

Book of Papers



GOVERNMENT OF THE REPUBLIC OF CROATIA
Office for Mine Action



The 14th International Symposium “MINE ACTION 2017”

25th to 27th April 2017
BIOGRAD, CROATIA





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The Journal: 20 Years of Mine Action

Heather Holsinger¹, Jennifer Risser²

CISR was founded in 1996 at James Madison University as the Mine Action Information Center. The Center started in response to the global landmine crisis that was brought to the world's attention in the 1990's by people like Princess Diana and Ken Rutherford, and groups such as the International Campaign to Ban Landmines. The Center was formed through a bi-partisan congressional effort in cooperation with the U.S. Department's of State and Defense. We operate through partnerships with nongovernmental organizations and government agencies in the U.S. and other countries and the majority of funding is through external grants. We are now in our 21st year. Our programs and publications are grant funded.

CISR supports the pillars of Mine Action through:

- **Senior Management Training**

CISR, working in close collaboration with faculty from JMU's College of Business (COB), specializes in management training for leaders in humanitarian mine action around the world. The Senior Managers' Course (SMC) in Explosive Remnants of War (ERW) and Mine Action seeks to integrate the latest thinking in the field of business management with the practical experience of ERW/mine action operators. The goal is to hone the skills of senior managers of national ERW and mine action programs so that countries can more effectively and efficiently clear their lands of landmines and other ERW that adversely affect their citizens' well-being and impinge upon economic development. The SMC began in 2004 when CISR was awarded the contract to implement the course by the United Nations Development Program (UNDP). Through UNDP support, CISR hosted five SMCs and trained more than 100 senior managers from over 30 countries. Since 2010, the U.S. Department of State's Office of Weapons Removal and Abatement (PM/WRA) has sponsored the SMC with an expanded focus to include conventional weapons destruction (CWD), small arms/light weapons and other emerging topics in the post-conflict recovery field. With PM/WRA support, CISR has hosted four additional SMCs on the JMU campus and five internationally (Regional SMCs). To date, CISR has trained 350 senior managers representing 48 countries through the SMC program.

- **Victim/Refugee Assistance Programs**

CISR has worked on disability rights, peer support and psychosocial support programs in Burundi, Colombia, Lebanon, Rwanda, Uganda, United States, and Vietnam. Our current project is focused on resettled refugees in Harrisonburg, VA where we are worked with local high school and refugee resettlement office to help refugee students new to the United States. Harrisonburg is a designated refugee resettlement city in the United States. The local high school has a diverse population of immigrants with 58 different languages spoken. Our program works with students new to the United States to help them adjust to their new home. CISR has also worked on a disability rights advocacy and capacity building project in Vietnam (2013-15) where we provided training to Vietnamese organizations to assist with implementation of their disability rights laws.

¹ Center for International Stabilization and Recovery, James Madison University, Harrisonburg, VA / USA

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We worked in Lebanon on a program called Pathways to Resilience (2011) where we trained persons with disabilities from Iraq, Jordan, Lebanon & Yemen in peer support techniques to take home and start support groups in their towns. We have also provided multiple peer support trainings and psychosocial support programs in Burundi, Uganda and Rwanda.

■ **Mine Risk Education**

In 2009–2010 CISR worked with a local partner in Jordan to produced “We Love Life,” theatrical play and art activities to teach landmine safety to children in Jordan. 15,000 children saw the play. In 2013–14 CISR again worked with a local partner in Jordan to facilitate “train-the-trainer” mine risk education workshops with 75 adult Syrian refugees living in Jordan. We also conducted school-based arts workshops to teach mine risk education for 500 Jordanian and Syrian children.

The Journal

Our primary tool for documenting and sharing information in the field of mine action is through *The Journal*. *The Journal* is the longest running publication of its kind – 21 volumes – and has been published by CISR online and in print since 1997. *The Journal* currently has 2,200 subscribers to the print version and is read in 178 countries (print & online). Subscriptions to the *Journal*, both online and print, are **free**.

The *Journal of Humanitarian Demining* was launched in 1997 as the field of mine action gained traction as a tool for the field to share information and lessons learned. The first three issues were online only and the first issue only had 4 articles!

The title changed to *Journal of Mine Action* in 1997 and broadened the focused of articles to include the five pillars of mine action:

1. Advocacy to universalize the Ottawa Convention
2. Assistance to landmine survivors/victims
3. Clearance of mined areas
4. Mine-risk education
5. Stockpile destruction

Issue 3.3 published in 1999 focused on Victim Assistance and featured Ken Rutherford on the cover. Ken became CISR director in 2010!

The title changed in 2008 to *The Journal of ERW and Mine Action* in response to the expanding role of mine action to include UXO, cluster munitions, gender issues, and environmental impacts, etc.

The most recent title change came in 2016 to *The Journal Conventional Weapons Destruction* providing an information exchange platform for stakeholders addressing the residual environmental, physical and psychological effects of conflict. We are particularly interested in topics regarding the destruction of stockpiles of surplus, obsolete or otherwise at-risk conventional weapons of war; and programs that increase civilian security by protecting lives and property through stockpile management, clearance, survivor assistance, risk education, and capacity building. Other topics concerning post-conflict recovery are considered upon submission.

The Research and Technology section of *The Journal*: Technical articles on current equipment, technology, trends and developments in the field of mine action and conventional weapons destruction will be considered. R&D articles should follow scientific methods and present testing methodology and results for

new technologies or procedures. Commercial companies, NGO's, and researchers are encouraged to submit.

Topics may include but are not limited:

- Current equipment
- Detection and neutralization of landmines, ERW, ordnance, and IEDs
- Mobile technologies
- Data fusion and information technology
- Biosensors (animals, plants, etc.)
- GIS, mapping, and terrain analysis

Peer Review: R&D articles are submitted to three subject-matter experts for anonymous peer review. Two of the three reviewers must approve the article for publication. Reviewers approve articles, suggest revisions or reject articles for publication. We are always seeking new peer reviewers for *The Journal*. If you are interested please contact Jennifer Risser at risserje@jmu.edu.

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Submission Guidelines:

- There is no cost to the author to submit and publish articles in *The Journal*.
- The editorial staff reserves the right to reject submissions that include text copied from other sources in part or as a whole.
- Works that have been published previously and for which the author retains publishing rights may be submitted reprint permission may be provided.
- Articles should be 800 - 1,200 words and submitted in Microsoft Word (or a digital file in a simple text format). R&D articles can be up to 2,500 words.
- The author should provide photos and figures with captions and credit information. Images must be in a digital format at 300 dpi or better when scaled. The larger the file size the better quality the photo when printed.

Access to all online formats of *The Journal*, and a form to subscribe to the print version is available on our website: www.jmu.edu/cisr.

Upcoming Issues:

- Issue 21.2 will be published in July 2017 featuring the Evolving Nature of Survey and Mobile Technologies, and spotlighting Southeast Asia. Submissions are due by 15 May 2017.

- Issue 21.3 will be published in November 2017 featuring Physical Security and Stockpile

Management, and spotlighting the Western Hemisphere. Submissions are due 15 September 2017. Submit articles directly to Jennifer Risser at risserje@jmu.edu

CISR envisions a world where people can build peaceful and prosperous futures free from the repercussions of conflict and disaster.

www.jmu.edu/cisr

Why we fail to meet the primary goal of the Ottawa Convention¹

A.V.Smith²

Abstract:

The primary goal of HMA as expressed in the Ottawa Convention is “to put an end to the suffering and casualties caused by anti-personnel mines”. This is not only to “reduce risk” it is to eliminate risk. Eliminating all risks may be impossible, but it is possible to do everything “reasonable” to make risk “tolerable”. Under the Ottawa Convention, signatories are obliged to make available all information about Mine Action topics to a UN database so that information can be shared and lessons learned. No UN database was ever established and, while some data is shared, two data-streams critical to evaluating the performance of search and clearance efforts have either not been collected at all or not adequately collected and made public. This is data about explosive hazards found after land is released as “clear” and the records of accidents that occur during demining. The failure to gather these datasets is “unreasonable”. As a result, donors are sometimes funding the use of demining equipment and systems that do not leave land safe for the people to use and that cause unnecessary deminer injuries. An argument is presented showing that the need to gather and share this data in a useful manner is both a humanitarian and a legal requirement.

Introduction

The primary goal in the 1997 Ottawa Convention is “to put an end to the suffering and casualties caused by anti-personnel mines...”. This is not only to “reduce risk”, it is to *eliminate* risk. Eliminating risk may not be possible, but it is possible to do everything “reasonable” in pursuit of this, which is the goal expressed in the International Mine Action Standards (IMAS).

The Ottawa Convention does not mention the IMAS because they did not exist in 1997, but the IMAS references the Convention and adopts the “Five pillars of mine action” from it. The stated purpose of the IMAS is “to improve safety, efficiency and effectiveness in mine action”³. It is relevant to notice the order in which these are listed, with “safety” as an implied priority. Because demining has always involved removing all explosive hazards, clearance is defined in the IMAS as: “... tasks or actions to ensure the removal and/or the destruction of all mine and ERW hazards from a specified area to a specified depth.”⁴ So the IMAS adopts the five pillars of mine action from the Ottawa Convention, defines clearance and prioritises safety.

Under the Ottawa Convention, Article 6 *International Cooperation and assistance*, paragraph 6, it is a requirement that “***Each State Party undertakes to provide information to the database on mine clearance established within the United Nations system....***”.

No UN database has ever been established so the UN has failed to comply with the Ottawa Convention, but it is not a “states party” so it was not required to do so. However, it did try. Also in 1997, the UN Mine Action Service (UNMAS) was established and a year later the new UNMAS supported the establishment of GICHD. One of GICHD’s tasks was to develop the Information Management System (IMSMA) and have all IMSMA data added to a hub database in New York, so providing the database mentioned in the Ottawa Convention.

Such a database would have given needs assessments a global perspective, which was understandably rather attractive to those at the hub. However, It was not so attractive to those in the field. The planned central hub database in New York was never developed partly because it would have been

very expensive, but also because many MACs were suspicious of sharing data without being able to control how it was used. Most demining organisations were also reluctant to share any data that might lead to criticism.

Missing data

To achieve the Ottawa Convention’s primary goal and “put an end to the suffering and casualties” caused by ERW (including deminer casualties) some data sharing is essential.

Two data-streams critical to anyone seeking to evaluate the performance of search and clearance efforts have either not been collected at all or have not been adequately collected, shared and made public.

The missing data-streams are:

- 1 data about explosive hazards found after land is released as “clear”, and
- 2 the detailed records of accidents that occur during demining.

The records made accessible to the broader industry need not include names and identifiers but should include details of the “clearance” procedures and equipment used along with an investigation that determines whether the event was an isolated anomaly or a systemic failure that should be broadly addressed.

Missed hazards

In some countries, hazards discovered after clearance are recorded but they are rarely investigated. Even when they are, there is no central dataset of these records so they are not easy to access. Without the collection and sharing of this data, it is not possible to begin to objectively assess which methods work reliably and which do not. As an example, I have MAC records of many instances⁵ of submunitions that have been discovered after clearance in Lebanon. The clearance was conducted by a range of demining organisations (INGO and commercial) using varied manual search SOPs. The common feature was the use of a detector that is very cheap but not fit for purpose. There were several severe civilian injuries and fatalities as a consequence – but that detector is still being used.⁶

I also have MAC records of mines having been missed by dogs in Afghanistan, Sudan, Kosovo and Lebanon, sometimes with severe consequences for civilians. Common features appear to be inadequate training and the use of a single dog.

This picture shows a tractor that was driven onto an AT mine left behind on land searched using a single dog. The driver was severely injured.



The picture above shows a few of the mines found after the use of flail machines.

Failure to formally gather this data and use it to discover which demining procedures and equipment do not result in land that is safe for civilian use is not only a failure to comply with the requirement of the Ottawa Convention to share data. It is a failure to do all that is “reasonable” to ensure that we clear land effectively.

Another result of this failing is that donors are sometimes funding the use of demining equipment and systems that do not leave safe land for the people to use. It has not yet been tested whether the donor shares some legal responsibility for the injuries that result when they have not performed “due diligence” checks on the ability of the systems it is funding to safely produce the required goal.

Demining accident records

IMAS 10.60 states that “all organisations should report any unplanned detonation of a mine, ERW or explosives... irrespective of the cause or outcome. The accident report shall be made available to other demining organisations operating in the country, and to other NMAA through UNMAS”. Many organisations do not do this, so do not work fully to IMAS. Ironically, this is partly the fault of UNMAS which has delegated responsibility for accident gathering to GICHD, and GICHD has decided that simplified spreadsheet data is sufficient.

The incomplete accident data that we have is kept in two accident datasets. The DDAS⁷, first published and distributed in 1999, and the RAPID⁸ spreadsheet, first published by GICHD in 2012.

RAPID uses summarised accident data to produce a broad-sweep analysis that allows managers and donors to gain a general view of the accident situation. The results are published annually in a brief report of a few pages. Rapid data entry can only be “rapid” by using drop-down lists of options in a simple spreadsheet. These are selected in an office by someone who may not know which answer is most appropriate and, because the actual accident report is not submitted, there is no potential to check whether their summary is at all accurate, so there is no Quality Control and no Quality Management.

The summary cannot be accurate because the drop down lists of choices in each of 44 fields are limited and do not appear to have been compiled by anyone who knew demining. For example, excavation and raking are combined as one choice so it would not be possible to separate raking accidents to assess their safety.

Accident ID	Accident cause	Date of accident	Time of accident	Device type	Device name	Ground composition	Soil compaction
1	Staff negligence, Support failure	May 25, 2000	Afternoon 12 - 18	AP	PMA-3	Muddy	A (soft)

Area type	Mine action activity type	Land classification	Demining asset	Victim ID	PPE issued	PPE worn
Pasture land	Clearance	CHA	Manual excavation/Raking	victim1	Jacket, Half-Face Visor	Jacket, Half-Face Visor

This is an example drawn from the GICHD RAPID spreadsheet. Notice the data that is circled.

This RAPID record was derived from a full accident report in the older DDAS. The DDAS is a real database so it has sophisticated search functions and can include the accident report written at the time. All the records in the DDAS have the names and identifiers removed before being published on-line for everyone to use.

The DDAS report shows that the deminer was not wearing a half-face visor or a PPE jacket. He was wearing a frontal apron and a helmet and visor. It also records that he was excavating a metal-detector reading with a short hand-tool. Other accident records in the DDAS show that he would have been very likely to avoid injury if he had been excavating the same metal-detector reading using REDs rakes.

The RAPID database errors may be unimportant in broad-sweep data analysis but they can be critically misleading when trying to understand what was happening in the field in order to avoid recurrence.

When RAPID started, MACs were told to stop sending full reports to the DDAS despite it having proved its value when determining PPE needs for the IMAS and in identifying inherently dangerous tools and procedures. So today, under UNMAS leadership, GICHD is not gathering accident reports and not studying them in order to identify risks that can be avoided or mitigated. The DDAS does continue, but unfunded and with very few accident reports submitted. Currently, the Explosives Knowledge Centre that is part of the ICI in Belgium is seeking the approval of UNMAS and GICHD in order to take over the professional maintenance of the DDAS. This is an initiative which I, as the originator and keeper of the DDAS, would wholeheartedly support.



This is the accident record in the DDAS from which the RAPID example was derived.

Failure to gather detailed demining accident data and use it to reduce the risk of severe deminer injury is not only a failure to implement the Ottawa Convention requirement to share data, it is also an obvious failure to do everything “reasonable” to prevent deminer injuries.

UNMAS may not be vulnerable to legal action but it does have an internal UN requirement to protect human rights which it is failing to uphold. GICHD is not above the law and is demonstrably failing in its declared humanitarian purposes, so could be risking both reputational and financial damage by pretending that a spreadsheet database of accidents is in any way sufficient to use in field risk management.

Legal consequences

In IMAS 01.10 Para 6.5 states that: “Countries which are States Party to one or more of the Anti-Personnel Mine Ban Convention (APMBC, the Amended Protocol II of CCW, Protocol V of CCW and the CCM have.... certain specific obligations regarding the marking and **clearance** of explosive hazards. The provisions of IMAS do not, however, replace the obligations detailed in these conventions.”

Failure to do everything reasonable to safely achieve clearance may be in breach of these conventions, which is obviously undesirable, but they lack any effective means of enforcement so this may not be considered all that important. Similarly, the 193 countries that are members of the UN have signed up to the Universal Declaration of Human Rights, but failure to comply with the spirit of the requirements therein is regrettably widespread without significant consequences.

However, International Human Rights Laws can be applied along with national laws covering employment conditions and Health and Safety. In two cases⁹, an international demining organisation has been taken to court for failing to do everything reasonable to prevent deminer injury and the cases were brought to court in another country. The definition of what is “reasonable” and “tolerable” in the country where the case is heard can be used to determine liability and assess compensation. In both cases, original compensation was greatly increased, with one case claiming a multi million dollar settlement. These were cases involving ex-pat deminers but there is a real risk that nationals will soon realise their right to seek redress through legal action in another country.

I have heard anecdotal reports of informal settlements being made but I have not heard of anyone making a legal claim for damages when explosive hazards are discovered on land declared clear. When they do, the only defence will be the same as it is in a demining accident. The organisation must show that they have done everything “reasonable” to achieve a safe outcome. Not having any hard evidence to prove that the methods used were as safe as possible might well be considered “unreasonable” in any court of law.

Without gathering the core “missed hazard” and “demining accident” datasets, the industry is behaving unprofessionally and not providing the required baseline data against which new developments can be judged. UNMAS and GICHD may think that they are protecting demining organisations from criticism but they are actually setting them up for a catastrophic fall. They are also permitting the presence of gross inconsistency in the IMAS.

We fail to meet the primary goal of the Ottawa Convention “to put an end to the suffering and casualties caused by anti-personnel mines...” every time that unsafe land is released and every time that deminers are unnecessarily injured in their work. This is because of systemic failures that are in direct breach of the IMAS requirement for Quality Management¹⁰ which relies on reliable and detailed data, and it is unreasonable that obvious shortcomings should have continued for so long without being corrected.

1 The 1997 *Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction* is often abbreviated to the “Ottawa Convention”.

2 AVS, Andy Smith, Research assistant with the University of Genoa, Italy. Andy Smith has worked in demining for twenty years, starting as a PPE designer and rapidly becoming a deminer/surveyor and then a Technical Advisor, trainer, programme manager and UNDP country CTA. The founder and keeper of the Database of Demining Accidents (DDAS), he has also developed and put into production the most popular PPE used in HMA. His latest tasks have included writing extensive field risk management training materials for GICHD. See www.nolandmines.com and www.ddasonline.com.

3 IMAS 01.10 (Guide for the application of IMAS)

4 IMAS 09.10 (Clearance requirements) and in IMAS 04.10 (Glossary, definitions and abbreviations).

5 Fourteen Lebanon MAC investigations of “missed hazard” records are held in the DDAS: www.ddasonline.com.

6 (In fairness, the Schonstedt stick detector has some uses, but is not suitable for any wide area search.)

7 DDAS – Database of Demining Accidents. On line at <http://www.ddasonline.com>

8 The GICHD RAPID excel spreadsheet is so simple that it uses spreadsheet rather than dedicated database software: see <http://www.mineactionstandards.org/rapid/reporting-to-rapid/>

9 DDAS accident 592 and DDAS accident 277 at <http://www.ddasonline.com>

10 IMAS_07.12_QM_DRAFT_Ed.1, published on the GICHD website in 2016. <https://www.mineactionstandards.org/standards/international-mine-action-standards-imas/imas-in-english/>

Comprehensive methodology for Technical Survey in Colombia.

Francy Maribel Bolaños Velasco³

Abstract:

Most mined areas in Colombia are detected and registered long after humanitarian demining tasks have started due to the amount and quantity of information available. Although Non Technical survey is a good method to map and register new information in these areas, there is still a gap between these areas with little or no information (due to the absence of population, difficult logistic support, deficient roads, among others) and further activities to release land in a safe, efficient and faster way.

For the last twelve years of humanitarian demining operations in country, there have been major limitations in the implementation, monitoring and recording of Technical Survey results. Although humanitarian demining operations started in 2006, the existing records only shows results in technical survey since 2010 and these results are shown in “Number of Technical Survey (operations) vs Improvised Devices reported per Municipality”. These results are just registered and recorded as Number of Interventions but there is no official record on the amount of square meters canceled, reduced or confirmed through a technical survey operation. On the other hand, the National Authority for Mine Action in Colombia hasn’t released any type of national standard that could regulate the Technical Survey activities in country in spite of the fact that demining organizations are reporting Technical Survey operations since 2010. Finally, taking into account the experience in field, all of the clearance operations in country started in 2006 with the interventions in military bases where Non-Technical Survey or Technical survey were not necessary due to the existence of mines installation records and the first-hand information about the location of these devices. During the transition from mine clearance in military bases to mine affected communities, demining units used first-hand information from population that had information about the precise location of mines in their territories. It wasn’t until 2010 that National Authority for Mine Action with existing demining units and demining NGOs agreed on report Technical Survey operational results in order to show, in a way, the kind of intervention being implemented at the municipality level, however, there wasn’t an agreed framework in order to separate the interventions from Technical Survey and Clearance due to the blurred scopes between these two in the Colombian context.

Two of the main factors to consider the implementation of a technical survey comprehensive methodology are related to time and available resources. While the National Authority is responsible for the level of confidence on cleared land, there is still the need to save time and money during the land release process in order to allow organizations and demining units to better allocate their resources and efforts, according to the level of impact of mines in the communities. In that sense, Technical Survey could be the quickest and safest option to release land in those areas where Non-Technical Survey tasks are not conclusive and Clearance tasks are expensive. According to records and reports from the Humanitarian Demining Battalion BIDES N°60, it takes from 1 to 3 years to release one single CHA, applying all reasonable effort and following all steps of Land Release methodology (Non-Technical Survey, Technical Survey and Clearance only). In addition to this, the methodology for monitoring Land Release tasks includes monitoring visits previous to deployment for each team and each task that could take up to 15 working days, added to the downtimes caused by weather conditions, logistics issues, and refreshment trainings indirectly cause limitations and restrictions in the time of interventions in the field.

³ Mine Action Consultant at National Center Against Mines and IEDs –CENAM. National Army of Colombia. Email:suvereval@hotmail.com.

In order to implement a proper methodology for Technical Survey, it is necessary to analyze certain conditions that combined could provide a better understanding of the context for demining in country. First of all, it is necessary to analyze the type of IEDs, regions and characteristics of areas of operations (logistic support to operations, geographical conditions like terrain, rain-sunny seasons, among others), level of impact by mines and IEDs at municipalities, and type of events with mines and IEDs. Using this information, it is possible to determine what kind of methods, techniques and operations will be more effective during Technical Survey to cancel, confirm or release land in a more efficient, safe and effective way.

Based on Army reports related to actions against mines and IEDs, there are 8 different regions according areas of responsibilities for Army Divisions (see annex A: Army Divisions) in which there are different types of illegal armed groups with different types and methods for fabrication, installation and storage of mines and IEDs. In annex A, information about areas, departments, type of IEDs and mines, logistics and geographical conditions are included. Taking into account lessons learnt and the experiences with mines and IEDs, there are common characteristics for one or more regions, like poor logistics support or geographical limitations, also there are special characteristics for specific regions, like several types of IEDs in a small area. All of these factors combined determine the method used for reduction of areas whether mechanical, manual or MDD and therefore the expected results in short, medium and long term

According to the level of impact of mines and IEDs in municipalities, the National Authority for Mine Action has established a classification for interventions with humanitarian demining that reflects the methodology for prioritisation of tasks. These types of municipalities reflect the situation in general terms and give guidelines to the decision makers in order to allocate resources and efforts. In annex B, specification on the criteria for classification of municipalities is given. According to the nature and level of prioritisation of municipalities and in order to implement a better land release process in these municipalities according to the level of impact, it is important to notice that those municipalities classified in Types I and II may be tasked with Technical Survey operations, taking into account previous interventions like Non-Technical Survey, Community Liaison and/or Mine Risk Education, while municipalities in Type III can be easily released with Non-Technical Survey operations. On the other hand, Municipalities classified in Type IV may be managed with local meetings including both communities and local authorities. This type of methodology for classification of municipalities is continually under revision due to the constant recollection of information process and the new events recorded and uploaded to the Information Management System for Mine Action data base.

Other important factor to be included in the definition and development of a suitable Technical survey methodology for the Colombian context is the type of events included in the IMSMA database. As this is the main source of information for demining tasks, in annex C there is a classification as included in IMSM database, in which the events with Mines and IEDs in country are related to a suitable approach for Technical Survey taking into account lessons learnt and results of previous demining tasks. It is important to notice that the classification provided in the table is the same as the one given by the National Authority and that some of the events are related to Antipersonnel Mines only. Due to the nature of the events and their relevance in terms of quantity and frequency, it has been chosen a different approach for technical survey that may help to: cancel those events classified as “Illegal Storages, Illegal Workshops and Confiscations” without applying clearance efforts; confirm hazardous areas where events marked as “Military Demining and Accidents”, and reduce suspicious hazardous areas/hazardous areas where “UXOs” are reported. All of the above in a faster, safer and more confident way.

Bearing in mind the previous analysis and data collection for Technical Survey, that is relevant to the present essay, it is necessary to establish a comprehensive methodology taking into account the nature of events, level of impact for mines and IEDs and the most suitable technique for area reduction according to logistic support; so, for region; (according to the type of level of impact in municipalities and the type of events), there is a specific method of intervention that could support land release processes in a faster and safer way than the current approach. In annex D, there is a proposed combination of methods and techniques that could increase the level of effectiveness for releasing land. In the table, for example, municipalities in region I, classified in Type I, it is suggested to implement manual demining due to the high level of metal content in IEDs, taking advantage of the good logistic support and taking into account the flat areas with low vegetation. MDDs are not recommended due to the high temperatures and the limited logistic support for veterinarian assistance in case of need.

In order to sum up, there are some recommendations to have in mind order to implement a comprehensive and suitable methodology for Technical survey in municipalities affected by IEDs and mines:

1. Technical survey will help to reduce areas where Non Technical surveys tasks haven't been conclusive or where type or events don't require further clearance tasks.
2. Technical survey tasks in type I and II municipalities could help to confirm 30% of new hazardous areas that are not included in IMSMA reports by Non Technical Surveys.
3. Technical survey tasks will cancel all events reported as confiscations, illegal workshops and illegal storages of IEDs and mines in their respective regions.
4. Technical survey approach will allow to confirm hazardous areas where clearance tasks are really needed, especially where Non-Technical survey tasks are not enough to clearly establish the presence/absence of contamination.

To sum up, this methodology could help Colombian mine action community to cancel 15% of registered events in IMSMA database without moving forward to clearance tasks; It is also recommended to investigate more in detail areas where events by military demining have been registered and where Non-Technical survey reports recommend further investigation due to the lack of information.

References

International Mine Action Standards 08.20. Technical Survey. United Nations Mine Action Service. First Edition 10 June 2009. Amendment 2 march 2013.
A guide to Land Release: Technical Methods. GICHD. Geneva. April, 2011.

Annex A. Characteristics of IEDs and regions.

Division	Departments	IEDs			Geographic Conditions	Logistics
		Activation System	Type Of Explosive	Metal Content		
I	La Guajira, Cesar, Atlántico, Magdalena, North Bolívar	Electric detonator, Command wire	Ammonium nitrate (HME)	High (metal container)	Mines and IEDs in flat areas, low vegetation, high temperatures	Highways available, good logistic support.
II	Norte de Santander, Boyacá, South Bolívar, Santander	Detonating cord (relay)	Amonium nitrate, TNT, Pentolite, clo-rate	Low – None (Fabric container)	Mountain ranges, high vegetation, medium-low temperatures	Difficult logistic support due to bad road conditions
III	Valle del cauca, Cauca, Nariño	Radio frequency, command wire	Nitrate, black powder, TNT, Pentolite	High (Metal container)	Mountain ranges, high vegetation, medium-low temperatures	Difficult logistic support due to bad road conditions
IV	Meta, Guaviare, Vaupes	Pressure, tension.	RDX, Pentolite, nitrate	Low-none (plastic container)	Flat areas, high vegetation, high temperature	Difficult logistic support due to lack of roads
V	Huila, Tolima, Quindío, Risaralda, Caldas, Cundinamarca	Pressure, tension	Nitrate, black powder, pent	Low-none (plastic container)	Mountain ranges, high vegetation, medium-low temperatures	Highways available, good logistic support.
VI	Amazonas, Putumayo	Command wire, electric detonator	Aluminium, black powder, ammonium nitrate	High (metal container)	Flat areas, high vegetation, high temperature	Difficult logistic support due to lack of roads
VII	Choco, Antioquia, Sucre, Cordoba	Radio frequency, command wire, remote control, mobile system	Nitrate, chlorate, ammonium nitrate, black powder, TNT	Low-none metal content (plastic container)	Flat areas, high vegetation, high temperature- Mountain ranges, medium-low temperatures	Difficult logistic support in flat areas, Good logistic support in Antioquia due to good roads.
VIII	Arauca, Casanare, Guainía, Vichada,	Detonating cord, electric detonator (Relay)	Nitrate, pentolite, TNT	Low-none metal content (plastic container)	Flat areas, low vegetation, high temperatures	Good logistic support.

Source: Directorate for Military Demining. CENAM. Updated to march 2017.

Annex B. Analysis of impact of IEDs and mines in municipalities

**Classification of municipalities according to the level of impact by EIDs and Mines.
(Source: Directorate for comprehensive antipersonnel mine action DAICMA).**

TYPE	IMPACT	MUNICIPALITIES
I	HIGH: Municipalities with events during the last 5 years and have a high humanitarian impact.	199
II	MEDIUM: Municipalities with no events during the last 5 years and recorded victims before 2011.	291
III	LOW: Municipalities with no recorded victims but record of events (military demining during operations, hideaways, etc)	183
IV	NO IMPACT: No recorded events	429

Source: Directorate for Comprehensive Mine Action. DAICMA. Updated to march 2017.

Annex C. Analysis of events registered in IMSMA vs. Recommended methods and techniques for Technical Survey

TYPE	QUANTITY**	STATUS	TECHNICAL SURVEY APPROACH
Military demining	21.165	Open	Targeted Survey Buffer Zones
Accidents	6.667	Open	Fade out Buffer zones
Illegal workshops	28	Open	Targeted Survey
Illegal Storages	8	Open	Targeted Survey
Confiscations	3.495	Open	Targeted Survey
Hazardous Areas	1.714	Open	Systematic survey
Unexploded Ordnance	44	Open	Inside out
TOTAL	33.123		

*Source: Directorate for Comprehensive Mine Action DAICMA. Updated to march 2017.
Type of Technical Survey approach according to the type of event.*

Annex D. Methodology for Technical Survey Approach vs Regions and characteristics of IEDs and Mines.

DIVISION	LEVEL OF IM- PACT IN MUNICI- PALITIES	TECHNIQUE	REMARKS
I	Type I (20%) Type II (80%)	Manual Demining	High metal content in IEDs
II	Type I (20%) Type II (25%)	MDD	Low metal content and high amount of explosive content in IED. Good logistic support.
III	Type I (50%)	Manual demining	Mountain range. High metal content and high explosive content in IEDs. Poor logistics.
	Type II (40%)	MDD	Mountain range. IEDs with low metal content and low explosive content. Poor logistic support.
IV	Type I (40%) Type II (30%)	Mechanical demining	Flat area with low-none vegetation. IEDs with low metal and explosive content. Good logistic support. Low quantity of events.
V	Type I (20%) Type II (40%)	MDD	IEDs with plastic container and low explosive content. Mountain range. Good logistic support.
VI	Type I (70%) Type II (5%)	Mechanical Demining	High metal and explosive content. Flat areas and good logistic support.
VII	Type I (50%)	Manual Demining	IEDs with high metal and explosive content. Flat areas. High vegetation and limited logistic support.
VIII	Type I (50%)	MDD	IEDs with low metal content and high explosive content. Flat areas with low vegetation and poor logistics.
	Type II (40%)	Manual demining	IEDs with high metal content. Flat areas with high vegetation and poor logistic support.

Proposed methodology for Technical survey tasks according to IEDs, logistic support, weather and geographic conditions and level of impact of antipersonnel mines and IEDs in municipalities.

Lessons Learned From Demining Accidents in Croatia and Bosnia and Herzegovina

Branislav Krljaš⁴, Dražen Šimunović⁵

Abstract:

Mine incident, statistics of casualties, types of injuries, casualty causes, methods of operations, terrain preparation, weather conditions, soil type, vegetation, injury circumstances, demining safety measures, evacuation, first aid, medical team, notification of family members and further assistance

Introduction:

Based on mine action/demining knowledge and experience gained so far in Bosnia and Herzegovina and Croatia, the aim of this paper is to acquire knowledge and improve skills of deminers that will result in positive change of behaviour, skills, habits or processes performed by persons engaged in demining operations. These positive changes are in the interest of their own protection and reduction of mine incidents and victims.

Demining Accidents and Mine Victims in the Republic of Croatia 2007 – 2017

In Croatia demining accident or mine incident is an event that occurred in the process of detection, removal, destruction of mines and /or UXO, but also during preparatory activities (mechanical preparation of the terrain, marking of the worksite, mine detection dog handling, etc.). According to available and existing data from CROMAC for the period 1991-2017, in 138 demining accidents 227 people were injured out of which 67 fatalities. In the period 1997- 2017, in 70 demining accident 101 people were injured out of which 36 fatalities. In the period 2007-2017, in 23 demining accidents 28 people were injured out of which 11 fatally. (remark: one person was involved in two mine incidents).

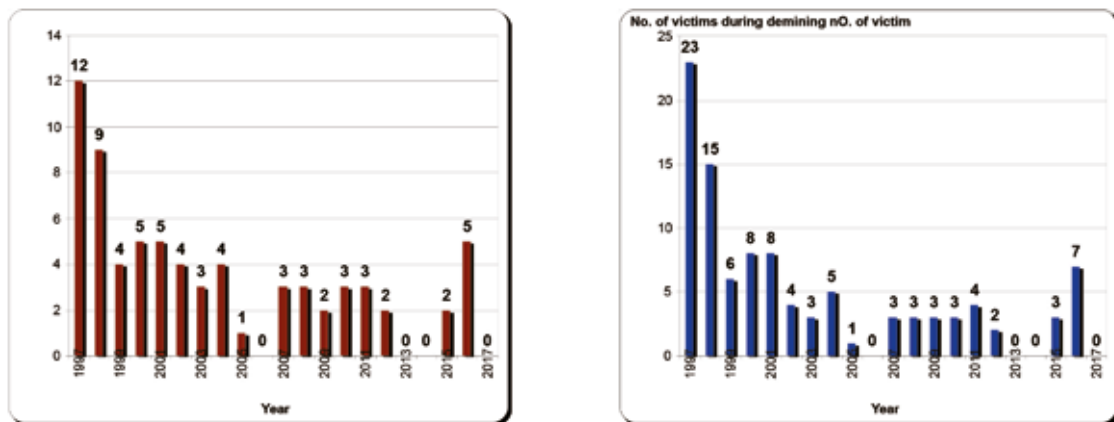


Diagram 1. Demining accidents and mine victims in the period 1997 – 2017

This article contains analyzed data of demining accidents in the last ten years (2007-2017) with indicators relating to:

- number of accidents, number of victims (injured) and types of injuries (fatalities, severely injured, with minor bodily injuries);
- circumstances in which accident occurred;
- type of mines and explosive remnants of war (ERW) which caused the accident;
- soil type;
- type of vegetation;
- number of casualties in one accident;
- time (time of the year, days, hours) and the place of accident (county);
- measures taken to ensure safety, age of deminers and years of working experience
- evacuation and urgent medical aid to the victims
- assistance to the victims and their family members.

⁴ BH MAC, Bosnia and Herzegovina

⁵ Mag. Ing. Mech, CROMAC, Croatia

1.1. Data analysis of demining accidents in the Republic of Croatia for the period 2007-2017

- a) In the past 10 years in the Republic of Croatia, in **23 demining accidents** 28 people were injured in which one person was involved in two mine incidents. Out of this number, 11 were fatalities, 7 people suffered major bodily injuries and 10 minor bodily injuries.
- b) By analyzing the circumstances of demining accidents it is noticeable that they primarily occurred **due to the excavation of detected metal fragment (in 7 accidents, 7 victims, 6 fatalities)** and during work with metal detector and/or prodder (in 5 mine incidents, 5 victims, 3 fatalities). Other causes of mine incidents are the result of stepping on a landmine, from the fragments of mines activated by other deminers from the adjacent line or during operation of demining machine, and other undetermined and unknown circumstances.

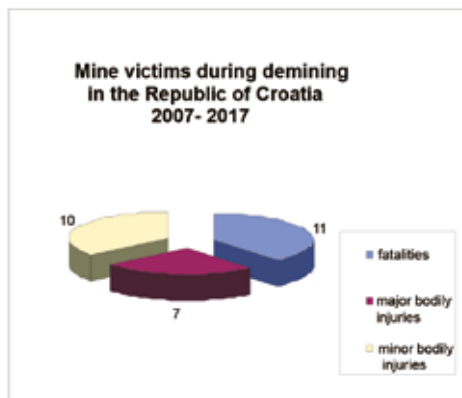


Diagram 2. Mine victims Diagram

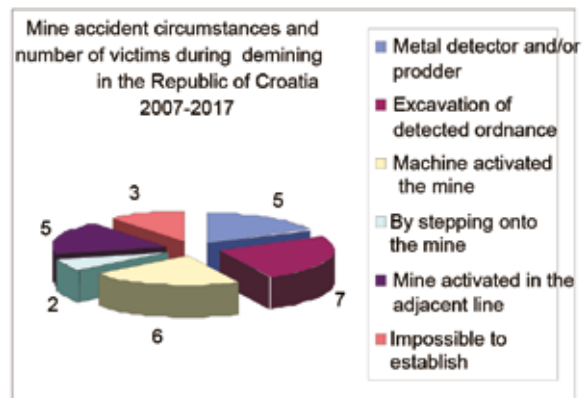


Diagram 3. Circumstances of demining accidents

- c) Mines and explosive remnants of war (ERW) which have caused most injuries during demining activities are primarily anti-personnel mines **PROM-1 (in 14 accidents, 19 victims, 9 fatalities, 3 with major bodily injuries and 7 with minor bodily injuries)**.



Photograph 1.
Anti-personnel mine PROM-1

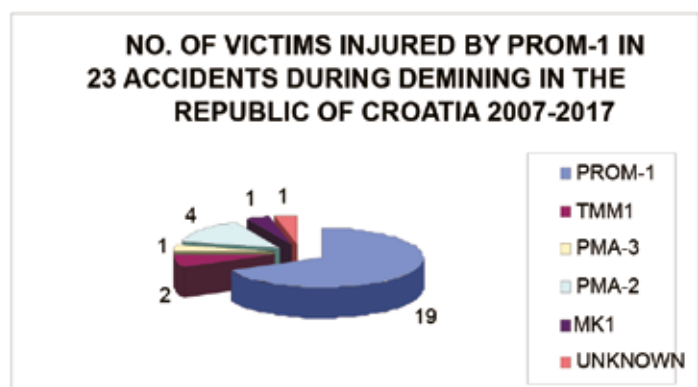


Diagram 4. Number of mine victims injured by PROM-1

- d) Analyzing data related to soil (land) on which mine incident occurred, it was determined that the majority of demining accidents happened on the soil which is flat, dry and hard (in 8 accidents, 12 victims, 9 fatalities).
- e) The vegetation is definitely one of the factors that affected the occurrence of mine incidents and due to that fact it was determined that majority of demining accidents and injured victims happened in high vegetation, forests (6 accidents, 7 victims, 3 fatalities), low vegetation, grass (in 4 accidents, 7 victims, 3 fatalities).
- f) Number of mine victims in demining accidents in the last ten years has mostly been individual (in 20 accidents, 21 victim was injured, 8 fatalities).
- g) As for the time of the mine incidents, it was determined that most of them occurred in the summer months (8 accidents, 10 victims, 4 fatalities). In addition, regarding the day of the week, it was determined that the majority of demining accidents occurred at the beginning of the week, mostly on Wednesday (5 accidents, 6 victims, 5 fatalities). Regarding the time period of mine incidents, from 8:00 AM until 1:00 PM, 17 accidents occurred in which 21 person was injured, 9 of them fatally. Most accidents occurred in the morning, from 8 until 10 AM (7 accidents, 8 victims, 5 fatalities). All mine victims were wearing protective equipment at the time of incident. In the past 10 years, most demining accidents occurred in Lika-Senj County - 4 accidents, 6 victims, two fatalities. Analyzing working experience of the people injured during demining of mine suspected area, most of them has working experience lasting 5-10 years, were aged between 35-40 (8 accidents, 10 victims, 4 fatalities), and between 30-35 (6 accidents, 6 victims, 1 fatality).
- i) The evacuation and urgent medical aid after the occurrence of mine incident was conducted in accordance with first aid medical standards and in due time in accordance with circumstances in which the accident occurred.
- j) In the Republic of Croatia, urgent medical aid is, in line with the Law on Mine Action, guaranteed to the mine victims in demining accidents as well to the victims' family members. Therefore, the aim is to raise the principles of humanity and assistance to mine victims to the highest level possible. From all the above elaborated, the conclusions below can be drawn and lessons learned that might assist mine action employees in their future work, provide better insight and raise their level of awareness of what can be disastrous and tragic in their daily work.

1.2. Lessons learned from demining accidents in the Republic of Croatia

- Fatality rate in demining accidents in the Republic of Croatia in the last ten years (2007-2017) is approximately 50% (11 fatalities in 23 mine incidents). It is 40% when compared to the total number of injured victims which is extremely large number related directly to the type of mine that caused the accident - PROM-1.
- The most common circumstances of demining accidents in Republic of Croatia occurred during excavation of detected metal. Mostly they are carried out by different types of knives and auxiliary tools, spades, hoes, etc. This is a very important issue. According to previously mentioned, it is necessary to identify the best solutions to check the metal detections in the soil that is mostly flat, hard and dry. This type of soil often contains lots of minerals and frequency of metal detection signal pretty high. The consequence is slowing down the work of deminers and lower daily capacity output. In order to achieve daily planned capacity output, concentration may be reduced, 'sense of false security' can lead to the thought that there is plain metal in the ground and this necessarily leads to tragedy. Also, security and check-up of metal detector functioning should be increased since prodger as well as metal detector are main tools for mine detection and second most frequent cause of mine incidents

- In the last decade, the most common cause of mine incidents and demining accidents is activation of anti-personnel mine PROM-1. In 80% of mine incidents, injury ends with death. From the debris (shrapnel) of this particular mine, deminers were killed, when it was activated during operation of demining machine or by deminers from the adjacent line. Despite the decision adopted at the end of the 1990-ies, according to which PROM-1 is the type of mine that should be destroyed on site and not to be demined (deactivated), injuries caused by this type of mine are most frequent and constant phenomenon. In the period 1997-2017, out of 101 injured victims, 56 were fatalities and in the period 2007-2017 in 23 mine incident, 19 people were injured (67.8%) out of which 9 fatally. The profession has to face this fact and provide a solution how to minimize the risk of further incidents.
- The conclusion is that most of mine incidents occur on a flat, hard and dry soil. Deadliness of mines and location of their placement are just perfect for this type of soil. On the other hand, this type of soil, in some way, is the ‘easiest’ to check, which often causes daily work becoming a routine, reduced vigilance and lack of concentration during „easier“ working conditions. This phenomenon is somewhat less frequent in case of vegetation removal and mechanical soil treatment (18% of mine incidents, 18% injured, 27% fatalities). Mechanical soil treatment reduces mine incidents to a certain point and provides safety to deminers when working after demining machines. This „false“ feeling of safety should not be taken easily due to the fact that we still report mine victims in the past ten years despite of application of this “combined method”.
- Low vegetation (grass) as well as high vegetation (forest) proved to be equally fatal for demining accidents. Link between the height of the vegetation and increased number of mine incidents cannot be determined.
- In most cases, safety distance-related measures are implemented, but should be more strictly controlled if the existence of mine PROM-1 is foreseen on a demining site. The area of shrapnel disbursement and the probability of shrapnel hitting its target is reduced with the increase of safety distance as has been demonstrated in theory and practice through numerous previous years’ papers.
- In terms of seasons, the majority of mine incidents occurred during summer months. Incidents occurred in the first half of the week, most critical is Wednesday. If we connect soil structure (dry, flat, hard) with previously noted facts, most harmful type of mine (PROM-1) and more frequent use of tools for metal detection excavation (hoes, spades) then it should not be taken as a surprise that summer months are most critical ones.
- Deminers in the Republic of Croatia (in 60% of cases) are injured between the age of 30 to 40 with 5 to 10 years of working experience. Mine incidents occurred evenly throughout the working day and the majority of fatal incidents (45%) occurred in the morning hours (8:00-10:00 AM).
- Protective equipment, protective vests and bulletproof vests are of crucial importance and their use is unconditional. This is confirmed by direct injuries of deminers when PROM-1 was activated by deminers or demining machine from the adjacent line. They all wore protective equipment and there were no fatalities in the adjacent line.
- It is necessary to provide conditions for more efficient evacuation of injured persons in inaccessible areas (helicopters, transport as quickly as possible).
- Notification of family members and assistance to the victims must be in accordance with the highest standards and principles of humanity but also legally supported and enabled.
- **Additional training and education is absolutely necessary after a certain number of years.**

Dražen Šimunović, Mag. Ing. Mech.

Demining accidents and incidents in Bosnia and Herzegovina

1.-Definitions: Standard BH – Issue II – 2003

Demining incident. Presents an unexpected activation of an explosive device (ED) in the demining process, without any consequences for health or life.

Demining accident. An accident involving a mine/UXO and which occurred during the conduct of demining operations.

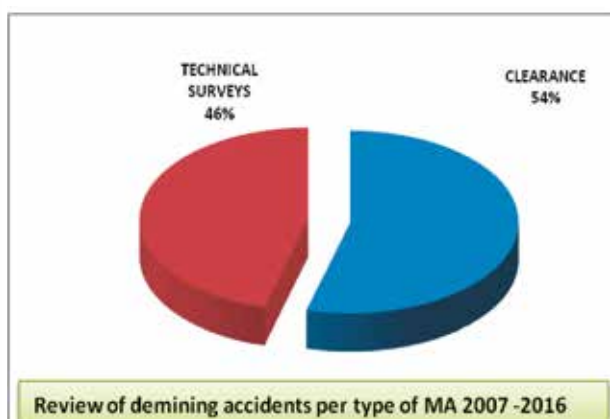
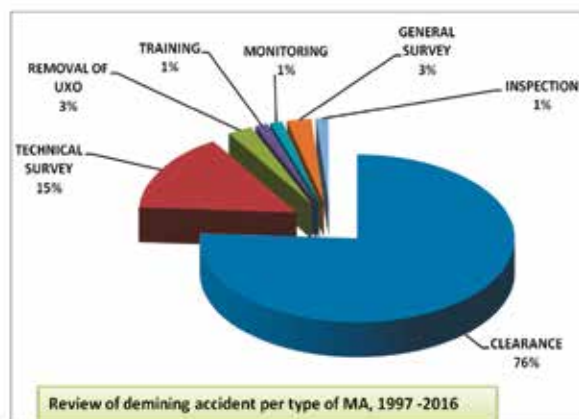
2.-History:

The war in BH from 1992-1995 had multiple and permanent consequences where the number of mine victims is certainly one of the most significant consequence. According to the data from BH MAC database, in the period of 1992-2016 there has been 8379 registered mine victims in BH, out of which 1751 victims registered once the war activities ended.

The history of demining accidents in BH overlaps with the history of humanitarian demining. In its first phase, it conducted with the support and monitoring of international experts. The establishing of the structure of Mine Action Centre in BH, BH State has taken over the responsibility for the process of removal of mines and explosive devices remained from the war.

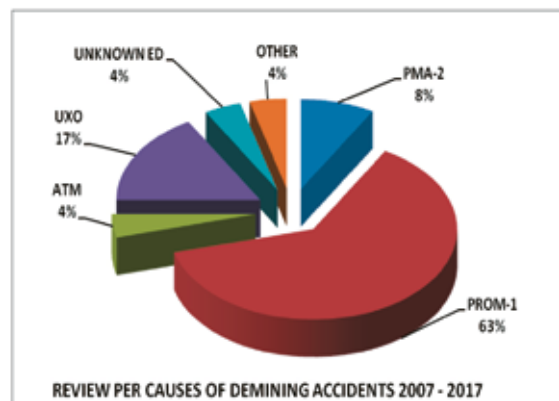
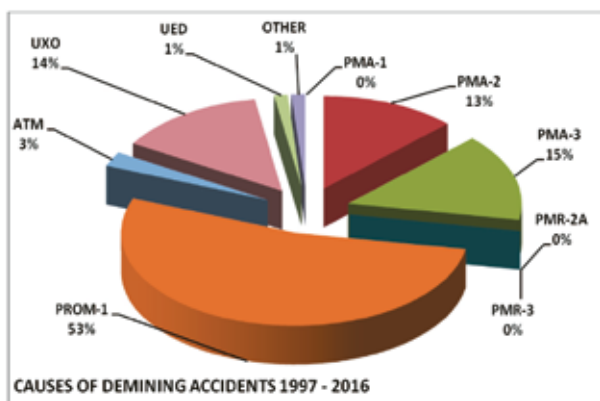
According to information from BH MAC for the period of 1997-2016 (20 years period), there were 79 demining accidents in BH, with the following consequences: 122 victims out of which 50 fatalities, 39 severely wounded and 33 lightly injured.

The lack of adequate procedures and under-developed management process in the first phase had for a consequence a significant number of victims amongst both operational staff as well as civilians in various mine action procedures, which was significantly visible in the first ten years period (1997-2007).



Hence, as for the second decade, all demining accidents occurred exclusively on demining sites and within the application of standardized procedures.

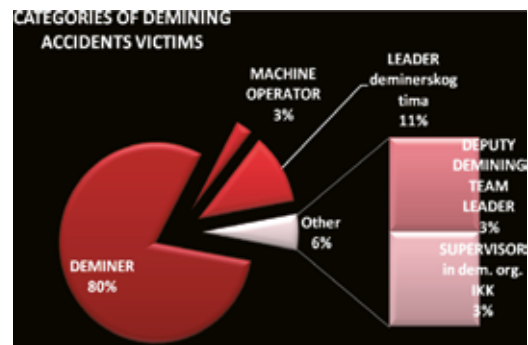
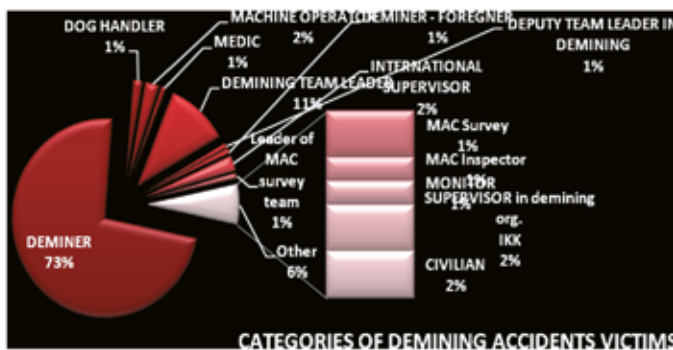
If these two periods are observed from the aspect of cause, we can perceive that PROM mine is not only the key reason and problem. It became a greater issue that needs additional analysis and discussion.



We consider it especially important to point out the changes in structure of the victims in mine action activities in BH. In the first ten years period, there were four (4) international experts registered as victims, four (4) BH MAC operational officers out of which two (2) fatalities, two civilians out of which one (1) police inspector, one (1) monitor from the monitoring organization, two (2) supervisors from demining organizations, one (1) medic, two (2) dog handlers, two (2) machine operators, sixty-one (61) deminers, nine (9) team leaders and one (1) deputy team leader.

In relation to the period of 1997-2007, the number of demining accidents significantly decreased in the period of 2007-2017. In the first ten years period, there were 55 demining registered demining accidents, while there were 24 demining accidents in the period of 2007-2017. The years of 2012 and 2015 were even accident free, unlike the previous period, when there was at least one or more demining accidents registered per year. The first demining years (1997-1998) were particularly fatal, with 10 registered demining accidents per year.

The decrease of the number of demining accidents and significant change to the structure of the victims themselves was certainly influenced by the Inspection Bodies of BH MAC and enhanced inspections by quality assurance staff in demining organizations. However, there is still a considerable and troublesome number of accidents in managerial staff in demining organizations, who have the responsibility for the safety and consistent application of the procedures.

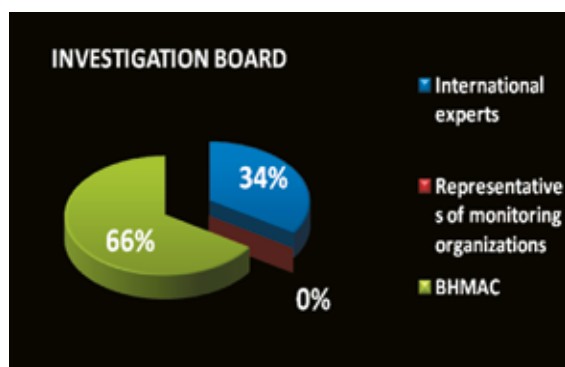


It is almost impossible to talk about demining accidents and incidents without considering all the aspects of the investigation process. Chapter XIII – Standard BH 2003 stipulates: *„Demining and mine accidents must be immediately reported to the Ministry of Interior and to BH MAC; they must be documented and investigated as soon as possible. Every demining accident that occurs during the operations of clearing mines or UXO must be the subject of full and independent investigation, in order to find out the cause and recommend the prevention measures for future operations. BH MAC Investigation Board shall conduct an investigation which is independent and which does not interfere with possible court or police procedure. “*

Parallel to the adoption of international procedures and development of its own demining accident investigation procedures, BH MAC also developed the structure of personnel who participate in the demining accident investigation.

In the first ten years period, international experts conducted a significant number of investigation, while operational staff of BH MAC conducted all the demining accidents investigations in the second ten years period.

The investigation procedure is not only complex but a risky procedure as well since it requires the engagement of the most expert and experienced operational personnel. In two investigations, the Investigation Board found additional mines which directly put them into harm's way.



3.-Analysis of information 2007-2017

a) - In humanitarian operations in BH for the previous 10 years, BH MAC has registered 24 demining accidents with 35 victims, out of which 19 fatalities, 7 severely injured and 9 lightly injured persons.

b) - 13 accidents occurred during mine clearance operations while 11 occurred during technical survey operations.

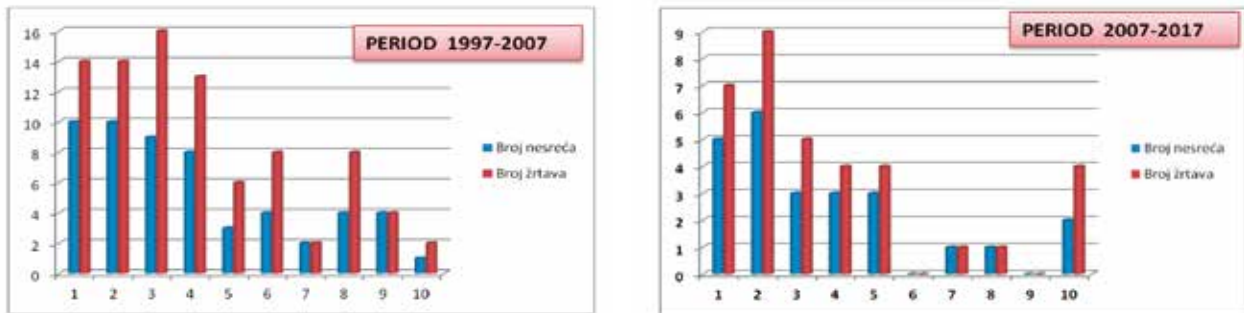
c) - Activation of the PROM-1 mine has been the cause of the accident in no less than 15 cases, which is a 10% increase in comparison to the period of 1997-2007. The number of accidents caused by other types of AP mines has been diminished primarily because of their uselessness; however, two new categories of cause were identified, where one is unknown explosive device (UED) and the other is the fall of deminer from the cliff/rock during the operations/application of standardized procedure (other).

d) - Activation of 15 AP PROM – 1 mines on demining sites in BH during 2007-2017 had for its consequence 17 fatalities, 3 severely injured and 4 lightly injured persons. The number of accidents and victims caused by the activation of AP mine PROM requires an expert discussion, a maximum number of engaged experts, improvement of procedures as well as raising the discipline and responsibility on demining sites to a significantly higher level. There was only one case in 2007 where the activation of PROM-1 mine did not result in a demining accident, due to a broken initiation chain, where the detonating cap “failed/wasn’t activated.”

d) - Unlike the period of 1997-2007 with victims from various structures, including BH MAC, the victims of demining accident in the period 2007-2017 were exclusively members from the structure of organizations accredited for demining. As for the said period, there were 28 deminers-victims, out of which 19 fatalities, 4 team leaders, one with severe and three with light injuries, one deputy team leader – fatality, 1 machine operator and 1 demining organization supervisor with light injuries, which is a total of 35 victims. The issue in question is accident with multiple victims, which is why we put the following table for consideration.

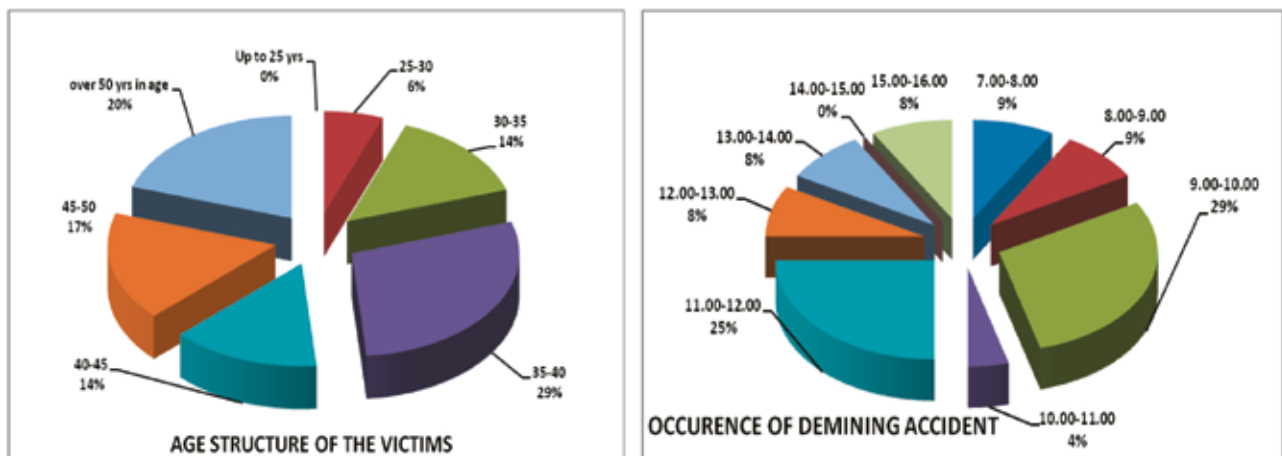
REVIEW OF DEMINING ACCIDENTS PER YEAR AND CAUSE, DEMINING SITES IN BH 01.01.2007 - 2017						
SER	YEAR	NUMBER OF ACCIDENTS	ACCIDENT CONSEQUENCE			
			LIGHT INJURY	SEVERE INJURY	FATALITY	TOTAL VICTIMS
1	2007	5	2	2	3	7
2	2008	6	1	2	6	9
3	2009	3	0	2	3	5
4	2010	3	2	0	2	4
5	2011	3	2	0	2	4
6	2012	0	0	0	0	0
7	2013	1	0	1	0	1
8	2014	1	0	0	1	1
9	2015	0	0	0	0	0
10	2016	2	2	0	2	4
TOTAL	10	24	9	7	19	35
			35			

Not only the number of demining accidents is decreased in the period 2007-2017 in relation to the previous decade. The number of victims significantly decreased per a demining accident, as shown in the following chart:



e) - The age structure in demining accidents victims varies, but it is typical that 7 out of 35 victims were over 50 years in age. Most victims (10) were 35-40 years of age on the day of the accident. Age structure of accredited deminers in BH is not an issue, but it might be a topic considering the number of victims who were 50 or over 50 years old.

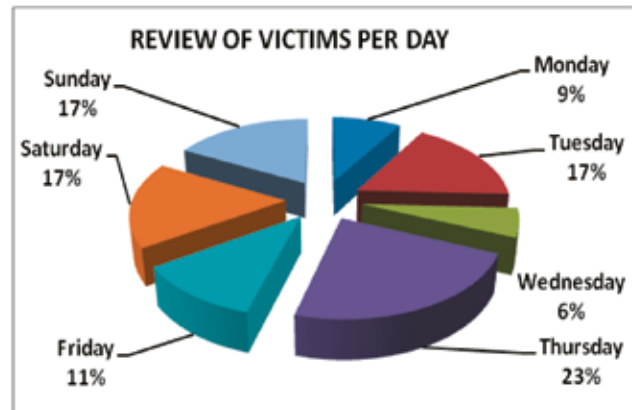
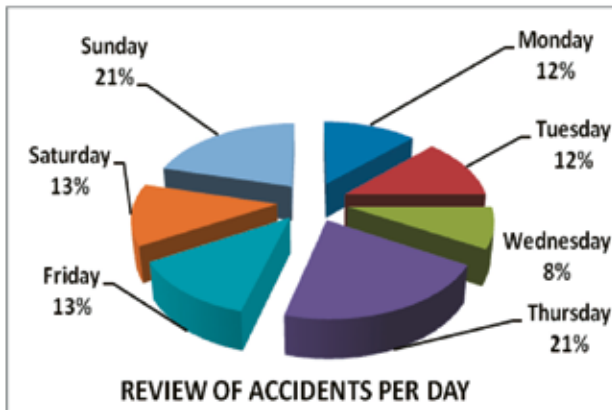
f) - Most demining accidents (7) occurred between 09:00-10:00 which is a significant detail from the aspect of managing the operational staff and the working discipline itself. Two accidents occurred practically at the very end of daily operations when the concentration was significantly diminished, while as an example accidents did not occur in the period of 14:00-15:00, which brings its own assumptions as a reason.



g) - Except for January and February, demining accidents occurred during all other months in the period 2007- 2017. March and August were months with 4 registered accidents each, while the other months registered less.

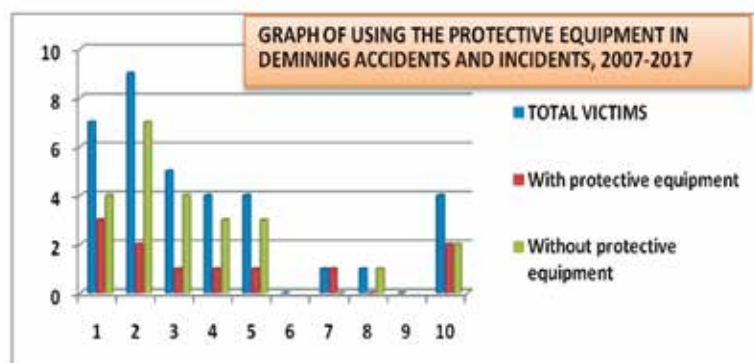
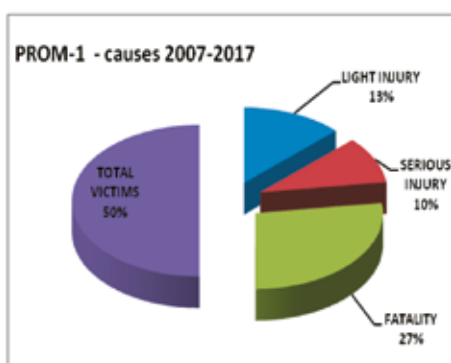
h) - Thursday and Sunday are the days in which demining accidents and incidents have occurred the most. It is evident that the days of the weekend are the critical days in terms of the level of security and safety in the demining sites. That may be due to reduced volume and intensity of the implementation of external and internal control on which BHMACH insists lately.

i) - It is interesting that 14 accredited demining organizations during 2007- 2017 had demining accidents. Most demining accidents in BH were registered with a demining company „Mine-tech“ from SAR (7), though the organization itself isn't accredited in BH for a long time now.



Experiences 2007-2017

- a) - Each demining accident requires a full, independent and highly expert investigation. However, due to consequence, the investigation of an accident caused by the activation of PROM-1 mine almost regularly requires additional consideration and discussion.
- b) - 90% of investigations determined the breach of working procedures in manual operations, where most was qualified as a “severe breach”. It had for a consequence new procedures for manual operations, adopted through Annex 2. of the BH Standard 2000.
- c) - Breach of working procedures as a rule is followed by poor working discipline, very often determined in personnel responsible for the establishment and maintenance of the very discipline. As a consequence, a document was issued in 2009, „Regulations on Accreditations and Authorizations of Personnel in Humanitarian Demining. Through its application, and after the severe violations were determined, the Investigation Board initiated the withdrawal of the working permit for the period of 6 months in 8 separate occasions.
- d) - The use of proposed protective equipment is an obligation from the moment of entering the operational part of the site, and the violation of this obligation has for a consequence withdrawal of permit. Regardless of the fact, out of 35 demining accident victims in the period 2007-2017, 22 of them were not using protective equipment at all, while only 11 deminers used full protective equipment. On two separate occasions, the usage of incomplete protective equipment has been registered.
- e) - When it comes to the victims of PROM-1 mines, out of 24 victims from the period 2007-2017, 5 of them used the protective equipment in the moment of detonation. On one occasion, the equipment was incomplete while in 18 cases, this obligation was completely ignored. This certainly opens and imposes the issue of the level of safety provided by standardized level and quality of the protective equipment in situation when PROM- 1 mine is the cause of the accident.



Out of 24 victims of PROM-1 mine for the stated period, 19 victims didn't use protective equipment, while only 5 victims had full protective equipment on in the moment of detonation

f)-In the process of investigation, each quality assurance aspect is analyzed separately. The investigation board provides conclusion and grade for each aspect. Particular attention is paid to being dedicated to mine situation, new signs of mines, organization of the site, management, choice of equipment and tools for work, terrain conditions including vegetation and medical support as one of the key aspects without whom the operations are both impossible and strictly forbidden.

The Investigation Board provides a recommendation for each registered remark, all in order to improve the existing standards and procedures, but also the creation and distribution of the LESSON LEARNED to all accredited organizations.

DATA COMPARISON

Analyzed data and causes of mine incidents / demining accidents	Bosnia and Herzegovina	Republic of Croatia
MINE INCIDENTS/DEMINING ACCIDENTS 1997-2017	79	70
Fatalities	50	36
Major bodily injuries	39	46
Minor bodily injuries	33	19
Total number of victims	122	101
MINE INCIDENTS/DEMINING ACCIDENTS 2007-2017	24	23
Fatalities	19	11
Major bodily injuries	7	7
Minor bodily injuries	9	10
Total number of victims	35	28 (27)
The most common mine and /or ERW – cause of mine incident / demining accident	PROM -1	PROM-1
Circumstances of injury	Violation of procedures in manual operations	Excavation of detected ordnance
Time of day /hour when the mine incident / demining accident occurred	9.00-10.00 AM	8.00 – 10.00 AM
The most common day of the week when the mine incident / demining accident occurred	Thursday – Sunday During weekend	Wednesday
The most common time of the year when the mine incident / demining accident occurred	March and August	Summer
The most common location of injury	Doboj – Maglaj	Lika – Senj County
The age of injured deminers (the highest number)	35-40 years	30 - 40 years
The age of injured deminers (the lowest number)	25-30 years	25-30 and 50 - 60 years
Working experience of injured deminers (in years)	More then 5 years	5 - 10 years

Number of injured persons in mine incident / demining accident		1 in 87% of incidents
The highest number of victims in one mine incident / demining accident	3	3
Type of soil in mine incident / demining accident	Different structures but with the possibility of use of prodder	Dry, flat, hard
Vegetation in mine incident / demining accident	Has an effect	Has no effect
Mechanical preparation of the terrain and clearing of vegetation	Affects the number of MI/DA	Reduces number of MI/DA
Demining safety measures taken	No	Yes
Safety distance during mine incident / demining accident	Not conducted - in all incidents injured more than one deminer	In accordance with Standard Operating Procedures
Protective equipment	In more than 70% of incidents not used	Yes
The evacuation and urgent medical aid	„No“ in 2 of 24 incidents	Yes (in all incidents)
Assistance to victims’ family members	Yes – from the insurance	Yes

Table comparing analyzed data and the causes of mine incidents / demining accidents in the Republic of Bosnia and Herzegovina and Republic of Croatia

Findings

Compatibility of the causes and consequences of demining accidents and incidents in the Republic of Croatia and Bosnia and Herzegovina was certainly influenced by very similar history of warfare, in which can be recognized the legacy of the military doctrine of the former JNA (Yugoslavian National Army) and use of the same or similar standards in formation and materially technical sense, especially in using explosive devices.

Due to all these similarities, the results of this analysis showed that this problem in the past was unduly neglected in comparison to other issues. This problem requires further discussion, especially because of a growing number of demining accidents and incidents that become the subject of litigation. Regardless of the significant individual and shared experiences, there are still a lot of open issues of which the most important are:

- Are the procedures in manual clearance operations adequate for the areas where AP mines type PROM-1 can be certainly expected,
- Is the Standard for safety equipment at the required level,
- Additional training or introduction of repressive measures aimed at raising labor discipline,
- Procedure of the investigation, jurisdiction and authority,
- Exchange of the experience at the regional level

Therefore, the forthcoming 14th International Symposium “Mine Action 2017”, organized by CROMAC will be an excellent opportunity to present our own and acquire new experiences.

14.03.2017. - Branislav Krljaš, BHMACH- Sarajevo

Psycho - social empowerment of war veterans through mine risk education

Đurđa Adlešić⁶



ABOUT THE ASSOCIATION

- The City of Zagreb has initiated, among others, the establishment of the Association for the support and encouragement of unity „Croatia helps”. The founders are cities of Zagreb, Dubrovnik and Osijek.
- The association was founded in order to promote common interests and cooperation between cities in Croatia, especially cooperation in the humanitarian and voluntary activities as well as social programs of their communities and international development cooperation.
- The Association „Croatia helps”, among other activities, organizes and provides assistance in mine action in Croatia

MINE ACTION

- Organization and conducting of Mine Risk Education to various target groups
- Raising funds for financing demining projects in the Republic of Croatia

EDUCATION OF EDUCATORS:

- Members of the Association of Special Police Unit “OSA” are qualified educators on mine danger.
- These are retired members of Special Police Units which significantly contribute to raising the awareness of mine danger due to their authority and experience. They are available at any time and proud of doing useful educational tasks
- The association „Croatia helps”, in cooperation with the Croatian Mine Action Center (CROMAC) and the Ministry of the Interior of the Republic of Croatia, has organized an education of educators (OSA).

BASIC EDUCATION TOPICS:

- to inform war veterans about basic principles of mine action
- to inform war veterans about mine danger
- to inform war veterans about basic characteristics of mines and UXO
- to inform war veterans about Mine Suspected Area (MSA)
- to inform war veterans about risky and proper behaviour and use of CROMAC MIS portal
- to inform education attendees about mine incidents involving members of special police and other groups of civilians
- to provide education on communication methods and skills so that they could successfully present the mine action-related knowledge they acquired

EDUCATION PROGRAM

- T-1 Program of introduction to mine danger – previous experiences
- T-2 Basic characteristics of mines and UXO

⁶ President of the Association for support and encouragement of unity „Croatia helps”

- T-3 Mine Action in the Republic of Croatia
 - basic features of Mine Suspected Area (MSA)
 - risky and proper behaviour inside Mine Suspected Area (MSA)
 - use of CROMAC MIS portal
 - mine victims in the Republic of Croatia
- T-4 Workshop: Basics of communication skills in teaching process

EDUCATION OF EDUCATORS – DARUVAR

Association of the special police unit „OSA“

- The education is a part of the project entitled “Psychological and social empowerment of Croatian war veterans, Croatian war veterans with disabilities, Croatian war and military veterans with disability, victims and family members of deceased, captured or missing Homeland War Veterans” organized by the Ministry of Croatian War Veterans.



- During two days training, twenty members of the Association ‘OSA’, in the context of lectures and presentations, were presented basic principles of mine action in the Republic of Croatia, mine danger, basic characteristics of mines and UXO, hazardous mine-

contaminated areas, risky and proper behaviour in case of running into mine suspected area (MSA)

- The Workshop consisting of practical exercises on “Basics of communication skills in teaching process” was significant in terms of attendees practicing different ways of establishing verbal and non-verbal communication.

EDUCATION OF EDUCATORS – LIPIK

Association of the special police unit „OSA“

- The Association for the support and encouragement of unity „Croatia helps”, in cooperation with Ministry of Croatian War Veterans, Ministry of Interior, General Police Directorate and Police Academy has organized and implemented pedagogical and instructive training for Mine Risk Educators, which was held from 5 to 7 December, 2016 in Special Hospital for Medical Rehabilitation Lipik. The training was intended for education of educators, retired employees of the Ministry of Interior, Ministry of Defence and Ministry of Croatian War Veterans and their pedagogical preparation for teaching and presentations.



ASPU “OSA”

- Conducted educations ■ Jasenovac ■ Rajić – Novska ■ Glina ■ Hrvatska Kostajnica
- Drniš ■ Ružić ■ Vodice ■ Lički Osik ■ Perušić ■ Gospić

MINE RISK EDUCATIONS – FOR CHILDREN FROM GUNJA:

- In cooperation with the Ministry of Interior, there was an educational training for children held



as part of their holidays. The topic of the training was protection against mines and UXO since the area mentioned was the scene of war operations during the Homeland War.

- The children were informed about danger threatening from residual mines, UXO and firearms i.e. physical contact with unfamiliar objects aimed at prevention of casualties.

MINE RISK EDUCATIONS – FOR CHILDREN FROM SREBRENICA:

- Upon request of the Red Cross Zagreb, in cooperation with the Ministry of Interior and CROMAC, the Association has organized educational training on protection from residual mines, UXO and firearms”.



- The trainings mentioned are held for school children. The children were informed about danger threatening from residual mines, UXO and firearms i.e. physical contact with unfamiliar objects aimed at prevention of casualties.



MINE RISK EDUCATIONS – FOR CHILDREN FROM UKRAINE:

- Education about mine danger was held by the Head of Anti-explosion Division of Primorje-Gorski Kotar Police Department



MINE RISK EDUCATIONS – FOR TARGETED GROUPS- CROATIAN HUNTING FEDERATION NEEDS

- The Association as the Project holder, in cooperation with CROMAC and Ministry of Interior’s Anti-explosion Division, organizes mine risk education (MRE) for the needs Croatian Hunting Federation and their members.

- The project aim is to increase the level of knowledge about mine risk and prevent injuries of hunters and

other target groups in the mine affected areas as well as provide them with information about mine action and mine danger on the territory of the Republic of Croatia.



MINE RISK EDUCATIONS – FOR CROATIAN HUNTING FEDERATION

Educations are held for the needs of:

- Zadar County Hunting Association
- Šibenik-Knin County Hunting Association
- Osijek-Baranja County Hunting Association and Croatian Hunting Association Huntress – CHF „Ladies”



VICTIMS INVOLVED IN MINE ACCIDENTS DURING THE HUNT

- Mine Risk Education (MRE) for hunters as a preventive measure of safety and protection from mine accidents during the hunt.



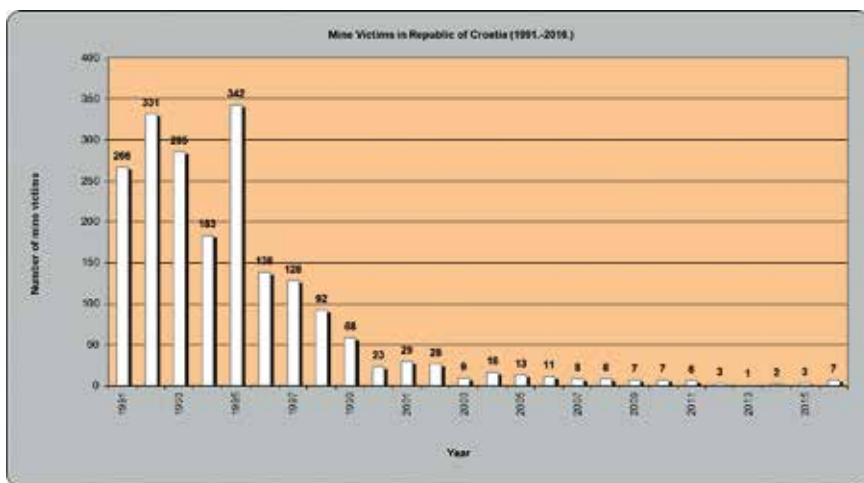
Education of Firefighters

- Fire fighters are one of the targeted groups threatened by mine danger during fire fighting near minefields or if the fire occurs inside the minefield
- They are educated through the same training program as hunters. It is a specific target group that operates in specific circumstances when mines are in the midst of the fire or in the vicinity.
- Mines placed inside the area which has been the scene of a fire are unpredictable and feature-dependent.

MOTIVATIONAL WORKSHOPS

- Organization and conducting of motivational workshops in order to develop entrepreneurial skills for the purpose of employment encouragement of Croatian war veterans, children of killed war veterans and captured and missing Croatian war veterans was organized in cooperation with the Ministry of Croatian War Veterans.
- During 2016, motivational workshops were held in Slunj, Rijeka, Osijek, Split, Zagreb and Glina. Workshops were attended by war veterans and children of killed and missing Croatian war veterans.
- Once motivational workshops were finished, war veterans were encouraged to continue mine action- related education and further transfer of knowledge to the mine affected population

MINE VICTIMS



Latest mine incident involving children occurred in November 2004 (Požega)

Latest mine incident involving civilians in the Republic of Croatia occurred in February 2014. (Oštarije, 2 mine victims, one with major bodily injuries and one dead).

EDUCATIONS - ORGANIZERS AND INSTRUCTORS

- Association for the support and encouragement of unity „CROATIA HELPS”
- Ministry of Croatian War Veterans
- Police Academy, Ministry of Interior
- Croatian Mine Action Centre (CROMAC)
- Croatian Hunting Federation (CHF)
- Association of Special Police Unit “OSA,,
- State Office for Croats Abroad
- Private colleges and universities



PRESIDENT OF ASSOCIATION:
Đurđa Adlešić

Residual Contamination Management Practices in Post-Civil War Spain

Branislav Jovanović¹ and David Gertiser²

Abstract

Spanish residual ERW contamination response is analyzed for statistical trends. Initial assessment appears to show random distribution, but statistical evaluation clearly demonstrates the same trends are present in Spain as in other ERW affected countries. Cumulative data tapering implies a gradual decrease in ERW recovery rates over time. Accurate modeling resulting from comprehensive data collection can inform more targeted policies. Evaluations of other data sets could validate the methodology or point towards helpful modifications of the model.

Introduction

Previous work on Residual Contamination has focused on the development and evolution of risk management practices concerning Explosive Remnants of War in European countries affected by the First and Second World Wars³, in comparison to more recent conflict zones, such as Cambodia, Lao PDR and Vietnam.⁴ Other work has looked at legislative development and national capacities in countries such as Mali, Nepal and Nicaragua.⁵

Absent in this discussion has been the impact and subsequent development resulting from the Spanish Civil War. Characterized by significant involvement by foreign powers in terms of munitions supply, the story has remained largely untold due to reticence in the population to engage with the topic.

This has only recently begun to change. With the publishing of various accounts and the writing of specific works there has also been an increase in news articles published on the topic.⁶ These articles have primarily been a result of Freedom of Information (FOI) requests. The results of this paper are a consequence of one of these requests.

Background on Evolution of EOD Response

Without doing the topic justice, some background information is still helpful. The Spanish Civil War began as a military coup by General Franco. In an effort to return to more traditional values of Church and King, General Franco gathered like-minded officers in a revolt. This was launched from the Canary Islands, where Franco was essentially exiled, and swiftly moved north through the Iberian Peninsula. General Franco met significant resistance in Madrid, and sought to cut Madrid's lifeline – the connection to the port of Valencia. The Republican Army tried to avoid the destruction of Valencia in a battle by engaging General Franco's troops in the rugged terrain 250 kilometers to the north.⁷

1 Branislav Jovanovic, Global Program Director Maavarim Group

2 David Gertiser, Residual ERW Consultant

3 Paunila, Samuel. “Managing Residual Clearance: Learning from Europe's Past”. The Journal of ERW and Mine Action. Volume 18. Issue 1. Spring 2014. <http://www.jmu.edu/cistr/journal/18.1/feature/paunilla.shtml> Accessed 11 March 2017

4 GICHD. 1st International Symposium on Residual Contamination. 2014. Siem Reap, Cambodia.

5 Massleberg, Åsa. GICHD National Capacities and Residual Contamination case study series. Available at <https://www.gichd.org/resources/publications/>. Accessed 11 March 2017.

6 “Alertan del peligro de las más de mil bombas de la Guerra Civil que se encuentran cada año”. 20 Minutos. 19 Oct 2013. <http://www.20minutos.es/noticia/1952417/0/artefactos/guerra-civil/tesoro-peligroso/#xtor=AD-15&xts=467263> Accessed 12 March 2017.

7 Author conversation with Miriam, guide at COMEBE, national museum of the Civil War in Corbera d'Ebro, Spain on 19 November 2016. Further information from <http://www.batallaebre.org/>, accessed 12 March 2017.



Figure 1: Innovations in artillery and aircraft bombing where tested during the Spanish Civil War⁸

Terra Alta and the banks of the Ebro River were the site of intense fighting toward the end of the Spanish Civil War. The battle here proved decisive in the outcome of the war, as the Republican Army staked almost all its resources, counting on international support. This support never came, based on a non-intervention agreements and promises made at the international level. While all sides found ways to remain involved, whether selling rubber, food or munitions, Germany and Italy, under the rule of Hitler and Mussolini respectively, contributed significantly to the cause of General Franco.⁹

Barcelona was not untouched, having been subjected to extensive air raids launched by Italian forces on the island of Menorca. Each Barcelona neighborhood collaborated to build bomb shelters as refuge against some of the first air attacks against a civilian population.¹⁰



Figure 2:
Classified Italian orders
to bomb Barcelona city center



Figure 3:
A Barcelona community
bomb shelter, staircase
leading down

⁸ Source: <https://www.pinterest.com/pin/245235142179867434/>

⁹ Ibid.

¹⁰ Author conversation with Jordi, guide of Tour of Barcelona Bomb Shelters, Muhba Refugi 307. 4 Feb 2017. <http://museuhistoria.bcn.cat/en/muhba-refugi-307> Accessed 12 March 2017. Photos by author.



Figures 4 and 5: Notices to citizens on appropriate action to take during a bombardment

The munitions, which remain scattered on the ground in the northeastern part of Spain, remained untouched unless recovered and dismantled by a growing cadre of self-taught bomb disposal amateurs. Destroyed crops, infrastructure and homes made metal recycling one of the few sources of income for populations in the affected rural area of Terra Alta. Accurate counts of the total number of munitions destroyed and number of casualties consequent to a school of trial and error in this period are not available. Those that survived passed on their hard-earned knowledge to fellow workers.¹¹

One such disposal worker, Pere Sanz, has established a visitor center called “La Trinxera” (The Trench) which documents in significant detail the work undertaken by the group of self-taught deminers.



Figure 6:
Pere Sanz, Owner,
Exposición Guerra
Civil La Trinxera

¹¹ Author conversation with Pere Sanz and visit to La Trinxera. 16 December 2016. Validated by author conversations with GEDEX officers in Tarragona, Spain on 17 January, 2017

In an interview in December, 2016, Pere Sanz discussed how he learned from previous experts, and how the dire poverty following the end of the Civil War forced many farmers to resort to the scrap metal trade to feed their families. He also commented on the changing regulations regarding the use of metal detectors.¹²

Official bomb disposal was originally the work of the military and then the Guardia Civil (Civil Guard). Under General Order of March 2nd, 1970, the Spanish government created the technical specialty for EOD and established what is now called Servicio de Desactivación de Explosivos (SEDEX). It has been adapted several times, including in 1979, 1988, 2000, and 2004. These structural and legislative changes consequently increased the remit of SEDEX to include Nuclear, Radiological, Biological, and Chemical (NBRQ) artifacts.¹³

SEDEX, the central authority, is complemented by the Grupos de Especialistas en Desactivación de Artefactos Explosivos y de naturaleza NRBQ (GEDEX), which exists on the provincial level and houses EOD experts who respond to ERW discoveries.¹⁴

In general, the use of metal detectors is covered by international conventions such as European directive 921 of 1981, and the Convention of Malta 1992. Spanish law Ley 16/1985, de 25 de junio, del Patrimonio Histórico Español (on Spanish Historical Heritage) penalizes the disturbance of heritage sites or objects and mandates reporting the discovery of anything over 200 years old.¹⁵ The only place in Spain with a unilateral ban on metal detection is Sevilla (Seville), where a permit is required.

Of interest to amateur treasure hunters in Northeastern Spain (mainly Catalonia), is a recent law that has prohibited the use of metal detectors without a permit which authorizes the searcher to explore a specific place for a specific time. The intent is to protect archeological heritage sites from being disturbed. The result, per discussions with amateurs who wish to remain anonymous, is that many activities are now pursued illegally. To avoid detection, searches are often conducted at night. This increases the risk borne by these searchers of inadvertently injuring themselves when an item of residual ERW is discovered.¹⁶

Problem Statement

Research Papers, Concept Notes, Issue Briefs and a Documentary Film have all recently been published considering the evolution of the risk management response to Residual ERW Contamination.¹⁷ Discussions consequent to these publications have illuminated a common trend of exponential decline in the frequency of ERW discoveries per year. The data behind these discussions have not been comprehensive, nor have they been published. This paper seeks to publish the existing discourse on tapering-off and to encourage data sharing. What lessons can be drawn from the evolution of the Spanish response?

¹² Ibid.

¹³ Guardia Civil. “Get to Know us: Specializations.”<http://www.guardiacivil.es/es/institucional/Conocenos/especialidades/tedax/index.html>. Accessed 11 March 2017.

¹⁴ Ibid.

¹⁵ Ley 16/1985, de 25 de junio, del Patrimonio Histórico Español. Boletín Oficial del Estado. Number 155, 29 June 1985, pages 20342 a 20352. <https://www.boe.es/buscar/doc.php?id=BOE-A-1985-12534> Accessed 12 March 2017.

¹⁶ Author conversation with amateur treasure hunter. 27 January 2017. Also Ibid.

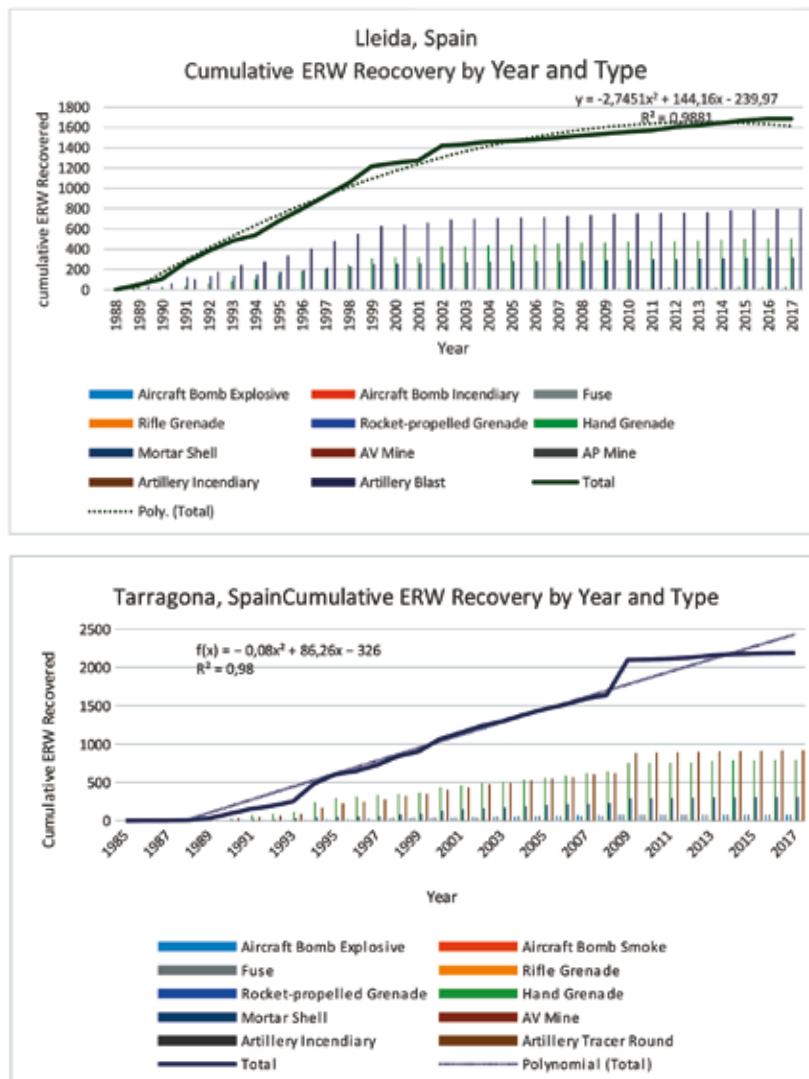
¹⁷ GICHD, Residual Contamination. <https://www.gichd.org/mine-action-topics/land-release/residual-contamination/>. Accessed 11 March 2017.

Methods

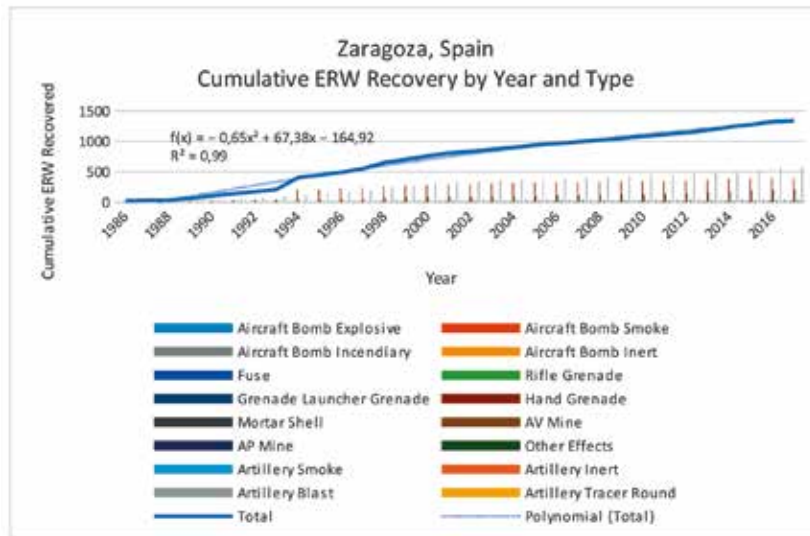
The research focused on the data pertaining specifically to the battle of the Ebro Valley, due to its decisive impact on the eventual outcome of the war, the significant involvement of foreign troops, and the use of the “baby brigades” (young soldiers) along with deployment of air power.

The authors submitted a Freedom of Information Request to the Spanish Government (General Administration of the Civil Guard, Madrid) for data pertaining to the research question above. The response was received by post several weeks later.

The data supplied exceed the scope of the original question, encompassing data from Lleida, Zaragoza and Tarragona (see map¹⁸). The analysis has therefore been expanded to consider these data as well.



18 Map of Spain. Ven a mi Casa. http://www.venamicasa.com/wp-content/uploads/2012/03/spain_map3.gif Accessed 20th March 2017



The data set from the Spanish authorities includes ERW recovery rates broken down by year and by munition type. The analysis uses the same munition typology as the Spanish government. Data in Spain appeared to follow a randomized, though decreasing, recovery rate.

The recovery rates seem to follow a random pattern at first look, failing to demonstrate an obvious decline over time as present in other affected countries. The data is then presented cumulatively (each year showing the total number of munitions recovered to date). This helps absorb some of the outlier incidents, such as when a large cache of munitions is discovered, which tend to skew trend analysis.

The cumulative data appears to show an almost linear increase over time, implying a continuous (and permanent) response rate. A trend line is added to match the total line, using the function with the highest R2 value, most accurately tracing the data set.

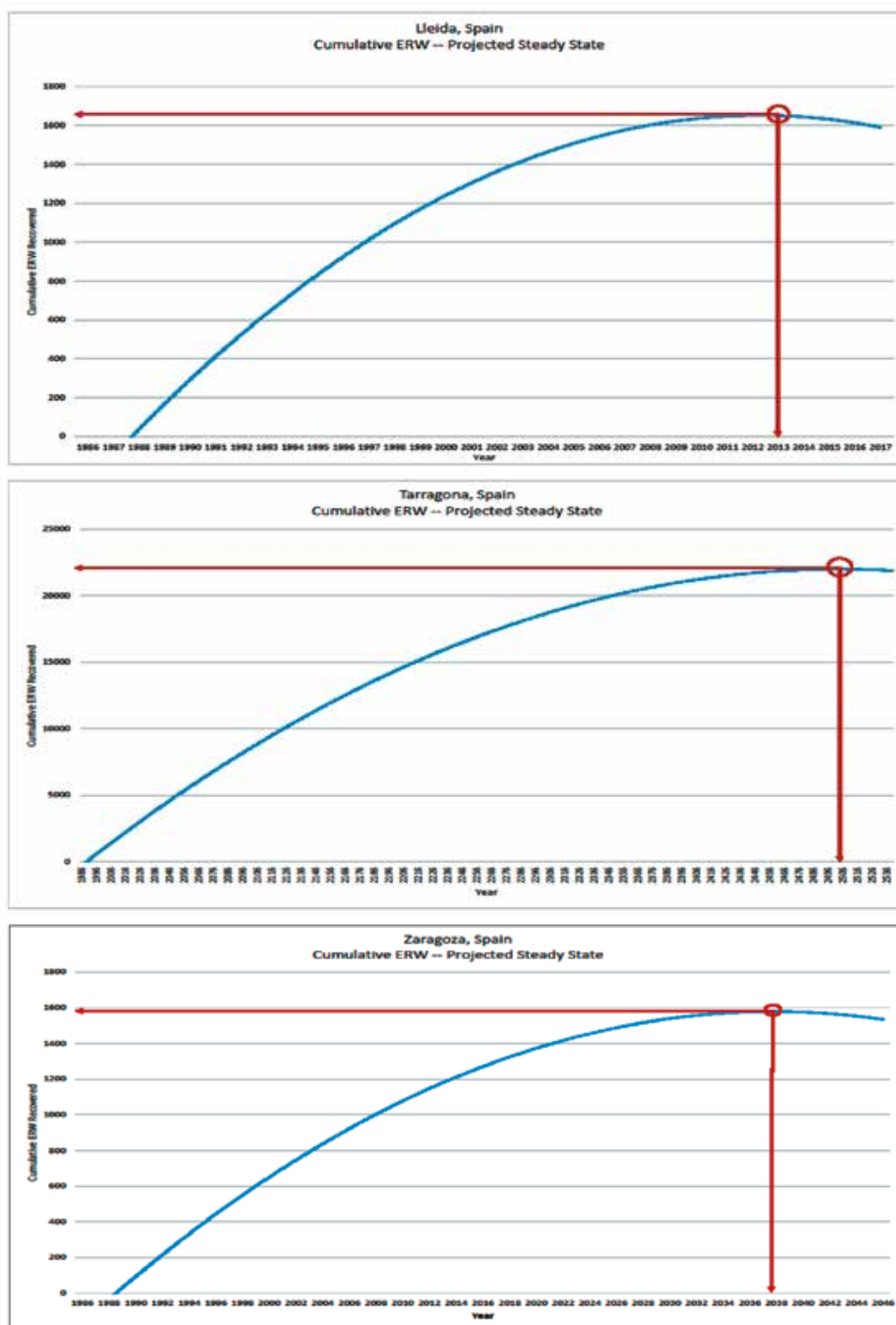
	Province					
Function/R ²	Zaragoza		Tarragona		Lleida	
Polynomial	$y = -0,6511x^2 + 67,384x - 164,92$	$R^2 = 0,9868$	$y = -0,0833x^2 + 86,261x - 326$	$R^2 = 0,9769$	$y = -2,7451x^2 + 144,16x - 239,97$	$R^2 = 0,9881$
Linear	$y = 45,899x - 43,171$	$R^2 = 0,9735$	$y = 83,43x - 309,49$	$R^2 =$	$y = 59,057x + 213,89$	$R^2 = 0,8751$
Power	$y = 13,081x^{1,4006}$	$R^2 = 0,9552$	$y = 0,732x^{2,483}$	$R^2 = 0,9448$	$y = 13,993x^{1,5986}$	$R^2 = 0,8095$
Logarithmic	$y = 475,2\ln(x) - 496,98$	$R^2 = 0,8686$	$y = 845,26\ln(x) - 1069,8$	$R^2 = 0,7901$	$y = 633,46\ln(x) - 447,16$	$R^2 = 0,9396$
Exponential	$y = 70,579e^{0,1142x}$	$R^2 = 0,7627$	$y = 17,687e^{0,1891x}$	$R^2 = 0,6955$	$y = 122,52e^{0,1167x}$	$R^2 = 0,4621$

Table 1: Comparison of best-fit curves to data sets based on R2 values

Results

In each of the three scenarios the highest R2 value (or best approximation of the data) was actually a polynomial function.

The three models allow for an extrapolation of the data to approximate the recovery rate evolution in specific provinces. The models predict a gradual reduction in recovery rates commensurate with current trends, tapering off at a final summit point. In the model this would represent the discovery and elimination of the last remaining item of ERW in the province.



The estimated end dates (year) for the three provinces can therefore be approximated in the graphs below. Tarragona, exhibiting the most consistent ERW recovery rates, is looking at the longest horizon, whereas Lleida and Zaragoza have final dates much sooner.

A detailed look demonstrates that while Zaragoza can expect to reach a steady-state (almost no recoveries per year) in twenty years, Tarragona can expect periodic discoveries of ERW for a few hundred years. Lleida should have already achieved this state in 2013, but the raw data show that Lleida has been recovering about twenty items a year for the past decade.

Limitations and Uncertainty

These models therefore do not predict a precise end date to EOD response operations in a territory. Rather, they are indicative of general trends. Further, the use of best fit curves should not give a sense of certainty implied by numbers with seeming great precision. Tarragona, where the curve predicts continuous recovery for hundreds of years, has been recovering just over ten items a year since 2010, whereas Lleida which should have already peaked, is recovering about twenty items a year.

There are several sources of uncertainty in these models, such as obtaining data only as of the mid-1980s, imperfect recording of all events and/or under-reporting. Changes in the legislative landscape, and changes in the socio-economic situation in rural areas are also not considered in this type of modeling. For future force-prediction (size of an EOD team) analysis it is important to take into consideration the evolution of the social context in the regions in which ERW are most frequently found.

Further Research

The data analyzed was not geo-referenced beyond the province level. More accurate position information would be useful in charting the evolution of discovery over time on a map. Further, the data request did not specify information on EOD staffing during this period. The following questions result from the above research.

Spatial mapping and workforce evaluation

What has been the change of workforce size and deployment over time within Spanish EOD? Has it been commensurate with the gradual decrease of ERW discoveries? Where have EOD operations mostly occurred: are they concentrated certain areas? Does this move with time, and can it be correlated to social, economic, political or legal factors?

A separate FOI request could be submitted to assess the evolution of Residual Contamination response in Barcelona province and the city more specifically. This could be compared more directly with bombing data and response evolution in similar situations, namely Dresden, Germany.

Munitions Comparisons

This research did not analyze technical aspects of munition degradation. Spain offers an interesting study in that many of the munitions were prototypes from foreign countries, and were built during (their) peacetime. Other munitions were surplus from the First World War. Manufacturing techniques are noted to vary starkly between war and peacetime, affecting both failure rates and degradation modalities. Further, the placement of specific German testing units in Spain to evaluate the performance of both aircraft and artillery (U-87, Me-109, 88 AA gun, 155 field artillery) is of interest.

Ageing of Munitions

Since the model suggests and experience confirms that munitions will continue to be recovered for the foreseeable future, assessments of risk degradation commensurate with munition decomposition can significantly aid risk management. Studies published by James Madison University¹⁹, GICHD²⁰ and Fenix Insight²¹ all clearly point to several failure modes regarding explosives. The particularity of these failure modes concerning the diverse weaponry used in the Spanish Civil War could offer valuable insight for EOD response and policy.

Conclusion

The “last remaining item” may be treated as an almost unattainable end state, as no true guarantee of 100% zero contamination can be made. It would be beyond the remit of the research to recommend a complete drawdown of response, though a reduction and centralization of main response, with a diffusing of residual capacity can be endorsed, as witnessed in the Spanish example. Municipal police generally are the first to respond and have received basic training in item risk identification, cordoning of an area, and appropriate risk-mitigation procedures.

Spain has been dealing with the consequences of its Civil War for almost 80 years. The response to ERW has evolved from a civil-led, locally oriented one to a professionalized and centralized capacity. For countries emerging from more recent conflict, this highlights that a final zero-ERW position is an unreal expectation, but that processes need be in place to effectively manage risks arising from residual ERW contamination.

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Counter IED UK a model for auditing and building capability against the IED threat

Paul Curtis¹, Bert Appleton²



Abstract

Counter-IED UK is a special interest group comprising of UK companies who specialise in equipment, training and services related to Countering Improvised Explosive Devices, including landmines and other Explosive Ordnance. Counter-IED UK leadership works alongside the UK Government Department for International Trade and the UK Ministry of Defence to build relationships in the commercial sector, government and security forces. With this expertise and these partners Counter-IED UK is well placed to assist overseas partner organisations to build capability and capacity for countering improvised threats. This paper will present a model that Counter-IED UK has successfully employed to support a capability audit against the threat which proposes a plan to ensure a coherent Counter-IED capability whether in the commercial environment or for end use by a government.

Who are C-IED UK?

Counter IED UK are a Special Interest Group of ADS, the UK Aerospace, Defence, Security and Space trade body. Counter IED UK receive's input from key stakeholders, shown in Figure 1 below, including the UK Ministry of Defence, the Defence Growth Partnership (a joint initiative between government and UK industry to grow defence exports) and the Department for International Trade. These stakeholders ensure that the Counter IED UK efforts are aligned with all required policy and practice.



Figure 1 - Counter IED UK Key Stakeholders

C-IED UK has 51 member companies, as shown in Figure 2 below, comprised of Small to Medium Enterprises (SME), Defence Prime Contractors, the UK Government and a coordinating Industry body. Together the membership of the ADS special interest group seek to serve overseas customers achieve their desired Counter IED capability.



Figure 2 - Counter-IED UK Membership

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The C-IED UK group have capabilities in the key areas shown in below in Figure 3. Running clock-wise from top left, this figure shows the following capability; Electronic Counter Measures, Vehicle Mine Detection, Forensics, Hook and Line kits, EOD Training, Defeat the Network, Virtual Training, Bomb Suits, EOD Robots & Disruptors, and Handheld Search tools. All types of related capability exist within the group.



Figure 3 - Counter-IED UK Group Capabilities

What benefits do the group deliver?

Counter-IED UK delivers a trusted, single point of contact to access the UK Counter-IED industry. We deliver access to experienced individuals in excellent companies and most important of all, we connect the right companies to clients at all levels of government and business.

To assist with the development of customer business case and commercial model, we deliver the commercial input vital to the planning of Counter-IED effort. We can offer clients a choice across all of the elements required to counter the IED threat, and more often than not, there are several vendors in the group who are capable of addressing a client need. This allows the client to run a competition in line with procurement best practice.

Often we find that clients have a unique problem to solve that can be more fully addressed with a tailored solution, in support of this we can deliver access to a significant level of technical depth, across the full breadth of industry research. Counter-IED UK is capable of offering equipment, training, research, experimentation, managed services and partnering.

How do clients use Counter IED UK?

Working shoulder to shoulder with UK MoD colleagues, we visit our international partners in joint missions to listen, understand requirements and offer support. This allows Counter-IED UK to share expertise with clients and present options for building Counter-IED capability. We often find that clients present Counter-IED UK with a set of user or system requirements and we then work with our group members to develop the best possible commercial and technical offering.

A model for auditing and building C-IED capability

In the fullest sense, ‘Capability’ means being prepared in every work stream, to have the ability to do something. For Counter IED and Countermine this involves not just the equipment, but also training, personnel, concepts and logistics. In a military context, these are known as lines of development and also include information, organisation and infrastructure allowing a capability to be delivered.

Counter-IED UK has developed a model for use with describing and controlling the steps involved with the process of assisting clients develop a potential Counter-IED capability. This model is shown in Figure 4 below. There are six stages running from the immediate actions (Stage 0) of capturing the requirement and scoping the need (Stage 1) given the clients unique mix of circumstances. This is best achieved with direct meeting between the group leadership and the client and can often involve demonstration of equipment to help the client visualise proposed options, as illustrated in Figure 5 below.

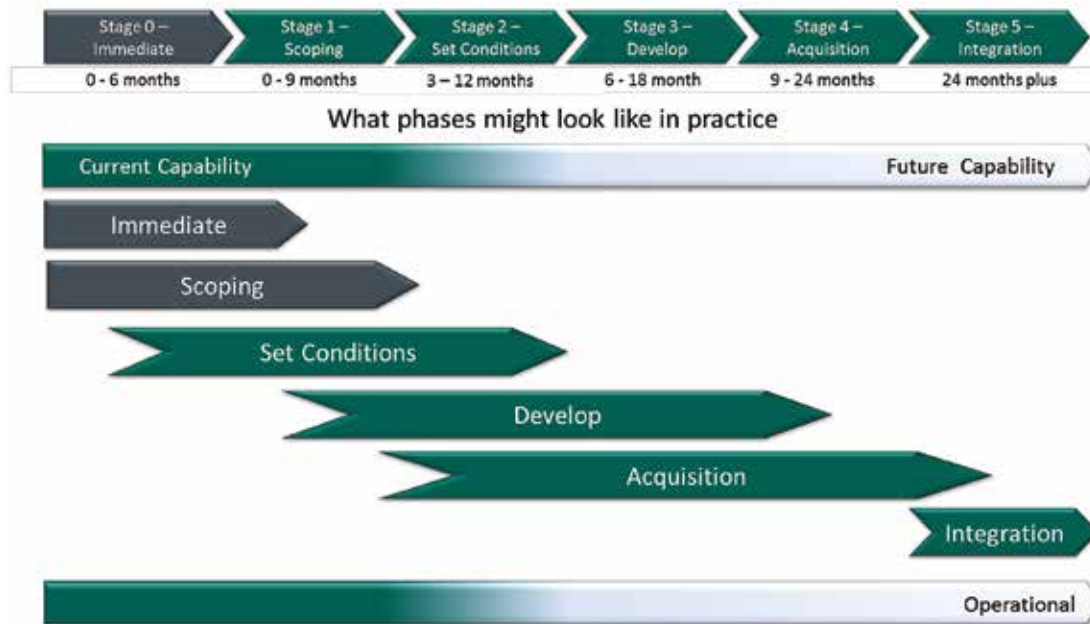


Figure 4 - A model for developing C-IED capability

The model then describes the need to set the conditions (phase 2) for success including a mutually reinforcing set of work streams, for example, planning for the acquisition of equipment and the associated training that is required. The next stage sets out the development (Stage 3) of the capability in terms of planning for ‘through life’ that is; training dates, in service dates, associated spares and repairs provisioning as well as planned end of life and the associated disposal.

Stage 4 is run by the client and contains the acquisition process itself where a competition may be run and the chosen equipment and services are down selected. Finally, with all the capability planning and support put into action, Stage 5 includes the integration of the chosen solution into service.



Figure 5 - Counter-IED UK Capability discussion with international clients

Conclusion

Counter IED UK can assist government and commercial organisations to develop capability in countering the IED threat through the provision of experienced industrial companies and personnel. This is bolstered by the support and advice of the UK Department of International Trade Defence Services Organisation who provide expertise within a technical and global context. Counter-IED UK provides a single contact to suppliers with a wealth of expertise, making a challenging search for capability straightforward.

Acknowledgements

Counter IED UK would like to thank ADS for their ongoing support with running the structure of the special interest group, UK MoD and DIT DSO for their support and advice through their network of serving personnel and civilian desk staff.

Counter-IED UK would like to thank the organisers of the Croatian Mine Action Centre for the privilege of presenting a paper on the abilities of the Special Interest Group and look forward to working together to counter the threat of IEDs.

State-of-the-Art in GPR-Based Detectors and Future Roadmap, a Cobham-Vallon Partnership

Paul Curtis¹, Blair Graham², Anthony Lucas³ & Adrian Payne⁴

Introduction

Ground Penetrating Radar (GPR) has emerged as the sensor of choice for Countering Explosive Ordnance such as Mines and Improvised Explosive Devices. GPR does not replace the Metal Detector (MD) in this regard, but instead, provides a powerful ally in the search for Explosive Ordnance by providing size and depth information, regardless of the material from which it is made. The Minehound family of detectors, developed jointly by Cobham and Vallon, as shown in Figure 1 below, was the first dual sensor MD and GPR to reach the market place in 2007.



Figure 1 - Minehound in service with HALO, Cambodia (Left) and TDI, South Sudan (Right)

The combination of the GPR and MD has proven successful in a significant number of mine affected countries offering the ability to detect improvised threats, as well as offering a powerful reduction in false alarm rate. GPR will of course detect non-metallic threats, as well as wires. The benefit of False Alarm Reduction comes from the fact that small metal fragments can be rejected by the GPR, meaning that the operator does not have to investigate every metal alarm. In practice, the use of GPR can reduce 9 in every 10 alarms. This translates into clearing a larger mine affected area for a given financial budget or time constraint. These twin advantages provide a compelling business case for the sponsor, contractor and Mine Action Centre.

Cobham and Vallon collaborated to develop, build and market the Minehound Series of Dual Sensor Detectors. There are a number of variants in the marketplace providing simple displays based solely on the LED, through to alphanumeric displays and graphical displays for the provision of GPR B-Scan data. These displays are shown in Figure 2 below.

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Figure 2 - Minehound Displays, LED (Left), Alphanumeric (Centre), Graphical (Right)

Improvements

Through a great degree of operational use and feedback, we have identified areas where the progression of technology is able to improve upon the current Minehound platform. Several market and technology trends have emerged which make this necessary. The first is the nature of the IED being distributed, but connected components, the second is the need to identify the nature of the threat, and the third is the need to be able to train and setup the detector with the lowest possible burden.

The IED and Wires

The rise in the use of the improvised threat means that devices are often split into several components which together produce a viable device. These components are often connected together using wires, hence, improved detection of wires will increase the utility of Minehound.

Whilst Minehound is fully capable of detecting wires, technology improvements have enabled more complex antenna designs and provided Radio Frequency components which will allow the switching of antenna modes. It is the combination of this market and technology trend that has made the inclusion of improved wire detection more viable for the end user.

Positioning Systems and the need to identify the threat

Positioning systems of modest accuracy (circa 1m CEP) used for tracking detectors have for some time had the potential to provide benefits to search operations. These benefits have included the ability to provide an audit trail of a detectors location and generate a progress map based on historical location data. Modern GNSS systems offer the potential for much higher position accuracy and open up new applications for Counter Mine and Counter IED.

As threats have become distributed and more complex in nature, the ability to identify the type of threat once a detection has been made has become more important. When threats may be improvised, this identification process is best performed by a human operator based on the highest resolution image that GPR can produce. The challenge here is that GPR images are best described as ‘blurry’ due to the fundamental nature of only being able to produce a pixel size which is limited by the wavelength of the illuminating radiation. This pixel size could be roughly approximated as 30x30mm on the basis of a centre frequency of 1GHz⁵. Once pixels are available, it is necessary to position them in a map to produce an image; this positioning of the pixels is best achieved using a technology that can provide accuracy to 10mm, preventing the image from becoming any more blurry.

⁵ In practice of course, higher frequencies are radiated but 1GHz represents an average

Accurate positioning systems such as GNSS (Global Navigation Satellite System) RTK (Real Time Kinematic) are approaching this level of accuracy and can be used to develop head tracking position data of a mine detector such as Minehound. Figure 3 shows a Minehound VMR3 equipped with GNSS RTK capable of tracking the detector head to within 30mm in real-time.

Working in partnership with Vallon, bringing together a detector with head tracking capability, algorithms capable of displaying map-like images and a screen capable of displaying them will provide increased utility to the operator. An example of this future display mode is shown in Figure 4, the shape of the image is due to the physical dielectric constant changing, and this is broadly proportional to shape of threat. The operator can then determine the nature of the threat based on experience and local knowledge, both of which will limit the boundaries of the problem at hand.



Figure 3 - Minehound VMR3 equipped with GNSS RTK head tracking

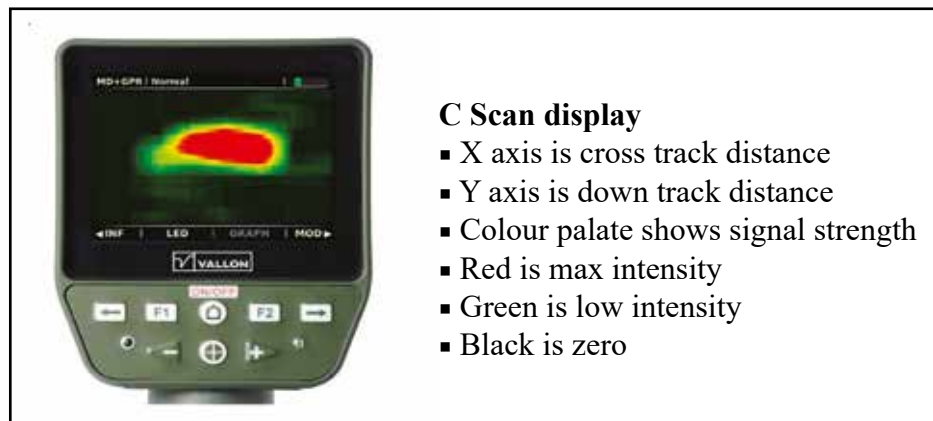


Figure 4 - Minehound VMR3G showing a simulated C Scan image

Simpler setup and training

The GPR element of Minehound adds a high resolution subsurface anomaly detector to the usual search apparatus form factor. The benefits of this type of sensor are well known, including non-metallic threat detection and False Alarm Rate reduction. These benefits are best realised with an optimal setup and optimal search technique, both of which require training and experience. Cobham and Vallon have gained significant experience and feedback in setting up and training the detector and as such have the right inputs to improve the ease of these tasks.

On setup, Cobham are developing techniques to use local soil data, made available to the detector through the use of the MIDAS CMT to aid user setup through the recommendation of a small set of setup scenarios. These scenarios are intended to take account of soil type, the presence of subsurface layers, and expected water content. This approach will allow the user to retain setup flexibility, whilst at the same time, taking advantage of advanced setup guidance from the MIDAS CMT.

On training, Cobham have developed both indoor (ITS) and outdoor (OTS) virtual training systems which are intended to provide expert training on the use of the detector in either a Mine Action or Military context. The ITS is fully immersive and requires the user to wear a virtual reality headset, whilst the OTS is non-immersive but still enables searching for virtual targets. The ITS and OTS are described more fully in a separate paper, referenceⁱⁱ.

Conclusion

Cobham and Vallon remain strategically committed to Minehound, and to further developing a product to provide improved utility to the end user, be this in Mine Action or in a Military Context. The future roadmap of providing a product which is more capable in terms of the spectrum of the threat that can be detected, more able to assist the operator with identification of the threat type, and simpler to train and setup has been described in this paper. The technologies developed under this roadmap also permit advances in the use of GPR on robotic Unmanned Ground Systems or Unmanned Air Systems.



Figure 5 - A view to the future of Minehound

Acknowledgements

The Authors would like to thank all of our customer base for the uptake and deployment of dual sensor technology and the Directors of Vallon GmbH and Cobham PLC for their ongoing support to the product development for the Minehound product line.

i Using MINEHOUND in Cambodia and Afghanistan, The Journal of Mine Action, Issue 18.2 Summer 2014

ii Immersive and Virtual Training Systems for Mine Detector Operators, CROMAC conference papers, 2017

Field Trials and Improvements of a Polymer-based Explosive Vapour Sensor System

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Abstract

Explosive vapour sensors based on luminescent polymer films have been identified in recent years as a promising tool for the detection of landmines and IEDs. Advances in the development of a portable sensing platform based on these materials have been made recently, with characterisation performed in the laboratory prior to field trials being undertaken to assess the feasibility of the method. The vapour-sensing prototype initially developed used a micropump to sample air; this proved unsuitable for field use due to sensitivity to weather. The prototype was upgraded to include a heating element, allowing polymer materials to act as “pre-concentrators” that increase the mass of explosive molecules in a REST filter configuration. One field trial was conducted in late summer in coastal Croatia with honeybee colonies used as the carriers of explosive molecules, with the hive air sampled for trace levels of explosives. Results from field trials are presented, alongside recent studies on molecular imprinting target molecules into sensor layers for analyte selectivity.

1 Introduction

Light-emitting conjugated polymer films are known to exhibit high photoluminescence-quenching behaviour in the presence of nitroaromatic molecules [1-5]. This drop in light emission on contact with explosive vapours has been used to develop sensors for landmines and other Explosive Remnants of War (ERW) in recent years, including a system recently developed by the authors for explosive vapour sampling from legacy landmines [6, 7]. While that system showed good sensitivity to simulated buried landmines at a depth of up to 10 cm, further development in both technology and methodology were required to enhance the platform’s suitability for robust, practical use in the field.

One of the most feasible methods for in-situ trace vapour detection would be to allow a type of REST sampling, where a rubbery fluoropolymer, in this case Aflas®, is used to adsorb and thus preconcentrate explosive vapours [8, 9] in the field. When this material is heated, the molecules are desorbed allowing for exposure to the sensor film. This then provides a higher concentration of vapour compared to that that may be sampled via pumping in-situ. This method, in conjunction with the passive method of sampling the air from foraging honeybee colonies, shows promise as a tool for surveying or quality control of demining sites.

Finally, in order to identify the types of explosives and improve selectivity, molecularly-imprinted sol-gels [10-12] (MISGs) were investigated. Sol-gels are a solution-processed, porous, glassy material that can increase the robustness of polymer films by acting as a protective layer while still allowing ingress of the target analyte [13-15]. By imprinting a specific molecule into the sol-gel layer, the sensor film then has a form of “lock and key” pattern recognition for the target molecule, which can prevent false positives from, for example, pesticides.

In this paper we describe recent efforts in increasing the field-functionality of an explosive vapour sensing platform, with initial findings from molecular imprinting of sensor layers for selectivity of target molecules.

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2 Experimental

2.1 Polymer fabrication

Films based on Merck Super Yellow were prepared by dissolving the polymer in toluene at a concentration of 6.5 mg/ml, prior to spin-coating at 2000 rpm on 1 cm² cover glasses from Agar Scientific. Film thicknesses, measured with a Veeco Dektak 150, were found to be 100 nm on average. Absorption and photoluminescence spectra were measured with a Cary 300 Bio UV-Vis spectrometer and Edinburgh Instruments FLS980 Fluorescence spectrometer respectively, and were 440 nm and 590 nm.

Aflas® was purchased from AGC Chemicals Europe Ltd, and was prepared by dissolving in Tetrahydrofuran at a concentration of 155 mg/ml. The solution was then drop-cast in a polka-dot pattern on a standard Whatman filter paper of diameter 4.5 cm and left to dry prior to use.

2.2 Instrumentation

Instrumentation described previously [6, 7] was adapted for use with the Aflas-coated filters. A heating chamber was placed inside an IP67-rated enclosure with a lock-in bracket for the exposed pre-concentration filter. The chamber was heated by a 15 V battery from Enix Energies with a valve separating the heating chamber from the sensing chamber. A blue excitation LED excited the Super Yellow sensing film via a window in the sensing chamber, and the resulting fluorescent emission captured by photodiode via collection optics on the opposite side of the chamber. Data was captured and processed by an Arduino microprocessor and sent to laptop via USB connection.

2.3 Preconcentration response – laboratory

The Aflas-coated filters were inserted into an in-house designed chamber and exposed to a flow of 2,4-DNT in nitrogen for 10 minutes. The filters were sealed in airtight containers until use. The filters were placed into a heating chamber and heated to 60°C for around 15 minutes to ensure desorption prior to a gate valve allowing vapour ingress to the sensing chamber. The photoluminescence was excited by a Crylas laser, with the decay measured by spectrometer.

2.4 Field sampling

Field sampling was conducted in Benkovac test site, Croatia, in late September 2016. A beehive had been in-situ for approximately 6 months with around 20,000 bees in the colony. The filters were inserted into a home-made nozzle and attached to the colony via a specialised cupola on the hive, with air being sampled for 10 minutes with the vacuum pump. The filters were then immediately placed in the heating chamber bracket in the instrument and the heating cycle begun. Once the heating chamber reached 60°C, a valve was opened to allow diffusion of the explosive-rich atmosphere to the sensing chamber.

2.5 Molecular Imprinting

Sol-gels were made by mixing PTEOS, TFP-TMOS, EtOH, water and HCl (all supplied by Sigma Aldrich) in a 1:1:6.25:4:0.007 molar ratio, with the imprinting molecule, 2,4-DNT, at a final concen-

tration of 100 mM. The silane precursors, solvent, water, catalyst and 2,4-DNT were combined in a glass vial on a magnetic stirrer, and stirred for 24 hours. The sol-gel was then spin-coated over the polymer layer, and placed in an oven at to cure. The composite films were then washed in an alcoholic acid solution to remove the imprinting molecule, rinsed in deionised water, and finally dried in a nitrogen stream. Films were tested by exposure to 2,4-DNT, DNB and DMDNB in nitrogen over 250 seconds, with excitation provided by Crylas laser and emission collected by spectrometer.

3 Results

3.1 Laboratory-based analysis vs Field sample analysis

Figure 2a shows the quenching response of a Super Yellow film to an uncoated filter exposed to 2,4-DNT, an Aflas-coated filter exposed to 2,4-DNT, and an unexposed control Aflas-coated filter. It can be seen that the strongest response is the 2,4-DNT exposed Aflas® filter, with a quenching decrease of 50% over 300 seconds. An uncoated filter by comparison decreases by 30%, while the control decreases by around 25%, attributable to degradation of the polymer under intense illumination in air. The exposure of the Aflas®-coated filter in the field in Figure 2b, to air from a honeybee colony, shows a decrease of around 60% for a filter exposed at noon (D2/6), and an exposure at 1730 from the same hive giving a decrease of around 50%.

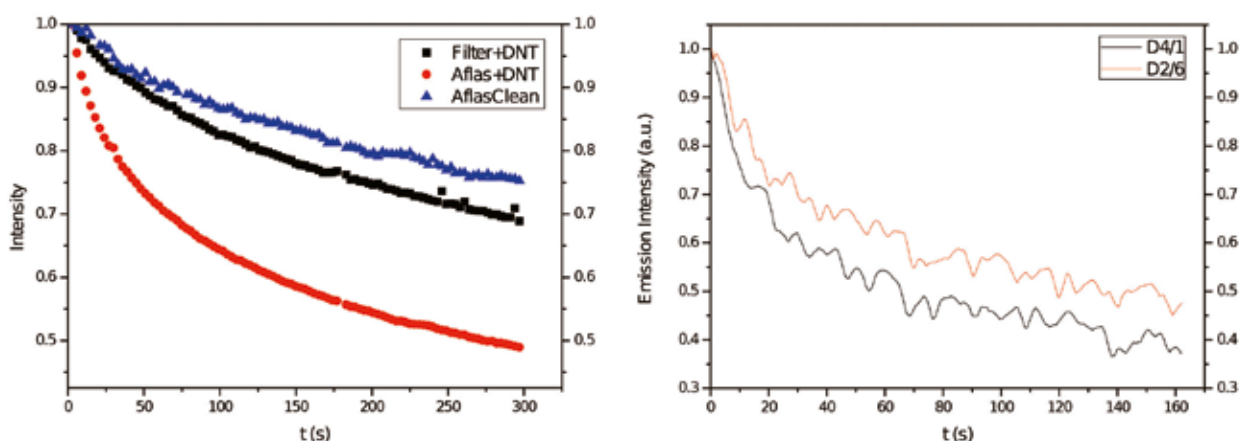


Figure 2 – (a) Response of Super Yellow to an uncoated filter exposed to 2,4-DNT (black), an Aflas-coated filter exposed to 2,4-DNT (red), and an unexposed control Aflas-coated filter (blue); (b) Response of Super Yellow to two Aflas-coated filters, sampled approx. 4 hours apart from a beehive in Benkovac, Croatia, September 2016

3.2 MISG

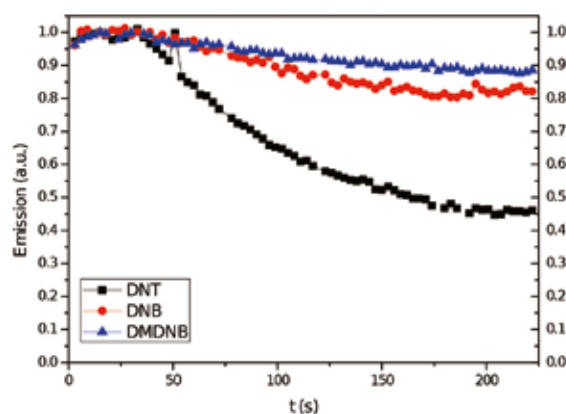


Figure 4 – MISG response to 2,4-DNT, DNB and DMDNB

Figure 4 shows the response of a 2,4-DNT imprinted sol-gel layer coated on a Super Yellow sensing layer. The 2,4-DNT vapour flow can be seen to induce a quenching response of approximately 55%, while the barrier action of the sol-gel layer prevents DNB and DMDNB from giving high quenching, at approximately 18% and 10% respectively. This indicates that imprinting a sol-gel layer can allow ingress of the imprinted molecule while preventing unwanted sensing of distractant molecules.

4 Conclusions

An instrument for detection of explosive vapours on-site was adapted for functionality in the field. A heating chamber was integrated to the system to allow a polymer preconcentration filter to be exposed to vapours from a bee colony and analysed in real-time on-site. Initial results show the system can be used for the in-situ detection of nitroaromatics, though further work is required for reliability and selectivity. A molecularly-imprinted sol-gel layer was investigated for a selectivity route, with initial results from a 2,4-DNT imprinted film showing good blocking attributes to the explosive vapours DNB and DMDNB. Further work will improve the response of the imprinted films and contribute to the avoidance of false positives from potential distractants, such as pesticides, in the field.

Acknowledgements

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Immersive and Virtual Training Systems for Mine Detector Operators

Paul Curtis¹, Blair Graham², Anthony Lucas³ & Adrian Payne⁴

In 2015, a consortium led by Cobham Antenna Systems were successful in securing an Integrated Application Promotion (IAP) funded project from the European Space Agency (ESA) which had the objective of instrumenting Mine clearance with space assets to improve operational efficiency through electronic management, monitoring and reporting. The IAP was named ‘Mine and IED Detection Augmented by Satellite’ (MIDAS) and the consortium included Optima Group, NEXT Ingegneria dei Sistemi SpA and Maelstrom Virtual Productions Limited.

The MIDAS programme has two deminer training components which are the Indoor Training System (ITS) and Outdoor Training System (OTS). These systems enhance pre deployment training and refresh training of the Mine action team during clearance operations. These training systems are particularly beneficial for training in the use of GPR-based detectors, such as the Vallon Minehound, which require more specific operating procedures than metal detectors. The ITS and OTS are shown in Figure 1 left and right respectively.



Figure 1 - Indoor Trainer (left), Outdoor Trainer (Right)

Indoor Training System

The Indoor Training System provides a fully immersive synthetic environment to offer initial familiarisation and subsequent sustainment training for the Minehound handheld detector.

The training environment is instructor controlled from a dual screen PC with options to specify a range of training environments and representative targets on the virtual training lane which can be tailored to the needs of a particular student and training scenario. The system consists of an instrumented headset worn by the student to provide the VR environment, an ergonomically representative Minehound handheld detector with sensors coupled to a three dimensional magnetic field based tracking

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system. A backpack worn by the student contains a battery pack and a PC to output the synthetic VR environment to the headset and also transmit it wirelessly to the instructor's PC. The system is easily transportable in a robust transit case to facilitate training in a wide range of locations. These system components are shown in Figure 2 below.



Figure 2 - Indoor Training System

The ITS provides a training environment of 4m x 2m in which the instructor places simulated targets (controlled from the instructor screen). The training lane may be extended in length to 8m to meet individual customer requirements, and multiple lane options are available to further increase student throughput. The system incorporates a state-of-the-art motion tracking system with six degrees of freedom to provide fully representative movement (swing, height and pitch) of the Minehound detector through the student's headset.



Figure 3 - Minehound Indoor Training System - Compound Scenario

Once the system has been calibrated the instructor selects the training environment and positions a range of targets on the virtual lane via the instructor controlled touch screen. Three different operational scenarios are available; compound, culvert and village; all available with background noise typical of an outdoor environment. Other options available to the user include the provision of a grid and a boundary rope to define the perimeter of the training lane, see Figure 3. Both of these features are included in the student's view if selected by the instructor.

The student adjusts the detector (shaft length and supports) and fits the headset before proceeding to sweep the virtual training lane. The system includes audible warning alarms to indicate if the student is operating the system outside of the set bounds (detector head ground clearance), replicating the alarm system of the Minehound GPR function.

Familiarisation to Assessment

For familiarisation, the transparent ground feature, as shown in Figure 4 left below can be used. This allows the locations of targets to be visible to the student and allows an opportunity to develop an understanding of the GPR response and the sensitivity of the detector when it is passed over a variety of threats. The transparent ground conditions feature of the ITS is an essential tool to help build up user confidence whilst seeing the detail of target types and positions. For assessment, the transparency can be turned off, as per Figure 4 right.

The ground conditions, target positions/depths and virtual training environment are selected by the instructor. The student is asked to sweep the training lane to identify threats. Once identified, the target positions are marked by the student by placing a marker chip in the virtual environment which is triggered by a button on the detector.

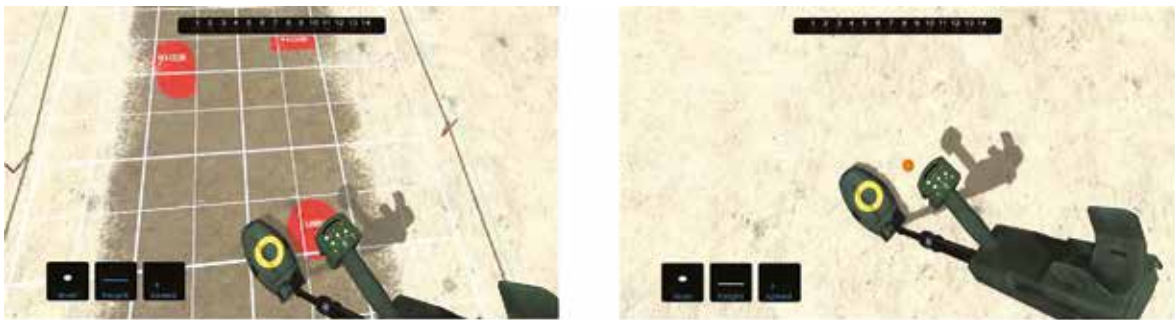


Figure 4 - Familiarisation (Left) and Assessment (Right)

Training Metrics

A number of training metrics are recorded by the system including ground coverage, sweep speed, detector head height and pitch, as well as the time taken to complete the training exercise. These metrics allow the trainer to provide feedback and learning for the student, ensuring that significant value is added by the training. The metrics are saved and reloaded at a later date. It is possible to play back each training session in a 2D or 3D view to review performance and for the instructor to highlight learning points.

Outdoor Training System

The outdoor trainer provides the ability to train anywhere outside. A training lane could be physically marked out in a car park, or on a hill side, and the corresponding virtual training lane defined in the Outdoor Training System software. In addition to the computer and software, the OTS comprises GNSS-based tracking modules that are added to a standard Minehound detector which then allows the detector to function in a virtual software-defined training lane with all the same features as the ITS. When the detector sweeps over a target, the Minehound detector sounds the appropriate alarm. The OTS is shown pictured in Figure 5 left below.



Figure 5 - MIDAS Outdoor Training System, Detector (Left) and Software (Right)

The Outdoor Training System uses the same software as the Indoor Training System described earlier in this paper and as such the same computer can be used to run either system. The computer shows a 2D map view of the training lane, location of targets and the position of the detector and training metrics, as illustrated in Figure 5 right above.

Conclusion

The MIDAS training systems are highly mobile deminer training systems suitable for use indoors, in an immersive VR environment, or outdoors in a simulated environment. This provides the ability to train in any location and does not rely on the availability of expensive and inflexible outdoor training lanes with physical buried targets.

The ITS and OTS provide unique training tools to develop user awareness of Minehound. They build confidence using features such as transparent ground conditions, enabling a rapid learning environment, and ground coverage indicator to help develop sweep technique.

The ITS and OTS also offer improved training efficiency and student throughput as one instructor may monitor several training lanes. Training scenarios may be quickly changed to suit operational requirements; and targets can be moved and updated to reflect new and emerging threats. Trials of the system have shown that it can highlight poor practice even for students that have already been trained by conventional training techniques, leading to improvement in the safety and efficiency of deminers.

Acknowledgements

The Authors would like to thank the European Space Agency and the Directors of Cobham PLC for their ongoing support to the product development for the Minehound product line..

Application of GPS-Tracked Detectors and Software to Mine Clearance Management

Paul Curtis¹, Blair Graham², Anthony Lucas³ & Adrian Payne⁴

In 2015, a consortium led by Cobham Antenna Systems were successful in securing an Integrated Applications Promotion (IAP) funded project from the European Space Agency (ESA) which had the objective of instrumenting Mine clearance with space assets to improve operational efficiency through electronic management, monitoring and reporting. The IAP was named ‘Mine and IED Detection Augmented by Satellite’ (MIDAS) and the consortium included Optima Group, NEXT Ingegneria dei Sistemi SpA and Maelstrom Virtual Productions Limited.

The MIDAS project delivers two key work streams to bring a highly capable mine-field Clearance Management System (CMS) to bear.

1. The Clearance Management Tool (CMT) (A software application)
2. GNSS RTK Tracking (to allow accurate location of the search head)

The CMT and GNSS head tracking are shown in Figure 1 left and right respectively.

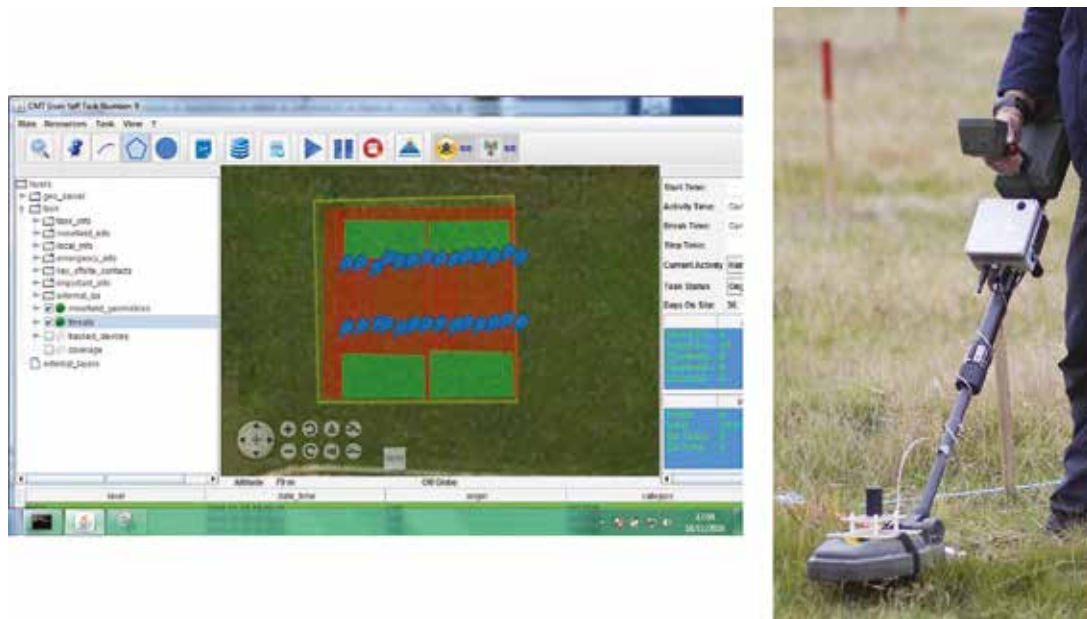


Figure 1 - MIDAS CMT (left) and GNSS Head Tracking (Right)

MIDAS Clearance Management System

The key part of the MIDAS CMS is the Clearance Management Tool which is a software application that runs on a computer. This tool shown in Figure 2 below provides an overview of all assets in the Minefield, including personnel, detectors and inventory.

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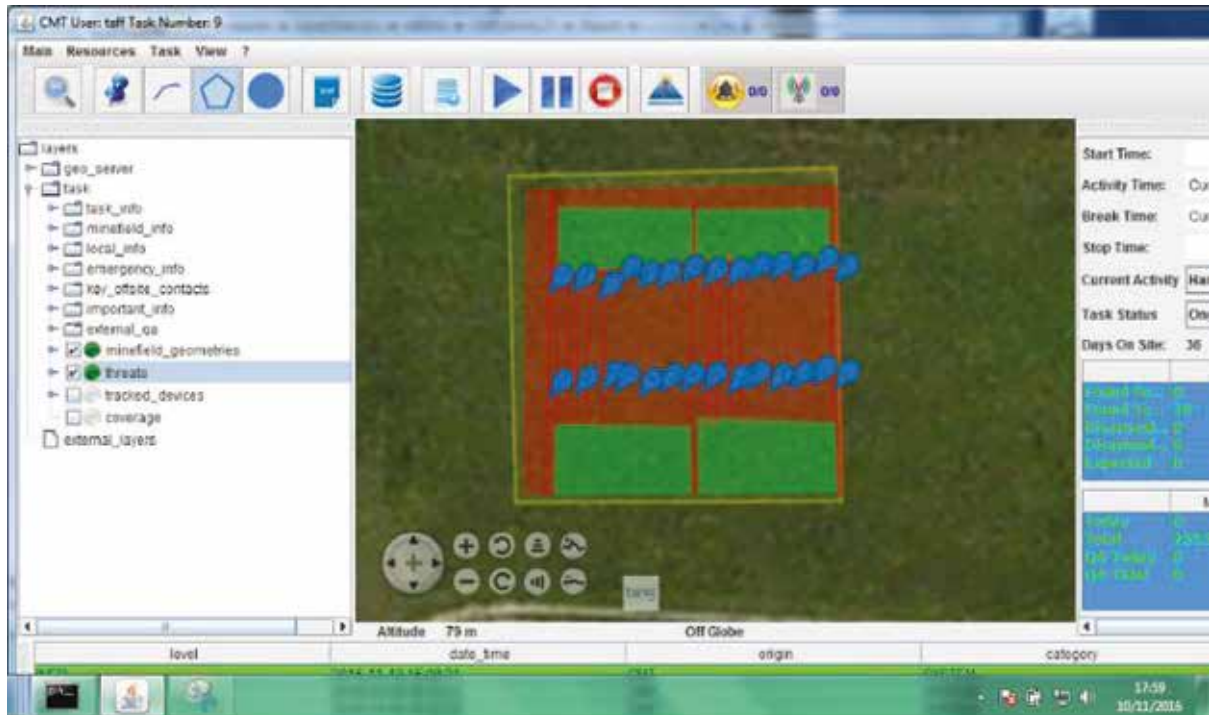


Figure 2 - Clearance Management Tool

The CMT runs on a standard Windows based laptop, as shown in Figure 3 right below, and allows the Minefield Manager to visualise the entire operation. The CMT has also been optimised for use on a tablet, as shown in Figure 3 left below, by other members of the team. In addition, the progress of all tasks at all sites can be monitored remotely, through the Internet, as a web page. This allows reach back of the clearance operation to the Mine Action Centre, or the NGO operational headquarters.



Figure 3 - CMT on a tablet (left), CMT on a standard windows laptop (right)

Search tools are instrumented with light weight GNSS RTK tracking systems that are accurate to approximately 1cm. This accuracy is achieved through the use of a RTK reference station which provides wireless GNSS correction data. The Minehound dual sensor detector is shown instrumented in Figure 1. This allows the CMT to record where threat and false alarms are found, as well as showing the area that has been covered through search. Minehound is shown in use with MIDAS in Figure 4 below.



Figure 4 - Tracking the Minehound Dual Sensor Detector

The MIDAS system is shown fielded and under trial at Cobham's Trials Site in Figure 5 below, a facility that has been developed specially for trials and development of mine and IED detection equipment and which is available for hire by third parties. A mock minefield is shown in the top half of the image and is highlighted in red for clarity. The Minefield Control Point, where the CMT computer is located, is based in the gazebo. The CMT was displayed on a large monitor for easier visibility by the team. The GNSS RTK reference station in the far left corner. Training lanes with different soil types are shown in the bottom right of the image.



Figure 5 - Fielding of the MIDAS system

The MIDAS CMS was designed to bring improved efficiency into mine clearance operations through a number of features which are described in Table 1 below.

Table 1 - MIDAS CMS Features and Benefits Feature Benefits

Feature	Benefits
Platforms	<ul style="list-style-type: none"> ▪ CMT software runs on a standard Windows PC or laptop ▪ Variant optimised for a mobile device such as a tablet, for use by team leaders
Location Tracking	<ul style="list-style-type: none"> ▪ Centimetre-level RTK GNSS receivers used to track detector location in real-time and transmit position back to CMT ▪ Location of search personnel is known at all times ▪ Monitor the area actually covered during search ▪ Threats can be recorded via a button press onto a map ▪ Markers can be placed on the map to aid survey
Mapping	<ul style="list-style-type: none"> ▪ A map of the minefield is imported from satellite imagery or on-line map ▪ Task map can be annotated with hazardous area, safe areas, other features ▪ Position, type and status of mines is recorded on the task map ▪ Position of false alarms and markers are also recorded on the task map ▪ Coverage area is updated ('painted') in real-time
Logistics	<ul style="list-style-type: none"> ▪ Location tracking of detectors, personnel ▪ Stock management of assets and consumables such as water, tools
Task information	<ul style="list-style-type: none"> ▪ Captures and displays all task information, replacing the need for a whiteboard ▪ Contact details for customer ▪ Records for on-site personnel ▪ Location of nearest facilities i.e. emergency or supplies
Electronic Reporting	<ul style="list-style-type: none"> ▪ Daily progress reports are generated at the click of a button with detailed data and progress map – no more time-consuming end of day report writing, no more lost or damaged paper files ▪ Complete electronic audit trail of task progress to support QA
Remote monitoring	<ul style="list-style-type: none"> ▪ Live progress monitoring through the Internet on a web-page ▪ Customer can view progress from multiple demining tasks

Conclusion

The MIDAS system is ready for an operational test and Cobham propose that the benefits derived from employing the system include; access to all clearance data including threats/false alarms and coverage, Electronic reporting in map and statistical form at the touch of a button, and remote access by senior/QA staff based on Internet connectivity. Cobham are seeking a Mine Action partner to pilot the MIDAS system and the author welcomes contact.

Acknowledgements

The Authors would like to thank the European Space Agency and the Directors of Cobham PLC for their ongoing support to the product development for the Minehound product line.

Mine action as a security imperative in Bosnia and Herzegovina

dr. sc. Darvin Lisica, dr. sc. Davor Kolenda¹

Abstract

Humanitarian imperative assumes that residual mines, cluster munitions and other explosive remnants of war create the hazard with its physical presence which then have negative social, economic and environmental impact on the population of the affected country. The state of contamination and the impact of mines in Bosnia and Herzegovina is still at a level where the humanitarian imperative remains an important determinant in creating policy and strategy for mine action in Bosnia and Herzegovina. In Bosnia and Herzegovina there is no systematic approach to analyzing and investigating potential security threats that can be caused by use of explosives which are located in the minefields. It should be emphasized that the use of explosives is recorded in a number of cases that had the character of the extremist violence or terrorist acts. In its annual report on mine action in 2016, the Mine Action Center in Bosnia and Herzegovina gives an estimate of 79,000 mines which are still in the mine fields in Bosnia and Herzegovina. Assuming that the distribution of mines remained similar as in data base of minefield records, one can calculate the mass of explosive charges in estimated residual minefields. It amounts to 9,233 kg for anti-personnel mines and 79,425 kg for anti-tank mines, which is a total of 88,658 kg of high explosives, mainly TNT.

In addition to humanitarian imperative, security issues have primacy in decision-making and priorities to reduce or eliminate the risk of mines and other explosive remnants of war. The security imperative is of particular importance for countries with unstable political and security situation, which is a characteristic of the post-conflict recovery. Taking preventive measures to avoid interaction between the two global phenomena such as the hazard of mines and terrorist threats should be imperative for all actors in mine action. Actually, there are two equally important imperatives of mine action. Co-existence of humanitarian and security imperatives will be one of the main demands in the planning, organization, execution and evaluation of mine action.

Humanitarian imperative domination in mine action

Known minefields in Bosnia and Herzegovina are marked with mine signs. These signs are not physical barriers to enter in the minefields but warning to the population that there is a hazard and that they should not enter in the mined areas. Unfortunately, it is a regular occurrence that the civilian population enters and gets injured or killed in the areas marked with mine signs, usually because of existential reasons (logging, collecting scrap metal, grazing, etc). Since the beginning of the war until the end of 2016 in Bosnia and Herzegovina there were 8,379 mine victims. After the war, in the period from 1996 to 2016, in Bosnia and Herzegovina there were 1,751 victims, of which 612 resulted in death. In 2016 there were seven accidents, 6 of which resulted in death and 6 were wounded (BH-MAC, 2017: 6). On a global scale, this is a very high density of victims in Bosnia and Herzegovina with 2,373 mine victims per million inhabitants. This situation has social, psychological, economic and other consequences for the victims' families, and complicates efforts aimed at their rehabilitation and integration in the society of Bosnia and Herzegovina. Size of the contaminated area, the number of affected communities, and the structure of blocked resources result in fact that residual mines,

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cluster munitions and other explosive remnants of war have a significant negative social, economic and environmental impact on the development of Bosnia and Herzegovina. The size of contaminated area in Bosnia and Herzegovina is 1,091 km², while 1,398 local communities in which live 545,600 inhabitants (15% of the Bosnian-Herzegovinian population) are threatened by mines and cluster munitions (BHMACH, 2017: 4-5).

Mine actions are relatively new concept of non-military action in which humanitarian access has achieved outweigh over the military-political approach. Although humanitarian demining originally developed from the principles and techniques of military demining, mine action are predominantly civil activities, which play an important role of international organizations and non-governmental sector. It should be noted that the armed forces of affected countries are more actively involved in mine action, while respecting the principles of humanism and framework that were set by International standards for mine action.

Mine actions are now mainly engaged in the social and economic effect of mines, cluster munitions and other explosive remnants of war on development of the affected countries, particularly on developmental priorities in terms of combating poverty. These countries have the least resources to address the leftover of mines and other explosive remnants of war, where the government and its infrastructure are in chaotic post-conflict social conditions, and economic recovery is hampered because of the consequences of previous armed conflicts. The post-conflict consequences determined that the humanitarian imperative - which includes the prevention and alleviation of suffering, the protection of life and health, the safe use of resources, and respect for human dignity (Dulić, 2008: 195-202) - dominates in the mine action policies of international organizations, national policies of threatened countries, the donors, and in the policies of mine action of non-governmental organizations in the past 30 years.

Humanitarian imperative assumes that residual mines, cluster munitions and other explosive remnants of war create the hazard with its physical presence which then have negative social, economic and environmental impact on the population of the affected country. In addition, the potentially possible activation of mines and other explosive that causes most often the victim is considered. Management and prioritization to reduce or eliminate the mine risk is considered from the point of vulnerability of the population, starting from the principle of the humanitarianism. On the whole, the state of contamination and the impact of mines in Bosnia and Herzegovina is still at a level where the humanitarian imperative remains an important determinant in creating policy and strategy for mine action in Bosnia and Herzegovina.

Residual minefields in Bosnia and Herzegovina and the threat of terrorism

In Bosnia and Herzegovina there is no systematic approach to analyzing and investigating potential security threats that can be caused by use of explosives which are located in the minefields. It should be emphasized that the use of explosives is recorded in a number of cases that had the character of the extremist violence or terrorist acts. One example is the terrorist attack on the police station in Bugojno 27th October 2010 which was executed by an explosive device made from tank mines and MRUD mine extracted from the minefield. On that occasion, a police officer Tarik Ljubiškić was killed and six policemen were wounded. According to available data, in Bosnia and Herzegovina 24 attacks have been registered in which explosive devices were used, mainly high explosives, mostly TNT. In several cases, it is confirmed or suspected that minefield explosive was used. In many police raids anti-tank and other mines were found in persons who were linked to terrorist groups (Kolenda, 2016: 144-145, 206).

Also, there is no comprehensive analysis of the reasons for the missing mines from minefields except for a few cases in which it is established that the mines were taken away from unexplained reasons. The analysis of missing mines in minefields in the three case studies on mine clearance tasks (carried out by the organization Pazi mine, Provita and Norwegian People's Aid) undoubtedly confirm that there are issues that has not been sufficiently explored nor adequately treated from the standpoint of security². The analysis included 60 records on the condition of found mines that were destroyed during the mine clearance. Results of the analysis showed that 31 minutes on the destruction of mines reported the existence of only mine body without explosives or just fuses. It is about 201 anti-personnel and 22 anti-tank mines. Weight of explosives in them is 180.34 kg, which can destroy very large objects and kill or injure many people if properly distributed and activated (Kolenda, 2016: 145).

Table 1: Type and number of missing mines (according Kolenda, 2016: 145)

Anti-personnel mines						Anti-tank mines	
PMR 2A	PMA 2	PMA 3	PMA 1	MRUD	PMR Č	TMM-1	TMRP - 6
171	3	6	2	12	7	21	1

There is no systematic approach to analyze the reasons why mines from minefields are missing, but it can certainly be concluded that minefields are a potential source of explosives and other components for making improvised explosive devices. This particularly applies to the following mines which disappearance from minefields is recorded: MRUD with explosives C4 mass of 0.900 kg per mine; anti-tank mines TMRP - 6 with a mass of 5.200 kg; anti-personnel mine PMA2 with TNT mass of 0.075 kg; PMA3 with high explosive hexogen and octol mass of 0.100 kg.

A mine clearance of anti-tank minefield which was done by Norwegian People's Aid in 2011 can be used as an example. During clearance, 21 TMM-1 anti-tank mine cover was found in places where the mines were buried, while the mine bodies with explosive charges were missing. Total of 157.5 kg of cast TNT was missing, without data on their destruction. The police was informed about this case but there was no feedback on the measures taken³.

For a better understanding of the seriousness of the threats that may be deliberately caused by explosives from the mines, the assessment of the mass of explosive charge in the minefields in Bosnia and Herzegovina should be conducted. In its annual report on mine action in 2016, the Mine Action Center in Bosnia and Herzegovina gives a conservative estimate of 79,000 mines which are still in the mine fields in Bosnia and Herzegovina. The methodology by which the current assessment of the remaining mines is conducted by the Mine Action Center in BiH is not clear. The report for 2010 stated the estimate of 213.000 mines, the report for 2011 stated the estimate of 200,000 mines, the reports for 2012, 2013 and 2014 stated the estimate of 120,000 mines and the report for 2015 stated the estimate of 82,000 mines. This rate of mine clearance has not been reached. Or this is the case of a wrong assessment or the mine clearance was not conducted as a part of operations of humanitarian demining. If the estimated number of mines is mapped to the structure of registered mines in the database of Mine Action Center in Bosnia and Herzegovina, it could be reached to the assessment of the current quantities of explosives in remaining mines.

² Case studies were made as part of the research and development of the doctoral thesis by Davor Kolenda on “Humanitarian Demining and its contribution to the fight against international terrorism in the territory of Bosnia and Herzegovina”.

³ Lisica Darvin: Presentation on the topic: Mine Action and security, Symposium “Humanitarian Demining and its contribution in the fight against international terrorism in Bosnia and Herzegovina”, Faculty of International Relations and Diplomacy University Herzegovina, Sarajevo, 28 May 2016.

Table 2 Assessment of mass explosive charge in the mine fields at the beginning of 2017 presents classification, number and participation of certain types of mines registered in the database, based on the analysis of the situation in the database of registered minefields (Lisica, 2006: 67, 247). Assuming that the distribution of mines remained similar to the present, one can calculate the mass of explosive charges for the estimated number of 79,000 mines at the beginning of 2017. It amounts to 9,233 kg for anti-personnel mines and 79,425 kg for anti-tank mines, which is a total of 88,658 kg of high explosives, mainly TNT.

Table 2: Calculation of the mass of the explosive charge in the minefields in Bosnia and Herzegovina at the beginning of 2017⁴

Calculation of mass of the explosive charge (high explosives, mainly TNT)	ANTI-PERSONNEL MINES									ANTI-TANK MINES									TOTAL			
	PMA-1A	PMA-2	PMA-3	PMR-2AS	PMR-3	PROM-1P	MRUD	OTHER PT MINES	UNKNOWN PP	TOTAL PP MINES	TMM-1	TMA-1A	TMA-2A	TMA-3	TMA-4	TMA-5	TMPR-6	OTHER PT MINES		UNKNOWN PT	TOTAL PT MINES	
	6.7%	12.0%	16.0%	32.7%	1.1%	4.3%	2.9%	4.9%	2.9%	83.5%	2.6%	0.4%	0.2%	2.7%	2.3%	0.7%	4.3%	1.2%		2.1%	16.5%	
	0.200	0.070	0.035	0.100	0.410	0.425	0.900	0.100	0.100		7.500	5.500	6.500	7.000	5.500	5.675	5.200	6.000		6.000		
	5,254	9,470	12,622	25,865	834	3,432	2,299	3,901	2,312	65,988	2,038	291	134	2,162	1,844	538	3,364	959		1,681	13,012	
	1,051	663	442	2,586	342	1,459	2,069	390	231	9,233	15,284	1,603	873	15,137	10,144	3,051	17,494	5,753		10,085	79,425	
	88,658																					

⁴ The analysis of the number of registered mines in BHMAL database from 2005 was used to estimate the proportion of certain types of mines in the remaining minefields in Bosnia and Herzegovina - according to Lisica D. 2006: 67

It seems that the security awareness of the stakeholders of mine action in Bosnia and Herzegovina - governmental, non-governmental and commercial organizations – is not at a satisfactory level. None of them dealt with the security threats related to the mines in a significant extent. This situation is not only present in Bosnia and Herzegovina, but also in other countries where mine action is performed in organized manner. Affected countries carry out a general assessment of the hazard of landmines, cluster munitions and other explosive remnants of war, following the guidelines given by International standards for mine action. In the current country assessments of mine situation, there is no serious analysis of the security threats that can be caused by relatively easy availability of explosives from the mine fields which are not controlled. Organizations engaged in mine action at the international or national level cannot ignore these security issues.

Coexistence of the humanitarian and security imperatives in mine action

Contemporary conflicts have led to an increase in the number of threats that endanger the fundamental human values both at national and international level. It opens up a number of questions pertaining to reduce security risks through various policies and measures of disarmament, whether it's about: political negotiating about conventions or other actions of international or regional character aimed at the control, reduction or a complete ban on weapons in particular those who have non-discriminatory effects and affecting the civil population; conflict prevention through reduction of armed forces; management of military infrastructure, mainly ammunition storage, in order to increase security measures and prevention of adverse events; management of the consequences of conflicts removing explosive, toxic, radiological remnants of war; and the protection of civilians in armed conflicts and others. The protection of the population from the consequences of the use of weapons makes the essence of the humanitarian imperative, not only in mine action, but also in the overall concept of humanitarian disarmament.

However, the risks of mines and other explosive remnants of war can be considered from a security perspective. In fact, when the existence of evil intentions and one's ability to realize this evil intention is added to their risk characteristics, then we can talk about security threats caused by explosive ordnances. The most dangerous situation is when explosive ordnances can be used for making improvised and other devices which usage makes a wider range of potential security threats that security structures should face with. Terrorist actions may be associated with remaining mines and other explosive remnants due to the relatively easy accessibility of explosives, fuses and other materials from the mine fields.

The security imperative in terms of research, assessment of the situation and the removal of explosive devices as potential cause of intentional threats is not seriously considered in the world, with some honorable exceptions. The article “Landmines / Explosive Remnants of War and the War on Terrorism in the Middle East and North Africa (MENA)” (published in the Journal of Mine Action, 2008) gives an estimate of 55 to 66 million mines that are in mine fields in the Middle East and North Africa. The author estimates that there is between 13.151 and 16.487 tons of live explosives in them that is available for “illegal activities”. Also, the article provides the examples of terrorist attacks in which most likely the explosives from the mine fields were used.

In addition to humanitarian imperative, security issues have primacy in decision-making and priorities to reduce or eliminate the risk of mines and other explosive remnants of war. The security imperative is of particular importance for countries with unstable political and security situation, which is a characteristic of the post-conflict recovery. Taking preventive measures to avoid interaction between

the two global phenomena such as the hazard of mines and terrorist threats should be imperative for all actors in mine action. Actually, there are two equally important imperatives of mine action. Co-existence of humanitarian and security imperatives will be one of the main demands in the planning, organization, execution and evaluation of mine action.

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15th IARP -ICI Workshop HUDEM’2017

TOWARDS a large Counter Explosives and CBRN Hazards (C-EH, C-CBRN) Community of Experts

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INTRODUCTION

The year 1994 may be considered as the first decisive year in the long struggle with the use and the removal of anti-personnel (AP) mines throughout the world, followed in 1999 with the Entry into force of the OTTAWA Treaty adopted on September 1997, the Convention on the Prohibition of the use, stockpiling, production and transfer of AP-mines and their destruction.

March 2013, new countries have been affected by the plague of disseminated unexploded devices, land-mines but also cluster munitions (now directly concerned by the OSLO treaty). New dangers arise in some North African Countries, Middle East, Asian and African Countries, called Improvised Explosive Devices and slowing the difficult tasks of Deminers. Last but not least, Improvised Explosive Devices (IED) appeared in conflictual areas, now exported to the European Countries facing terroristic actions...

IEDs (possibly combined with CBRN agents) are complex threats that involve and require multiple actors to defeat it. A holistic approach is required to counter the IED networks (see Figure 1).

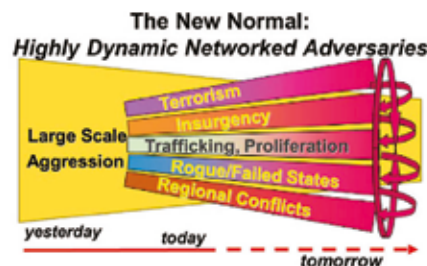


Figure 1 (source: NATO C-IED COE)

The current threat is global and EU countries are suffering inside their borders the consequences from regional conflicts in Middle East. European countries are sending their nationals as foreign Fighters, and their radicalization process happens within our borders, and those ones that survive in the conflict areas return to Europe ready to keep on fighting for their faith, extremist ideas, etc. Within this realm IED is the weapon of choice for terrorist, insurgency, criminal organizations, radical groups... and the knowledge to make IEDs is available in open sources (Internet), as well as the TTPs (Tactics, Technics and Procedures). Terrorist groups use the new technologies to foster their activities, exploit their success and recruit new members. Hence, western societies are facing a hybrid threat. Hybrid threats combine conventional, irregular and asymmetric threats and could involve a range of state, trans-national groups, and individuals operating both globally and locally.

The European Commission confirmed in 2011 and today its efforts towards a mine-free world by important financial contributions (to Demining operations AND to R&D in support of such operations) and she will continue to consider landmines and explosive remnants of war (ERW) within a broader context of humanitarian assistance as well as long-term and sustainable socio-economic development programs..

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The EC then decided to fund two large projects including about fifty European organizations, NGO, Universities, SME and industrial partners. The RMA coordinated one of both projects, called TIRA-MISU, the second one being coordinated by Airbus Defence and Space SAS and called D-BOX: both projects led to reliable R&D results to be exploited from 2016 on.

Beside these projects, and more specifically oriented to the European Security, projects focusing on CBRNE threats and crisis managements were entrusted to several Consortia: IDIRA, FORLAB, OPTIX, PRACTICE, EDEN are some of them [1]

As a consequence, and taking the new objectives of the European Union into account, it has been proposed to create a Community of Experts focusing on the exploitation of the toolboxes developed by the 50 partners of the FP7 Consortia, in close cooperation with existing Centres as the GICHD, but also the NATO EOD Centre of Excellence, the NATO accredited C-IED Centre of Excellence, the International Centre of Demining located in Madrid, the European Corporate of security Associations (ECSA), the NATO-EAPC Ad-Hoc Group on Mine Action and Small Arms and light Weapons, avoiding useless duplication and pursuing the HORIZON European objectives.

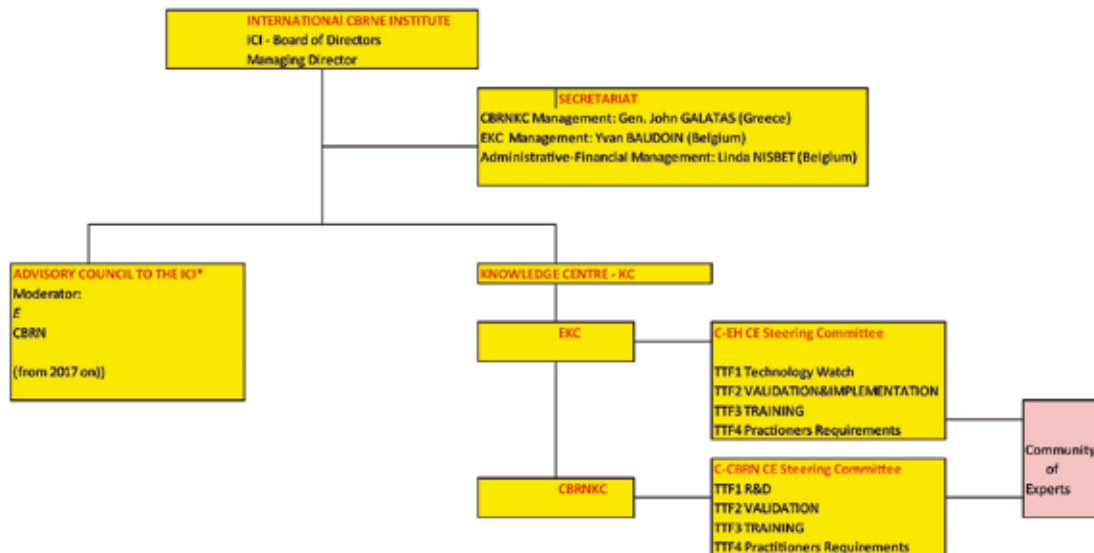


Figure 2a. Integration of the EKC, CBRN KC inside the ICI

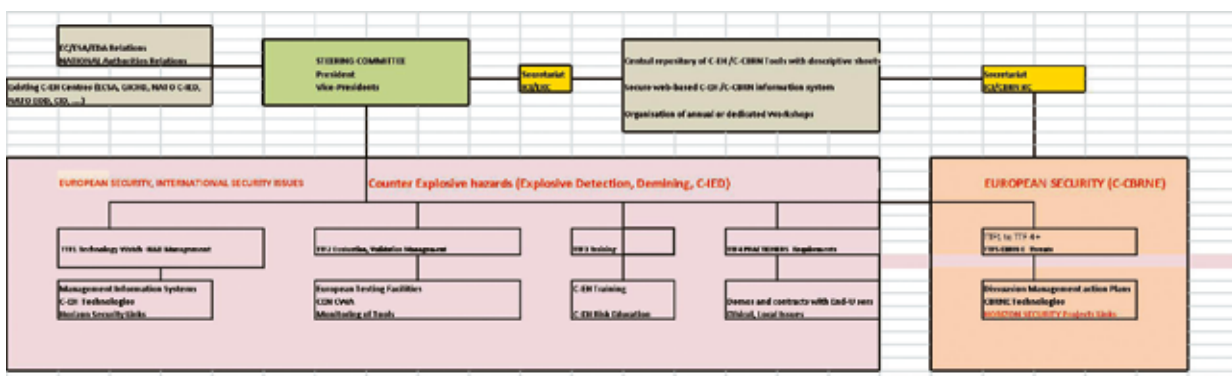


Figure 2b. Explosives Knowledge and CBRN Knowledge Centres Schemes (ICI/EKC – ICI/CBRN KC)

TTF 1 (Task Force ‘Technology Watch’)

It’s essential to improve new technologies through a continuous exchange of R&D information and results among the scientific Community and through an adequate policy of Technology Transfer. The hand-over of all Counter (Explosives and/or CBRN) activities to Practitioners who can perform the majority of the work and can gain skills while participating to the creation and maintenance of new technology

The following R&D areas, among others, have been identified as impacting the counter threat:

OBJECTIVE TTF1: The sharing of Expertise through dedicated Scientific Workshops and bi(multi) lateral work-meetings, in close cooperation with the above mentioned Centers will improve and promote the implementation of such tools and their dual use, in particular in the current context of ‘Terroristic threats’ in Europe.

TTF2 Evaluation, Validation, Standards

The ICI Knowledge Centre would involve a dedicated area of permanent lab-space for baseline testing of performance – detection in air, detection “halo”, battery life, signal clarity, reliable replication of results, etc. As far as possible, this would lead to a series of quantifiable, comparable and replicable results that manufacturers could not reasonably question. A full test would also involve field testing in dedicated test areas (Support of the CID and NATO C-IED Centers in Spain, HOTZONESOLUTIONS Network of Testing bases (figure 2) and the CTRO Test Facilities in Croatia) leading to results that were semi-quantitative but still meaningful because the test context was the same for each test (although weather variations, etc. would be noted). The field test would include a subjective assessment of ergonomics and ease of use for lengthy periods. The field results would not guarantee that the equipment would be suitable in the field in every country – but poor results would strongly imply that poor results might be expected elsewhere, which would be very useful to know when selecting equipment.



Figure 3. Some Testing Centers associated with the ICI

OBJECTIVE TTF2: validate emerging Counter CBRN-E tools, and possibly propose CEN workshop agreements. Improve the TRL (Technical Readiness Level) of tools developed by our partners and help to their exploitation.

TTF3: Training, Risk Education

With the progress of developments in information and communication technology, e-learning is emerging as a platform for modern education and training. E-learning is a general term referring to the use of digital technologies to support learning and teaching [3]. The Joint Information Systems Committee (JISC) defines e-learning as “learning facilitated and supported through the use of ICT”. In the last two years, CTDT (Croatian Partner of TIRAMISU) received about 35 requests for EOD Training I-V Level courses from several Countries in Europe, Asia and Africa, that also justify the development and validation of a EOD e-Tutor.

Mine Risk education tools have also been developed and tested (TIRAMISU, in Cambodia and Western Sahara, among others) that could be added to the GICHD Risk education topics. We suggest to improve such tools for use in the Refugees Camps, a new plague of this Century affected by unstable and worrying situations in North Africa and the Middle East.

With the Psychological Guidance Service „Youth Center of Prevention and Psychotherapy MOP” of Warszawa, Poland, Psychological Guidelines for Assumptions on Educational Computer Games on Subject Matter of Mine Risk have been developed that could help to amplify the use of computer games, on Electronic Devices now accessible to all Countries.

OBJECTIVE TTF 3: Training and e-Training will be offered by the ICI and the members of the EKC/CBRN KC, combined with Risk Education Software. Let us mention (among others):

- CBR training for EOD/IED.
- Live Agent CW/RAD/BIO training (LAT)
- CBRN EOD/IED Incident Command Course
- Information Management Systems (IMS)

TTF4 Users requirements

One of the most important characteristics of the EU projects lies in the development and validation of performing Information Management Systems allowing proposing a comprehensive use of the developed Mine Action Tools.

We are convinced that synergies have to be realized within a partnership of the Centers focusing on the Counter Explosive Hazards Actions, and that links could be improved between our Systems and Security challenges of the European Union (Surveillance of Borders, CBRN-E threats, Environmental Protection, etc.)

Information management should address two important needs of HD: the need to create and improve procedures, the need to provide the best information to all the chain of stakeholders of the domain, up to the European Union and even the United Nations and donors. One of the difficulties of the domain is to gather information from the field of operations and manage the quality of this information all along the decision chain.

Furthermore, conflicts that have generated the use of Anti-personnel mines, Sub-munitions and several kinds of explosive devices in the Countries affected by these plagues have dramatic consequences on the environment, and consequently on the health of the local population. Therefore it is important

to ensure that the accumulation of explosive contaminants does not occur at levels that will result in adverse effects to the environment and the loss of the use of the range. In order to control these risks, it is important to know what kind of residues are released from different types of munitions and explosive devices, how the residues behave in the environment, and how they are distributed throughout the environment. This information will assist in calculating the environmental loads of constituents from live-fire interventions.

OBJECTIVE TTF4: The assessment of the methods and techniques for threat analysis will be based on the concrete experience of the KC’ experts and will be developed in several incident scenarios. These will be taken as a basis for extracting problems, needs and requirements provided by the experts who will indicate who else should be contacted. Scenarios, needs and requirements will be validated and prioritised during workshops (TTF1,TTF2). They will be numbered and clearly documented in a matrix, to ensure traceability on a permanent way, at disposal of the stakeholders, practitioners and R&D Institutions.

TTF5 C-IED, C-CBRN

Even simple improvised hazards present a greater risk than other munitions because their design is not known in advance, because they may have been rigged to prevent them being disarmed and because there may have been variations in production even when the design seems familiar

According to the IMAS, organizations engaged in humanitarian Mine action have a duty of care to their employees and must minimize their risk at all time. To achieve this, attempting to dismantle or disarm any device that is not known and documented should not normally be a part of Humanitarian Mine Action. That constraint does not apply to the police and security forces or those engaged in the conflict for whom the recovery and forensic examination of IED parts and components can help identify who made them and so prevent repeated attacks.

As resulting from the previous TTF, new European projects have been proposed, namely ECHEC (European Counter Hazardous Explosive Threats Community of Experts) and DISSUASIVE (Development of Innovative Assessment Actions countering and Explosive Threat).

These projects combine in-depth monitoring from Security experts to better identify threats: scientists to analyze and assess the developed tools, Training Experts to define optimized training procedures based on realistic scenarios and a continuous updating of the proposed solutions on the secure interactive website of the international CBRN-E Institute (ICI). This will be at the disposal of (and with the close cooperation of) varied practitioners of Counter Explosive Hazards activities. The network will include Practitioners selected by the European Corporate of Security Associations (ECSA) and others selected from the global field of demining action in conflict regions. Realistic scenarios will be developed to cover different types of explosive (CBRN) hazard, different means of transit and deployment and all the predictable contingencies/variables that may influence the efficiency of surveillance, detection, neutralization and the cost-effectiveness of the varied potential solutions identified.

OBJECTIVE TTF5: the ICI/KC will follow the European Calls for Security and introduce proposals, in close cooperation with Industrial, Academic partners, Practitioners and Stake-holders (among others).

CONCLUSION

The ICI's CBRNE expertise and knowledge is available to national and international experts, relevant international organisations and their staff members, and interested governments, so as to support them in adapting their doctrine through active risk management, reshaping or reorganising their CBRNE response capabilities and capacities to become more flexible, responsive, multidisciplinary, and multi-agency

Forming an integral part of the International CBRNE Institute (linked to the OPCW) , the EXPLOSIVES KNOWLEDGE CENTER / COUNTER EXPLOSIVE HAZARDS Community of Experts (EKC/CEH CE) as well as the CBRN KNOWLEDGE CENTER intend to ensure sustained impact on the Counter CBRN-E Threats Community and value to the general public, support the European Union (EU) Security and welcome Experts in Explosive/CBRN Hazards-related issues.

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Objectives of the International CBRNE Institute and its Explosives Knowledge Centre

Yvan Baudoin¹, et Al

1. INTRODUCTION

Allow me to give you some information on and on behalf of the European Counter Hazardous Explosive Threats Community of Experts (called EKC, Explosive Knowledge Centre of the International CBRNE Institute).

The EKC currently counts 77 members from 15 European Countries, coordinated by 15 partners focusing on several issues

The EKC will follow the European Agenda on Security and the new EC security research programme in HORIZON 2020.

To avoid duplication and ensure the ongoing exchange with practitioners and experts, cooperation with existing Centres will be established, e.g. with the NATO Explosive Ordnance Disposal Centre of Excellence, the Counter Improvised Explosive Devices Centre of Excellence (C-IED COE), the International Centre of Demining (CID), located in Madrid, the Geneva International Centre for Humanitarian Demining (GICHD²), the European Corporate of Security Associations (ECSA³), without excluding other Partners as illustrated by this slide. For starting our activities, we collected the information and outputs from three sources: from the previous and current European projects, from the NATO C-IED CoE and EDA, also from the GICHD.

From the EC projects

The major operational tools developed by the consortia focus on the detection of illicit production of explosives/precursors by networks of specific sensors, stand-off detection sensors based on radar techniques, detection sensors based on bio-chemical sensors, use of land/aerial/Sea robotics systems. As a particular example, the TIRAMISU project I personally coordinated, with my colleague dr Yann Yvinec from the Royal Military Academy, from 2012 to end of 2015, generated detection tools and protection testing procedures, essentially for Humanitarian demining purposes but also exploitable for C-IED issues.

From the NATO C-IED COE and associated European Defence Institutions

The NATO C-IED COE, located in Madrid, near an International Demining Centre offering Testing sites, support our objectives, among others, by supplying current information on the explosives and the easy way to produce them, but also on the methods used by terroristic groups to exploit their illegal production or acquisition for planned attacks.

It will be essential for us to develop credible scenarios based on this continuously updated information for predicting and preventing threats, and also, for analysing and improving the security of Urban and public infrastructures

From the GICHD

Since March 2013 (theoretical deadline of the OTTAWA treaty imposing the total demining in the States Parties), new countries have been affected by the plague of disseminated unexploded devices, landmines but also cluster munitions (now directly concerned by the OSLO treaty). New dangers

¹ Manager of the ICI/EKC (www.ici-belgium.be)

² www.gichd.org

³ www.ecsa-eu.org

arise in some North African Countries, Middle East and Asian Countries, again Improvised Explosive Devices, slowing the difficult tasks of Deminers, but also locally tested and finally too imported in European countries, among others. The status followed by the US States Humanitarian Information Unit and the GICHD underline the size of the current risks

2. STATUS OF CURRENT SENSORS

Without forgetting that the prediction and the prevention require a multiform analysis including, for instance, the cybersecurity, and other techniques and procedures (legal and ethical issues included), I will limit this presentation to the Detection and Protection technology and tools developed by our partners and available for exploitation (TRL>7), but I also want to underline the current gaps we have to face.

THZ

The characteristics of THz waves (100 GHz to 30 THz-1012Hz) make them especially interesting in the domain of security and threat detection as Explosives and Related Compounds (ERCs), drugs and other bio-molecules often have very distinctive, and detectable, intermolecular vibrational modes in the THz spectral range. However, constraints have to be examined/solved:

- a) Improve the ratio probability of detection versus imaging time for a THz screener taking into account the persons walking through the scanner and avoiding disrupting the flow of persons
- b) Analysing the added value of a network of passive THz camera's for the surveillance of a given space
- c) Investigating the potential of a hand-held camera for a quick non-contact inspection of boxes/bags left in a public or private space

Radio command/controlled IED

The evolution and proliferation of the Radio-Controlled Improvised Explosive Device (RC-IED) has presented a low cost, highly adaptable and unpredictable threat challenge to Radio

Frequency (RF) countermeasure developers. Radio reconnaissance techniques have to be assessed for enhanced detection of suspicious radio signals, and for the optimum driving of the complementary jamming subsystem. This one must be able to intelligently activate the right jamming waveforms into the right frequency slots and spatial directions so as to maximize protection from IED radio triggering while eventually allowing operation of specific radio communications which may be needed for the success of the C-IED intervention.

Surveillance Radar

Surveillance radars have been in use for a multiple of applications for many decades (e.g. air and ship traffic monitoring, military surveillance, etc.). In the last two decades its capabilities were extended for the use in security and safety applications, like intruder or concealed object detection. The development of new semi-conductor and component technology and the increased use of integrated circuit technology (e.g. MIC – Microwave Integrated Circuit, MMIC – Monolithic MIC) allow the use of frequencies from lower microwaves up to millimetre-waves and even higher, thus increasing continuously the range of applications from very high-resolution imaging (e.g. SAR - synthetic aperture radar - technique) to the detection of buried or concealed objects (e.g. buried landmines, weapons and explosives under clothing, through-wall imaging).

Such innovative high-performance radars can be candidates for detecting especially Improvised Explosive Device (IED) in transit, and in particular in a flow of vehicles and/or people by analysing signature properties and anomaly behaviour. Detection and Identification are still to be combined on an efficient way.

Multispectral Spectroscopy and Analysis

Multispectral imaging Raman spectroscopy has been demonstrated to be a powerful tool for detection of explosives traces. The interest in Raman spectroscopy for standoff explosives detection has been demonstrated in several European Projects. Further analysis has to confirm the identification properties of such tool confined in a portable kit and interfaced with a reliable explosives library.

Non-linear junction detection system for IED detection (NLJDS)

A non-linear junction is a junction between different materials for which a change in the voltage applied across the junction does not produce a proportional change in the current flowing through the junction. These non-linear junctions are found in semiconductor components such as diodes, transistors and integrated circuits.

Non-linear junction detectors have to be used to detect and locate covert surveillance devices that may be hidden in rooms/halls/factories/airports/railways stations for the purpose of making audio or visual recordings of the activities occurring in the room. The remote capability in detection (about 10 m) has to be improved.

Chemical and Bio-inspired Sensors

The most commonly used approaches to detect trace levels of explosives in complex (urban, industrial, etc) areas are sniffer dogs and ion mobility spectroscopy (IMS). In each the “sensor” is directly exposed to the vapour (smell) of the explosive. Dogs offer exceptional sensitivity to explosive vapours, but do not provide information of quantity or composition of the vapour, and can only operate for limited periods during a day. IMS provides compositional information but is normally used in airports in combination with a wipe test to analyse a swab.

We now want to test novel polymer based sensors (from the FP7 TIRAMISU results) for detection of explosives vapours from IEDs and combine these for the first time with electrochemical- and Molecularly Imprinted Polymer (MIPs)-based sensors evaluated in the EDA project BURMIN to form multianalytical sensor arrays that could enable an automated detection of trace explosives in a flow of people (“short time scale”), or in e.g. a wastewater pipe connected to a suspected bomb factory (“long time scale”).

Robotics

Recent dramatic events such as the terrorist actions in Tokyo, New-York, Madrid, London, Sharm-el-Sheikh, Paris, Brussels have shown that local civil authorities and emergency services have difficulties to adequately manage the crisis and are more and more a secondary target in order for the terrorist to increase the casualties. We will propose, through operational research, the use of existing UGV/ UAV (equipped with adequate sensors) in outdoor as well in indoor environment, where cost-effectiveness justifies it.

OBJECTIVES of the EKC Partners

FRAUNHOFER

The Fraunhofer Institute Chemical Technology is concerned with all aspects of the development, manufacture and application of propellants and explosives. Beside defense applications, security research is becoming increasingly important in the civil sector. Current research topics include the detection of explosives, micro process engineering technologies, energetic ionic liquids and molecule-specific sensor layers. The department operates a test center for the detection of explosives on behalf of the German Federal Police Force. Funded by the FP7 projects EMPHASIS (detection of illicit production of explosives in urban areas) and BURMIN (detection of traces in water, for instance sewages), it develops sensors in close cooperation with the EDA and the Bundeswehr.

A new FP7 project called XP-DITE focuses on the optimal use of detection sensors at security checkpoints. Results are expected by March 2017.

SEADM

SEADM is a Spanish technological SME, whose aim is to become a Centre of excellence in the field of analytical instrumentation for the detection of trace elements. SEADM's range of instruments is based upon proprietary ion mobility and ionization techniques including SESI, DMA as well as integrated analysis equipment based in SESI-DMA-MS.

Funded by the HORIZON SME ACES project, LFSESI is an improved configuration of secondary electrospray ionization, termed Low Flow SESI since it requires a very low flow of sample gas and increases the ionization efficiency by almost two orders of magnitude. This architecture, in tandem with a Differential Mobility Analyzer, enables the detection of explosives vapours at the sub-ppq level.

SERSTECH-HOTZONESOLUTIONS

Serstech combines cutting-edge nanotechnology and spectroscopy techniques with advanced algorithm know-how to bring convenient chemical identification. Partner of Hotzonesolutions (The Netherlands) and ICI, two specific kits are proposed on the market. Two performing kits are available:

The first kit is a portable, handheld Raman instrument Serstech 100 Indicator (<http://serstech.com/our-offer/serstech-indicator-kit/>). The instrument features a nice new explosives related library made by the Swedish Defence Agency

The second kit is the Hotzone Technologies product: Hotzone Identifier Explosives. The kit can be used for identification of explosives, as a stand alone unit, but fits the best with Raman and/or FTIR (Fourier Transform Infrared Spectroscopy) handheld equipment. The kit contains quick tests for pH, presence of sugar, hydrocarbons and indication of their classes, identity of metal powders, presence of sulphur and phosphorus, detection of different oxidizers (organic and inorganic peroxides, nitrates, chlorates, chromates, permanganate), ammonium nitrate based explosives, PETN, RDX, TNT, oxidizing salts, urea nitrates, azides. The kit is self-contained and field ruggedized.

DLR

DLR is the national aeronautics and space research Centre of the Federal Republic of Germany. Member of the Consortium TIRAMISU, it develops a stand-off detection System of Explosive buried or hidden devices based on the SAR. Through the EDA project SUM it also exploits the millimeter-wave properties for developing a counter-threat detector.

One of the most challenging situations is the case where large crowds of people or large accumulations of vehicles are in permanent motion, as it is the case for people on public areas or events and vehicles in dense traffic. Here the problem is the big number of objects to be investigated rather in

parallel, and the fact that the objects may mask each other, preventing proper and complete scanning of them. Consequently sensor types and architectures have to be explored in order to overcome such problems.

A useful technology for such applications is given by microwave remote sensing where a range of frequency bands between 1 and 300 GHz typically is used.

First experiments have started.

CSIC

CSIC (Agencia Estatal Consejo Superior de Investigaciones Científicas) is the largest public multidisciplinary research organisation in Spain and it is the 5th organisation in Europe in project execution and funding. Under the 7th FP, CSIC has signed 280 projects. Its mission is to promote, coordinate, develop, and disseminate multidisciplinary scientific and technological research to contribute to economic, social, and cultural development.

CSIC started research activities on the dynamical detection of abnormal behaviours in a flow of people.

Human Behaviour in Biometrics can be divided into **physiological** and **behavioural**:

- A **physiological trait** tends to be a more stable physical characteristic, such as finger print, hand silhouette, blood vessel pattern in the hand, face or back of the eye.
- A **behavioural characteristic** is a reflection of an individual's psychology. Because of the variability over time of most behavioural characteristics, a biometric system needs to be designed to be more dynamic and accept some degree of variability. On the other hand, behavioural biometrics are associated with less intrusive systems, conducing to better acceptability by the users.

However, to my opinion, even if our Minister of Interior reported that the behavioral characteristics allow to identify suspected people in a flow of people, according to his recent visit in Israël, the technique is not yet convincing: may-be could our invited speakers confirm it... Anyway, the realization of Wireless Sensor Networks (WSNs) for automatic and real time explosive detection can pave the way for installation at public domains to safeguard lives and property of citizens.

UV and INFRASTRUCTURE

I want to close this presentation with three last issues that are to be considered.

The first one, privileging the safety of the practitioners during their intervention by alarm or by explosion, lies in the possible use of unmanned vehicles.

The Spanish IN-NOVA Group has developed, carried by aerial and surface UV, Laser Induced Break-down Spectrograph for the detection and identification of explosives: the RS2000 can support special operation missions in river areas flowing through cities. IN-NOVA is currently working for the Spanish Ministry of Defense and has developed air and ground radar systems aimed for the protection of critical infrastructure.

E&Q Engineering Solutions and Innovation S.L. (E&Q, Spain) is a private company, working too for the Ministry of Defense but also the Security corps of the Ministry of Interior. Through projects for the NATO and the EDA, E&Q developed software related to the characteristics of weapon systems and a UAV module for several C-IED activities.

The second issue lies in the personal protection equipment: the assessment of the resistance of a material under near simultaneous multiple impacts, as in a case of the fragmentation generated by IED explosion, can be roughly described by single ballistic impact tests. Therefore the Department of Weapon Systems and Ballistics of the RMA, has developed a technique that takes into account the interactions of multiple near simultaneous impacts.

This technique, called Triple Launcher, has certified the new fabric developed by Hotzonesolutions. Last but not least, an important issue lies in the safety/security of the (Urban) Infrastructures self. AMARANTE International is a leading European supplier in the Security Market. With its large

experience for Companies and Institutions like the European External Action Service, the CNES, the ESA, the Banque de France, Airbus, the French Atomic Energy commission, ITER, among others, AMARANTE proposes a lot of services aiming the protection of critical infrastructures against terrorism plans.

3. CONCLUSION

All mentioned techniques will be analyzed, possibly improved and validated through operational research activities the ICI/EKC will conduct till end of 2018, through realistic scenarios wherefore we hope your cooperation.

APT – an appropriate demining machine

Andy Smith¹, University of Genoa, Italy

1. INTRODUCTION

This paper introduces a new machine for use in support of Humanitarian Mine Action. Developed under the EU FP7-TIRAMISU R&D initiative, the machine is reliable, easy to deploy and has a low cost of ownership. It is designed to drive over an area preparing it for manual demining, so is made to withstand any AP blast and fragmentation mine detonations that occur. Small and highly manoeuvrable, it can climb steeper inclines that other machines and also drive over roads to deploy without an expensive transporter. The paper describes how it meets a need and reports on its performance in testing/acceptance trials in Croatia. It also describes plans to extend its utility as a C-IED tool.

2. STATUS

Over twenty years in demining, many machines have been improvised to help in area preparation. Based on existing plant and agricultural machinery, their success has often been ignored because they are not commercially available.

The first such machine may have been an old tractor with a side cutter attached and some light armouring. This was used to cut undergrowth on road verges in front of manual deminers in Cambodia² in 1997. Around the same time, converted military mine protected vehicles were also being used to cut undergrowth in Angola and converted back-hoes were used in Afghanistan. The back-hoe excavation bucket was later refined for area preparation in Sri Lanka where Arjun raking excavators were widely used until 2011.



The pictures shows a backhoe in Afghanistan, an articulated hydraulic mulcher arm on the back of a Werewolf MPV in Angola and an Arjun³ raking excavator in Sri Lanka.

Not all improvised machines have been that big. For example, in Myanmar during 2015 it was impossible to get government permission to import any equipment at all. For a particular task involving small gelignite pressure mines, a small area preparation machine⁴ that removed the undergrowth and detonated some devices in advance of manual demining was made. This was a task specific machine, only suitable for that threat on level ground but it did the job well. The two-wheeled rice tractor on which it was based is back working in the rice paddies now.



1 Andy Smith has worked in demining for twenty years, starting as a PPE designer and rapidly becoming a deminer/surveyor and then a Technical Advisor, trainer, programme manager and UNDP country CTA. The founder and keeper of the Database of Demining Accidents (DDAS), he has also developed and put into production the most popular PPE used in HMA. His latest tasks have included writing extensive field risk management training materials for GICHD. See www.nolandmines.com and www.ddasonline.com.

2 The author saw this in use with HALO Trust in 1996.

3 For details of the Arjun demining system, see http://www.nolandmines.com/Arjun_Demining_System.htm

4 This small machine was made and used by the author. For a video including the use of the rice-tractor machine, see <http://www.vimeo.com/102096029>

3. The APT

What was needed was a more versatile machine, able to follow narrow paths, climb steep inclines, and be radio controlled when working in areas with larger hazards. At that time, the Locostra tractor being developed under the TIRAMISU project was attractive⁵, but it was unfinished and unproven. Towards the end of the project, the machine matured, getting a bigger engine, armouring, cameras and a new name. Because the machine was singularly “appropriate” for its purpose, it became known as APT, the Area Preparation Tractor.

The developers of APT do not pretend that it is something it is not. It is not a mine clearance machine. It is designed to prepare the area before manual search and clearance. It will detonate some mines but, like all other demining machines, it will leave some mines and almost all ordnance behind. It is designed to climb hills, manoeuvre around obstacles and shrug off AP mine detonations while preparing the ground for the thorough manual search and clearance that will follow.

The working tool cuts undergrowth and processes the ground surface to a few cms depth to make follow-up demining faster. When mines detonate as it works, that can help to identify the hazardous hotspots in an area. When tripwires are shredded and fuzes are broken from fragmentation mines, which reduce risk to the deminers. And because most demining accidents occur when excavating an explosive hazard⁶, loosening the ground surface reduces risk by making excavation easier. The author, after more than twenty years in this industry, believes that this is a simple machine that has been too long coming.



APT is based on a popular and proven agricultural tractor that is widely used in steep Italian vineyards. Small, with a low centre of gravity, it is steered via wheels and an articulated chassis. The combined steering means that it can manoeuvre tightly around obstacles without having to leave a wide area unprocessed.



The machine has innovated blast resistant wheels that successfully absorb the energy of AP mine detonations without the shock wave damaging the bearings and chassis. Its engine, hydrostatic drive and articulated chassis have been well proven in years of hard agricultural use, so are both robust and reliable. The radio control system is also robust and has proven reliable over several years in the construction sector.

⁵ The author had designed the prototypes of its wheels in 2011.

⁶ Study of the Database of Demining Accidents (DDAS) confirms this: <http://www.ddasonline.com>.

Its hydrostatic drive means that it can move forwards and backwards with the same ease and speed, so allowing the user to choose which approach is best suited for a specific use. For example, when visibility is limited, it can make sense to cut breaches into undergrowth and then return along the same path, processing the area a second time.

With dual radio - and manual - controls, the top of the cab armour lifts off so that it can be driven conventionally over roads to the working area, then radio controlled to work in hazardous areas. This allows the total cost-of-ownership to be low because it need not include an expensive transporter. Its ability to deploy itself also avoids a problem often experienced with large machines when the combined weight of the machine and its transporter causes damage to roads, bridges and culverts.

Being based on a tractor, APT can be fitted with a wide range of other tools and can tow a trailer carrying its blast-resistant wheels and the deminers' equipment, water and other base-camp essentials.

In May 2015, the first complete prototype APT machine was shown at the 2015 CTRO Symposium in Croatia. Afterwards, it was subjected to a series of independent explosive tests at the CTRO test site. Multiple⁷ blast and fragmentation mines were detonated beneath the wheels and the working tool in “worst-case” positions without any impact on the machine's ability to perform. In later analysis, there was no evidence of shock wave transfer to the bearings or chassis.



Having performed well in the explosive tests, the same machine was field tested by CTRO over five days. Testing took place on abandoned agricultural land and in a forest that was a Suspected Hazardous Area⁸.



⁷ The mines used were: 5 x PMA 1A, 5 x PMA 2, 5 x PMA-3, 1x PMR-2A and 1 x PROM-1.

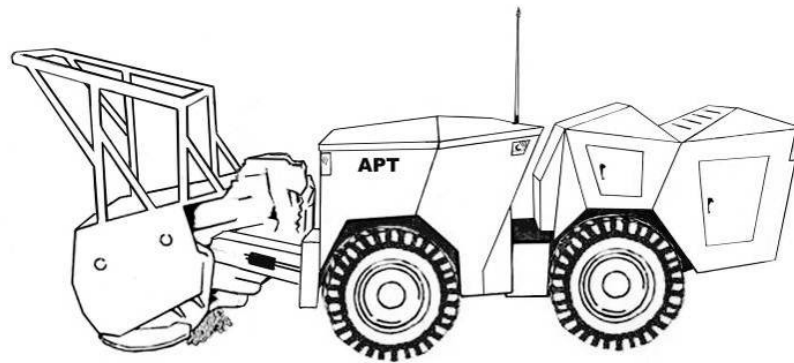
⁸ It was verified as cutting vegetation (up to 10cm Ø) at a rate of 2739 m² per hour in the test area.

Side to side area preparation was augmented by cutting breaches through the heavily vegetated area. The work included testing deployment approaches and operator training materials. The testing⁹ was successful and a CTRO accreditation certificate was issued in July 2015.

4. FUTURE

With the end of the R&D project, there is a need to move towards exploitation. The manufacturer¹⁰ is a small independent who makes and sells agricultural tractors. His company has no marketing budget and he enjoys no access to the demining networks. The University of Genoa is seeking further support to move this project to a sustainably commercial conclusion with the machine being used in the field. This machine would be useful almost anywhere with an AP mine threat but could have been specifically designed for conditions in Myanmar and Colombia.

Minor refinements that are planned include reshaping the armour for easier removal and access to the engine, as shown in the schematic below.



The University of Genoa has extensive experience in robotics, so it is also planned to develop a lifting C-IED platform including a dozer blade, large manipulator arm, small manipulator arm with disrupters, winch and extra cameras. APT C-IED's generous power (>100HP) allows it to carry and power multiple devices electrically, by direct rotation PTO, or hydraulically. This means that proven or preferred manipulator arms and disrupter devices can be used.

The C-IED platform can simply replace the mulcher on a demining APT or can be fitted to a dedicated C-IED APT with upgraded (rifle resistant¹¹) armour and refined decontamination features.

The C-IED APT will be able to:

- move rubble and obstructions aside (delicately when appropriate);
- conduct a rapid camera survey of an area, producing accurate map records;
- investigate suspicious objects either robustly or delicately;
- collect ordnance that may not be considered safe to move by hand;
- disrupt potential IEDs with either a water charge, frangible or solid projectile:
each of three disrupters feature three pre-loaded barrels - 25.4mm and 40mm;
- fire a closed grapnel and line that can then be used to pull the target;
- place explosive charges to disrupt/destroy IEDs;

⁹ There are some video clips of the testing in a short film online at www.nolandmines.com/APT_Movie_3.wmv

¹⁰ Giovanni Polentes at the Pierre Trattori factory, Italy: http://www.pierrettra.it/index.php?option=com_content&view=article&id=73&Itemid=682&lang=en

¹¹ The current plan is to protect against 5,56 NATO BALL ammunition (steel core). Enhanced protection will add between 500 and 1000kg in weight depending on whether shaped-charge amelioration is required..

- attach hooks and a winch cable to drag heavy items to another place;
- deploy cutting equipment able to cut an additional entry into a vehicle/container;
- deploy a COTS freeze neutralising kit;
- gain safe entry to a vehicle for internal camera inspection;
- carry a multi-channel (selective) wireless signal jammer to prevent wireless initiation systems being used in the vicinity;
- carry and place smaller robots when access through small openings is required.

One advantage it will have over all other similarly sized C-IED machines is the ability to drive to the area of need. Its small footprint and manoeuvrability will allow it to drive over sidewalks when traffic is gridlocked following an incident. It can push or lift debris aside to access an area, and its flexible chassis and ground-clearance allow it to move over rubble to get where it is needed.

For more information about the Demining APT, contact andrew.vian.smith@edu.unige.it at the University of Genoa. For more information about the C-IED APT, contact Matteo Zoppi at zoppi@dimec.unige.it.

Mobile Technologies in Mine Action

Torsten Vikström, Stefan Kallin¹

Abstract

Mines and unexploded ordnance all over the world are still taking its toll as lifelong suffering or death. It strikes blindly and effects 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 effective and safe solution is the TIRAMISU Information Management System, T-IMS.

T-IMS is a GIS centric stand-alone software application built for mobile use to support all field data collection within the scope of Humanitarian Demining, following the steps of Non-Technical Survey, Technical Survey and Clearance operations to Quality Assurance/Quality Control as well as the final Reporting.

T-IMS improves the general survey processes with significantly increased finalization of activities directly through field work – without additional office work. The recording of the path of the surveyors and geospatial positioning significantly improves safety of field activities.

T-IMS combines easy-to-use computer software with the use of standards for information storage, data exchange and increased interoperability. By following and adapting to widely accepted and used standards, such as International and National Mine Action Standards (IMAS/NMAS) and standards developed and maintained by the Open Geospatial Consortium (OGC) and the Geneva International Centre for Humanitarian Demining (GICHD), organizations using T-IMS have the ability to connect, integrate and exchange information and reports with other systems and tools commonly used by the Mine Action Community, such as IMSMA.

T-IMS has been operationally validated by CTDI and CROMAC.

Introduction

“There is an emergent consensus that an excessive use of clearance resources in areas that may not contain landmines and/or explosive remnants of war (ERW) represents an error in miscalculation rather than justifiable prudence. Tens of millions of dollars have been invested in survey since 2009. At large, the global survey efforts did not yield any conclusive data and could have been applied differently. This is a concern which continues to be the single biggest obstacle to faster and better aimed mine clearance. This has increased the inability to establish a clear baseline of the remaining hazard, time and resources needed, which are fundamental for the eradication of this global threat. To treat this problem a solid information management system is required.”

M. Bold – GICHD

Technology Development

The technology developments at the turn of the 21st century now offer a broad range of new technical breakthroughs such as information technology and telecommunications. Yesterday’s powerful desktops are being transformed to sensory input and output devices merging intelligent software and extensive connectivity. We are getting more reliant on current existing multifaceted network connections and adapting to “smart environments” that are changing the ways we operate and interact. Easy access to interactive global networks with further simplification of computer use, can improve the ways we gather, analyze, monitor and evaluate information.

Mine action would benefit immensely allowing it to shift away from the traditional hierarchical command and control structures and hence opening up for horizontal networks and co-operative teams. Consequently, this would enhance the ability in decision-making, monitoring and evaluation in par-

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allel with continuous improvement. In consequence, this will increase efficiency but at the same time will also provide scope for growing transparency along with the national capability to bridge mine action with human security.

Mine action needs to embrace a culture of creativity, experimentation and openness for change. Nonetheless, technological advances in themselves provide no conclusion as to the extent and manner in which they can be used unless resources are freed to allow creativity.

The importance of standards

By combining easy-to-use computer software with the use of standards for information storage, data exchange etc. increased interoperability is enabled. By following and adapting to widely accepted and used standards, such as International and National Mine Action Standards (IMAS/NMAS) and standards developed and maintained by the Open Geospatial Consortium (OGC) and the Geneva International Centre for Humanitarian Demining (GICHD), organizations using T-IMS have the ability to connect, integrate and exchange information and reports with other systems and tools commonly used by the Mine Action Community, such as IMSMA.

Mobile Technology in Mine Action



Still as of today, a lot of the information collected in the field by surveyors and deminers is captured by hand with the use of pen & paper, separate GPS-units and hand drawn maps over the current area and situation.

Over time, this is a very time and effort consuming way – often combined with high risk – to collect sensitive information. Information that often need to be passed several steps by hand to finally end up in an IM-system, where it is consolidated and make basis for new and improved manual maps to be drawn.

By using modern mobile technology tools for field data collection, such as T-IMS, this approach and process will be vastly improved in many areas:

- All captured information in the field – what, when and by whom – is accessible for reporting and communication in native form, which means that no further modification of data need to be done.
- Everyone involved in survey, clearance and QA/QC could and should be able to contribute & report.
- No more human errors and errors from manual handling.
- Situation awareness. Digital up-to-date maps with historical information, also showing the carriers' current position substantially improves safety in the field.
- Standardized map symbology – for the whole process of land release – minimizes the risk of misunderstanding and misinterpretation.
- Collected and captured information over larger areas can be compiled periodically and shared – in a common and standardized way – with donors and others of interest.
- Provides a basis for making the right priorities for action: Put action where action is needed.

T-IMS – TIRAMISU Information Management System

T-IMS is a stand-alone very user-friendly Field Data Collection tool primary for the deminer's use in the field. It is for use in the early stages of Non-Technical Surveys through the phases of Technical Survey and Mine Clearance as well as the following Quality Assurance and reporting. With T-IMS, hazardous areas (SHA/CHA), indicators of mines or UXOs, GPS-trackings etc. can easily be defined and positioned in the GIS map module.

With T-IMS' intuitive search engine, findings such as UXOs or landmines will easily be identified and can likewise be positioned with high accuracy in the map. T-IMS is optionally equipped with off-line CORD (Collaborative ORDNance data repository) which is a result of the cooperation with the James Madison University – JMU). This database consists of approx. 5 000 ordnance objects. Any type of attachment – such as geo-referenced photos, voice recordings, videos, images and documents – may be attached to any activity.

T-IMS is built for use under rough conditions as well as in extreme environments. It runs with 100% of its functionality off-line. The overall concept, design and usability have been evolved by deminers with many years of use and great experience from earlier generations of like applications. It is built for use in the field and its user interface is completely adapted to touch technology, meaning that data capture with T-IMS is extremely intuitive and easy. T-IMS is fully usable without a touchpad or a mouse.

The TIRAMISU project

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. The project, funded by the European Union's Seventh Framework Program (FP7), aimed to provide the Mine Action community with a global 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. This toolbox covers the main mine action activities, from the survey of large areas to the actual disposal of explosive hazards, including mine risk education. To reach the level of expertise needed the TIRAMISU team included organizations that were involved in some of the most important European and international research projects in mine action of the last fifteen years. The TIRAMISU consortium consisted of 26 partners from 12 different countries, with a total budget of approx. EUR 20 million. The TIRAMISU project started up in 2012 and was ended by December 2015.

The TIRAMISU Information Management System (T-IMS) – described in this document – is an outcome of the TIRAMISU project.

Acknowledgement

The research leading to these results and information has received funding from the European Union's Seventh Framework Programme for 2007-2013 under grant agreement n° 284747, project TIRAMISU. T-IMS has been operationally validated by CROMAC/CTDT within the TIRAMISU project.

T-IMS has been evaluated in Cambodia together with GICHD and CMAA, on three minefields in the Battambang province where CMAC was conducting clearance operations. Article in The Journal of CWD, 20.2.

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Protection of combat vehicles against mines: design concepts

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Abstract

The paper presents the threats posed by land mines and IEDs (improvised explosive devices) to combat vehicles and the need and necessity of faced by the constructors/designers of undertaking actions which would guarantee crew safety. The idea of anti-mine protection for tanks has been given using flexible, multilayer armour and an electromagnetic field (EM) and infrared (IR) emitters mounted to the front of the tank. The design of the armour has been analysed, as well as its mounting methods and its mode of interaction with the mines. The results of the impact of 0.4 kg TNT explosion on the flexible armour have been presented, as are the test results aimed at assessment of the degree to which the detonation of a scatterable EFP mine had been weakened by the flexible armour. Furthermore, a concept of an explosion-proof set for wheeled vehicles has been described. The design of the set has been analysed, as well as its mounting methods and its manner of a multistep method of attenuating the detonation energy. Finally, a concept of a rope explosion-proof panel has been given with its mounting method to the bottom of vehicle hull.

1. Introduction

Military conflicts involve a wide-spread use of different kinds of vehicles and combat vehicles in particular. Such modern combat has to be tailored to be performing tasks in regular warfare carried out in open space, as well as in urban environment with increasingly dense and high developments [1]. During these operations, the vehicles are forced to move both on the roads and off-road, where they can encounter individual mines and improvised explosive devices (IEDs) (in case of roads) and minefield sectors and off-route mines emplaced by the adversary. Considering the above, in order to provide safety to the crew and ergonomic transport conditions, such vehicles should be characterized by high mine- and IED-detonation resistance. All in all, at the vehicle design stage, particular attention should be paid to the vehicle hull construction (its shape, rigidity and armour), its suspension, chassis, floor construction and seat fixing method in the crew compartment.

2. Threats posed to combat vehicles by mines and IEDs

Currently, various kinds of typical anti-tank (AT) mines, scatterable mines and off-route mines are in service with armies all around the world. Depending on their construction, typical AT mines can be divided into blast mines and shaped charge (HEAT) mines. They can contain pressure fuses which cause the mine to detonate under the wheel of the vehicle, as well as non-contact fuses (initiated by magnetic influence) which explode underneath the hull of the vehicle. In asymmetric warfare [2], IEDs are used most often. They enable effective resistance to the better equipped soldiers of the world's wealthiest armies to be posed by the insurgents. The experience drawn from the local conflicts (such as the Balkan conflict), Russian-Afghan war and the experience of the Polish contingent in Afghanistan [3-5] indicate that mines and IEDs play a significant role as one of the more efficient weapons. Directional and fragmentation IEDs (such as explosively-formed projectiles – EFPs) are used most frequently. In case of blast IEDs [2] their explosive content equals 50 kg, which practically guarantees that each and every combat vehicle, the latest generation of battle tanks included, will be destroyed.

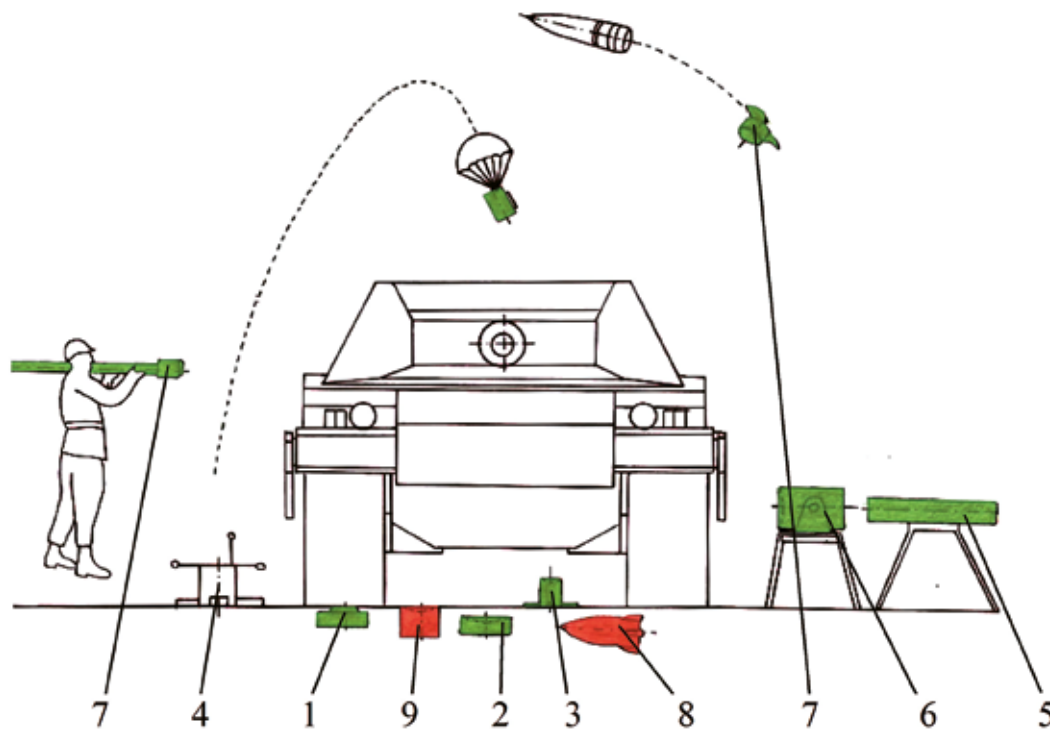


Fig. 1. Threat caused by typical AT mines, projectiles guided from upper hemisphere, from RPG launchers and IEDs:
 1 – typical pressure-activated AT blast mine, 2 – typical non-contact fuse AT blast mine,
 3 – scatterable AT shaped charge mine whose impact is exerted underneath the hull of the vehicle,
 4 – scatterable AT shaped charge mine whose impact is exerted on the upper hemisphere of the vehicle hull,
 5 – rocket-propelled off-route shaped charge mine. 6 – off-route EFP (explosively formed penetrator) mine,
 7 – RPG, 8 – IED containing high-explosives, 9 – IED containing a shaped charge

Scatterable mines are most often equipped with non-contact fuses and include a shaped charge. Off-route mines are produced with either the contact- or non-contact fuses but can also be remotely detonated by an operator. They are designed to be effective when detonated next to a side of an armoured vehicle. The threat generated by mines, IEDs, projectiles and RPG-launchers is presented in Fig. 1.

3. A concept of equipping a tank with an explosion-proof armour

Military Institute of Engineer Technology (WITI) developed a concept of a flexible, multilayer explosion-proof armour for tanks (see Fig. 2) which increases the protection of the hull against the destructive impact of mines and IEDs of various kinds. The frontal part of this armour [6] is mounted to the brackets via a coupling and axis in front of the tank. Then the armour is directed underneath the hull through tensioning mechanism (cable drum, drive shaft and brackets) to the rear of the tank hull.

In travelling order, the explosion-proof armour occupies position on top where it rests on the bottom of a tank. If the tank is to enter the area of potential explosions, the flexible, multi-layered armour is lowered just above the ground surface, as the result of lines unreeling from the drum of the tensioning mechanism.

What such an armour does, is cause the detonation and weaken the impact of the detonation energy of various kinds of mines, including:

- scatterable mines containing shaped charge, as the result of the mine tilting (initiation of anti-handling device) or the impact of magnetic field emitter;
- tilt rod full-width attack mines, as the result of the fuses breaking;
- typical non-contact, magnetic fuse AT blast mine, as the result of the impact of magnetic field emitter;
- off-route mine (with detonation under the vehicle), as the result of the impact of thermal emitter.

Diagram of the impact of explosion-proof armour and signature duplication systems on AT mines is shown in Fig. 3.

Should a mine or IED detonate under the tank hull, the armour would either mechanically disrupt the formation of shaped charge jet, weaken the impact of shaped charge jet as the result of the detonation of the charge, or weaken the detonation pulse.

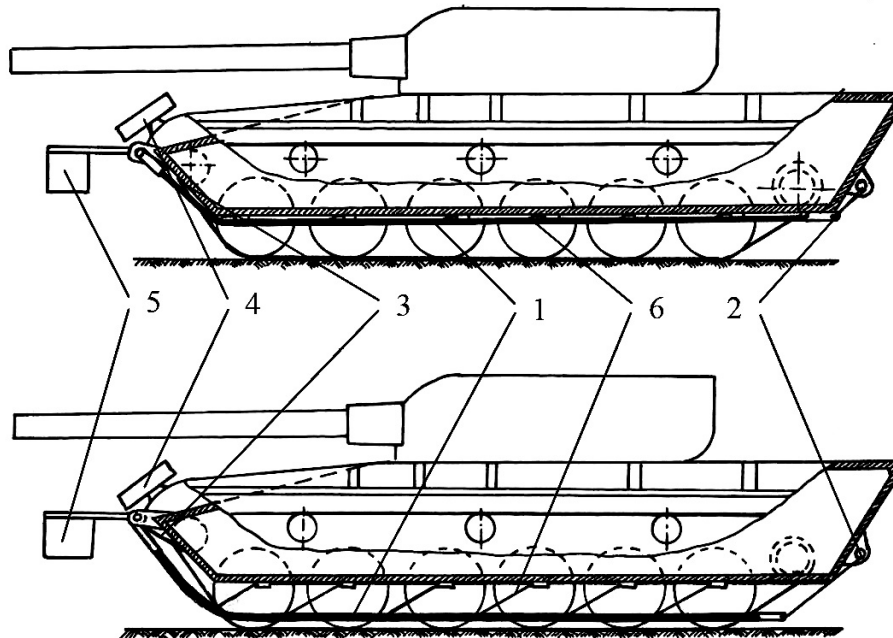


Fig. 2. Tank with flexible armour mounted

1 – explosion-proof armour, 2 – tensioning mechanism, 3 – torsion springs, 4 – electromagnetic field emitter (magnetic signature duplicator), 5 – thermal emitter (thermal signature duplicator), 6 – supporting lines

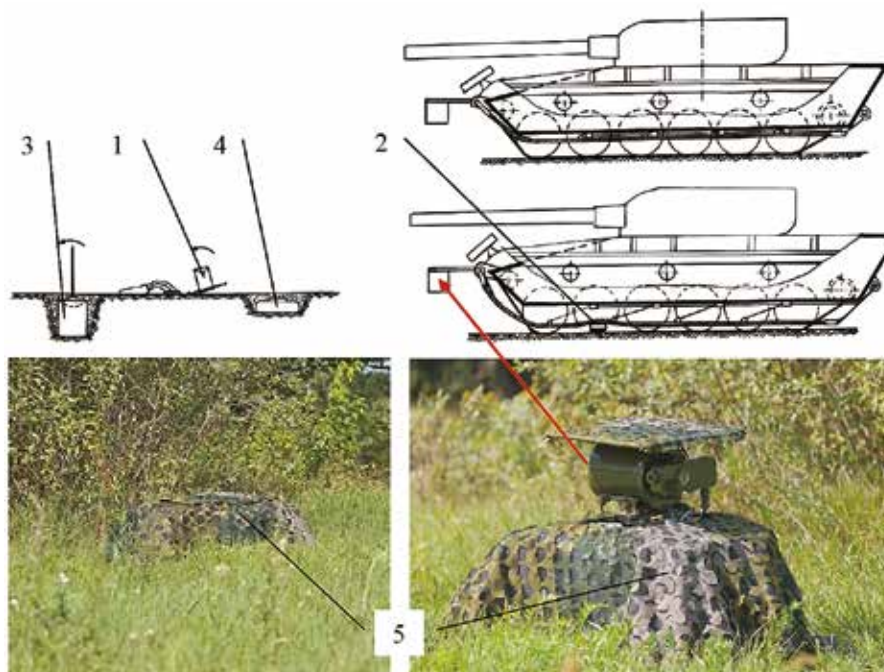


Fig. 3. Diagram of the impact of explosion-proof armour and signature duplication systems on AT mines:
1 – scatterable shaped-charge AT mine (on ground surface); 2 – scatterable shaped-charge AT mine (under a battle tank) 3 – tilt rod full width attack mines; 4 – typical magnetic influence fused; 5 – off-route mine

4. Impact of explosion on a flexible armour

Military Institute of Engineer Technology conducted tests aimed at the weakening of the blast wave by a flexible armour. In order to achieve that, a flexible armour made of rubber and weighing 20 kg (dimensions: $3000 \times 800 \times 8$ mm) was placed over a standard block of TNT – 15 cm above ground. The ratio of the mass to the mass of the explosive charge equalled $K = 50$ (20 kg/0.4 kg). The testing area is illustrated in Fig. 4. The explosion was recorded using ultrafast Phantom V-711 using Phantom Camera Control software. Fig. 5 presents blast wave generated (transferred) by the rubber armour as the result of the shield being impacted by the blast wave generated as the result of 0.4 kg TNT detonating. Blast wave velocity at the height of ca. 2.1 m equalled about $V_2 = 510$ m/s. Fig. 6 presents the rubber armour being thrust in the air. Its average velocity equalled ca. 55 m/s.



Fig. 4. Area where the impact of explosive charge explosion of the flexible armour was tested:
1 – flexible armour; 2 – explosive charge; 3 – height gauge

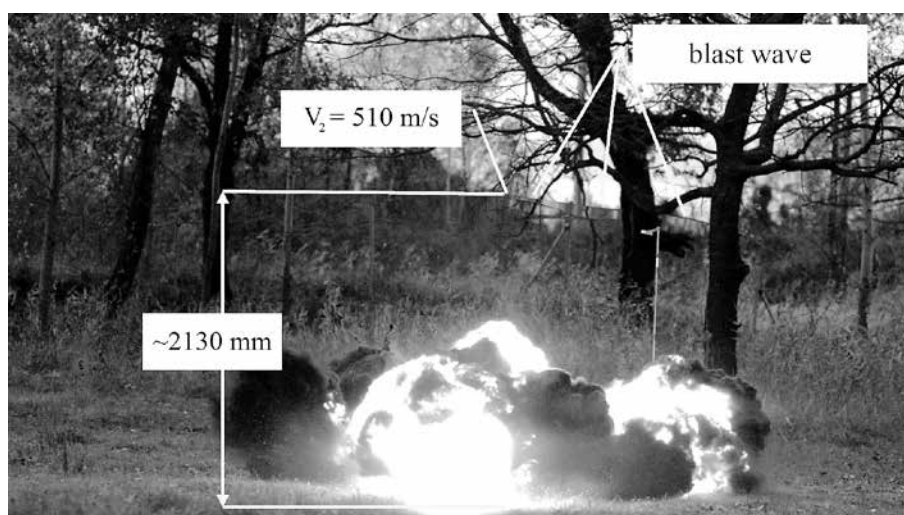


Fig. 5. Blast wave generated by the rubber armour

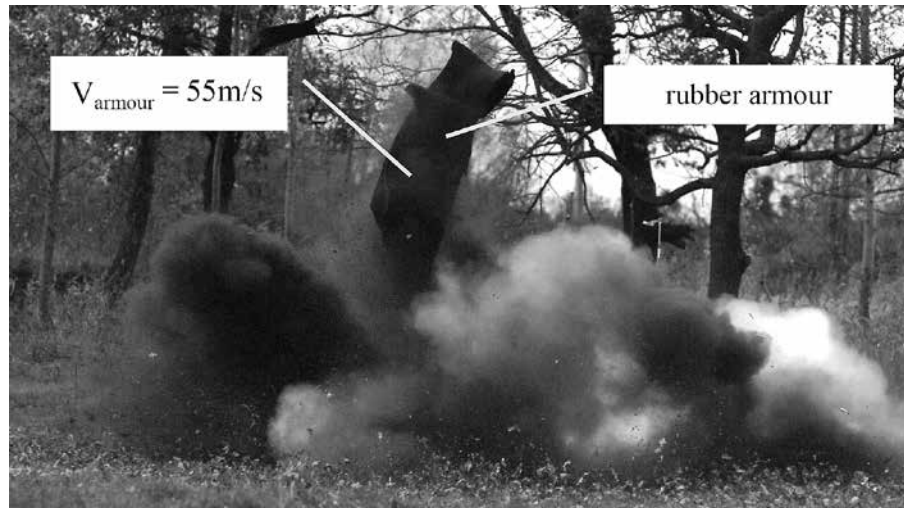


Fig. 6. Rubber armour being thrust in the air

Later on, a detonation trial was conducted: a 0.4 kg block of TNT was detonated with no armour. The course of this trial was registered with ultrafast camera as well. Blast wave detonation velocity was also been recorded at the high of 3.0 m from the point where the TNT block touched the ground. This blast wave velocity equalled $V_1 \approx 710$ m/s. Fig. 7 presents graphic representation of the blast wave generated by the armour as the result of being impacted by a 0.4 kg TNT exploding.

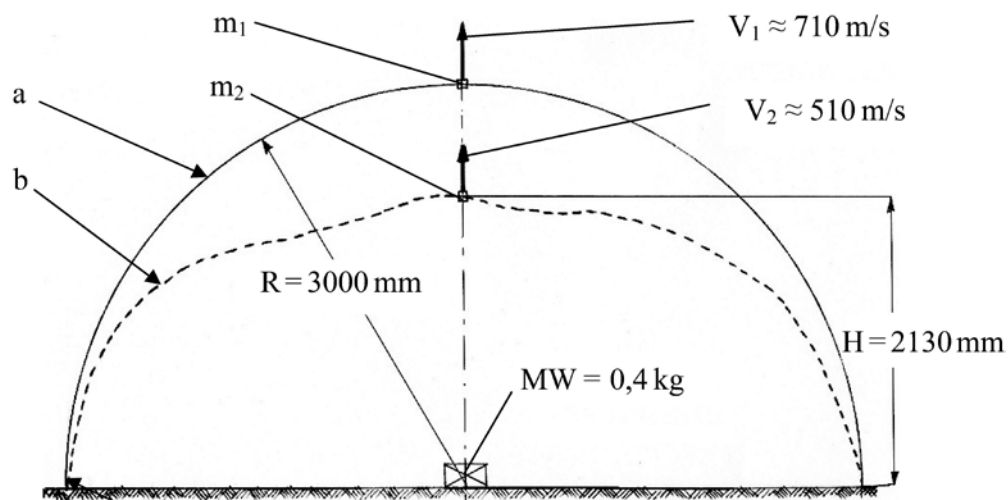


Fig. 7. Propagation of the blast waves as the result of a 0.4 kg TNT block detonating, where
a: no rubber armour – solid line; b: with rubber armour – broken line

Following the trials, calculations were made [4], the results of which stated that the 20 kg rubber armour (dimensions: 3000 x 800 x 8 mm) having been impacted by a 0.4 kg TNT explosion [$K=50$ (20 kg/0.4 kg)], will indeed weaken the impact of the explosion on the underside of the vehicle by about 50% assuming that it would not be ripped. Furthermore, the analyses and partial tests indicated that the flexible multilayer armour is indeed suitable as protection of the lower part of combat vehicle hulls, since it both dissipates and absorbs a significant portion of blast wave energy. Among other, this results from the fact that rubber is characterised by low sound propagation velocity ($V = 30 \div 60$ m/s), much smaller than that of other structural materials (steel $V \approx 5000 \div 6000$ m/s, aluminium $V \approx 6300$ m/s, composites $V \approx 3500$ m/s), or air itself ($V \approx 340$ m/s). Its additional advantage is that after being thrust up following a mine or IED explosion, it adjusts to the shape of the chassis and does not damage its components.

5. The impact of scatterable mine with shaped charge on a flexible armour

Military Institute of Engineer Technology conducted tests aimed at estimation of the degree of penetration of a scatterable shaped charge mine placed under flexible armour of a battle tank (Fig. 2).

The shaped charge mine used for the tests (directional with the cover being ejected) penetrated an 80 mm-thick armour plate from the distance of 0.5 m. During the tests, a 50 cm-high stand was placed on an 80 mm-thick armour plate and an AT shaped charge mine was laid on the stand using two 8 mm-thick elastic bands (Fig. 8). The elastic band was equipped with rubber coatings and a core made of cotton lines and woven fabric. Following the detonation, it was found out that proper formation of the stream of metal did not take place and thus the armour plate penetration equalled only 20 mm. Test results are illustrated in Fig. 8.

The tests conducted indicated that even the elements with weakest armour on the bottom of the battle tank, with the flexible, multi-layer armour (Fig. 9) are capable of withstanding the impact of modern scatterable AT mines.

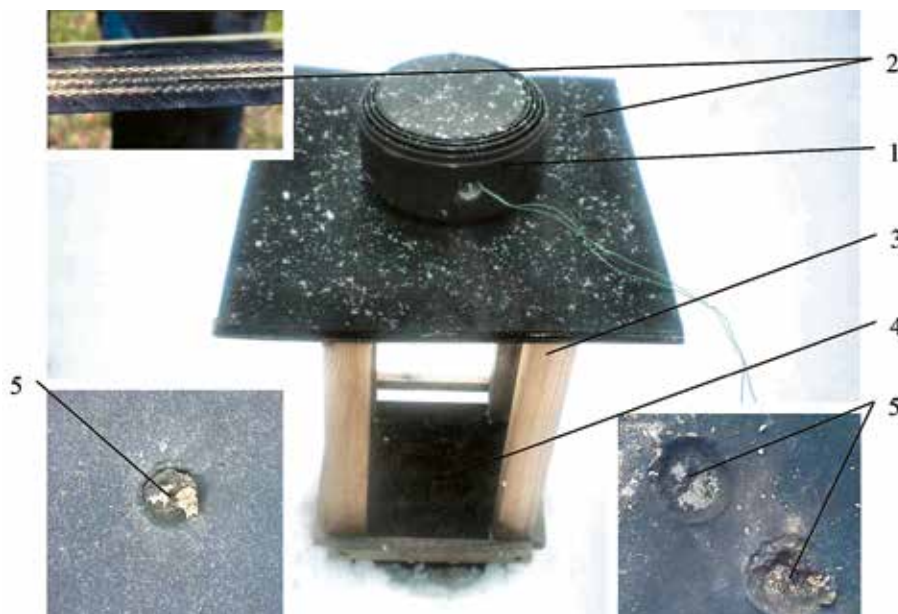


Fig. 8. Scatterable shaped charge mine armour-plate penetration test bed with the mine being placed on the flexible armour and a stand: 1 – scatterable shaped-charge AT mine, 2 – elastic band, 3 – stand, 4 – armour plate, 5 – projectiles stuck in the armour plate

Based on the results obtained via testing of the explosion on the flexible armour (see chapter 2) and the impact of a shaped charge mine on the flexible armour (see chapter 3), it must be assumed that flexible explosion-proof armour should be characterized by being multilayered and containing joined (either with an adhesive or via vulcanization) elastomeric (e.g. rubber) bands, alternating with technical fibres (such as carbon ones or aramid ones) – see Fig. 9. Having been mounted to the front of the tank, the armour was weight, and its mass equalled ca. 560 kg, plus the tensioning mechanism (ca. 90 kg), which would make the total mass to be about 650 kg. This would not impact the tank dynamics in a significant manner, but it would greatly improve the crew safety during operations in area infected with mines and IEDs.

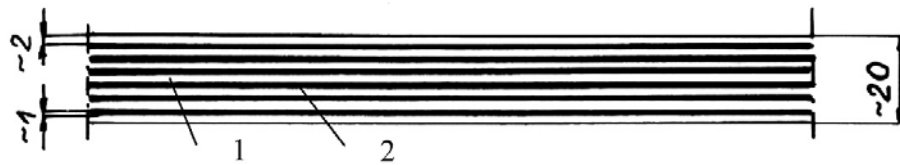


Fig. 9. Flexible multilayer armour: 1 – elastomeric tape, 2 – carbon fibre fabric

One of the key stakeholders on the side of the producers – the Polish Bumar-Labendy company – was interested in this solution being attached to tanks. The company is sure that the increase of mine resistance, HEAT (shaped charge) mines in particular, would contribute to the improvement of technical and tactical parameters of battle tanks to a considerable degree. The work effected in a patent application No. 214980, 2013 entitled “Explosion-proof armour” [6].

6. The idea of equipping an armoured personnel carrier (APC) and a mine-resistant vehicle (MRAP) in an explosion-proof set

The favourable shape of „V-shaped” underside, as far as dissipation of a significant part of energy is concerned is contrasted with its negative consequence, namely accumulation of the part of explosion energy which had not been dissipated within the vehicle hull. This fact resulted in WITI deciding to initiate analyses into either the elimination, or at least significant limitation of this unfavourable phenomenon. The findings from the analyses are presented below. Blast wave is a spatially-wide, mechanical wave, propagating in material media (solids, fluids and gasses) only, and would not propagate in a vacuum. These properties were taken into consideration by researchers in WITI when developing an idea for an explosion-proof set for an armoured personnel carrier (Polish KTO) and an MRAP [7, 8].

WITI foresees that the set would be utilised in these areas of the world, where the mine and IED threat is high, and when no longer needed, the set could be removed. Fig. 10 presents explosion-proof set mounted on base vehicle (side view), whereas Fig. 11 shows the cross-sectional view of the set.

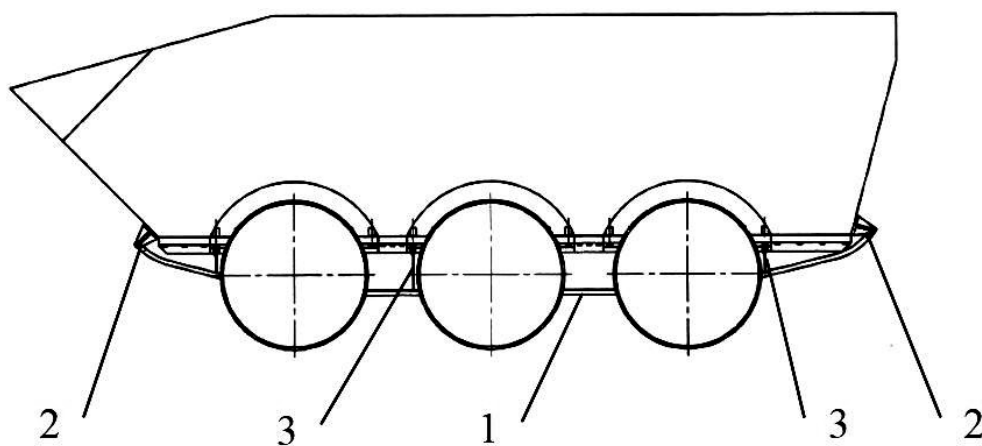


Fig. 10. Explosion-proof set mounted on base vehicle

1 – multilayer flexible armour, 2 – supports, 3 – supporting ropes

Explosion-proof set (Fig. 11) consists of flexible armour 1, vacuum container 2, bubble wrap panel 3, and a protective panel 4. Explosion-proof armour 1 is equipped with supporting ropes attached to brackets 6. In between the lower bottom 7 and higher bottom 8, vacuum container 2 is inserted. Bubble wrap 3 and protective panel 4 are located inside the hull and their shape reflects the shape of the free space of the floor.

The advantage of using explosion-proof set is the fact that the flexible armour 1 intercepts the fragments of exploded mines or IEDs and partially dissipates the blast-wave energy, as the result of the set's inertial loads, whereas the vacuum container 2 precludes the propagation of blast wave from the underside of the vehicle towards its interior. Another advantage in the form of bubble wrap panel 3 is that it protects the legs of the crew from the harm resulting from the deformation of the upper bottom 8 of the vehicle hull.

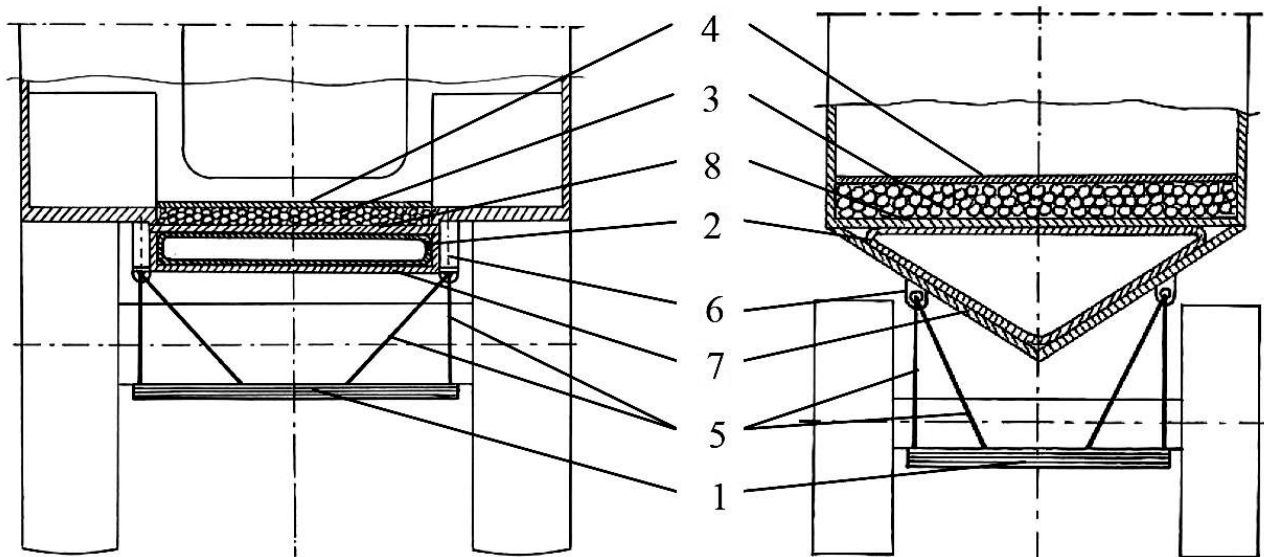


Fig.11. KTO vehicle concept (on the left hand-side) and MRAP vehicle (on the right) with explosion-proof set attached [7, 8]: 1 – flexible explosion-proof armour, 2 – vacuum container, 3 – double wrap panel, 4 – protective panel, 5 – supporting ropes, 6 – brackets, 7 – lower bottom, 8 – upper bottom

What should be considered here, is that the deformation of the hull underside causes the deformations and vibrations of the side walls joined to it. The walls also generate a spherical blast wave, the propagation of which is directed towards the insides of the vehicle. That is why total elimination of pressure pulsation in the crew compartment is a practically impossible task.

7. Rope explosion-proof panel

Rope explosion-proof panel [9] is to be used to protect the underside of vehicle hull against the impact of blast wave generated as the result of a detonation of explosive (Fig. 12). Rope explosion-proof panel contains suppressing layers 1, perpendicular to each other, which are connected to elastomeric linings 3 using elastomeric adhesive 2. Suppressing layers 1 are composed of braid weaves 4 connected to one another with elastic lines of technical flame-resistant fabrics 5. The braid weave 4 contains three elastic lines made of flame-retardant fibers 6. Rope explosion-proof panel 1 is mounted to the plate 7 underside of vehicle hull and wheel arches 8 of the combat vehicle 9 hull.

The great advantage of this kind of explosion-proof panel design is the high capability of blast wave attenuation as generated by the detonation of explosive. What follows, is a conclusion that the velocity of sound propagation in an elastic rope perpendicularly to its longitudinal axis and in elastomeric linings is significantly lower than, as was already mentioned, in other structural materials, such as composites, polymers or materials used for explosion-proof shields, such as aluminium foams, or even in air. The great benefit, in case of rope explosion-proof panel, is its simple manufacturing process and ease simplicity of the mounting process to the underside of vehicle hull by the crew.

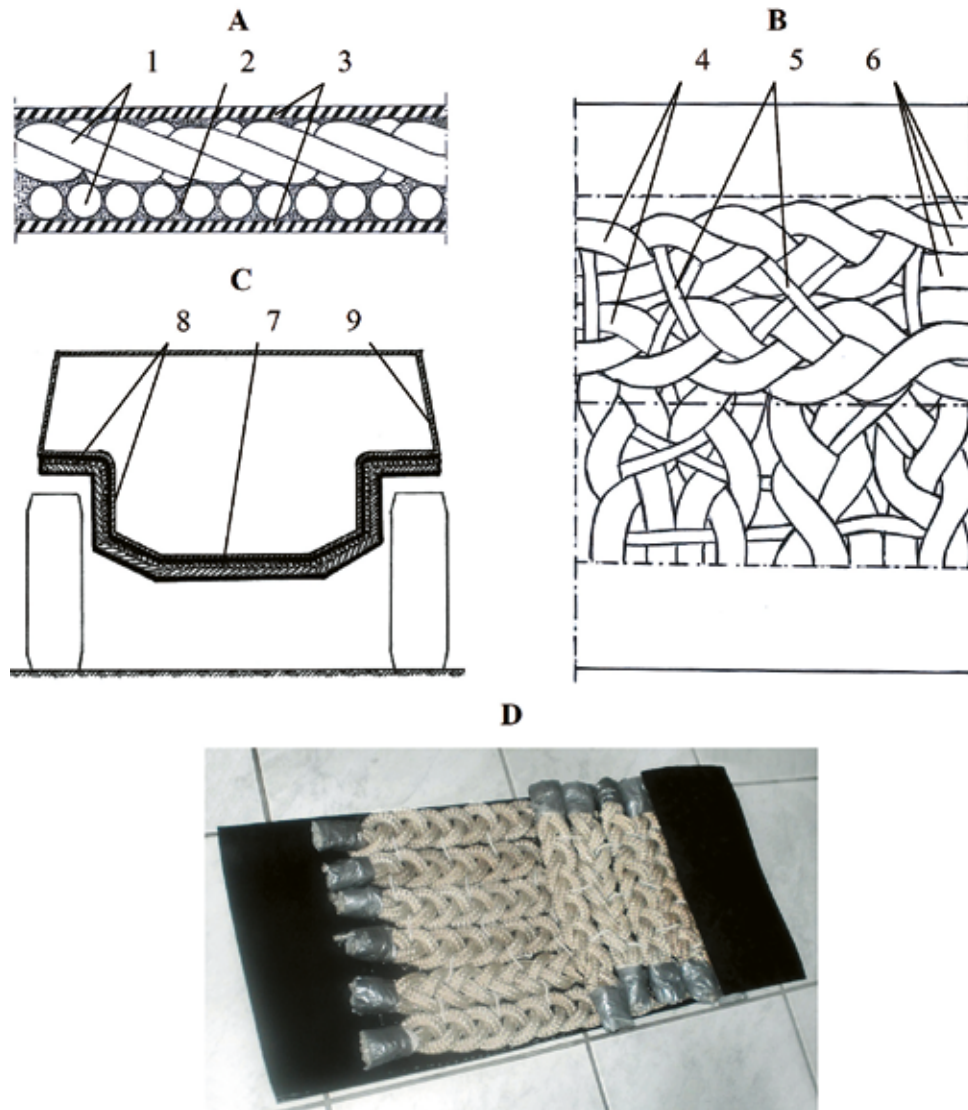


Fig. 12. Rope explosion-proof panel – frontal view (A); panel with suppressing layers exposed (B) – top view; panel mounted to the bottom plate and arch plate of a combat vehicle (C) panel section suppressing layers exposed (D) [9]

8. Conclusions

The following conclusions can be drawn from the work presented:

1. The conflicting sides of the contemporary military conflicts widely employ mine warfare, that is the use of various mines and IEDs.
2. Optimal (streamlined) vehicle hull underside design, its reinforcement and increased ground clearance and the application of explosion energy suppressing measures decreases the efficiency of the mine and IEDs' impact on the vehicle hull underside.
3. The idea of explosion-proof multilayer flexible armour for a tank, the explosion-proof for KTO and MRAP vehicles and rope explosion-proof panel are possible means of increasing the protection level of the hull underside's resistance to the above-mentioned range of threats.
4. Explosion-proof multilayer flexible armour intercepts fragmentation, disturbs the impact of a superplastic metal jet and an explosively-formed projectile (EFP) and partially disperses the blast-wave generated by a high explosive detonation.

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Developments of military institute of engineer technology in the area of C-IED

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Abstract

The paper concerns a wide spectrum of all range of hazardous materials, including mines, unexploded ordnance (UXO), improvised explosive devices (IEDs), munitions and explosives. The paper contains a description of new detection methods, disposal and transport of mines, UXO, IEDs, munitions and explosives used to construct IEDs. In the part of the paper dedicated to the detection of hazardous materials, information on the findings and the results of Military Institute of Engineer Technology's (WITI's) studies dedicated to the detection means and methods, as well as new detection equipment, including advanced sensor technology is provided.

1. Multisensor Mine and IED Detection System (MMIDS)

Multisensor Mine and IED Detection System consists of a boom with supporting wheels (Fig. 1); detection heads: the first one with infrared camera and the second one with a ground penetrating radar (GPR) with metal detector sensor, a signal processing array and a marking system for marking detected hazardous objects (Fig. 2). The system can be adjusted to be mounted on all kinds of armed vehicle used in Polish Armed Forces.



*Fig. 1. Multisensor mine and IED detection system constructed
in the Military Institute of Engineer Technology for the Polish Army*



*Fig. 2. Multispectral detection head and examples of antitank mine detection with different sensors
(from left to right: GPR, MD, IR) of WITI's the multisensor mine and IED detection system*

2. Multisectional Mine Detector System (MMDS)

MMDS multisectional mine detector system (see Fig. 3) was developed in WITI, as part of the project for the Polish Armed Forces.

The MMDS comprises the following elements:

- Detection head mounted on hydraulically controlled boom;
- Visualisation and control system;
- Optical and acoustic system;
- Marker detection system.



Fig. 3. Two examples of multisectional mine detector systems constructed in Military Institute of Engineer Technology for the Polish Army

3. Microsensor for Detection of Explosive Materials (MEMS)

Engagement of the Polish Armed Forces in stabilisation missions both in Afghanistan and in Iraq verified the requirements of the modern battlefield. One of the areas requiring equipment upgrade was the issue of detecting and neutralizing IEDs. IEDs are characterized by diversified construction and application of different explosives derived from artillery shells, mines and grenades from antitank grenade launchers. It was their existence that prompted the introduction of new technological solutions in the field of mine and IED detection methods. Despite the high degree of diversification, as far as IED construction is concerned, one feature common for all of them is high content of explosives (see Table 1).

Commercially available explosives	Chemical compositions
c-2	RDX, TNT, DNT, NC, MNT
c-3	RDX, TNT, DNT, TETRYL, NC
c-4	RDX, Fuel oil, Polyisobutylene
Cyclotol	RDX, TNT
DBX	TNT, RDX, AN, Al
HTA-3	HMX, TNT, Al
Pentolite	PETN, TNT
PTX-1	PETN, TNT, Teteryl
PTX-2	RDX, TNT, PETN
Tetroyl	TNT, Teteryl
Dynamite 3	NG, NC, SN
Red diamond	NG, EGDN, SN, AL, Chalk

Table 1. Chemical composition of selected, commercially available explosives [1]

According to the data in the Table 1, most of the commercially available explosives contain TNT and RDX. If an IED contains one of these chemicals, it is possible to detect some small content of trace vapours exuded by either TNT or RDX and which are found above the IED (see Table 2).

Table 2. Properties of explosive materials [2]

Compound	Gas density		
	No. of molecules in 10 ¹² air molecules (ppt)	No. of molecules in 1 cm ³ air	Mass of the explosive 1 cm ³ air
TNT	10 ⁴	10 ¹	10 ⁻¹¹
TNT	10 ⁰	10 ⁸	10 ⁻¹⁴

This miniscule number of explosive material particles requires the detection equipment to include state-of-the-art MEMS (Microelectromechanical Systems) based detectors. Cantilever-type MEMS are characterized by small dimensions of which the smallest is in the range of micrometers.

It is because of these small dimensions that these structures are capable of converting weak intermolecular forces into electrical signals, measurable in macroscopic scale. When explosive material particles are settled onto the sensor surface, a change in mass is noted, and a characteristic resonant frequency is depended upon this change:

$$k = \frac{Ewt^3}{4(1-\nu)l^3} \quad f_1 = \frac{1}{2\pi} \sqrt{\frac{k}{0.24m}}$$

where E and ν are Young's modulus and Piosson's ratio characteristic for the microcantilever material, respectively, while l, w and t are the length, width and thickness of the microcantilever, respectively.

The value of 0.24 is used to convert the mass of the whole microcantilever into the effective mass focused at its end. The change in resonant frequency allows for the determination of the presence of the explosive material particles on the surface of the sensor.

To obtain high selectivity of the microcantilever sensors, a chemically-active layer is applied onto their surface and the layer is to attract TNT and RDX particles. 4-Mercaptobenzoic acid self-assembling layer is used most often.

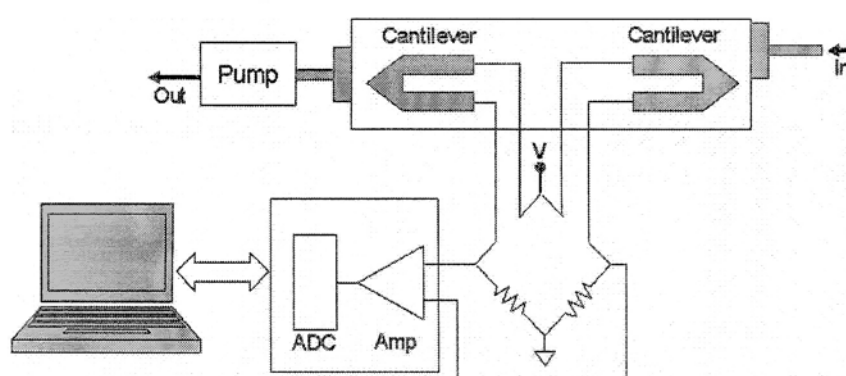


Fig. 4. Example of construction of microcantilever sensor [2]

4. Non-linear Junction Detection (NLJD)

Non-linear junction detection principle, also called nonlinear radiolocation [3], is based on nonlinear effect of the generation of harmonics and combination frequencies at semiconductor electronic components and contacts of metallic parts contained in objects exposed to electromagnetic field in specific radio frequency band – Fig.5.

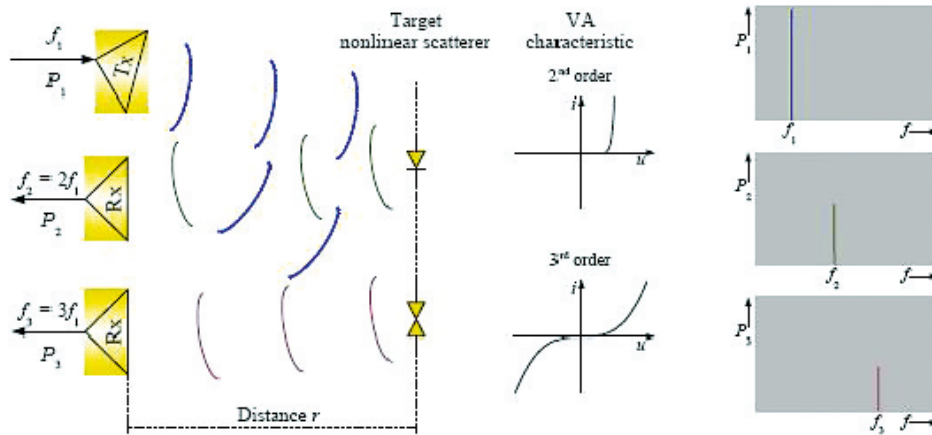


Fig. 5. General principle of nonlinear junction detection

$$f_x = mf_1 + nf_2 + \dots + qf_r$$

In general the frequency of the excited signal f_x is determined by the simple relationship where f_1, f_2, \dots, f_r are the transmitter frequencies; m, n, q are positive or negative integers (including zero), while the sum $|m| + |n| + \dots + |q|$ denotes the order of the intermodulation interference, in the simplest case f_x is the frequency of a harmonic of appropriate order.

The measuring system consisted of a frequency generator on the transmitting side and spectrum analyzer on receiving side. The generator was linearly swept in 10 MHz bandwidth from 890 to 905 MHz, so the frequency limits of the second harmonic response are determined in range from 1785 to 1805 MHz. The distance between antenna is $R = 2r = 0.4$ m and the scatterer was placed in-between.

5. Family of Modular Vehicles for Road Reconnaissance and IED Disposal (MVRR)

The system will consist of three different light armoured vehicles tailored to performed specific tasks – Fig. 6.

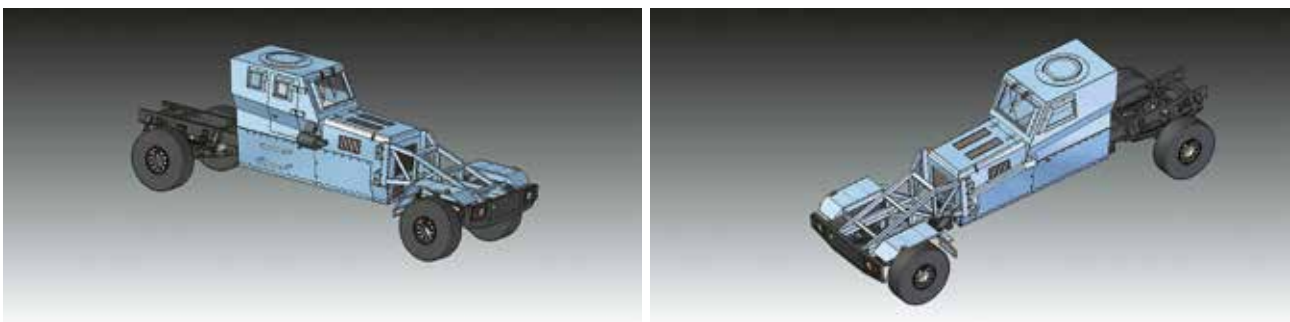


Fig. 6. Light, Modular vehicle designed to specific tasks

The system allows disposal, detection and handling of mines, UXO, IEDs and explosives. Each vehicle of the system has its own dedicated equipment. The first in the group has a mine flail, the second one – a GPR with metal detector, and the third one – a boom with manipulator to pick the detected object up – Fig. 7.

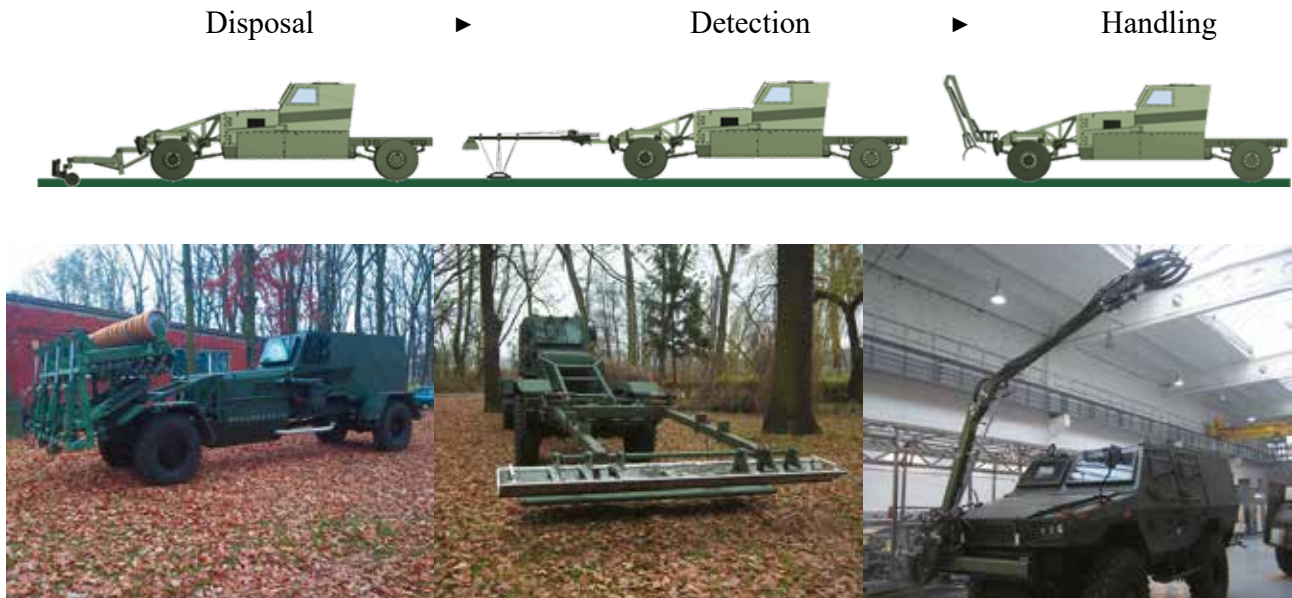


Fig.7. Equipment for a light vehicle: multisensor detector (metal detector and GPR), mine roller; arm used to remove hazardous objects

Resistance to bullets fired from heavy machine guns, AP ammunition, in accordance with STANAG 4569 level 4. It is also resistant to 8 kg blast AT mine under the centre of the vehicle and to 10 kg blast under the wheel of the vehicle.

Detection:

- typical scatterable AT mines – down to the depth 0.5 m,
- AP mines – down to the depth of 0.2 m,
- firing pin – down to the depth of 0.2 m.

Mine-clearance:

- typical pressure-activated and non-contact fuse AT blast mines
- scatterable mines.

Handling of objects of the following dimensions:

- length: 100 – 1000 mm,
- diameter: 100 – 500 mm,
- mass: 200 kg.

6. Hand-held Hazardous Materials Detector (HHMD)

The Project is aimed at developing a state-of-the-art hand-held detector combining the technology of both pulse induction metal detector (PIMD) – Fig. 8 and GPR.

Hand-held detector contains:

- Detection head (in ver.1 – a PIMD; in ver.2 - a PIMD & GPR head);
- Ergonomic boom;
- Optical and acoustic alarm system;
- GPS and recording system.

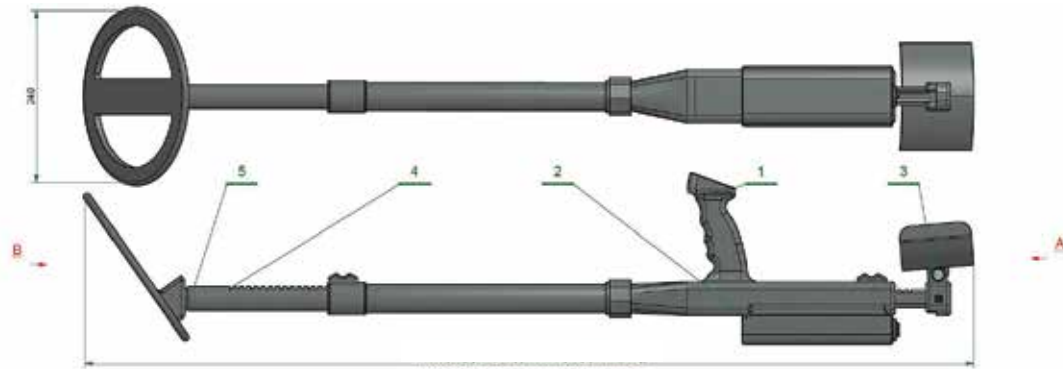
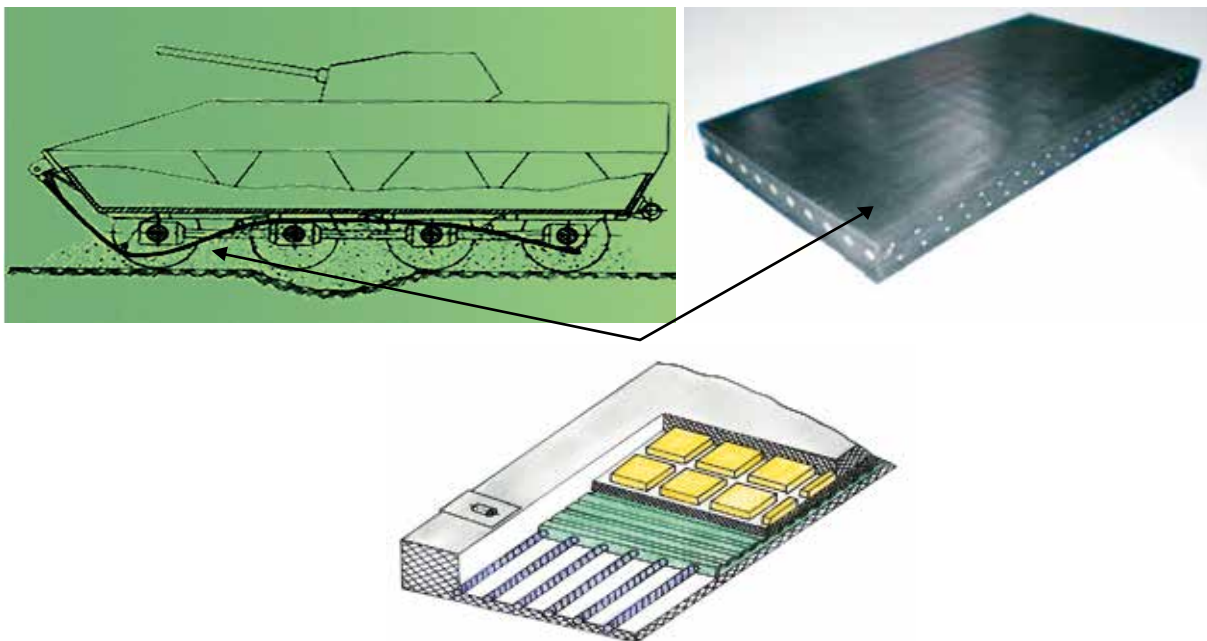


Fig. 8. Light hand-held detector

7. IED protection system for vehicles (ERA)

The aim of the Project is to develop a detailed idea of protecting a wheeled vehicle hull underside using a flexible explosive reactive armour (ERA) – Fig. 9, which would mitigate the impact of explosive detonation impulse and also weaken shaped charge jets.



In case of a mine- or IED blast, the ERA operating principle consists in weakening the mine/IED products' pressure impulse transferred to the vehicle underside. Some part of this energy is utilized on tossing the flexible ERA whose inertia causes partial dissipation of detonation products along the sides of the vehicle up .

In case of mines and IED containing shaped charge, the obstacle in the form of a flexible ERA which the forming projectile encounters precludes its proper and therefore decreases its effectiveness. In turn, detonation of the explosive within the ERA which ensues following the impact of the mine's shaped charge (plasma) jet limits its penetration ability.

8. Humanitarian demining tools (Tiramisu project)

TIRAMISU „Toolbox Implementation for Removal of Anti-personel Mines, Submunitions and UXO ” Project has been developed as part of EC’s Seventh Framework Programme (FP7).

The tools designed by WITI included a blast-containment vessel and a mine roller.

According to the design, the ERW blast containment vessel (Fig. 10) is to be used to transport and temporary store items containing an explosive charge up to 1 kg TNT.

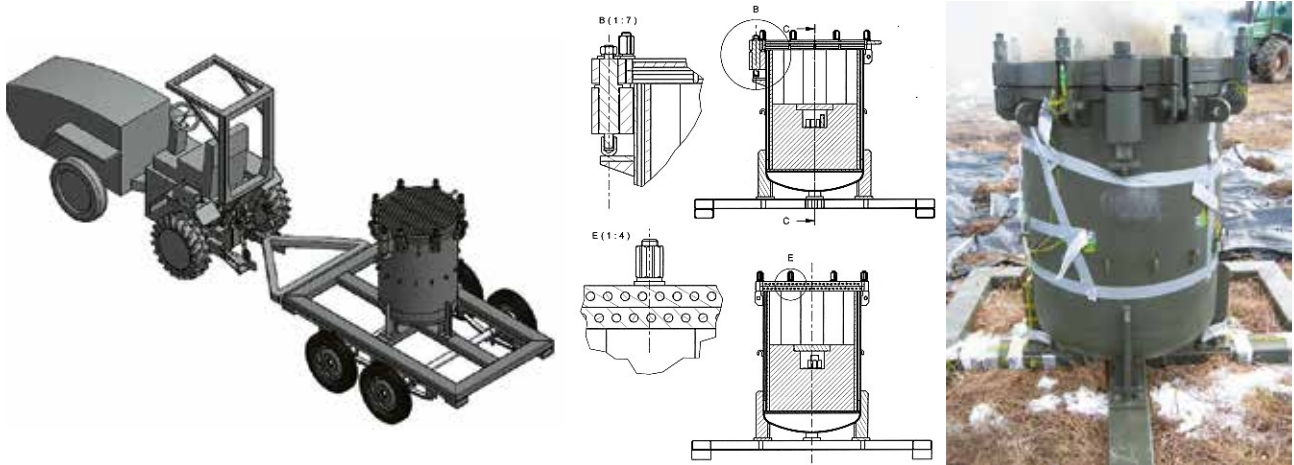


Fig. 10. ERW blast-containment vessel

In Poland, the proper regulations (Journal of Laws, item 1421 dated October 20th, 2014); specify that following an explosion of an explosive transported either by a vehicle or in a blast-containment vessel, the following rules have to be obeyed:

possible fragmentation should not be send out directly in horizontal plane;

area hazardous to human health and resulting from the impact of shock-wave (atmospheric pressure of over 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.

THE ABOVE-DESCRIBED DESIGN FULFILLS ALL THE CRITERIA LISTED.

The mine-roller construction (Fig. 11) is capable of resisting blast-wave generated as the result of a 1kg TNT explosion. Its aim is to neutralize AP mines.

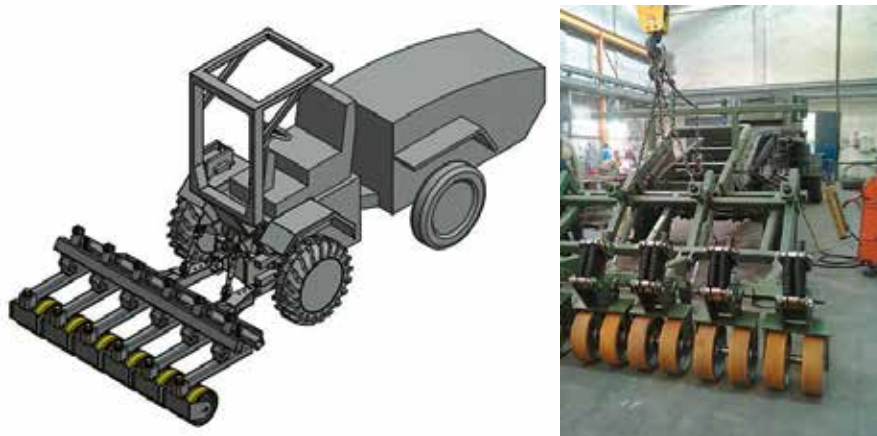


Fig. 11. Mine roller

THE ABOVE-DESCRIBED DESIGN FULFILLS ALL THE CRITERIA ASSUMED.

Acknowledgments

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MINERVA: a vehicle mounted ground penetrating radar system for IED and mine detection

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Mines and improvised explosive devices (IEDs) pose a constant threat to military personnel and equipment as well as civilians living in conflict or post-conflict zones. Often hidden in the environment or underground, they are difficult to detect and as well as potentially inflicting casualties their presence results in areas or routes being dangerous or impossible to use.

Starting from the experience gained during previous European research projects on humanitarian demining, including the most recent FP7-TIRAMISU project (2012-2016), and a national project co-funded by the Italian Ministry of Defense for counter-IED (C-IED) applications, IDS – Ingegneria dei Sistemi S.p.A. has developed an operational C-IED tool named Minerva.

Minerva is a vehicle-mounted ground penetrating radar (GPR) sensor for counter-IED and mine route clearance.

It is a product of IDS's past experience in developing and manufacturing market leading GPR systems and its expertise in radar systems and antenna design. It uses from one to four modular antenna arrays to produce radar images of the subsoil, from simple 2D images to complex real-time high resolution 3D tomography.

Minerva is capable of automatically detecting both metallic and non-metallic objects, and then extracting their features and electromagnetic signatures. These are then used as input of the detection and classification algorithm, suitably trained with prototype based training set. The system has a high level of mobility as the antenna height does not need to be continually adjusted to account for ground level changes. The radar's performance is optimal even with a variable antenna stand off from the ground.

One of the most appealing features for end-users is its automatic detection and classification of anomalies, which has proven reliable in different realistic soil types in dry to moderately moist conditions.

Deploying Low Cost, Small Unmanned Aerial Systems in Humanitarian Mine Action

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Abstract: Small unmanned aerial systems (sUAS's), which are made up of an unmanned aerial vehicle (UAV or 'drone'), a payload, ground control system, live video feed and other peripherals, can provide great utility in humanitarian mine action (HMA). Uses include: site overviews for pre-deployment planning and progress reporting during clearance operations; up-to-date, high resolution situational information and reconnaissance; evidence gathering as part of the non-technical survey (NTS) process; and real time video feeds during explosive ordnance disposal (EOD) & improvised explosive device (IED) operations.

sUAS's can help improve safety, increase productivity, make reporting more transparent, and provide better quality information to aid decision making during the land release process. This paper presents sample data outputs from low cost, off-the-shelf mini sUAS's, ranging from overhead snapshots, through to high resolution cartography and detailed GIS information. Tests were conducted using both standard imaging and GIS capabilities, plus near-infrared modified cameras that show better vegetation contrast. These results can be achieved using readily available commercial sUAS's with a take-off weight of less than 2kg.

Even though a number of past sUAS research projects have been undertaken in the HMA sector, the next step is addressing deployment challenges. Requirements such as creating standard operating procedures (SOP's), developing training programs, gaining permission to operate from national authorities, and investment in the infrastructure required to support each sUAS programme are addressed. The popularity of UAV's as a consumer electronics device means that millions of units are now being sold each year. However, there has only been limited deployment on a routine basis, without integration into standard HMA operations. The issues limiting the application of sUAS's will be addressed. Keywords: UAS, UAV, RPAS, drone, remote sensing, photogrammetry, aerial survey, mapping, GIS, EOD, IED, humanitarian mine action

Introduction

A multirotor, small unmanned aerial system (sUAS), is generally an electronic aircraft system kept aloft by multiple propellers, four, when in a quadcopter configuration. Being able to accurately position such a system in three dimensional space has made multirotor sUAS's popular for imaging and surveying uses ranging from airborne real estate photography to aerial archaeology.

A number of trials have taken place using airborne platforms in humanitarian mine action (HMA)^{[1][2][3][4][5][6]}, helping demonstrate key advantages of either an airborne camera, sensors or mapping platform. This paper builds on such findings in relation to a category of multirotor sUAS that are low cost, with a retail price of under 3,500 USD and a flying weight of less than 2kg. One of the most popular mini sUAS's is a DJI Phantom quadcopter, with the latest model in the series being the Phantom 4 Professional^[7], with a take-off weight of 1.4kg (Fig.1). A gyroscopically stabilised 20 Megapixel camera is included, with an auto pilot and flight time of up to 30 minutes.



Figure 1: Shows a 1.4kg, DJI Phantom 4 Professional, mini-size quadcopter. Image credit www.dji.com.

sUAS's like this can assist HMA and explosive remnants of war (ERW) reduction programs in many different ways, offering utility ranging from simple aerial snapshots to detailed geographical information system (GIS) outputs and forward-looking reconnaissance. Manual pilot input is via a handheld controller, with a real-time video stream displayed on a tablet or other type of monitor. Many sUAS's are also capable of flying pre-programmed waypoint missions, controlled via a PC, tablet device or smartphone. A number of sensors enable self-stabilizing capabilities for the aircraft to maintain a precise hover, supplemented by added camera stability offered by a gyro-stabilized gimbal.

Survey, Intelligence Gathering & Situational Awareness

Research into the use of sUAS's for landmine detection is ongoing however the use of commercial, off-the-shelf (COTS) micro sUAS's as a survey and intelligence gathering tool is possible with existing available technology. The primary sensor is an optical camera, capturing imagery and video in the visible light spectrum. On most digital cameras, the performance can be improved by removing the infrared blocking filter which results in enhanced sensitivity to the very near infrared. Vegetation typically has a strong reflection in the near infrared, known as the 'red-edge'. Modifying the camera to make it sensitive in this region provides significantly better vegetation contrast, as shown in Figure 3 and Figure 6.

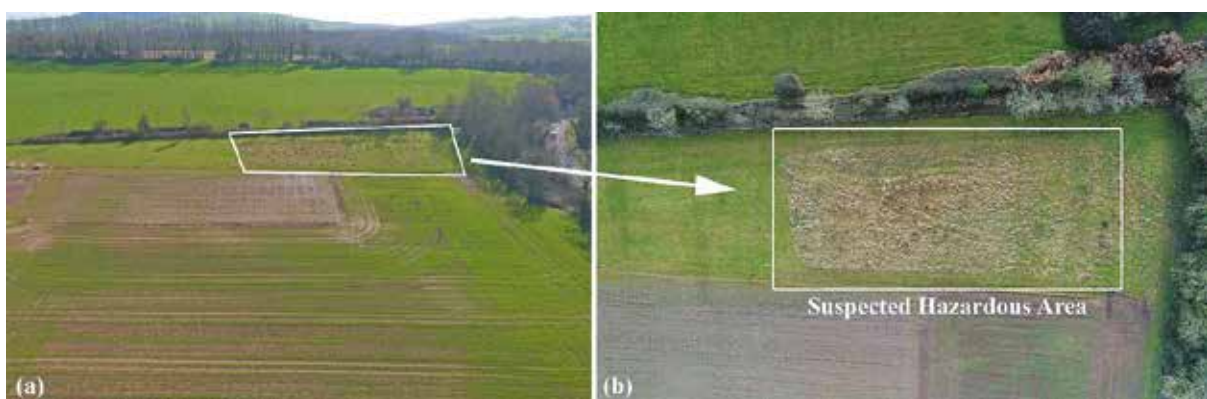


Figure 2: Shows (a) evidence of land use, most of the area is being farmed. And (b) the suspected hazardous area (SHA) in relation to land used for farming.

Objects may be spotted that represent direct evidence of explosive hazards, in addition to capturing secondary evidence and providing situational awareness. Gathering visual evidence fits within the scope of non-technical survey (NTS), with a sUAS being a tool that helps deliver a form of NTS+. Up-to-date, high resolution aerial imagery (Fig. 2) can complement other sources of information such

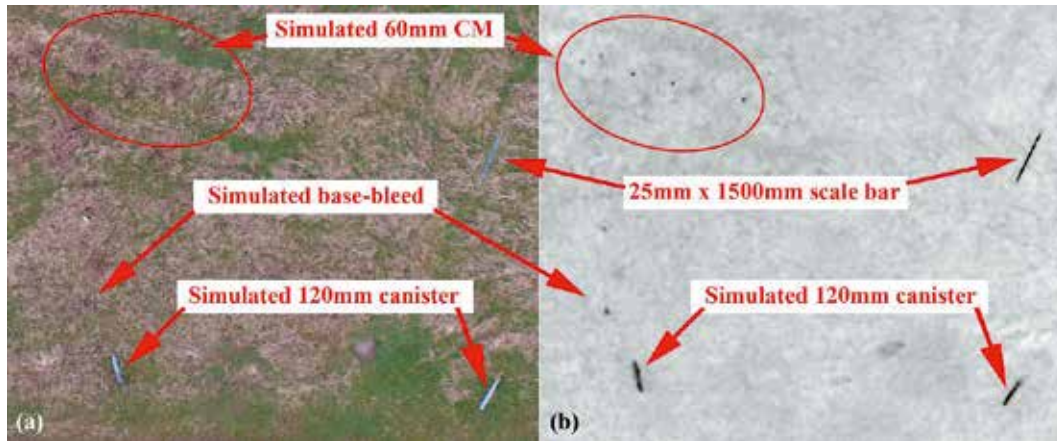


Figure 3: Shows evidence captured from a height of 20m. Image (a) is a standard photo. Image (b) is a 'red-edge' processed photo from a modified camera for better vegetation contrast.

as the history of a conflict, battlefield maps, information from combatants and local informants, in addition to observations made on the ground by members of a NTS team.

Risk Assessment & Planning

The scope for sUAS's goes beyond NTS, as up-to-date, high quality situational information is also useful for pre-deployment planning during clearance operations, risk assessments, progress reporting, quality assurance and site monitoring. Speed is a major advantage for reporting and planning, with a single overhead snapshot only taking minutes to capture, less time than it would take to walk around the perimeter of clearance operations. Snapshots taken on a routine basis can be used for a time-se-

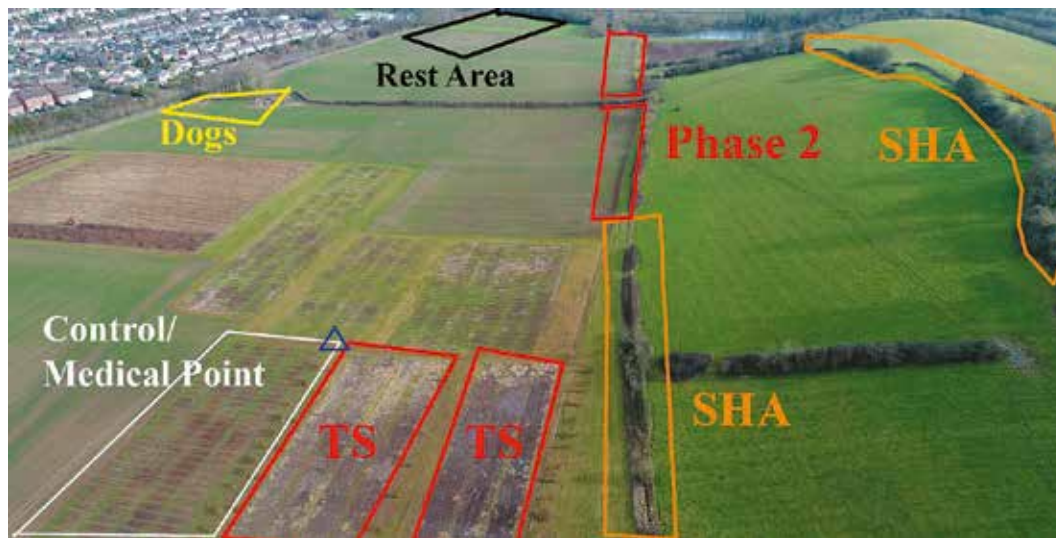


Figure 4: Shows how overhead visibility for a roof inspection can be valuable in a complex urban environment. This example shows evidence of a cluster munition strike. Image credit: Andy Smith.

ries analysis of progress during operations. Satellite imagery may not exist for certain locations or be obsolete, so an up-to-date, high resolution site overview can provide many advantages during pre-deployment planning.



Figure 5: Shows how an up-to-date, high resolution sUAS image can be used for pre-deployment planning.

Access to Difficult Locations

Areas of interest can be difficult to access due to rugged terrain, obstructions, or complex environments, such as compromised, multi storey buildings in urban post-conflict environments (Fig. 5). In many cases, reconnaissance and evidence gathering from above will assist the quality of reporting and may improve safety. Being able to inspect roofs, fly over obstacles and difficult terrain can also mean faster access to visual evidence.

Very Close Inspection

A mini sUAS is in effect a small flying robot, being able to move around an object to gain forward looking reconnaissance via a live video feed, storing 4k video on an internal memory card. The sUAS can hover in a stationary position or fly around suspect objects (Fig. 6), tilting the camera up or down.

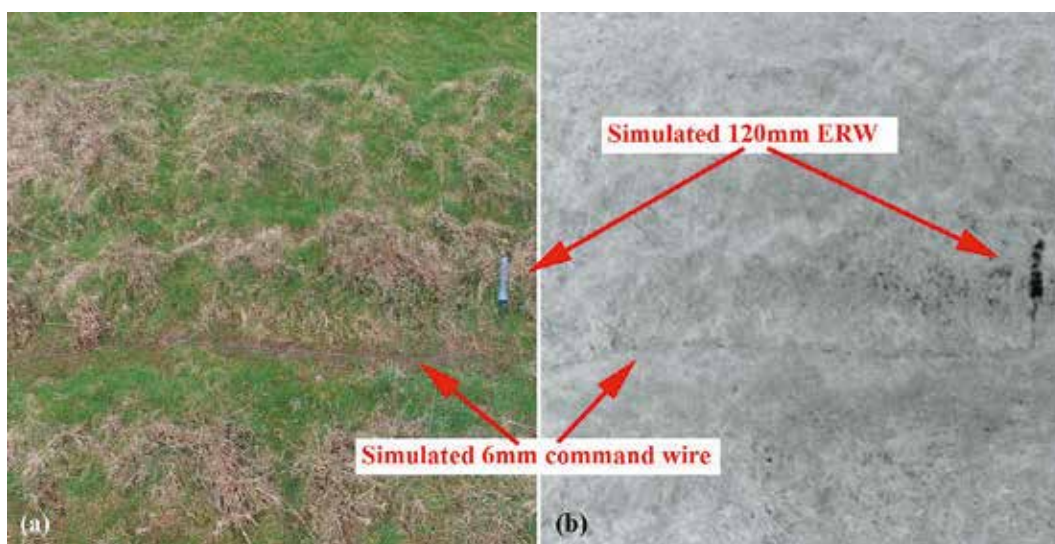


Figure 6: Shows close reconnaissance from 3m above the ground. Photo (a) is from a standard camera. Photo (b) is from a 'red-edge' modified camera for better vegetation contrast.

Pan can be achieved by either rotating the sUAS, or in some cases, separate camera control is possible by a second operator.

The cost of a sUAS is a fraction of that of ground robots used in EOD operations and is within the reach of humanitarian budgets. Some operators may find a mini sUAS to be a useful tool for forward looking intelligence during high-risk operations, particularly in environments where asymmetric conflicts took place. Very close reconnaissance would be an advanced, Level 3 operation (Fig. 8), due to risk and reduced stand-off distances from objects and the ground.

GIS Capabilities

Capabilities go beyond just taking photos and video, even from a 1.4kg, micro quadcopter. Many sUAS's incorporate a sophisticated autopilot, which makes pre-programmed waypoint flying possible. During a waypoint mission, the sUAS can fly a set pattern in strips over an area of interest, capturing images at a set altitude, with a predetermined amount of overlap between lane widths. Images are then stitched together and converted into a high resolution orthomosaic, point cloud, digital surface model and three dimensional representation of the environment. Resolution can be less than a centimetre per pixel, with the ability to create topographic maps with sub centimetre contours. In this case, the sUAS becomes an ad-hoc, high resolution GIS and cartography tool (Fig. 7).

At a basic level, quadcopters like the Phantom series of quadcopter[7] also geotag photos, embedding GPS coordinates regarding the location of each shot, which can be useful for a number of HMA uses, particularly NTS reports.

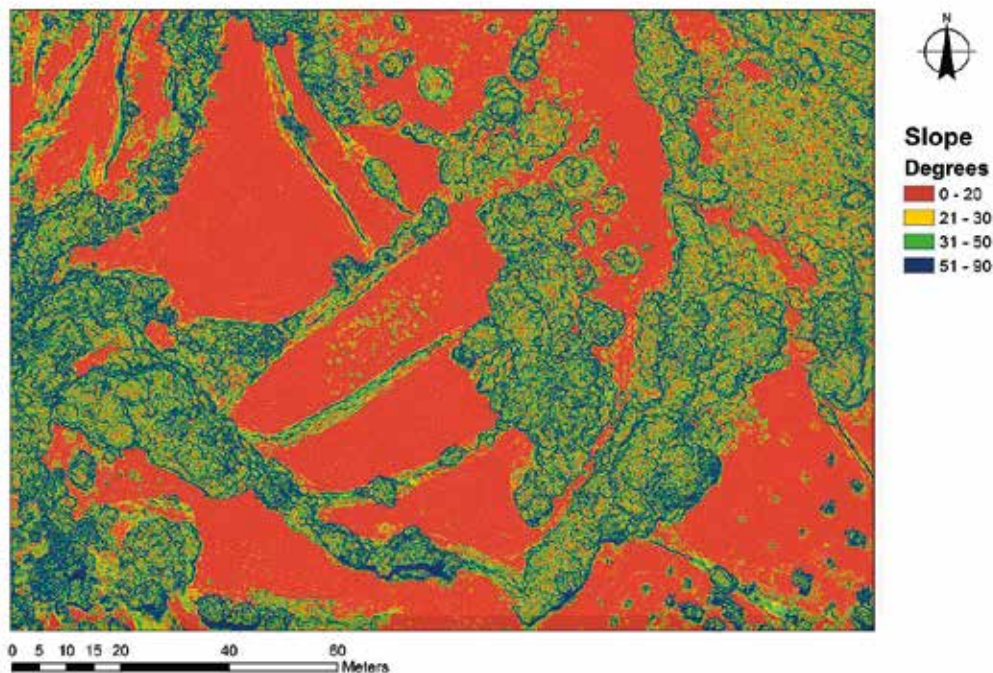


Figure 7: Shows an example of advanced GIS and cartographic capabilities from a micro sUAS. A map of the terrain has been made to indicate where a demining machine can operate, with an incline of up to 20 degrees.

Value to HMA Sector

New models of mini sUAS's on sale today perform better than predecessors but previous models have been capable of delivering similar benefits for several years now. Deployment has been limited in HMA compared to the uptake for surveying and inspection in other industries, with many deployment challenges needing to be addressed. Embedding trials, with a qualified sUAS operator taking part in routine operations even for a limited period of time would be one way to gain relevant, demonstrable data to help prove the validity of such a tool. There is also a need for NGO's and national authorities to share knowledge, ideally through sUAS case-studies, for the benefit of the HMA sector overall.

Standard Operating Procedures & Training

As with other humanitarian demining operations, a partnership should be established with national mine action authorities in the trial of, and eventual deployment of sUAS's. There is a lot to gain, particularly as better quality information can lead to more informed decisions.

To aid the HMA sector in writing standard operating procedures (SOP's), a set of example operational parameters based on standards set by major aviation authorities around the world, combined with experience from commercial operations in the civilian UAS sector are listed in Figure 8. A framework for three levels of operations has been established, from Level 1 for standard operations, through to Level 3 for higher risk missions. A modular structure has been utilized, in a similar way to how EOD training and operating limits are set. The aim is to deploy in stages, and launch at Level 1 without delay, whilst providing pilots sufficient training and minimising risk.

Risks for new pilots include: collision with objects such as a tree branches, losing orientation, or loss of signal by flying too far away, or operating in environmental conditions beyond the operator's skill level. Potential risks are addressed by creating a parameter specifying the minimum operational separation from structures, people and the ground, plus limits regarding maximum distance and defining an operational weather envelope for each level. Smaller, lighter sUAS's pose less risk in the case of a malfunction or collision, with weight limits indexed to operator competency. There is general consensus that a sub 2kg object poses a low risk of explosion if it was to fall onto a mine field. However, there will be a moral issue of leaving a small flying machine in a hazardous area where a child or member of the local community might try and retrieve it. Hence, a procedure is needed in a SOP to deal with a lost sUAS, such as having an EOD team clear a lane to recover it.

Table 1 lists suggested training and testing requirements for validating pilot competency. It is recommended to distribute palm-size nano quadcopters to potential candidates, as control stick movements are similar to outdoor sUAS's, for self-paced practise in advance. Those with aptitude could then participate in a Level 1 ground school, and then attend a flight school module. Competency should be tested at both ground and flight schools. A minimum amount of flying hours should also be logged prior to fieldwork in hazardous environments, and currency maintained in terms of a minimum amount of flight hours in the last three months, before work is undertaken after extended breaks.

Table 1: Training Recommendations				
Op Level	Ground School	Flight School	Pre-requisite	Min. Flying hours
Level 1	2 days	1 day	Nano flight test	2
Level 2	2 days	2 days	2 days	10
Level 3	2 days	2 days	2 days	30

Objective	Minimum Separation	Operator Level		
		UAS 1	UAS 2	UAS 3
Photo capture	30m	✓	✓	✓
Video capture	30m	✓	✓	✓
Inspection	30m	✓	✓	✓
Close Inspection	10m		✓	✓
Very Close Inspection	3m			✓
Waypoint flying (for GIS)			✓	✓
Max Wind speed		25 km/h	UAS limit	UAS limit
Maximum take-off weight		2kg	5kg	20kg
Minimum visibility		600m	300m	50m
Max Height ¹		120m	150m	300m
Max Distance (line of sight) ¹		300m	500m	1000m

Figure 8: Example multirotor sUAS operational parameters for deployment in HMA.

Summary

sUAS's commercially available today deliver all those capabilities listed, and more. Such a device should be a viable option in the HMA toolkit, and when targeted for specific uses, can provide additional safety and incremental value to operations, often in unique ways, not readily available through other methods.

Our primary recommendation is to find ways to increase confidence in the use of sUAS's by the HMA sector, with a view towards deploying low cost, low risk mini sUAS's at Level 1 as a starting point. A lot of value can be gained from Level 1 operations, from small, low cost products. Activities that lead to operational exposure for NGO's and mine action authorities are suggested, so both management and field staff can see a sUAS in action and appreciate the value of the real-world data that they can provide. Such demonstrations are very powerful.

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¹ Subject to national regulations.

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Contribution to e-Training in Military & Humanitarian Demining Unmanned Robotic Systems

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Abstract

The need of training of Military & Humanitarian Demining Unmanned Robotics Systems (M & HD URS) operators is discussed, and the way to satisfy this need by e-training is suggested. E-training is understood here as an extension of e-learning: e-learning consists in computer-network-based obtaining of knowledge, e-training has in view obtaining of operation skills. Similarly as in the case of e-learning, e-training systems will be able to serve large number of geographically dispersed learners, and self-paced courses accessed 24 hours a day, whenever they are needed, will be possible. Propaedeutic to e-training in MR & HD URS is given by the project concerning development a platform for design of computer trainer-simulators for operators of mobile robots. Development of such computer platform, intended to enable designing trainers-simulators for training in operation of different types of mobile robots - finding their application in the missions conducted in different environments, as well as in missions of military or police character - and creation of software for them, is the aim of this project. One can anticipate that diverse types of robots, differing by kind of traction, load capacity, range, manipulation ability, equipment with sensors will be applied in these missions. A need to train significant number of persons in operation of these robots, and obtaining high proficiency in operation, will come into being particularly in police and military forces for the sake of possible contact with explosives and toxic substances creating dangers for operator, population, and environment. Training tasks require many hours of exercises with different types of robots. Conducting of such training with use of real robots would be unprofitable, and probably unfeasible for the technical and organizational reasons – for difficulties of creation of all possible situations and coincidences with which an operator of robots has to cope. The use of trainers, simulating robots' behavior in different situations and circumstances, will be a necessity. Such trainers, for different types and variants of robots, will have to be designed, manufactured, delivered to users and serviced, so establishing of an innovative enterprise of adequate profile will be justified. Computer platform being a subject under consideration will be the basic “manufacturing appliance” of such enterprise.

The framework for M & HD URS operator training design will be also presented. The basic idea of the framework is to provide advanced software tools to improve the performance of the mobile robot simulation design that are applicable for operator training. The simulator is the end product of the framework. It is important to emphasize that presented result is a new approach related to mobile robots applications in M & HD and potentially can improve also the process of advance mobile robot application design as well as professional training of the operators.

IED Risk Management by Response Training in HMA

Ben Remfrey MBE, MI Exp. E

Introduction

The Humanitarian Mine Action (HMA) industry has seen an increase in the challenges it faces over the past 2 decades with the use of what is not a new phenomenon. IEDs have been deployed by terrorist groups for many years where they have utilised their destructive effect globally. In countries, such as Afghanistan, Libya, Syria and Iraq we have seen extremist groups use IEDs to maximum effect where the HMA industry are now conducting clearances of these devices on a large scale. The legacy of seeding routes, buildings, defensive positions and large areas of land with IEDs has become a huge burden in addition to the other ERW such as mines and UXO which also pose a further risk.

The industry is well placed and highly skilled in dealing with conventional clearance tasks such as Battle Area Clearance and demining. The challenges faced by vast numbers of legacy / abandoned IEDs is a relatively new threat, one which is a difficult and complex problem to mitigate. The scale of the problem and the complexity of clearance demands that increasing numbers of nationals and HMA personnel require C-IED and Search risk management training to deal with this dangerous and ever present threat. Conduct of clearance operations needs to be tightly managed and the ability to identify the risks and clearance techniques required to remove them fully understanding.

The risks involved in dealing with IEDs are extremely high and as such it is vital that there are standards, procedures and protocols put in place from which to found one's operations, management and training.

PCM & MK recognise the need for mitigating the IED risk and have developed several bespoke and focused training courses to disseminate the knowledge and skills required for management and clearance personnel to safely and effectively deal with this threat. The scale of the problem is such that the HMA industry can no longer rely on ex-military EOD / IEDD personnel to meet the challenges of this problem and must build its own capability. This requires IED risk management by response training in HMA.



International Mine Action Standards (IMAS)

Over many decades, UNMAS, the GICHD and the HMA industry have collectively developed an industry standard for clearance operations such as, IMAS, NTSGs, TNMAs, T&E protocols, IATG, bespoke publications etc. on which clearance operations, planning, conduct and operational procedures are founded; these are in essence HMA risk mitigation processes. They have been developed and are a well proven set of standards which lay out the levels and disciplines required for the safe conduct of clearance operations. This framework enables organisations to develop focused training and SOPs for subsequent clearance operations.

The HMA industry has taken the skills sets, experience and procedures utilised by military forces in countering IEDs and further developed them for use in HMA. C-IED and Search techniques are now taught by many organisations across the Middle East. It is important to realise that the concept of C-IED from a military point of view is one of identifying the IED risk and avoidance. Those operating in clearance also need to identify the threat, however rather than avoidance they then target the areas of highest perceived risk to locate and render safe the IEDs.

			Phases of Risk Management					
			Phase 1 Identify Hazards	Phase 2 Assess Hazards	Phase 3 Develop Controls	Phase 4 Implement	Phase 5 Supervise and	Phase 6 Manage Residual
Mine Action Processes	National Recovery Plan				X			X
	Mines Awareness -Pre-Mine Action				X	X		
	Level 1 Survey		X	X				
	Mine Action Plan			X	X	X	X	X
	Level 2 Survey		X	X				
	Level 3 Survey		X	X				
	Mines Awareness -During Mine Action		X		X	X		X
	Mine Clearance	Reconnaissance	X	X				
	Programmes	Planning		X	X			
		SOP Preparation			X	X		
		Training			X			
		Clearance/ Disposal	X	X	X	X	X	
		Quality Auditing	X	X	X	X	X	
		Mines Information Managment		X			X	X
	Mines Awareness -Post Mine Action		X		X	X		X
	Victim Support					X	X	X

Table 1 - Risk Management Process for Mine Action

The skills required to render safe an IED or boobytrap device is painstakingly slow and mentally taxing. Those working in areas where there are IEDs must systematically work their way through the environment where anything and everything has the potential to be a trigger. The training required to ensure risk managers and clearance operators have the requisite skills needs to be founded on IMAS with a period of on the job training (OJT) and mentoring to ensure success from its infancy to completion.

Risk Management Process for Mine Action

The phases of risk management are clearly laid out in the table 1 below for each phase of clearance operations. Following the phases of management and structuring training programmes through the IMAS, T&E and the CEN one can focus training delivery encompassing all perceived risk at each IMAS level 1 to 3+, ensuring the processes taught are fully compliant with IMAS. When courses are fully developed, they are reviewed by an external accrediting body and ratified as meeting the standards of IMAS at the identified level of delivery. In the case of C-IED and Search the procedures are based upon NATO C-IED TTP which have been adjusted to meet the requirements of conducting operations within HMA with the training objectives, enabling objectives and key learning points mapped to the IMAS CEN.

Training Delivery in Syria – (IED Risk Management by Response Training)

PCM & MK are currently delivering IMAS EOD, C-IED and Search training in Syria where the process of training delivery is structured and designed to ensure successful IED risk management and mitigation.

Risk management and mitigation through training methodologies: The principles for training delivery implemented by PCM & MK to mitigate IED risk in Syria;

1. Training Needs Analysis (TNA) – A full and detailed TNA conducted in response to the client’s requirement for training in addition to identifying the in-country threats and risks posed by ERW and IEDs. In addition, in country SOPs, EOD equipment, current operational tasking, training locations, resources, staffing and numbers to be trained was reviewed. Identification of those to be trained, their roles and future employment role, their background and any EOD experience they may have. This identified all risks to be mitigated through the production and delivery of training.

2. Training Course Development – All courses are fully compliant with IMAS, in country SOPs and developed to incorporate the current equipment and resource capability of those to be trained. (train them to use what they have). Additional time added to course length to allow for translation time during each lesson. Course training material translated into Arabic prior to deployment. Structured balance of theory verses practical training.

3. Interpreters - Interpreters qualified in EOD to IMAS standards to the level of course delivered. This ensures they understand the material being delivered and are familiar with terms and reference.

4. Instructor Staff – Identifying suitably qualified and experienced instructors is vital to successful delivery. All staff CV’s vetted and staff interviewed prior to employment. Instructors must be a minimum of 1 IMAS level above that of the course delivered.



5. In country preparation – All training staff deploy 2 weeks prior to commencement of training to establish the course environment. Lesson rehearsals, building of training aids, equipment testing, identifying suitable training areas, classrooms and preparing course material such as student handouts etc.

6. Progressive and Structured Training – All trainees are first introduced to the fundamentals of HMA through attendance on IMAS EOD level 1 with those showing aptitude selected to return for further training at IMAS level 2 having gained experience on deployed operations. Trainees who graduate out of the level 2 training go onto attend C-IED (team member) training. Through OTJ and mentoring those demonstrating strong management and EOD skills are selected to attend IMAS level 3 and then C-IED as a team leader. This stepped and tiered approach ensures all trained personnel can absorb the nuances of HMA at each IMAS level and can gain valuable experience before attending the next level of training. This process also allows for periods of on OJT and mentoring where staff can identify those stronger individuals for advancement.



7. Phased Assessments – Throughout the courses phase assessments are conducted with those not meeting the required standard given additional training or removed as unsuitable to continue. Assessments reviewed to ensure no training points have been missed or wrongly taught. Training courses are not attendance courses.



8. OJT and mentoring – C-IED and ERW disposal by its nature is dangerous and complex and as such it takes time and experience to become competent. OTJ and mentoring is vital to ensure all trained individuals can reach back or be given guidance as they build their skills sets and gain confidence. Instructors regularly meet with the mentoring teams and discuss the trainee's performance in the field. This enables instructors to identify training issues and individuals who have the aptitude to go onto the next levels of training. Mentoring and OJT should be for a minimum of 4 weeks.

9. Training Review and Assessment of Task Performances – All courses on completion are reviewed to identify areas of improvement and amendment. In addition, operational performance and the types of tasking are reviewed to ensure exercise scenario and practical training is specific to requirement; and to identify areas of weakness where training may be focused to improve future performance.

10. Continuous review of in theatre threats – Instructors are kept abreast of the latest threats and the emergence of any new IED or changes to SOPs. These will then be reviewed and changes to TTP and training incorporated for future courses.

11. Exercises and Assessment. All aspects of training are assessed to ensure trainees have assimilated the information delivered. Those who fail a phased assessment will be given further training before advancing onto the next phase. Those who fail assessment and do not demonstrate an aptitude will be removed from the course.

12. Trainee Selection for Advancement. – Only those personnel who demonstrate the aptitude and performance on operations will be selected for further training.

13. Course Duration – Courses are 4 weeks in duration to allow for the course content to be delivered through interpreter at a pace suitable to the trainees.

14. Capability verses Training – Only those who are IMAS EOD level 3 will go onto become C-IED team leaders. This ensures they have gained the requisite experience and levels of training to perform as a team leader and conduct the associated operational tasks. C-IED team leaders will be trained to conduct single searcher, render safe and disposal techniques on IEDs and again all team leaders will be mentored for a minimum of 4-weeks to ensure they are competent in their duties.



In Summary

Through a structured system of progressive training, gaining experience and OJT / mentoring the trainee can develop their personal skills and understanding at each IMAS level as they progress through the tiers of management and responsibility, thus mitigating risk through training.

Controlled management of training design and delivery PCM & MK are confident that clearance personnel will be successful in the mitigation and management of IED clearance operations.



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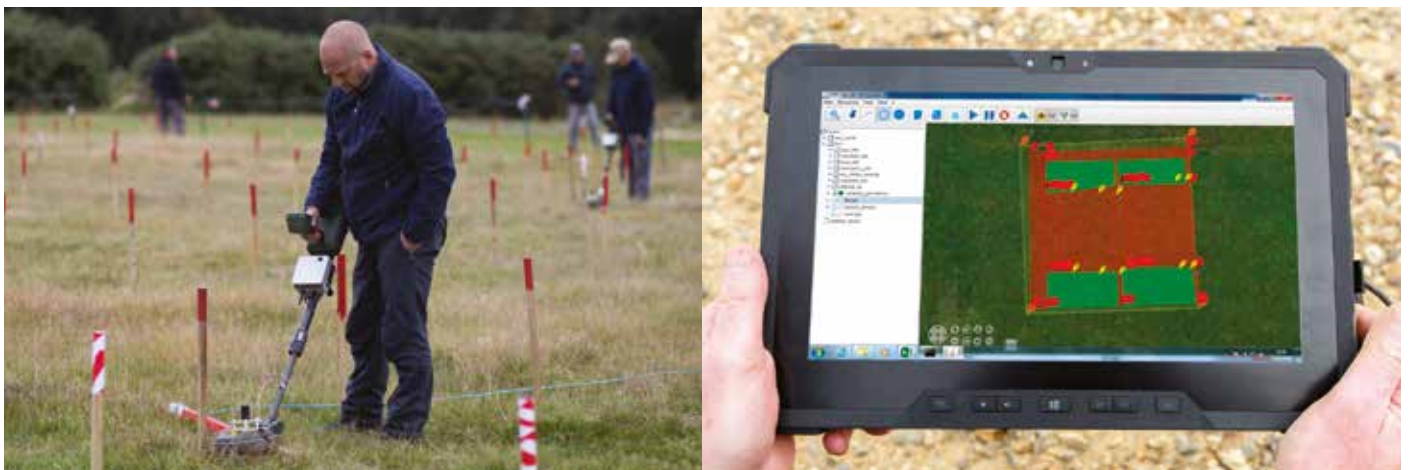


Mine and IED Detection Augmented by Satellite (MIDAS)

Ground Penetrating Radar (GPR) has emerged as the sensor of choice for Countering Explosive Ordnance such as Mines and Improvised Explosive Devices. GPR does not replace the Metal Detector in this regard, but instead provides a powerful ally in the search for Explosive Ordnance by providing size and depth information, regardless of the material from which the Explosive Ordnance is made. The Minehound family of dual detectors is jointly developed by Vallon and Cobham Antenna Systems.

In 2015, a consortium led by Cobham Antenna Systems was successful in securing an Integrated Application Project (IAP) from the European Space Agency (ESA), which had the objective of instrumenting Mine clearance with space assets to improve operational efficiency through electronic management, monitoring and reporting. The IAP was named 'Mine and IED Detection Augmented by Satellite' (MIDAS) and the consortium included Optima Group, NEXT Ingegneria dei Sistemi SpA and Maelstrom Virtual Productions.

MIDAS is now a suite of technologies that support demining operations. MIDAS includes hardware and software tools to support the planning, execution and post-operation analysis phases of a demining operation. Using satellite navigation aided by RTK reference signals, MIDAS provides highly accuracy real-time tracking of detectors. Clearance progress and threats are marked on a map which can be displayed on a PC, tablet and remotely on a web page. MIDAS additionally includes immersive software tools with virtual targets, to train deminers in the correct use of detectors, without the need for physical, buried targets.



Find out about MIDAS at MINE ACTION 2017:

- MIDAS minefield Clearance Management System and training system demonstration on Wednesday
- Presentation "State-of-the-Art in GPR-Based Detectors and Future Roadmap, a Cobham-Vallon Partnership" on Thursday
- Three papers in this book provide more detailed information
- Cobham staff will be on hand in the exhibition hall to answer questions



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With its testing capacity (test sites and equipment) and highly professional staff, the Centre offers the following services:

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- 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