining. The ISU is funded on a voluntary basis by States Parties to the Convention.

The Use of Unmanned Aerial Vehicles “multirotors” in the demining process – first results

Goran Skelac³²; Tomislav Žaja³³

The aim of this presentation is to introduce basic technical characteristics of small Unmanned Aerial Vehicles – multirotors (commonly known as drones) and the achievements so far in the application as well as the specific needs and opportunities associated with the demining process. Multiple “low-cost” of this technology, mobility, maneuverability and small size caused a very rapid application UAV in numerous commercial, industrial and scientific projects.

After the last years presentation of Unmanned Aerial Vehicles - Multirotors at conference “Ottawa Convention Seminar RACVIAC, CROATIA 18-20 November 2013” in Rakitje near Zagreb, there has been some progress and here we present the results.

Use of Unmanned Aerial Vehicles and foto/video equipment at several minefields locations in Croatia during demining, give the first results in form of informative public Video clip. Further on, this action gave us guidelines for applications in the systematic field survey and documentation that can be used for planning of demining process and media presentations. Here is list of conclusions our team has come to using drones/multirotors in numerous different fields of documenting such as demining, archaeology, traffic jams, rescue actions, fire and floods interventions and more:

Accessibility Access to inaccessible terrain and monitoring the situation on the ground

Mobilisation time - because of the small size and portability, it takes very short time to carry out an aerial survey of the field

Security of human potential in the process of implementation of the survey and demining

Precise documenting - current photo and video documentation of the condition before, during and after clearance with the possibility of GPS trails and marking of individual mines or groups of mines for mapping a minefield

Low Cost - compared with all other methods for aerial survey and monitoring, UAV is extremely cost-effective and efficient

In technical sense there are number of technological improvements applied on multirotors such as:

Autonomous time with one battery charge, 10 - 25 minutes (the length of the flight will depend on the amount of equipment and cargo on aircraft and temperature).

Carrying a payload up to 10 kg.

Flight radius of 1000 m, altitude 300 m

Working conditions – 15 C to +40 (at lower temperatures reduces the time autonomy).

Autopilot functions: - maintain altitude with a barometer, maintain position using GPS - back home (the starting position) in the case of loss of signal stations, automatic take-off and landing, loose routing aircraft regardless of its orientation, selection of points of interest and automatic circular flying around (no limitation).

Management of aircraft by clicking on the map, automatic flight of the defined waypoints (100 travel points to 1000 m in diameter Display flying position in real time on the map (Google Maps))

First person view –constant video monitoring

Dimensions from 35 x 35 x 15 cm to 140 x 140 x 55 cm

Weight without battery : 1.2 kg, 2 kg with battery – to 8 kg, 10,4 with batteries

Cargo from 0.5 kg up to 10 kg

Total max. weight with weight from 2.5 to 20,4 kg

Speed of Uav can be programmed from 1 m/s up to 15 m/s

UAVs are actually robotic remote controlled models of aircraft, helicopters and multirotors - 3, 4, 6 or more propellers (often called quadcopters, hexacopters or octocopters). The latter, because of the ability to hover, VTOL (Vertical Take Off and Landing) and autopilot functions in flight appears to be the most appropriate for the purposes of surveillance and documentation of the field with suspected hazardous potential.

One of most important capability is Vertical Take Off and Landing (VTOL) that enables operator to use drones at almost any terrain.

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New steps

Next mission for our team concerning demining process was to design UAV with ability to fly and to work with equipment of 5 -6 kg of weight. For that purpose we redesigned and strenghten octocopter UAV MR8 and got satisfactory results. MR8 can fly up to 12 minutes with such weight with one set of batteries.

Next task was to make tests flying Autopilot GPS positions - way points into a given grid to cover mine field in dense grid with overlapping of photos or video data or any data recorded at field. During these test we also measure precision of trajectory and consistency of default speed. Results were very good and gave us data for calculating possible area drone can cover with flights at daily bases.



1. Multirotor MR 4 qudrocopter – “Scout”



2. Multirotor MR 8 octocopter – “Heavy lifter”



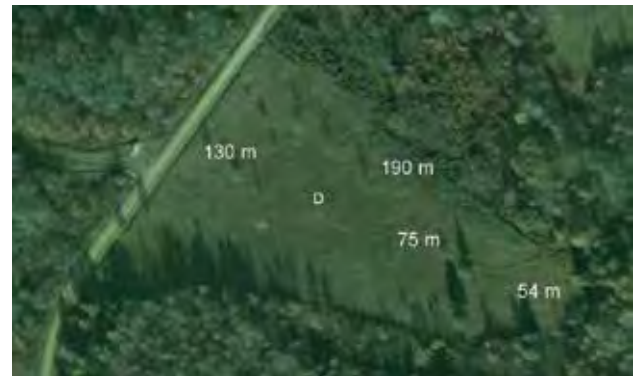
3. Multirotor MR X8 coaxial octocopter – “Explorer”

Test of Autopilot way point flying was repeated at 30, 60, 90 and 120 m of altitude and at parallel grid with offset of 5, 10,20 and 50 m.

All of this results will be presented to public very soon.

As the main result of our work so far, we present short public video.

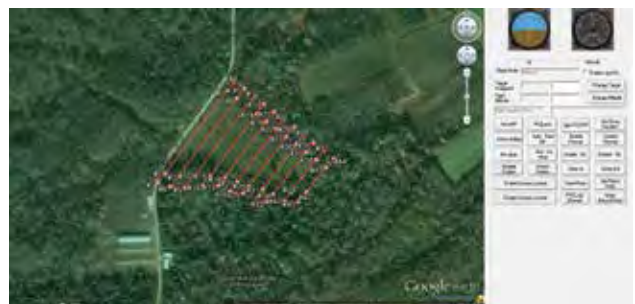
Demine Croatia video was shoot from September to December 2013 at locations Josipovac, Tenja and Kopački rit sites near Osijek, at Mošćenica near Sisak and at Škabrnja near Zadar . Movie is directed and produced by Tomislav Žaja and financed by Office for demining of Republic of Croatia and Croatian mine action centre.



4. Mine field with dimensions, task to fly in grid to overlap data



5. Preparation of grid with offset



6. Way points – plan for flight in parallel lines

D-BOX Cultural Guidelines for demining managers

Dave Usher³⁴, Dominic Kelly³⁵, Stewart Grainger³⁶

Abstract

The cultural background of members of a demining team will probably differ considerably from that of the local people. Language, dress, attitudes, opinions and affluence are all likely to diverge. This makes it easy inadvertently to transgress unwritten rules of behaviour and disrupt the goodwill that is so important for the efficient completion of the project.

The D-BOX project is funded by EU Framework Programme 7 to provide a Toolbox to assist in humanitarian demining. One of the Tools it contains is ‘Cultural Guidelines for demining managers’. The document provides guidance on issues such as religion, dress, gender, corruption, ethics and law, as well as offering practical suggestions for recruitment and procurement policies that recognise the EU’s commitment to human rights.

The D-BOX cultural guidelines should prove valuable to demining projects and the communities in which they take place.

1. INTRODUCTION

The Demining Toolbox (D-BOX) [Ref ^{vi}] is a project funded by the EU to provide assistance for those engaged in any aspect of humanitarian demining. Some of the tools in the Toolbox will be technological – equipment for mine detection, neutralisation and so on – others provide advice and guidance for planning, supporting and executing a demining project. This presentation describes one of the D-BOX deliverables – the Cultural Guidelines.

The cultural background of demining contractors will probably differ considerably from that of the local people. In order to foster and preserve the goodwill essential for a safe and efficient project delivery, the contractors must be aware of the cultural sensibilities of the local population. The Cultural Guidelines help demining managers to:

- develop and sustain the necessary cultural compatibility between the communities.

- promote the inclusion of local people in mine clearance projects, in recognition of their right to free choice of employment.
- improve on best practice where achievable, rather than simply reflect it.

The final Report contains 55 Guidelines, formulated as short sentences in the active voice. They are presented in four formats – by order of appearance, by phase, by task and by implementation stage. Each Guideline is hyperlinked to the discussion of the underlying issue in the body of the Report. The principal cultural issues informing the Guidelines are set out below.

2. CULTURAL INFLUENCE

A demining project will inevitably have a significant impact on the local community. There might be a large influx of (mostly male) foreign workers. Catering requirements must be met. Machinery of various sorts will require fuelling and maintenance. There might be attention from the world’s news media.

Local entrepreneurs will be quick to identify the opportunities: new businesses will be set up – cafés, restaurants, hotels, room rentals and workshops – which might involve culturally unfamiliar practices. For example, the demand for alcoholic drink might be such that its consumption becomes accepted, contrary to local tradition.

It is clear that some cultural change must be regarded as an inevitable result of increasing globalisation. However, Project managers should endeavour to limit such change to the extent felt appropriate locally.

3. THE COMMUNITY LIAISON GROUP

It is essential that the Project is perceived by the local people and observers as beneficial, legal and necessary. Moreover, it must be clear that every effort has been made to minimise any negative social consequences. For this reason, great care must be exercised when interacting with the local people and their ‘representatives’.

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A Community Liaison Group (CLG) should be formed to provide a forum for communications between the deminers and the local community. There is no guaranteed formula for selecting the members of the CLG. Demining managers must be aware that it will be tempting to accept the help or advice of those from whom it is most easily obtained, without ensuring its legitimacy, and that ill feeling might arise between those who have been selected for the CLG and those who have not.

4. CULTURAL TOPICS

4.1. RELIGION

Every religion has its customs, rites and festivals, and the demining manager must identify those of significance to the local community and the deminers themselves.

Holy days have been found to pose a challenge to demining work. In an area with several religions, there might be more than one such day in the week, or they might occur irregularly. Insofar as the productivity and safety of the Project require a unified day of rest, negotiation will be essential. It might be appropriate to adopt the holy day of the majority of the stakeholders (the migrant deminers, the local deminers and the local people) if it can be ascertained and if doing so does not seriously disadvantage any particular group.

4.2. GENDER

The concept of gender refers to women, men and the relations between them. Gender systems are institutionalized through education, politics, economics, legislation, culture and traditions. They are learned through socialisation processes and consequently are impermanent and flexible. An effective strategy for integrating an awareness of gender into humanitarian programmes is ‘gender mainstreaming’ [Ref^{vii}] – assessing the different implications for women and men of any planned action, legislation, policies or programmes, in all areas and at all levels. Gender mainstreaming integrates consideration for (and awareness of) the concerns and experiences of women and men in the design, implementation, monitoring and evaluation of policies and protocols in all contextually specific political, economic and societal spheres [Ref^{viii}].

4.3. CORRUPTION

Corruption is the abuse of entrusted power for private gain [Ref^{ix}]. It arrests economic development, prevents a free market operating for businesses and consumers and further exploits marginalised groups. For those in a developing country who cannot access health care, education or even food and water without paying bribes, it is a daily problem. The extent of corruption varies widely between societies [Ref^x]. For example, in some cultures, the payment of bribes to officials is accepted as normal, almost as a fee for a service. In others, corruption is more insidious – such as favouring people from a particular class, background or school.

Deminer managers should strive to avoid corrupt practices. The central guiding concepts are honesty, equality, openness and process. For example, goods and services should be procured for the Project in accordance with a published policy, freely available in the local community, which guarantees equal access to all tenderers. The selection of suppliers should be based on the most economically advantageous tender, perhaps (subject to local legislation) giving extra weight to social considerations such as increasing local employment.

4.4. RECREATION AND SOCIAL LIFE

Demining is dangerous and stressful for all concerned, and the mental and physical health of deminers should be safeguarded by encouraging leisure pursuits. For example, sports facilities (such as football pitches and table-tennis tables) should be provided for the shared use of deminers and the local people. The arrangements should be managed carefully in collaboration with the CLG to ensure local customs are upheld, particularly with regard to clothing, gender balance and sanitation. The overarching requirement is to ensure that the deminers are physically rested and mentally alert at the beginning of the working day.

It is important to encourage leisure activities that benefit both the local people and the deminers. For example, the deminers could provide evening classes in English and the local people could reciprocate with classes in local languages. The shared intellectual challenge would inevitably improve the goodwill between them.

Care must be taken in particular to avoid doing harm in sexual relations with local people. In particular, any

such relationships must only involve consenting adults. A gender-mainstreamed approach will help foster an awareness of the implications and consequences of such relationships for women and men. Any instances of sexual harassment must be treated seriously and dealt with immediately in accordance with the local jurisdiction.

In conjunction with the CLG, a Code of Conduct should be drawn up, to set out the behaviour expected of employees at all times. It should be reinforced by providing training in child protection, personal security and the avoidance of sexual harassment [Ref^{xi}].

5. RULE OF LAW

If the government of a country has broken down because of a prolonged period of war, its laws might be enforced sporadically, arbitrarily or not at all. However, deminers must recognise that the legal framework still exists in this situation and that when government is eventually restored any transgressions of local laws might be subject to litigation. Therefore, as far as practicable, the demining Project should be conducted under the local legal system.

The treaties and other legal understandings between states that constitute ‘international law’ are enforceable if they have been adopted and incorporated in the local jurisdiction. Deminer managers must therefore endeavour to determine the applicability of international treaties.

6. HUMAN RIGHTS

The 59 Articles of the European Convention on Human Rights [Ref^{xiii}] reaffirm the profound belief of the signatory nations in the freedoms that underlie justice and peace in the world. The EU also upholds the 54 Articles of the Charter of Fundamental Rights [Ref^{xiii}]. The Cultural Guidelines embody the human rights to which the EU subscribes.

However, while the importance of human rights is broadly accepted in the economically developed world, this is not necessarily true of the countries in which demining operations take place. The legislation described above might not be adopted there or indeed the authority of the EU and UN might not be recognised. Where government has broken down, human rights are unlikely to be respected.

In such circumstances, it should be recalled that demining is clearly for the greater good of the community and

the purpose of the Guidelines is to provide assistance in delivering the contract rather than to frustrate the negotiation of practical solutions based on compromise. Best endeavours should be used to protect the human rights of the people affected by the Project to the greatest extent practicable.

7. EMPLOYMENT

7.1. LOCAL PEOPLE

Demining managers should actively encourage the employment of local people. This not only helps to complete the Project efficiently, but also develops the local economy, feeding families and transferring marketable skills. Local labour should be engaged through an agent (perhaps via the CLG), familiar with the local laws and languages. Job advertisements should be spread widely in the local shops and in the media. The career structure provided by the employment should be explained to applicants, and career progression should be based on merit.

Gender mainstreaming will help account for the different implications for men and women of involvement in demining activity. Where appropriate, childcare facilities should be provided at the Project Camp.

7.2. RATES OF PAY

The rate at which demining workers are paid is an important ethical and cultural issue. The sponsors of some demining projects have specified a single rate for demining work in the Invitation to Tender. This ‘Equal Pay for Equal Work’ approach is preferable ethically and should be encouraged.

Often, due to the commercial imperatives of the contract, professional deminers are recruited from an economically underdeveloped country to work in a wealthy one. Despite their greater skills, this can result in them earning less than deminers recruited locally. In other cases, deminers might be brought from a wealthy country to provide expertise to a project in a less economically developed one. In recognition of the ethical problems that arise when people carrying out the same work are paid at different rates, demining managers should consider mechanisms for avoiding the perpetuation of inequality, such as payments-in-kind, family subsidies and children’s

education allowances. Demining managers have also found it helpful to provide workers only with pocket money during the course of a project, sending the remainder of their salary home. This can make the differences in the relative wealth of employees less pronounced. Equal conditions of bed and board must of course be provided for all employees.

7.3. WORKING AGE

Children should not be employed on the Project. In accordance with the UN definition of a child [Ref ^{xiv}], managers should take steps to verify that all employees are at least 18 years old. The CLG should be consulted regarding a suitable upper age limit.

7.4. EQUALITY

The Equality Act [Ref ^{xv}] provides a useful model for ensuring equality of opportunity to people whatever their gender, disability, ethnicity or sexuality. If such rights and freedoms are not supported in the local legal framework, they should be included explicitly in the employment contract.

7.5. LAND HANDOVER

The final handover of demined land is of course an event of considerable significance for the community. The land might have been inaccessible for many years, causing hardship and inconvenience to its owners, tenants and users. The demining manager must communicate to the local people complete confidence in the quality of the work. A useful strategy is to hold a sports match involving as large an area of the cleared land and as many deminers as possible.

8. DISSEMINATION

The D-BOX Cultural Guidelines Report will be published on the D-BOX website [Ref ^{xvi}] and other public platforms. The Guidelines will be passed to GICHD, for consideration as a mine action standard, and submitted as a candidate CEN Workshop Agreement, the first step in the process of establishing the Guidelines as a European Standard.

The Cultural Guidelines will also provide content for

the ‘Aide Mémoire’ for deminers, another D-BOX deliverable. Inevitably, field trials and further iterations will be necessary before the Guidelines can be established as a robust and valuable Tool. Translation into languages other than English will also be essential.

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TIRAMISU: A review of Mid-Term Progress in Developing New Tools for Mine Action

Yann Yvinec³⁷

Review of various tools under development

TIRAMISU is a research and development project funded by the European Commission. The objective 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 tools are being developed at different speed and have now different maturity. Since the project has reached the middle of its four-year duration, now is a good time to review some of the achievements.

To help non-technical survey the work on an Advanced Intelligence Decision Support System, called T AI-DSS, is worth mentioning. The work on the module for the analytical assessment of suspected hazardous areas is described by Matic et al (1). Details on the data acquisition for this tool is given by Ivelja et al (2). A key aspect of this tool is the concept used for semi-automatic interpretation which is explained by Racetin et al (3).

A light-emitting polymer sensor is being developed to detect explosives. The work of Morawska et al is presented in (5). For the development of an intelligent manual prodger, see Baglio et al(8).

Some work was done also to help bring detectors safely to a dangerous areas. For instance a metal detector array mounted on a mobile robot is being tested. More details are provided by Balta et al (6). A novel approach of using hyper-spectral cameras mounted on a ground vehicle is explored by Bajic (15). LOCOSTRA, a vehicle derived from agriculture that can be equipped with various implements, is described by Cepolina (11).

Some of the tools being design will help the disposal of explosive ordnance. An ERW blast containment vessels was field tested. The tool is described by Szczepaniak et al (10).

Two are being developed for mine risk education. A radio broadcast theater play which included mine risk education

messages was tested in Algeria. The concept of this method is given by Scapolla and Cepolina (9). A computer game, which also embeds mine risk education message is being developed and is described by Kaczmarczyk et al (12).

Training is a task of paramount importance. A human-machine interface for training activities with hand-held detector is presented by Fernandez et al (7). Operating a robotic platform also requires training. A training system for such a purpose is presented by Bedkowski et al (13).

One challenge in having a toolbox and not only a set of tools is to design tools that can exchange data with each other. The solution that is proposed is the TIRAMISU Repository System which is described by Peeters et al (4) and Lizska (14).

Standardization: two new guidelines being drafted

Two CEN Workshop Agreement are being drafted. Since the objective of technical survey is not to detect and destroy all mines, the performance of a mechanical asset used for this purpose cannot be measured only by its ability to destroy mines as in CWA 15044 (2004). A new definition of ‘performance’ and methods to measure it must be developed. The requirement for such guidelines can be found in Cepolina (16).

In 2007 CWA 15756 was drafted to specify “methods for the testing, evaluation, and acceptance of PPE [personal protective equipment] for mine action against anti-personnel blast mines”. Unfortunately some methods proved to be too severe and some PPE failed the test, despite a good track-record. This led to the withdrawal of the CWA. There is therefore a need to revise this CWA and make the test more realistic. The protection against fragmentation will benefit from the work of Kechagiadakis and Pirlot (17) who designed a system to testing equipment under near-simultaneous triple impacts to take into account that an explosion of a mine or ERW generates multiple fragments that may hit a PPE nearly simultaneously with consequences that are very different from multiple single impacts.

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T-AI DSS module for analytical assesment of MIS data

Cedo Matic¹, Davor Laura¹, Andrija Krtalic²

Abstract

The crucial document for the success of T-AI DSS application is the analytical assessment of the suspected hazardous area (SHA) based on data and information that are available in MIS of MACs. The outcomes of this analysis are the general and specific requirements for the airborne and space borne collecting and producing new, additional data, information and evidences about the former situation in SHA. The requirement for improvement of this module implies the determination of general guidelines for the implementation of this analysis in any MAC's of mine-affected countries. According to this requirement, within this T-AI DSS's module, general guidelines for conducting of the analytical assessment for better definition of the SHA and the definition of general and specific requirements for the collection of additional data (with T-AI DSS) for better re-definition of the SHA have been developed.

1. Introduction

T-AI DSS is a tool to support decision about the status of SHA. The input includes data from mine information system (MIS), expert knowledge, airborne and satellite data, contextual data, etc. The outcomes are detected and proved positions of indicators of mine presence (IMP) in space, reconstruction of battlefield (in time and space), better (re)definition of SHA, proposals for exclusion from or inclusion in the SHA (thematic maps). The requirement for improvement analytical assessment of (MIS) data module of T-AI DSS refers to the need to determine the general guidelines for the implementation of this analysis in any MAC's of mine-affected countries. Due to this requirement, general guidelines for conducting of the analytical assessment for better definition of the SHA and the definition of general and specific requirements for the collection of additional data (with T-AI DSS) for better re-definition of the SHA should be developed within this T-AI DSS's module. Another requirement for the research within the scope of this module is the need to develop simplified version of the T-AI DSS (without the airborne multisensor acquisition and satellite images) that can be used in MAC's for the support of the SHA assessment, reduction, re-categorisation and inclusion, only with indicators of mine presence and mine absence derived from MIS data and MAC's standard operational procedures.

2. Analytical assasment

Analytical assessment for the process of collecting additional data on a SHA consists of an in-depth comprehensive analysis and interpretation of all previously collected data stored in the MIS. Furthermore, analytical assessment is a basic stage in the processes of technical and non-technical surveys of SHA. Primary goal of analytical preparation is spatial positioning and contextual interpretation of all the data stored in the MIS. This makes a strong analytical basis for identifying general and special requirements for collecting data on SHA which are missing in the MIS. Analytical assessment and its results (general and special requirements) are desirable preconditions for high quality usage of AI DSS in humanitarian demining.

The results of analytical assessment should provide:

- Assessment of the condition of the SHA based on existing data,
- Assessment of rough boundaries of the SHA within which data will be collected, and
- Requirements for data collection in the field.

Mine action experience in the Republic of Croatia and Bosnia and Herzegovina has shown that minefield records and other fundamental documents about minefield laying do not provide complete and precise data which would enable to determine realistic condition of the SHA. In specific war-time conditions, mine laying documents were not always made, existing documents are incomplete or imprecise, some have been lost or destroyed during the war, and some of them are probably still unavailable. This is why all available data related to mine laying should be researched through analytical assessment, in a systematic way, in order to make up for the lack of original mine laying documents.

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Due to the fact that original mine laying documents are missing or they have not been made at all for certain areas, SHA assessment must be focused on the research of the way in which the war was fought, on the history of military activities during the war and on reconstruction of the battlefield. In such conditions, research of consistency of military activities, terrain characteristics and engineer support of combat operations, is of utmost importance in achieving an optimal assessment of the SHA condition.

Analytical assessment comprises the following procedures: investigation of existing data and phenomena, examination of their content, comparison, systematization and gradual integration according to military activities and order of battle in a certain area. In doing so, it is important to explore the chronology of military activities during the war, with a special emphasis on relocations of units and other indicators of organization and implementation of defensive and offensive activities that influenced the construction of barrier minefields.

The experience from the Homeland War in the Republic of Croatia (1991-1995) and Bosnia and Herzegovina has shown frequent cases of shifting of defensive lines and positions (temporal component in analyzing the condition of the SHA), introduction of new units into the existent order of battle, certain *overlap* of areas of responsibility of the units in new situations on the battlefield, or of taking over the positions of the opposing side. Such cases can make the mine contamination situation more complicated. They require serious analytical work through the process of preparing for collection of data in the field.

2.1 The tasks of the analytical assessment

In order to understand the working process better and to implement the process in a more efficient way, the tasks of the analytical preparation for collection of additional data may be conditionally divided into three groups:

1. Individual analysis of existing data, entering the data into the MIS, reliability assessment of the positions shown on GIS maps (a part of MIS containing geographical and geodetic bases used for entering and positioning data in the MIS) and defining of requirements for data collection in the field.
2. Integration of existing data into the system of organization of defensive and offensive activities of the units, improvement of the results shown on GIS maps and definition of requirements for data collection in the field.
3. Analytical assessment of the initial SHA state, with a list of requirements for collection of additional data about the terrain.

The first phase of the process of analytical preparation for collection of additional data about SHA is the analysis of existing MIS data. The tasks of analytical preparation of the existing data comprise the following:

- detailed individual analysis,
- comparison and linking of data,
- spatial positioning (on GIS maps),
- entering (storing) into MIS and
- gradual interpreting according to dynamics of fighting and disposition of units on the battlefield.

In order to fulfil the tasks of analytical preparation, suitable GIS maps are needed that will allow marking of geospatial data as accurately as possible. Different symbols, colours, cross-hatches and other signs should be used in data presentation, in order to ensure that the data, functional ownerships and mutual relationships of the elements inside a system of organization of the defence of the units are clearly shown.

Through analytical assessment, additional data for MIS are created. In order to enter (store) the data obtained by analytical preparation, it is necessary to create adequate overviews in form of vectors and tables. Through final integration of all available data, these overviews will enable detection of new indicators of constructing barrier minefields in certain areas. That is to say that it is necessary to determine positions of all material or contextual data about barrier minefields (obtained by analytical preparation), as precisely and as accurately as possible, on GIS maps, and store them in MIS, in form of a symbol, a line or a polygon.

The overview of analytical assessment tasks comprises data which in practice can appear as existing data or mine contamination indicators in the system of organization of disposition of units in defensive and offensive activities.

2.2 Significant factors for analytical assessment

The analysis of the following factors has significant impact on fighting characteristics:

- Area (type of terrain) where the fighting takes place,
- Time when the fighting takes place,
- Combat capability of the opposing troops,
- Level of technical equipping of the opposing sides,
- Force and equipment usage skills.

Analytical assessment for collection of additional data about SHA is a process in which we should analyze all existing data individually, present the data, as precisely as possible on GIS maps and store the data in MIS; identify their connections through integration according to chronological order of military activities and create an analytical assessment of the condition of the SHA. At the same time, through the process of analysis, we identify missing data which should be collected for better assessment/definition of the existing SHA assessment. In this way, analytical assessment represents the basis for collection of additional data about mine contamination situation in specific areas.

The given concept of analytical assessment presumes that, when making an assessment, it is necessary to detect the cause and effect connections between mine laying and the course of military activities. Analyzing and integrating available data, it is necessary to reconstruct the laying of minefields resulting from war-time military activities, and disposition of units on the battlefield.

2.3 Basic activities in the analytical process

Investigation and analysis of available data, spatial representation of data on GIS maps and storing in MIS, are basic activities in the analytical process of assessing/defining the SHA. In general, these activities are conducted through continuous work, i.e. continuous redefining of SHA is conducted on the basis of newly collected data. Specific information tools are created for storing the data, in order to enhance efficiency of data comparison, their integration and establishment of links between construction of minefields and disposition of units in a specific phase of military activities. The area of analytical work is a rough area which requires to make analytical assessment of the SHA and to define requirements for collection of additional data.

A rough area may be:

- the overall area covered by war-time military activities for the purpose of creating the initial assessment of the condition of SHA for mine action purposes,
- areas that were not fully researched through previous data collection activities, i.e. areas with imprecise and insufficient indicators of the SHA condition,
- areas expected to meet conditions for exclusion of certain areas and buildings from the SHA,
- areas planned for humanitarian demining, so that development of demining projects can be as precise and of highest possible quality.

The borders of the area which is to be analyzed are harmonized with the order of battle of both conflicting sides and organizational military units which were active in the area.

3. Conclusion

The above presented procedures define important indicators of the condition of SHA, so that the mine action system in any given moment may have relevant data for efficient planning and organization of humanitarian demining activities. The results of the overall analytical work will greatly depend on expert military knowledge, skills and affinities of the members of analytic teams of researchers. The main results (for T-AI DSS usage) of analytical assessment are definition of general and special requirements for collection of additional data with T-AI DSS. Someone should assess the possibility to use T-AI DSS for collection and processing of all available data (MIS data and additionally collected data).

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Data acquisition within T-AI DSS

Tamara Ivelja¹, Ivan Racetin¹, Andrija Krtalic¹

Abstract

The module of T-AI DSS for data acquisition should provide the stability and reliability of (aerial) data acquisition on each platform. Subsystems (system configurations are different for different platforms) for aerial data acquisition will be examined on multiple platforms (Mi-8, blimp, Bell-206) and should have stable operation, without cancellation, on every platform. A new system for aerial hyperspectral survey: *TIRAMISU light hyperspectral imaging system* (T-LHSIS), was conceptualized by CTDT, designed, constructed and manufactured by FGUNIZ. T-LHSIS was tested on two platforms: blimp and Bell-206 helicopter by CTDT and FGUNIZ. The features of the system shown in the following text. T-LHSIS is a new tool, which can be used as stand alone equipment or in T-AIDSS. The helicopter Bell-206 is a new platform which can be used within T-AI DSS. The continuous and stable electricity supply for the aerial acquisition multisensor subsystem is re-designed, developed and built up in T-AI DSS. It is necessary to provide the independence of the power supply for the aerial acquisition system of AI DSS. This module is used for the collection of additional data from the depths of SHA. The requirements (general and specific) for the collection of additional data on SHA-in are the result of work in the module for the analytical assessment of the data in MIS.

1. Introduction

The aerial acquisition multisensor subsystem of existing AI DSS (before TIRAMISU) consists of:

- matrix cameras: Nikon D90 (collects information in the visible part of the spectrum), DuncanTech MS410 (collects information in the visible and infrared part of the spectrum, 0.4 – 1 μm) and Photon 320 (collects information in the thermal part of the spectrum, 8-14 μm),
- hyperspectral linear scanner (ImSpector V9, collects information in the visible and infrared part of the spectrum, 0.43 – 0.9 μm),
- system for power supply (batteries, system to retrieve the current from the Mi-8 platform),
- navigation devices (inertial measurement unit (IMU) - iMAR, GPS devices),
- desktop computer, laptops (for navigation and iMAR management), monitor.

The current sub-system of AI DSS, module for aerial multisensor data acquisition, has been re-designed and used in military helicopters Mi-8 and Bell-206 (from 2008 to 2011) (Fiedler *et al.*, 2008), (ITF, 2010 and ITF, 2011). But, the military helicopter Mi-8 has limited availability, the flight cost is high (in Croatia) and in some mine-affected countries it is unavailable. Bell-206 is more accessible and less expensive platform but much smaller payload (only one operator for all function modules for aerial data acquisition). The dependence of the variety of electrical power sources used in the helicopter decreases the operational availability of the system. On board of the helicopter Mi-8, the following sources of the electric power were used:

- own batteries (batteries, one weighing 75 kg (210 Ah), and one smaller about 10 kg (45 Ah), 12 V DC,
- 28-30 V DC from the helicopter's spare generator,
- inverters from 28-30 V DC to 220 V AC 50 Hz.

Before TIRAMISU project, the flying platforms used for aerial data acquisition (within AI DSS) were helicopters. During the series of tests and airborne missions, several technical disadvantages of this flying platform were detected. This included the issues related to the stability of platform (minimum speed for safe flight, the critical speed) and vibrations they caused during the flight. These disadvantages influenced the quality of the collected data (images, GPS data, flight parameters: roll, pitch and yaw). These requirements are largely related to survey with the hyperspectral line-scanner and to pre-processing of hyperspectral images (parametric geocoding).

To achieve the images with good quality, the following requirements for platform and sensor have been defined:

- It needs to be able to operate at low speed.
- It needs to be able to operate at low heights.
- Platform swinging and vibrations must be minimal.

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The aerial acquisition multisensor subsystem of existing AI DSS (before TIRAMISU) consists of:

- matrix cameras: Nikon D90 (collects information in the visible part of the spectrum), DuncanTech MS410 (collects information in the visible and infrared part of the spectrum, 0.4 – 1 μm) and Photon 320 (collects information in the thermal part of the spectrum, 8-14 μm),
- hyperspectral linear scanner (ImSpector V9, collects information in the visible and infrared part of the spectrum, 0.43 – 0.9 μm),
- system for power supply (batteries, system to retrieve the current from the Mi-8 platform),
- navigation devices (inertial measurement unit (IMU) - iMAR, GPS devices),
- desktop computer, laptops (for navigation and iMAR management), monitor.

The current sub-system of AI DSS, module for aerial multisensor data acquisition, has been re-designed and used in military helicopters Mi-8 and Bell-206 (from 2008 to 2011) (Fiedler *et al.*, 2008), (ITF, 2010 and ITF, 2011). But, the military helicopter Mi-8 has limited availability, the flight cost is high (in Croatia) and in some mine-affected countries it is unavailable. Bell-206 is more accessible and less expensive platform but much smaller payload (only one operator for all function modules for aerial data acquisition). The dependence of the variety of electrical power sources used in the helicopter decreases the operational availability of the system. On board of the helicopter Mi-8, the following sources of the electric power were used:

- own batteries (batteries, one weighing 75 kg (210 Ah), and one smaller about 10 kg (45 Ah), 12 V DC,
- 28-30 V DC from the helicopter's spare generator,
- inverters from 28-30 V DC to 220 V AC 50 Hz.

Before TIRAMISU project, the flying platforms used for aerial data acquisition (within AI DSS) were helicopters. During the series of tests and airborne missions, several technical disadvantages of this flying platform were detected. This included the issues related to the stability of platform (minimum speed for safe flight, the critical speed) and vibrations they caused during the flight. These disadvantages influenced the quality of the collected data (images, GPS data, flight parameters: roll, pitch and yaw). These requirements are largely related to survey with the hyperspectral line-scanner and to pre-processing of hyperspectral images (parametric geocoding).

To achieve the images with good quality, the following requirements for platform and sensor have been defined:

- It needs to be able to operate at low speed.
- It needs to be able to operate at low heights.
- Platform swinging and vibrations must be minimal.

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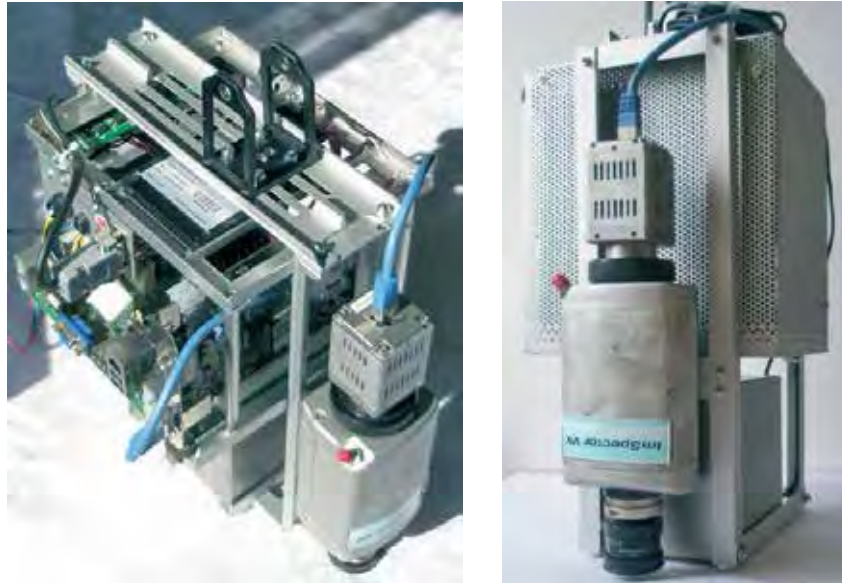


Figure 2. Two versions of the construction of T-LHSIS.

2.3 Platforms

The surveying with T-LHSIS was made with two platforms: blimp and Bell-206 helicopter. Due to the fact that it previously used the Bell-206 helicopter (during the development of the AI DSS before TIRAMISU), this platform was used for hyperspectral surveying of exploded ammunitions depot in Padjane.

2.3.1 Blimp

Operability of T-LHSIS has been tested on blimp (Figure 3) in relation to the given requirements. Controllability of a blimp has been tested, as well as the quality of collected hyperspectral images during these flights. T-LHSIS is controlled wirelessly from the ground.



Figure 3. Blimp with T-LHSIS (in two green rectangles).

The declared favourable flight parameters (characteristics) of this particular blimp are: low speed flight (about 4-5 m/s), low altitude flight (less than 30 m) and insignificant swinging and vibrations. The main restrictions of this particular blimp (before testing) are: the maximum bearing weight (payload, 3,8 kg), pilot must have visual contact with the aircraft during the entire flight, the system is powered with battery of 12 V DC (2200 mAh/12V), resulting in short duration of the flight (about 30 min with payload of 3,8 kg (weight of T-LHSIS, Table 1).

Declared flight parameters were not confirmed during the testing in the operating conditions. The declared minimal flight altitude (less than 30 m) and speed (about 4-5 m/s) for the platform for hyperspectral survey were different after testing in operating conditions. Furthermore, the test results showed that the greatest limitation of this blimp was associated with the flight parameters: roll (rotation of blimp around the axis of the direction of flight) and pitch (rotation of blimp around an axis perpendicular to the direction of flight). The combination of the impact of these parameters caused unacceptable deformation of hyperspectral images. The results depend primarily on the specific atmospheric conditions in the moment of surveying and the combined influence of pitch and roll parameters. On the platform and on T-LHSIS, certain changes were made (in attempt to reduce the influence of these phenomena) that resulted in reducing the phenomenon (pitch has decreased to about 2° and roll to about 6°). But still, the range of roll parameter remained high (over 6°) and it was very difficult to control. The distortion was still present to great extent.

2.3.2 Bell-206 helicopter

Bell-206 helicopter was re-entered in the focus of interest as a platform for aerial data acquisition sub-system of T-AI DSS after the production of T-LHSIS and after unfavourable results of testing the system on blimp. This platform (figure 4) is more easily accessible and much cheaper (about 6 times per hour) than the Mi-8 helicopters.



Figure 4. Helicopter Bell-206 with the T-LHSIS in the orange-black container installed under the helicopter.

The declared flight parameters (characteristics) of Bell-206 helicopter are: minimum steady flight speed is about 70 km/h, minimum height of stable flight with minimum flight speed is about 200 m (above ground), and the endurance is about 2:15 h. Compared to the blimp, Bell-206 helicopter can carry a higher burden, there are fewer problems with roll and pitch parameters, but the vibrations are higher. Furthermore, the minimum speed and height for hyperspectral recording are much higher. Vibrations, minimum speed and flight altitude are lower (more favourable) than with Mi-8 helicopter, but the capacity is smaller, there is no power supply from the helicopter and only one operator can go with the system.

After defining and eliminating some technical problems with T-LHSIS, the confirmed endurance during testing and surveying was not less than 2h, and the performance was mostly stable. The recorded data and flight parameters were very much satisfactory. Low value of oscillation of the flight parameters led to high quality of parametric geocoded hyperspectral images.

3. Conclusion

This module should ensure the stability and reliability of (aerial) data acquisition for non-technical survey of SHA on each platform. The new power supply system for module for aerial data acquisition (for Mi-8 platform) which is re-designed, developed and built up for T-AI DSS improve the robustness and stability of the system. These changes have resulted in changes in the configuration of the system for aerial data collection.

Subsystem (system configurations are different for different platforms) for (aerial) data acquisition was examined on multiple platforms (Mi-8, blimp, Bell-206) and can operate in stable manner, without cancellation, on Mi-8 and Bell-206 platforms (helicopters).

A new system, T-LHSIS, for aerial hyperspectral data survey has been produced. Technical stability and robustness of the T-LHSIS was confirmed by testing and evaluation (based on the behaviour of the system during the data collection over the test areas) of the systems on different platforms and operational missions in Croatia in the period from June 2012 to July 2013. Blimp can fly with T-LHSIS but it is difficult to be managed, and the parameters of the conducted flight do not provide a satisfactory quality of hyperspectral images. So, the testing of the blimp as a platform for T-LHSIS (line scanner for hyperspectral survey) disqualified it for further testing. A similar platform will be tested for a matrix cameras of T-AI DSS. Flight parameters of Bell-206 helicopter as a platform for T-LHSIS provide a satisfactory quality of hyperspectral images. T-LHSIS is a new tool, which can be used as stand alone equipment or within T-AIDSS.

4. Acknowledgement

These are people who have participated in these activities on a project TIRAMISU (for CTDT or FGUNIZ, in alphabetical order): Milan Bajic, Hrvoje Gold, Tamara Ivelja, Tihomir Kicimbaci, Marko Krajnovic, Andrija Krtalic, Josipa Nikolac, Ivan Racetin, Luka Valozic, Dejan Vuletic. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2012-2013) under grant agreement n° 284747, project TIRAMISU.

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The concept of method for semi-automatic interpretation within T-AI DSS

Ivan Racetin¹, Andrija Krtalic¹, Zlatko Candjar¹

Abstract

Computer-assisted image processing for extracting of IMP on the basis of object oriented analysis (using images segmentation) was carried out (by means of factor and cluster analysis) within the interactive interpretation of images. The final evaluation will be conducted by experienced interpreter and it will be also carried out on the basis of NIIRS and IQM parameters. The one aim of this research is to establish a methodology and guidelines for interactive semi-automatic interpretation of digital images in humanitarian demining for the purpose of detection and extraction of (strong) indicators of mine presence and absence which can be seen on the images. The experience gathered in working with AI DSS in undertaken projects led to the conclusion that a man (the human eye and contextual view on the scene) as interpreter (of mine scene) can hardly be replaced by automatic methods of digital image processing. However, some methods of digital image processing (implemented in certain ways) may help the interpreter in the identification of certain anomalies in the scene and easier detection of indicators. The basic idea of interactive methods of semi-automatic interpretation of digital images of SHA is to provide assistance to the interpreter in the interpretation of digital images rather than to replace him. The objective of this method is to be sensor independent and independent of object of research. The concept of this method was defined and initial research carried out in 2013.

1. Introduction

The one aim of this research is to establish a methodology and guidelines for interactive semi-automatic interpretation of digital images in humanitarian demining for the purpose of detection and extraction of (strong) indicators of mine presence and absence which can be seen on the images. The experience gathered in working with AI DSS in undertaken projects led to the conclusion that a man (the human eye and contextual view on the scene) as interpreter (of mine scene) can hardly be replaced by automatic methods of digital image processing. However, some methods of digital image processing (implemented in certain ways) may help the interpreter in the identification of certain anomalies in the scene and easier detection of indicators. The basic idea of interactive methods of semi-automatic interpretation of digital images of SHA is to provide assistance to the interpreter in the interpretation of digital images rather than to replace him. The objective of this method is to be sensor independent and independent of object of research.

2. Method for semi-automatic interpretation within module of T-AI DSS

The method consists of the following procedures (figure 1):

- Pretreatment of images and transformation into other forms of display – PCA, ICA, CIELAB,
- Segmentation,
- Statistical analysis of the parameters of segments - finding of isolated parameters,
- Using of common methods of images processing - according to isolated parameters,
- The combination of the results of image processing - to enhancement objects.

2.1 Pre-treatment of images and transform into other forms of display

Image enhancements (PCA, ICA), processing (TVI, NDVI,...) and transformation in different color space (CIELAB) have aim to rearrange information in order to obtain independent entities for further processing. The accent will be focused much more on the benefits of chosen enhancement or transformation to another colour space than the actual mathematical and scientific background.

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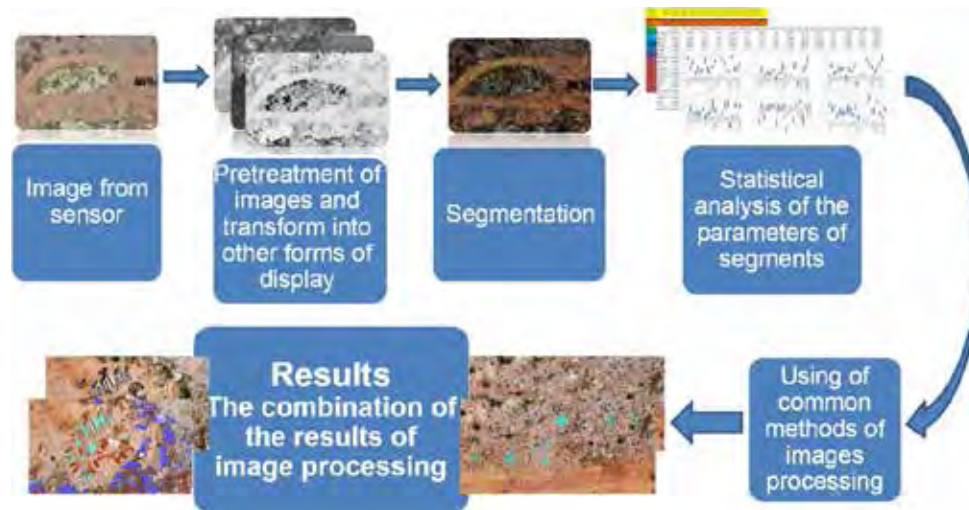


Figure 1. Schematic representation of Method for semi-automatic interpretation within module for T-AI DSS.

2.2 Segmentation

For the purpose of feature analysis of each indicator (object) on the digital image, it is necessary to determine the pixels that form the object in the image. Image segmentation is used for this procedure within the T-AI DSS. Statistical methods like factor and cluster analysis are used for radiometric and geometric analysis of these newly created segments.

The segmentation of digital images is a process of decomposition of digital images into smaller parts (segments) that have common characteristics (features). For this research, multiresolution segmentation (Figure 24b) is performed within the software package *Definiens Professional 5.0* (DEFINIENS, 2006). Multiresolution segmentation algorithm is an optimized heuristic procedure that minimizes locally averaged heterogeneity of objects within the image resolution images, and is based on five criteria: scale parameter, colour, shape, smoothness and compactness (DEFINIENS, 2006).

Related parameters as colour and shape, and smoothness and compactness. The sum of the coefficients of their impact is always 1, and the condition is that the colour parameter can never be 0. Segmentation is performed on a set of images of different resolutions and it is therefore possible to weight the images according to the needs of analysis and resolution of images. All these segmentation parameters depend on the scale of images (pixel size and resolution) and the size of the object.

2.3 Statistical analysis of the parameters of segments

The segments represent the observed indicator and the objects that surround it (for analysis of the degree of discrimination of targeted objects from the environment) in the best possible way. Statistical analysis of radiometric and geometric parameters is performed in order to identify parameters which will enable discrimination of targeted objects from the environment. That can be distinguished according to their feature values. If it can't be done directly, with one processing, then a combination of processing is looked for which can extract the desired object (an indicator or some percentage of its surface) on the resulting image.

The inputs for statistical analysis are digital numbers of pixels and statistical parameters of the segments (radiometric (figure 2) and geometric) which are incurred in the process of segmentation. Radiometric parameters that were used in research are: mean, standard deviation and coefficient of variability.

Cluster analysis indicates classification of segments according to their characteristics. First, the clusters (categories, classes) of entities were formed according to some common characteristics, and then the relationships between them defined. The specificity of this approach relates primarily to the use of cluster hierarchical clustering methods by which it is possible to homogenize the group in some set in objective manner.

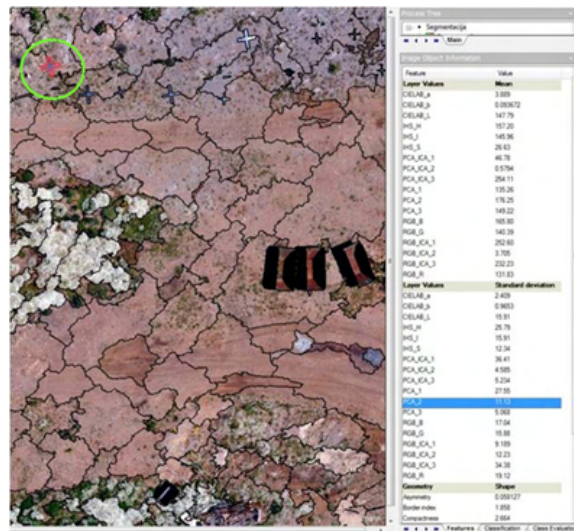


Figure 1. Segmented image (aluminium cross in green circle) and statistical parameters of one segment (right table).

Research for the semi-automatic methods of interpretation was carried out with the indicators of mine presence (on images from previous projects) and UXO (area exploded munitions depot Padjene). In this paper are shown only analysis of UXO.

3. Analysis of UXO

The object of interest, in this case are unexploded ordnances (UXO), but this method is possible to apply to any other object of research which can be seen on the digital images. The data used for this research are visible (by Nikon D90 matrix camera, Figure 4a) and near infrared (by DuncanTech MS4100 matrix camera, Figure 4b) aerial images of exploded ammunition depot located in Padjene, Croatia. The unplanned explosion, caused by extensive forest fire, happened on 13 September 2011, and the airborne multisensor mission, covering the area of interest was executed from 11 to 15 June 2012. The consequence of the explosion were spatially scattered UXOs. The aim of this study is to examine the possibilities of enhancement or extraction of UXO's using known techniques of digital image processing, or combinations of these results.

This kind of data analysis, as already said, is independent of the sensor used. The only difference can be in the image processing which is possible for given sensor data. Aerial images of the area where explosive materials are located (controlled by the military) that can be found in the area of interest and marked with aluminium crosses (for better detecting of explosive devices in the figures) were selected for initial analysis (Figure 4).

The first step needed to do is to execute the series of various image processings which will help the photo interpreter in his work. In this special case, transformation in CIELAB colour space has been used. Apart from that, Principal Component Analysis (PCA) and Independent Component Analysis (ICA) have also been applied, and for the sensor with data from near infrared spectrum, vegetation indexes have also been calculated. The second step is to perform multiresolution segmentation (Figure 3).

After the preferred image processing had been performed, all this newly created data was imported into software supporting the object oriented analysis (Definiens Professional 5.0). This data can be seen as new channels or layers which are added to original image. By segmenting the image and obtaining the adequate image objects (segments), it is possible to acquire and export extensive data sets about radiometric and geometric parameters of objects of interest.

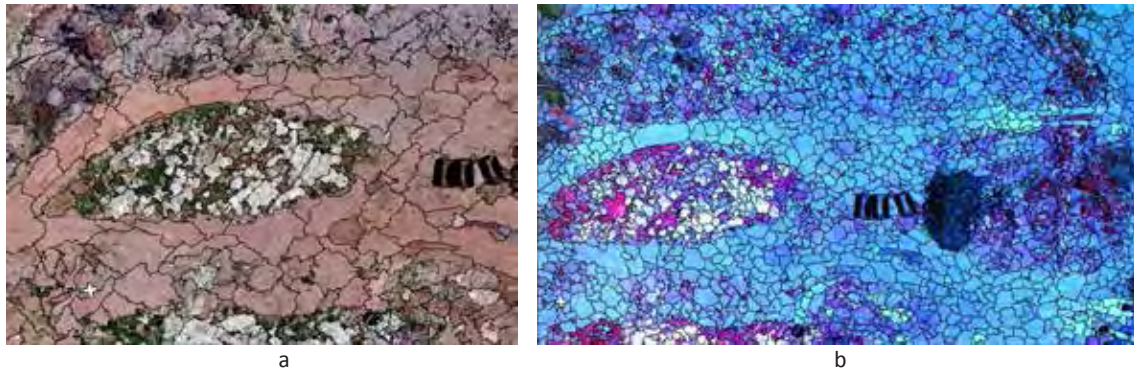


Figure 3. a) The segmented colour image captured by the Nikon D90 camera. b) The segmented infrared colour image captured by the DuncanTech MS4100 camera.

The next step of computer supported interpretation is further analysis of statistical parameters with the aim of finding regularities in a set of images (thresholds, raster calculator) by which the desired objects can be extracted. By setting a threshold for a particular feature (mainly radiometric), it is possible to highlight certain binary objects of interest. Furthermore, these binary images are suitable for raster calculation with the aim of highlighting or marking certain objects in the pictures.

Access to the selection of the threshold parameters can be twofold. The first approach involves the selection of such thresholds, which will directly extract only the object of interest or more of them. Another approach involves capturing objects that are not of importance, such images are used as a mask to input images. In cooperation with photo interpreter, it is possible to make conclusion about capabilities of interpretation of targeted objects. It is a kind of internal evaluation of the method. The goal is to determine which objects are and which cannot be interpreted on given images or their processing.

3.1 Preliminary results

The best response is from targeted objects which are made of polished aluminium, and not corroded, this includes following UXOs: Training missile VRZ 57mm P1, some pieces of Artillery shells 130TF for M46, Air cluster bomb RBK – 250 and Cluster bomb BL-755, container for cluster bomb. It must not be forgotten that airborne mission was executed nine months after the accident, and most of UXOs were already rusty in the time of the mission.

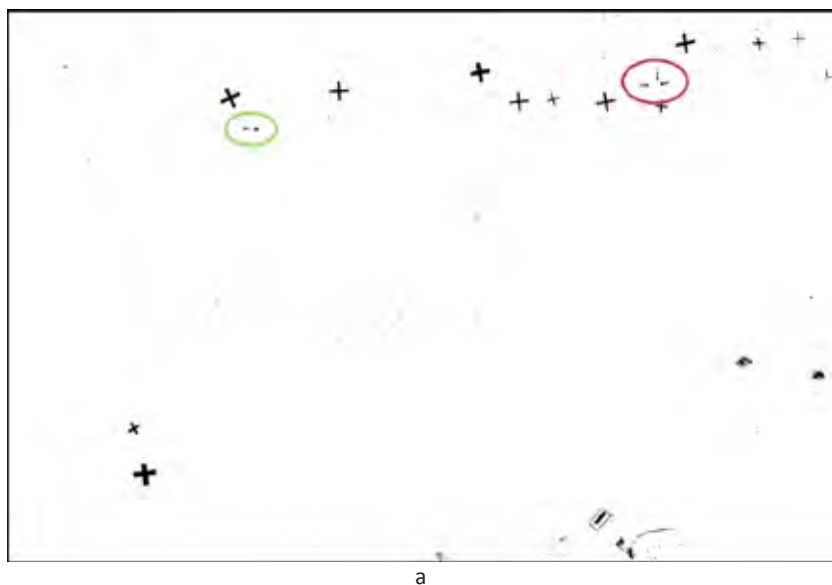


Figure 4. a) The main (binary) result of established method in the research carried out so far. The positions of two types of explosive ordnance: air cluster bomb RBK (green ellipse) and VRZ training missiles (red ellipse) and polished aluminium crosses (black crosses) are clearly separated from the environment.

Statistical samples were the basis for determination of threshold values and for the selection of channels in order to achieve the desired results. In the pictures that are shown above, a part of the original image (figure 4) can be seen, as well as the results of applying the thresholds and raster calculation of the images and their processing.

4. Conclusion

Defined concept of Interactive semi-automatic interpretation of digital images in humanitarian demining for the purpose of detection and extraction of UXOs (strong) or indicators of mine presence and absence which can be seen on the images # showed some potential in practice. The research by means of the method for semi-automatic interpretation will continue in 2014. It is necessary to direct research towards integrating the analysis of radiometric and geometric parameters of the segments, and to exploit all the advantages given by one and the other. Furthermore, if possible, it is necessary to find the legality of the parameter values of the same object in different images and terrains. This would be a way to write guidelines for the implementation of processing to extract specific objects of interest in digital images.

5. Acknowledgement

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2012-2013) under grant agreement n° 284747, project TIRAMISU.

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Centralized data management in the demining world : the Tiramisu Repository Service

Dirk Schmidt, Gerd Waizmann, Didier Peeters, Sepp Riesch, Björn Liszka, Eléonore Wolff

1. Introduction

Demining is a dangerous activity. It is also a complex series of operations, ranging from satellite images study to the practical disposal of unexploded ordnances. Whether it is operated by national authorities or by mandated private companies it requires a good economy and an efficient management to achieve its task over time and proceed by priority order.

Every year new tools and methods are proposed and tested for this never efficient enough discipline lacking of means and time. Efficient or not these tools are essentially addressing specific tasks, field mine detection, personal equipment, GIS, management, ...

Each task is more and more efficiently operated and the whole activity has become more and more complex, so that a missing link has appeared right in the center of the set: a way to manage and integrate all the valuable information produced all along the line of operations.

As a demining toolbox producer the TIRAMISU project has introduced the idea of centralizing the information produced at each step and used by its tools in a specific structure, free to use and open to any other tools.

2. Questions

- What data/info does a 15-25 year demining mission handle?
- How is the data/info communicated between actors in the demining mission?
- Is the data/info (and if so how is it) evolving over time?
- How do we assure traceability in the data/info over time?
- Is it possible to supplement sensor data to improve quality assurance and liability?
- What are the “lowest common denominators” regarding this data/info?

- When there is a lot of data/info... How do we easily find what we are looking for?
- Is it possible to safeguard that the data does not fall into the “wrong hands”?
- Who is in charge of the data/info?

3. Description

More than a software, what we actually propose is an operational standard for data storing and exchange between all the contributors of a local demining organization. The objective is to address all the questions and needs expressed above, and to improve the security on the field by providing accurate and exhaustive information, as well as the overall efficiency of the management.

Practically, the Tiramisu Repository Service (TRS) is a database with geographical capabilities, working in a client-server architecture and in which different tools store and read data. The inner structure is made of tables in which the data are organized so as to ensure the efficiency of the whole system and to secure the storage. It will be hosted in an office on a desktop computer and will have its robust, battery-driven field lighter version for accompanying the field missions. So the TRS centralizes the information and makes it available to all the tools whenever and wherever they need it.

As in the usual IT world what we call a standard is *a normative specification of a technology or methodology*, applicable here to the IT demining operations. Its objective is to guarantee a universal compatibility between different systems developed independently.

In the text below we will distinguish two different versions of the TRS:

- the National repository hosted in the national demining headquarter,
- and the Field-TRS which is hosted on a rugged Unix-box (or perhaps even on a laptop) and used outdoor.

What tools are involved

We consider different types of tools to benefit from the data repository:

The data producers

These are expected to be, by nature, the main data providers.

- The sensors:
Sensors are producing information related to the UXO detection; usually they produce a signal when encountering a potentially hazardous object. After a field screening information has been produced which could be advantageously stored. This information is basically 'where' the UXO's are, when they were detected and by what system. Tiramisu is also developing a companion device called the TCP Box [1] that will provide a high precision location and a time stamp, which is designed to communicate the data generated by the sensors and transfer them to the repository. Consequently the UXOs data will be kept as well as the precise delineation of the places without any UXO's.
- The GIS data and operations [2]:
The repository includes the support of geographical data type, vectors and rasters. Basic geographical data (e.g. satellite or aerial images, digital terrain model or topographic maps) as well as geographical data, resulting from Advanced General Survey (AGS) and Non-Technical Survey (NTS) can be stored and accessed from regular GIS softwares (QGIS, GVsig, ArcGIS, MapInfo, GRASS, ...). The functionalities of the repository itself allow also the direct GIS processing.
- The 'human' information sources:
Expertise and population survey are also a source of information that will be stored in the repository through some interface, like web-based interface.
- The field observations:
During the field work and/or during the inspection missions data will be collected regarding the possible presence of UXO's or assessing the suspected hazardous areas (SHA) determined by previous operations.

Storing this information will allow for improving the already stored information and will generate a useful feedback.

- The regional geographical information:
Besides the data generated by the demining activity other information can be stored, as the communication networks, the regional topology, the soil coverage, the cadastre, ... This general information is useful for the general management of the demining activities.
- UXO's description databases and other international demining oriented databases.

The data users

Any actor of a Mine action Center (MAC) is a possible data user, including those who are also data providers. The data stored in the repository can feed specific tasks and can be used for general reporting of the ongoing or past work. Whatever the schedule of the successive demining operations, the data produced at each step is always available, even if the operations are interrupted by long periods of inactivity. Moreover the data stored in one local unit can be easily centralized in the headquarter.

As stated above the data is also useful for preparing field missions and a snapshot of the repository can be transferred to the Field-TRS to make the previous information available on the field.

- Different tools can use data produced elsewhere.
The TRS replaces in this case the numerous files produced for storing and exchanging data and always likely to be duplicated, with all the problems of incoherences between the versions of the same file, or lost in a file system complicated by the succession of operators.
- The management:
can take advantage of a centralized architecture for reporting or statistical study of the activity and the efficiency of the tools involved. The different databases of the MAC's antennas can be merged into a single structure.
- The engineers:
can use the stored data to study carefully the

situation and develop better procedures or new functionalities.

How it works, what it does, what it does not

The main function of the TRS is to store and share the data generated during all the demining operations in a predefined structure designed to cover all the aspects of the activity in an efficient and secure way. The TRS aims at supporting the regular activities - not to do any of them - and to enhance their efficiency by ensuring a better data exchange between all the actors.

- **GIS side**
Strictly talking the GIS side can be considered as a module providing the specific structure for the AGS and the NTS, coming from the development made in the TIRAMISU project on this topic. Aerial and satellite images would be stored after initial and very specialized processing, as well as the general geographic information and the SHA resulting from the NTS tools. The storage of the detected mines is more related to the field detection side, but the NTS could also process information stored in documents giving the mine positions.
- **Sensors side**
Sensors are usually not designed for communicating with a database server, therefore their data will reach the TRS via the TCP-Box, which transfers the sensor data wireless from technical survey – attached with a timestamp and a geo-coordinate – to the field repository service (TRS).
- **Others (Management)**
By keeping track of the activities and results, the TRS is an obvious excellent source of information for documentation, reporting and decision support. This aspect is nevertheless left aside for later development, once the essential ones are done. These functionalities will be efficiently be handled by web interface, but many systems could be used to query the database and synthesize its content.

- Data exploration and Interaction between people, tools and data flow
- Direct connection, web interface or MaXML for standardized data exchange

Technical installation description

Technically speaking the TRS is characterized by :

- a client - server architecture, based on the DBRMS PostgreSQL, which is a professional standard available with an open-source license.
- a compliance with most of the operating systems (Windows, Linux, Mac, ...)
- Multi-users access control: PostgreSQL provides infinite possibilities of access rights tuning
- GIS efficient with the PostGIS extension: PostGIS is the spatial extension of PostgreSQL. It provides the support of geographical data types and hundreds of functions for GIS processing.
- web interface for displaying purpose and exchange: the OGC web-based communication protocols (WMS, WFS, WPS, WCS) will also be implemented.
- open for free further developments: as a SQL and PostGIS system the TRS offers the ability to query the database and to develop custom functions, without the need for any extra license.

Scalability / Openness / Adaptability

Because of the openness of the TRS, it is possible and highly desirable that other actors, among which the MAC, develop their own functionalities to enrich the TRS capabilities. As it is said above there are different ways to interact with the TRS and as long as the authority in charge of operating the system allows it by defining the access rights, anything is possible. Moreover the add-ons developed by third parties could easily be shared between the different actors.

4. Scenario

To illustrate the role of the TRS here's a simple scenario of hypothetical successive demining operations:

1. Limited-size satellite images or aerial photos over a mine contaminated suspected area and/or vectorial delimitations/characterizations of SHA (= Suspected Hazardous Areas resulting of the remote sensing analysis) are stored in the TRS by analysts using Land Impact Survey Tools,
2. and transferred to a field device (tablet or laptop) for exploration purpose. [Result: a SHA is identified and reported to a field device.]
3. In the field a report is generated (possibly with T-IMS), then stored in National TRS.
4. The geographical material and the field report are used for further analysis. The analysis result with the image(s) – now probably augmented with drawings/markings from the analysis staff – is stored in the TRS.
5. The analysis result is used for decision makers to task a Technical Survey Team (TST) to enter the area. The task is defined in an order generated from data stored in the TRS.
6. A “snapshot” with the relevant data is transferred from the National-TRS to the Field-TRS.
7. During Technical Survey, the sensor data of the mine detector(s) with position and timestamp are stored in Field-TRS.
8. Map layers for image and sensor data are generated to show this data in the GIS and browser based in the field on the tablet PC of the Head of the Technical Survey Team, combined with the tracks.

adjunction of new ones. A demonstration version is being developed within the TIRAMISU project with a very limited number of sensors and a set of GIS functions. After this initial step new tools will be added.

5. Implementation strategy

Due to its modular structure (GIS, sensors, management, ...) the TRS can be initiated with a minimum of functionalities and grow with the

6. Schematic technical description

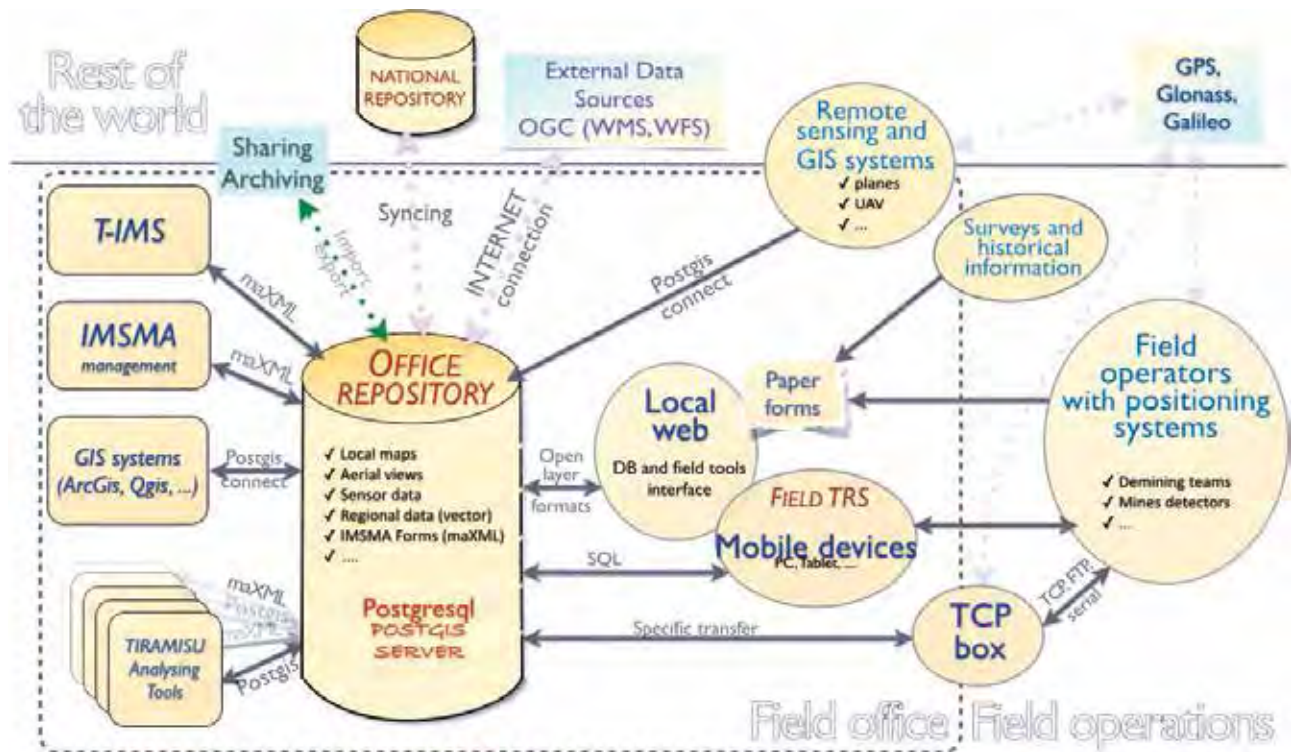


Figure : the mine action data workflow with the TRS

Description of the elements in the graph

• IMSMA

We imagine here a possibility to interconnect IMSMA with our TRS for sharing data, but this is only a technical possibility not a project yet. It would be an interesting feature for the MAC users.

• GIS

systems Having a PostGIS server allows to process the data with many different GIS software, like (among many) QGis which is a free software and offers tools to execute PostGIS functions, or ArcGIS which is a proprietary software and for which an institution like the GICHD has developed tools like MASCOTT to compute action priorities and which uses geographical data. TRS allows the users to keep their own GIS system, as long as they respect the standards (see below).

• Analyzing tools

As TIRAMISU is developing tools - not only GIS tools - TRS is their source of data and storage system. Any tool will be able to access any kind of required data with the same easiness without having to wait look for it. This should open the possibilities for all the developers. After the end of Tiramisu, other developers, like people working in MACs, will be able to easily create new tools, for instance with the PostGIS functions, and share them with whoever they want.

• External data sources

We consider here the possibility to download data from external sources whenever an internet connection is available. This could be mines data, maps, or any useful existing database..

• Local Web

A local web interface will be set up to allow users to easily enter data coming from sources that don't use a standard

communication protocol. This means that users can manually or semi-automatically import data.

- **Remote sensing and GIS systems**, like aerial images or specific geographic data will be imported in the TRS.
- **Surveys and historical information** the information collected from the population and/or from military archives or others may also be used to describe the hazards and this information can therefore be stored in the TRS through a web interface.
- **The sensors** used in the fields will also of course produce data to store in the TRS, while these can also receive data (like soil texture, geo-references, previous results...) from the TRS in order to be tuned before the detection work. This is likely to be done through a box (the TCP box) which will make the interface between the sensors and the TRS.
- **GPS, Glonass, Galileo**: In the field the sensors get their positioning from any of the three possible satellite systems.

- **Sharing and archiving**: The database can be shared, or a snapshot can be exported in a “central” TRS, supposedly at the national level. This allows large scale analyses to be made by the national authorities. There must also be a backup system to protect the data. Finally it is also possible to load some data into the TRS through the same dumping/restoring feature.

Using the TRS

The final user will not have to «work» himself on the TRS. TRS will be hidden and used by the software that connects to it when necessary. It is exactly the same situation for IMSMA which has also a storing system in a relational database, while the regular user can't «see» it.

Nevertheless it is possible for «power» users to act directly with the database functions and develop new tools, even in a MAC, since it only requires knowing the SQL language and the GIS functions. The developers, like the partners in TIRAMISU, have to design their tools so that the data retrieving and storing will be done in the TRS.

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The development of light-emitting polymer sensors to detect explosives for humanitarian demining

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Abstract — This paper presents an overview of progress towards the development of a compact polymer-based explosives vapour sensor, under development within the TIRAMISU project for the detection of landmines. Materials optimisation of the sensor films is discussed and a novel LED-powered polymer laser sensor is presented.

1. Introduction

A current challenge for the mine action community is how to increase the efficiency of landmine clearance. The TIRAMISU Project aims to address this issue by developing a toolbox of detection and disposal tools that advance and complement the technologies currently in use. In humanitarian de-mining it is necessary to achieve complete removal of explosive ordinance before land is released back to the local community. The processes of close-in detection and disposal of landmines is slow and costly, and so it is important both to identify the correct search area and to minimise the false alarm rate of positive detections.

Close-in detection of buried landmines commonly uses metal detectors. However these can suffer from false positive detections of innocent fragments of metal. Combining metal detectors with ground penetrating radar can help to reduce false detections, but it would still be desirable directly to detect the presence of explosives in the proximity of a possible landmine. An approach which sensitively detects explosive vapours in a technology that could be correlated with a metal detector search would help characterise buried objects as landmines.

One approach to reducing the area required for mine clearance is to make a technical survey using remote explosive scent tracing (REST). The REST technique involves drawing air and dust into a storage filter, to sample for explosives over a survey area. The filter is subsequently presented to animals (dogs or rats) to sniff for traces of explosives^[1]. This approach has been successfully implemented with animals by Mechem and others, but there could be advantages in using a sensitive electronic detector that can quantify the explosive residue in the filter, or even identify the constituents.

Within the TIRAMISU project, we are currently developing novel polymer-based sensors for detecting explosive vapours from landmines. These sensors work by detecting a change in the light emission from a semiconducting polymer film.^[2] When exposed to very dilute vapours of TNT-like compounds, the explosive molecules adhere to the film and turn off the light emission, due to a molecular interaction between the polymer and sorbed TNT molecules (figure 1). If the plastic film is removed from the vapour, the concentration of explosives molecules in the film decreases and the light emission returns to its original efficiency. In this paper we describe progress towards the development of a compact polymer-based explosives

vapour sensor that could be used for on-field mine detection. We describe the underlying principle of operation, optimization of polymer film properties for fast detection and implementation of a compact prototype sensor using a plastic laser powered by an LED.

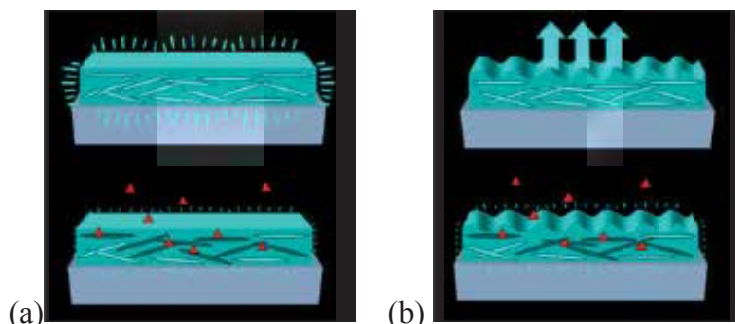


Figure 1 (a) concept of explosive vapour sensing using fluorescent polymer films (a) and polymer lasers (b). (a) Top panel shows blue fluorescence from a film of polymer molecules (blue rods). Bottom panel shows effect of TNT vapour exposure- when the TNT molecules (red triangles) come into contact with the polymer chains they switch off much of the light emission. (b) Top panel shows a blue laser beam emitted from a corrugated film. Bottom panel shows effect of TNT vapour exposure, switching off the laser emission, leaving only weak fluorescence.

2. Principle of sensor operation

The underpinning principle of detection is via a change in the light emitted from a luminescent semiconducting polymer film.^[2] When a very thin film, typically a few 100 nm in thickness, is illuminated by UV or blue light, it absorbs the light and re-emits it in a longer wavelength range as fluorescence. If the film then comes into contact with explosives vapours such as TNT or a similar nitro-aromatic compound, some molecules of the vapour will adhere to the surface of the film and may penetrate deeper into the polymer. These explosives molecules can then have a dramatic impact on the light emission. For now if the UV light is absorbed in the film near one of the explosives molecules, it is more likely that the photo-excited polymer will transfer an electron to this molecule than emit light. As a result the light-emission from the film rapidly decreases with time (see for example figure 2 for the change in light emission from a polyfluorene film when exposed to vapours of various analytes). If the plastic film is then removed from the vapour, the equilibrium concentration of explosives molecules in the film decreases and the light emission returns to its original efficiency. Fluorescence sensing has previously been studied in laboratory conditions and in the field as the Fido sensor from Flir Systems.

As well as having an effect on fluorescence, the presence of the explosive vapour can also quench laser emission from the polymer films.^[3-6] When suitably designed and photopumped with intense pulses of light, the luminescent polymer films can generate short pulses of laser light.^[7] Usually this involves a configuration in which the polymer film is deposited on a nanostructured substrate to form a plastic distributed feedback resonator (figure 1(b)). Above a characteristic minimum excitation intensity of a pump laser (the so-called laser threshold), laser action from the polymer film starts, emitting a well-defined beam of light from the surface of the film. The presence of the explosive vapour can increase this laser threshold thereby switching the polymer laser between laser emission and normal fluorescence, and

affect other characteristics of the laser operation. The lasers have potential for higher sensitivity and faster response to the presence of the explosive vapours than fluorescence based sensors.^[4-6]

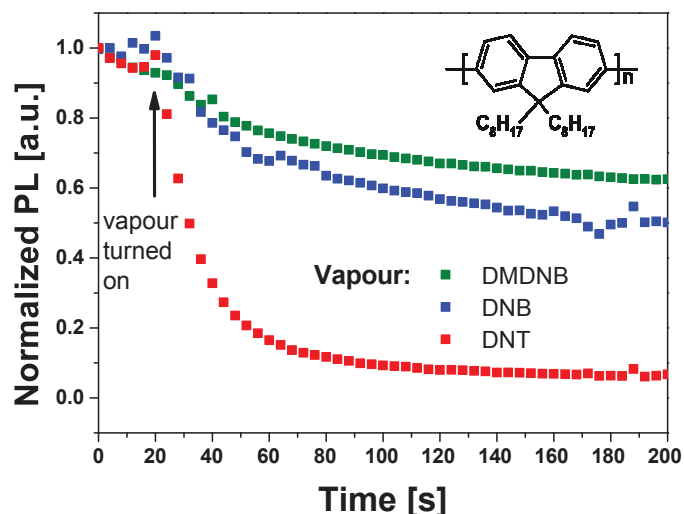


Figure 2. Example response of a polyfluorene sensor to DNT, the simulant DNB and taggant DMDNB. Inset shows molecular structure of polymer.

3. Molecular optimisation of polymer sensor element

The development of the explosive sensor requires optimizing the response to nitro-aromatic vapours (including speed of response, sensitivity, selectivity and ability to reset the sensor). Once the vapours have been sorbed into the polymer film, the change in light emission depends on interactions between the molecules on very short length-scales. To control these, we have studied various aspects of the molecular design, film conformation and preparation processes.

We have been studying how the molecular design of the light-emitting material can offer the best configuration for future sensor applications. This is achieved through vapour sensing tests using families of molecules with systematic changes in the length of the side arms off the polymer backbone. Such studies allow nanometre-length control of the gaps between the molecules in the sensor film, which can potentially affect the sorption of explosive molecules into the film and the efficacy of the sensor quenching mechanism. We find that denser films can improve the speed of response and sensitivity to vapours.

We have also been exploring how to optimise the fabrication of the polymer film. The deposition process for the polymer film can strongly affect the molecular conformation, and in turn its optical and sorption properties. During this study it was found that the spin coating of films of polyfluorene from different solvents, and at different temperatures, could significantly affect the sensitivity of the sensors. We found that an enhancement of the sensitivity and recovery (sensor reset) process for the sensor can be obtained by controlling the amount of β -phase molecules in a polyfluorene film (the β -phase is a more ordered molecular conformation of polyfluorene polymer).

4. LED-powered polymer laser sensor

A key step to compact and light-weight versions of a polymer laser based vapour sensor is to achieve very low-threshold laser operation to allow them to be combined with a compact pump source. We developed state-of-the-art polymer lasers that can be integrated with, and powered by, a pulsed LED as shown in figure 9, and showed that the laser could be used to detect ppb levels of nitroaromatic vapours, with scope to detect lower concentrations. Details of this prototype sensor was published in *Laser and Photonics Reviews*.^[8]

The laser was based on the green fluorescent polymer BBEHP-PPV and configured as a surface-emitting distributed feedback laser. This was fabricated by depositing a thin film of the light-emitting polymer on a specially designed nanostructured glass substrate which controls the propagation of light in the film. The laser was mounted in contact with a commercial blue LED, which was driven with a pulsed current source. Above a threshold LED intensity the film emits a green laser beam, which was detected and characterised by a spectrometer and fast photodiode.

We investigated the response and sensitivity of the InGaN LED pumped BBEHP-PPV laser sensor to the presence of dinitrobenzene vapours (a simulant for TNT/DNT with a vapour pressure similar to TNT).^[8] We monitored changes in the LED intensity required to initiate laser action and in the output efficiency of the plastic laser. The DNB concentration was varied in the parts-per-billion range using a calibrated vapour source. These studies show that the preferred approach for gaining the lowest limit of detection will be to monitor the change in the laser emission intensity when the sensor is operated in a regime in which the presence of vapours can switch it from laser operation to fluorescence, Figure 9. Experiments to extend these measurements to lower concentrations are underway by combining a commercial Owlstone OVG-4 vapour source with an in-house designed apparatus for vapour dilution.

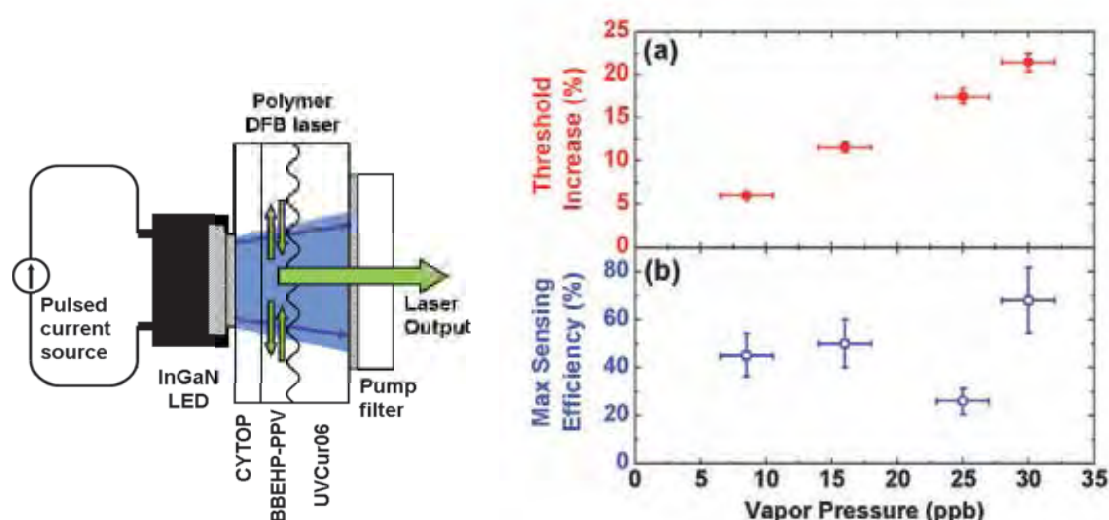


Figure 9. Left: schematic design of the LED-pumped polymer laser sensor. Right: (a) Increase in the laser threshold due to the exposure to the different DNB vapour pressures (b) maximum sensing efficiency of the laser sensor as a function of DNB vapour concentration. Reproduced with permission from reference ^[8].

5. Modular design of compact sensor system

We are currently developing a compact and portable vapour sensor system suitable for field tests planned in 2014 and 2015. The portable sensor system has a modular design, and several different modes of operation are anticipated for explosives detection:

- *Stand-alone “safe/unsafe” operation.* This base functionality allows the user to operate the platform with the aim of detecting the presence of explosive vapours; when vapour is detected an audio-visual alarm is triggered. This method indicates a threshold quantity detected but does not provide more quantitative information
- *Integrated monitoring.* The sensing system will monitor changes in light emission which should be able to be calibrated to provide vapour concentrations according to the received signal from the microprocessor. In this mode the sensor output is sent via USB to a computer; this can be upgraded to communicate wirelessly at a future stage. It is expected that power can be supplied by the carrier vehicle/robot in the field, but an internal battery can supply power otherwise.
- *Polymer laser explosive detection.* This functionality includes a commercial laser head to pump the polymer film (which is configured as a polymer laser), where the polymer laser emission is subsequently quenched by introduction of explosive vapour into the polymer matrix. For more robust operation in initial trials, a commercial pump laser has been selected for the initial implementation. It is envisaged that this could be replaced in the future by the more compact LED pump module.
- *Photoluminescence explosive detection.* This method is similar to the threshold detection functionality, and offers the potential for a lower weight and power implementation by using a simpler excitation source, but may not provide the same level of sensitivity or response time.
- *REST filter sampling.* The sensor will interface with a REST filter in a sealed container to allow it to measure the equilibrated vapours in the container. In preliminary tests we have found that vapours from explosive particles can readily be detected after 20 minutes settling time (at 20°C) for particle mass/container volume ratios down to ng/ml. With longer settling times and higher temperature, lower limits of detection are anticipated.

6. Conclusions

Within the TIRAMISU project, we are developing compact sensors to detect vapours of explosives from landmines and other unexploded ordinance. We have been optimising the response of detection of polymer films through studies of molecular design, processing and with combinations of different materials. A prototype test using an LED-powered polymer laser sensor has been successfully shown to detect nitroaromatic vapours, and a modular compact sensing system is currently under development. During the next phase of the project, the optimised materials will be tested in the compact sensor system, in laboratory and field

tests during 2014 and 2015. Another aspect of ongoing research involves the improvement of the selectivity of the sensor to discriminate against potential distractions in the field.

7. Acknowledgements

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Integrated Mobile Robot System for Landmine Detection

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ABSTRACT: In this paper, we discuss the integration process of a mobile robot and multi-channel metal detector system intended for humanitarian demining applications within the EU FP7 TIRAMISU project. The paper describes how a standard tele-operated Explosive Ordnance Disposal (EOD) robot was upgraded with electronics, sensors, computing power, motor control units and power sources, such that it becomes able to execute humanitarian demining tasks. To be able to detect land mines we have integrated with the mobile robot platform a multi-channel metal detector system which is a specialized sensor system for demining platforms developed by Vallon GmbH. In order to evaluate the proposed system integration we have performed first test and validation activities done at the SEDEE-DOVO test field (dummy minefield and UXO test site) of the Belgium Defense. Our first data acquisition results obtained during test and validation activities with the systems are reported. Lessons learned during the work conclude this paper.

KEYWORDS: Mobile robot, Multi-Channel Metal Detector, Landmine Detector.

1. INTRODUCTION

The idea of using robotics for humanitarian demining and/or advanced light-weight modular low-cost robots for technical survey and/or close-in-detection has been proposed by numerous authors [1]. Even though none of the current robotics platforms seem to have reached production on a larger scale (except for military EOD/IEDD tasks), many lessons may be learned from several projects and experiences. Robotics solutions properly sized with suitable modularized structure and well adapted to local conditions of dangerous unstructured areas can greatly improve the safety of personnel as well as the work efficiency, productivity and flexibility. In this sense, mobile systems equipped with manipulators for detecting and locating antipersonnel landmines are considered of most importance towards autonomous/semi-autonomous mine location in a proficient, reliable, safer and effective way [2].

In this paper we describe the work effort done within the EU FP7 TIRAMISU project¹. The TIRAMISU (which stands for Toolbox Implementation for Removal of Antipersonnel Mines, Submunitions and UXO) project aims to provide the foundation for a global toolbox that will cover the main mine action activities, from the survey of large areas to the actual disposal of explosive hazards, including mine risk education and training tools.

The results presented in this paper are developed within the WP 310 Tools for Close-in-detection for the Sub-WP314 Multi-Channel Metal Detector (MCMD). The goal of VALLON GmbH was to develop a Multi-Channel Metal Detector for integration with the mobile robotic platform tEODor, which was upgraded by RMA. In order to evaluate

¹ More information about TIRAMISU (www.fp7-tiramisu.eu).

the proposed system integration we have performed first test and validation activities at the SEDEE-DOVO test field (dummy minefield and UXO test site) of the Belgium Defense. Our first data acquisition results obtained during test and validation activities with the systems are presented in the paper. The same platform may be used for in-field quality tests.

2. SYSTEM SETUP

2.1 tEODor MOBILE ROBOTIC PLATFORM

The mobile robotic platform used for the integration with the MCMD is shown in Figure 1. The base vehicle of this unmanned platform consists of an Explosive Ordnance Disposal (EOD) robot tEODor, a heavy outdoor robot. We chose to use a standard EOD robot platform for several reasons:

- As a platform, it has proven its usefulness in dealing with rough terrain with excellent maneuverability and good off-road performance.
- With a gross load weight of around 350 kg, it makes it possible to carry multiple sensors and on-board processing equipment.
- The rugged design of the platform makes it capable of handling unfriendly environmental conditions.
- Recycling a standardized platform is a good means of saving costs and avoiding buying expensive dedicated platforms.



Figure 1 tEODor mobile robotic platform with the MCMD

An important drawback of the standard tEODor platform is that it does not feature any autonomous capabilities. To overcome such a constraint the tEODor platform was upgraded by RMA with necessary electronics, sensors, computing power, motor control units and power sources in order to be able to execute remote controlled and semi-autonomous tasks. More information can be found in [3, 4].

During our past field demonstration tests we have discovered that the tEODor platform has proven its usefulness in dealing with rough terrain, with excellent maneuverability and good off-road performance. In addition, the rugged design of the platform makes it capable of handling unfriendly environmental conditions which is crucial for demining tasks. Some of the characteristics of the RMA tEODor platform are given in the table 1.

Table 1 Characteristic of the RMA tEODor mobile robot platform

Length:	1300 mm ≥1350 mm (system in packing position)
Width:	700 mm
Height:	(depends if we have the sensors or not attached to the robot) without sensors it is around 1000 mm
Weight:	350kg (standard configuration including batteries without sensors) the MCMD is around 27 kg
Speed of the platform*:	max. 3.0 km/h
Turning circle:*	1460 mm (theoretical)
Climbing ability (slopes):*	45 °
Climbing ability (obstacles):	250 mm
Wading depth:	≤ 250 mm
Payload:	≤ 200 kg
Power supply:	Lead-gel rechargeable battery; 4 x 12V, 85 Ah
Battery charger:	Standard AC connector input (AC 230 V/50 Hz)
Endurance (Nominal life)*:	approx. 2-3 h mixed operation
Temperature range :	-20 °C to +60 °C
Remote control operational range*:	around 50 m

* Depending on surface and environment conditions

2.2 MULTI-CHANNEL METAL DETECTOR SYSTEM

The MCMD system from VALLON, shown in Figure 2, is a specialized sensor system for demining platforms. It provides five 30 cm coils (overlapping perpendicular to the direction of movement to reduce sensitivity variation over the width) with a differential setup (which has lower sensitivity than absolute coils but is far less responsive to external EMI disturbance). The coils are arranged in a plane to allow for minimum standoff height of the coil plate and for best sensitivity.

The MCMD consists of 5 independent metal detectors; their data stream is gathered by an embedded platform based on an OMAP3 board with embedded Linux and is made available as streaming data via Ethernet. OMAP3 stands for is an *Open Multimedia Application Platform it is an image/video processors developed by Texas Instruments*. For wireless connectivity a WLAN - Access point was used as an Ethernet to WLAN Bridge for the Metal detector (TPLINK consumer type).



Figure 2 Five Channel Metal Detector from Vallon GmbH

2.3 MOUNTING MECHANISM

Figure 3. shows the mounting mechanism of the coil plate. On the back and front side of the coil plate spoilers are mounted that enable the plate to slide over obstacles.



Figure 3 Mounting mechanism with the MCMD and the tEODor platform

3. ADDRESSED ISSUES DURING INTEGRATION

During the integration work we have discovered several issues:

- Electromagnetic interference from the motor drivers of the tEODor coupling into the coils (radiated): We measured the rms noise with the motors either off or on (a handheld detector was lying in 50 cm distance on the ground in front of the vehicle):
 - Differential 30 cm coil: 53 LSBrms w/o motor, 58 LSBrms with motor.
 - Absolute 30 cm coil: 62 LSBrms w/o motor, 66 LSBrms with motor.

This proved the tEODor mobile robot as an ideal platform for integrating the Multi-Channel Metal Detector System as it did not significantly decrease the signal to noise ratio of the sensor.

- Electromagnetic interference from the power supply into the detector electronics (conducted): Noise of the MCMD was app. 280 LSB when being supplied directly from the tEODor mobile robot. An additional filter in the power supply line could improve the noise to the values shown above.

4. TEST AND VALIDATION ACTIVITIES

In order to evaluate the proposed system integration we have performed first test and validation activities done at the SEDEE-DOVO test field (dummy minefield and UXO test site) of the Belgium Defense (located in the city of Meerdaal, Belgium). A conceptual view of the Dummy Minefield and UXO Test Site can be seen in Figure 4. The test site is delineated by three zones with a total size around 15 x 7.5 m.

The configuration of the zones is given below:

- Zone 1: Anti-personnel mines & grenades (depths from 1 to 3 cm)
- Zone 2: Anti-tank mines (depths from 10 to 20 cm) & UXO (depths from 10 to 30 cm)
- Zone 3: UXO's (depths from 10 to 30 cm)

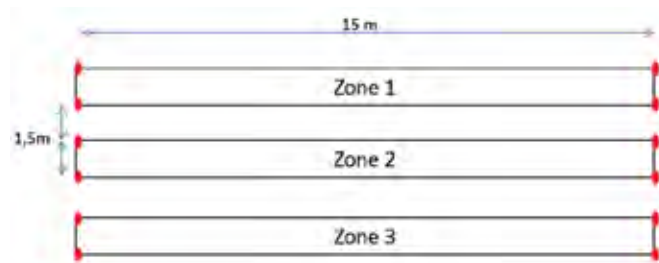


Figure 4 Conceptual view of the Dummy Minefield and UXO Test Site

Examples of field demonstrations are shown in Figure 4.



Figure 4 Presents some instants of the Dummy Minefield and UXO Test Site activities.

5. RESULTS OF THE TEST AND VALIDATION ACTIVITIES

The test zones 1-3 were scanned with the sensor, however a geo-referencing system based on GPS navigation device (e.g. TCP box) was not available at the time of the test so the sensor data could only be referenced by time. This leads to a time shift of objects between the scans. First R&D measurement data were gathered with the Vallon client software, which under development for TIRAMISU. Then data were evaluated in an experimental manner by Scilab 5.4.1.

The Figure 5 shows the color maps of all three zones, as the exact location of the objects is not yet known the probability of detection cannot be calculated yet but will be once the positioning data is available.

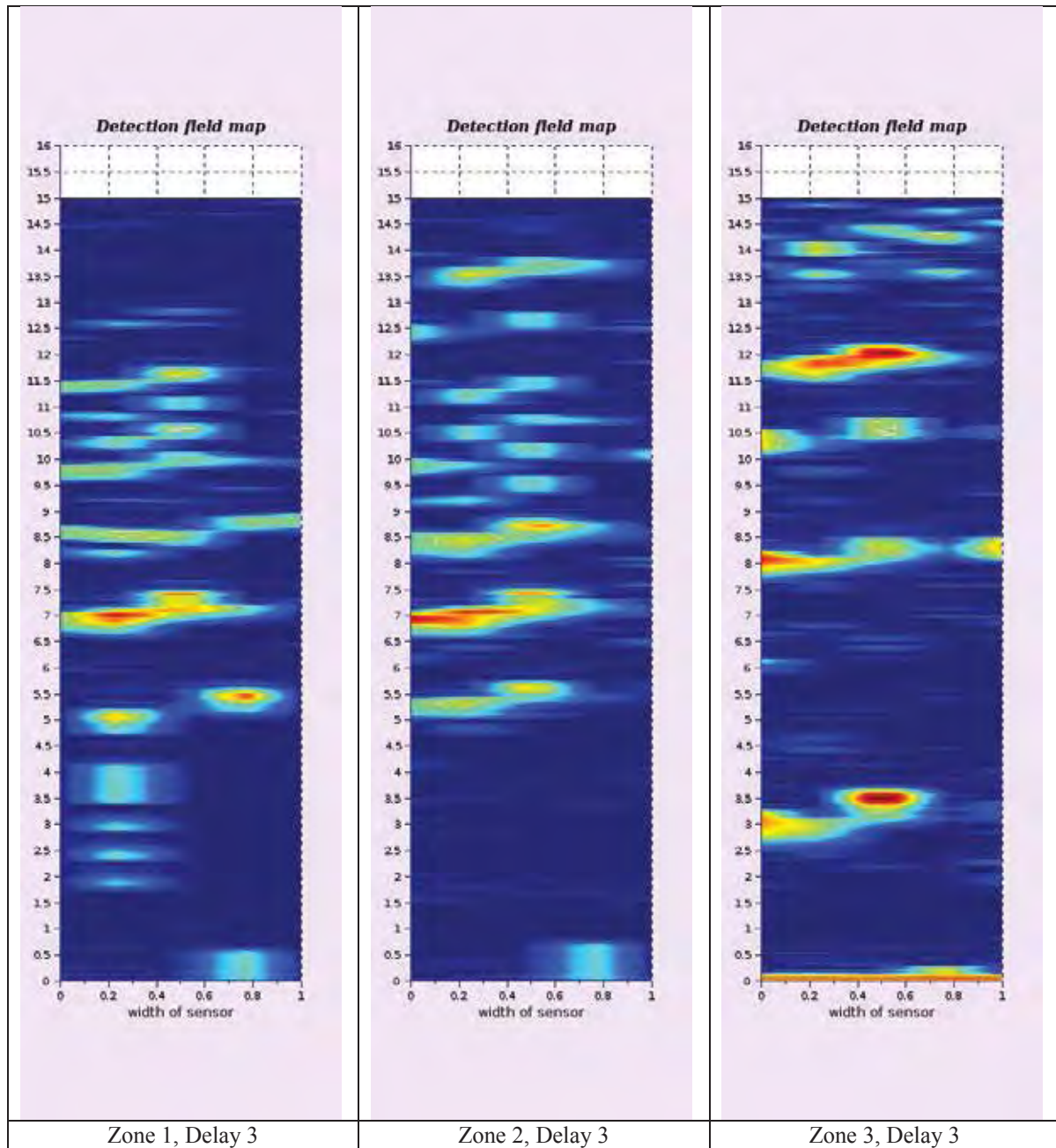


Figure 5 Color plot of all three zones

6. CONCLUSION

In this paper, we have presented an Integrated Mobile Robot System for Landmine Detection. We show how an upgraded tele-operated Explosive Ordnance Disposal (EOD) mobile robot was integrated with a multi-channel metal detector system which is a specialized sensor system for demining platforms developed by Vallon GmbH. In order to evaluate the proposed system integration we have performed first test and validation activities done at the SEDEE-DOVO test field (dummy minefield and UXO test site) of the Belgium Defense. Our first data acquisition results obtained during test and validation activities with the systems are reported.

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 of the TIRAMISU Project.

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DESIGN OF THE HUMAN MACHINE INTERFACE FOR TRAINING ACTIVITIES WITH HAND-HELD DETECTORS

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Abstract

This paper presents the preliminary design of the Human Machine Interface (HMI) that has been conceived for improving the training activities of demining operations carried out with hand-held detectors. The proposed system can be used in two different scenarios: when the expert's skills are studied in order to quantify some critical performance variables that could help to update the training goals and strategies, and when the deminers' performance is evaluated during the close-in-detection training tasks, in order to provide significant feedback for improving the human operators' competences. The HMI will assist in gathering, analysing, presenting and consolidating the information acquired with the hand-held detector sensory tracking system that has been especially designed for interacting with this application. The friendly graphic user interface will present the data received in an efficient format, maximizing the instructor's ability for monitoring, processing and assessing the trainee and/or the expert performance. The different components, features and functions of the HMI are described in detail through this document.

Introduction

Today, most humanitarian demining is done by using hand-held detectors, attempting to carefully locate each explosive item and then either blow it up or burn it in situ, or render it safe and remove it for dismantling or disposal elsewhere. Although metal detectors are utilised as the principal equipment for detection due to its simplicity and affordability, dual sensors are taking increasingly acceptance in the demining community [1]. Those dual sensors that combine an electromagnetic induction sensor, ground penetrating radar (GPR) and sophisticated algorithms offer better and more reliable detection capabilities than other options that are still under research, such as the nuclear quadrupole resonance technology and trace/vapour detection [2-5].

The way human operators interact with the hand-held detectors during the close-in detection tasks largely determines their effectiveness and inherently the safety of the operations. That is the reason why training offers the possibility to optimise efficiency and get the best out of both user and equipment. A training tool for analysing with the final goal of improving the use of hand-held detectors in humanitarian demining has been proposed within the framework of the TIRAMISU EU Project [6-7]. The tool consists of a Human Machine Interface (HMI), and a hand-held detector sensory tracking system. 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:

1. The study of the expert's skills by quantifying some critical performance variables, so that they can be used later as reference values for the training tasks.
2. The efficiency evaluation of novice operators during the training tasks with hand-held detectors in order to give them feedback about important information for improving their competencies.

The emphasis in this article will be put on the design approach selected for the HMI. The interface will be responsible of collecting the data acquired by the hand-held detector sensory tracking system, processing and analysing the measured performance variables, and presenting the essential information required during the training sessions. The rest of the paper is organised as follows. Section 2 briefly introduces the hand-held detector sensory tracking system responsible for acquiring the performance data during the training sessions. Section 3 explains the methodology adopted for the design of the HMI. Section 4 describes the screen components, links and functions of the HMI and finally, Section 5 summarises major conclusions.

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Hand-held detector sensory tracking system

A metal detector VMC1 manufactured by Vallon [8] has been selected as hand-held detector for the sensory tracking system. 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 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.

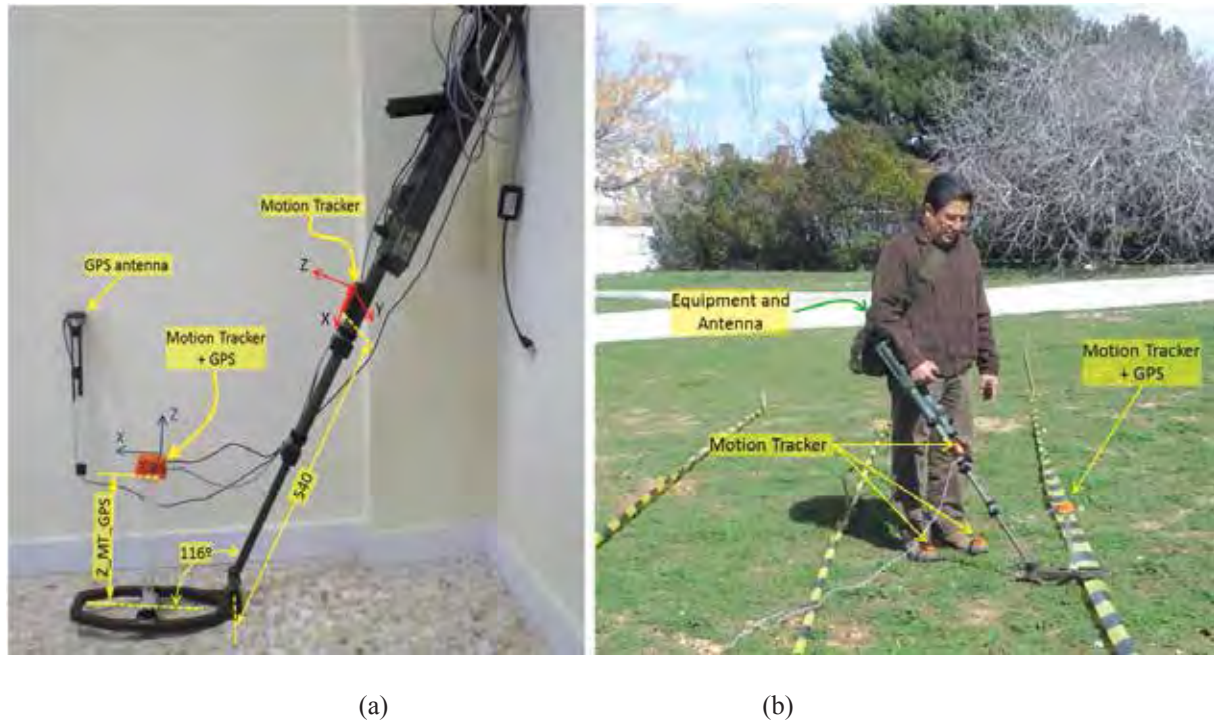


Fig. 1. (a) Hand-held detector instrumentation. (b) Operator with hand-held detector training tool during outdoor experiments at the Centre for Automation and Robotics – CAR (CSIC-UPM).

HMI design process overview and methodology

The HMI design process consists of three differentiated phases: (i) Assessment of HMI needs and requirements, (ii) Design of the graphical user interface, and (iii) Identification of HMI design considerations. A fourth phase that includes post-implementation activities would start after the design of the HMI is complete and it would close the design cycle.

Following the flow described above (see Fig. 2), the design process started with a review of the SOP carried out with hand-held detectors, the functional needs, systems requirements and the objectives of the training activities. The review performed is based both on findings from literature and on dedicated interviews and workshops with representatives of various institutional and private organisations that are concerned with training for humanitarian demining. Next, main functionality and key components of the HMI were identified and defined, and a draft version of the HMI was developed. Finally, system capabilities were evaluated to ensure that the HMI design would fulfil all of the needs and requirements identified for it.

Once the preliminary design of the HMI is achieved, it is still need to complete the post-implementation activities, which involve conducting user acceptance and user verification tests. Results from these tests could lead to additional modifications of the HMI design.

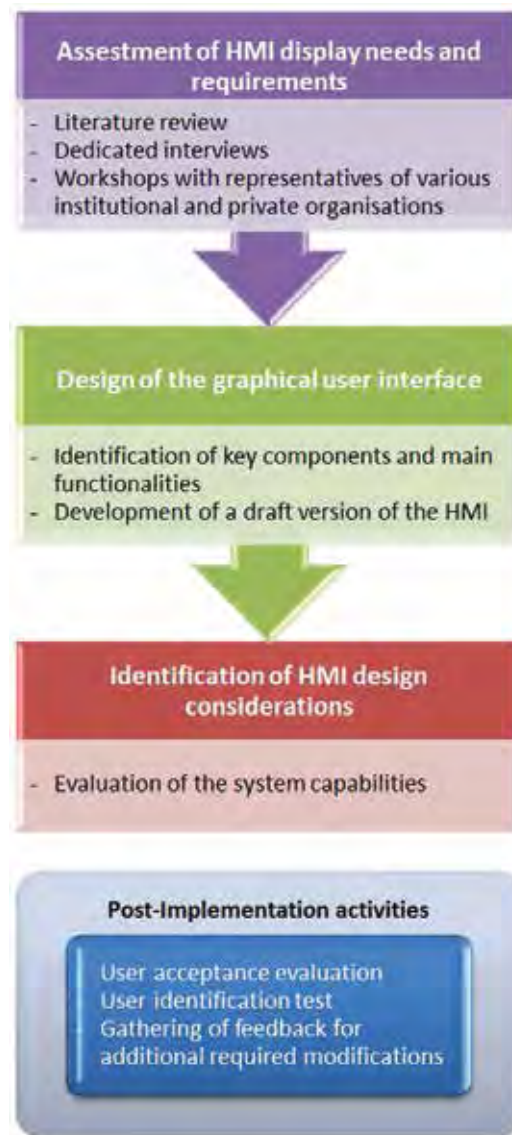


Fig. 2. HMI design process.

During this design process, special attention has been paid in make a clear distinction between tasks for the overall system and the skills required for the human operator. Performing the same task under different circumstances can involve totally different skill, and this should be taken into account during the definition of the training requirements. In general, there are two methods to analyse human tasks and skills:

- Theoretical or analytical analysis: in this case, anticipated skills are identified and the training is prepared based on available system and mission scenario description.
- Empirical analysis: by observing and measuring actual performance, new knowledge is acquired on the real skills and the causes of the training problems.

The first theoretic approach defines the tasks to be performed by the humans operators based on insights on the characteristic of future systems and the environmental context. The second approach is more practical and uses observations and studies of human operator behaviour while performing their work in reality. The advantage of the latter is that the environmental context is actually present, so critical interactions and features can be defined or even measured objectively. These approaches have not been considered as mutually exclusive during the designed process, but as complementary. Therefore, the proposed tool will enable the development and implementation of instructions based on scientific knowledge rather than on personal introspection and intuitions of the training designers.

The key performance variables that have been identified as essential for being monitoring during the training activities are the safety distance to advance the detector search-head on each sweep, the swept velocity, the scan height, and the inclination of the hand-held detector head with respect to the ground.

Key characteristics identified for the graphical user interface design include:

- Clear and meaningful presentation of the information
- User-friendly display layout
- Convenient and efficient process for automatic storage and analysis of data acquired with the hand-held detector sensory tracking system.

HMI console

The HMI console, also called graphical user interface for the 3D tracking sweep monitoring, is the principal mechanism through which instructor interacts with and controls the performance of both expert operators and trainees. The design of the HMI console is based in the key need for instructors to quickly and intuitively interpret all the data captured by the hand-held detector sensory tracking system. The main goals in the design of the graphical user interface are to reduce the fatigue error and discomfort during its utilisation, as well as improve productivity and the quality of the interaction.

The main HMI console is divided into six sections. These six sections are described below (see Fig. 3).

Session Info

This section contains three different elements. The first one consists of two radio buttons mutually exclusive for selecting if the session will be devoted to study the expert's skills in order to quantify some critical performance variables or if will be directed to evaluate the performance of the deminers during the training tasks. The second and third elements enable to introduce the session id and the name of the operator that is being monitored with the proposed tool. These texts entries will facilitate the orderly storage of the data and the reporting phase.

Initialisations

This section encloses one button called “*Config file*” that permits to load a configuration file for modifying the objectives of the training session, and a second button called “*New Session*” that is activated only after the communication with the hand-held detector sensory tracking system has been established by pressing the “Search H-H Detector” button of the *Controls* section, and enables to reset all the data contained in the interface, without losing the aforementioned communication.

Controls

Four different buttons are included for starting the interface activities. The “Search H-H Detector” button begins the WIFI or USB communication with the sensory tracking system installed on the hand-held detector. The “Sync Initial Point” button permits the definition of the home position for all the measurements. The “Start” button initiates the acquisition and visualisation of data, and finally the “Stop” button halts all the functions of the HMI.

Sweep Monitoring

The graphic displayed on this section reconstructs in real time the sweep movements carried by the human operator. The sweep movements are shown over a simulated training lane. This graphic permits a clear visualisation of the sweep coverage area and enables the instructor to check if each sweep across the lane is overlapping the previous one by about one-half the width of the metal detector head, which is one requirement for ensuring the safety of the operator during the detection tasks. In addition, colours are utilised in this graphic to indicate if the performance is holding or not within the training objectives: green is used for indicating that all the evaluated variables are within the training objectives, yellow for warning that the values are starting to deviate from the goals and red for values out of the defined safety ranges.

Speed, Height and Inclination Data

In this section, data acquired by the hand-held detector sensory tracking system is turn into useful information that will help the instructor to monitor the current situation. Four performance variables have been selected for this purpose: the velocity or sweep rate in m/s, the height of the head detector above the ground in cm, and the

pitch and roll angles in degrees for checking if the search head is keeping parallel to the surface. Analog representation of these values, indicating their value relative to normal, abnormal and alarm conditions are displayed. The alarms included for each variable will enable the operator to quickly detect values outside the safety range, so he wouldn't have to relay in his memory and mentally compare each value to its corresponding defined range to discover deviations of trainee objectives.

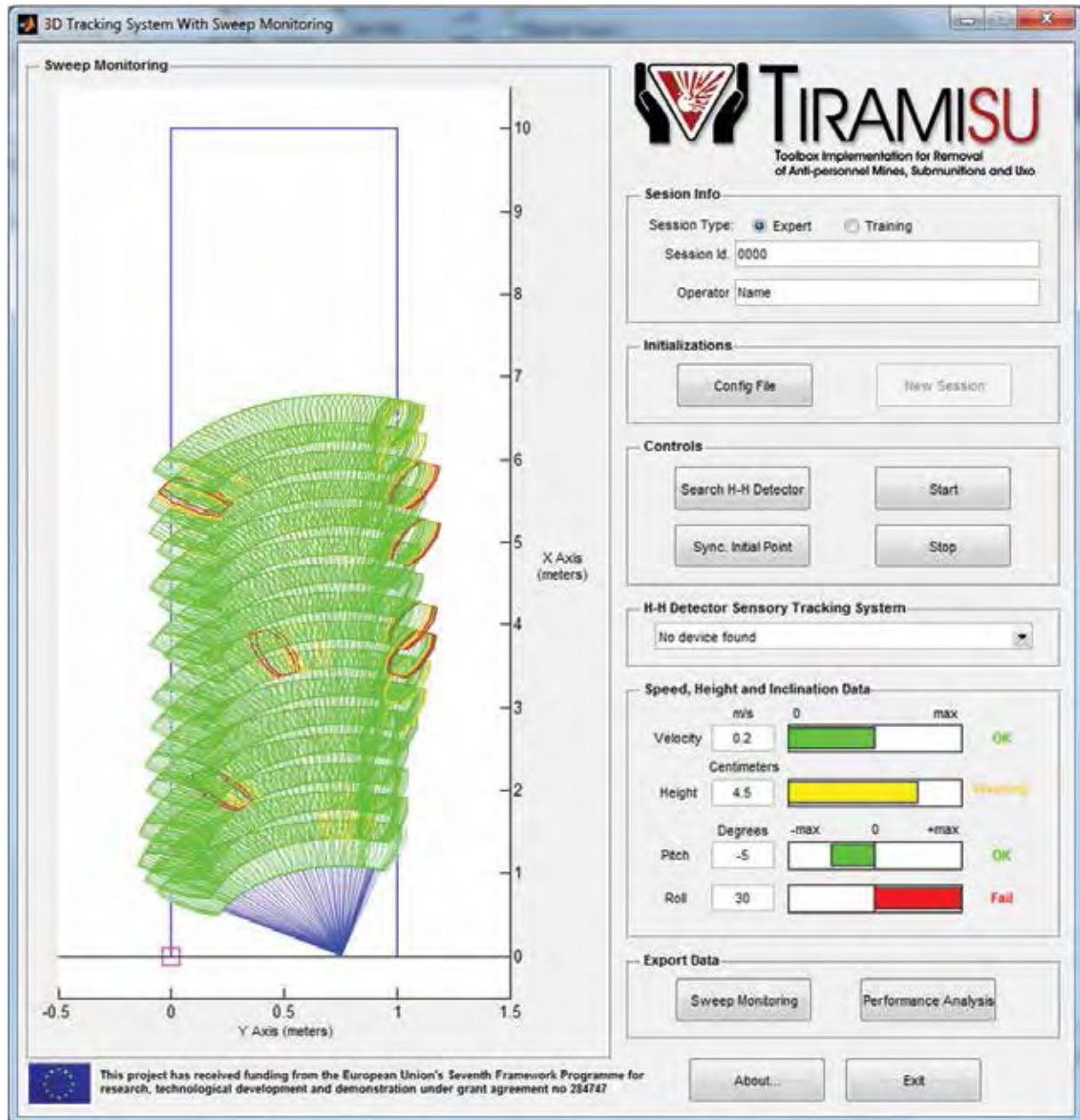


Fig. 3. HMI console.

Export Data

This section encloses two buttons called "Sweep Monitoring" and "Performance Analysis". The first one saves all data acquired by the hand-held detector during the active session in a MySQL data base. Lastly, the second button links with an external application that conducts the performance evaluation of the operator and generates the corresponding evaluation report. The performance analysis can be done from the last active session, or from

any other session that had been previously stored in MySQL data base. The external application could be implemented in Matlab, Java or by means of a web page with PHP.

In addition, the graphical user interface has:

- Grey background to minimise glare
- No animations, except for the sweep monitoring
- Analog representation of important measurements, indicating their value relative to normal, abnormal and alarm conditions
- A proper hierarchy of display content providing for the progressive exposure of detailed information as needed

Therefore, with the proposed easy-to-use interface, the instructor is capable of:

- Monitoring all the performance variables of the operator
- Recording all the acquired information in a database.
- Studying the experts' skills
- Assessing the performance operation of the trainees.
- Automating the reporting tasks.

Discussion

In this work a HMI has been proposed as part of a training tool for improving the deminers' skills during close-in detection tasks with hand-held detectors. The approach taken to develop the HMI interface design, as well as an outline of the main features, functions and components of the HMI, has been presented. The HMI designed has the advantage of providing an overview of the entire scanning operation carried out with the hand-held detector and a limited number of well-defined alarms. In this way, the instructor, or the trained operator could see the entire operation almost at-a-glance. Therefore, it is envisioned that the graphical user interface will improve the instructors' ability for monitoring, processing and assessing the performance training data, reducing the total cognitive load required.

Acknowledgment

The authors acknowledge funding from the European Commission under 7th Framework Programme (TIRAMISU Grant Agreement N° 284747) and partial funding under Robocity2030 S-0505/DPI-0176. Dr. Héctor Montes also acknowledges support from Universidad Tecnológica de Panamá. Special thanks are for Vallon, partner of TIRAMISU project, who provided to the CSIC the VMC1.

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The development of an intelligent manual prodder for material recognition

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Abstract

The paper describes an active prodder for the recognition of touched materials. The proposed system has been developed with feedback from deminers expertise, keeping into consideration their remarks from past research activities for a better understanding of the reasons for failures in the adoption of the previously developed prodgers. It is important to underline that this intelligent prodder is not intended to be used directly for searching mines, but as a complementary tool to recognize the material of a suspected object once it has been detected by using other tools (metal detectors, GPR, etc.). According to the statistical data many accidents on deminers occurs during prodding and excavation; as a consequence the realization of an intelligent prodder could help deminers to recognize the material just when a small part of the suspected object is cleared.

The device conceived is based on piezoelectric actuating and sensing strategy and the elaboration of the obtained output signals was performed in frequency domain. Moreover, another advance was the integration of the prodder with other sensors such as a force sensor and an inclinometer.

The choice to integrate a potentiometer coupled with a calibrated spring as force sensor has the function to guarantee a constant application force since the operator's hand cannot assure it. This introduces the advantage to have a good repeatability of the piezoelectric response. The inclinometer gives useful information on the angle of attack to improve the reliability of the contact. A prototype was built and characterized in laboratory and outdoor in a simulated minefield. The activity had several phases: the study of state of art, the development of a recognition strategy and the design, fabrication and characterization of the instrumentation.

Introduction

One of the most important application fields for material recognition is humanitarian demining [1]. The prodder is mainly adopted as a complement to the metal detectors, so that once a possible target has been detected, the prodder is used to unearth an object from the terrain for the identification; nevertheless it still remains the major cause of accidents during demining operations [2]. This issue is primarily determined by two factors: when a classical prodder is used to recognize the object, the deminer often has not idea of the real force he is exerting on the unknown material surface and of the angle with which the object is approached.



Fig. 1 Impact angle between prodder and terrain. It's possible to distinguish the dangerous zone from the safe one.

As it can be seen in Fig 1, the deminer should touch the object with an impact angle not greater than 30 degrees [3]. The intelligent prodder developed by this research team, within the EC project TIRAMISU [4], is equipped with two sensing units capable of giving continuous feedback information about the force applied to the unknown material and the contact angle between the ground surface and the direction of approach and to alert the operator when one of these parameter is out of safe range.

The recognition principle exploited is based on the analysis of the frequency response of a piezoelectric sensor. Any material in fact, when stimulated by a mechanical stress exhibits a particular deformation, due to the oscillatory motion of its external atoms [5]. This deformation depends on the intrinsic characteristics of the material and can be

estimated using the direct piezoelectric effect. A piezoelectric sensor is in fact composed of a material that, when subjected to a deformation, produces an output voltage. Once the piezoelectric response is acquired, the recognition process ends with a second phase. The acquired signal is first analyzed in the frequency domain, by extracting the spectrum via a specific algorithm, then the spectrum is compared with other known spectra (as it can be seen in Fig. 2) of responses, relating to a set of materials previously processed and stored in a database.

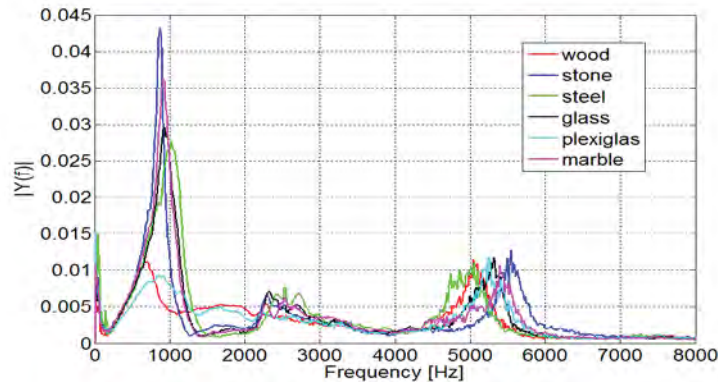


Fig. 2: Some characteristic frequency spectra for known materials. As it can be observed the hardest materials (e.g. steel, marble, stone) have a resonance peak at a higher frequency, differently from the softer materials (mine, wood).

Intelligent prodder

In this paragraph a detailed description of the developed instrumented prodder is given. The system can be used in many application fields where a material classification is required. It was decided to develop an active probe whose scheme is shown in Fig. 3

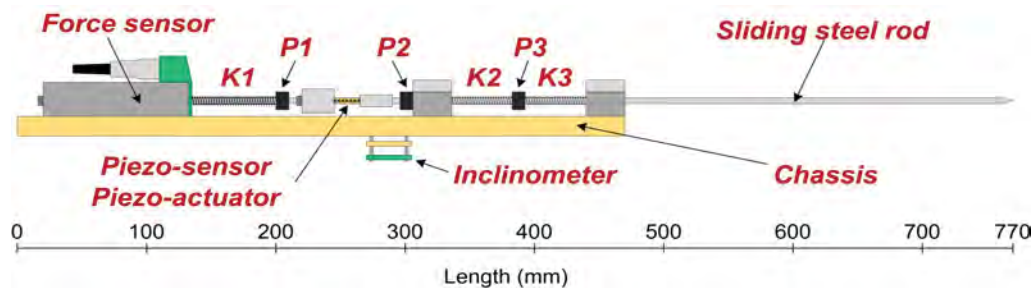


Fig. 3: Scheme of active probe.

This system is composed by four principal components:

- A pair of piezoelectric transducers, used as actuator and sensor.
- A force sensor used to know the force applied to solicit the materials.
- An accelerometer, which is used as inclinometer.
- A mechanical system composed of a chassis, a sliding steel rod, and other elements.

The main elements of the developed active probe are the two piezoelectric transducers. The first one is used as actuator to apply the mechanical solicitation to the material to be recognized through reverse piezoelectric effect, while the second one as sensor to transduce the response of the material.

The output voltage of the piezoelectric sensor is manipulated by a conditioning circuit, developed in order to allow the interfacing between the probe and the elaboration system. It includes an instrumentation amplifier to convert the differential signal of the piezoelectric sensor to a single ended signal, a low-pass filter to eliminate high frequency noise, a linear compression circuit, and a protection circuit.

The force sensor has been implemented by using a position sensor and a system composed of some springs and pivots (K1, K2, K3, P1, P2 shown in Fig. 3), able to perform a linear position-force conversion. The choice of the spring constant values is related to the maximum applicable force to the material. This value must be lower than a safety threshold, but at the same time fixed and sufficiently high to give to the material surface a suitable solicitation. The force applied by the probe on material is equal to algebraic sum of three elastic forces:

$$R = K1 + K2 + K3$$

The pivots P1, P2 and P3 are fixed directly to the steel rod of the probe to define the working condition of the springs. When a force is applied, the springs K1 and K2 are compressed while K3 is expanded. Knowing the length and the spring constants of each springs, the conversion by displacement to force can be obtained. This element has a double role: to give force feedback information to the operator and to guarantee the repeatability of the solicitation to the surface material. As said before when material recognition is applied to humanitarian demining operations it's very important to know the impact angle with terrain surface, because for safety reasons the operator must stay out of the dangerous zone (as shown in Fig.1). For this reason a triaxial accelerometer has been mounted and calibrated to operate as inclinometer.

Experimental validation and results



Fig. 4: Samples of materials used to test the experimental setup.

The frequency spectra for the six materials shown in Fig. 4 have been calculated by averaging 150 trials (training set). Then, 100 additional experimental tests for each material (test set) have been carried out to perform the material recognition and test the validity of the proposed approach. This preliminary test (both training and test set) have been performed in laboratory with an impact angle of zero degrees, as it can be seen in Fig. 5:

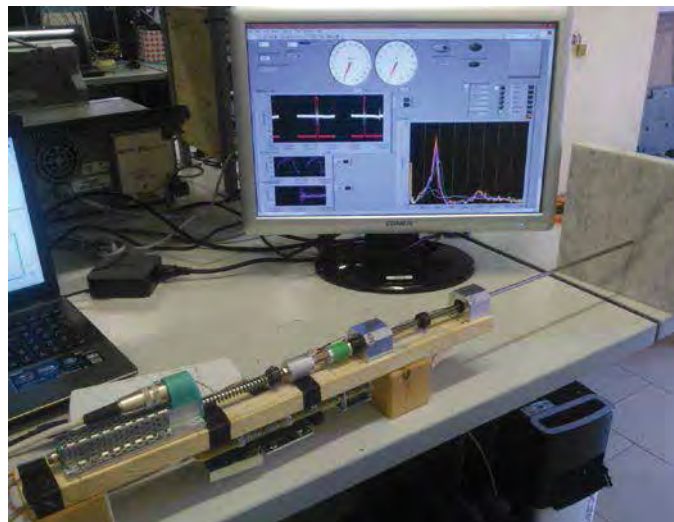


Fig. 5: The experimental setup: the instrumented prod, a sample of marble and the monitor showing the graphic user interface of the material classification software.

Results obtained during these preliminary evaluation tests are reported in Tab. 1:

Tab. 1: Experimental results obtained by carrying out 100 tests for each considered materials.

OUT IN	Wood	Plexiglass	Steel	Glass	Marble	Stone
Wood	83	17				
Plexiglass	3	97				
Steel			94	9		
Glass			4	96		
Marble					89	11
Stone					9	91

By reading the data obtained and presented in Table 1, it can be summarized that the failed tests have been 53 out of 600 performed, which corresponds to a rate of 8.83%. It should be observed however that these failed tests are among materials that are similar in term of their stiffness.

Conclusion and future trends

This paper describes the work carried out in order to develop an intelligent prodger able to perform a classification of different materials, exploiting the direct piezoelectric effect. An experimental prototype has been designed and fabricated to test the validity of the proposed working principle. The prodger is also equipped with a force sensor and an inclinometer in order to give a useful information feedback and to guarantee the repeatability of the applied mechanical stress. Laboratory experimental trials, with several materials, have been performed and the instrumented prodger has exhibited promising results.

Acknowledgments

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Upgrading Metal Detection to Metallic Target Characterization in Humanitarian Demining

Davorin Ambruš¹, Darko Vasić, Vedran Bilas

Abstract

Conventional metal detectors used in humanitarian demining feature high sensitivity to extremely low quantities of metal, such as those found in low-metallic content landmines. On the other hand, enormous false alarm rates (up to 1,000 alarms per mine) are introduced, due to detectors inability to discriminate between metallic parts of a mine and non-hazardous metallic clutter. If metal detectors could be upgraded such as to provide information on target's size, shape, position, orientation and material properties, false alarm rates could be significantly reduced. In this paper, we present the basic concept of model-based metallic target characterisation (MTC) and the related work of our research group. Also, we discuss some practical implications of the proposed methodology with respect to its possible deployment in the field: either in a form of handheld device or for mounting on robotic platforms.

1. Introduction

In spite of recent developments in landmine detection technologies for humanitarian demining, metal detectors still remain the tools of choice when it comes to close-in detection in the field [1]. Metal detectors are devices that operate on a well-known principle of low-frequency electromagnetic induction (EMI). Although commercial devices differ in terms of their technical and implementation details (such as excitation type, signal processing, soil compensation techniques, etc.), the operating principles and basic functionalities are essentially the same.

Conventional metal detectors are sensitive to extremely low amounts of metal such as those found in low-metallic content landmines. On the other hand, enormous false alarm rates (up to 1,000 alarms per mine) are introduced, due to detectors inability to discriminate between metallic parts of a mine and non-hazardous metallic clutter. Since the high probability of detection is a top-priority requirement in humanitarian demining, recent developments of metal detectors have been predominantly focused on increasing their detection sensitivity, enhancing performance in non-cooperative soils and improving other technical features such as power consumption and device ergonomics.

At the same time, the problem of false alarms resulting from metallic clutter has often been seen as a nuisance and an inevitable side-effect of the humanitarian demining process. Such observation is usually attributed to scenarios where the mine suspected area needs to be completely cleared from all metallic objects (both mine and clutter), as required by actual regulatory procedures. However, there are many cases where such requirements are almost impossible to implement and where the false alarm rate problem should be addressed in order to improve the overall speed, cost and safety of humanitarian demining.

In both cases, a deminer would clearly benefit from a detector featuring additional target information that goes beyond simple audible metal detection signal. The characterisation of metallic target should be implemented in such a way that the target could be classified as potentially hazardous or non-hazardous with a sufficient confidence level. Such information would be helpful with the final “mine-clutter” and “dig-no dig” decisions, but also during confirmation and excavation phase. It is important to note that the concept of metallic target characterisation (MTC) is fundamentally different from multi-sensor detection systems that have been employed recently (e.g. tools that combine metal detectors with ground penetrating radars (GPR), explosive detectors, etc.). Instead of using mine detectors of different sensing modalities, in the proposed approach a single (EMI) modality is used to extract information on target geometrical and electromagnetic properties.

2. Metallic target characterisation concept

In the context of EMI-based landmine detection, MTC refers to getting information on targets:

- average size,
- shape (principal axes aspect ratio),
- spatial orientation,
- relative 3D position,
- material properties (electrical conductivity and magnetic permeability).

If the given information could be estimated from actual sensor data acquired during scanning over the target area, it could serve as a reliable basis for further target classification and identification process. From a practical point of view, most landmines have some common features with respect to the aforementioned properties: vertically or horizontally oriented firing pins (mostly of cylindrical shape), small burial depth (up to 20 cm), etc. Furthermore, it is reasonable to assume that only a limited number of different types

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of landmines would be present on a particular mine suspected area. Therefore, the complexity of the initial “mine-clutter” problem could be significantly reduced.

2.1. State-of-the-art in MTC

MTC techniques that utilize analytical EMI-based models have proved to be very effective for a range of problems in security, geophysical surveys and non-destructive testing (NDT) applications. Physics-based models are used to describe the relationship between the EMI response of a detector and the geometrical and electromagnetic properties of a target. Model parameters, obtained from data observations through estimation (inversion) procedures, can be used to extract the information needed for classification and identification purposes.

Different analytical models and corresponding inversion procedures that relate to the MTC problem have been reported in literature. Most of these methods are (to some extent) based on the magnetic dipole approximation, which enables computationally efficient parameter estimation, capable of operating in real-time. These methods can be roughly classified in the two main categories: methods relying on the induced dipole model [2] and methods based on a discrete number of spatially distributed magnetic dipoles [3]. While the former methods are well suited for relatively small metal targets (such as low-metallic content landmines), the latter methods are required when dealing with larger and possibly heterogeneous targets such as unexploded ordnance (UXOs).

Induced dipole model and related inversion techniques have been successfully applied for real-time detection, localization and identification of hidden metallic objects in walk-through scanners for airport security [4]. Within the UXO research community, several sophisticated instruments using complex dipole-based models and fast inversion techniques were recently designed [5]. However, to the best knowledge of authors, there are still no commercial devices utilizing the principle of model-based MTC for application in humanitarian demining. Adaptation of such methods for landmine detection brings a number of research challenges. One of the major challenges is the optimization of inversion procedures and sensor geometry with respect to the operation in environments with low SNR (signal-to-noise ratio).

2.2. Induced dipole model

The induced dipole model assumes the buried target's size to be much smaller than the size of a detector coil. Therefore, if the object is not too close to a detector, it can be treated as a single magnetic dipole and described by the magnetic polarizability tensor of rank 2, i.e. the 3x3 symmetric polarizability matrix [3]. Basic mathematical description of the model is given by expressions (1)–(3).

$$\mathbf{m}_{\text{target}} = \mathbf{M} \mathbf{H}_{\text{prim}} (\mathbf{r}_{\text{TX}} - \mathbf{r}_{\text{target}}) \quad (1)$$

$$\mathbf{H}_{\text{sec}}(\mathbf{r}, \mathbf{r}_{\text{TX}}, \mathbf{r}_{\text{RX}}) = \frac{1}{4\pi|\mathbf{r}|^3} \left(\frac{3\mathbf{r}(\mathbf{r} \cdot \mathbf{m}_{\text{target}})}{|\mathbf{r}|^2} - \mathbf{m}_{\text{target}} \right) \quad (2)$$

$$\mathbf{u}_{\text{RX}} = f_{\text{FWD}}(\mathbf{M}, \mathbf{r}) \quad (3)$$

The target magnetic moment $\mathbf{m}_{\text{target}}$ is linearly proportional to the primary magnetic field \mathbf{H}_{prim} via polarizability matrix \mathbf{M} , (1). The secondary field \mathbf{H}_{sec} , sensed by the receiver coil, is essentially the magnetic field of a dipole, (2). From (1) and (2) a forward function is obtained, (3), describing the relationship between the receiver coil voltage \mathbf{u}_{RX} , magnetic polarizability matrix \mathbf{M} and the target position \mathbf{r} .

2.3. Estimation of target geometry and material properties

In order to characterise the target using the induced dipole model, the parameters of a model (\mathbf{M}, \mathbf{r}) need to be estimated first by fitting the measured voltages \mathbf{u}_{RX} to model predictions. Since the inversion problem is nonlinear (in terms of \mathbf{r}), the solution can be found by applying some of the nonlinear optimization algorithms based on the least-squares criterion, (4).

$$\arg \min \left(\left\| \mathbf{u}_{\text{meas}} - f_{\text{FWD}}(\mathbf{M}, \mathbf{r}) \right\|^2 \right) \quad (4)$$

The relative target position \mathbf{r} follows from the inversion procedure directly. Other target properties can be obtained from a diagonalized form of the polarizability matrix \mathbf{M} , (5), (6).

$$\mathbf{M} = \mathbf{R}^T(\theta, \phi) \mathbf{\beta}(\omega) \mathbf{R}(\theta, \phi) \quad (5)$$

$$\mathbf{\beta} = \begin{bmatrix} \beta_x(\omega) & 0 & 0 \\ 0 & \beta_y(\omega) & 0 \\ 0 & 0 & \beta_z(\omega) \end{bmatrix} \quad (6)$$

The spatial orientation of a target can be derived from the rotation matrix \mathbf{R} . On the other hand, information on the target size, shape and material properties are contained in frequency-dependent eigenvalues of \mathbf{M} , $\beta(\omega)$. Some of the basic principles of estimating target geometry and material properties from the polarizability matrix are given in Figure 1.

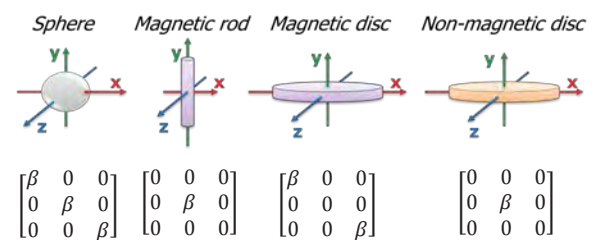


Figure 1. Basic principles of estimating target geometry and material properties from the magnetic polarizability matrix.

3. Experimental research

Based on the previously described MTC methodology, experimental research was conducted by the Advanced Instrumentation Group (AIG, University of Zagreb, FER-ZESOI). The research is conducted within the framework of the project DEMINED, aimed at the development of a next-generation EMI detector for landmine detection in humanitarian demining [6].

Experiments were conducted on laboratory samples of test targets that correspond to metallic content typical of a class of landmines, in accordance with the CWA-14747 standard [7], Figure 2.a. Test targets include spheres, cylinders and tubes of different geometries and materials (steel, aluminium, copper, etc).



Figure 2. a) Laboratory test samples (ITOPs), b) commercial landmine fuze (UPMAH-2).



Figure 3. Laboratory prototype of a sensing head.

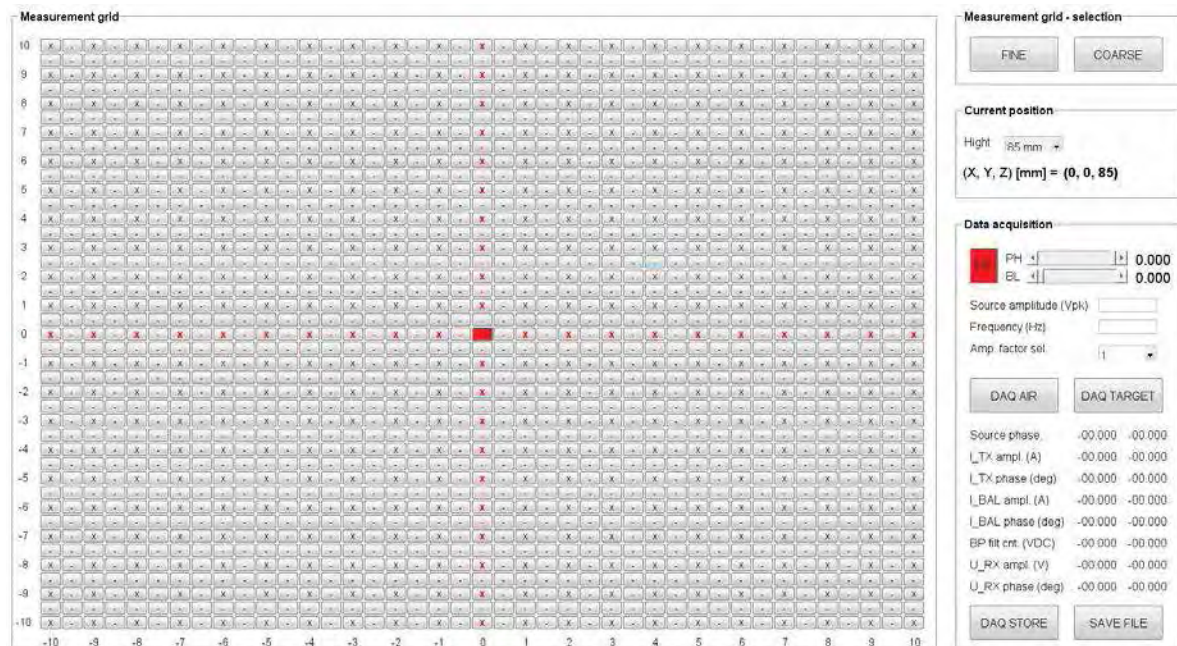


Figure 5. Graphical user interface of the application program for conducting experiments with test targets (MATLAB).

Measurements on commercial mine fuzes (explosive-free), Figure 2.b, shall also be performed in order to validate the methodology with real-world targets.

The experimental set-up is comprised of a laboratory sensing head prototype [8], Figure 3, non-metallic testing stand with measurement grid, some custom-designed electronic circuitry, standard laboratory instruments and high-speed data acquisition devices. Experiment control, digital signal processing, modelling and inversion procedures are implemented in MATLAB, Figure 5. An illustrative example of an experiment covering a rather simple characterisation of a steel sphere is shown in Figure 4.

Future experimental work will focus on inversion procedures for the estimation of target position and magnetic polarizability matrix, optimized with respect to execution speed and low SNR. The ultimate goal is to develop a field-deployable demonstrator device.

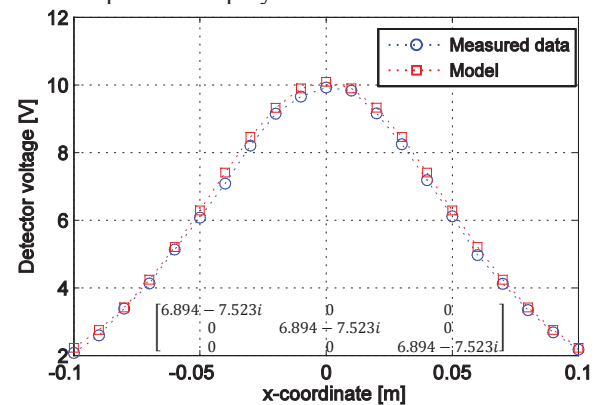


Figure 4. Modeled and measured EMI responses of a steel sphere (10mm diameter) with inverted polarizability matrix (at 50kHz).

4. Towards deployment in the field

For a practical implementation of next-generation EMI devices featuring the MTC concept in a real-field scenario, there are several technical challenges that need to be addressed. One of the major ones is a problem of tracking the relative position and spatial orientation of the detector's sensing head during its scanning motion over the suspected area. This information should be made available to the inversion algorithm in real-time since different sensing head positions (relative to the position of a target) are used to obtain the complete set of observations, required for reliable inversion.

The position and orientation of the sensing head should be determined with respect to its local coordinate system, which could be either stationary (using ground as reference) or dynamic (i.e. referenced to a deminer or a robot). In case the sensor is mounted on a robotic vehicle, its position and orientation are clearly defined in a robot coordinate system by the kinematics of a manipulator. On the other hand, if a handheld device is used, a separate tracking system has to be provided. Different approaches have been proposed and evaluated for this particular problem, such as inertial sensors, optical systems using visual markers and stereo cameras, ultrasonic localization systems, EMI-based methods, Figure 5, etc. Optimal tracking system would provide sub-centimetre accuracy, high update rate (in milliseconds range), minimum complexity and unobtrusiveness.

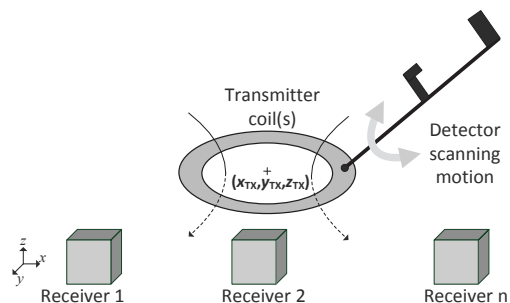


Figure 5. Principle of EMI-based method for sensing head tracking.

Another issue when it comes to the implementation of MTC concept in humanitarian demining is the preferred mode of operation. For manual detection, a two-step procedure is envisaged. In the first phase, a device would operate in a standard, deminer-familiar metal detector mode. After a detection signal is obtained, a deminer could simply switch the device into the MTC mode and use the additional target information for its decision on how to proceed. On the other hand, for robotic applications, such approach is not necessarily the most effective. The choice actually depends on objectives and requirements of a particular robotic mission and involves a number of different issues such as path planning, type of environment, etc.

5. Conclusion

In order to overcome the well-known limitations of existing metal detector technology in terms of false alarm rates, a new mine detection concept relying on model-based metallic target characterisation (MTC) is proposed. Such concept has already been verified in other applications, such as security and UXO detection, which provides strong motivation for its potential application in humanitarian demining. Initial results of our experimental work in this field suggest that the proposed concept could lead to a new enabling technology for developing next-generation detection devices – either in the form of manual mine detectors or for integration with robotic systems.

Acknowledgment

This work has been supported by the European Community Seventh Framework Programme under grant No. 285939 (ACROSS). The research is also supported by Croatian Mine Action Center – Center for Testing, Development and Training (HCR-CTRO) through expertise and help during the testing phase.

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Development of a tool for testing PPE under near simultaneous Triple Impacts

Georgios Kechagiadakis, Marc Pirlot

The deminers are the backbone of Mine Action. Even though the incidence of accidents is limited, the risks involved may inflict a hit on the motivation of the endeavor. PPE serve this way a double purpose. The obligation of the scientific community is to provide with efficient tools to the manufacturers to tune the performance of their products and clear guidelines to the end users for selecting them. Current practices for assessing the performance of PPE have been proven significant but inaccurate. This has led to designs of PPE that overestimate (expensive, non ergonomic), or underestimate the threats deminers are dealing with.

This paper describes the development of a new tool for assessing the performance of Personal Protect Equipment against fragment impacts. This technique involves near simultaneous impacts of three projectiles in close proximity to one another. The interactions between the three impacts are analyzed to predict the resultant ballistic performance. An important factor for this assessment is the degree of simultaneousness of multiple impacts and its influence towards the ballistic performance. This setup was realized in order to simulate the conditions that are typically identified during an explosion of an AP blast mine. The development of the main tool for testing is described in detail and the results of its assessment through the steps of its development are submitted. Important diagrams of velocity as a function of powder mass and dispersion are analyzed.

BILLY GOAT RADIO: THE METHODOLOGY

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Abstract

The paper presents the results obtained during the development of a tool for mine risk education (MRE) based on entertainment-education principles that uses radio for diffusing the educational messages. The paper particularly focuses on the adaptability system conceived to make the tool suitable to different contexts, characterized by different cultures, environments and MRE related issues (such as conflict stage, type of threat, target audience ...). This methodology, still under development, uses a system of cards, questions and answers to create the script of the educational serial drama that will be radio broadcast and performed live in front of local audience.

Introduction

Billy Goat Radio is a tool aimed at spreading Mine Risk Education messages through the use of a combination of a mass medium, the radio, and a traditional medium, a simplified kind of itinerant theatre. Although the work on Billy Goat Radio is still under development as it takes place within the context of TIRAMISU research and development project started in January 2013 and ending in December 2015, it was already brought to the field for a first test between September and October 2013, when the tool has been evaluated in the Sahrawi refugee camps located in southwest of Algeria. Results achieved by the pilot Billy Goat Radio MRE campaign carried out by Snail Aid – Technology for Development in strict collaboration with Brimatech (in charge of evaluating the effective impact of the tool on the target audience) and the local organization Asociación Saharaui de Víctimas de Minas (ASAVIM) were very promising both from educational and audience's approval point of view. During this mission, the educational serial drama was recorded and performed live by local actors in front of the public of three different refugee camps, broadcasted by Radio RASD (a local station) and followed by group discussion sessions facilitated by Snail aid, Brimatech and ASAVIM attended the same people who previously were in the audience of the live shows.

The methodology

The tool under development consists of a modular kit aimed at enabling operators to write and produce educational short serial dramas suitable to the local context, broadcast them by radio and bring them to mine affected areas during live shows followed up by group discussions.

The tool has been conceived answering the requirements of cost-efficiency, rapidity in planning and implementation, capacity building for local operators and with the goal of having the greatest possible diffusion.

The modular kit under research embeds three separate elements:

- A set of technical equipment allowing the practical production of the Billy Goat Radio tool, enabling the recording, post-production and playback of the episodes, and
- An adaptability system allowing the writing of the script of the short serial drama
- A set of guidelines for facilitating group discussions taking place after itinerant live shows in which the short serial drama episodes are performed live in front of an audience.

While the research on guidelines for group discussions is aimed at enhancing the reinforcement of messages, the liaising with the communities and the evaluation of the tool on a continuous basis, the research undergoing on the set of technical equipment is aimed at achieving a simpler user interface and a shorter post-processing time, the research undergoing on the adaptability system is aimed at creating a simple system that drives local operators into the creation of an original script for the short serial drama tailored to the local context.

The radio broadcast serial drama consists of a short story divided in six episodes. Plot characters, whose roles have been written following the Sabido's role models structure ² [Barker et Sabido, 2005], are entrusted with the task of conveying educational messages embedded in the story. This means that the story is built around the happenings of good characters (who portray positive models), bad characters (embodying negative models), and evolving characters (who, during the plot's development, evolve from their initial negative position to portray a positive role at the end of the story) [Scapolla et Cepolina, 2013]. The drama's story involves universal dramatic themes such as love, money, dignity, good and evil, which could be observed in popular stories from all over the world.

The tool is therefore based both on the entertainment-education (Edutainment)¹ concept and on the identification of radio as the best communication means in terms of widespread availability and

¹ Merriam-Webster Dictionary defines edutainment, or educational-entertainment, as any “entertainment content that is designed to educate as well as to entertain”. Descending from socio-psychology and human communication theories, entertainment-education principles aim to modify behaviour by information spreading. The Social Learning theory developed by Bandura in 1977, according to

cost-effectiveness. Serial dramas have been chosen for the purpose thanks to their high entertainment-education value, exploited world wide and in particular in developing countries where they are often used to diffuse health care messages such as family planning and HIV safe messages.

The adaptability system

Focal point of the tool is its adaptability, which should allow the tool to adhere to every different local context, both from the point of view of everyday-life mirroring, to catch the audience attention and from the point of view of MRE messages that should be appropriate to the particular threats and addressing the actual at-risk part of population. In this way, for example, a scene originally set in a café can be re-placed in a tea-room, a character who often drinks beer can become a betel leafs chewer, or a woman worker can become a housewife without having to change the whole plot structure or wasting a long time in re-writing.

Essentially, the system includes:

- two complete plots built around the positive/negative/evolving characters, written in the form of a script and suitable to be extensively but rationally adapted;
- one set of cards for each plot, containing all the different possible solutions in terms of local context's daily life mirroring, called Dramatic Cards;
- one set of cards containing all the different possible solutions in terms of mine risk education messages, structured according to three variables: conflict stage, type of threat and target audience, called Explosive Cards;
- informational material containing technical and literary instructions and examples of already achieved projects.

The two plots have one main story and two sub-plots each: among them it's necessary to choose the story with the highest adherence to the local context in terms of social habits and explosive threat. Each plot is supplied with a detailed description of characters and scenes in a draft version, written in English, where the parts which are susceptible of local adaptation are pointed out to the attention of the operators.

The core of the adaptability system are the two kinds of card of cards: the first one, the Dramatic Cards, about the dramatic aspects and the adherence to the social context, report questions and

which individuals change behaviour by observing role models, particularly in the mass media, is the fundamental of entertainment-education projects, which, therefore, have imitation and influence as expected outcomes

possible answers related to the particular plot they refer to and to the different possible local contexts.

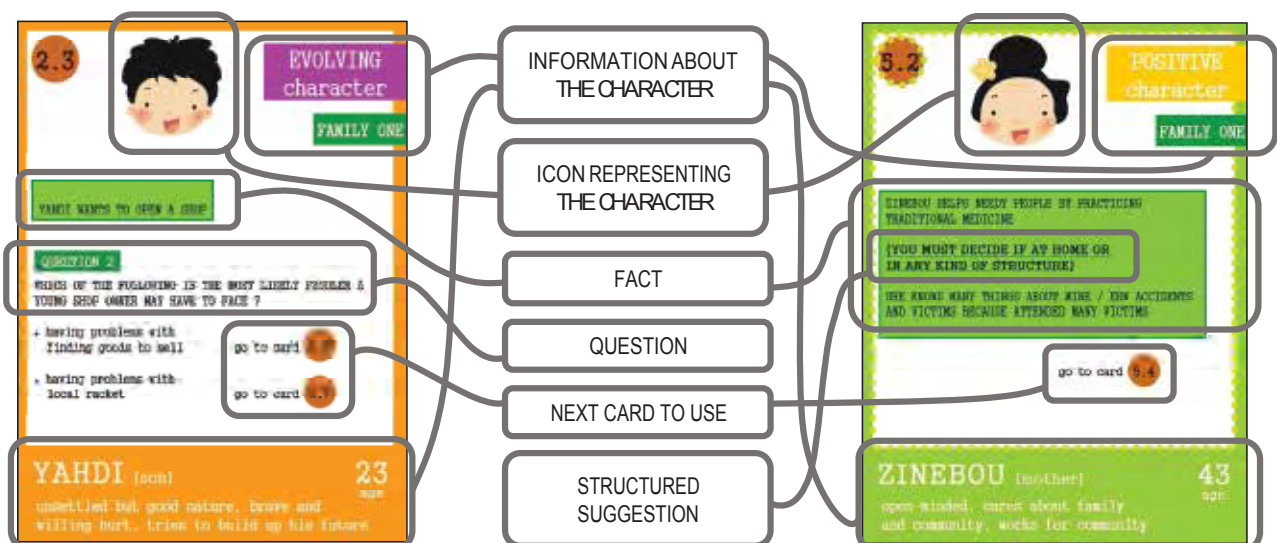
The other set of cards, the Explosive Cards, are relative to the diverse threats (mines, cluster bombs, UXO ...) and to the categories of people targeted by the MRE messages (unaware, uninformed, reckless, intentional at-risk people).

Dramatic cards have been developed thanks to a tree system, in which the answers to the questions included in one card lead to other questions and then to the final result.

Since the system foresees two different plots, each of them has its particular Set of Dramatic Cards (see Fig.1). Each card of both sets is associated to one character, indicated by an icon of his/her face, and contains short information about the character, a green box reporting a fact related to the character or to the dramatic situation and/or one or more questions whose answers drive the user to choose a further card. As a further step of adaptation, the green boxes can contain a suggestion dedicated to the writer, which advises her or him it is the moment to make a choice about a specific topic of the plot. The colours of each element on the card have a meaning: there is a different colour for each character, a particular colour for each role model (positive, negative or evolving role models) and a colour representing the belonging of each character to one or another family. This way the cards result immediately comprehensible and can be quickly grouped following different themes: for example it is possible to easily group all the evolving characters, or all the members of a family, or to put together all the cards relative to one character.

By choosing the cards and putting them in order on a table, the user builds a visual image of the story and its adapted features.

Figure 1– Two cards of the Dramatic Set and their contents



Not all Dramatic cards will be on the table at the end of the writing process, since many of them are only transitional elements between the start of the procedure (a not-adapted plot) and its final stage (the ready and adapted plot). The cards which report information and details useful for the final version of the plot and which will compare on the table are marked by a dotted coloured frame, as the cards on the right in the Figures 1 and 2.

Figure 2 – An example of a card selection (Dramatic Set)



The tree diagram portrayed in figure 3 was used for developing the cards of the Dramatic set for the character called Mariam and shows how the choices referred to one character have direct effect and reliance on the features of the others. The yellow frames on the right connect in fact Mariam's literacy or illiteracy to the same features of her fiancé Yahdi, the protagonist.

The choice of cards is less complicated for the Explosive Cards set concerning the educational messages. The educational messages to choose from are included in a table developed by Snail Aid in 2013 in the attempt to merge all available data found in literature differentiating the messages used according to three variables: conflict stage, type of threat and target audience. The scheme is divided in eight sub-tables, each one dedicated to messages addressing a different type of risk-taking category. Moreover, for each type of risk taking category there are two tables: one relative to messages generally used in the case of a threat characterized by UXO/Cluster Munitions (CM) and one relative to messages generally used in the case of a threat characterized by landmines/ IEDs. Figure 4 shows as an example one of the sub-tables.

Figure 3 – Tree diagram used for the Dramatic Set

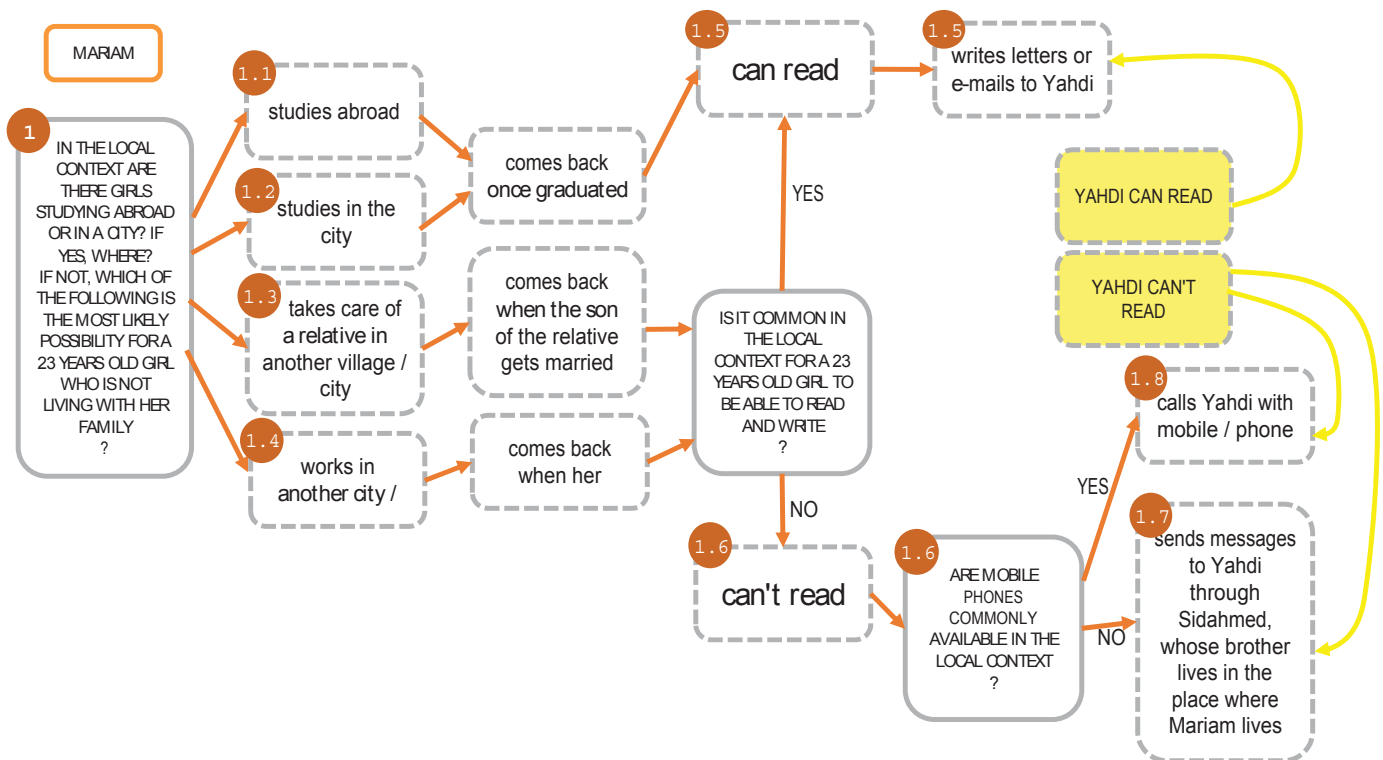
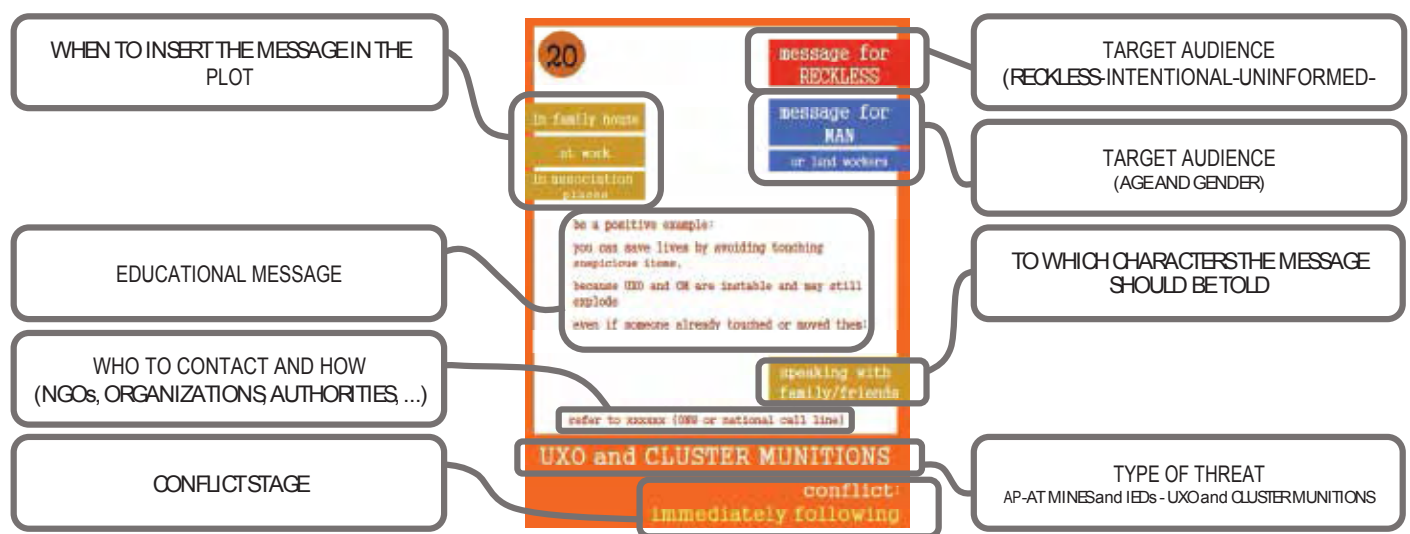


Figure 4 – UXO – Cluster Munition - Reckless

target audience	conflict phase	d i f f e r e n t m e s s a g e s			
		women	children	young male	men
reckless who knows about threat (unexploded ordnance and bombs are lying in the fields around your homes) and save behaviours (never touch anything you don't know or pick them up or kick them, stay away from any unknown objects), but decide to ignore them, mostly because of brag	immediately following the conflict	"make your family aware about threat and explain it's better to be alive than to look hip or strong; refer to xxxxxx (ONG or national call line)"	"don't touch unknown objects you find outside and don't believe who says they're safe, everything could be dangerous"	"if you want to show your bravery, report to deminers if you notice something suspicious: you can save someone's life; refer to xxxxxxxx (ONG or national call line)"	"be a positive example: as UXO and CM are instable and may still explode even if someone already touched or moved them, you can save lives by avoiding touching suspicious items; refer to xxxxxxxx (ONG or national call line)"
	conflict past time ended	"make your family aware about threat and explain how people admire positive examples, not negative ones; refer to xxxxxx (ONG or national call line)"	"follow deminers recommendations, don't touch unknown objects you find outside and don't believe who says they're safe, don't be silly: your future is too important to loose your time by risking life"	"UXO and CM are instable, may still explode even if someone already touched or moved them. It's not worth risking your life: if you want a better future, start now by avoiding touching suspicious items; refer to xxxxxxxx (ONG or national call line)"	"be a positive example: if you want a better future for your family, start now by avoiding touching suspicious items: you can save lives, because as UXO and CM are instable, they may still explode even if someone already touched or moved them; refer to xxxxxxxx (ONG or national call line)"
		women	children	young male	men

Each Explosive card (see Fig. 5) reports one educational message and the contact details of one or more organizations to whom the audience can refer for a specific need related to explosive threats. Moreover, on each card there are several brown boxes giving suggestions about where and in which occasions to insert the message inside the plot, while other boxes explain which target audience the educational message is addressed to, and the notices on the card frame indicate which type of threat the message is dedicated to and which should be the conflict stage at the moment of the MRE campaign.

Figure 5 – A card of the Explosive Set and its contents



The operator chooses which card and therefore which educational message to use by selecting those cards which contain in the coloured boxes data appropriate to the specific local context they are operating in. On each card there are boxes containing information about gender and age of the people who should receive the message, and every different possibility has been connected to a particular colour: in Figure 5, for example, it is portrayed how adult MAN receivers are marked in blue. Other colours represent women, children and young males. In the same way, the red colour of the box in the Figure 5 has been connected with RECKLESS receivers (while other colours represent unaware, uninformed and intentional people). The frame of the card changes its colour depending on the threat: orange for UXO and cluster munitions, red for AP-AT mines and IEDs.

In this set there are no transitional cards, and each card can be chosen for the final stage of the writing process without limiting the number of messages.

The combination of the chosen cards of sets of Dramatic and Explosive Cards with the chosen plot gives the operators the possibility to create an entertainment-educational serial drama which is suitable to the threatened reality.

In order to provide end-users with a “ready to use” package, Billy Goat Radio includes also a complete set of sound effects in digital format, which can be integrated by operators with new sound effects made on purpose and recorded with the technical equipment provided or downloaded from the internet.

Between September and October 2013, when Billy Goat Radio was tested in field, the adaptability system was still at an initial researching stage, and the story chosen had to be adapted to the context of the Sahrawi refugee camps after a deep investigation of local reality conducted from Italy by Snail Aid staff. Although not yet at an advanced stage, the tool’s adaptability system had good results: both translators and ASAVIM staff agreed in saying that the story and the characters in the script were “very Sahrawi”. Such a successful adherence to the context was a consequence of the accurate investigation of the local daily life carried out before the mission and of several questions for the translator, which were disseminated in the plot in every point where adaptation was required.

In its final stage, the adaptability system won’t need to be manipulated by external hands, but will be ready to be used during the writing process, following the steps suggested by the tool itself. The costs of the MRE campaign in terms of money and time will therefore be drastically reduced.

Acknowledgments

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DIGITAL SIMULATION AND TESTING OF EXPLOSION INSIDE THE CONTAINER FOR THE TRANSPORT OF EXPLOSIVE REMNANTS OF WAR AND UNDER THE MINE ROLLER CARRIED OUT ON A PROVING GROUND – TIRAMISU PROJECT

Results of a digital simulation of a detonation of explosive charges inside the platform designed for the TIRAMISU project used for the transport of mines and ERW (explosive remnants of war) and under the mine roller constructed for the same project are presented. The stresses in structures of the two devices and the total effect of the impact forces generated during explosion are included herein. In the second part of the paper the proving ground tests of a detonation of explosive charges under real objects and the results of the recorded mechanical stresses forming in the structures, propagation of the blast wave and fragments are described presented. Conclusions drawn from the comparison of the results of computer simulations and obtained as the result of real tests in relation to the changes in the design of the proposed device are also found in the paper. The final version of the trailer for the transport and temporary storage of ERW, as well as the final version of the mine roller together with the remote-controlled tractor of the Pierre Trattori company is presented.

1. INTRODUCTION

While conducting the mine clearing operations one should be aware of the possibility of the occurrence of the controlled or uncontrolled explosions. These can occur mostly during the mine clearing and transport of explosives collected. For that reason, the Military Institute of Engineer Technology conducts studies of devices which maximize the safety of the operations. The innovative mine clearing device and a simple and low-cost container for the transport of various types of explosives according to the state-of-the-art in that field have been designed and manufactured at the Military Institute of Engineer Technology within the TIRAMISU project.

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1.1. Description of the container for the transport of explosives

The vessel developed is a blast-containment container made according the project presented in Fig. 1 and it is designed for transport and storage of products containing explosives containing up to 1 kg. of TNT or TNT equivalent.

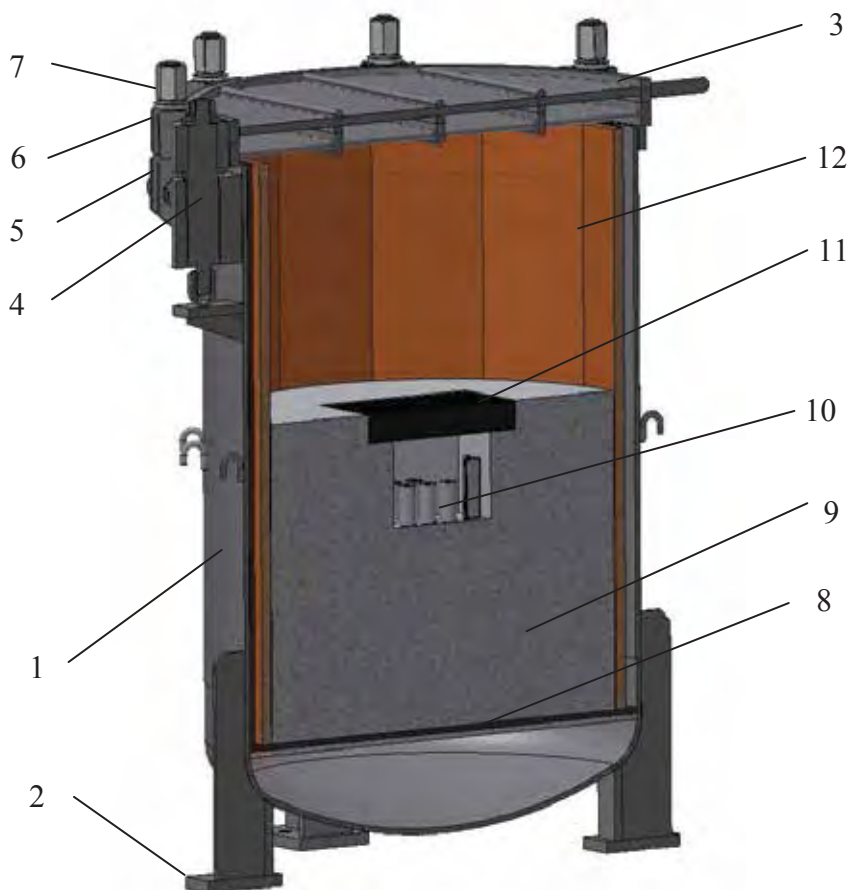


Fig. 1. Explosion-proof container

1 – body; 2 – foot; 3 – cover with grate; 4 – axis of rotation; 5 – eye bolt; 6 – bolt lock; 7 – nut; 8 – inner floor; 9 – foamed polystyrene filling; 10 – explosive; 11 – lid; 12 – surrounding boards

The container has a body (1), inside which on the circumference and at the bottom the elements are mounted for explosion energy dissipation. These elements are wooden boards (12) spaced circumferentially and connected together by rubber bands. The floor with a rubber covering (8) is located in the lower part of the container. The foamed polystyrene filling (9) is placed in the mid part of the container. The explosive (10) is placed in the chamber of the foam polystyrene filling.

Design basis.

- Inside the container, there is a filling material, whose task is to absorb some of the energy of the explosion.
- The top cover should have a shutter/grate construction allowing the release of overpressure in the upward direction but the cover prevents the solids being ejected from the container.

1.2. Description of a mine roller for anti-personnel mines

The equipment development is a mine roller manufactured according the project shown in Fig. 2 and it is designed to clear anti-personnel mines containing explosive charge up to 1 kg of TNT.



Fig. 2. Geometric model of the mine roller

1 – carrier frame; 2 – mounting bar; 3 – rocker arm; 4 – end stop; 5 – wheel set

The mine roller consists of a carrying frame (1) connected with mounting bars (2) on which the rocker arms are mounted rotationally (3). The wheel sets (5) after the detonation are able to tilt from the end stop (4).

Design basis.

- The mine roller has a modular construction consisting of easily replaceable elements which can be damaged by the explosion and which should be replaced quickly.
- The mine roller (wheel sets) is placed on movable bars (the so-called rocker arms) which move back during the explosion thus minimizing the destructive effects exerted on the device.

2. DIGITAL SIMULATION OF THE EXPLOSION

In this paper, the Finite Element Method (FEM) is a fundamental method of analyzing the impact of the explosion. The study adopted the following system of the numerical options available in the LS-DYNA [1] system:

- explicit algorithm used to solve equations pertaining to structure dynamics in the nonlinear range,
- elastic-plastic material model,
- rigid material model,
- deformable coating elements of the SHELL type (type 2) [1],
- deformable solid elements of the SOLID type (type 1) [1]
- initial and boundary conditions considering the gravitation effect, large deformations and

displacements.

The phenomena discussed in the paper are characterized by the following features:

- quickly changing in time (shot duration),
- great geometric nonlinearities (large deformations, displacements, contact) and significant physical nonlinearities (material nonlinearities),
- they require the small time increment Δt .

The following parameters of TNT were accepted:

- density: 1640 kg/m³;
- detonation rate: 6930 m/s;
- Chapman-Jouget pressure (PCJ): 27 GPa.

The numerical calculations using the FEM method were conducted using the LS-Dyna program by Livermore Software Technology Corporation (LSTC) company, version 6.0, explicite option. The calculations were carried out by means of the KMiIS WAT calculation cluster named „Dobrawa”, using 16 CPUs.

2.1. Digital simulation of explosion inside the container

As a result of numerical calculations, maps of displacements, strains, stresses and graphs of selected physical parameters in respect to the time were obtained. This is presented in the figure below (Fig. 3):

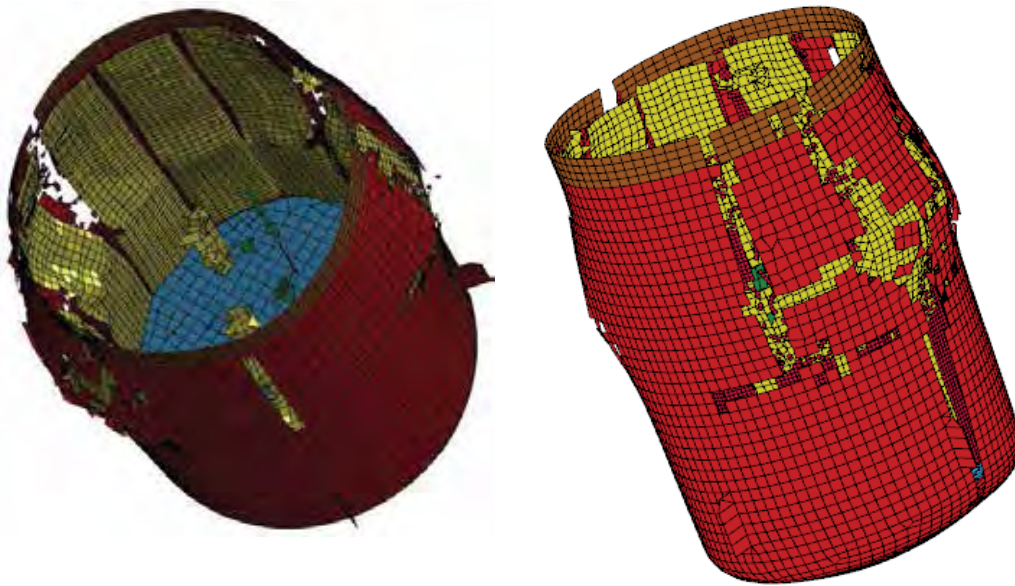


Fig. 3. Damage to the container after the explosion of 1 kg TNT

Maps of total deformations of the container body for $t=2\text{ms}$ presented in Fig. 4.

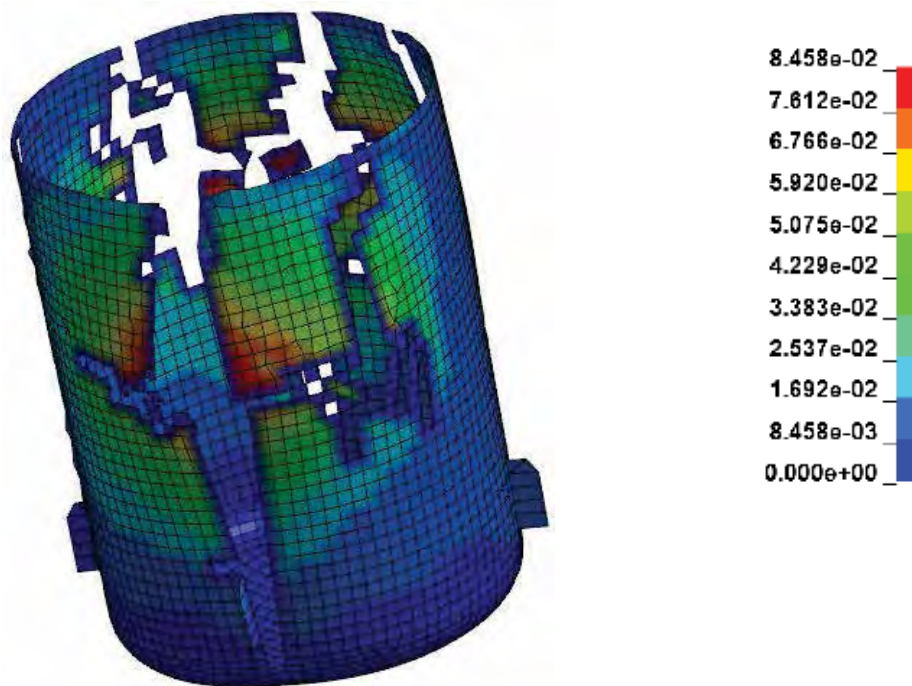


Fig. 4. Map of total deformations [m]

Maps of reduced stresses are presented in Fig. 5:

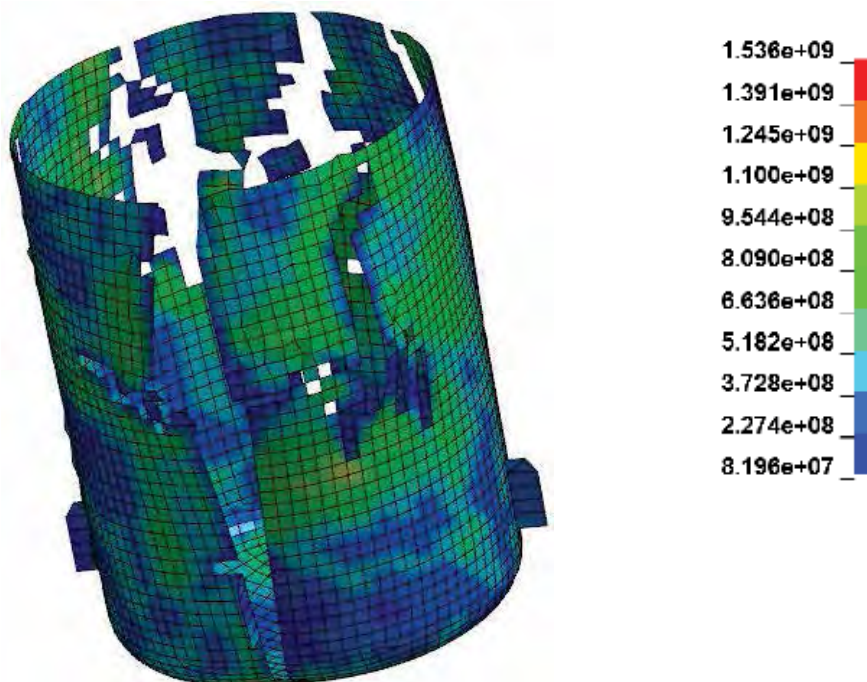


Fig. 5. Map of reduced stresses (acc. to Huber criterion) [Pa]

Structural elements absorbing the energy of explosion (wooden boards, rubber) are completely destroyed (Fig. 3). The container skin is deformed and there is the possibility of breaking the structure (Fig. 4). In the Fig. 5 one can see that the part of the body is critically stressed. The range of deformation of the container body is generally smaller than that of the energy-consuming elements.

2.1. Digital simulation of the explosion under the mine roller

The numerical model was built basing on the CAD geometric model (Fig. 2). Then, the model was divided into finite elements and the physical characteristics were given by defining the materials, thickness and connections between different parts of the mine roller. Consequently numerical model of the mine roller (Fig. 6) was developed.

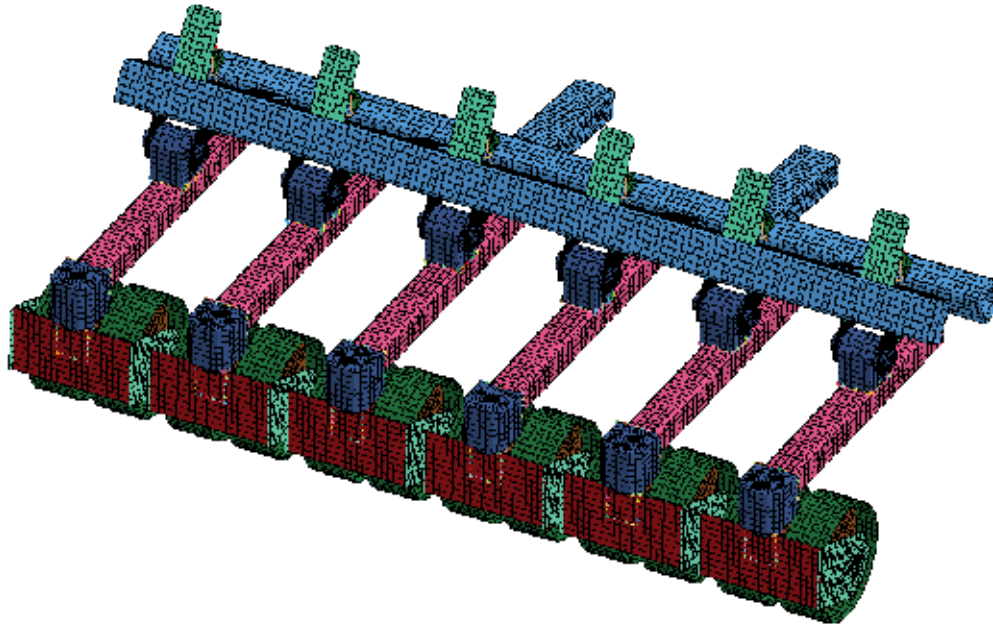


Fig. 6 Numerical model of the mine roller – general view

The explosion of 1 kg TNT applied under the middle wheel set was assumed for the computer calculations. The results are presented (Fig. 7) in the form of distribution of reduced stresses acc. to Huber hypothesis. The results are expressed in MPa.

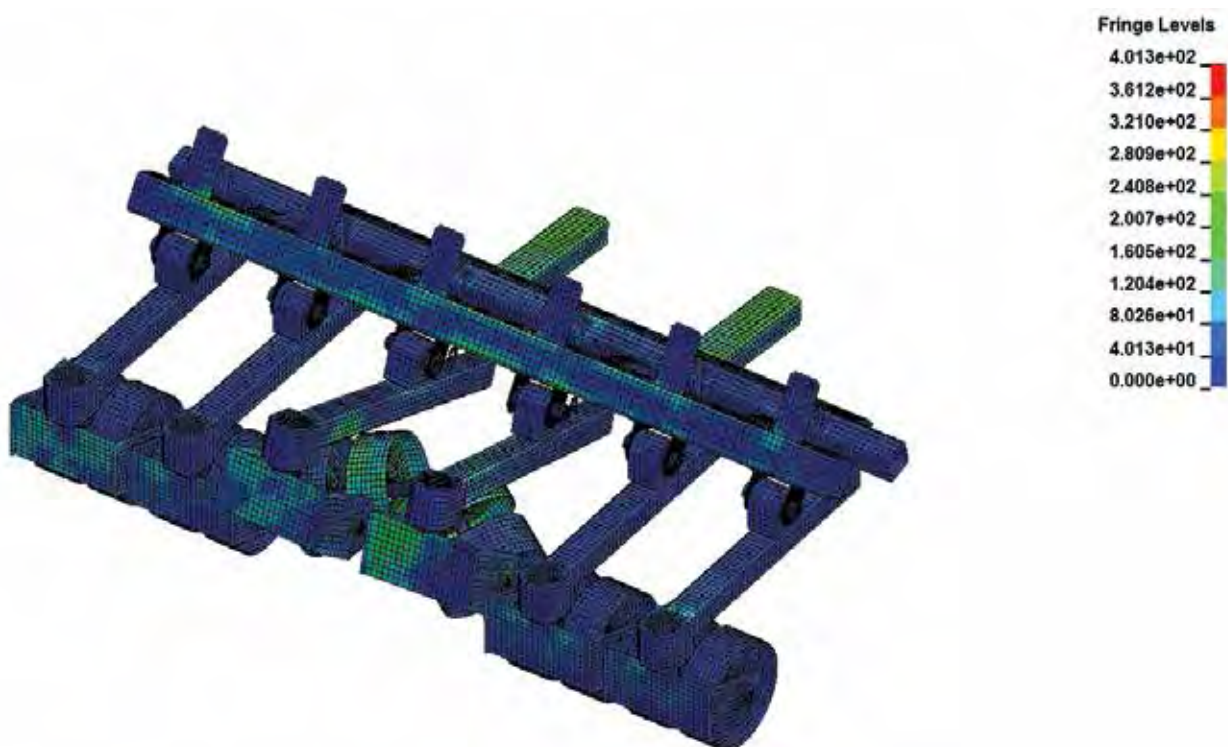


Fig. 7 Distribution of reduced stresses

It is possible that the roller which will be directly over the explosive charge can be completely destroyed. The whole mechanical construction of the mine roller will not be destroyed, because during the explosion the rocker arm together with the wheel set are to be thrown into the air (Fig. 7) and the energy is not transferred to the main part of construction. This phenomenon confirms the design basis.

The damaged rocker arm should be replaced after the explosion. The mine clearance can continue.

3. EXPLOSION TESTS ON THE PROVING GROUND

The subject of the study were also the field tests of the container for transport and temporary storage of hazardous objects and the mine roller carried out on the proving ground. The subject is part of the TIRAMISU project.

3.1. Explosion tests inside the container carried out on the proving ground

The proving ground stand for testing the container is presented in Fig. 8. The black foil placed on the ground and four control shields deployed around the container were used to assess the fragment scatter. The shield height was 3 m and its width was 2 m. The distance from the shields to the container axis was 6.5 m. The ICP 137A23 pressure sensors were used to measure the pulse and overpressure parameters at the front of the shock wave. The distance from the container axis to the first pressure sensor was 3.25 m, to the second sensor – 6.5 m and to the third sensor – 10 m.

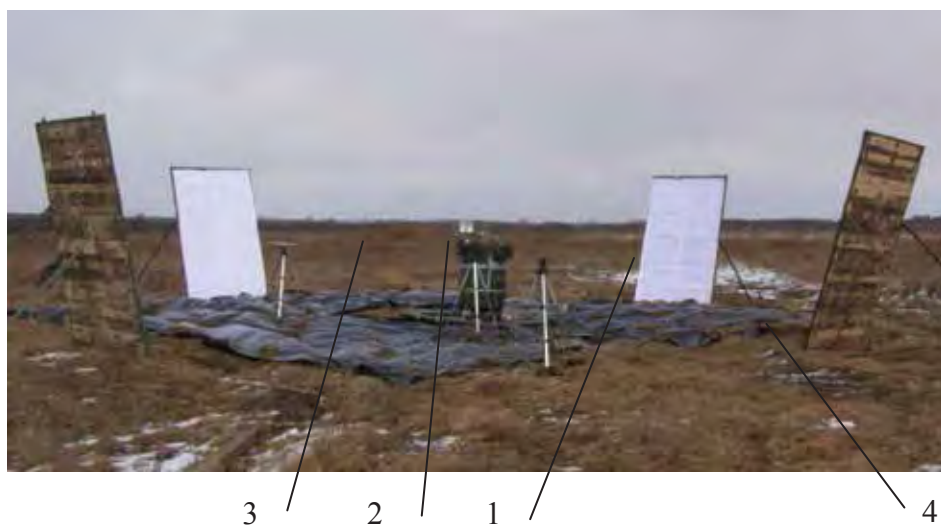


Fig. 8 The proving ground stand for container tests.

1-container; 2-pressure sensor; 3-shields, 4-foil.

The explosive charges used for testing included lethality enhancers. These charges were made of TNT pressed blocks weighing 75 g (11 elements) and a single 200 g block (1 piece). The lethality enhancers were steel balls (bearing balls) with the diameter of 6 mm. The total number of balls amounted to 2000. The 200 g TNT block has a body made of 2 mm steel sheet. The explosive charges were placed in the container and then armed with the “ERG” electrical detonators. Then they were connected to the measuring apparatus. The explosive charges were detonated by means of a TZK-100A electric blasting machine.

The effect of detonation of explosive charges is presented in Fig. 9. The container inspection was carried out after the trial and deformations of the container side surface in two areas were noted: larger, in the middle part (Fig. 10) and a minor one – of the container cover.



Fig. 9 Effect of detonation of explosive charges in the container
1-steel balls; 2-pressure sensor; 3-control shield

The inspection of the area covered with foil and of the control shields was carried out after the detonation. A dozen or so steel balls were found on the foil with a radius of 4.0 m from the container axis. Some wooden splinters of the damaged boards and of the cover of the cavity for explosive charges were present too. Not one steel ball had hit the control shields. The obtained results indicated that the substantial majority of balls remained in the container, only a few were ejected outside and fell around it. As a result of the impact of the high temperature of the post-explosion gasses, the wooden and rubber components inside the container had incinerated.

The experiment showed that the container was not damaged as a result of detonation of fragmentation explosive charges and that the explosion had no impact on the safety of its use. Tensile stresses of the side part of the container body, eye bolts and the frame of the container did not exceed the limit values for tensile strength. The probable cause of deformation of the container side surface in two places the impact of the 200 g block of TNT, which after detonation divided into two parts.



Fig. 10 Deformation of the container side surface-front view (top figure) and side view (bottom figure).

The maximum deformation values (Fig. 11) were 10÷11mm and 4÷5mm, respectively.

The courses of pulse and overpressure at the front of the shock wave registered by sensors are presented in Fig. 11.

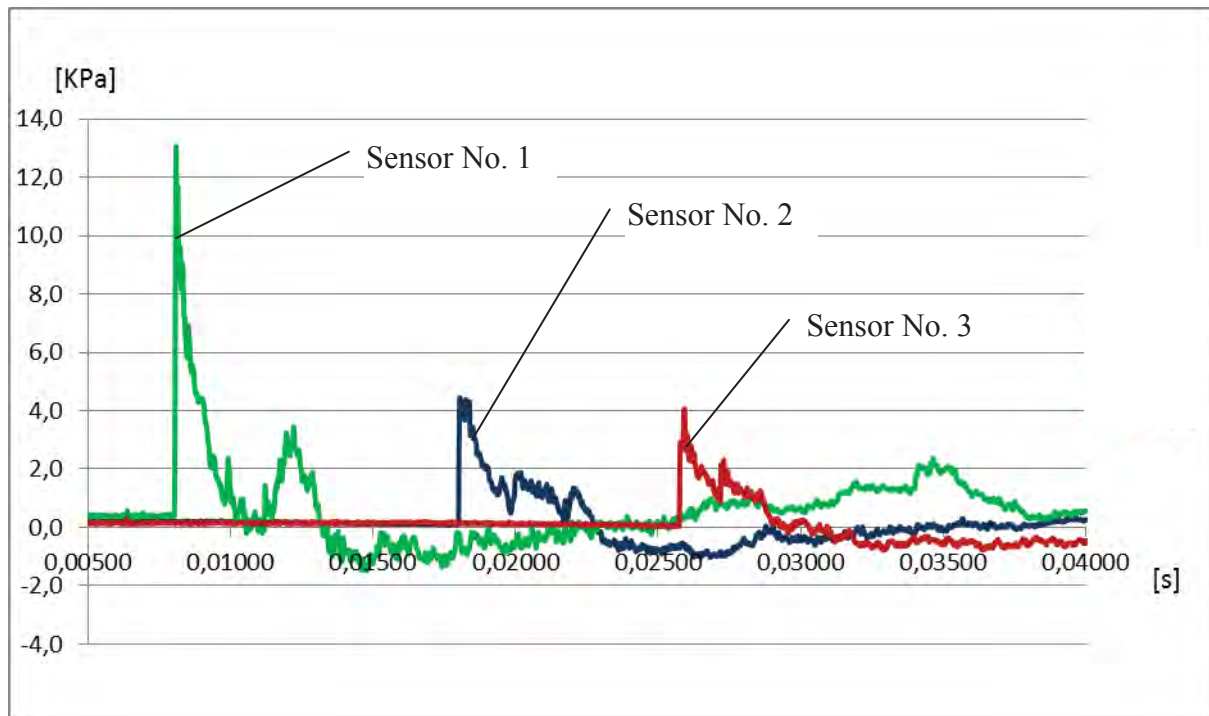


Fig. 11. The course of the pulse and overpressure at the front of the shock wave.

The peak values of the overpressure for the shock wave and reflected wave registered by separate sensors were as follows:

Sensor No. 1 – ΔP – max1 – 13.06 kPa; max2 – 3.45 kPa;
 (distance from the container axis – 3.25 m)
 Sensor No. 2 – ΔP – max1 – 4.45 kPa; max2 – 1.74 kPa;
 (distance from the container axis – 6.5 m)
 Sensor No. 3 – ΔP – max1 – 4.03 kPa; max2 – 2.14 kPa;
 (distance from the container axis – 10 m).

Area hazardous to human health and resulting from the impact of shock-wave (atmospheric pressure exceeding 0.1 standard atmosphere) measured from the centre of the explosion should equal:

- from 0 to 6.5m for a charge containing 2kg of TNT,
- from 6.5 m to 9.0m for a charge containing 5kg of TNT

according to the Ordinance of Ministers of Internal Affairs, National Defense, Finances and Justice (Journal of the Laws, No. 165, item 992 dated August 2nd, 2011).

Thus it can be concluded that the **hazardous area for the tested container carrying fragmentation explosive charges up to 1 kg of TNT ranges from 0 m to maximum 4 m, which is well below the Ordinance regulation.**

4.1. Mine roller tests on the proving ground

The test stand was designed and erected to carry out explosive tests under the mine roller on the proving ground. The mine roller was presented in Fig. 12.



Fig. 12 Mine roller in the test stand

The test stand consisted of the mine roller mounted on the auxiliary frame loaded with the weight of 26.7 kN. Sequences of the selected registered images during the trial of dynamic load caused by the detonation of 8 kg cast TNT in form of 400 g 20 blocks placed indirectly under the mine roller wheel are presented in Fig. 13.

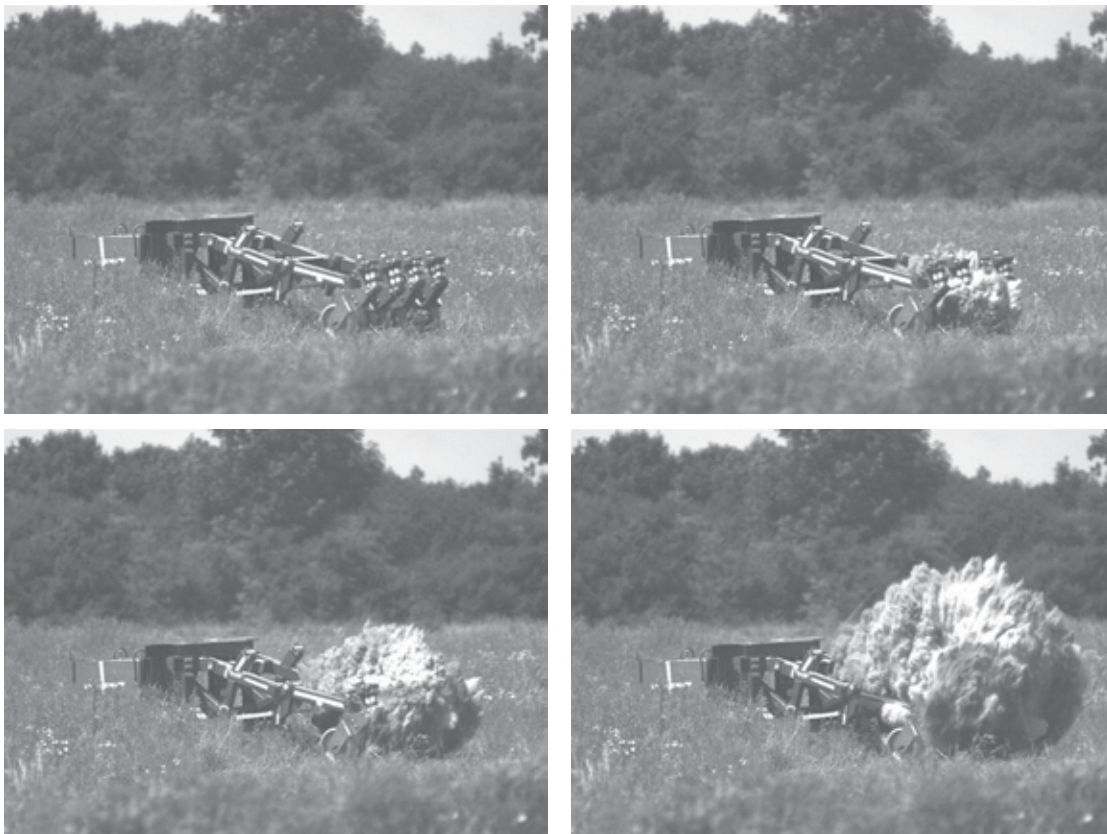


Fig. 13 Images registered during trial by the high speed camera No. 1

The above images were registered by means of a high speed camera.



Fig.14 Image mine roller after trial

Only a wheel set on the rocker arm directly over the explosive charge was destroyed. The remaining rocker arms and elements were in good condition.
The trial result confirmed earlier calculations.

4. Conclusions

The use of computer-aided design software allows the user to create models of devices and to perform simulations without having to build models in real terms. Such methodology can significantly reduce the cost of implementation of the devices. This way the design basics are also verified.

The methods of digital prototyping and simulation of explosive phenomena were described in the paper. These methods were verified by experiments on the proving ground.

Generally speaking, the design basics were met. The assumed construction of the mine roller with modular structure consisting of quickly replaced elements which would be damaged as a result of explosion proved effective. In particular, the mine clearing elements (wheel sets) were designed so as to be placed on movable bars (the so-called rocker arms) which move back during the explosion thus minimizing the effects of the destruction on the device. Both the digital simulations and the proving ground tests indicate that this concept is sound and solid.

During the design of the container to transport explosives, it has been assumed that the part of energy of explosion should be absorbed by the material filling the container inside to protect the container against disintegration. At the same time, the overpressure of the shock wave will be released vertically upward through the shutter structure of the upper container cover. The design of the shutter/grate should not allow significant ejections of the solids from the container. Basing on the tests carried out, it can be concluded that the design basics have been met.

The designed container should comply with the legal document connected with the impact of the shock wave. In this paper, it has been shown that the hazardous zone for the tested container has a radius of 4 m, what is not only acceptable but well below the legal requirement.

On completion of the work, the following observations were made:

- calculations of explosion under the mine roller and the explosion on the proving ground confirm the accuracy of calculations;
- the explosion of the container on the proving ground did not confirm the calculations – the damage to the container was minor, while according to the calculations it should have been great.

Considering, the present state of knowledge it is necessary to experimentally confirm the results of digital simulation calculations related to the phenomena of explosives.

The applications (Fig. 17) of tested devices coupled with the Pierre Trattori (TIRAMISU Partner) remote-controlled tractor can be proposed.

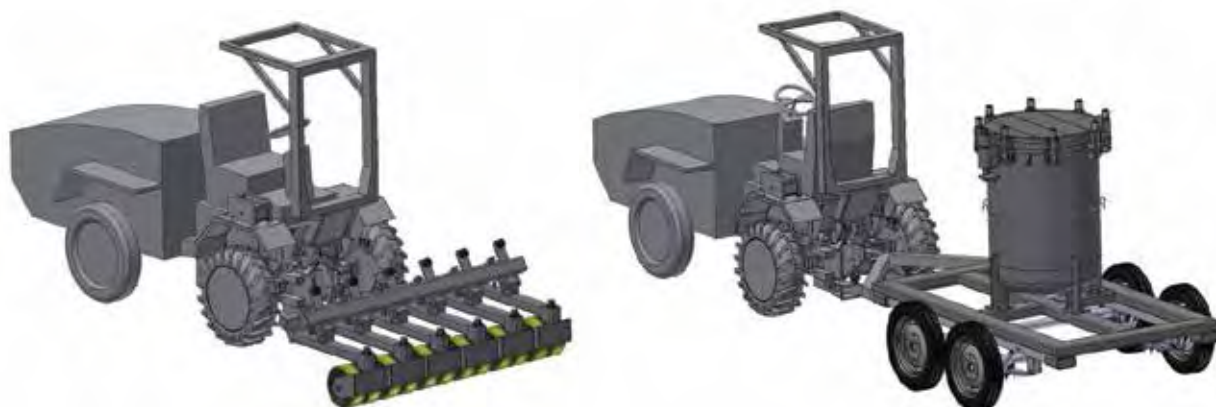


Fig.15. Application of devices tested on a tractor

Basic vehicle

tractor: Pierre Trattori
engine power: 58.1 kW
hydraulic pump: 180 bar, 36l/min
mounting: TUZ (three-point linkage)
with load bearing capacity of 1.350 kGm (relative to wheel axis)
unmanned operation – remote-controlled (wireless)
vehicle's resistance to explosions of anti-personnel mines (on steel wheels)

Literature

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2. LS-DYNA Keyword User's Manual (Version 971).

Acknowledgements:

The research presented was made possible as part of EC founded 7FP TIRAMISU (Toolbox Implementation for the Removal of Anti-personnel Mines, Subminitions and UXO).

Toward the accreditation of LOCOSTRAv2: results of pre-tests

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Abstract

The paper presents results from a long work aimed at filling an important gap in the standardized protocols for testing and evaluating demining machines. While, a CEN workshop agreement (CWA) on testing and evaluation of demining machines designed to detonate hazards exists, no such a similar agreement is in place for testing and evaluating demining machines for technical survey and area preparation. The work introduced here aims at filling this gap, explicitly stated in the CWA currently in place: “It is recognised that this CWA [CWA 15044:2009] concentrates on the testing of machines employed to clear mines, and there is a need to expand future work to address a number of issues”. Preliminary results obtained applying the proposed system to the pre-test of LOCOSTRAv2 machine are also presented.

Existing standards and needs

The current CWA on T&E of demining machines (CWA 15044:2009) is explicitly targeting machines designed to detonate or destroying landmines, in particular flails and tillers. Their evaluation is based on their ability to initiate, neutralise or damage mines.

IMAS 09.50 (August 2012) defines demining machines as “all machines that are designed to be used in hazardous areas”. Demining machines are then divided into three categories: “machines designed to detonate hazards; ground preparing machines; and machines designed to detect hazards”. At this time, there is no CWA (or other standard) defining how to test and evaluate ground preparing machines or machines designed to detect hazards.

IMAS 09.50 (August 2012) states that while ground preparing machines are aimed at “improving the efficiency of demining operations by reducing or removing obstacles”, machines designed to detect hazards “may do it physically, as with sifting machines and rollers, or by carrying a detection technology such as metal detector arrays or vapour sampling devices”. There are guidelines appropriate to the test and evaluation of some detection devices in CWA 14747:2003 Test and Evaluation of Metal Detectors. Machines carrying ground roller systems fit into the definition of machines designed to detonate or destroy hazards.

Because no standard means of testing and evaluating them exists, it is appropriate to include both sifting machines and ground preparing machines in the broader category of machines for Area Preparation. In both cases, when machines are used in a land release process, they need a manual follow-up. This usually is done in-situ but can be conducted remotely when the machine moves the processed soil and the sifted material is examined in another location.

Currently, machines designed to detonate or destroy mines such as flails and tillers are frequently used in Technical Survey (TS) [Cepolina E.E., 2013] operations because they are the only machines available. Their use can be inappropriate because the objective of TS is not to destroy mines, but to collect information about the threat. According to IMAS 08.20 (March 2013) among the assessment of the performances of different assets in the survey role “the extent to which the asset will preserve information associated with hazard items and other aspects of the surrounding environment” should be taken into account.

To comply with IMAS 08.20, when evaluating a machine’s suitability for use in TS, it is not appropriate for the assessment to be based on its ability to initiate or damage mines as though that were an essential feature.

During TS, other assets are often used after the mechanical assets and the procedures conducted subsequently should be informed by the output of the mechanical assets. For example, the evaluation of machines for TS should include assessment of characteristics that may affect the selection or performance of metal detectors, mine detection dogs or any other follow-up asset, including other implements attached to a machine.

When assessing a machine’s suitability for use in TS tasks, its ability to withstand the detonation of explosive devices should be assessed with reference to the manufacturer’s claims for the machine’s capabilities. For example, if the manufacturer claims that the machine can withstand the blast from an AP mine under its wheels or tracks, an explosive test should be conducted to verify that claim.

Guidelines that take into account all useful outputs of machines for TS and the effects on assets used after them when testing their performance would be beneficial to the mine action community.

The fact that there is no agreement on how to test and evaluate machines for TS and Area Preparation has two main drawbacks: it makes their adoption difficult for any organization and so makes machines designed to detonate or destroy mines the most obvious choice in every occasion, even when the output desired is not the one of detonating or destroying mines. This leads to a misuse of machines that may lead to unnecessary waste of resources and a reduction in safety for those working after the machine.

By providing a framework for defining the role of varied machines in TS and Area Preparation and by agreeing the performance expected from these machines, the path towards a widespread and informed adoption of new, cost-efficient, TS technologies can be opened. Machines have the potential to be used for Area Preparation and TS on a much wider scale because their cost can be reasonably predicted to be much lower than the cost of those demining machines designed to detonate or destroy mines. The role of a machine for TS and Area Preparation is limited to the investigation of Suspected Hazardous Areas (SHA) so they do not have to withstand multiple detonations. When a detonation occurs, the contaminated area has been located and the machine can be either withdrawn or moved to another area.

The test and evaluation shall provide users and donors with useful and reliable data. This will permit users, donors, machine designers and others to assess the effectiveness and efficiency of particular equipment and so improve operational effectiveness and safety in HMA operations.

New test and evaluation protocol

The proposed new test and evaluation protocol follows the structure of the current CWA protocol and is divided in a step by step approach. In fact, it foresees a pre-test assessment, a performance test, a survivability test and an acceptance test. The difference between the current CWA and the new protocol lays in the fact that the new test is thought to take place in contaminated countries, partly in cleared areas nearby SHA and partly in SHA.

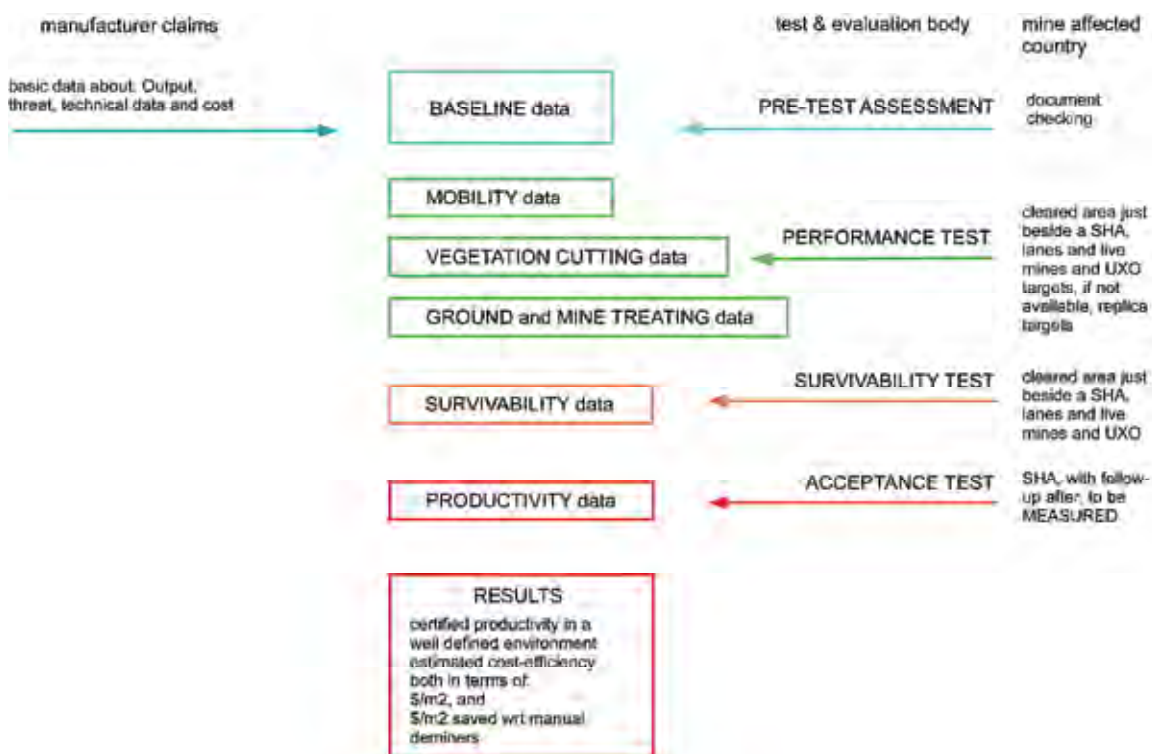


Fig.1. Scheme of the proposed new test and evaluation protocol for demining machines for TS and area preparation

The main idea is to assess the performance of machines in realistic conditions and then to define the characteristics of the particular realistic environment in which the test took place using a limited number of meaningful parameters easy to measure in the field by any non specialised team.

For this purpose, it seems particularly appropriate to use a parameter developed by the WES US military to define the soil compactness with a single number, the cone index value.



Fig.2. Cone penetrometer

The cone index is a light, relatively cheap and easy to use tool, whose reading brings together three soil characteristics, the soil cohesion, the angle of internal friction and the angle of friction between metal and soil. Although the influence of each one of these three parameters cannot be isolated and therefore the theoretical maximum drawbar pull of a machine cannot be calculated using theory (cohesion and angle of internal friction would need to be known), the cone index value allows to estimate the ability of a vehicle to move and to carry implements on a certain type of ground. Thanks to a large literature on the empirical correlations between vehicle performance and cone index values, many different equations have been developed and can be used to predict soil trafficability.

Thanks to its simplicity the cone index value is largely used also in agriculture to predict the drawbar pull of tractors on different soils and match them with the right implements.

Therefore, by characterizing the ground in which tests take place and associating measured results to a particular type of soil, it would be possible to create a library of reliable data on the realistic performance of a certain machine in different environments. If this library would be made public, it would help program managers to use the safest, most cost-efficient and the most appropriate machine for their needs.

Pre-test of LOCOSTRAv2

In parallel to the work on a proposal for a new CWA, the pre-tests of LOCOSTRAv2, aimed at pre-verifying the performance of LOCOSTRAv2 before the official accreditation in a mine affected country, are under going.

Pre-tests on LOCOSTRAv2 therefore follow the steps proposed for the new CWA: pre-test assessment, performance, survivability and acceptance tests. Because the pre-test are taking place in Italy, not all steps are taken. For the moment, the research team is focusing on pre-test assessment and performance test.

The pre-test assessment scheme developed for LOCOSTRAv2 and proposed for the new CWA consists of the verification of baseline data provided by the manufacturer. The manufacturer is asked to fill in a form including data about the following topics:

- Output expected from the machine in terms of vegetation processing, ground processing and mine processing, removal of obstacles, geometry and mass properties allowing to estimate the soil trafficability for different environments characterized by different values of cone index at chosen wheel slip and types of vegetation.
- A section dedicated to technical data provided by the manufacturer; to be as objective as possible, these data should be supported by relevant documentation, such as data sheet of engine used in the machine.

Some of the technical data presented here are underlined, because they are measured. Some of these can be verified by the entity in charge of the test and evaluation.

- The last section of data refers to cost-efficiency data. Here data about the ordinary maintenance of each separate component of the machine (such as engine, implement) should be reported together with an estimation of the lifetime of the machine and tools and the cost of transportation and custom. The latter have to refer to the cost incurred to bring the machine to the test site in the mine affected country and have to be supported by invoices.

The data contained in the baseline data form feed two separate excel sheets called soil trafficability model and cost-efficiency model.

These two models allow predicting the drawbar pull of the machine in different types of soils, characterized by different cone index values, the first, and predicting the effective cost per metre square of the machine, the second. The latter needs to be fed also with results from performance tests to assure accurate estimation of fuel consumption and speed of work are taken into account.

Thus, a comprehensive system has been developed that allows the user to get a quick and meaningful picture of the machine.

Figure 3 shows preliminary results of the soil trafficability model fed by geometry and mass properties from the baseline data form for LOCOSTRAv2. The soil trafficability model developed compares results obtained using three different empirical equations, cited by [Macmillan, 2002], developed by [Wismer and Luth, 1973] and Brixton [ASAE, 2006] respectively.

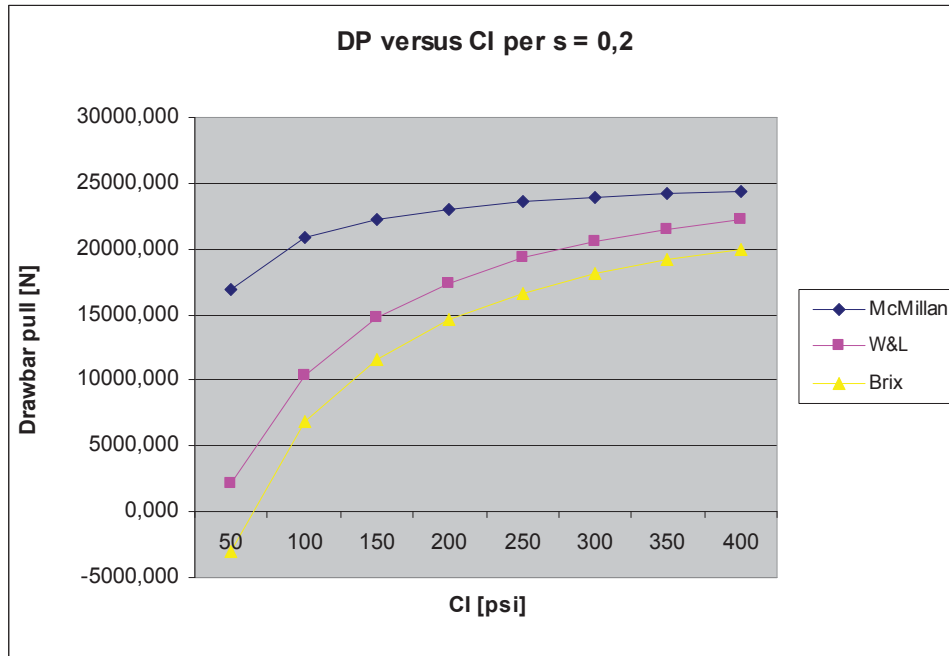


Fig.3. Drawbar Pull (DP) versus cone index values of different types of soils at wheel slip (s) equal to 2%, value typically used in military soil trafficability analyses.

While a different form has been developed for LOCOSTRAv2 equipped with every implement, a single trafficability model exists, containing in separate sheets also the predicted draught force required for each implement according to the depth of work and the type of soil.

The performance test scheme developed for LOCOSTRAv2 and proposed for the new CWA foresees the measurement of performance results of the machine. The first category of performance values to measure regards the mobility of the machine. Then the performance in terms of fuel consumption and productivity, with respect to the output stated in the baseline data form, is measured in different types of soils and vegetation.

Figure 4, 5 and 6 show the preliminary measurements of the minimum radius of curvature of the machine equipped with a trailer to carry a ripper implement, the preliminary measurements of capacity on vegetation cutting, beside a table presenting cone index values measured in four different points at the test site.



Fig.4. Mobility measurements in performance tests: measurement of minimum radius of curvature



Fig.5. Performance tests: measurement of capacity in vegetation cutting.

Depth [mm]	Cone Index (CI) at point n.1 [psi]	Cone Index (CI) at point n.2 [psi]	Cone Index (CI) at point n.3 [psi]	Cone Index (CI) at point n.4 [psi]
76	150	170	50	100
152	180	250	100	180
228	200	300	180	180
304	210	250	200	200
380	190	200	210	100

Fig.6. Cone index values measured at test site.

Acknowledgments

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Great Rally on the back of electronic turtles Computer game for children MRE

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1. INTRODUCTION

“Great Rally” is an educational computer game under development in the TIRAMISU project.

There are two kinds of tools for MRE (Mine Risk Education) in this project, tools that are to satisfy two complementary needs. One of these needs relates to education on current dangers and safe behavior of all members of community, particularly on the territory of action conducted by demining/MRE teams in a given area. For satisfying this need theatre/radio plays have been selected. Another need is of far-reaching character, relates to molding safe behavior – of children first of all – in the face of permanent mine risk being a residual problem of successive generations of people on a given territory. Computer games have been selected just to meet this need with regard to children.

The games are designed for implementation on Internet-connectable mobile devices (iPad mini tablet of Apple has been chosen for tests), and for school-like use with teacher-instructor participation. Because in the case of educational games with defined objectives the possibility of attractiveness extension is really limited, motivation of children to play MRE games can be effected by competition. Motivation by possibility of entering a competition international, under auspices of a prominent institution, should be exploited in MRE computer games further development, maybe even after the TIRAMISU project end. The essential condition under which international competition can be organized is equality of chances and comparability of results of participants. So, MRE games making up the competition ground should be as universal as possible, should appeal to common characteristic of children of the human species. “Ethnicalization” of MRE games, limited to necessary differences in language, landscape and photo-realistic dangerous objects can be treated as customization of a product with the same, unified general characteristics.

The “Great Rally” game is developed according to the above assumptions, meaning based on sport type competition and cultural universality. Present plain version is designed for primary testing with participation of children at the age of 8-10, and can be changed and enriched after tests. Safety rules in the face of mine risk aren't to be presented the gamers during gaming but before the gaming session, in a “briefing” before the Rally. The game itself is destined to exercise these safety rules use, and to toughen knowledge about them, thus to form - in the long run - desirable children's behavior.

Didactic aims attributed to present version of the game are the following:

- If a child is in an unknown place then has to keep particular caution, to keep ears and eyes peeled, and to comply with learnt safety rules that should keep always in mind.
- A child should inform authorities and the community about the strange objects recognized.

This paper doesn't present any final result of the game development but work in progress, the concept of the game and its graphical implementation in particular. The aim is to obtain

opinions and suggestions from humanitarian demining experts for use in further work on the game.

2. THE GAME’S CONCEPT AND GRAPHICAL REALIZATION

The game is multiplayer one, of the board type, and rally on the backs of electronic turtles through a terrain with mine risks is its content. Title screen of the game, being also its logo, is presented on the Fig.1.



Fig.1. Great Rally logo

Electronic turtle, serving as a pawn in the game, is depicted as three-wheeled vehicle, equipped with camera and tiny intelligence - derived from cybernetic turtle that was designed for initial cybernetic experiments with artificial intelligence. Graphical presentation of turtles is shown on the Fig.2.



Fig.2. Electronic turtles

Pawn-turtles move on paths plotted on the game board, and are feed on “grains of movement”; one grain (graphical image of which, used on a grain counter visible for the gamer, is presented on the Fig.3) lets the turtle to make one step on the path. Each step is triggered off by gamer by touching the path on the screen, but can be executed only if there are grains of movement in the turtle’s resource. The turtle is equipped with some resource of grains on the beginning of the game, but this resource isn’t sufficient for reaching the finish line, and has to be replenished during the game. Replenishment is accomplished automatically as a result of specific gamer’s actions fulfilled on the way, and in waysides Information Outlets (graphical image on the Fig.4).



Fig.3. Grain of movement



Fig.4. Information Outlet

The board of the game depicts a map with a net of paths connecting start point with finish line of the rally (Fig. 5).



Fig.5. Board of the game

Different solid, immobile objects are showed on the map, some of them dangerous, some neutral. Examples of such objects are presented on the Fig.6.



Fig.6. Examples of solids objects showed on the map

On the paths of the board “touchable points” are marked (as one can see on the Fig.5). Pawn-turtle occupies its position only in these points and can make a movement as single step from just occupied point to the next one, forward or back as well as left or right on paths intersections. Each step-movement is caused by gamers by touching one of neighboring points. In this way gamers can aim at the finish line choosing different paths, taking into account dangerous objects.

Some of marked points are active, meaning stepping with turtle on such point causes certain after-effect. Of course active points aren’t distinguished by different marking, the gamer doesn’t know which points are active before stepping on them. There are three types of active points in the game.

Active points Type I correspond to stepping on mine and evoking explosion, and bring disqualification of the gamer as after-effect. If turtle step on such point, then the board of the game disappear from the gamer’s tablet, and the screen of disqualification (presented on the Fig.7) is shown for 15 seconds, and next final screen (Fig.8) remains on the tablet till the end of the game.



Fig.7. Disqualification screen

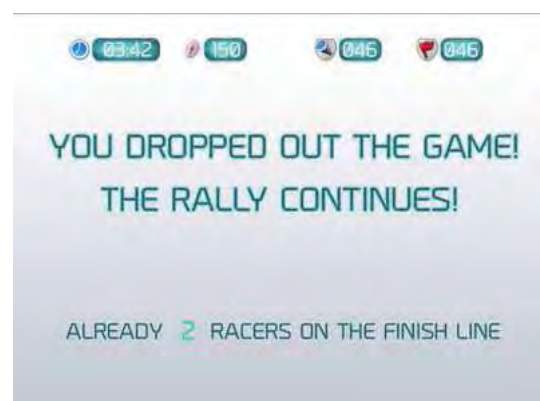


Fig.8. Final screen for disqualified gamer

Active points Type I are situated nearby dangerous solid objects showed on the board of the game – for example bunkers or water wells. However there is also another, second philosophy of Type I points localization, namely in conjunction with active points Type II.

Stepping on a point of Type II, electronic turtle perceives (with its supposed camera) an object – mobile one – situated in the next point on the path, and shows this object on the tablet screen. The object can be dangerous or not, and the gamer has to decide what to do: go forward, turn back, as well as left or right on intersection. Examples of dangerous and neutral objects located on the path and showed by the turtle are presented on the Fig.9.



Fig.9. Examples of mobile objects on the path showed by the turtle with its camera

In the case of dangerous object showed by the turtle in the Type II point, the next step forward leads to a point of Type I with disqualification as the after-effect. To choice other way to finish line is the right gamer's decision in this case.

Active points Type III serve for replenishment of grains of movement resource. Similarly as in the case of the Type II points, the turtle shows with its camera different objects, dangerous and neutral, but this time not situated on the path but past it. The gamer ought to observe these

objects and report if they are dangerous or not. Correct reporting causes replenishment of the resource of grains of movement. The reporting is done with use of the report screen (showed on the gamer's tablet), by pushing red (dangerous object) or green (neutral object) button. The screen with buttons, and examples of dangerous and neutral objects are presented on the Fig.10.

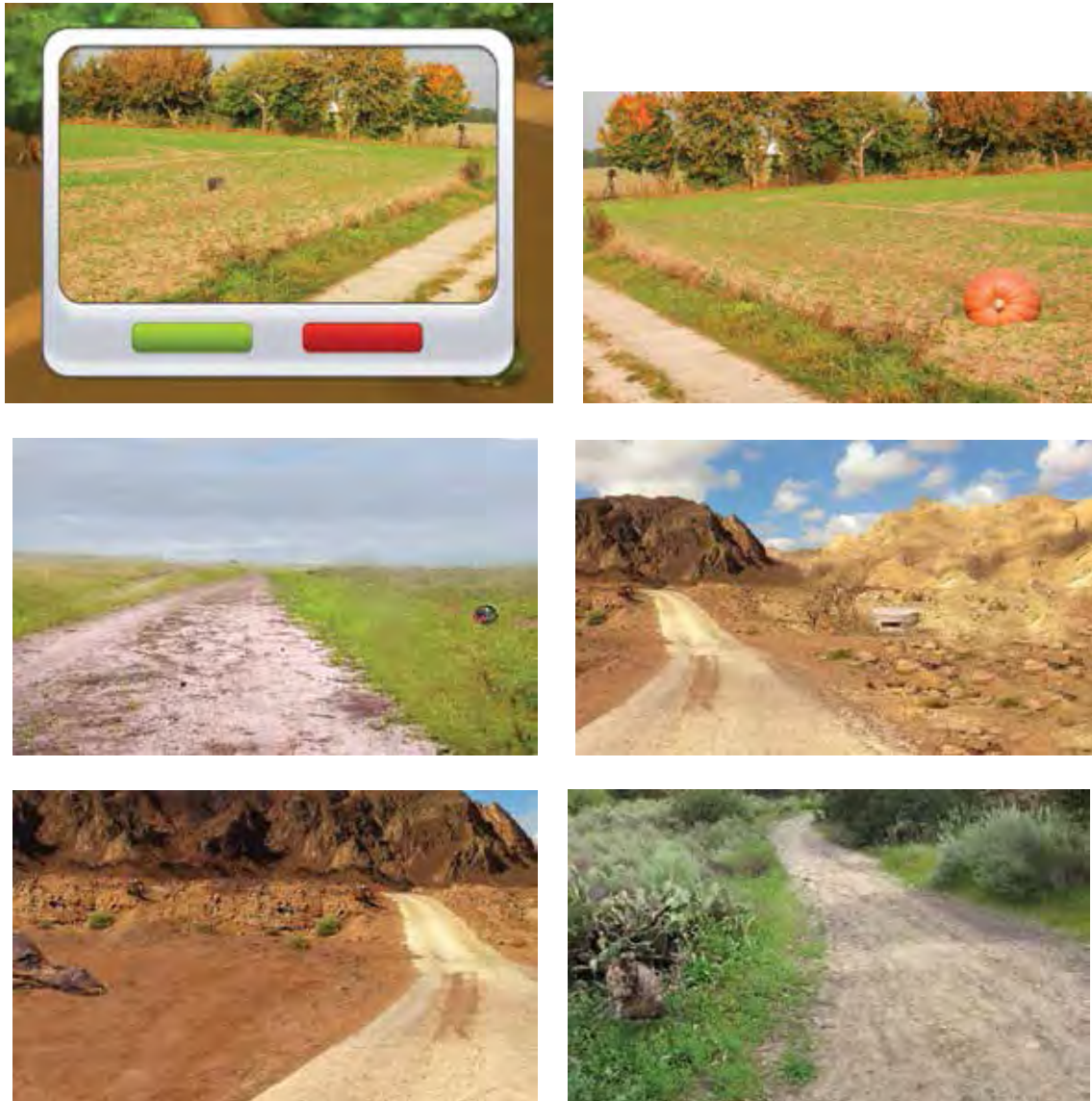


Fig.10. Report screen and examples of dangerous and neutral objects past the path

Reporting from the path serves not only for replenishment of resource of grains of movement. Correct reports are rewarded also with score points enabling to earn a proficiency – like scout proficiency, namely the Observer Proficiency.

There is also other way to replenish the resource of grains of movement and to obtain score points, namely via taking quizzes in Information Outlets. The Information Outlets are situated on the board-map, next to the paths, and to visit an Information Outlet is a free decision of the gamer. Thus, Information Outlet can be compared with filling station where payment is executed by correct answers to questions of the quiz. The answers are given by gamers without words, neither written nor spoken, only by touching screen. The quizzes are related to

the knowledge on mine dangers, and obtained score points enable to earn the Guide Proficiency. An example of the Information Outlet’s screen – that appears on the gamer’s tablet when the turtle steps on the path’s point attributed to the Information Outlet – is presented on the Fig. 11. Four icons located at the top of the screen presents counters of (from the left): time, grains of movement, score points for the Observer Proficiency, score points for the Guide Proficiency.

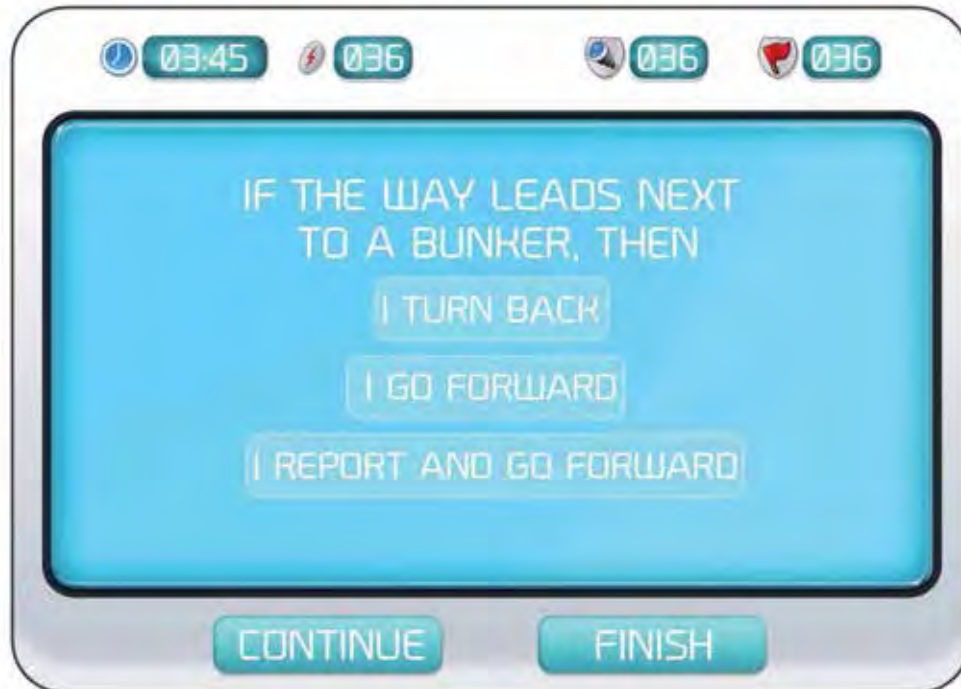


Fig.11. Information Outlet’s screen with one of quiz’s questions

When a gamer reach the finish line, then the final screen for successful gamer, presented on the Fig.12, appears on the gamer’s tablet.



Fig.12. Final screen for successful gamer

Finally, when all non-disqualified gamers arrive the finish line, or after a given time passage, the Rally ends, and the closing screen presented on the Fig.13 appears on the tablets of all gamers.

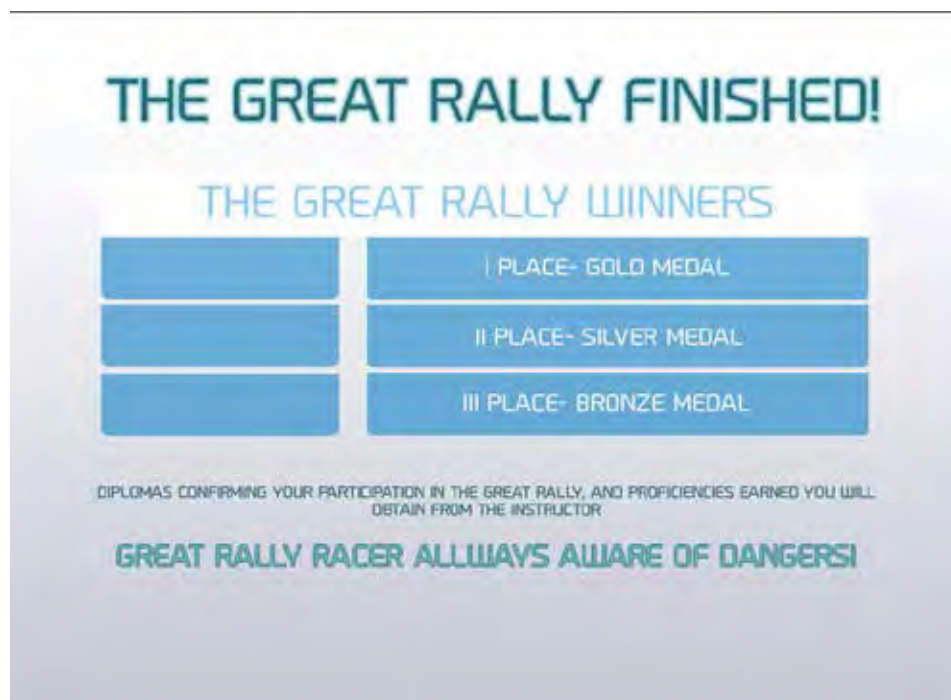


Fig.13. Closing screen

Participants of the Great Rally receive paper diplomas documenting their attainments. The following diplomas are provided for in the game: I, II, III places, the faster contestant, observer proficiency, guide proficiency, taking part in the rally. All these diplomas have the same graphical form, with places for hand-written content and signatures. Two examples of diplomas are presented on the Fig. 14.



Fig.14. Examples of diplomas

3. CONCEPTUAL PROBLEMS TO SOLVE

The problem to solve, having an interdisciplinary research aspect, is a method of determining of final result of the rally-game. Granting gamers I, II, III and next places ought to result from certain calculations of their times to reach the finish line, score points obtained by reporting and taking quizzes, and maybe other factors as e.g. consumption of grains of movements. Moreover final results can be calculated for single game as well as for a set of games each one with use of the board-map with differently located active points. The method of calculation should be optimized for the best educational results (the most desirable behavioral changes in the long run). So, interdisciplinary psychological and mathematical approach is needed to solve the problem, and testing of different calculation algorithms is necessary for this aim. Finding of such optimal solution isn't in the range of the TIRAMISU project. Practically acceptable solution with simple algorithm understandable for children will be adopted as a result of game testing planned in the TIRAMISU. However, further research work can be useful outside of humanitarian demining, and possible results could find their applications in various rally-type competitions, both virtual and real.

4. CURRENT WORK IN PROGRESS

As it has been stated in the beginning of the paper, iPad mini tablet of Apple that costs \$299 will be used as gamer's device. Client-server architecture with authoritative server technology, Internet as a communication medium, publish-subscribe architecture, and HTML5 standard have been chosen as the basis for the software. The subject of current work on this software is a tool for model of the game editing; the tool will enable “defining” in software the game graph, active points, and so on.

Other essential subject of current work is the game tests preparation. Pre-tests with children participation will be conducted in Poland, and full tests in Croatia. An important task is preparation of means and procedure of the game validation. The validation is to be conducted with use of questionnaires filled in before and after gaming by instructors/teachers and children (in some cases by parents as well). These questionnaires should to “measure” a grade of acceptance of the game by children, and a grade of change in children's knowledge on mine risks caused by gaming. Drawing up the questionnaires is important subject of present work.

5. REFERENCES

The concept and graphical realization of the game “Great Rally on the back of electronic turtles” are original work of the doers' team. References related to the general assumptions on computer MRE games have been presented in the TIRAMISU deliverable D410.1 “Mine Risk Education Tool Description”, March 2013.

Acknowledgments:

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Mobile robot virtual training system for robot operators

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In this paper the progress of development of multi robot training system, dedicated for use in TIRAMISU project, is described. The system allows for training of multiple UGV (Unmanned Ground Vehicles) operators during one training scenario. Maximum number of user is 10. The core of the system are VORTEX physics engine, for robust simulation, and OSG (Open Scene Graph) for rendering purpose. The system allows for online, robust simulation of the robots and environment. System architecture allows for scalability: new user can be attached dynamically. The robots can interact with each other, including colliding and realistic gripping simulation. Two models of robots are available in the simulator: a) iRobot-PackBot b) LOCOSTRA - a TIRAMISU dedicated robot in two configurations: equipped with a UXO (UnExploded Ordnance) detector or a trailer for UXO transportation. An example of multi robot mission will be shown.

Keywords: Humanitarian demining, mobile robot simulation, operator training

I. Introduction

This paper repost of the progress of development of high fidelity simulator for TIRAMISU project. Currently a high number of multi-robot simulators exist on the market. Examples are: Gazebo[1], USARsim[2], ARGoS[3], SARG[4]. A comparison of different physic simulation systems can be found in [5]. However our experience form other projects thought as that often such ready to use environments lack in robustness for serious gaming simulation purpose (example [6]). Our experience is related with joint simulation and gasping in Nvidia PhysX[7] engine. If such a limitation is reached it is often very hard to improve existing software in the middle of simulator development, especially in time critical projects. This leads to subpar decisions about lowering accuracy or using bypass methods(unrealistic parameter tuning). Thus for current work we decided to develop current simulator based on a profesional serious games engine VORTEX [8]. VORTEX assures high Rigid Body simulation fidelity. The accuracy assures proper training experience for a sensitive task of demining and UXO removal. For visualization purpose OSG (Open Scene Graph) is used. The communication is done using TCP and UDP protocols.

The report is organized as follows. Section 2 describes the architecture of the software along with the description of features and functionalities. Section 3 describes example mission scenario done using the simulator. The paper finalizes with conclusions and future work in chapter 4.

II. Architecture

The simulator is designed to allow dynamic changes to the environment. The core element is the main simulation server that is responsible for physics calculation. This is the only part of the system that performs direct VORTEX computation. The system is designed to work

best with use of multiple computers. Central computer runs the server, where users each have it's own machine. This allows for performance to be equal for all users, independent of their computers' configurations. Users connect to the system as clients. During initialization the server sends the location of all scene objects to the clients. Initialization of communication and initial scene configuration are send via TCP connection. During exercise execution only information about objects that had their state changed are send. To lower network traffic updates are send via UDP using producer-consumer communication. Each user has access to camera and sensor view of one robot, along with controls. Control orders to each robot are send by TCP. The overview of the architecture is shown in figure 1.

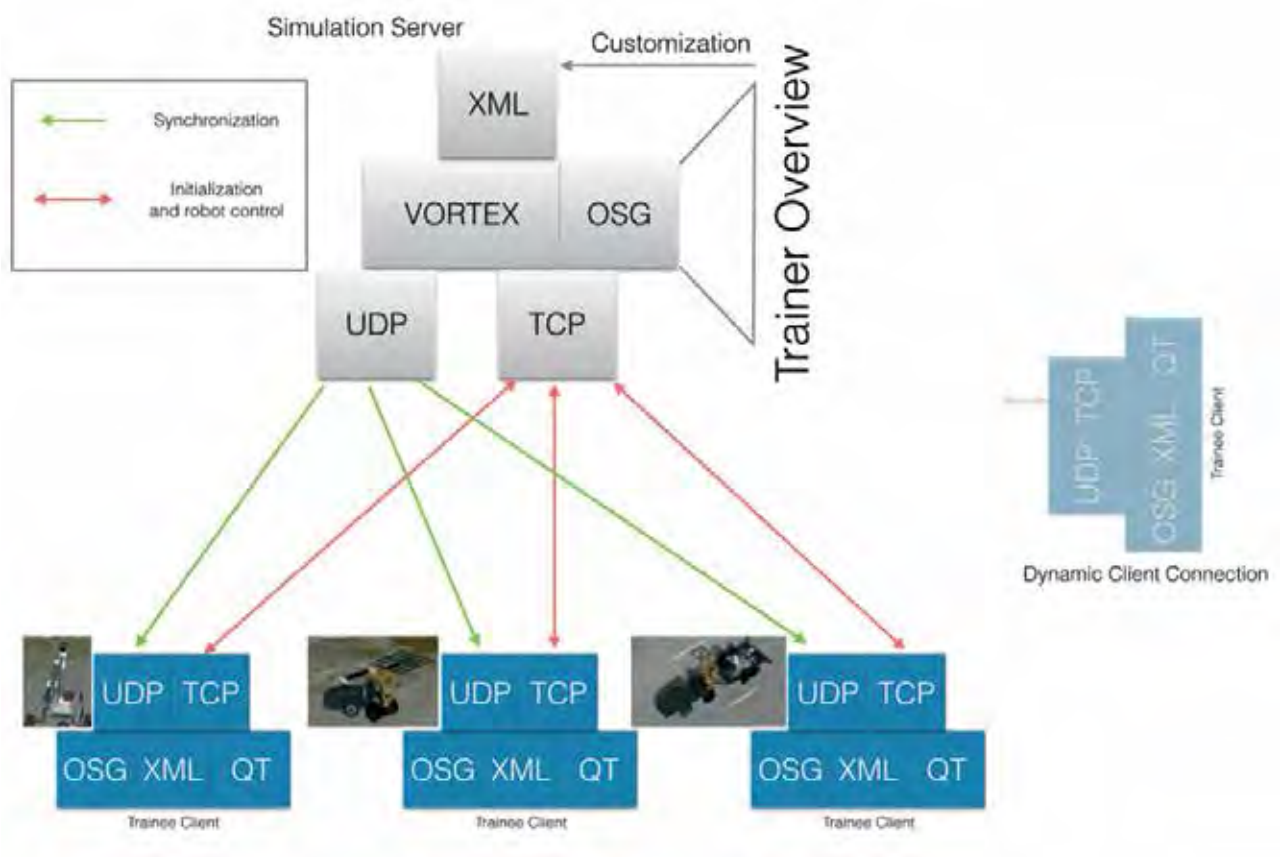


Figure 1. System architecture.

The main server module can be used as Trainer overview. From here the Trainer has access to a global view of the scene and views from each robot camera. Additionally the trainer can customize the scene configuration. All objects of the scene, along with parameters, can be customized. Robots configuration can be changed, by, for example, removing cameras, simulating damage. All configuration is done using XML files. Additionally the trainer can change lighting and weather conditions.

The system can work fluently with up to 10 users being connected simultaneously. This number may be increased by providing better network connection. Simulated robots may interact

with each other. The interaction includes: proper collision model, realistic joint model that allows to simulated a robot with a trailer movement, realistic friction model that allows for one robot to be transported by another and proper grasping model that uses friction for simulation instead of false joint creation.

III. Example mission scenario



Figure 2. Three robots used in the example mission

Figure 2 shows the robot models used during the scenario. The goal is to locate and remove an UXO. Three robot interact in this scenario. First is LOCOSTRA equipped with GPR-Ground Penetrating Radar. The operator is responsible for exploring a rubble pile and locating the dangerous material. In second stage, a LOCOSTRA, equipped with a trailer arrives at the scene. The trailer has a hazard disposal bin. Along with the second robot arrives the third, PackBot, which is brought on the trailer. PackBot operator is responsible for leaving the trailer by a ramp, picking the UXO and putting it to the bin and then getting onto the trailer. This tasks has to be done only using the cameras of the PackBot robot. Figures 3,4,5 and 6 show different stages of the mission: UXO localization, leaving the trailer, putting the UXO into the bin and getting onto the trailer. Picture 7 shows the view from one of the PackBot's cameras.



Figure 3. Mission execution: UXO search and removal

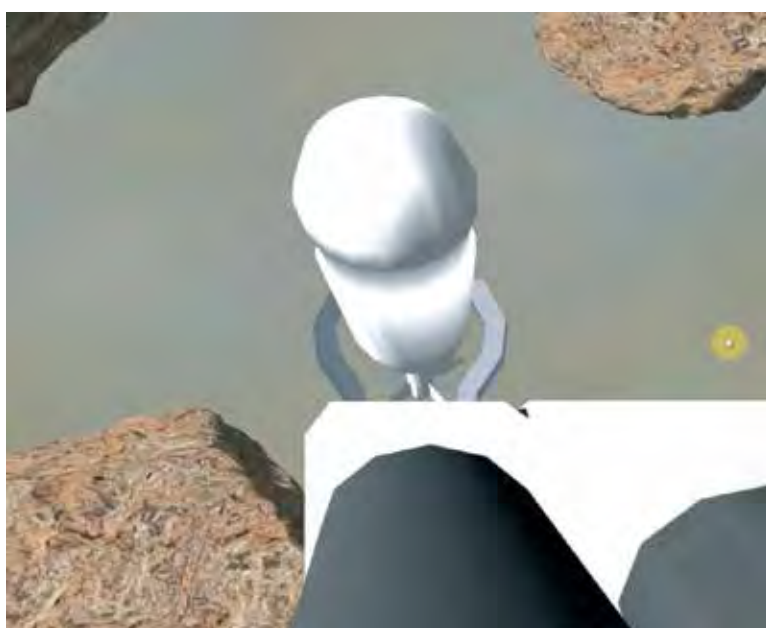


Figure 4. View from PackBot camera.

For this experiment the server runed on a modern mobile computer equipped with Intel i7 CPU and mid-end graphics cards. We did not observe any performance issues. The frame rate was above 25 fps for the Trainer console, higher on the clients. This proves that the systems is robust enough for this type of scenarios.

IV. Conclusions and future work

This paper presents a short description of progress in development of training simulator for TIRAMISU project. The system allows for multi robot simulation and concurrent task execution. Using VORTEX physics engine as core allows for high fidelity modeling of robot's interaction including: collision, grasping, towing and friction. Client server nature of the system allows for maximizing cost to performance ratio and producer-consumer UDP synchronization lowers the communication load and assures proper simulation speed. The system allows for dynamic client addition.

Future work on the system will concentrate on implementing events for documenting object interaction and integrating digging capabilities with the scene module. Alongside the certification module is being developed.

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FSR Backpack: A Wearable Device to Improve Humanitarian Demining Operations

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Abstract

This paper presents the Field and Service Robotics (FSR) Backpack, a wearable kit that was designed to improve and speed up field demining operations. We describe the hardware and the integration of all sensors comprised in the kit, as well as the software developed, which enables real-time monitoring of humanitarian demining tasks. A preliminary field test was conducted to assess the localization system and overall potential of the FSR Backpack and we discuss the usability and advantages of using the device. The results show promising system capabilities and enable us to outline future directions of research work in the context of the EU FP7 TIRAMISU project.

1 Introduction

Humanitarian Demining is a serious problem in post-war countries. Around 55 people are killed or injured every day in landmine related incidents, specially civilians. Clearly, there is a need to improve safety, reliability and speed of demining operations while reducing time, labor and fund wasting due to false positive detection as well as tediousness and stress levels of demining operation teams [1, 2].

The objective of the EU FP7 TIRAMISU project is to provide the mine action community with a toolbox to assist in addressing the many issues related to humanitarian demining, thus promoting peace, national and regional security, conflict prevention, social and economic rehabilitation and post-conflict reconstruction [3]. The team at the Institute of Systems and Robotics of the University of Coimbra (ISR-UC), a project partner, has been developing research related with robotics tools for field demining operations, chemical sensors and sensor fusion for landmine detection [4, 5].

Having this in mind, in this paper we present the FSR Backpack (*cf.* Fig. 1), a wearable kit that was designed to improve and speed up field demining operations. Using this device, a human deminer can test the adequacy of commonly used sensors in field robots, continuously transmit field data to a remote center of operations such as camera feeds or accurate position, record field datasets for further assessment, receive instructions related with trajectory planning and coverage, and much more.

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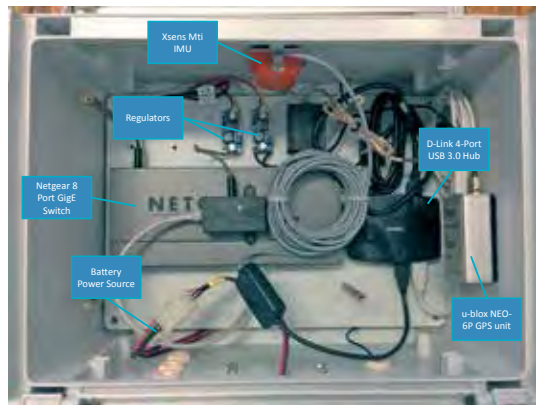
Figure 1: An operator equipped with the FSR Backpack during field experiments.

In the remaining of this paper, we describe the hardware components that are integrated in the FSR Backpack and make a brief overview of the software developed to provide intelligent capabilities to the device. We also conduct a field trial for preliminary validation of the FSR Backpack and discuss the results obtained in the field. Finally, the article ends with concluding considerations and future research directions.

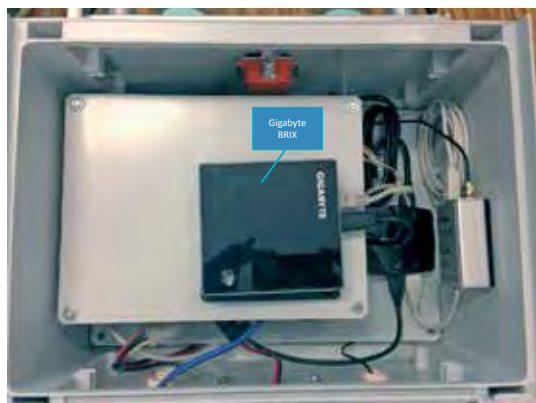
2 The FSR Backpack

The FSR Backpack is comprised of several sensors and hardware. Most of them are placed inside the main compartment, where two shelves enable an adequate organization of the components. The disposition of these components is displayed in Fig. 2. Below, we describe the modules that integrate the kit.

A diagram of all the modules, which illustrates how they communicate and how they are powered is presented in Fig. 3. The power of the kit is handled by a Bosch 36 V battery which is placed under the main compartment, as shown in Fig. 1. Four regulators provide the needed outputs of 5 V, 12 V, 19 V and 24 V to power all the components of the backpack. As seen further on, the latter regulator was not necessary since we did not make use of the optional laser range finder.



(a) Lower Shelf.



(b) Upper Shelf.

Figure 2: Hardware and sensors inside the main compartment of the FSR Backpack.

Regarding sensors, two IDS uEye GigE cameras are placed over shoulders height to provide real-time imaging in the field with a resolution of 1280×1024 at 50 FPS and equipped with 8 mm lenses. These cameras are mounted on ball joints on top of rails that allow adjusting the baseline and camera orientation. A wide variety of computer vision algorithms [6] can be used to perform different tasks in the field such as stereo reconstruction, visual odometry localization, tracking of a hand-held mine detecting systems, and more.

Additionally, an Xsens MTi-300 Inertial Measurement Unit (IMU) provides 3D orientation, acceleration and rate of turn to the FSR Backpack. This component features vibration-rejecting gyroscopes and a novel sensor fusion algorithm that overcomes limitations in Kalman filtering, named Xsens Estimation Engine (XEE). It also has a 1.0 degree accuracy in roll, pitch and yaw measurements. This equipment enables us to track the backpack pose in 3D, and can optionally be used to control and stabilize the cameras.

A very useful sensor for outdoor navigation is a Global Positioning System (GPS) unit. The FSR Backpack is equipped with the u-blox NEO-6P GPS, which combines the high performance of the u-blox 6 position engine with Precise Point Positioning (PPP) technology. It yields extremely high levels of position ac-

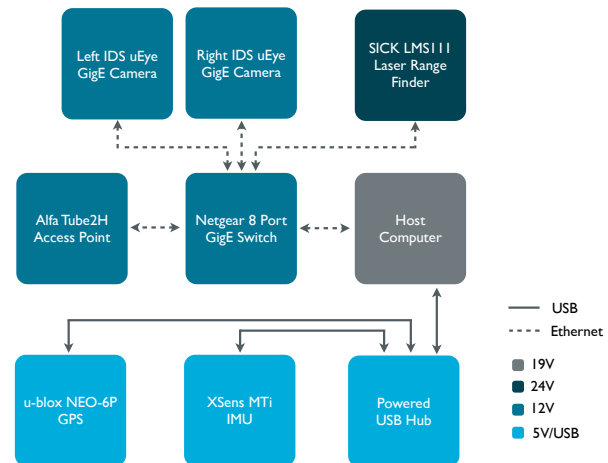


Figure 3: The FSR Backpack hardware.

curacy in static and slow moving applications. The raw data output is used by the Real-Time Kinematic (RTK) software to improve the estimation of latitude and longitude, providing global positioning with centimeter-level accuracy.

Finally, an optional sensor is included in the FSR Backpack: the SICK LMS111 Laser Range Finder (LRF). This is a commonly used sensor in Robotics for 2D distance sensing, obstacle detection, navigation and mapping. It scans the environment using laser beams to determine the distance to objects and build 2D representations of the environment, eventually allowing RGB-D perception if used together with the stereo pair. The maximum range of the SICK LMS111 is 20 meters at 25 to 50 Hz, with a field of view (FOV) of 270 degrees and a resolution between 0.25 and 0.5 degrees. In the preliminary outdoor tests reported herein, we did not make use of this sensor.

In addition to the above sensors, the FSR Backpack includes some more hardware components. The AlfaTube 2H is an outdoor WiFi access point, which is equipped with a 2.4 GHz and 9 dBi outdoor Omni Antenna, being placed on the side of the backpack (*cf.* Fig 1). This equipment enables the Backpack to be persistently connected to a base station, receiving feedback and retrieving field data for online and offline analysis. Furthermore, to enable the interaction between all modules, an 8 port switch and a USB 3.0 hub are placed inside the kit. The switch used is a Netgear GS108T-200 GigE with a 16 Gbps full duplex bandwidth, which provides Ethernet interface between the stereo pair cameras, the LRF and the access point to the host computer. On the other hand, for USB interface a D-Link 4-Port USB 3.0 Hub at 4.8 Gbps connects the Xsens IMU and the GPS unit to the host computer.

Finally, the host computer chosen to process all data and run the developed software is the ultra compact Gigabyte BRUX with an Intel Core i7-3537U at 3.1 GHz, with 8 GB DDR3 RAM and a 60 GB solid-state disk (SSD). The BRUX computer is currently the only com-

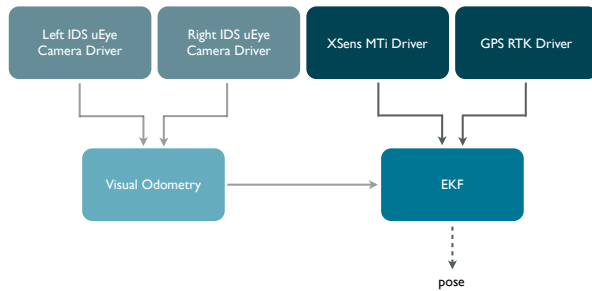


Figure 4: Pose estimation algorithm, which fuses data from the the IMU and the GPS unit, and optionally from the visual odometry estimation using the stereo pair cameras.

ponent placed on the top shelf, which has additional space for further extensions. Depending on the application, other sensors and hardware can be added.

In terms of software, the FSR Backpack is fully integrated in the Robot Operating System (ROS) framework [7]. All the components are launched using appropriate ROS drivers, which are responsible for publishing sensor data in dedicated ROS topics. The integration in ROS is beneficial as it promotes hardware abstraction and code reuse, therefore several algorithms available by the community can be utilized in field experiments, such as Particle Filter (PF) or Extended Kalman Filter (EKF) localization by fusing multimodel sensor data, Visual Simultaneous Localization and Mapping (Visual SLAM), object recognition and perception, etc.

3 Field Trial

A fundamental capability of the FSR Backpack is localization. Endowing the kit with accurate pose estimation, enables the system to identify the areas traversed by the human operator in the field, as well as those that should still be visited, *e.g.* for mine clearance in demining operations. In this section, we focus on the description of a preliminary field trial conducted to test the localization system of the FSR Backpack. Having this in mind, in Fig. 4 we present a diagram of the pose estimation algorithm.

Sequential images provided by the stereo pair of cameras may enable the system to extract odometry-equivalent information to estimate the distance traveled by the operator. Such approach relies on image processing to remove lens distortion effects, matching features across the two images obtained by the cameras at the same instant, and constructing optical flow fields to estimate camera motion. Despite its usefulness, visual odometry [6] is expected to accumulate error over time, thus by itself it does not represent an accurate pose estimation algorithm. Therefore, a classical pose estimation method - the EKF - can be primarily used to fuse the output data of the visual odometry algorithm, together with the global position estimate given by the GPS unit and the Euler angles provided by the IMU. This way, we expect to have high localization precision coming from

the EKF in outdoor field experiments.

In this section, we present our first validation test of the EKF using only information from the IMU and GPS unit, and we leave the fusion of the visual odometry estimates for future work. In order to test the aforementioned localization approach, we carried out tests with the FSR Backpack in an open outdoor area with irregular terrain relief in the University of Coimbra - Pólo II Campus¹. The operator was instructed to follow a cyclic path with quadrilateral shape, visiting four known landmark positions in the terrain.

During the experiment, the FSR Backpack was connected to a base station running the Ubuntu 12.04 Linux OS with the ROS Hydro distribution, which was responsible to monitor the whole experiment. In particular, the base station had real-time access to the data of all the sensors of the backpack and was able to track the position of the operator during the experiment. Additionally, it served as a single reference station with known and fixed position, enabling the RTK software to provide real-time corrections of the GPS estimates of the backpack position.

Figure 5 illustrates the path followed by the operator by the end of the experiment in the ROS visualization software *rviz*². As can be seen, the resulting estimated path from the EKF is consistent with the four defined landmarks, which shows that the method is extremely accurate, yielding a centimeter-level accuracy.

In addition to validating the system's pose estimation algorithm, the field trial has proven the suitability of the hardware and sensors chosen to incorporate the kit. Also, important sensor data has been collected, which will be subject to further analysis in the near future.

Given the localization accuracy obtained by fusing the IMU and the GPS data, instead of using the stereo cameras for visual odometry, alternatively these can be used to track a hand-held mine detection tool carried by the operator in the field, to register the covered area by the detection system and improve the security of the demining operation. Ensuring at the same time a 100% clearance ratio in a demining task.

4 Conclusions

In this paper we have described the FSR Backpack, a wearable sensor suite developed to speedup and improve the safety of humanitarian demining operations in the field, providing means to collect important field data, receiving and sending communication to/from the remote center of operations, and test new algorithms and methods for humanitarian demining, such as sensor fusion of different detection sources for mine identification, field coverage algorithms, localization and several more.

Being equipped with modern sensors and hardware for pose estimation, global positioning, vision, range de-

¹<https://www.google.com/maps/@40.184853,-8.4146164,206m/data=!3m1!1e3>

²<http://wiki.ros.org/rviz>

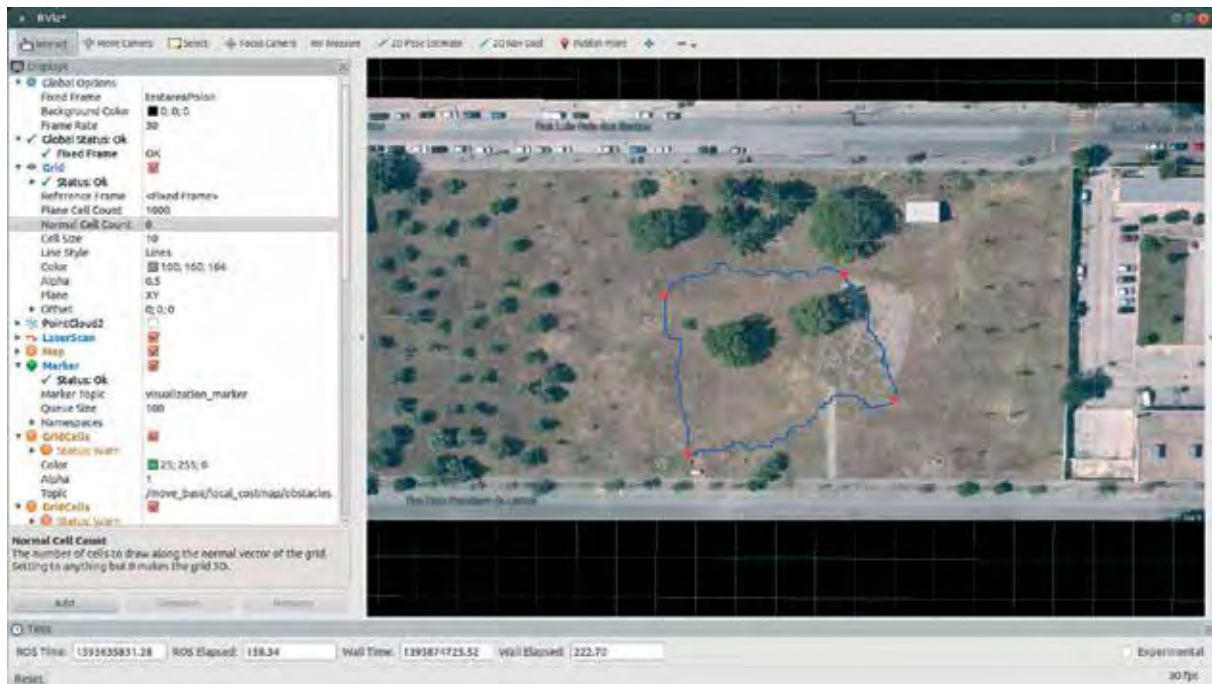


Figure 5: Final trajectory obtained from the pose estimation algorithm. Red stars depict the known landmarks defined *a priori* for the operator's trajectory.

tection, long-range wireless communication, processing power and a robust power supply, the FSR Backpack has demonstrated its usefulness in a preliminary field experiment where its localization system was assessed.

In the future, we intend to test the stereo cameras together with the laser range finder for terrain examination and traversability analysis, as well as using the FSR Backpack together with a lightweight mine detecting system carried by a human operator to perform coverage tests and analyze the success of sensor fusion algorithms for mine detection, as illustrated in Fig. 6.



Figure 6: Backpack and Advanced Lightweight detecting system performing coverage of the area to be cleared.

Acknowledgment

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Integrated Robotic Systems for Humanitarian Demining and Integrated Robotic Systems for growing organic fruits and vegetables in an open-air environment for fresh consumption and their delivery – interconnection

Author: Marin Midilev

Abstract: Minefields, which have remained uncleared after military conflicts and wars, still can be found in more than 2/3 of the countries in the world. Basically, fertile areas are being mined. More than 1.5 billion people worldwide suffer from malnutrition. An article from the Institution of Mechanical Engineers reports that between 30 and 50 % of all food produced in the world is thrown away. This is approximately between 1.2 and 2 billion tons of wasted food annually. Due to bad size or bad appearance 30 % of the vegetables in the United Kingdom aren't harvested at all. Almost half of the food bought in the United Kingdom and the USA is usually discarded by the consumers. On a world scale about 550 billion m³ water is wasted annually for watering crops which in fact never reach the human mouth. The energy expenditure used for delivery surpasses several times the energy expenditure used for growing fruits and vegetables! The solution to the problems mentioned above lies in the design and commissioning of Integrated systems for growing organic fruits and vegetables in an open-air environment and their delivery, with the help of existing technologies, technological solutions and ready-to-use elements. In order to achieve greater effectiveness it is necessary to unify the Integrated Manufacturing Systems according to the types of fruits and vegetables as well as the geographical features! The design and commissioning of Integrated Manufacturing Systems is appropriately to be used on a large unoccupied space or on areas already cleared of minefields by the Integrated Robotic Systems for Humanitarian Demining. Integrated Robotic Systems for Humanitarian Demining as principles of operation and organizational structure are versions of Integrated Systems for growing organic fruits and vegetables in an open-air environment for fresh consumption.

An integrated system for picking and delivering of cherry fruit can be considered as a basic project.

The annual world production (as of 2007) of cultivated cherry fruit is about two million tonnes. Around 40% of world production originates in Europe and around 13% in the United States.

The fruits of cherries are at a height of several metres from the ground depending on their sort. Cherry picking in Europe starts in the beginning of April and ends by the end of June. It is mainly done by hand. Mechanical picking is based on the vibrational technology, which shortens the life of the trees and most of the fruits get damaged.

As for the robotic fruit picking, there are developments based on mobile robot platforms with mechanical arms equipped with harvesting instruments.

Robot fruit picking can be arranged on the base of air multi rotor drones (VTOL technologies - drones). The potential of the drones is to work together simultaneously and form particular interconnected configurations in the air, which allows the fruit picking robot, the qualification system, the storage system and the system for wrapping transport to be directly connected. The mobile robot platform serving the drones can also serve as a platform for the drones to fly off and land and as a temporary storage of containers - boxes for storage of cherries and energy centre as well (Option 1 - management and transmission of electrical energy through cables, Option 2 – independent management of the drones with a periodical change or battery charging needed). The automated fruit picking drones are necessary to be supplied with automatic pilot. The transfer of picked production to the delivery means of transport out of the plantation can be arranged with the help of another robotic platform to a temporary storage.

From the temporary storage to end customers within a radius of 16 km - families, restaurants, vending machines, delivery can be arranged with drones. See references [4], [5], [6], [7]. For long distances to the scheme of delivery it is proper drones technologies of Black Knight Transformer's type [8] and others developed by the TIRAMISU partners to be brought in. The delivery is made to the end storehouse. From the end storehouse to the

end customer the delivery can be made according to the described scheme at short distances. To the temporary storage there should be a photovoltaic plant for battery charge as well as a centre for management where the operators and ground pilots will work. Navigation should be based on Galileo, Probe –V and other programs of the European Space Agency ESA. In order to accomplish the described scheme, a specific wrapping for packing the picked production is needed.

An integrated system for mine fields demining can have the same basic elements as a final point of each mine is the utilization technology. The utilization technology can be stationary or mobile, but in most cases it is at a long distance from the minefield. Because all types of mines are standardized, an assembly line for demining and disassembling of preliminarily fool-proof infantry and tank mines. Demining can be done by preliminarily packaging based on digging in a cylinder around the mine. Demining is a kind of packaging before taking the mine out of the ground. The instrument for mine packaging can be carried by drones. Other options are using a mobile robot platform with a mechanical arm or a person to set it on the ground above and around the tank or infantry mine. The possibility of the drones to work together simultaneously allows them to be used for detecting tank or infantry mines - Geo radar GPR, metal detectors, etc. By using an integrated system for demining, the time taken for clearing minefields is shorter.

In reverse order, the main elements of the integrated technology for minefields demining can be used for creating fruit growing plantations and planting trees. The means of transport are used by the seedlings production enterprise to the field. Each tree is grown and transported in a pot made of bio plastic.

The creation of integrated systems for organic production of fruits and vegetables in open areas and their delivery is necessary to start a project for building a Technology Park on FP 8 - Horizon2020 with:

Main partners – the TIRAMISU partners.

Appropriate area – the area of Dimitrovgrad municipality, Haskovo district

Regional planning - South-Central region, Bulgaria

Priorities [9]:

- a. European production region with the best flavor qualities of fruit and vegetables – Thracian lowland
- b. Existence and construction of the necessary infrastructure
- c. Existence of available unused areas where the production can be arranged
- d. Other

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- [7] http://news.cnet.com/8301-11386_3-57601531-76/drones-in-china-deliver-packages-even-a-birthday-cake/?goback=%2Egde_84160_member_271531863#%21
- [8] <https://www.advancedtacticsinc.com/>
- [9] http://www.hs.government.bg/images/stories/2013/07/dok/os_rfin1.pdf



DOK-ING

DON'T SEND A MAN TO DO A MACHINE'S JOB



VIDEO REMOTE CONTROLLER

- Operational distance up to 1500m
- Battery capacity up to 16 hours
- Complete control of all functions
- High resolution display



With **more than 15 years of experience** in mine clearance technology, our solutions are field tested and trusted by the most advanced military outfits of the world.

DOK-ING machines are designed for one purpose - **to protect human life in extreme conditions.**

We pride ourselves in innovations that bring safety and security in harshest, most demanding and dangerous environments known to man.



Armor plates of 10 to 20 mm thickness
All exposed MV-4 parts are supported with special Swedish HARDOX 400 armor plates.



1 person to operate
Only 1 person is needed to fully independently operate MV-4



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)



Field crew
Operator assisted by a mechanic can service and maintain MV-4 in the field



>>> TILLER TOOL



>>> ROLLER TOOL



>>> GRIPPER TOOL



>>> BLADE TOOL

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MV-4 THE WORLD'S LEADING DEMINING MACHINE

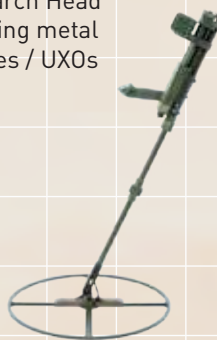


MINE & UXO DETECTION

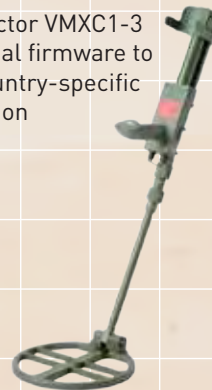
Metal Detector VMH3CS
with pinpointing feature



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



Dual-Sensor-Detector VMR3G
with Graphical Display
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

PrimeTech: a wide range of demining machines!



PT-300
D:MINE

PT-400
D:MINE

- CERTIFIED MEDIUM AND HEAVY DEMINING MACHINES
- REMOTE CONTROLLED AND OPERATOR CONTROLLED MODELS
- HEAVY DUTY DESIGN - HIGH RELIABILITY
- RANGE OF OTHER ATTACHMENTS AVAILABLE

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CENTER FOR TESTING, DEVELOPMENT AND TRAINING



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Fax: +385 1 652 0301

www.ctro.hr



With its testing capacity (test sites and equipment) and highly professional staff, the Centre offers the following services:

- testing and certification of:
 - demining machines
 - mine detection dogs
 - metal detectors, PPE and prodders
- field testing and operational validation of technologies used for mine contaminated area detection and mine suspected area reduction
- training and issuing certificates for the use of metal detectors
- training of EOD officers, worksite managers, demining teams and monitoring personnel
- organizing workshops, conferences and other gatherings on the subject of mine action
- preparation for introducing quality management in demining companies as per ISO 9001:2000
- lease of test sites
- implementation of research and development projects in the field of mine action

kala



Centre for Security Cooperation



International Advanced
Robotics Programme

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