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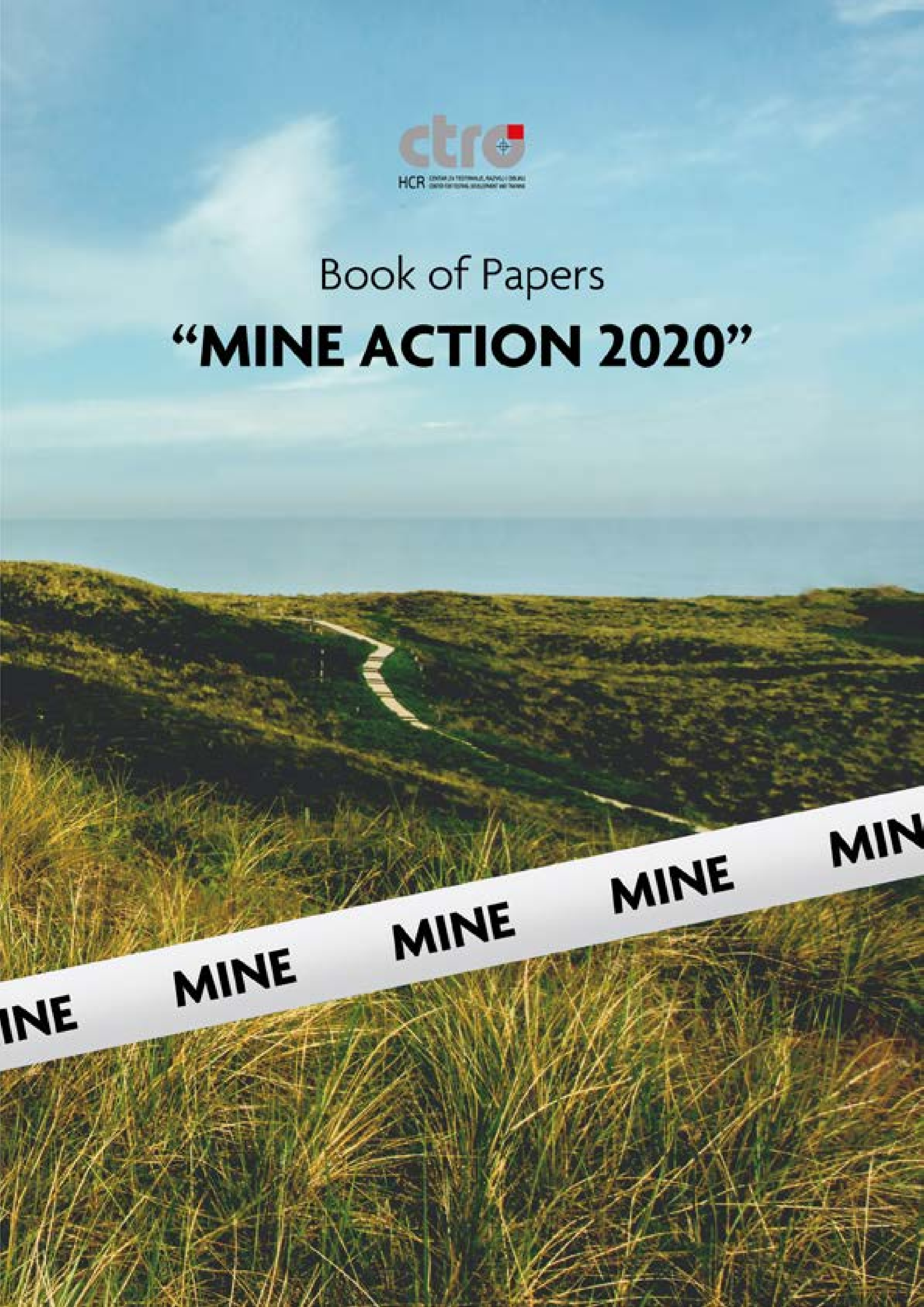
“MINE ACTION 2020”



Mine Action 2020

HCR CENTAR ZA TESTIRANJE, RAZVOJ I OBUKU
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Humanitarian Demining in Ukraine. National Dimension.

Tymur Pistriuha

NGO "Ukrainian Deminers Association", Ukraine, tymur.pistriuha@gmail.com

Introduction

In 2014, at the beginning of combat action in the East of Ukraine, the huge problem of contamination by explosive remnants of war (ERW) appeared in the middle of Europe. Unfortunately, every year of war the situation in the Eastern Ukraine is getting worse. Therefore, on 12 November 2018 a national nongovernmental (non-profit) organization "Ukrainian Deminers Association" (hereafter – UDA) was created. The main goal of the UDA is solving problems on Mine Action in Ukraine.

The UDA was created by initiative group of deminers and currently the members of the organization are 142 people from all regions of Ukraine. The UDA is a permanent member of mine action activities (meetings, round tables, conferences, etc.) under international organizations (UNDP, PCU OSCE etc.) and governmental authorities (Ministry of Defence, State Emergency Service, Ministry for the Reintegration of Temporarily Occupied Territory, etc.). The UDA is listed in the database of the MA organizations of the Geneva International Center for Humanitarian Demining [1]. The members of the UDA are part of various working groups aimed to solve state issues in MA sphere, in particular, lawmaking process.

Humanitarian Demining Problems in Ukraine

Based on analysis of official reports on situation of humanitarian demining in Ukraine the UDA's Expert Board achieved the following outcomes.

1. The latest report Landmine Monitor 2019 indicates that Ukraine is among the five most affected countries in the world and needs immediate response. The continuing high total was influenced by casualties recorded in countries facing armed conflict and large-scale violence, particularly Ukraine [2].

2. According to UN data, the area size of Government-controlled territory of Donetsk and Lugansk regions that is contaminated with mines and unexploded ordnance is more than 7000 square km. Moreover, another mined territory of the non-Government-controlled territory of Donetsk and Lugansk regions is about 9,000-16,000 square km.

Based on world practice, the "year of the war is ten years of humanitarian demining". Taking into account that the fighting in the eastern part of Ukraine, at the present time, has characteristics of a position war, it is possible to assume that the humanitarian demining of the territory of the Donbas can reach more than 40 years.

It should be noticed, that only a few percent of the Donbas are cleared. The map of sites contaminated with explosive objects in the Donetsk and Luhansk regions and more detailed statistics are on the official website of the Ministry of Defense of Ukraine [3].

3. Despite the fact that on 6 December 2018 the Ukrainian Parliament (Verhovna Rada) adopted the Law on Mine Action in Ukraine, the Law is not implemented so far. The implementation of Mine Action Law would allow to establish the national mine action authority as an administrative body and mine action center as an operational body [4]. As a result,

it brings Ukraine to effective execution of humanitarian demining tasks.

4. One of the key issues in the humanitarian demining of the Donetsk and Lugansk regions is that the hostile party is not a signer of the Ottawa Convention [4] and aggressor uses anti-personnel mines actively, which are the greatest threat to the civilian population.

In addition, some particularities of the territory of Donetsk and Lugansk regions that is contaminated with explosive objects are:

- a large number of unexploded ordnance of the canon and jet artillery systems ("GRAD", "URGAN", "SMERCH");
- unexploded artillery shells and mortar mines;
- different various of grenades and grenade launches;
- anti-personnel (in particular, PFM-1, PMN, PMN-2 - prohibited by the Ottawa Convention), anti-tank, anti-vehicle, anti-missile and special mines;
- cluster munitions;
- improvised explosive devices (IED), mine (booby) traps (surprises) (such as MS, ML) installed for non-extermination with various sensitive sensors;
- the latest designs and designs of the regular ammunition of the Russian Army [5].
- mined areas of agricultural fields, forests, infrastructure objects (roads, bridges, overpasses, buildings, etc.) and the coastal zone of the Azov Sea.

5. It should be noted, that the Ukrainian national capacity for humanitarian demining was increased significantly. In particular, Ukrainian deminers gained a knowledge and a huge practice, a valuable experience; humanitarian demining operators became more technical equipped; the first Ukrainian operator – Demining Solutions company appeared. Yet, the national capacity is not enough for solving mine action problems in Ukraine. Partner countries do not pay enough attention to develop the Ukrainian national capacity; the first of all, for supporting the humanitarian demining procedures.

Moreover, in spite of high statistics of Mine/ERW casualties in Ukraine, there are no using of any remote-controlled mine clearance system, e.g. MV-4, MV-10, Bozena-4, Bozena-5, MineWolf, etc. Involving the above-mentioned machines would increase effectiveness significantly and save lives of deminers [6].

7. Nevertheless, the key point of humanitarian demining issues in Ukraine is lack of financial support by donors.

A total of 43 states and three other areas received $569.7 million from 31 donors in 2018. A further $72.9 million, was provided to institutions, NGOs, trust funds, and UN agencies without a designated recipient state or area. As in previous years, a small number of countries received the majority of funding. The top five recipient states - Iraq, Afghanistan, Syria, Croatia, and Lao PDR – received 55% of all international support in 2018. Iraq received the largest amount of funding (18% of all international support) from the largest number of donors (18) [8]. Even though Ukraine is one of the five most affected countries, our country received just 11,9 million financial support from donors; yet Ukraine is not included even to top ten recipients.

Furthermore, due to lack of financial resources for humanitarian demining in Ukraine, there are only one Ukrainian operator Demining Solutions (without any donors) and three international NGOs: The Halo Trust, The Danish Refugees Council – Danish Demining Group, Swiss Foundation for Mine Action. That number of humanitarian demining operators is obviously not enough for Ukraine.

Conclusion

Ukraine has been facing a huge problem as a contamination of its territory with mines/ ERWs for 7 years of war in the Donbas and the situation becomes worse day by day. Based on the UDA analysis of humanitarian demining problem in Ukraine, key points for solving this issues are:

comprehensive financial support by international donors and organizations directly for clearance of contaminated areas;

immediate implementation of Mine Action regulatory framework in Ukraine and establishment of national authorities in this sphere;

development of Ukrainian capacity for humanitarian demining, in particular Ukrainian operators by close cooperation with country partners.

References

[1] Webpage of the Geneva International Center for Humanitarian Demining https://www.gichd.org/en/resources/organisations/

[2] Landmine Monitor 2019, 21st annual edition, November 2019, 53-64 pp.;

[3] the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, Oslo, 18 September 1997;

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[5] D.Derigin, Manual "Danger Mine", 2019 issued by Ukrainian Deminers Association

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[7] Multi Mission EOD Robotic System MV-4, MV-10, DOK-ING, 2020

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Management of ERW risks in Montenegro

Management of ERW risks in Montenegro

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Abstracts

For a small country, Montenegro has a long, rich, and eventful history. Its rugged terrain and jagged shoreline have witnessed many conflicts and wars. The legacy of this colourful Montenegrin history is still dangerously present today for its citizens and the rising numbers of tourists visiting each year. With an annual average of more than 12.000kg of ERW needing safe removal each year this past decade, the Department for UXO, in the Emergency Management Directorate of the Ministry of Interior of Montenegro faces tremendous challenges and threats in building an efficient system of disposal.

This paper considers the lessons-learned in Montenegro and ideas on how to build an effective and efficient national system of ERW removal with the support of the international community.

Photo 1: ERW after industrial demilitarization

Introduction

The diversity of ERW risks in Montenegro is a direct consequence of its long, rich, and eventful history. Today, almost all types of ordnance from the last 100 years can be found on the territory of Montenegro: underwater UXOs from WWI and WWII in the Adriatic Sea, lakes, and rivers; ERW's on the land; scatter ammunition from UEMS; and cluster sub-munitions and air bombs from raids 1999.

Montenegro, as a responsible country and a reliable partner, supports and participates in all regional initiatives.

Convention	Sign	Ratify	Status
Mine Ban Policy	2006	2007	Fulfilled
Cluster Munition Ban Policy	2008	2010	Ongoing 2020
Casualties and Victim Assistance	2006	2006	Permanent obligation
CCW Protocol (V)	2016	2016	Permanent obligation

Table 1: Status of conventions
Note: Montenegro regained independence in 2006.

From the very beginning, the Montenegrin government, with the support of the U.S. State Department, established the Regional Diving Centre for Underwater Demining and divers training 2002; the same organizations play the role of NMAC till 2014. In 2014, the Montenegrin government posted information that all areas affected by landmines and cluster bombs have been addressed and thus decided to shift NMAC to the MoI, Emergency Management Directorate – Department for UXO as part of permanent activities on residual ERW contamination.

Photo 2: Preparation for UXO disposal at a temporary demolition site

Organization history

Shortly after this reorganization, the Department for UXO gained new information on cluster munition SHA, which demanded continuity of Montenegro's MACs exiting.

The Department for UXO, with just five employees, plays several roles in Montenegro:

1. Montenegro MAC
2. National EOD unit (hotspot tasks across the country),
3. Supporting the forensic center in the explosive ordnance field,
4. Storage of explosive ordnance with an unknown history,
5. UXO clearance teams for national interest sites.

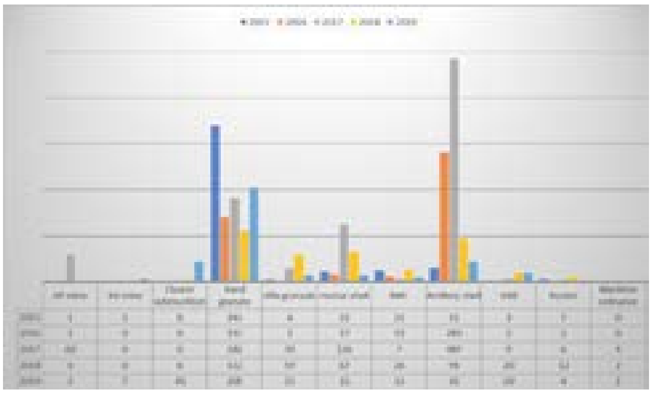
Due to its vast range of responsibilities, EMD, MoI, decided from the beginning to ask the international community for support. At the same time, the Department for UXO worked daily to clear what it could.

The clear outputs, transparency, proactivity, and dedication of the whole of Government resulted in the Norwegian Peoples Aid starting a cluster munitions clearances project in 2018. This project will help Montenegro to achieve the status of a "Cluster Munition Free Country" this year. To date, the NPA has safely cleared 1,613,146 sqm of land and found 82 sub-munitions (BLU-97, Mk-118 and Mk-4).

The ITF was active in Montenegro from the early beginning (2002–2012), supporting the Mine Action and Conventional Weapons Destruction Program. ITF started demining activities on the border between Montenegro and Croatia in 2003 and later continued with underwater demining at the Bay of Kotor.

Since 2016, ITF and the Montenegro Mine Action Centre (MMAC) have carried out several meetings and field visits through which it was determined that Montenegro is still struggling with various mine/cluster/UXO challenges both on land and underwater. Currently, the ITF, with support from the U. S. State Department Office of Weapons Removal and Abatement (PM/WRA), is restarting its activities in Montenegro, specifically in physical security, stockpile management, and conventional weapons destruction in cooperation with relevant national authorities.

Results



In this article, we focus on the period of 2015-2019. Activities of the Department in the field and its media presence helped gain the trust of local populations across Montenegro. This fact results in an increasing number of „harvest" ERW and decreasing numbers of ERW in „strange" places, i.e., wells, potholes, under the bridges, etc.

Total munitions found average more than 12,000 kg of various ERW per year. In the first quarter of 2020 alone, the Department of UXO collected more than 30,000kg of ERW.

Due to Montenegro's environmental regulations, all unnecessary blow in place (BiP) disposal must be avoided. This has led to a vast number of collected ERW being stored by the Department of UXO (Photo 3). In the beginning, the Department utilized what they had, all disposal relied on „temporary" sites. (Photo 2). However, those sites cannot serve as permanent solutions. With the restart of cooperation between the ITF and Government of Montenegro, as a gesture of commitment, the Montenegrin government reallocated financial support to the industrial demilitarization of ERW.

With support from the U.S. State Department, ITF, together with its Montenegrin colleagues, has found that industrial demilitarization of ERW is the best (safest, most cost-effective, and environmentally friendly) option for already collected ERW. Due to the nature of the risk of handling ERW, in cases of the highest risk identified before additional transport, the EOD team performed X-ray inspection of ordinance. Activities on demilitarization have been followed by the Department for UXO, ITF team, and inspected by all Montenegrin authorities, particularly ecological authorities.

Photo 3: Department of UXO temporary storage place

Plans

With experience and discussions with the international community and its partners, the Department for UXO found the below weaknesses of the system and strategy:

No	Weakness	Status	Founds
1	Missing legal frame	In preparations	Partially funded from Montenegro Government
2	Lack of appropriate training	Ongoing with support of USA via ITF	Founded by USA, State Department
3	Lack of demolition polygons	Waiting decision of the Government	-
4	Temporary ERW storage out of dated	Ongoing with support of USA via ITF	Founded by USA, State Department
5	Missing national ERW risk map	In preparations	Partially funded from Montenegro Government
6	Disposal aircraft engine with ionizing radiation	Environmental Protection Agency of Montenegro start activities	Partially funded from Montenegro Government- According to the national strategy
7	Underwater UXO - Zeta river	Technical solution	No founds
8	Land release locations affected by UEMS	Land release	No founds
9	Reduce the stockpiles of obsolete and hazardous Explosive Remnants of War (ERW).	Ongoing with support of USA via ITF	Founded by USA, State Department
10	Underwater UXO-Boka Kotorska bay	Technical solution	No founds
11	Underwater UXO-Adriatic sea	Technical solution	No founds
12	Reduce the stockpiles of obsolete and hazardous stockpile ammunition (MoD).	Ongoing activities	Founded by the USA, State Department via ITF NSPA OSCE SEESAC
13	Assessment and potential clearance of ERW abandoned storage in Herceg Novi/Petrovići-Potkop	Technical solution	No founds

Synergy between national authorities, the international community, and donors, with clear outputs, transparency, proactivity, dedication, and last but not least open communication, is the safest, fastest, and only realistic approach for all ERW risks.

Instead of conclusion

"The slowest person, if he does not lose sight of the goal, is faster than one who wanders aimlessly" Gotthold Ephraim Lessing

Evidence based
Field Risk Management

Evidence based Field Risk Management

Andy Smith

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In Humanitarian Mine Action there are two main types of field risk to be managed. The first is the risk of failing to enhance the safety of those using the land. If we release unsafe land, we increase the risk to people who had previously avoided it but now believe it is safe to use. The second risk is that of staff suffering explosive related injury during their work.

The IMAS[1] 07.12 Quality Management and 07.14 Risk Management both stress the need for decisions to be based on 'evidence'. Also, the success of the approach to Land Release detailed in the IMAS relies entirely on the need to gather and act on evidence. An individual's experience is recognised as evidence, with the constraint that there is a human tendency to believe that something personally experienced must be common.

A written record extending over time allows individual experience to be assessed in the context of a more objective overview and so is the best evidence available. True, there is often a human tendency not to be entirely honest or critical in a written report, but it is hard to conceal the facts in a well detailed report, so the truth often remains manifest to an informed reader.

If Land Release is to be managed without a reduction in safety, it is essential that the systems used to decide when to release land are tested. This should be done by checking whether unsafe land has been released. When explosive hazards are found on released land, these incidents should be investigated to determine how the error arose, so allowing the Land Release system to be refined and improved. This does not happen very often. Few countries treat these incidents in the same way as a demining accident and genuinely investigate with the goal of improving their Land Release systems. For most, finding explosive hazards on land that has been released is an embarrassment because it implies error. Often, no individual is at fault but the new evidence gained from an investigation can allow the imperfect system to be improved – which is central to Quality Management.

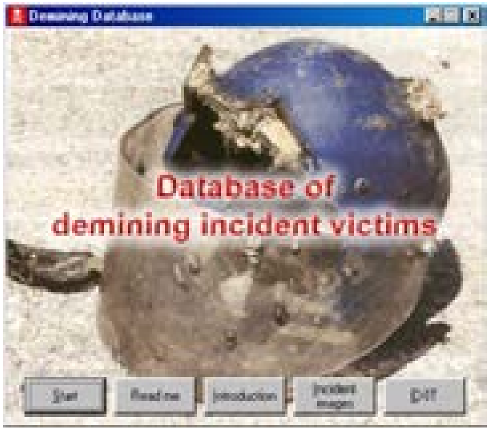
Although some INGOs have done so, there is little evidence that the leaders in HMA have adopted the self-critical 'wheel' of review and improvement that the IMAS require. Although it is often called a 'cycle', the process is not a cycle that returns to the same point: it is a wheel that progresses forward over time.

GICHD and UNMAS have not supported the gathering of incident and accident data despite it being critical when evaluating and improving performance in HMA. Their failure may reflect the fact that the evidence would show that our supposed successes in increasing efficiency are not all that they seem. Lowering cost can look like an improvement in efficiency, but that is a falsehood when doing so means that the primary goal of all HMA has to be ignored to get there. I cannot publish proofs that this has occurred but I have often shown evidence that risk management issues have not been given the priority that might be expected in a humanitarian endeavour.

1 *IMAS – International Mine Action Standards*

Accidents and incidents

In this paper, a demining 'accident' is defined as an unintended explosive-related event that occurs during demining activities. An 'incident' is defined as the discovery of an explosive hazard on land declared safe for release. Both should be investigated whether or not injury results, and the investigations should be shared so that lessons can be learned.

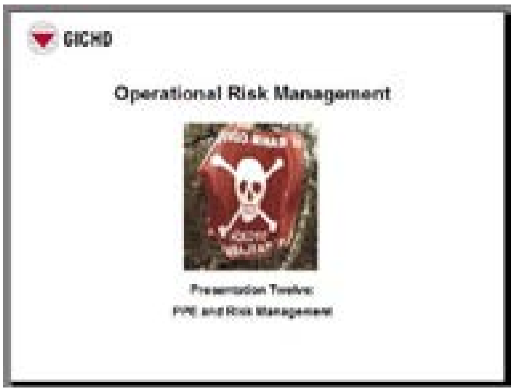


There is a demining accident and incident database. I started it in 1998 and first published it in 1999. UNMAS gave me a letter of support and I did my best to keep it up to date until 2010 when GICHD launched its RAPID spreadsheet accident record. They did this at a National Directors Meeting in Geneva where MACs were told not to send me reports anymore. I have continued to add data when I get it, but have not been able to gather enough. At every opportunity over the next six years I asked GICHD to reverse this decision and either take over my database or get MACs to send me their accident reports[2]. I was told that while individuals recognised its value, there was no money for them to take over the database. In 2017, I approached UNMAS asking for a letter of support for the database that I could send to the MACs when asking for data. They also recognised the value of the database but my request was refused[3].

2 *Several email exchanges with Guy Rhodes, Operations Manager at GICHD are held on record.*

3 *An email exchange with Abigail Hartley acting for Agnes Marcaillau at UNMAS is held on record.*

In late 2017, the CISR[4] at James Madison University agreed to take over my database and store it in their data repository. They renamed it AID – the Accident and Incident Database for HMA. I was hopeful that they would maintain it but they have not found a way of gathering data, so the only data added since they took it has been collected by me. The AID database at the CISR is effectively a back-up that needs funding support to turn into the useful tool that it should be. And it is a useful tool.

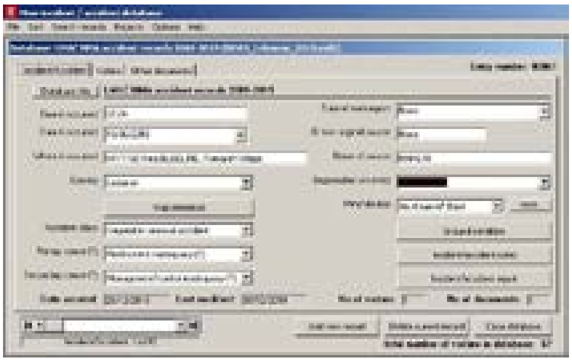


In 2017, I was contracted to produce a range of field risk management training presentations for GICHD – drawing heavily on the evidence in the database of accidents and incidents to do so.

Just this year (2020) I was contracted by UNDP to assist with the revision of the national standards for Lebanon. This involved integrating new Risk Management and Quality Management IMAS in their National Mine Action Standards (NMAS). The need for evidence on which to base decisions was clear, but they did not have most of their own accident and incident data. This is not unusual. NPA, MAG, DDG and HALO have asked for their past records at one time or another, as have two national MACs. (I have always answered these requests at no cost.) So I was able to give Lebanon back more than 50 of their own accident and incident records, add recent reports, and present them with a working database of evidence to use in their field risk management efforts.

4 *Centre for International Stabilisation and Recovery, James Madison University, USA.*

The Lebanon Mine Action Centre is impressive despite the inevitable constraints associated with being a military centre in which staff rotation frequently led to experience being lost. An easily accessible record of accidents and incidents (and the previous attempts at risk management) was especially useful to them.



While in Lebanon, I was asked by NPA to go to Kosovo to advise over PPE needs. Using relevant records from the database, I was able to give pragmatic, evidence-based advice that was well received by the people who will be taking the risks, both managers and field staff. I also left them with a working database of the accident records for Kosovo.

In both Lebanon and Kosovo, the accident record I hold is particularly well detailed and includes some records of incidents when hazards were found on land that the INGOs and commercial companies had declared clear. For this I should thank John Flanaghan and Chris Clark, both pioneers of Quality Management.

The first version of the database software was poorly designed because I did not know all of the questions that I would need to ask until I was actually using it. I quickly made revisions, but the structure needed to become a 'relational' database and that needed a complete software rewrite. When that was funded by the UK government in 2003, that was the only time that the database has received any funding support at all. The new software was released in 2005 when I also published the records on-line.

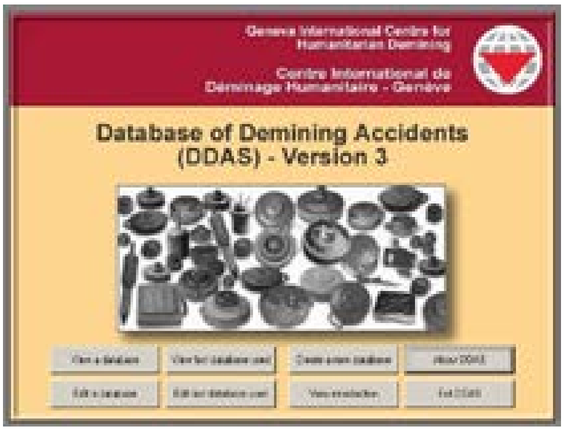
The records have no names of individuals or demining groups, but the best include enough detail about the circumstances surrounding the event to be really useful in risk management and training.

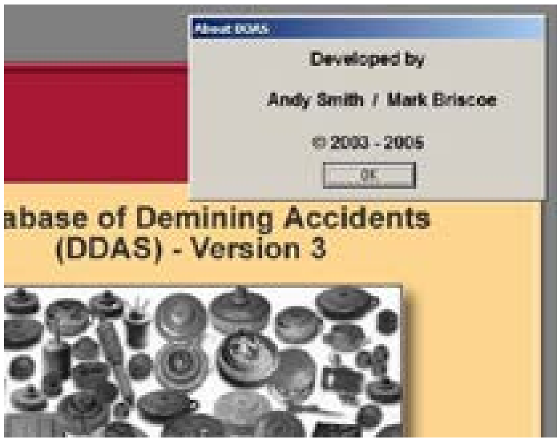
Today, with more than 2GB of data inside it after 15 years, the software has become out of date again. It creaks and labours unless the main dataset is divided, but it still works perfectly with smaller datasets. I also keep the original accident and incident files, which often include far more photographs and ancillary papers than can be included in the database itself. Keeping the original papers allows for anyone with a particular interest to request access.

For the past ten years, I have been offering all of this to anyone who will keep and maintain it and now the CISR has shown interest. At the National Director's Meeting (NDM) in Geneva in February 2020, there was a side event to discuss the need for accident and incident data. CISR asked me to come and explain the database. I agreed to do so at my own expense but GICHD vetoed my attendance so the invitation was withdrawn. GICHD objected because I have criticised GICHD for its failure to value or support the database in the past, and GICHD cannot abide criticism, no matter how justified. They should remember that only by being critical, and self-critical, do we learn – which is a principle of the Quality Management that they ask others to adopt. Yes, I have made fun of their RAPID spreadsheet alternative which reduces all accident records to a few ill-chosen options in limited drop-down lists. It is inappropriately designed, has been very poorly supported, and is worthless as a field risk management tool. These facts were admitted during the side-meeting at the NDM.

The meeting at the NDM centred around plans by GICHD and the three biggest INGOs to start an entirely new database, designing it from scratch. They will seek funding for software development and then the INGOs themselves will decide what goes into it, and what comes out. While one of those INGOs has a good record for sharing accident data, the others do not. GICHD will control the programme, and its record over valuing the collection and sharing of accident and incident data is not what one might wish. It has never been a good idea to expect competing agencies to police themselves, and it is not necessary.

I do not think there is anyone at GICHD today who saw the 2005 revision of the database software when it was released. The UK government channelled its funding through GICHD and I was contracted to design and manage the work. Ironically, given the antipathy towards it, today's leadership probably does not know that the software bears the GICHD logo and that GICHD was once proud to be a part of the endeavour.





The Intellectual Property Rights are mine, but I am willing to cede them freely to anyone who wants to use or improve it while maintaining transparency, honesty, and access. The data inside it belongs to us all.

I cannot keep the database going alone. CISR has the software and a name-free dataset, so they could – but they would need UNMAS support over gathering data and would need to spend money on data entry and analysis. If they got both, I would happily give them all the back-up data and supporting records that I have collected. For a limited time, I would also be prepared to consider gathering data, showing people how to enter records and showing how to use the database. If GICHD support for this were evident, a tacit acknowledgment of error would be implicit and I would feel obliged by my Quality Management principles to forget our past differences. There really is a need for management to start leading by example.

Evaluation of the use of unmanned aerial vehicles in-country assessment of suspected hazardous areas in Bosnia and Herzegovina

Evaluation of the use of unmanned aerial vehicles in-country assessment of suspected hazardous areas in Bosnia and Herzegovina

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Abstract: Bosnia and Herzegovina have submitted an extension request to fulfill the obligation under Article 5 MBT. Through 2017-2018, a project funded by the European Commission was launched, a methodology for country assessment developed and survey teams were trained. Through December 2018 to December 2019, 14 survey teams from BHMAC, Norwegian People's Aid and Bosnia and Herzegovina Armed Forces performed field and other activities under country assessment of SHAs contaminated with mines, cluster munitions and other explosive remnants of war. Survey teams have been used different techniques to collect data and analyze evidence of the presence of explosive threat and the characteristics of existing SHAs. They were equipped with 14 UAVs DJI Phantom 4 PRO V.2 with a color camera. The use of UAVs for assessment at the country level was a novelty which required more careful planning and training of teams to use UAVs. Evaluation of the use of UAVs includes analysis of planned and performed flights, the ability of teams to record, process and analyze data, UAV flight outputs including utilization of photos for mine situation analysis, geocoding, photomosaics and survey with questionnaire among teams. The evaluation results provided a better understanding of the extent to which UAVs contributed to the efficiency and quality of the country assessment of SHAs.

Keywords: unmanned aerial vehicles, country assessment, suspected hazardous areas, Bosnia and Herzegovina, Norwegian People's Aid, AIDSS, Multi-Criteria Analysis

Introduction

Bosnia and Herzegovina (BiH) have submitted an extension request to fulfill the obligation under Article 5 MBT. Through 2016-2017, the Demining Commission in BiH and the BiH Mine Action Centre (BHMAC) developed a national Mine Action Strategy 2018-2025. The work on the operationalization of the Strategy identified some obstacles. (1) There was no updated baseline of mine contamination and its impact in BiH for the Strategy implementation. The previous country assessment of suspected hazardous areas (SHAs) in BiH was based on an outdated methodology from 2001 which was no longer comply with IMAS and its land release concept. (2) Application of IMAS evidence-based decision making was not applied fully into Bosnia and Herzegovina mine action management. It requires an inventory of remaining direct and indirect evidence on mine threats. BiH must complete the development of more efficient land release and planning to accelerate compliance with Article 5 MBT. Both obstacles limited the country's ability to anticipate the extension of the obligation under article 5 MBT supported by an effective mid-term plan for the land release of SHAs. The solution was to implement a new country assessment of SHAs with an improved country assessment of the size and impact of the explosive threat and its impact in BiH. A project funded by the European Commission was launched, a methodology for country assessment developed and survey teams were trained by the end of 2018.

Through December 2018 - December 2019, 14 survey teams from BHMAC, Norwegian People's Aid (NPA) and Bosnia and Herzegovina Armed Forces (BHAF) performed field and other activities under country assessment of SHAs contaminated with mines, cluster munitions and other explosive remnants of war. Survey teams have been used different techniques to collect data and analyze remaining evidences of the presence of explosive threat and the characteristics of existing SHAs, such as desk study, measurements for positioning evidences and SHAs, gathering and analyzing contamination and impact data through observations, interviews, community questionnaires, and unmanned area vehicles (UAVs) use. Survey teams were equipped with 14 UAVs DJI Phantom 4 PRO V.2 with a color camera. Evaluation of the use of UAVs includes analysis of planned and performed flights, the ability of teams to record, process and analyze data, UAV flight outputs including utilization of photos for mine situation analysis, geocoding, photomosaics and survey with questionnaire among teams. The evaluation results provided a better understanding of the extent to which UAVs contributed to the efficiency and quality of the country assessment of SHAs. Besides an analysis of the recorded data, 14 survey teams involved in the country assessment (9 BHMAC, 3 NPA, and 2 BHAF) completed the questionnaire for the evaluation of the use of UAVs during February 2020.

Contribution of UAV flights in filed survey operations

Until 20 February 2020, survey teams planned and used UAV for data collection and assessment on 44% of 427 processed SHAs. An area of 89.42 km2 or 10.4% of the total size of SHAs was covered by UAV flights. Teams performed 384 flights with a duration of 6,761minutes, which is 17.6 minutes per flight on average (Table 1).

Among survey teams, there are different practices in the intensity and the way of the use of drones caused by (1) different levels of training, knowledge, skills, and competences in data collection and processing using UAV; (2) different environmental conditions in which the teams worked (topography, terrain characteristics, vegetation, population, etc.); (3) skepticism towards the use of new technologies in the survey. Survey teams have successfully used the existing SOP provisions on the use of UAVs.

Use of UAV as a tool to strengthen evidence-based decision-making approach

Survey teams have been recorded 10,620 photos or 27.7 photos per flight on average. Out of the total, 2,510 photos or 23.6% have been used for the analysis of mine contamination. It is 6.5 photos per flight on average. About half of the utilized photos are geocoded to locate evidence. Two survey teams used photomosaics as an improved analysis of canceled areas. Teams recorded 187 videos while 23.5% of them are used for the analysis of mine contamination (Table 2).

The survey team processed and recorded 14,513 pieces of evidence using all survey techniques (8,955 direct and 5,558 indirect shreds of evidence). Out of total 1,770 or 12.2%, evidence was processed using results of UAV flights. It is 4.6 evidence per flight and 3.8 flight minutes spent per evidence. They include 156 or 1.74% of all direct evidence recorded and 1,614 or 29% of all indirect ev-

From 30 November until 20 February 2019		Total	Per the survey team			
			Average	Median	Min	Max
The period in which the survey teams used UAVs	months	156.89	11.21	10.90	7.13	15.06
All SHAs where field surveys were completed (all techniques)	#	427	30.50	29.50	10	58
	km2	858.02	61.29	66.67	20.03	88.90
SHAs where UAVs were used (size of the area surveyed with UAV only)	#	188	13.43	10.00	1.00	32.00
	km2	89.42	6.39	0.85	0.10	34.34
Number of flights	#	384	27.43	13	1	95
Flights duration	min	6,761	482.93	276	10	2,220

Table 1. Use of UAV by survey teams during a country assessment of suspected hazardous areas in BiH

From 30 November until 20 February 2019	All teams	
	#	%
All photos recorded by UAV and reviewed	10,620	
Photos utilized to analyze mine situation	2,510	23.6%
Photos geocoded	1,309	12.3%
Photomosaics	12	
All videos recorded by UAV and reviewed	187	
Videos utilized to analyze mine situation	44	23.5%

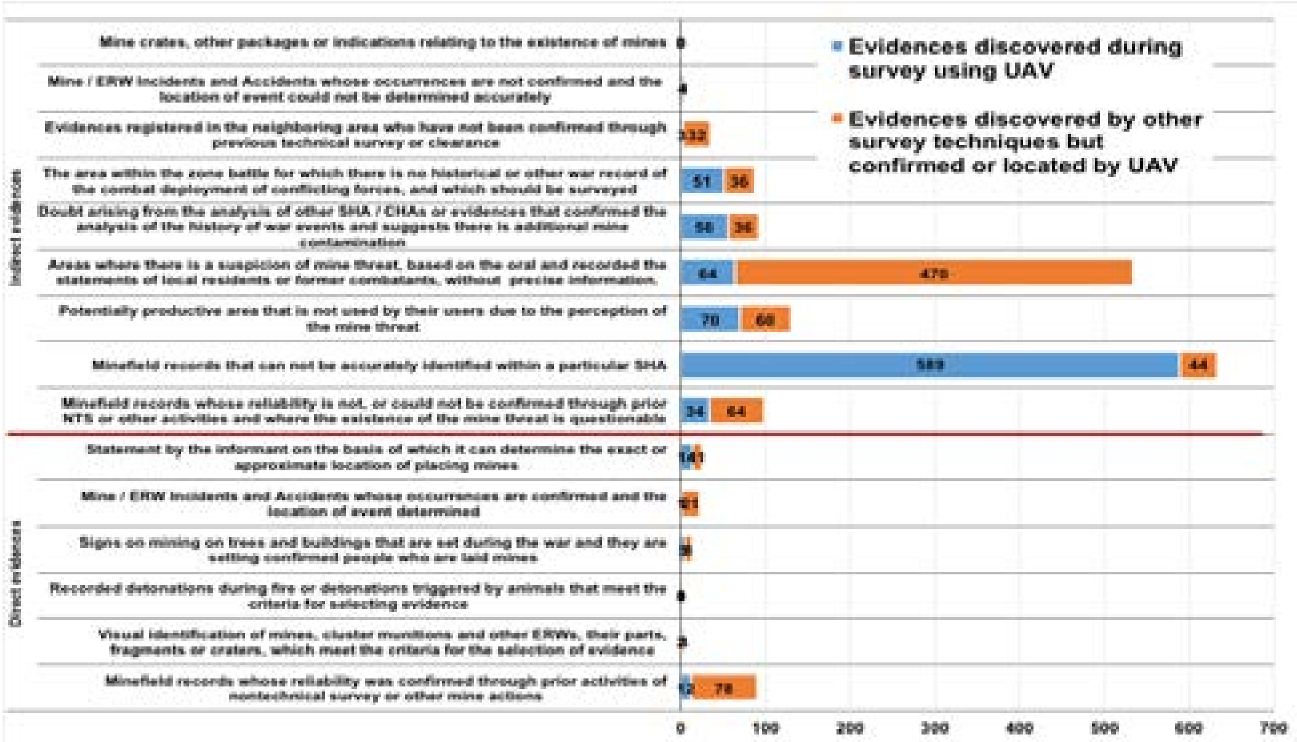
Table 2. UAV flights output

idence recorded). Use of UAVs equally supports UAV's data collection analysis as a first technique to discover new evidence (906 or 51.2% of evidence) and discovering evidence by other survey techniques and confirmed or located by UAVs (743 or 48.8% of evidence). Considerable variations were observed in the collection and processing of different categories of evidence (Graph 1). UAVs were mostly used to identify and locate data on mine threats, whether it be on record in the database or on the statements of witnesses. This applies to both direct and indirect evidence. The teams also had the opportunity to give their opinion on the usefulness of UAVs for collecting and analyzing data in the survey SHA. They ranked eight purposes for which the most used UAVs for the survey. According to the teams, UAVs are mainly used for the analysis of the spatial characteristics of the SHA, for the application of cancellation criteria and a more accurate location of evidence (Table 3).

Regarding the use of drones, teams were offered six statements where they answered via a Likert scale of agreement. They have a positive opinion (fully agree or agree) for next statements: (1) the use of drones as a data collection technique has enhanced our work in the assessment of environmental conditions (vegetation, land, topography, etc.) (14); (2) we would recommend the use of drones in the future operations of non-technical survey (13); (3) the use of drones as a data collection technique has advanced our work to identify indirect evidences of mining (trenches, bunkers, etc.) (13); (4) the provisions of the chapter "Flight by drone to collect data" from the

Ranking results by 14 survey teams	Ave-rage	Rank
For the assessment of environmental, soil, topography and other environmental characteristics of SHAs	2.57	1
To sub-division, increase, or cancel SHAs	2.57	1
For the more accurate location of evidence	5.64	3
To analyze mine contamination history within an SHA	6.07	4
To confirm evidence of contamination which has been previously identified by other techniques.	6.71	5
To check data on mines and other explosive devices collected from the population or through some other techniques	6.79	6
To detect explosive devices on the ground	8.29	7
To discover new evidence of mine contamination	9.43	8

Table 3. Question: For what purpose was the drone most used in collecting and analyzing data in the Country assessment of SHAs in BiH?



Graph 1. Structure of evidence on the presence of mine threat processed using UAVs by survey teams

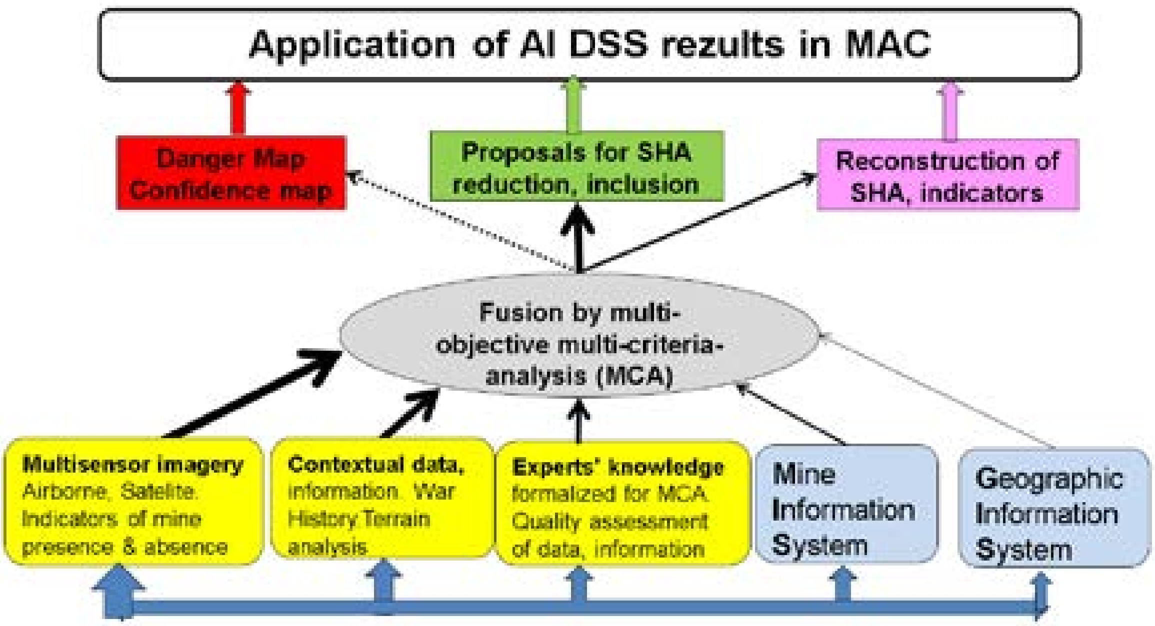


Figure 1. Scheme of AIDSS application in Bosnia and Herzegovina [1].

SOP "Country assessment of SHAs in BiH" are clear and easy to follow (13) and; (5) the use of drones as a technique for data collection has full applicability in our work on the non-technical survey. Teams have mainly negative opinions on the statement: (6) the use of drones as a data collection technique has advanced our work to identify direct evidence of mines (visible mines, etc.) (6 disagree, 5 neutral).

Advancing processing and interpretation of collected photographs and videos

The data collected by the use of UAV with a color camera are interpreted subjectively and the results are evaluated in the previous text. Here we briefly consider options for advancing the interpretation outcomes of collected photographs and videos, based on a similar project done in a project "Determination of Mine - Suspected Area near Bihać, Mostar,

	Indirect IMP	B	M	T
1	Trench	30	30	2
2	Bunker	32	9	
3	Pedestrian's shelter	37	109	20
4	Dry stone-wall	3	15	3
5	Destroyed building	1	9	6
6	The road not in use	11	3	
7	Dugout	5		4
8	Shelter	3	10	4
9	Tank shelter	3	1	
10	Artillery shelter	2		
12	Shelter of multiple launch rocket system	1		
13	Mortar shelter	1		
15	Surveillance post		7	6
16	Stone bank		17	

Table 4 Indirect indicators of mine presence IMP, [1].

Trebinje by Advanced Intelligence Decision Support System (AIDSS) Bosnia and Herzegovina", [1]. The relevant methodology and results are presented in [2], [3], [4], [5]. The scheme of the AIDSS, a list of indirect indicators of mine presence (IMP), areas, for three analyzed regions, near Bihać (B), near Mostar (M) and near Tebinje (T), show benefits obtained by AIDSS methodology. In a whole process is applied objective methodology of the fusion of the data, information, knowledge of mine information system (MIS), geographic information system (GIS), experts' knowledge with results of processing the collected imagery. For fusion is applied multi-criteria analysis (MCA) methodology, Fig. 1, Tab.4 reflects differences of IMPs due to the differences in contamination situations and terrains.

The aerial platform for a multisensory system used in [1] was helicopter Mi-8. Although it has many limitations if applied for humanitarian mine action, valuable results are obtained.

The country assessment of SHA in Bosnia and Herzegovina, 2018-2019, is based on the use of 14 UAVs, with color cameras collecting photographs, Fig.2, Fig.3, and color videos. The survey teams also added other kinds of data and information, by conventional non-technical survey methods, Fig. 4.

Figure 2 Trenches and shelters Berkovići.

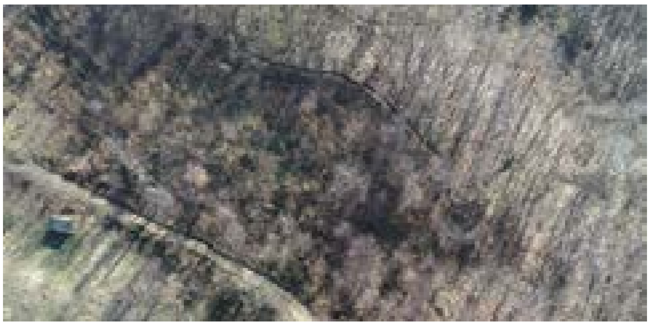


Figure 3 Separation defense lines Paležnica

Figure 4 Inclusion in SHA, an example of an outcome from NTS based on UAVs.

The survey teams collected very valuable images and videos, several of them made mosaics and final products, maps for cancellation from SHA or for inclusion into SHA. Authors prepared PowerPoint presentations which will include mentioned contributions. The achieved level of processing and interpretation is evaluated in previous sections, while here we propose to apply whole AIDSS methodology and derive outcomes with the highest level of reliability.

Conclusion

The widespread use of UAVs requires careful monitoring and evaluation of activities performed to understand better the benefits and how to improve applied UAV flight techniques. The introduction of UAVs has improved the efficiency, quality, and accuracy of SHA assessment. When it comes to identifying and analyzing a mine threat, the level of participation of UAVs in the identification and analysis of the evidence of 12.2% of all evidence is above expectations, especially considering that it took significantly less time to identify those using UAVs than when using other techniques to detect data collection and analysis.

The use of UAVs for assessment at the country level was a novelty which required more careful planning and training of teams to use UAVs. We propose to apply AIDSS methodology on the whole amount of data collected till 20 February 2020 and derive objective outcomes with the highest level of quality and reliability.

Acknowledgment

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Testing of new imprinting technique for the training of mine detection dogs on a carousel scent discrimination device

Testing of new imprinting technique for the training of mine detection dogs on a carousel scent discrimination device

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Abstract

The standard imprinting techniques on a carousel or alike scent discrimination devices assume that dogs associate odor of explosives and mines with known odor of the kong toy and after recognizing that odor above the mines buried in the ground. The time required for a dog to associate known odor with the odor coming from a mine depends on several factors such as type and depth of the mine targets, but also on various environmental factors affecting the vaporization and the contamination extent. This means that imprinting process requires longer time when conditions are not optimal. If searching scenarios change, the process often needs to be repeated. Field teams sometimes experience difficulties with imprinting at the locations with different operational conditions, but it is commonly attributed to acclimatization or human (handler) factor.

The aim of developing a new imprinting technique is to provide odor picture closest to the odor of the buried landmines and present it to the dogs at earliest training stage as possible. Following this logic, the new imprinting protocol has been created and tested with 20 dogs from the beginning of their imprinting training over several months in Norwegian People's Aid Global Training Center for Mine Detection Dogs. Analysis of testing results explains influence of factors contributing to detection rates and to the duration of the entire imprinting process exposed during the testing of new techniques. Further development of the techniques may significantly reduce landmine scent imprinting time, as well as needs for extensive re-training due to changes in operating environment.

Keywords: odor detection, mine detection dogs, imprinting, Norwegian People's Aid, Global Training Center, TNT contamination, land mine detection

Introduction

Mine detection dogs (MDD) are widely used in humanitarian demining operations for half of the century. There are still various methods of training and application range, often subject of disputes within the wider community, as well as among dog trainers and operators. Although several research studies were conducted on the applicability of the MDD systems, the training techniques are commonly not explained or supported by scientific evidence. There are several ways and approaches to teach dogs to detect explosive odors and landmines. The most common approach is to assist dogs with associating odor of explosives by presenting it together with an odor that is very familiar to the dog. This familiar odor is usually a toy that is being used to play with a dog. Playing with a toy is actually main rewarding method for the dogs and detection training process begins with searching for the toys. Some dog training schools are reducing amount of familiar odor (a toy) in searching exercises, while some attempting to associate familiar odor directly with the mines.

The standard imprinting techniques on a carousel or alike scent discrimination devices assume that dogs associate odor of explosives and mines with known odor of the kong toy and after recognizing that odor above the mines buried in the ground (Bach & Kelly, 2004). The time required for a dog to associate known odor with the odor coming from a mine depends on several factors such as type and depth of the mine targets, but also on various environmental factors affecting the vaporization and the contamination extent. This means that imprinting process requires longer time if conditions are not optimal, and sometimes the process needs to be repeated when searching scenarios change. It is not uncommon that teams experience difficulties with imprinting at the locations with different operational conditions, but it is often attributed to acclimatization or human (handler) factor.

The aim of developing a new imprinting technique is to provide odor picture closest to the odor of the buried landmines and present it to the dogs at earliest training stage as possible. The initial idea was to contaminate soil with the explosive and use it instead of explosive pieces from the beginning of the imprinting process. The amount of explosive odor in the contaminated soil is far less comparing to the odor of the visible explosive fragments. Furthermore, the odor of the contaminated soil is much closer to the composition and the amount of the odor available above the mine in the ground. Following this logic, the new imprinting protocol has been created and tested using 20 dogs from the beginning of their imprinting training over several months in Norwegian People's Aid (NPA) Global Training Center for Mine Detection Dogs (GTC). The protocol prescribes procedures for detection of the soil samples contaminated by the gradually reduced amounts of TNT. In the first phases samples are presented on the carousel, later on the ground, while in the last phase the samples are being associated with the buried landmines. On each searching session, negative samples and distracting odors were presented beside one to three positive samples. The last testing phase was conducted under unfavorable environmental conditions in unknown test area that hasn't been used before.

Problem

The standard imprinting techniques on a carousel is entirely based on dog's ability to associate smells from the mine location with the samples presented during the training. However, the fact that process has to be repeated when conditions on the ground change, indicates that odors presented during the training and odors above the buried landmines are not necessarily similar and easy to generalize.

The first significant difference is amount of the chemicals found in training samples and above the mines in the ground. It has been argued that that presence of the explosive chemicals do not necessarily meet minimum odor requirements for dog detection (McLean & Sargisson, 2005).

Concentrations of explosive originating chemicals above the buried land mines are usually measured in nanograms per gram of soil (Phelan J. and Webb S., 2003). However, concentration of explosive substance used in samples for detection training are at best measured in milligrams, which is thousands of times bigger concentration of the chemical comparing to those found above the buried mines. These facts lead to the questions if (1) can the imprinting training process be improved to provide more relevant odors on the carousel and similar techniques, and (2) can such training shorten imprinting training and minimize difficulties when searching scenarios are changed?

Designing and the application of a new imprinting technique

In order to make training odors more relevant to landmine searching context, NPA explores alternative ways for creating samples. The proposed idea is to contaminate soil with an explosive substance and use that soil instead of explosive and landmines pieces from the beginning of the imprinting process. The amount of chemicals in the contaminated soil is obviously much closer to the amount of chemicals found around the landmines out in the field. It is not expected that artificial contamination will be much higher comparing to the real conditions, as the soil around landmines reaches equilibrium of saturation at some stage (Phelan J. and Webb S., 2003). The soil contaminated in such way can be used instead of pure explosive pieces even in early imprinting phases. To test the concept, NPA chose to use TNT military grade explosive used in PMA 1 landmine. Samples of the soil are collected at sufficient distance from possibly contaminated area. After collection, the samples are stored in the hermetically closed glass jars together with a piece of TNT (100, 50, and 10 grams). The piece of a white paper has been stuck on the inner side of the jars' lids. As it is known that substances changes color to yellow or red when exposed to TNT, this paper is used as an indicator that soil is saturated with the TNT chemical. The jars are left to soak indoors, at the room temperature, until the indicator paper changed its color. For the control purpose, the dummy soils samples should be prepared. Contaminated soils and dummy soils are stored in separate rooms. Both rooms shall have the same conditions, so temperature and humidity shall be monitored.

The testing protocol prescribes procedures for detection of the soil samples contaminated by the gradually reduced amounts of TNT. In the first stage samples are presented on the carousel, later on the ground, and in the last phase the samples are associated with the buried landmines. On each searching session, negative samples and distracting odors were presented beside one to three positive samples. At the beginning, the carousel work was divided in four phases of detecting contaminated soil samples: (1) Samples of soil contaminated with 100 g TNT presented with known odor ('kong' toy); (2) Samples of soil contaminated with 100 g TNT; (3) Samples of soil contaminated with 50 g TNT; (4) Samples of soil contaminated with 10 g TNT. One sample used in training contains one teaspoon of the soil. The dog transits from one to the next phase after three successful detection sessions. If dog doesn't detect the sample, or make a false indication, it will repeat the previous phase.

Starting position for the dog should be determined randomly. The dog can be rewarded with 'kong' toy, other toy, or food. After the dog indicates, the cup with the positive shall be removed. The session ends when dog runs full circle without indications. After the session is completed by one dog, all cups and carousel shall be clean by acetone.

After all phases on carousel are successfully completed, the samples will be presented for outdoor training on the ground in next three phases: (1) Sample of contaminated soil on the ground; (2) Samples of contaminated soil above the buried mine; (3) Buried mine only. The principal of the progress from phase to phase is the same: after three successful detections.

To prevent dogs cueing other signals, it is important that sufficient soaking time has elapsed that all ground disturbance from digging has disappeared. Besides, surface laid mines must not be used. The last testing phase was conducted under unfavorable environmental conditions in unknown test area that hasn't been used before.

Adjustment of training protocols after analysis of initial results of control tests

To test training protocols, seven dogs were selected. After the first results, more dogs were included in the trial, including operational dogs and dogs that already completed imprinting on TNT and landmine pieces. As expected, most of the dogs were able to detect samples of contaminated soils without major problems. However, the initial test results indicated some problems that required the upgrade of the new imprinting technique: (1)The dogs that were only trained to detected contaminated soils did not detect TNT if presented separately; (2) Some dogs that were detecting landmines in the field, and the TNT on the carousel, were not detecting contaminated soil; (3) Most of the dogs had difficulties detecting soil contaminated with 10 g of TNT. It should be noted that paper indicator in the jars for point 3. didn't change the color even after several months of soaking time. Considering above points, it has been decided to change the testing procedure and remove 10 g contamination until the preparation of the samples is better understood.

Analysis of testing results

Analysis of testing results gained using new imprinting techniques includes: (1) Analysis of the learning phase which included learning new odor (TNT or contaminated soil); (2) Analysis of success during training on carousel device; (3) Analysis of the field testing results.

Analysis of the success rate of the learning phase is conducted to confirm training level of the dogs required for advanced detection tasks. It basically means that in order to proceed with detecting new substances, it had to be confirmed that dogs are trained to search on carousel, indicate, and recognize odor of very small amount of kong toy. Detection success rate for the learning phase for the standard imprinting technique is 98,9 % for the 89 sessions. Such result proves that dogs entering imprinting phase have developed good detection ability on the kong toy and are consistently indicating it regardless of it size and background odors.

Detection rate of the dogs presented with the contaminated soils instead of solid TNT are 82,4 % for 68 sessions. Even though it may look as low total success rate, several dogs completed this phase with 100 % success rate. The total rate is affected due to the fact that some dogs in this group were already imprinted on TNT and did not search for kong pieces for at least several months. These conclusions are confirmed with the analysis of the next phases of carousel work which included more 1300 sessions.

The second analyses explore detection work on the carousel. Through 2019 to February 2020, dogs were tested with new imprinting techniques on various TNT and contaminated soil samples: (1) TNT pieces amounting 0,3 to 2 g; (2) Soil contaminated with 100, 50 and 10 g of TNT; (3) Contaminated soils presented together with TNT piece 0,5 to 1 g. This analysis explores influence of dog handlers, individual dogs, presented target substance, room temperature and sample preparation time to the actual result of the detection training session (success of detection, target missing, and false indication). In these phases detection rates of the dogs trained on contaminated soil were even higher than rates of the dogs detecting solid TNT. Lowest detection rate was on the soil expected to be contaminated only with 10 g of TNT. The success level was 65.2% which does not meet the detection criteria set for the initial training phase. Further testing is needed to explore relevance of usability of such samples in imprinting training.

Target	False indication		Missed target		Hit		Total tests
TNT	63	11.4%	61	11.1%	428	77.5%	552
TNT							
10 gr	4	17.4%	4	17.4%	15	65.2%	23
TNT							
50 gr	31	14.6%	15	7.1%	166	78.3%	212
TNT 100 gr	19	11.6%	10	6.1%	135	82.3%	164
Total tests	117	12.3%	90	9.5%	744	78.2%	951

Table 1. Results of testing on a carousel 2019-2020

Cross checks of results have shown that several dogs trained on contaminated soil were not automatically detecting solid TNT. While it was expected that dogs trained on solid TNT might be not detecting contaminated soils, missing solid TNT after detection of samples with enormously low concentrations of the same substance, suggests only that dogs do not perceive those two odors as the same.

After the small TNT pieces have also been added in contaminated soil samples, detection rates improved and matched those for solid TNT and contaminated soils. False alarm rates are lowest for this combination (6,7%), while false alarm rates on solid TNT are more than 10 %.

Highest detection rates are observed when samples are prepared and searched during the same day (80.9%). It decreases down to 70.7 % after an overnight, and even down to 46.2 % after 64 hours. As the preparation process is well controlled, soaking time effect proves that odor in the contaminated soils definitely changes over the time, and likely over the mines as well.

Soaking time (h)	False indication		Missed target		Hit		Total
0.5 to 6	108	10.6%	86	8.5%	822	80.9%	1,016
17 to 21	20	17.2%	14	12.1%	82	70.7%	116
64	4	30.8%	3	23.1%	6	46.2%	13
Total tests	132	11.5%	103	9.0%	910	79.5%	1,145

Table 2. Influence of soaking time to results

The effect of soaking time was analyzed only for contaminated soil samples. The obtained results suggest that detection rates are significantly deteriorating with time elapsed from samples preparation to detection session (soaking time). The other contributing factors are handlers and dogs. While some dogs have consistently high detection rates regardless of training phases and used target substances, some dogs struggle to maintain good detection rate and often falsely indicate. This behavior could be explained also with the handler factor which may contribute in different ways: from disturbing dog during the work, mimicking, to simply affecting the dog with his or her presence. However, the handlers behavior was not subject of this testing and observations in that regards are not recorded. The results obtained indicate the need for the further upgrade of the protocol with the variables that better measure the impact of the handlers, which implies closer supervision of their work.

The last analysis includes 113 tests in the field to explore possible influence of external factors on detection success (handler, type of target, environment parameters - temperature, relative humidity, heat stress index, ground temperature, and the ground level relative humidity). The detection rate was 63%, while false alarm rate was 18 %. The results also show that the dogs trained only trough ground contamination technique detected mines in a same rate as dogs trained following standard technique. The environment and weather data were gathered for statistical analysis. Some weak correlation with the temperature has been identified. There was no correlation found with the depth of the landmine targets. It is noted that the number of collected data is insufficient for reliable conclusions on field stage of testing.

Conclusions

The imprinting on TNT contaminated soil samples is the detection dog training technique that is still being developed. This testing encompassed entire standard and new imprinting techniques on a carousel device with several dogs of different training level and detection experience. During the testing period the procedure has been adjusted several times in order to apply experienced results. The testing in the field has only been conducted during short winter period in quite unfavorable ground conditions. The information gathered during this limited period was not at the level required for correlation analysis. Therefore, the influence of the factors contributing to detection rates is still not fully explained. However, there are indications that further development of the techniques may significantly reduce landmine scent imprinting time, as well as needs for extensive re-training due to changes in operating environment.

Test results so far indicate that dogs can detect odors in samples contaminated with TNT at the same level or with higher contribution of hits as in previous standard training protocols on carousel. Exploring alternatives and testing of the new imprinting technique also exposed some weaknesses in standard training systems, as well as in following training routines and procedures. The questions are raised about the adequacy of the standard imprinting method, in particular: (1) Are the samples used during the training process really relevant? , and (2) Can the whole process with recognizing explosive substances on the carousel be skipped, and imprinting training conducted only with association of familiar odor – for example with a kong toy?

Further development and testing of imprinting techniques should take in account the conclusions of these analysis: (1) Odor of contaminated soils and solid TNT samples are perceived as different by dogs. Training only on solid particles of the landmines might not be always enough. In the other hand, if solid TNT is used for the purpose of developing association for dogs, the process is likely excessive; (2) Imprinting on soil contamination shortened process to the detection of PMA 1 landmine; (3) Dog behavior and dog's previous experience is still the most significant factor determining detection success. Skipping training phases and lack of understanding how dogs are perceiving the odor will affect the detection rates.

The final conclusion of the analyses is that suggested technique should be further developed, and testing expanded to include other soil types, landmine targets, and different climate zones. Besides, focus should be paid on the impact of the handlers and strict adherence to the procedures.

The continuation of activities is justified, as such technique has potential to reduce required time for imprinting on target substance, possibly reduces needs for a training areas and number of targets with relevant soaking time, and improves quality of daily testing in the field operations.

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A thermal infrared video provides the gain to the separability of the target

A thermal infrared video provides the gain to the separability of the target

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Abstract

We consider the main differences between the survey from the remotely piloted aircraft systems (RPAS) if done by longwave infrared (thermal infrared - TIR), or by sensors in visible wavelengths (color). The color survey is almost always applicable if the light conditions are on average normal. The thermal contrast Tt/Te of the target Tt and the environment Te shows significant daily changes. Due to the described and other critical facts, the TIR survey from RPAS is not simple like the color visible. There is a need to provide the matching parameters of the TIR survey to features of the targets and the environment: landmines (LM), unexploded ordnance (UXO), improvised explosive devices (IED), cluster munition (CM), and provision of needed detecting probability for the considered targets and the environment. The currently used thermal infrared cameras provide recordings in two formats of thermal images, 640x512 pixels, and in video (e.g. MV4) format, with 30 (or 25) frames per second, each frame has 720x480 pixels. We report the outcomes of the testing and analysis of the TIR survey, which shows the increase of separability and thermal contrast if are used TIR video recordings, [1].

Key words: Longwave IR, thermal IR, TIR video frame, TIR image, target, environment, separability

The TIR video provides the gain to the separability of the target

Thermal Imager Zenmuse XT 640 × 512 pixels. Pixel Pitch 17 µm, Sensitivity (NEdT) <50 mK at f/1.0, Photo JPEG (8 bit) / TIFF (14 bit), Video MP4,30 Hz, 720x640 pixels, Lens 9mm, Field of View 69ox56o Software: FLIR tools, MapInfo, Pix4D, [1], [2], Fig.1

Figure 1. Thermal Imager Zenmuse XT.

The TIR video recording can be exported into a sequence of images (frames), every frame has 720x480 pixels, with a frequency of 30 frames per second. When RPAS flies over the target, the received TIR radiation coming from a target increases gradually to a maximum and decreases gradually. In this process exist TIR frames that have stronger recorded data then the data of the TIR image 640x512 pixels, Fig.2.

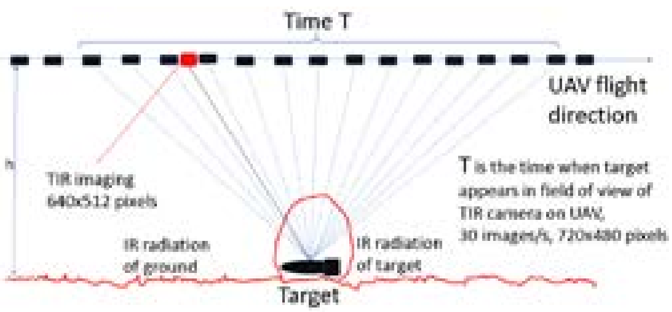


Figure 2. When RPAS flies at height h above the target on the ground, with speed v (m/s), the TIR sensor receives TIR radiation of the target during the time T. In thermal video

frames (720x480 pixels) this happens more often. The measure of the benefit is the separability S, Fig.3,

$$S= |\mu_t-\mu_e| / [(\sigma_t^2+\sigma_e^2)^{1/2}] \qquad (1)$$

where μ_t, μ_e are mean values, σ_t^2, σ_e^2 variances of target (t) and environment (e).

Figure 3. The definition of a separability S.

Separability obtained from TIR video frames 720x480 pixels shows significant gain if compared to the separability obtained from TIR images 640 × 512 pixels. During time T, when the target is visible from the thermal sensor on an RPAS, its separability obtained from thermal frames is always larger from the separability obtained from the thermal image. The detection of targets in a TIR survey from RPAS in NPA practice is performed: a) by manual search the targets on the collected images or the videos, which are collected by the automatically programmed survey flights; b) by free RPAS flight, when the operator manually guides the RPAS while searching the suspected objects - targets. For search targets in the video is needed real-time processing hardware, but this can be solved by a tool that enhances the edges of the target, in a sequence of TIR frames exported into image format, Fig.4.

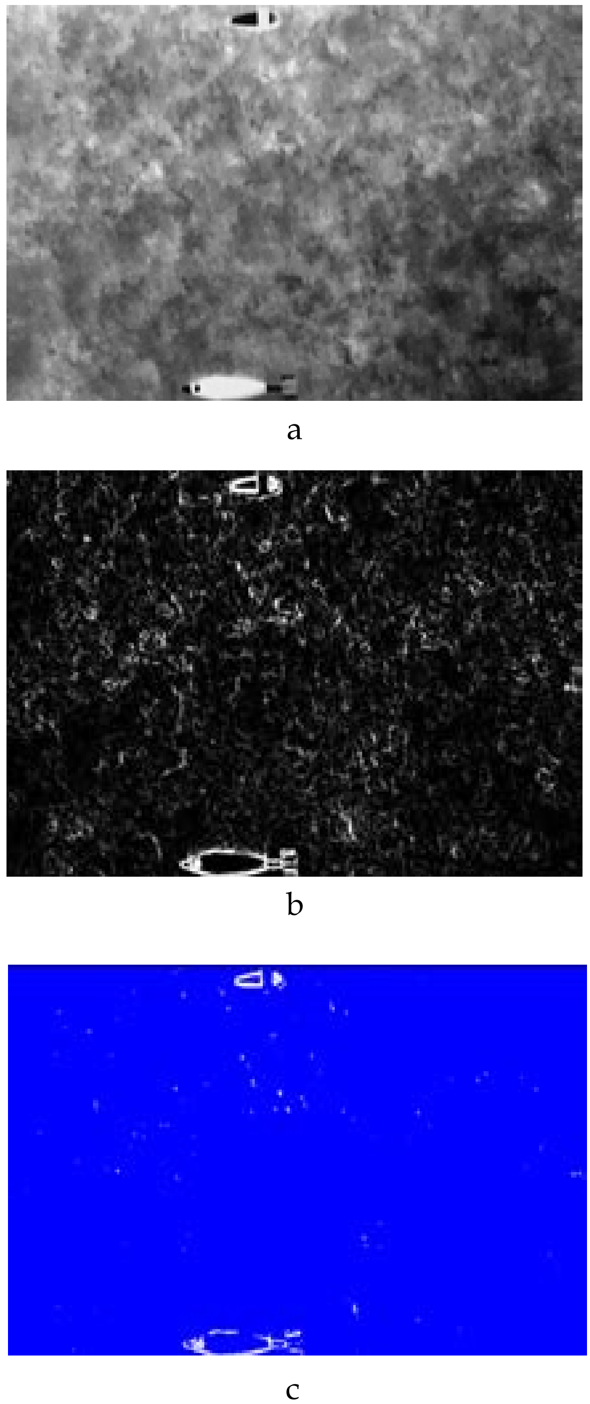


Figure 4. Tool for the detection edges of targets in the thermal infrared video recordings. a) Two targets in 720x480 pixels video frame, b) The enhanced edges of targets, c) The clutter suppressed.

The goal of [1] was to analyze the difference between TIR and color visible survey via RPAS and apply outcomes into elements for standard operating procedure. The eleven explosive targets were selected, for this purpose, Fig. 5 and Fig. 6.

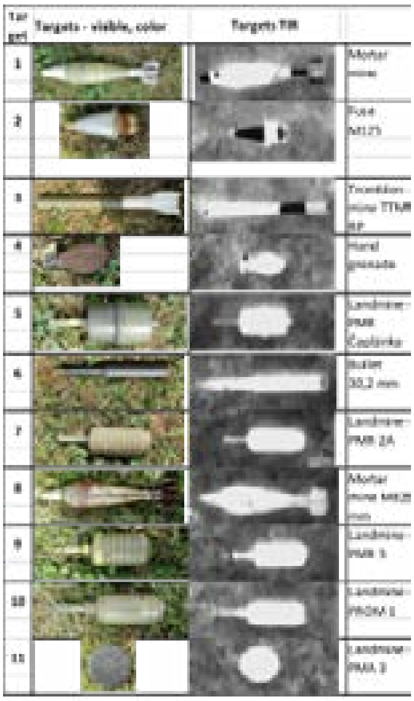


Figure 5. Targets and their TIR images.

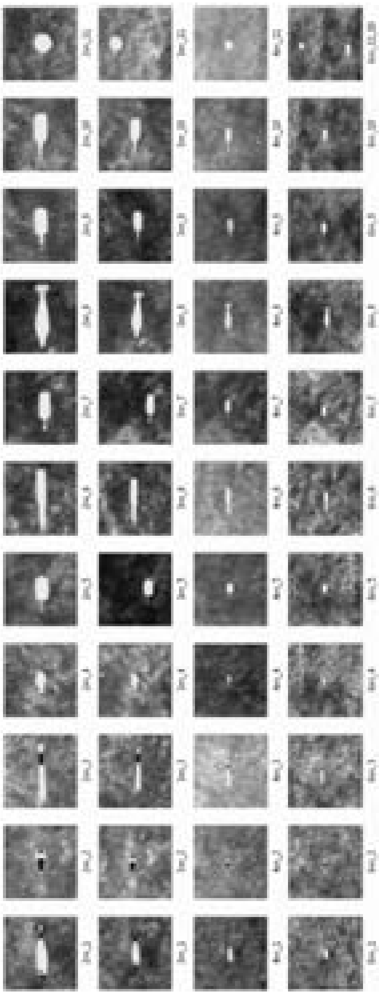


Figure 6. TIR visibility of 11 explosive targets, from RPAS at heights 2 m, 3 m, 4 m, and 6 m.

In Fig.6. is presented the influence of RPAS flight height on TIR visibility of target, while in [1] is derived, full quantitative model. The color visible survey is almost always applicable if the light conditions are average normal. For the TIR reliable survey, and detection of targets, the Sun insolation is obligatory, but this is not enough, the thermal contrast Target/Environment shall be > 1. The TIR survey is additionally limited by the emissivity ε of the target, $\varepsilon<1$. Emissivity, reflection, imaging angle decrease the probability of the target detection & identification via the TIR measurement. The atmosphere attenuation is negligible if RPAS flight heights are lower then 10 m. The thermal contrast of the target and the neighborhood shows significant daily changes, [2]. For the reliable detection of the target, the number of pixels on its area should be high, this is defined by Johnson's criteria, [3]. Due to described facts, the TIR survey from RPAS shall provide the following, [1]:

- Matching parameters of the TIR survey to features of the targets and the environment, landmines (LM), unexploded ordnance (UXO). In future Improvised explosive devices (IED).

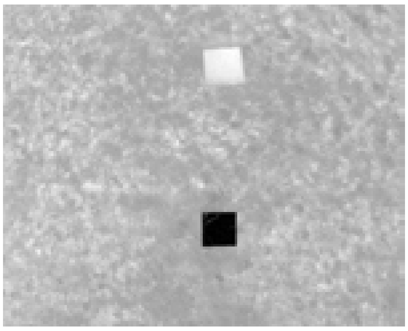
- Provision of needed detecting probability for the considered targets and the environment.

- Optimizing the UAV based TIR acquisition for Land Release, Non-technical and a Technical survey.

- Evolutionary design of the standard operating procedures (SOP) for the TIR survey, verified in several totally different environments and situations.

Operational calibration of TIR spatial resolution

The probability of a survey mission by a TIR camera on board of RPAS depends on the achieved spatial resolution of the collected images and video frames. While there are numerous causes that decrease obtained spatial TIR resolution, it is mandatory to check achieved spatial thermal resolution. For this task, we applied operational calibration by the use of polished aluminium markers. The aluminum square polished surface appears in the TIR image black and has a large contrast to other parts of the terrain. The use of such markers enables the operational calibration of the spatial TIR resolution. The wooden or paper markers that are painted black, appear in thermal images as white squares.Fig.7.



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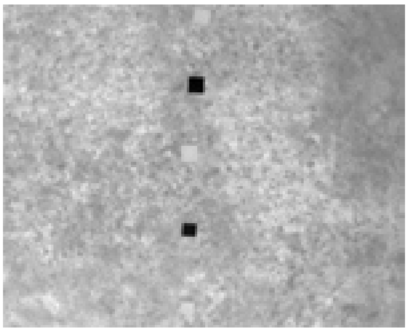

b

Figure 7. TIR image of the calibration markers.

a) h = 2m, markers 15x15 cm,

b) h = 6 m, markers 15x15cm, 10x10 cm.

Knowing the dimensions of the calibrating markers, numbers of pixels in the horizontal axis (M=640), the vertical axis (N=512) one can calculate the dimension of the pixels of the considered survey. The measured TIR resolution is always coarser of theoretical value, due to several causes, e.g. the blurring the images due to movement and the vibrations of the camera on RPAS, weather conditions, thermal conditions. The success of a TIR survey mission by RPAS is often uncertain while the use of dual-sensor (thermal infrared camera and visible color camera integrated into one unit) can overcome this problem, Fig.8.

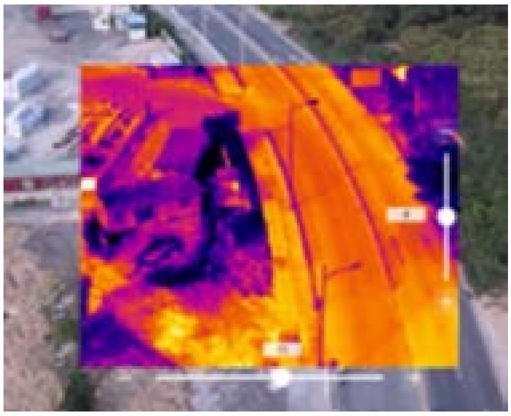

Figure 8. The visible wavelengths image and TIR image are fused in dual-sensor camera.

Acknowledgments

Norwegian People's Aid, Mine Action and Disarmament Programme Bosnia and Herzegovina, provided tests and data for use in [1], [2] and in this conference article.

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Application of LIDAR technology on remotely piloted aircraft system in Monte Negro and in Bosnia and Herzegovina

Application of LIDAR technology on remotely piloted aircraft system in Monte Negro and in Bosnia and Herzegovina

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Abstract

The LIDAR is an active sensor, working in near-infrared wavelengths, and can be used at night. It radiates quick laser pulses and records received optical echos from the object's surface. The received pulses form a cloud of data and after processing are obtained high-resolution digital surfaces, digital terrain elevation model. LIDAR on remotely piloted aircraft system (RPAS) was implemented in NPA for 3D analyses of the terrain for purpose of assessment of risk caused by exploded ammunition storage (in Montenegro) and of engineering objects of a former battle area in Bosnia and Herzegovina. LIDAR recordings enable us to classify several classes of the surface and several classes of materials. The important factor of the LIDAR survey is spatial density, the number of LIDAR points on one square meter. The highest density was achieved in the case of the Vlašić 20 m data, 1596,7 points/m2, while in other cases it was from 343,4 to 345,9 points/m2. In further research and development of the survey should be investigated the relation between points density and targets. The fusion of LIDAR classification data, DSM, color visible data and thermal infrared data, all collected via RPAS, can be very successful technology for land release, for assessment hazardous suspected area, for detection of the explosive targets on the land surface.

Key words: LIDAR, RPAS, ammunition storage, engineering objects, Rogami, Vlašić, NPA

1. Introduction

The nontechnical survey by use of a very high-resolution color camera on the remotely piloted aircraft systems (RPAS) is a mature technology in humanitarian mine action. Due to the availability and use of the very advanced hardware and software, it is possible to produce a digital orthomosaic and digital surface model, at a high-quality level, from a large number of images, [1], [2]. The examples [2], [3] provide quantitative pieces of evidence of this statement. There was used color camera FC6510_8.8, providing images 5472x3648 pixels, ground sampling distance 1,76 cm. Was covered area 0,089 km2, used were 893 images, time of initial processing was 2h3min. The main products are Orthomosaic, Digital Surface Model. In [3] was shown the application of the mentioned system for the risk assessment for populated places in the vicinity of the ammunition storage area Rogami in Montenegro, [Fig.1], while in [4] are derived contour lines (vector data) and fused with orthomosaic (raster data), Fig.2. The fused vector data and raster data enable the application of the fused data in projecting clearing. Starting by described technology, in the next section, we consider LIDAR technology used via RPAS.

2. Initial test of LIDAR on RPAS for NTS

There is one new technology, LIDAR sensor on RPAS, that can advance the non-technical survey (NTS) and the detection of improvised explosive devices in the surface layer of the asphalt or concrete road, of the pavement. The LIDAR recordings enable the production of the cloud of the surface points, classification of different materials, and 3D data for presentation of the surveyed surface, [5], [6]. The NPA Bosnia and Herzegovina started testing LIDAR surveys via RPAS in 2019, in a hazardous suspected area in Bosnia and Herzegovina, considered in the next chapter, from Fig. 3. to Fig. 7.

a b

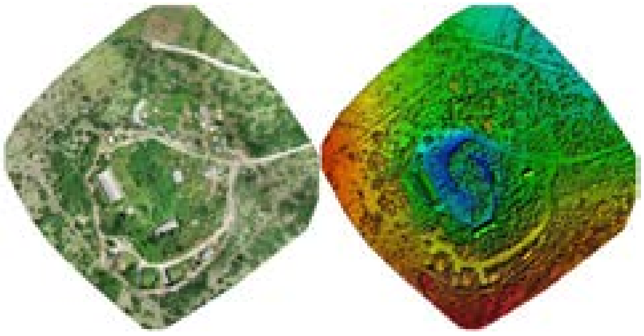


Figure 1. a) Orthomosaic, b) digital surface model of ammunition storage area Rogami, [2], [3].

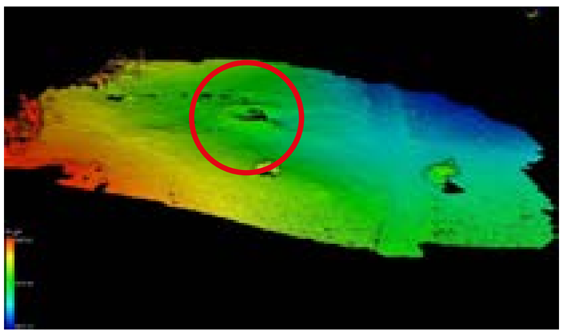
Figure 2. The contour lines developed from the digital surface model, shown overlapped onto the color orthomosaic of ammunition storage area Rogami, [4, p.14].

NPA Bosnia and Herzegovina collected LIDAR and color images of a former battle area on the mountain Vlašić, [4]. This is (first) set of LIDAR data of a hazardous suspected area, which can serve to initialize operational research of LIDAR value for humanitarian demining needs.

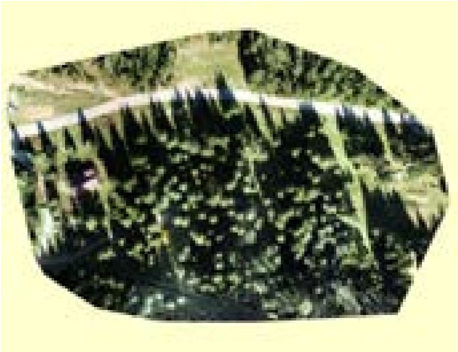
The likelihood of detection of former engineering objects from nadir images is often at a low level, Fig. 3. There a visualization of LIDAR points Fig.4, and 3D data Fig.5, assist to solve this problem.

Figure 3. Color nadir image of shelter, Vlašić, RPAS height was 20 m.

Figure 4. The visualized shelter by LIDAR point cloud data [4, p.32].



5. 3D The visualized shelter by LIDAR point cloud data. The shelter is approved.



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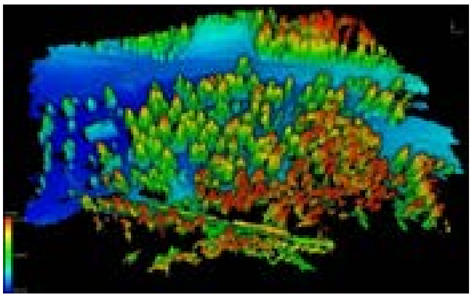

b

Figure 6. Vlašić, forest color image, and 3D LIDAR view. RPAS height was 30 m.

a

b

*Figure 7. a) Color visible mosaic of NPA test site Blagovac, an image of the scene at nadir. b) 3D model of Blagovac derived 23.01.2020 from LIDAR *.LAS data.*

There are other domains in humanitarian mine action in which LIDAR used from RPAS can contribute. A first is the detection of the changes of asphalt or concrete road surface. The potholes, longitudinal or transverse cracks, subsidence of rutting are ordinary indicators of the distress of the road surface. LIDAR can be used for collecting recordings of road surface distress via RPAS, [7]. This is a new potential not used before for the detection of fresh buried IED or landmine in the road.

The second challenge for LIDAR is its application via RPAS for detection command wires laid on the ground surface or above it. It is known that LIDAR is an efficient tool for detecting the wires of an electric high tension network. Thre is a reference about tests done for detection wires in the desert surface, [8].

Acknowledgments

The tests of LIDAR on RPAS have been done by Norwegian People's Aid, Mine Action and Disarmament Programme Bosnia and Herzegovina, in 2019. They provided LIDAR data for use in [4] and in this conference article.

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Mobile Remotely Controlled Toolbox Against CBRNE threats including deployable efficient hyperspectral sensor systems

Mobile Remotely Controlled Toolbox Against CBRNE threats including deployable efficient hyperspectral sensor systems

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Forming an integral part of the International CBRNE Institute (ICI) , the CBRN-E Knowledge Center Community of Experts intends to ensure sustained impact on the demining community and value to the general public, support the European Union (EU) Security facing CBRN-E hazards threats and welcome Experts in Explosive (E) and CBRN Hazards -related issues.

The proposed Community of Experts shall, inter alia, focus on the exploitation of the toolboxes and initiatives developed in EC (European Community) projects so far and on expanding their application to risky hazards threatening civil society. The CBRN-E KC 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 have been or 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 (GICHD), the European Corporate of Security Associations (ECSA).

The Community, administratively managed by his Knowledge Centre (KC) is coordinated by a Decentralised Steering Committee (RMA, CTRO, CSIC, SITE), responsible for external relations and visibility, while the members of the community are acting in five Technical Task Forces, or TTF, namely Technology Watch, Validation and Standards, Training, Analysis of User's requirements and counter Improvised CBRNE Devices.

CBRNE Crime Scene Investigation

The use of chemical weapons during the Syrian civil war in the Khan al-Asad attack that befell in the suburbs of Aleppo in March 2013 and in the Ghouta attack in the suburbs of Damascus in August 2013, the intensive bombing of Syrian areas as well as the Kuwait mosque suicide bombing in June 2015, and more recent terrorist actions in several African Countries bring into relief that both military and civilian population can be exposed to highly hazardous Chemical, Biological, Radiological, Nuclear and Explosive –CBRNE- agents following conflicts, natural disasters, industrial accidents or terrorism attacks. All CBRNE incidents should be handled and investigated with a possible future litigation in mind. With that we mean that the area should be regarded as a crime scene until proven otherwise, and that all forensic evidence should be tracked and analysed safely and properly. However, once an accident or a terrorist attack involving CBRNE material (including improvised devices) has taken place, efforts of first responders are primarily focused on the fast rescue of surviving victims, their evacuation out of the hot zones and the preparation of decontamination (including demining)points. Although these first actions are crucial for the lifesaving of many citizens and for mitigating the harmful effects of the incident, unfortunately, they can also contribute to the destruction of relevant forensic evidence, thus hindering the event scene investigation. Sampling, collection and exploitation of evidentiary material are of utmost importance for the determination of the causes that originated the incident and for the identification and subsequent prosecution of the perpetrators in case of a terrorist attack. Therefore, concurrent with the immediate incident response must be a forensic level response, in case samples and information are required as part of a criminal investigation and before they can be destroyed, damaged, comprised or lost. In contrast to a conventional crime scene, forensic investigation in a CBRNE scene require special considerations such as considerably shorter time in the hot zone, longer distance between the forensic team and the CBRNE agent source and the use of personal protective equipment, which add complexities to the response. In order to strengthen and significantly improve the capabilities of the EU law enforcement agencies responsible of forensic investigations in CBRNE scenarios, the HOTZONESOLUTIONS and ICI l aims to extend the current Forensic knowledge and the offered CBRNE detection technologies by the continue updating of a catalogue of performing tools and the creation of a new paradigm in CBRNE Forensic Science: A Mobile Remotely ControllEd ForensicS TOolbox for CBRNE Crime Scene InvEstigation to be built-up by a highly configurable, modular, combination of advanced robotic systems, modular sensors and state of the art ICT technologies that will be capable of (among others):

Identifying the CBRNE agent

Terrorists potentially have a wide range of available weapons, ranging from very simple to exceedingly complex. Terrorist weapons can be categorized into five major groups: (i) conventional weapons and explosives; (ii) nuclear and radioactive weapons; (iii) chemical weapons; (iv) biological weapons (v) Improvised CBE (Chemical, Biological, Explosive) devices These weapons can be combined or used sequentially. After a CBRNE event has taken place, the earlier identification of the CBRNE agent can mean the difference between life and death.

The RICOPTER (from HOTZONESOLUTION)

For identifying the agent, our partners can provide the capability for real-time, wide-area reconnaissance by using modular portable CBRNE sensors integrated in a tele-operated all-terrain mobile robot (as the tEODor, for example) and an auxiliary UAV (as the RICOPTER). Depending on the features of the incident scenario, it will be possible to deploy only one of these reconnaissance units or both working in a collaborative manner. For radiation surveillance, the proposed sensor subsystem can based on the integration of new miniaturized sensors for gamma radiation and a high efficiency neutron detector based on novel silicon technologies. Such a sensor subsystem has already been designed, implemented and validated in the European FP7-REWARD Project (Radiation Surveillance System. For Chemical Warfare Agents (CWA) identification and Toxic Industrial Chemical (TIC) detection), Ion Mobility Spectrometry (IMS), infra-red spectroscopy, Raman spectroscopy, colorimetric and Surface Acoustic Wave (SAW) sensors are considered as well. Hyperspectral imaging systems as well as vapour sensors based on fluorescence polymers are currently evaluated for accurate explosives trace detection in a NATO project coordinated by our Croatian partner.

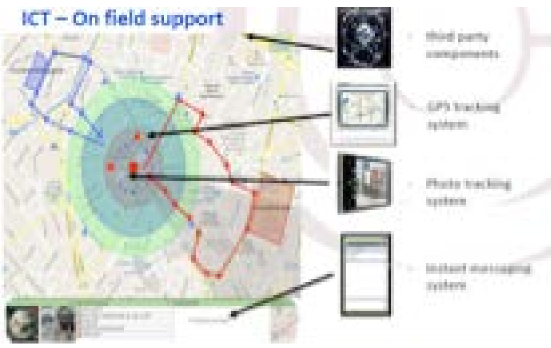
- Detecting and locating the source, when possible
- Robust collection and preservation of potential evidentiary material
- Packing, labelling and transport of collected material, putting maximum effort in the custody chain preservation
- On-site investigation of contaminated exhibits
- 3D Forensics registration of the incident scene
- Offering minimal disruptive effect on the crime scene and high resilience against environmental hazard.
- In-situ sample screening and searching

Today, screening and searching of samples are performed by the National Police CBRNE-specialists, veterinarians, and microbiological experts at the site. These specialists that are trained to work in a "hot zone" with personal safety equipment are exposed to dangerous and hazardous agents that can put at risk their lives. Sampling Protocols in hot zones, Knowledge about the requirements from the legal system with regards to forensic evidence, chain of custody is essential for such sampling. For in-situ sample screening and searching, a tele-operated all-terrain mobile robot can be equipped not only with modular CBRNE sensors, but also with a vision system, mounted o, a pan-tilt unit, consisting of hyperspectral, SWIR, LWIR and high definition RGB cameras,providing the operator a better situation awareness.

The tEODor robot (European FP7-ICARUS-TIRAMISU Projects)

- Communicating with the remote command and control centre – mobile CBRNE lab

Essential! The information on the status of the accident has to continuously be shared between the local intervention unit and the Crisis Centre. Locally, a Deployable Analytical Laboratory (DAL) can be use, while a management software (SPHYNX) can be proposed in the regional or national Center: the ICI-HOTZONESOLUTION developed and experimented both tools.



Materials for passive sampling and optical sensing of explosives, and an active method for landmine detection

Materials for passive sampling and optical sensing of explosives, and an active method for landmine detection

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Light-emitting organic semiconductors are highly sensitive to trace vapours of explosives at ppb concentration levels and below. However, detecting trace amounts of explosives in field conditions is highly challenging, especially under variable environmental conditions. Preconcentration techniques allow the explosives to sorb and accumulate on a material over time, thus a higher concentration can subsequently be thermally desorbed and detected via a loss of emission from the organic semiconductors. We present results from field trials using honeybees to passively collect explosives from the environment prior to deposition on preconcentrator materials in the colony entrance and compare with lab results. To assess optimal preconcentration materials, different polymers were loaded with 2,4-DNT and their retention and desorption characteristics were measured for a wide range of analyte concentrations, and thermal desorption temperatures. Camera-equipped drones were also used with signal-processing algorithms to monitor trained honeybees swarming around vapour plumes. We demonstrate an end-to-end methodology with promising results for humanitarian demining efforts.

Introduction

Novel technologies for trace chemical detection of explosives have been developed in recent years, with an emphasis on optical sensing1-5. The chemical signature emitted from landmines over time has traditionally been detected by dogs, but the drawbacks with dogs including costs of upkeep, animal behaviour, and time allowed on-site per day6. Optical chemical sensing can allow comparable sensitivity to dogs, with the added advantage of low-cost, portable instrumentation with no limits on operational time.

Remote Explosive Scent Tracing (REST) is a common technique for sorbing explosives to a mesh material prior to interrogation via sniffer dog. This method can be used in conjunction with optical sensors, which have drawbacks in field conditions, particularly with windy conditions dispersing trace vapour plumes prior to detection. Preconcentration materials have been characterised with a range of explosives, where the explosive molecules sorb to the surface over time which can then be thermally desorbed to deliver several orders of magnitude higher masses of explosives to the sensor element. Many of the polymers investigated and characterised are however very expensive and not suitable for mass use in humanitarian demining. Some chemically similar materials available off the shelf are promising alternative materials, like fluoropolymer Aflas and PBE.

Finally, the use of honeybees provides a method to survey a wide area without risking human life. Honeybees collect material from the environment electrostatically during natural foraging activity. Explosives present in the environment from landmines can be picked up with pollen and brought back to the hive, which can then be analysed and detected.

A complementary active method involves training bees to fly towards a specific odour in a contaminated area. This is achieved by exposing the bees to TNT, for example, when given a food source like sugar solution. The bees associate the smell of TNT with a food reward, and so when released into the field they hover above a vapour plume. Over distances, the bees are followed by using high-definition cameras and thermal cameras mounted on drones. By using three such drones simultaneously the area can be overlaid for higher reliability. From georeferenced high-resolution video, a map of space-time density of trained bees over the suspected area is generated, which allows the determination of the precise location of an explosive device.

We present recent results from the Bee4Exp project, which aims to use honeybees in a passive method to survey wide areas for landmine contamination, with a subsequent active method where the honeybees are trained and followed by a camera-equipped drone to pinpoint landmines in that area. The aspiration is to provide a new tool for safe humanitarian demining.

Experimental

The methodology for sensor fabrication, preconcentrator preparation, and bee colony preparation is outlined in detail in a previous work7. Briefly, the fluorescent polymer Super Yellow (Merck) was dissolved in toluene and spin-coated onto clean glass slides. To assess the performance of thin-film preconcentrators, the fluoropolymer Aflas was compared with a phenol-based epoxy polymer (PBE). Each was dissolved in Tetrahydrofuran to deposit thin films.

To assess the affinity of the preconcentration polymers to DNT, and the optimum temperature to induce thermal desorption, a thin film of the sorbent material was loaded with a known concentration of DNT and heated using a hot plate for 3 minutes for each of a series of temperatures starting from 40°C in steps of 10°C. After each heating step, an absorption measurement using a UV-Vis spectrometer was performed.

For in-situ placement of the preconcentration material in the hive entrance and exit, sheets of poster canvas were blade-coated with polymer solution and cut into squares before being rolled into tubes and inserted in Standard Lexan plates (1 × 1 cm tube) cut into 10 cm lengths and used as a cartridge with 4 channels and inserted into the entrance of the hives. The cartridges containing the preconcentrators were left in place throughout the day to allow bees to return from foraging and deposit any explosive materials (Figure 1).

Figure 1 - Honey bee in cartridge tunnel containing a preconcentrator.

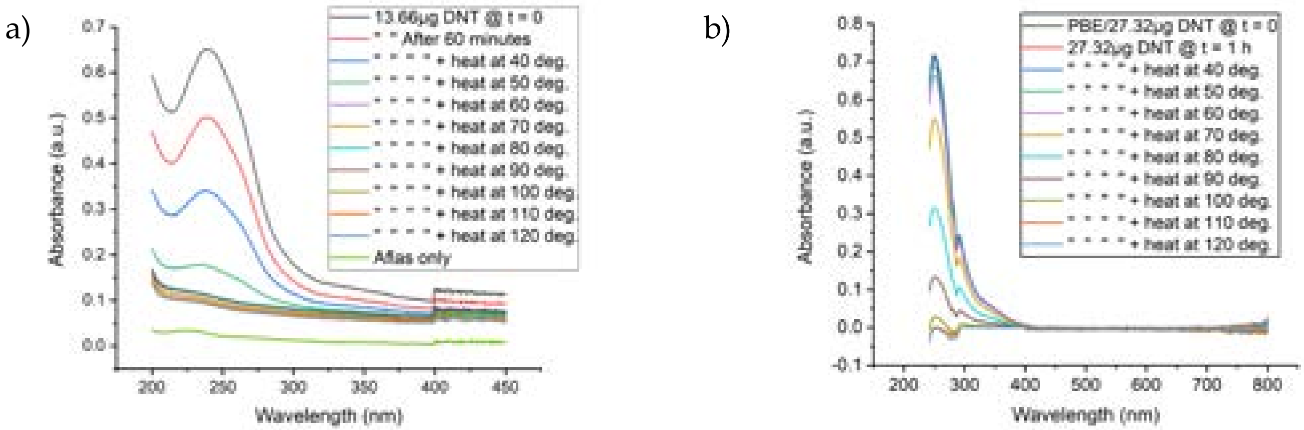

Figure 2 - (a) thermal desorption of DNT from Aflas over 40°C - 120°C; (b) thermal desorption of DNT from PBE over 40°C - 120°C.

To test the preconcentrators for explosive residue, the canvas square was placed on a heating element near the sensor in a homemade cell. The sensor was excited with a blue laser diode and its photoluminescence measured over 5 minutes. The photoluminescence at room temperature was measured for 30 s, then the heating element turned on for approximately 100 s to heat the sample to 100°C. The loss in light emission was measured. After measurements had been completed the chamber was flushed again with clean nitrogen to clear the chamber of any residual explosive vapours.

The acquisition hardware consists of video capture using a UAV equipped with an ultra-high definition video (UHD) and a thermal camera (TC). UHD video resolution was chosen to cover the largest possible ground in one frame, so each frame contains more than 8 million pixels. The UAV hovers at around 8 to 10 meters and camera is equipped with a 50 mm lens (equivalent to a 35 mm system), and so each honeybee covers the area of around 20 pixels.

The UAV includes a DYS Saga aluminum gimbal suitable for large DSLRs with a net weight of 1.6 kg and capability to carry more than 3 kg of payload, and a 5.8G video transmitter. This system is compatible with Panasonic GH4 and Sony A7 digital cameras. The camera is enclosed in a steel case with two Li-Ion 18650 batteries and a mount for GoPro RGB camera. The camera has a Ulis Pico 640 image sensor with 17 µm pixel size with a 100 mm lens.

Results

The results from loading the Aflas and PBE films with DNT are shown in Figure 2. The use of Aflas as preconcentrator material has been shown to be effective for adsorbing explosive materials for subsequent thermal desorption and detection, and Figure 2a shows desorption at close to ambient temperatures. Better retention in the polymer allows the samples

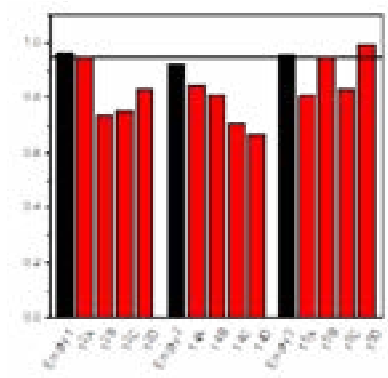

Figure 3 - Typical results from three different colonies

Figure 4 - Images of honeybees during a free flight. The yellow circles marked automatically detected honeybees.

to remain stable with the original mass of deposited explosive on the surface, leading to more pronounced fluorescence quenching. The polymer PBE shown in Figure 2b exhibits effective loading of DNT, with no desorption noted until heated to 80°C.

Figure 3 shows typical field results using Aflas as the preconcentrating medium. The black bars indicate "clean" runs to ensure the test chamber has not been contaminated with explosives between tests and should be close to unity each time. The spread of results showing between 0 and 40% light loss indicates a different mass of explosive being deposited on each preconcentrator.

Results from the camera-equipped drone is shown in Figure 4. The yellow circles show individual bees detected via the algorithm, pointing towards a successful method for identifying honeybees in real time when they swarm above an explosive vapour plume.

Conclusions

Results from a project combining free-flying honeybees for passively sampling explosives materials, and actively trained bees to detect buried explosives with UAV-assisted monitoring, have been presented. Materials Aflas and PBE have been investigated for their affinity to explosives and thermal desorption characteristics. Passive sampling allows for explosives to be collected by foraging honeybees which then deposit the explosives on the surface of a preconcentrator which can then be exposed to an optical sensor for detection; this method is anticipated to be useful for area surveying and Quality Assurance post-clearing. The active method is intended to be able to pinpoint individual land mines in an area, with bee swarming over a suspected mine being followed and recorded by a dual camera system mounted on a UAV. Both methods together may provide a robust beginning-to-end procedure for humanitarian demining.

Acknowledgments

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IED - searching and elimination of threats, Polish systems and tools.

IED - searching and elimination of threats, Polish systems and tools.

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Introduction

In recent years awareness among soldiers in Polish Army about IED's and ways to cope with them significantly increased. Thanks to NATO missions in areas such as Afghanistan and Iraq Polish combat engineers could elaborate new skills and help constructors in mother country to construct innovative systems and tools to neutralize threats resulting from the IED's. On the other hand Polish Army since 1945 have been providing humanitarian demining in cities, rivers, forests, farm fields, etc.. That helped to develop its own unique approach to this subject. As commonly known Humanitarian Demining is a thorough, time-consuming process that seeks to pinpoint the locations of all mines so that the land or sea area in question may be safely returned to its original use. A comprehensive approach to ensuring this process is carried out effectively is vital.[1] There are many tools and systems using in Poland to deal with UXO's, IDE's and regular demining of land mines fields. To keeping in mind that explosives devices of all kind hidden in ground are a major problem in Balkan and more countries in Europe there have been developed several prototypes and computer systems to counteract threats related to IED's and UXO's[2].

Presence of both: Soviet and Nazi army in XXth century on territory of Poland still have impact on everyday life people living there. In 2019 demining patrols and mine divers in only one district remove over 6500 ERW's[3]. There is still huge amount of UXO's and Explosive Remnants of War across the whole coutry. As you probably heard there's still waiting big challenge for Polish divers and combat engineers in the Baltic sea-famous British earthquake bomb using during World War II- Tall Boy.

Replacing old with new

Despite of Poland doesn't have to deal with IED's on its own territory, Polish Army gained valuable experience in NATO missions in Afghanistan and Iraq. Basing on experience of that combat engineers who were there to help bring peace in these regions, we created our own systems and prototypes of devices for better and safer operating in hazardous areas. Leaving behind post-soviet constructions we enter a new era w demining systems. Polish scientists, engineers and constructors shown that they can compete with the best in the world and they're replacing old systems with brand new ones.

Computer systems

Demining begins with reconnaissance so we need a proper system to correctly mark those hazardous areas. And here comes technology and software named "ZSRI-Integrated System of Engineer Reconnaissance".[4]

It's a special software intended for data collection, logging, transfer and processing pertaining to engineer situation of friendly and enemy troops. The data transfer can be done by means of wired, fibre-optic or radio communication The ZSRI enables the accomplishment of missions connected with the preparation reconnaissance reports. The data are obtained from on-board and portable devices as well as by reconnaissance patrols. The system in compatible with all the communication and command systems being service with the Polish Army. The data base includes the following elements:

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[1] *Tiramisu 2012-2016 Humanitarian Demining Toolbox*

[2] *International Symposium "Mine Action" ISSN 1849-3718, Tiramisu 2012-2016 Humanitarian Demining Toolbox*

[3] *Brygada Zmechanizowana w Złocieńcu-Clearence patrol statistic in 2019 (https://www.wojsko-polskie.pl/2bz/articles/aktualnosci-w/2019-12-174-podsumowanie-roku-patroli-rozminowania/)*

[4] *WITI Military Institute of Engineer Technology Wroclaw „Catalogue of Accomplished Projects. dr hab. inż. Januszko Adam*

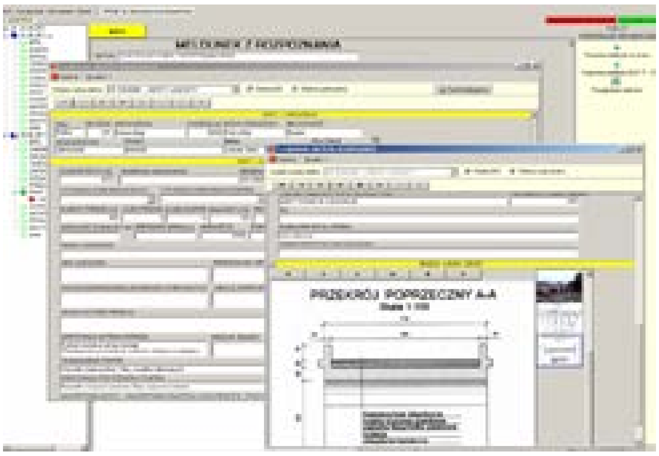
• Mines and dangerous objects.

• Communication objects being in the country,

• Water regions, water courses and hydrotechnical objects,

• Minelaying, mineclearing and demolitions,

• Tactic-technical parameters of equipment.



Proper vehicle

So far Polish Army is using post-soviet vehicle; TRI – Engineer Reconnaissance Vehicle with archaic tools for its missions. It correctly fulfils its function but it's too old if compare it with modern equivalents from other countries. This bring us to our prototype – brand new KRTI – Wheeled Engineer Reconnaissance Vehicle.

The KTRI with on-board and portable equipment is able to perform engineer reconnaissance missions by intelligence sub-units of engineer troops and to send report by means of its communication equipment independently of the day-time, weather climatic and geographic conditions.

Portable system of neutralization IED's and UXO's

For situation when needed special tools to destroy landmine on the spot. Thermal Neutralizer or Explosive Neutralizer – this choice leaving for us Military Institute of Engineer Technology. Both of those solutions are offering different resultants after use. First-thermal neutralizing hazardous objects, such as mines and Improvised Explosive Devices via deflagration in temperature exceeding 2000°C without producing dangerous products of this reaction.

From the other hand Explosive Neutralizer is aimed only to destroy detonator of mine by using small explosive charge. Explosive set consist of three main elements: an explosive charge, a pointer, and a tripod.

If Explosive device is in urban area or neutralizing on the spot creates threat of getting casualties in buildings, the best way to deal with that in the safest way is to take it to range and neutralize there. But that requires appropriate conditions to safe passage by civilian roads. "Blast-Containment Vessel" is answer for those problems.

The vessel was manufactured out of 10-mm steel sheet connected with a tank head, the frame, on which the vessel is mounted. It is part of a much bigger program TIRAMISU about which will be said later.

TIRAMISU PROGRAM

TIRAMISU is extensive project leading by multinational team including Polish engineers and scientists which was realized by European Partners from 27 countries (www.tiramisu.com). It touching all aspects of demining civilian areas, from creating brand new prototypes to running courses about mine risk and how to avoid them. In previous editions of this symposium Tiramisu was mentioned few times.[5]

[5] *International symposium "Humanitarian demining" ISSN 1848-9206*

Blackadder Disrupters

Blackadder Disrupters

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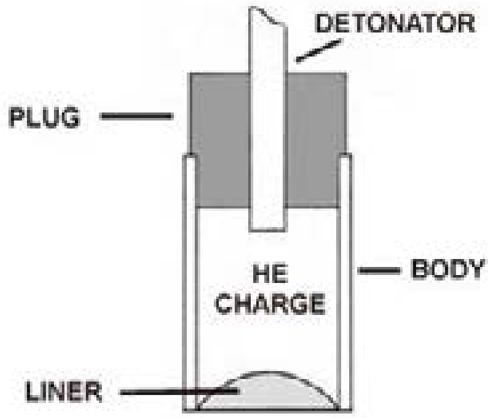
For those who do not know, the most common explosive disrupter in use is called a 'Baldrick', shown above. Baldrick was the name of the servant in the UK television comedy series Blackadder. Blackadder was rather more intelligent that Baldrick, so these improved disrupters are called Blackadders, or Bl'adders for short.

Explosive disrupters use a shaped liner to create a 'shaped charge' which has the unlikely effect of focusing the way that the pressure wave expands when high explosive (HE) detonates[1]. The liner is usually made of pressed copper, but many materials can be used and an expensive variant using pressed magnesium is widely available.



With a shaped charge, the energy released by a very small amount of high explosive can be used to penetrate armoured vehicles and this has been exploited in munitions such as the M42 sub-munition, which has a conical shaped charge.

The shape of the liner varies from munition to munition. In the infamous BLU-97, it is a blunted cone with a rim.

The liner's shape and composition effects the dynamic plastic flow of the material and the 'focus' of the high pressure jet or projectile that is formed. Despite being commonly called 'plasma', this is only a very high-pressure jet. When shallow liners are used, it may be called a 'slug' or projectile rather than a 'jet'. Surprisingly, the temperature of the explosion is not enough to melt copper but the immense pressure of the focused blast expansion produces speeds that can be measured in kilometres a second and this makes the liner change shape as if it were a fluid. When it strikes the target, the material of the target flows away from the impact as if it were molten but it is not.

1 *This effect was first noted by Monroe in 1888.*

Conical liners make a narrow jet able to penetrate a metal target to greater depth than shallow cup liners. Shallow cup liners make a slug that makes a bigger hole like that shown above, which allows better venting of the burning explosive inside a munition. Liners recovered after a penetration have shown copper folded around the steel of the casing.

Using the research conducted to optimise the effectiveness of munitions, I set out to make a disrupter able to destroy munitions more reliably that the Baldrick. These disrupters are used to penetrate the casing of a munition in the attempt to make the explosive burn without fully detonating. Avoiding detonation has the advantage of limiting the risks of damage or injury, but disrupters are notoriously unreliable. They sometimes fail to form a penetrating jet, and sometimes form more than one jet so dividing the force needed to penetrate the target.

Identified causes included a failure to pack the explosive evenly into the disrupter so that the liner could shape the charge. It was said that the body of the disrupter had to be made of thick-walled metal to help focus the detonation, and so a length of thick metal pipe is often used.

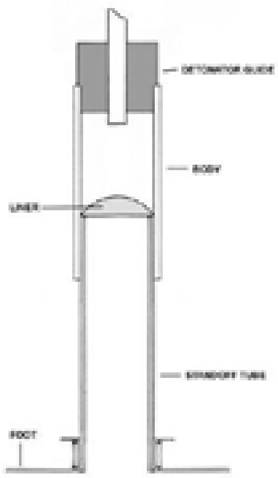
If clear plastic pipe was used instead of metal, the person filling the disrupter could see that the explosive was packed around the liner without any cavities, so overcoming this problem. In more than fifty tests, the clear acrylic body of the Bl’Adder has always worked.

Another cause of failure was reported to relate to the incorrect positioning of the detonator. If it were not positioned centrally or if it were pushed into the explosive too far, it was believed that the shock wave would not focus effectively.

In the Bl’Adder, a long resin bung (which may be called a ‘reflector plate’) holds the detonator centrally so that it can be pushed into the explosive a measured distance. The bung flattens the top of the explosive fill, so preventing any accidental shaped-charge effect at that end of the explosive.

With many disrupters, there is no set distance that the disrupter must be positioned away from the target. The conical liners in munitions collapse very quickly and need little standoff. With shallow liners the optimal standoff distance is greater as shown in the diagram below.

The Bl’adder can be positioned further away, but is designed so that it cannot be closer than the minimum stand-off distance dictated by the stand-off tube as shown below.



An incidental benefit is that the acrylic body burns on detonation, so avoiding the fragmentation hazards associated with using a steel body.

The entire Bl'Adder is made using transparent plastic parts that are assembled before use without the need for tools. The picture above shows one containing a measured 50g of plastic explosive. For consistency, all testing has been conducted using 50g but it is believed probable that 30g would produce a very similar effect.

A unique Bl'adder liner

When using a disrupter on a live munition, the shock of the impact may cause a detonation, especially when the penetration occurs close to the detonator. In other cases, the high explosive burns rapidly and the temperature increases to that at which the remaining high explosive detonates. When most of the explosive has already burned, this is called a 'deflagration' and the impact of the munition detonating can be much reduced. However, whenever any explosive disrupter is used, it is always possible that its use will cause a full detonation.

The hot slug produced by most disrupter liners does not reliably ignite the explosive inside, especially if it passes through both sides of the munition so is not in contact with the explosive for more than a microsecond.

I made a range of liner designs with a view to achieving a reliable wide diameter penetration, a reduced tendency to penetrate both sides of the munition, and greater reliability in inducing a low velocity burn in the explosive filling.

The liner inside the Bl'adder had to be made using materials that were widely available and not restricted for air transport.

Some of the liners made and tested are shown above. They had varied chemical payloads and were of very different shapes, so gaining experience of the effect that the geometry and the density of materials had on the blast wave.

An extensive series of empirical testing conducted with the help of MAT Kosovo in both Kosovo and Montenegro allowed me to refine and select a unique disrupter liner that promotes the desired low temperature burn. I was also able to compare its performance against conventional liners, and confirm that it performed better.

In the chosen Bl'adder liner, a thin copper dish with a specific curvature has a chemical mix added on top. The mix could be called 'thermite' because it contains fuel and oxygen, but is not the same as other thermite mixes which usually require a very high temperature to ignite and then burn at a very high temperature. When delivered inside the munition, the Bl'adder's chemical payload contains enough fuel and oxygen to start a reliable burn at a relatively low temperature. The shape and increased weight of this liner also reduces the chance that it will pass through both sides of the target.

In all the controlled and witnessed[1] tests to date, the Bl'adder disrupter has worked efficiently and the high explosive (TNT) inside the munitions has burned. Even with small targets, there has been no penetration of both sides of the munition.

With these live mortars, the fuze was blown off by gas expansion, but the munitions burned out completely without detonating.

This work has been a 'proof of concept', proving that using an acrylic body increases reliability and that the idea of introducing energetic materials which burn at low temperature inside the munition is both practical and effective. I have also shown that this can be achieved without high cost, while avoiding any import constraints.

This work was started when I was a research assistant in the Engineering Department at the University of Genoa (UNIGE). While they did not actually fund the work, their stipend and intellectual support allowed me to do it – and I will always owe a dept of gratitude to Dr Matteo Zoppi[2] of UNIGE. I am also indebted to William Bagley[3] of Johns Hopkins University (JHU) in the USA who has advised and assisted freely in much of this work. Thanks also to a British volunteer, Cris Chellingsworth, who contributed invaluable ideas in the early days, and to John Fardoulis, who overflew some of the testing with a UAV and provided valuable video footage.

Finally, I believe that there are plans to produce the Bl'adder commercially now, plans which I support in the hope that this will give me the opportunity to gather evidence about field use, then make further tests and refinements. But of course, others could do this just as well. Although this is 'rocket science', readers should not be intimidated by that. Optimising shaped charge use has always needed a practical empirical approach – and lots of testing.

[1] *Testing was witnessed by MAT Kosovo staff, who also provided the EOD oversight and expertise required. Contact Ben Remfrey: ben@pcm-erw.com*

[2] *Dr Matteo Zoppi, engineer extraordinaire: zoppi@dimec.unige.it*

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Innovative cost-effective approach for EORE that can serve years (digital campaign, VR/AR)

Innovative cost-effective approach for EORE that can serve years (digital campaign, VR/AR)

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580,000 children in Ukraine were affected by an armed conflict in the Eastern part of the country. Ukraine is fast becoming one of the world's most mine contaminated countries. From 14 April 2014 to 31 January 2020, OHCHR recorded 530 conflict-related civilian casualties among children: 147 killed (98 boys and 49 girls) and 383 injured (234 boys, 133 girls and 16 children whose sex is yet unknown).

From 14 April 2014 to 31 January 2020, OHCHR recorded 174 civilian casualties **among children** (38 killed and 136 injured) **resulting from mine-related incidents** (MRI)[1] and handling of explosive remnants of war (ERW)[2]. Of them: 43 casualties (16 killed and 27 injured) resulted from mine-related incidents, and 131 (22 killed and 109 injured) resulted from ERW handling

Families who are coming back and those who remained at post-conflict areas of Donbas are at risk due to a lack of knowledge about the dangers of landmines and other explosive devises. Children are not properly informed about how to stay safe in areas where they are present. With aim of protecting schoolkids and preventing injuries among children, UNICEF Ukraine has developed an entertainment education program to educate children about safe behaviors called "Superteam against mines". Based on the KAPB baseline conducted with main audiences, key messages were developed. The most critical practices were embedded in the characteristic of each Superteam's hero appealing to children with lifesaving rules educating them how to avoid landmines and Unexploded Ordnance (UXO): Notice!, Bypass!, Report!, and Don't panic!.

It used multiple platforms to reach children living in high-risk areas to promote safe practices among adolescents through digital platform (www.inforce.team), social media, printed comics, stickers, posters, school diaries and notebooks. A video featuring UNCEF Goodwill ambassador Orlando Bloom (https://goo.gl/bCfPSa) was intended to reinforce lifesaving practices among adolescents, motivating them to actively use the website to seek for related information.

The edutainment campaign reached 2.4 million children online. Among them, over 500,000 children received comic books, posters, stickers and about 200,000 children were engaged in direct training sessions during 2016-2017.

The post-campaign survey stated that knowledge and intended practice of safe behavior when observing mines increased by 12% among children in affected areas. The ability to identify risky areas among children have increased by 15%; ability to identify suspicious and dangerous objects increased by 20% among teenaged children living in affected areas.

The Superteam against mines concept was used for conducting interactive education games for children of preschool and elementary school age was turned into series of cartoons.

[1] Incidents in which civilians were killed or injured by mines (antipersonnel or anti-vehicle) or explosive devices triggered in the same way, such as booby traps, or by ERW (explosive remnants of war) that were inadvertently detonated by unsuspecting civilians.

[2] Victims of ERW handling manipulated with an ERW for a certain period of time and took additional efforts to make it detonate (for instance, by trying to dismantle it), or were near those, who manipulated an ERW.

Lessons learnt

Why the edutainment approach was selected to be the most effective:

Main audience were teenagers who are less receptive to traditional media, have lower risk perception and are always eager to try all new. Motivating safe practices were effective through to educate through entertainment;

Increasing risk perception among children in humanitarian context cannot be done through traditional communication – showing a consequences of unsafe practices. Children are already traumatized and many of them faced psychological distress. Therefore, edutainment as more positive and empowering way of communication serving effectively for the conflict affected audiences.

Following the joint advocacy with partners, the content and information materials with Superteam are being included in the methodological recommendations by Ministry of Education to teachers. Therefore, sustaining the programme and introducing edutainment components in school education could be a way forward for improving quality of formal mine risk education.

After 6 years of conflict even more **profound edutainment approach is required**. UNICEF Ukraine work on VR and AR (**AUGMENTED REALITY**). Children will get **the very first VR and AR experience** and that information will definitely get into the **long-term memory**. **Project contains 3 tailored VR / AR videos for**: primary school, secondary school and adults.

Linking mine action and infrastructural development in the republic of Serbia

Linking mine action and infrastructural development in the republic of Serbia

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Abstract

This paper deals with the interaction of mine action and infrastructural development in the context of the current expansion of construction and the need to create conditions for safe execution of infrastructural projects that is a prerequisite for future investments in the Republic of Serbia. Requests for clearing the terrain from explosive remnants of war are numerous. The assumption is that there will be more and more requests, given the reform and European integrations processes. Taking into account the fact that armed conflicts of different intensities took place in the territory of the Republic of Serbia during the two World Wars, as well as the 1999 bombing, we can reasonably assume that the land and facilities in the war affected areas have been significantly contaminated with different types of explosive remnants of war, such as artillery ammunition, air bombs of various caliber 50-1000 kg. The role of the Mine Action Center as a national mine action coordinating authority, as well as the role of all other relevant stakeholders, is of vital importance. There is a need for a strictly regulated system, compliance of deadlines, accomplishment of tasks and creation of a sense of security for investors to further invest in infrastructural projects. Prerequisites for this are, among other things, reliable contractors - mine action organizations with qualified staff and technically equipped to carry out demining/clearance operations on such projects. Furthermore, a higher level of awareness on risks of explosive remnants of war is needed and taking appropriate measures prior to carrying out excavation related works.

Keywords: mine action, infrastructural development, explosive remnants of war, raising awareness on risks of explosive remnants of war.

Introduction

In addition to systematically land contaminated areas with cluster munitions, air bombs - rockets and underwater contamination originating from the 1999 bombing, by groups of mines originating from 2000-2001 conflicts along the administrative line with Kosovo and Metohija, in the territory of the Republic of Serbia, there is still a huge contamination with explosive remnants of war from the First and Second World War, as well as the ERW contamination due to explosions and fires in military depots, etc.

For coordination of humanitarian demining operations, in 2002, the Serbian Mine Action Center (SMAC) was established as an independent state body, which focused its activity firstly on what was at that time urgent and important, and those were the areas contaminated with mines, cluster munitions and air bombs - rockets, given that these are explosive ordnance that directly threaten people's lives and prevent their movement and work.

Clearance of the areas contaminated with cluster munitions, mines, air bombs-rockets and other UXO has contributed to safety of local population, creation of conditions for safe construction of infrastructure facilities, safe exploitation of forests, development of agriculture and tourism. Also, environmental and fire protection have been improved significantly. Considering that the areas in question have been mostly located in underdeveloped municipalities, in order to develop them and stop population from emigrating for economic reasons, demining/clearance of contaminated areas enables implementation of infrastructural projects, such as construction of solar power plants, development of wood industry, i.e. exploitation and processing of wood.

On the other hand, the areas systematically contaminated with ERW during the two world wars have been treated sporadically.

It is known that the territory of the Republic of Serbia was bombed and destroyed during the First World War in 1914 and 1915 by Austria-Hungary and Germany, in the Second World War in 1941 and 1944 by Germany and Allies. During the bombings, heavy weighted air bombs and artillery shells of various calibers were used. There is a large probability that some of them have failed to explode, but are in the ground, thus posing a real hazard in case of earthworks or the use of other modalities of ground disturbance.

Role of SMAC and other relevant stakeholders

SMAC does not carry out demining/clearance, but, among other things, conducts specialized tasks in the area of mine action, which include survey of areas suspected to be contaminated with cluster munitions, mines and other ERW, develops demining projects, follows the implementation, controls the quality of demining, educates the population about the dangers of mines and other unexploded ordnance, participates in the training of staff for performing general and technical survey and demining.

In Serbia, demining is carried out by specialized companies and other organizations that are accredited, technically equipped and with staff qualified to perform these tasks.

There are more and more infrastructural projects of public interest that include clearing of terrain and construction, relocation or reconstruction of infrastructure facilities, construction of business - residential and other facilities, which implies construction works with excavation of soil.

Last year, SMAC developed an ERW clearance project that comprised a site in Niš, which, during the 1999 bombing, as a site within military barracks, was repeatedly targeted by cluster munitions and air bombs. It has been planned to build apartments for members of security forces on this site.

Furthermore, SMAC developed a project that included a site in Kragujevac where search and excavation of ERW was conducted, and now the construction of the Secondary Government Data Center/Disaster Recovery Centre is in progress on this site.

Fig 1: Armored excavator used on ERW clearance project in Niš

Special attention is drawn to Project for demining and technical survey (UXO risk reduction) in the areas of construction of the main gas pipeline route from the border with Bulgaria (in the vicinity of Zaječar) to the border with Hungary (in the vicinity of Horgoš). Implementation of humanitarian demining operations on this project has provided conditions for safe engineering-geological and geotechnical exploration of soil and construction works on the main gas pipeline route from the border with Bulgaria to the border with Hungary, so called Turk Stream.

In the coming period, SMAC is expected to develop an ERW clearance project involving a complex inside the Smederevo Fortress, which was shot with the 42 cm cannons and badly damaged during the First World War and the crossing of the Danube by the Austrians. In the Second World War, it was devastated by a large explosion of ammunition that was stored there. Towards the end of the war, it was also destroyed by Allied bombers. In order to create conditions for the safe conduct of systematic archaeological investigations in the Smederevo Fortress, as well as to maintain and use this cultural and historical complex to the fullest, it is necessary to search and remove ERW first.

Contractors

In order to best respond to an increasing number of requests for ERW clearance of terrain, contractors have to be mine action organizations with a serious approach to the task, fully committed and above all, with the state of the art technology equipment. Such equipment can enable them to work more efficiently and accurately than ever before. In Serbia, devices developed for the detection of ferromagnetic objects buried underground at a depth of about 6 m have been used on several projects. The devices are equipped with data loggers having software that is used to analyze data recorded in the field.

Photo 2: Use of devices that allow the application of a passive and active method on ERW clearance project related to Data Center construction site in Kragujevac

Analysis of data in the field determines whether there are ERW or anomalies indicating the existence of an object of a mass within the limits of the critical error established by an ERW clearance project.

Photo 3: Transfer and analysis of data acquired by data logger on an ERW clearance project in Kragujevac

Such is, for example, a MAGNEX 120LW device with a recording width of 2.5 m or an UPEX 740 M device with a recording width of 2m.

Photo 4: Use of MAGNEX 120LW and UPEX 740 M on ERW clearance project in Novi Sad

Depending on the terrain to be searched, MAGNEX 120LW device can be hooked up as a quad trailer for faster and easier search of the area to be cleared. The maximum speed of the vehicle for which the detector is attached is 10 km / h.

Photo 5: Use of MAGNEX 120LW device on Demining and Technical Survey Project (UXO risk reduction) in the areas of construction of the main gas pipeline from the border with Bulgaria (near Zaječar) to the border with Hungary (near Horgoš).

Raising awareness

In connection with this issue, SMAC intends to invest considerable resources in raising awareness with various mine action actors, and international organizations, as well as in the country, in particular with employees of institutions responsible for construction and communal operations, members of the Ministry of Interior, firefighters, hunting associations, mountain societies, entities of importance for protection and rescue and other interested parties. The intention is to carry out ERW risk education and training activities connecting theory and practice.

Conclusion

It is necessary to strengthen the influence of mine action institutions and instruments with a focus on the regulation of the system. In addition, continuing education and training, keeping track of the state of the art technology, but also the establishment of an effective communication platform and networking of mine action actors are needed.

References:

1. Archives of the Serbian Mine Action Centre

Historical analysis as residual ERW contamination risk assessment tool: Case study Sarajevo

Historical analysis as residual ERW contamination risk assessment tool: Case study Sarajevo

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Fifteen unexploded aircraft bombs are found in the Sarajevo area since 2015. Ten of those are found inside the city limits and eight were 1000 lbs. (454 kg) bombs. Seven bombs are found in the already processed or built up areas; one in the foundations of the house, one under the street, one under the parking lot, and four in the foundations of the factory building at depths from 1 to 5.5 meters. Three bombs were set as demolition charges with remote firing. Four bombs were found over a 6-day period in September 2019. All bombs found inside the city limits were less than 150 meters away from the residential buildings and five of those were less than 50 meters away. Thirteen bombs, all found in the city area among them, originate from the World War Two period, 10 were British, three French, one US and one German.

Even though the majority of the bombs were found in the populated urban area where uncontrolled detonation may have severe consequences, until now, no formal risk analysis has been undertaken. Following MORE guidelines[1] risk exists on the location where contamination is present during the activities which can interact with the contamination, so for the understanding of the risk it is necessary to analyze all available pieces of information related to the characteristics and distribution of the contamination[2]. Practically that means search for the available historical sources and testimonies, their verification and the analysis of the data collected from those sources.

Sources and data collecting

As 14 out of 15 bombs originate from the World War Two, focus of the research is put on that historical period. In order to identify data sources with satisfying level of information, first we had to determine which air force units were engaged in the bombardment of Sarajevo and then to conduct search for the documents related to those units.

Initial research was reduced to examination of the previous studies on the air war from 1941 to 1945. We found works of Shores and Cull[3], Richard G. Davis[4], Kevin A. Mahoney[5], Allan Grainfeld[6] and Jeff Jeffords[7] extraordinarily useful for this part of work, since above mentioned authors identified units engaged in bombardment and in few cases dates of the attacks and gross tonnage dropped.

Based on those data we conducted search for the published and unpublished archive documents in order to find records that contain bombing related data. Unpublished archive materials were found in The National Archives of UK in fund 'Air Ministry and Successors, Operational Record Books, Squadrons', and in the Air Force Historical Research Agency (AFHRA) in fund 'Documents and

[1] *Management of the Residual Explosive Remnants of War (MORE), (2015). Geneva: Geneva International Centre for Humanitarian Demining.*

[2] *International Mine Action Standards, IMAS 07.16, ed.1, amandment 14, 19. mar 2019, 7.2.3, pg. 7.*

[3] *Christopher Shores, Brian Cull (1987), Air War for Yugoslavia, Greece and Crete, 1940-41, London: Grub Street.*

[4] *Davis, R.G. (2006) Bombing the European Axis Powers-A Historical Digest of the Combined Bomber Offensive1939–1945. Maxwell Airforce Base, Alabama: Air University Press.*

[5] *Mahoney K. A. (2013) Fifteenth Air Force against the Axis: Combat Missions over Europe during World War II. Lanham, Toronto, Plymouth UK: The Scarecrow Press, inc.*

[6] *Grainfeld, A. (2011) Bombers over Sand and Snow: 205 Group RAF in World War II. Pen and Sword Books*

[7] *Jefford, J. (2009) 'The Balkan Air Force', Royal Air Force Historical Society Journal, 46, pp. 63-80*

Publications'. From these sources we obtained following documents: operational orders, summary and narrative reports, operational records and photographs related to the bombardment groups' and squadrons' missions.

Published archive materials were found on the historical web sites of the bombardment groups that were part of the USAAF 15th Air Force. These sources provided facsimiles and transcripts of the operational orders, narrative reports and vertical photographs of the bombing of the targets in Sarajevo. Problem which we encountered during the analysis of these documents was their verification. To avoid working with unverified documents all the data were exclusively collected from the official web sites and all collected documents were crosschecked by comparing to the verified data. If document was not verified in this manner, it was not used. Primary sources in our work were authentic archived documents while documents obtained from the web were used only in cases in which no other source was found. For three Luftwaffe (German air force) attacks no authentic documents were found. Data found in the documents obtained from mentioned sources were used in the analysis of the contamination characteristics; types and quantities of the bombs dropped and fuzing setups. These sources have also contributed data about the attacked targets; ie. distribution of the contamination, but many more details on this subject were found in the documents produced by local military and civilian authorities in Sarajevo. Military authorities' documents are published in the Corpus of the Documents and Data from The Liberation War by Military History Institute of the Yugoslav People's Army in Belgrade[8], while civilian authorities' documents are kept in the inventory of The Historical Archives of Sarajevo in fund Kotarsko nadzorništvo narodne zaštite (District Inspectorate of Peoples Protection).

[8] *Zbornik dokumenata i podataka NOR-a, tom IV i V (1959), Beograd: Vojni istorijski institut Jugoslovenske narodne armije.*

Data interpretation

Through the analysis of the available sources, 18 bombing missions on targets within Sarajevo city limits, and 51 fighter-bomber attacks in the vicinity of Sarajevo are identified. Due to the fact that bomber attacks delivered approximately 20 times more bombs across a much narrower area, this analysis is focused on the bombings within the city limits. In the documents obtained from The National Archives and AFHRA, data related to the 11 attacks were collected while the documents obtained from the web provided data for the 4 attacks. No original documents related to the German bombings were found. In the local military and civilian authorities' archives, records of all bombings, except the German ones, were found. Bombing unit records contain following sets of the related data; target bombed, sighting method, formation and bearing of attack, amount and types of bombs dropped, fuzing setups and delay, target area coverage and bombing efficiency. Local authorities' records contain data on; estimated number of bombs dropped, stricken locations, unexploded bombs found after the attacks, damage and victims. While analyzing these data it was noted that data in different documents related to the same aspect of the bombing are significantly different. To avoid equivocality and confusion in the analysis, only data that could be reliably identified by the author of the record or the document, and which were relevant for the outcome, were used. From bombing unit's records data related to the types and quantities of bombs, fuzing setups and target area coverage are used, while from local authorities' records are used data on damage, stricken locations and unexploded bombs. Also, for the specific bombings, number of the remaining craters, if available, was compared to the number of dropped bombs.

German attacks were researched indirectly by coopting data from previous studies[1] and recorded testimonies[2], so this part of the analysis is not complete and results are not final. Level of data in collected records enabled successful establishing of the contamination distribution ie. identifying locations where presence of the unexploded bombs is plausible. For several locations approximate characteristics of the contamination are identified while for some, the only characteristic determined is the origin of the bombs with no data on type and quantity.

Results

Results are presented in the narrative and tabular form by chronological bombing order and in geographic form by marking stricken areas and other data in the GIS base. One set of analyzed data contains: target attacked, quantity and origin or gross tonnage of the bombs dropped, fuzing setup and stricken location. As no preserved records of unexploded bombs found from the end of World War 2 to 1990s are found, general risk assessment based on trend during last 15 years is made. Due to the limited format of this paper only summary of the narrative report will be presented here.

Target: Airfield Rajlovac, 80 pcs. of 250kg, 220 pcs. of 50 kg of German made bombs. Stricken: airfield.

Target: Sarajevo downtown, unknown quantity of German made bombs. Stricken: Main post office building, court building, railway station (old), hotel Zagreb, Cirkus-platz (area surrounding Holiday hotel), Veliki park, Bistrik, Bembaša, Medrese, Bjelave, Hrid i Vratnik, streets: Šenoina, 6. novembra, Masarikova, Skenderija, Jakubovića bašča, Pionirska streets.

[1] *Shores and Cull (1987), Air War for Yugoslavia, Greece and Crete, 1940-41.*

[2] *Sulejman Šefkić (1972), Stradanja stanovništva od prvih bombardovanja, Sarajevo u revoluciji, knjiga 2, Sarajevo: Istorijski arhiv Sarajevo.*

Target: Railway workshops and barracks in Pofalići, 4 pcs. of US made 500 lbs bombs. Stricken: fields between Terazije i Urijan dedina streets.

Target: Railway workshops and barracks in Pofalići, 162 pcs. of AN M64A1 500 lbs. bombs. Stricken: Trebevićka, Travnička, Cicin han, Gornji Soukbunar, Mjedenica, Balibegovica, Bistrik, Turbe, Medrese, Pirin brijeg, Sagrdžije, Kaukčije Abdulah-efendije, Toromanova, Kečina, Ćemrlina, Hrgića streets. 97 craters were found after the bombing.

Target: Airfield Rajlovac, 5 tons of US made bombs dropped. Stricken: area 500 meters north of the airfield. Three entry holes of suspected unexploded bombs were found.

Target: Railway workshops and train station in Pofalići, dropped 30 pcs. of MC500 bombs. Stricken: Osman-paša baracks (today University of Sarajevo Campus) and Kovačići area. 23 craters were located and three unexploded bombs in Miljacka riverbead were found.

Target: Alipašin most marshaling yards, dropped: 810 pcs. of AN M64A1 500 lbs. bombs. Stricken: Alipašin most and Kovačići, fields in Dobrinja, Alipašino polje, Saraj polje and Buljakov potok area.

Target: Alipašin most marshaling yards, dropped: 40 pcs. of 500 lbs. British bombs. Stricken: marshaling yards and its vicinity. 3 unexploded bombs found near road to Ilidža.

Target: Alipašin most marshaling yards, dropped one HC4000 bomb. No explosion was seen.

Target: Alipašin most marshaling yards, railway workshops at Pofalići and bridges at Dolac Malta, dropped: 63 pcs. of GP1000 i 7 pcs. of HC4000 bombs. Stricken: Alipašin most, Švrakino selo, Kolonija Dolac and Pofalići areas.

Target: railway stations, marshaling yards and bridges, dropped: 740 pcs. of AN M64A1 bombs. Stricken: Alipašin most, Švrakino selo, Kolonija Dolac area, and Ilidžanska and Gračanska streets.

Target: Alipašin most marshaling yards, railway switch at Dolac Malta and workshops at Pofalići, dropped: 350 pcs. of GP250 bombs (2 with 12hrs delay), 386 pcs. of GP500 bombs (75 with 6-12hrs delay), 342 pcs. of GP1000, 4 pcs. of HC2000 i 4 pcs. of HC4000 bombs. Stricken: Hakije Hadžića, Fra Jukića (at present Danijela Ozme), Husein-kapetana, Mažuranića, Skenderija, Donji Soukbunar, Zagriće, Čobanija streets, vicinity of the military hospital, Alipašin most, Kolonija Dolac, Čengić Vila, Novo Sarajevo, Švrakino Selo areas, city gasworks and train station. Unexploded bombs were found in Sokbunar, Mrakuša, Điđikovac, Nuzurova, Starčevićeva, Staro Hrasno, Kranjčevićeva, Jukićeva, Alibega Firduza, Husein kapetana and Hadži Idriza streets.

Target: Alipašin most marshaling yards and railway switch at Dolac Malta, dropped: 10 pcs. GP500, 200 pcs. of GP1000, 4 pcs. of HC2000 and 4 pcs. of HC 4000. Stricken: Alipašin most, Kolonija Dolac and Pofalići areas.

Target: Alipašin most marshaling yards, dropped: 224 pcs. of AN M64A1 bombs, 50 with 6 to 72hrs. delay. Stricken: Alipašin most, Vraca, Butmir and village Kovači under Igman mountain. Unexploded bombs were found in Vraca area and Ilidžanska, Marulića and Butmirska streets.

Target: Alipašin most marshaling yards and railway switch at Dolac Malta, dropped: 48 pcs. of GP1000 bombs. Stricken: Hrasno, north part of Koševo, Alipašin Most and Osman-paša barracks. 8 unexploded bombs were found in Staro Hrasno area.

In three missions bombs were not dropped as clouds covered the target areas.

Conclusion

99,5% of bombs dropped on Sarajevo targeted railway installations in Alipašin most, Dolac Malta and Pofalići areas. Out of 10 bombs found within Sarajevo city limits during the last 15 years, 2 were found within 500 meters from the railway switch and the bridge at Dolac Malta, one within 500 meters from old train station at Pofalići and 7 within 700 meters from Alipašin most marshaling yards (four in the target area). Comparing this number with the historical analysis' findings, localities of Alipašin most, Buljakov potok, Alipašino polje and Švrakino selo in municipality of Novi Grad have a high risk from unearthing of an unexploded bomb at depth of 3 to 6 meters. Localities of Dolac Malta, Hrasno, Čengić vila, Otoka, Pofalići and Buća Potok in municipality of Novo Sarajevo have an intermediate risk of finding of an unexploded bomb. As bombings struck every part of the city, findings are also possible in the areas within municipalities of Centar and Stari Grad but risk of finding them in these areas is low.

Information Sharing Across the Mine Action Sector: Why Is It Important and How Do We Do It?

Information Sharing Across the Mine Action Sector: Why Is It Important and How Do We Do It?

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Military to Humanitarian Demining

As far back as the Second World War, insufficient record keeping practices and the absence of standard practices for the armed forces caused numerous complications and casualties for those involved in mine laying as well as clearance efforts. The extensive defensive preparations—which involved 338,500 to 350,000 landmines—of the United Kingdom during World War II to prevent a German naval invasion and the subsequent clearance efforts are discussed in detail by Roly Evans in *The Journal of Conventional Weapons Destruction*. He notes the British military "accepted that clearance resources were insufficient to guarantee zero risk from explosive hazards."[1] While minefields were laid hastily in 1940 due to fears of German forces on UK soil, development of techniques such as recovery wires and safety distances, as well as recognizing the need to prioritize clearance, helped shaped standard practices for future mine action; however, the military-issued certificates stated "no guarantee can be given that the area may be considered safe."[2]

Before the late 1980s, most countries did not view landmines as a humanitarian issue but as a problem for which the military was primarily responsible.[3] However, following the withdrawal of the Vietnamese from Cambodia and the Soviet Union from Afghanistan, the global community awoke to the scale of the problem addressing post-conflict mine clearance.[4] Ian Mansfield writes that the mine action field began in Afghanistan in 1988, and Chris Horwood notes that in October 1988, the United Nations, on behalf of the country of Afghanistan, sought funding to provide "humanitarian demining" for issues caused by post-conflict contamination.[5] In time, more NGOs began to do work around humanitarian demining, including the Hazardous Area Life-Support Organisation (The HALO Trust, HALO) in 1988 and the Mines Advisory Group (MAG) in 1989.

Together with other nongovernmental organizations (NGOs) and international charities, HALO and MAG, the United Nations' relief efforts helped coordinate resources to fill the much-needed void for specialist organizations.[6] In 1996, international support helped create a mix of commercial companies, NGOs, and government agencies in Bosnia and Herzegovina; however, funding competition, differing goals, and insufficient record keeping and oversight prevented a national plan from achieving results.[7]

[1] *Evans, Roly, "World War II Coastal Minefields in the United Kingdom," The Journal of Conventional Weapons Destruction 21, no. 1 (April 2017): 33.*

[2] *Evans (2017).*

[3] *Mansfield, Ian, "Humanitarian Mine Action in Afghanistan: A History," The Journal of ERW and Mine Action 19, no. 3 (December 2015): 43.*

[4] *Horwood, Chris, "Humanitarian Mine Action: The First Decade of a New Sector in Humanitarian Aid." Relief and Rehabilitation Network, no. 32 (March 2000): 1-3.*

[5] *Mansfield (2015); Horwood (2000).*

[6] *Mansfield (2015).*

[7] *Mansfield, Ian, "The Early Years of Demining in Bosnia and Herzegovina: Transfer to National Ownership," The Journal of Conventional Weapons Destruction 21, no. 1 (April 2017): 20.*

Information Sharing Helps Shape a Community of Practice

The Center for International Stabilization and Recovery (CISR), established in 1996 as the Mine Action Information Center (MAIC) by the U.S. Department of Defense to share information between the military and NGOs, contributed to the understanding by the emerging mine action "community of practice" of the need for cross-sectoral information sharing. The creation of *The Journal of Mine Action*, today known as *The Journal of Conventional Weapons Destruction*, has, for twenty-three years, facilitated dialogue by giving technical experts, policy advisors, field practitioners, academic researchers, and advocacy groups a platform to discuss their experiences, lessons learned, challenges, and innovative technologies and methodologies.

Along with availability of a "trade journal" dedicated to the humanitarian mine action (HMA) community, the growth of the internet and expansion of organizations' websites also promoted the sharing of information on the activities of different operators, the status of mine-impacted countries, research results, guidelines, and best practices. The MAIC, in keeping with its mission to serve as a clearinghouse of information on mine action, included on its website news from the field, a conference calendar, an online version of *The Journal*, databases and munitions guides, digitized reports, conference proceedings, and risk education materials. By the early 2000s, many HMA operators and national programs had a web presence that continues to expand and feed the community's need for information and resources.

In the early years of the development of the community of practice, the face-to-face exchange of information proved crucial to improving the knowledge of best practices and the application of novel techniques. They also moved the community along towards the creation of agreed safety measures, effective operational procedures, and more standardized systems of information management. Noteworthy examples of international meetings that prompted further development of the community of practice are The International Conference on Mine Clearance Technology held in Denmark in 1996 that spurred on the first version of the *International Standards for Humanitarian Mine Clearance Operations* (March 1997), and The Global Mine Action Information Coordination Workshop hosted by the MAIC at James Madison University (JMU) in April 2000. Over the next five years, the Information Management System for Mine Action (IMSMA), one of several information management systems compared at that JMU conference, emerged as the common system used by the HMA community.

As the community of practice evolved and diversified, the need for international guidelines to help organizations adapt and standardize their own activities based on their unique circumstances, abilities, and available resources became increasingly apparent. The initial attempt at developing mine clearance standards started by the 1996 meeting led to further collaborative and consultative efforts supported by the United Nations Mine Action Service (UNMAS) and involving various HMA authorities. In 2001, the International Mine Action Standards (IMAS) debuted, which continue to expand as the scope of "humanitarian mine clearance" broadens to account for more contemporary explosive hazard threats and nuanced challenges.[1]

Together with a community of authors, *The Journal* continues the conversation on understanding the inter-relationship among donors, national mine action authorities and centers, and implementing partners in order to better address the guidelines laid out in the IMAS. Additional publications such as *The Landmine*

[1] Fiederlein, Suzanne, "New International Standards Debut October 1, 2001," The Journal of Mine Action 5, no.3 (2001): 115.

and Cluster Munition Monitor and *Mine Action Review* pursue the goals of seeking better understanding of community experiences and lessons learned. Moreover, periodic meetings and workshops such as the Mine Action Symposium, the biennial Mine Action Technology Workshop organized by the Geneva International Center for Humanitarian Demining (GICHD), and the annual meetings of National Mine Action Directors' and UN Advisors in Geneva are integral for providing opportunities to share information, seek assistance, and call for action, all with the goal of improving the performance and safety of the sector.

In addition, resources such as The Global CWD Repository housed at JMU on the Scholarly Commons library platform (https://bit.ly/3fAdSM7), provides a place of safe keeping for information and universal access for the HMA community of practice. The HMA community has much to share not only among its current and future practitioners, but also with other fields such as the movement to ban nuclear weapons and autonomous conventional weapons, and efforts to mitigate the effects of human-made climate disasters. The scope of HMA's records, from the early days of typed reports, hand-drawn maps, and personal accounts to today's high-quality digitized maps, sophisticated databases, and information dashboards all need to be preserved and made available.

Information Exchange as the Community Matures

Among specific issues of concern and debate within the community, we can point to a few examples of ones discussed in recent Journal articles that represent the breadth of the discourse. In 2018, Pehr Lodhammar argued for the need to determine standards for valuing clearance. By assessing the effect clearance has on a community, the field can create a metric by which the monetary cost of clearing explosive hazards can be judged on the socioeconomic impact it has on an area instead of the per-unit price of clearing landmines in a rural village under ideal conditions.[2]

Information sharing of demining accidents and incidents in HMA remains an ongoing challenge. The community should share and study accurate accident and incident records in order to learn how to avoid making the same mistakes in the future. Protective equipment may reduce injury, but avoiding accidents is the only way to prevent injury. In the early 2000s, Andy Smith started the Database of Demining Accidents (DDAS), which gathered detailed information as it became available.[3]

The DDAS has since been transferred to CISR as the Accident and Incident Database on the Global CWD Repository and contains over 800 accident reports dating from 1977–2019. In the 2010s, the GICHD developed the RAPID database, which reduced accident and incidents to statistical reporting. For a number of reasons, neither database has had the buy-in of the HMA community so as to encourage voluntary reporting. Many NGOs and donors have their own internal investigation and reporting requirements, making an additional reporting requirement a burden. In addition, there are concerns about privacy and liability that discourage reporting. However, IMAS 10.40 and IMAS 10.60 are currently being revised and have led to discussions within the IMAS Review Board about the need for a universal reporting mechanism in place for all demining accidents and incidents. A working group that includes GICHD, CISR, MAG, HALO, Norwegian People's Aid (NPA), Humanity and Inclusion (HI), and several national directors formed in 2019 to develop a

[2] *Lodhammar, Pehr, "How Iraq Is Changing What We Do: Measuring Clearance in Urban Environments," The Journal of Conventional Weapons Destruction 22, no. 2 (August 2018): 30.*

[3] *Smith, Andy, "The Database of Demining Accidents: A Driving Force in HMA," The Journal of ERW and Mine Action 15, no.2 (Summer 2011): 30.*

reporting schema that will be a useful learning tool for the community, one that takes into consideration time constraints, privacy issues, and desired outcomes in terms of reporting.

The issue of how to handle or even recognize improvised explosive devices (IEDs) has been an ongoing conversation among HMA actors. How to dispose of and detect IEDs has become a prominent issue in land clearance. In recent years, NGOs and similar organizations have worked together to share information in order to protect themselves and local civilians and gain a better understanding of IEDs. A large part of IED clearance is detecting and neutralizing the devices but also addressing the networks of IED manufacturing.[1] Therefore, information sharing between international and national law enforcement agencies, as well as NGOs, is instrumental in being able to minimize risk and plan strategic actions accordingly. Information sharing allows other groups in HMA to adopt and adapt IED clearance practices, which also allows actors to continue land clearance while gathering more information.[2]

Numerous articles in *The Journal* focus on IEDs and the importance of information sharing. In an editorial on whether the existing IMAS were applicable to respond to the emergent IED threat, Guy Rhodes, former Director of Operations for GICHD, writes that "Mine action operations are not defined by weapon type, but by the objectives they pursue and the context in which they take place."[3] Moreover, Lieutenant Colonel Shawn Kadlec discusses the benefits of military-civilian partnerships, explaining that opportunities for cooperation are only possible if both recognize each other's roles, responsibilities, and limitations. He points out that information sharing and knowledge exchange can achieve a unity of understanding and help organizations leverage individual strengths to complete shared goals. [4]

Where Next?

Despite new challenges such as IEDs and now a global health pandemic, the community keeps progressing toward the goal of a "Mine-Free 2025." New advances both in technology and the application of survey and clearance methodologies are real and a testament to the creativity and accumulated knowledge of the sector these past three decades. These advances and successes are fed by both informal and formal information exchange—the private discussions between colleagues in the field as well as research presented at workshops, and information shared in journals, reports, databases and repositories.

The advantage of formal information sharing is that it reaches a greater audience and can be preserved for the benefit of future operators. The value of information preservation and exchange cannot be overrated in a field like HMA, where evidence is crucial to knowing where we have been, where we are now, and where we can go in the future.

[1] *"An Initial Study into Mine Action and Improvised Explosive Devices," Geneva International Centre for Humanitarian Demining (February 2017): 46.*

[2] *"IEDs – A Growing Threat." United Nations Office for Disarmament Affairs, Accessed 4 March 2020, https://bit.ly/2POH7kj.*

[3] *Rhodes, Guy, "Improvised Explosive Devices and the International Mine Action Standards," The Journal of Conventional Weapons Destruction, 21, no. 3 (November 2017): 4.*

[4] *Kadlec, Shawn, "HMA in the Gray Zone," The Journal of Conventional Weapons Destruction 23, no. 3 (January 2020): 5.*

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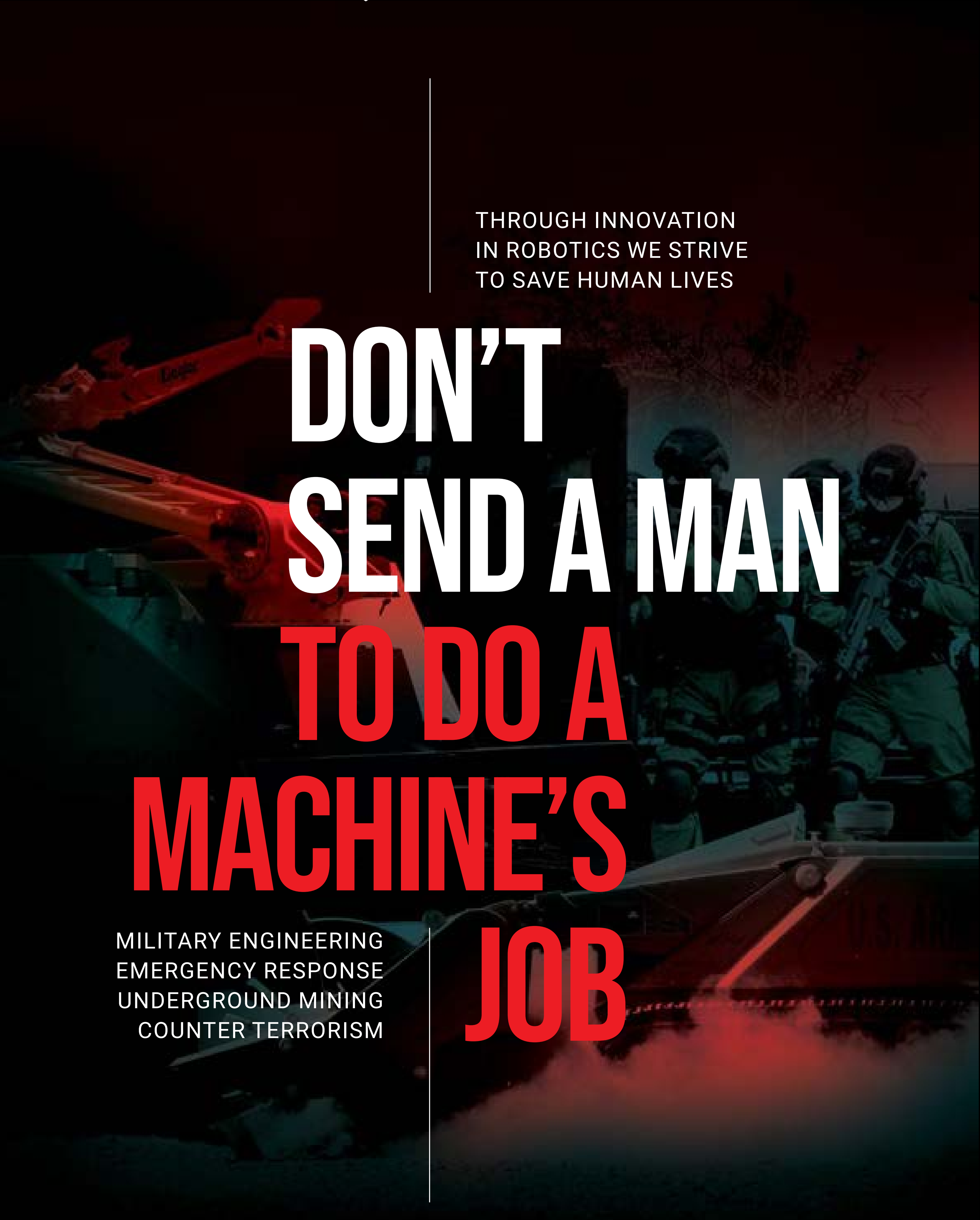

THROUGH INNOVATION
IN ROBOTICS WE STRIVE
TO SAVE HUMAN LIVES

DON'T SEND A MAN TO DO A MACHINE'S JOB

MILITARY ENGINEERING
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