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MINE ACTION 2019

Slano, Dubrovnik-Neretva County

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(contamination with mines and ERWs)

20 years of protecting civilians: Mine action as protection and the Oslo Action Plan

Ambassador Hans Brattskar, Permanent Representative of Norway to the UN and other International Organizations in Geneva and President of the 4th Review Conference of the Anti-Personnel Mine Ban Convention

Envisaged for Tuesday 9 April.

Excellences, Friends and colleagues,

I am pleased to be here with you all today. It is a great honor for me, as the President of the Anti-personnel Mine Ban Convention, to attend the 16th International Symposium on Mine Action here in Slano. Anti-personnel landmines are a problem that affect all regions of the world, including here in Europe.

On 1 March this year we celebrated the 20th anniversary of the entry into force of the Mine Ban Convention. That gave us an opportunity to reflect on what has been achieved and what are the remaining challenges. The Mine Ban Convention, which was adopted in Oslo in 1997, should be regarded as one of the most successful multilateral disarmament treaties of recent times. 164 States Parties, and a thriving network of international organizations and civil society actors, work towards a shared goal of a mine free world.

The Convention has established a strong norm against any production, trade and use of anti-personnel landmines. This norm is adhered to by many more than just the States Parties. Almost 52 million stockpiled mines have been destroyed, and vast areas have been successfully cleared and released to communities. The rights of victims and survivors have been recognized and assistance has been provided to many. This is truly a great achievement.

We can celebrate that 31 States Parties to the Convention have successfully finished clearance and been declared landmine-free. Several of these states are found in this very region. Many of you have experienced firsthand the impact of contamination on local communities. Mine action is in fact a prerequisite for any kind of development. 32 States Parties still have landmine contamination and clearance obligations in line with the Convention. Three of them are found in this region.

We don´t know how many lives have been saved or how much development has been achieved because land has been cleared and released. What we do know is that each of the almost 52 million stockpiles mines that have been destroyed has potentially saved a life or a limb. We know that countless children can now walk to school without fear of landmines, that farmers can work their land in safety. This is protection of civilians put into practice.

We also know that when all landmines have been cleared and all stockpiles have been destroyed, landmine victims and survivors will still have to live with the legacy of landmines for the rest of their lives. The Mine Ban Convention has been instrumental in recognizing the rights of landmine survivors, and persons living with disabilities in general. Still, many persons with disabilities do not have access to health services, to education and to employment opportunities. As states parties to the Mine Ban Convention we have an obligation to ensure that victims of landmines can enjoy their full rights and rightful place in society.

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Norway has been a strong supporter and a consistent partner in mine action since before the Mine Ban Convention was adopted in Oslo in 1997. Humanitarian mine action continues to be a priority for our government. We aim to use our presidency of the Mine Ban Convention this year to bring renewed political attention to mine action and to the continued relevance of the Mine Ban Convention. Protection of civilians, and mine action as protection, is our priority.

In 2017 landmines and explosive remnants of war caused more than 7000 registered deaths and injuries. 87% of these were civilians. In cases where the age was known, children accounted for 47 % of recorded casualties. At least 2 452 children were among the recorded deaths and injuries in 2017. These stark numbers remind us of what our joint purpose as a mine ban community is: to put an end to the human suffering caused by anti-personnel mines. Each victim is one too many.

***

Landmines are indeed not a problem of the past. In recent years, we have witnessed new and widespread use of improvised landmines. Many of these are produced and used as tools of war by non-state actors. While improvised landmines themselves are not a new concept, the scale of the problem is. Anti-personnel mines are prohibited and fall under the obligations of the Mine Ban Convention, no matter whether they are manufactured or improvised. If we want to protect civilians effectively, we must address new contamination through effective mine action, while not losing sight of legacy contamination.

In many ongoing conflicts, mine action is required for delivery of humanitarian assistance, reconstruction and to create the conditions for the safe and voluntary return of refugees and displaced persons. We know that many people displaced by recent conflicts will be returning to heavily mined areas. I therefore believe more should be done to prevent new casualties. We need to make sure we can deliver targeted and relevant mine risk education to vulnerable communities and groups of people. I believe more can be done to standardize and improve the relevance, quality and gender sensitivity of mine risk education. As presidency, we have initiated a dialogue with humanitarian operators, UN agencies such as UNICEF and UNHCR, and the Geneva Centre for Humanitarian Demining on how to achieve a broader and more coordinated effort and approach to risk education.

We must do more to protect children from the threats posed by landmines and other explosive ordnance. No child should risk stepping on a landmine years after a conflict is over and become victim of a war fought by a previous generation. Neither should a child risk losing a limb or their life in one of the ongoing conflicts of today – where children have no part. This is an area where we are encouraging increased cooperation and coordination between the mine action sector, the humanitarian and child protection sectors.

As we focus on protection, we must understand *who* is affected by landmines and *how*. We know that risk patterns vary for girls, boys, women and men – with young boys often being at highest risk of becoming a casualty. In other words; we must apply a gender perspective in all parts of our work in order to ensure effective protection for all. We would therefore like to challenge the sector to focus on advancing the gender perspective in *all* parts of mine action.

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This is my third visit so far during my presidency to countries contaminated by landmines or cluster munitions. I have previously travelled to Thailand and Cambodia, and to Ethiopia. The purpose of my travels is to identify best practice and experience that can be shared with other states facing similar problems, and to encourage increased political commitment to obligations of the Convention. Travelling also gives me an opportunity to learn more about how states and civil society are working at country level.

As president of the Convention, I would like to see as many countries as possible finish clearance before 2025, the deadline set by the Review Conference in Maputo five years ago. During the Norwegian presidency, we aim to provide political support, encourage wider donor engagement and stimulate national leadership to improve the pace of clearance. It is an ambitious goal, but by no means impossible. We have seen before that a country´s political commitment to mine action and national clearance obligations is perhaps the single most important determining factor to achieve success. We rely on the political commitment of Bosnia and Herzegovina, Serbia and Croatia to clear remaining contamination as soon as possible. We would like to see clear, concrete, country specific and time-bound plans for how each country will become mine-free.

Currently a small number of countries represent more than 70% of all funding for global mine action. We would like to see many more countries become donors and we would like to see increased cooperation and learning between mine-affected countries.

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We look forward to welcoming the mine action community to the 4th Review Conference in Oslo in November this year. We aim to adopt an ambitious Action Plan to guide us for the next five years. Our aim is to build on the strong foundation from the Maputo Action Plan and ensure that the challenges and opportunities of today are reflected in the new action plan. The goal of a mine free world by 2025 remains our vision and our rallying cry.

The Oslo Action Plan should provide a strong impetus to finish the job in as many countries as possible. I intend to consult extensively with States Parties, civil society, landmine survivors, the UN and other international organizations in developing the Oslo Action Plan. There is much expertise in this region. You know what has worked here and what areas of mine action still need more attention. I invite you to contribute actively in the preparations of the Oslo Action Plan. This workshop provides a great opportunity to share experiences, success stories and ideas on how to reach the goal of a mine free world.

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To conclude, let me once again highlight the objectives of the Convention; to save lives, protect civilians, assist survivors, and enable sustainable development for affected countries.

These issues are as relevant today. Let us therefore work together with undiminished strength to achieve a mine free world by 2025.

Thank you!

MINE ACTION CHALLENGES AND MIGRANT CRISIS

New challenges for Mine Action posed by illegal migrations

Milan Bajić[1], Željko Tkalčević[2]

Abstract

Illegal migration of persons towards Europe produces new challenges in many domains in EU countries, but only in Croatia this phenomenon is linked with mine action. The Croatian borders are 2374 km long, and the one with Bosnia and Herzegovina, 1011,4 km long, is the most vulnerable. The Balkan illegal migration route from Bosnia and Herzegovina ends in Croatia where exist large hazardous suspected areas (HSA) which are marked with warning tables maintained by Croatian mine action center (CROMAC), which maintains on Internet the selectable scale maps of existing HSA. The MAC of Bosnia and Herzegovina has on the Internet the map of HSA at the constant scale 1:400,000. Illegal migrants cross the border outside the traffic routes and making the permanent space-time surveillance of the area impossible if done only by ground forces. The illegal migrants are exposed to high risk if enter the HSA. Croatian border police are exposed to very high risk while they have to repeat search while controlling the regions near the border. Although the border police have helicopters for the land border surveillance, only a dual sensor (visible color and longwave infrared – thermal) surveillance systems with remote piloted aircraft systems (RPAS) can be a sustainable solution for permanent control of this EU land border with HSA. The Mine Action experience of RPAS application for Non-Technical Survey (CROMAC) and Targeted Survey (NPA Bosnia) in „difficult" terrains provides background for deployment the RPAS surveillance in considered new domain.

Keywords: Illegal migration, border, hazardous suspected area, HSA map, Croatia, Bosnia and Herzegovina, RPAS, dual sensor, longwave infrared

1. Introduction

Illegal migration of persons towards Europe produces new challenges in many domains in EU countries, but only in Croatia, this phenomenon is linked with mine action. The Croatian borders are 2374 km long, and the one with Bosnia and Herzegovina, 1011,4 km long, is the most vulnerable, [1], [2]. The Balkan illegal migration route from Bosnia and Herzegovina ends at its land border with Croatia in the regions contaminated with HSA. HSAs in Croatia are marked with warning tables established by former Croatian Mine Action Centre (CROMAC), which maintains on Internet the selectable scale maps of existing HSA, [3]. The MAC of Bosnia and Herzegovina has on the Internet the map of HSA at the fixed 1:400,000 scale, [4]. In a normal situation, without an increased number of illegal crossings the border, this satisfies all standards and practice of mine action. But the illegal migrants cross the border outside the traffic routes, making the permanent space-time surveillance of the region near the border extremely demanding as regards the human resources of the border police. Here we consider another additional problem, the increase of safety risk due to HSA, for illegal migrants and also for Croatian border police. The illegal migrants are exposed to high risk if and when they enter and cross the HSA. Croatian border protecting forces are exposed to very high risk while they have to repeat search while protecting the regions near the border. Although the border police have helicopters for the land border surveillance, a sustainable solution for permanent space-time control of this EU land border with HSA should be searched in another technology. This can be the advanced Non-Technical Survey made by combined dual sensors onboard of remotely piloted aircraft system (RPAS). Scientific Council of HCR-CTRO has several serious references for this domain, [5], [6], [7]. The goal of the paper is to analyse this idea on a representative case of combined borders and the HSA, Fig.1, to test and evaluate foreseen technology, derive and verify standard operation procedures, establish resource (unit which can be activated on demand) for day and night surveillance of the mentioned HSA, for education and training, and to verify and estimate the optimal quantity of surveillance sets.

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2. Case study region

In the paper are analyzed basic operational and technical requirements, for the part of border region in Croatia with HSA from community Dvor (upper right corner), HSA = 17,91 km^2 and Donji Lapac (lower left corner), HSA = 15,00 km^2, Fig. 1, Fig. 2. This region is selected for the case study in this paper. Note that there are other large HSAs which should also be analyzed. The total HSA in the considered region near the border in Croatia is 42,65 km^2. The flow of illegal immigrants in 2018 was the most intensive in this region and can be expected in 2019, also other regions should not be neglected. The majority of illegal immigrants in Bosnia and Herzegovina have been concentrated in Bihać, Cazin and Velika Kladuša, Fig.1, and from these locations, they permanently attended to cross the Croatian border. The trespassers' favorite paths change in time, mainly due to weather conditions and the availability of temporary stay (Bihać was one the largest in 2018). If the favorite paths are assessed they are not public. Therefore we will suppose that illegal immigrants can cross any of HSA, Fig. 1 and Fig. 2 and that the probab ility of this event can be uniform.

The total HSA in Croatia is 355,6 km^2, the perimeters are marked with 12280 warning tables.[3] The simplest initial decrease of risk due to illegal crossing the HSA can be done by increased density of the warning tables on the perimeters of each HSA. This should be done by HCR inside of Croatian Ministry of Interior, but additional financing should be provided. It is obvious that the distribution of warning tables is more frequent in regions where is the intensive activity of inhabitants. In other regions their distribution is sparse, see an example of HSA between Dabar and Glibodol, norther from Otočac, Croatia, Fig. 3a.

3. Preliminary analysis of HSA

The nearly permanent space-time surveillance of the long border with HSA can be realized by a number of systems, each consisting of the dual sensor onboard of RPAS. To evaluate this solution shall be done several analyses of HSA. The objectives of the preliminary analyses of HSA in the case study region shall be done using GIS data of HSA. The experience from 2014 in the project [5], shows that simple in office planning capacity of RPAS survey was too optimistic (instead of to provide 31 km^2 only 6,02 km^2 color imagery was achieved by two independent RPAS teams). Thus we will follow procedure applied 2017-2018 in Croatia on 23,74 km^2 HSA Dabar – Glibodol, Fig. 3b:

- Analyze the selected HSA, assess their rank of importance
- Assess the safe access road, paths to the HSA
- Assess the accessible locations for vertical take-off and landing the RPAS, which enable dual sensor surveillance; determine the differences in flight height over HSA
- Derive the polygons in HSA which enable dual sensor surveillance with RPAS which have limited autonomy
- Estimate a time needed for video and digital photography surveys, for color and for longwave infrared (thermal) sensors.
- The initial estimation of needed time can be the final capacity achieved with two RPAS systems in the project [5]. It this project the daily capacity for color images was 0,25 km^2. For the HSA from Fig.1, needed acquisition time is at least 171 h. A travel time to VTOL locations is not included in this estimate. While thermal sensors have a smaller number of pixels, the time for this kind of acquisition will be larger.

4. Establishment of the initial status of HSA

- Make survey with color sensor onboard simple RPAS available in HCR-CTRO in a photogrammetry mode and derive digital ortho mosaics for selected HSAs. Orto rectify obtained mosaics on digital ortho maps, while they will present the current state of HSA
- Identify the potential indicators of illegal crossing in HSA
- Estimate capacity km^2/day and time needed to acquire color and thermal images and video for each considered part of the HSA

5. The day and night surveillance on demand by dual sensor onboard RPAS

The first objective of this work is to establish resource (structure, unit) in HCR-CTRO, which will be able to provide day and night surveillance of the HSA on demand (in the case of emergency in HSA), with approved technology (sensors, RPAS, SOP, deminers – surveyors). With members of the HCR-CTRO Scientific Council, this unit will be also a key resource for education and training for the Non-Technical Survey with RPAS based surveillance systems.

3 http://www.civilna-zastita.hr/podrucja-djelovanja/razminiranje/minska-situacija-u-rh/145 accessed 9.03.2019

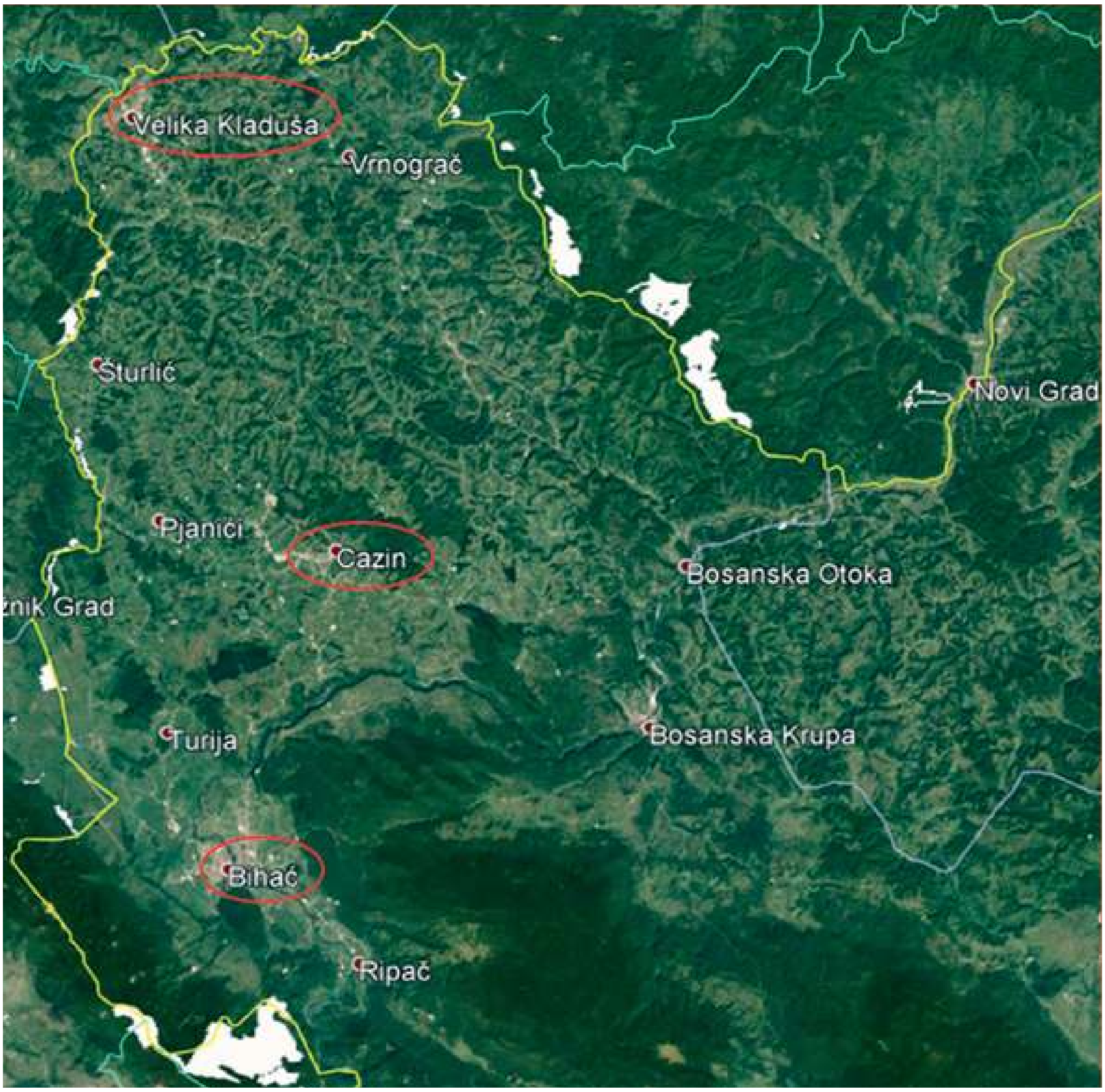


Figure 1. The hazardous suspected areas (HSA) in Croatia (white polygons) in the border region with Bosnia and Herzegovina, where the illegal crossing had its maximum in 2018. The borderline is yellow. Selected for an initial case study. Shown on Google Earth satellite map.

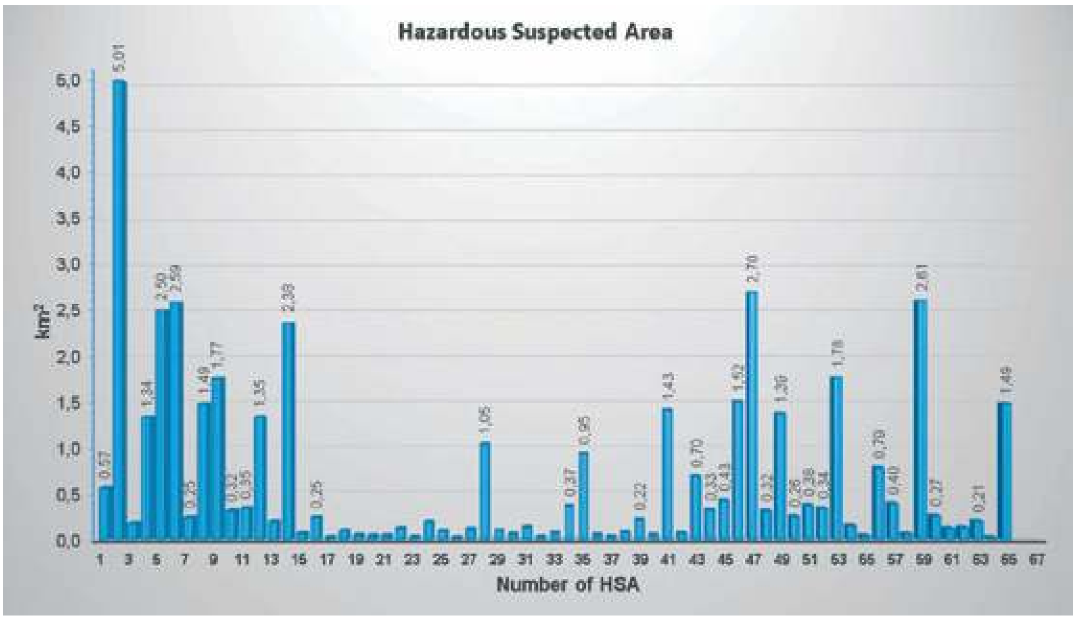
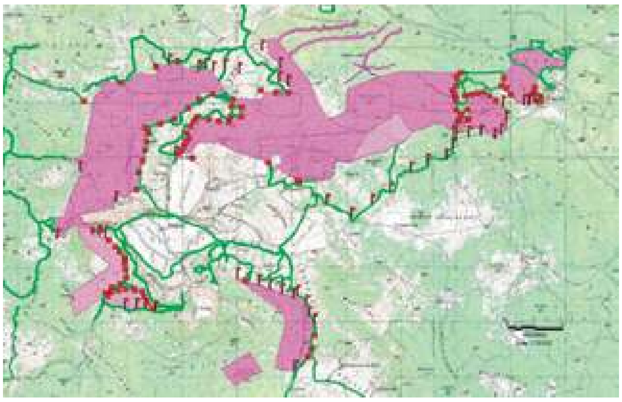


Figure 2. Distribution of SHA from Fig. 1. Estimated are SHA greater than 0,20 km^2.



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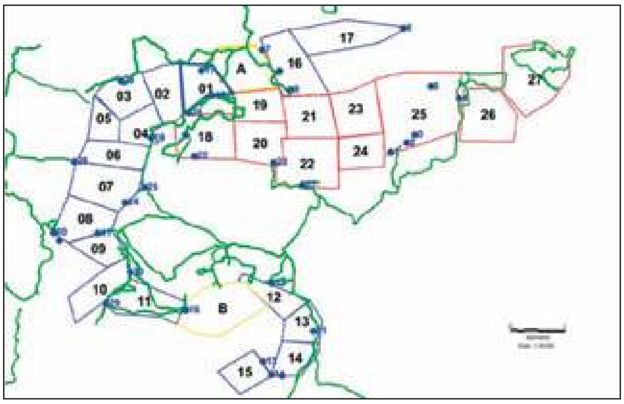

b

Figure 3. a) Example of the warning tables („HSA") distribution in the HSA. Legend: table on the pole, table on the ground. Note that HSA borders are not continuously marked. Therefore exist the risk that illegal immigrants and Croatian border police enter in the HSA. b) Locations for vertical take-off and landing (VTOL) RPAS (blue circles) and polygons (blue, red, yellow) around HSA foreseen for imaging from RPAS.

The second objective of this work is to operationally test, evaluate and validate a considered technology for Non-Technical Survey of HSA in border regions and to support its deployment in other regions with HSA in Croatia. The developed technology is suitable for other similar application in HSA and we invite to cooperation.

6. Conclusions

We do invite and encourage donors and invite to cooperation in the implementation and deployment of RPAS based day and night surveillance of HSA near the border, on illegal migration routes.

Surveillance of the border regions and HSA with remotely piloted aerial systems was initiated by HCR-CTRO Scientific Council in 2017. Due to organizational changes of Croatian Mine Action Center (CROMAC), this activity stopped in 2018, again we activate this idea.

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Mine action challenges during the migrant crisis

Esed Aletić[1]

Bosnia and Herzegovina still has a huge problem with mines and unexploded ordnance that were placed in the ground during the 1992-1995 war. The current size of mine suspected area in Bosnia and Herzegovina is 1.018 km2 or 2.1% out of the total size of BiH.

A general assessment of the impact of mines/cluster munitions/ERW in 129 cities/municipalities in BiH identified 1,398 affected communities under the impact of mines/cluster munitions/ERW.

Out of the total number of affected communities, 1,369 communities are contaminated with mines, while 60 communities are contaminated with cluster munitions (of which 31 communities have combined contamination of mines and cluster munitions).

Microlocations contaminated by landmines/cluster munitions/ERW directly affect the safety of 545,000 inhabitants or 15% of the total population of BiH. Out of this, microlocation contaminated by mines affects the safety of 517,238 inhabitants, while microlocation contaminated by cluster munitions affects the safety of 54,314 inhabitants (of which 25,949 inhabitants are affected by combination of mines and cluster munitions).

Through the systematic survey operations it has been defined 8,525 mine suspected microlocation where about 75,000 mines/ERW could be found. In the database (BHMAIS) there are currently 20,220 mine records.

We can say that for us who are engaged in mine action, a mitigating circumstance was that, up until last year, migration processes took place through the routes that went through neighboring Serbia and Croatia, while Bosnia and Herzegovina did not face a larger number of migrants but only sporadic entrances and exits from the country.

At the beginning of 2018, the situation changed drastically and there was a sudden inflow of a large number of migrants who were trying to reach the countries of Western Europe through Bosnia and Herzegovina. The influx of migrants and refugees made relevant institutions to start facing the challenge in human and financial resources.

In the first half of 2018, Bosnia and Herzegovina witnessed a drastic increase in the number of migrants and refugees who entered its territory: this number goes from 237 recorded in January to 2,557 recorded in May and 2,493 in July. (The total number of recorded arrivals from January 1 to July 31, 2018 was 10,145 (compared to a total of 218 recorded in 2017), out of which 175 are unaccompanied children and children separated from parents or caretakers. Refugees and migrants entering BiH illegally use two main routes, mostly entering BiH from Serbia and Montenegro. Most migrants and refugees who came from Serbia remained in that country after Hungary closed its state borders in 2015. The second main route starts in Greece and moves through Albania and Montenegro to BiH. In the first months of 2018, migrants and refugees quickly moved from the border areas towards Sarajevo, receiving a certificate from the field offices of the Service for Foreigner's Affairs. In July, when this assessment was carried out, a new trend was noticed in which refugees and migrants increasingly escaped Sarajevo and moved directly to the Una-Sana Canton. Accommodation for migrants and refugees remain a major challenge. BiH has a limited number of reception and transit centers, and none of them are at entry and exit points at the border, although there are plans to open additional facilities. Generally speaking, accommodation for migrants, refugees and asylum seekers varies from place to place and includes many ad hoc and unofficial solutions. According to the BiH Border Police, the country of origin of most migrants and refugees is determined on the basis of their statements since most of them do not possess identification documents. However, according to IOM data, countries of origin are mostly: Pakistan (31%); Syria (17%); Afghanistan (13%); Iran (12%); Iraq (9%).

Most migrants and refugees are located in informal settlements in Bihac and Velika Kladusa, with the intention to continue their journey to Croatia. As the number of people in these settlements increases, life and hygiene conditions are getting worse. For example, it is

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estimated that at the end of July there were over 4,400 migrants and refugees in the Una-Sana Canton without formal accommodation, basic hygiene conditions or access to the official asylum procedure. In an effort to solve this problem, in late July, the authorities of the Una-Sana Canton secured accommodation for 110 vulnerable migrants and refugees at a local hotel. Most actors emphasize food, accommodation and health care (especially secondary and tertiary care), as well as hygienic necessities and legal status as the greatest need of migrants and refugees in BiH – data from OSCE Mission to Bosnia and Herzegovina.

The main actors for the care of the migrant population are:

1. **Border Police of Bosnia and Herzegovina,**
2. **The Service for Foreigners Affairs of BiH,**
3. **Health care centers / hospitals,**
4. **Centers for Social Work,**
5. **Local administrations,**
6. **Local law enforcement agencies,**
7. **Informal volunteer groups,**
8. **Religious communities.**

Among the main actors listed in the documents and studies related to migrants and the migration, problem of mines is rarely mentioned because this problem is much less present in Serbia, Montenegro and Croatia. Bearing in mind the current mine situation and the fact that there is a continuity of mine accidents and incidents in Bosnia and Herzegovina since the end of the war, we can only say that we are extremely fortunate that none of the migrants has ever been injured or killed by mines or UXO. We also need to keep on mind the fact that there are cases of smuggling and human trafficking. While I was preparing this text, I could not find any recommendation to the Ministry of Security of Bosnia and Herzegovina that relates to undertaking measures aimed at the prevention from mines and UXO.

In the past year, there have been several individual actions by governmental and non-governmental organizations that have created posters and leaflets in English, Arabic and Persian. The leaflets were distributed in the most vulnerable municipalities: Cazin, Velika Kladusa and Bihac.

Bosnia and Herzegovina Mine Action Centre (BHMAC) has conducted marking activities targeting the migrant population in the municipality of Bihać. However, the main problem is the poor coordination between actors involved in working with migrants and their ignorance of mines and minefield issues.

It is necessary to educate staff working with migrants about the risks they are exposed to when it comes to mine situation. In addition to food, accommodation and health, mine risk is one of the biggest dangers to which migrants are exposed.

The OSCE Mission to Bosnia and Herzegovina, within the framework of the study they produced and whose data I used in this paper, issued several general recommendations on working with migrants:

- Strengthen the capacities of relevant government institutions to adequately address the situation of migrants and refugees, including potential victims of human trafficking, especially in places with a large number of migrants and refugees;
- Adapt support to migrants and refugees by ensuring the presence of a sufficient number of trained and qualified staff, including translators, cultural mediators and clerks;
- Improve data collection and data management (including gender and age data) to ensure more effective monitoring of the situation and contribute to the development of strategies based on evidence / contingency plans;
- Establish an effective communication network to ensure that information is transmitted correctly at the local, cantonal, entity and state levels.

I would add that it should be mandatory to include into the support system to inform migrants and all mine risk actors on current mine situation in BiH.

NEW TECHNOLOGIES IN MINE ACTION

Stepped Frequency and Pulse based radars for land–mine detection

Danijel Šipoš[1], Marko Malajner[1], Dušan Gleich[1]

Abstract

This paper presents two methods land mine detection using propagation of electromagnetic waves. The goal was to develop a low-cost and light weight ground penetrating radar using standard radio frequency components. There exist two approaches, time domain and frequency domain approaches. The first one requires a pulse with short duration, typically few 100 ps and the other approach, which is easier to implement is to observe the amplitude and phase change between the transmitted and the received signals. This paper describes the construction of both radars and presents the experimental results using land mines buried 50 cm below surface. Experimental results showed that land-mines can be detected using both principles.

Keywords: Radar, digital signal processing, landmine, detection, ground penetrating radar

1. Introduction

Landmine detection represent challenging task worldwide, because of the materials from which they are made of and their small sizes. In over 70 country's there are still laid more than 110 million landmines, which every day injure or kill more than 70 people, and therefore still represent a serious problem. Landmines are made of metal or plastic, and there are many known detection principles or methods.

Great effort has been invested in landmine detection research, where different methods have already given promising results. Known methods mostly base on ultrasound [1], infra-red radiation [2], electromagnetic induction [3], microwaves [4] [5], etc. For this purpose, an EM based radar or Ground Penetrating Radar (GPR) has been developed which has also some needed features and advantages for the proposed solution with comparison to other methods. The main feature for this task is the ability to detect metal as also plastic landmines, which can be located above or below the ground surface. The second advantage of this system is the small size and low cost in comparison to other solutions.

GPRs can be further subdivided into subgroups. Here known is the UWB Pulse GPR which is a subgroup of the time-domain radars or the Stepped Frequency Continuous Wave (SFCW) GPR which is an subgroup of frequency-domain radars. First landmine detection research with pulse GPR for on drone landmine detection has been investigated in our previous work [6]. Positive preliminary results have been achieved, but the second radar has several advantages with comparison to the UWB pulse GPR. The signal is down modulated to a lower base band frequency, which has no need for a high speed ADC and therefore drastically reduces the price of the whole system. Due to the use of continuous wave (CW) signal, a high average power can be reached, which increases the penetration depth. Transmitter, receiver and antenna non-linearities can be eliminated over software with a calibration procedure. As also no modulations occur on the CW signal due to the antenna as this can happen on the pulse signal.

2. Stepped frequency radar

Stepped Frequency Continuous Wave (SFCW) Radar is a system which transmits electromagnetic radiation by increasing the frequency over a chosen band with fixed steps. SFCW Radar systems are based either on the homodyne or super-heterodyne architecture. The homodyne architecture is simpler, with only a single frequency down conversion, while the super-heterodyne performs two frequency down conversions to produce the base-band signal. The super-heterodyne architecture gives better performances, but firstly we will focus on the homodyne architecture and latter present implementation of the super-heterodyne structure.

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SFCW Radar is a system which transmits electromagnetic radiation with increasing the frequency over a chosen band with fixed steps as is shown in Fig. 1. The frequency at given step n is switched after time τ and can be expressed as

$$f_n = f_0 + n\Delta f\,,\; n = 1, 2, \dots N \qquad (1)$$

where f_0 is the starting frequency, Δf is the frequency step size, N is the number of steps in one measurement intend and limits the step number is between $0 < n < N$. Time $N\tau$ represents one burst duration and repeats continuously. The SFCW Radar bandwidth is defined as:

$$B = N\Delta f \qquad (2)$$

and is directly proportional to the range resolution and so on $\Delta R = c/(2B)$, where c is the speed of light. The maximum Radar range is given by $R_{max} = N\Delta R$, which means that at fixed B, N has to be increased arbitrarily to increase the maximum range.

It is challenging to design an antenna which has a bandwidth greater than 2 GHz and the lower frequency limit at about 500 MHz. Amplifiers that have to be used on the transmitting and receiving side must be chosen carefully, because they are also limited with the bandwidth at lower frequencies. The signal is transmitted over a custom built UWB horn antenna [7], shown in Fig. 2(a). The antenna design and its Σ_{11} parameters are shown in Fig. 2(a) and 2(b), respectively.

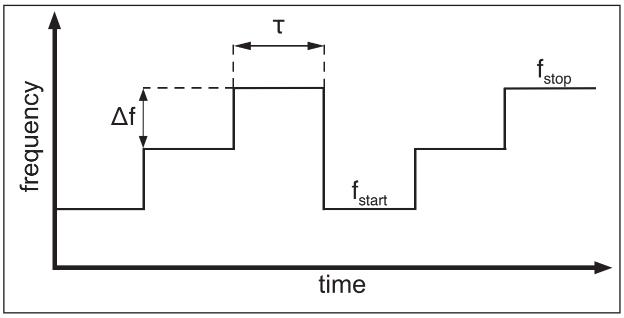


Fig. 1. Basic working principle of SFCW Radar

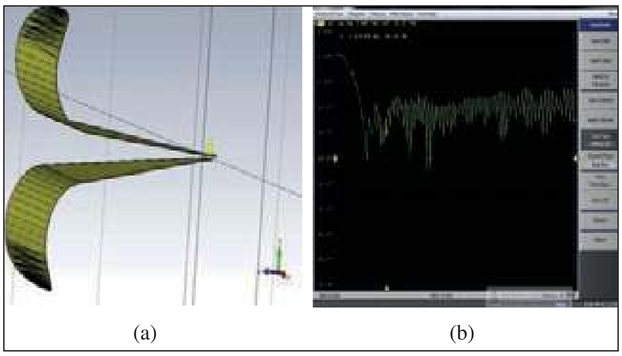


Fig. 2. (a) Antenna design. (b) Its Σ_{11} parameter vs frequency.

3. Hardware design of transmitter and receiver using a super heterodyne structure

We have designed a new platform for CW radar, which was based on super homodyne architecture to reduce target aliasing. We have used a low noise level amplifier used at the receiver side, which has a consequence of SNR improvement with use of external ADC. Additionally, the FPGA was used for digital quadrature mixing and on-board signal filtering. The results were stored and transferred to on-board SD card or external host computer. Fig. 3(a) depicts the homodyne structure of the radar and Fig. 3(b) depicts the super heterodyne structure of the radar. They differ in the receiving site, since different up and down conversion frequency are used for all generated signals. This structure was implemented, and details are depicted in Fig. The realization of the hardware is shown in Fig. 5.

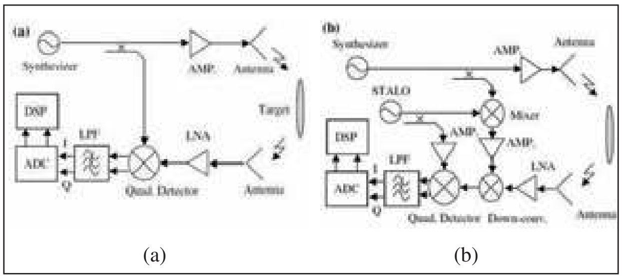


Fig. 3. A block diagram of the (a) homodyne and (b) super heterodyne stepped frequency radar.

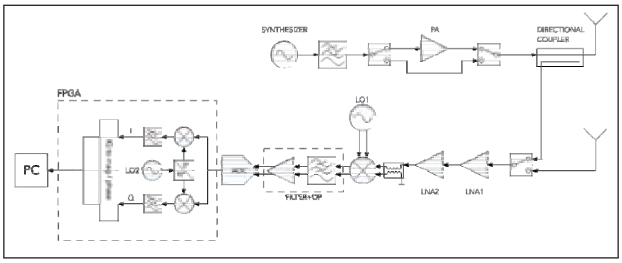
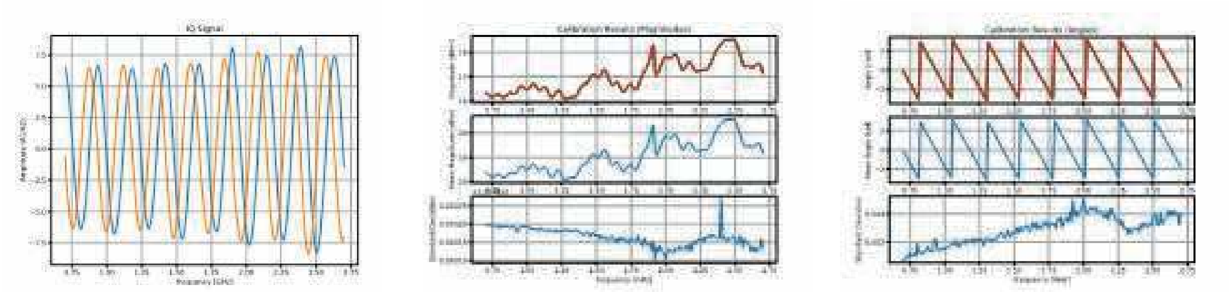


Fig. 4. A structure of super heterodyne stepped frequency radar.

Fig. 5. Hardware realization of the Steeped Frequency Continuous Wave Radar.



a) b) c)

Fig. 6. Calibration. (a) Transmitted and received signals obtained with the connected TX and RX with 1 m long cable. (b) Free space responses of the radar and the standard deviation of the response differences between 4 subsequent measurements. (c) phase and standard deviation of 4 subsequent measurements.

Calibration

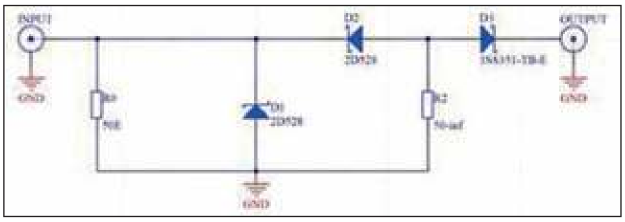
The designed radar was calibrated using 4 subsequent measurements. The radar responses were captured, and the response was normalized using those measurements. Fig. 6(a) shows the calibration results using 1 m long wire, which was connected between the TX output and RX input of the radar. In Fig 6(b)-6(c) show the averages of amplitudes and phases of the received signals and the standard deviation of 4 subsequent measurements are shown. They confirm that the phase and amplitude are stable.

4. Time domain radar

The Ultra-Wide Band (UWB) radar is based on picosecond pulse generator. Ultra-short pulses can be achieved with step-recovery diodes (SRD). In ON state the SRD diode behaves as ordinary signal diode. Positive signal if passes through the diode in forward regime. When signal changes polarity from positive to negative, ordinary diode switches off. SRD stores charge in forward regime and when signal changes polarity, the SRD does not switch off immediately due to stored charge. Near the end of the storage phase, PN junction increases the resistance and finally switches off the junction during the decay time, which is extremely short. Switch off phase is of the order of picoseconds for an SRD.

The authors reported many designs of pulse generator using SRD. Most common design is using single step recovery diode to generate a pulse with picosecond rising edge, which destructively interferes with an opposite-polarity delayed replica of it produced by a short-circuited stub. Pulse width is equal to the round-trip time along the stub. The stub configuration suffers from spurious reflections, which produces ringing tails in the output signal. We designed pulse generator based on reference [8]. The authors of [8] used two SRD diodes, one input Schottky diode for blocking input negative voltages and one output

a)



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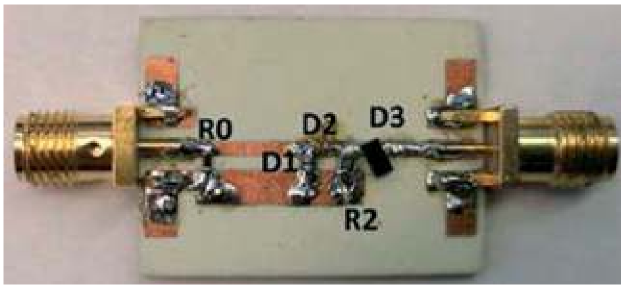


Fig. 7. (a) Schematic of pulse generator. D1 and D2 are SRD for generating short pulse; D3 is Schottky diode for pulse shaping. R0 is input matching resistor and R2 is resistor for setting pulse width. (b) Fabricated pulse generator.

Schottky diode for pulse shaping. Generator is biased with negative DC voltage. Generator is driven by square-wave from 0-2.5 V. We modified the described design by removing the input diode and by removing the negative DC voltage supply. We used a square-wave input from -1 V to +1 V generated by low jitter clock CDCM6208 from Texas Instruments. The used step recovery diodes are 2D528 with 50 ps decay time and 0.8 pF capacitance. For pulse shaping at output the Schottky diode 1SS351-TB-E is used as shown in Fig. 7(a). PCB is implemented on Rogers, R04350B laminate with $\mathcal{E}r$ = 3.66 (Fig. 7(b)). Pulse width and amplitude can be adjusted with R2. We used R2=6.8 kΩ and achieved pulse width of 116 ps which occupy 9 GHz of bandwidth. Fig. 8 shows the magnitude and duration of pulse.

Fig. 8. Output pulse from generator captured by oscilloscope.

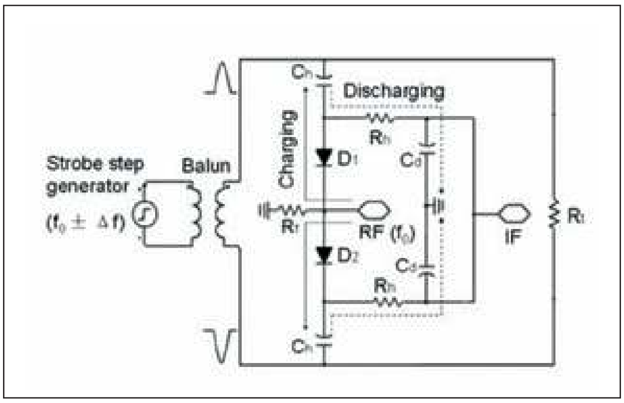


Fig. 9. Schematic of sampler. pulses from balun opens the bridge and RF signal charge Ch. When bridge is closed, signal discharging trough Rh and Cd. On IF port appears the stretched RF signal.

Sampling mixer for short pulses

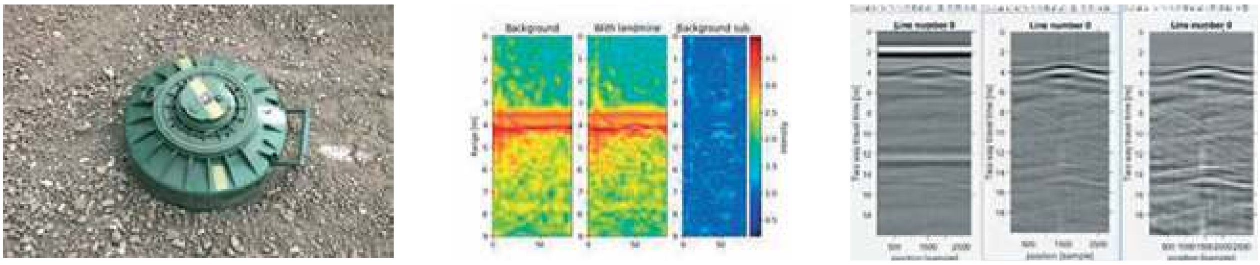
To detect very short pulses in the range of hundred picosecond (about 5 GHz bandwidth), analog to digital converter (ADC) with at least 10 Gsamples/s is required. ADC with such performance is very expensive and complex. As an alternative to real-time sampling, the so-called signal stretcher is used. The idea is to sample a small fragment of the input RF signal at each time. We assume that the input RF signal is equal in many repetitions. In each subsequent repetition of the RF signal, the sampler takes the next fragment. The output of the sampler is stretched signal assembled from sampled fragments. With such sampler, we can stretch the signal from picosecond range to microsecond range. Authors in [9] designed sampler with two diodes in a bridge configuration. The diodes are opened and closed by narrow strobe pulses, which are triggered by a precise time base. A repetitive train of identical input RF pulses with frequency f_0 are required. Strobe pulses are triggered with slightly offset frequency ($f_0 \pm \Delta f$). The strobe and RF signal are mixed in such way that strobe signal slowly scans across the scanned RF signals. The received signal can be reconstructed after complete scanning cycle with a total time equal to $1/\Delta f$. If the f_0 is set to 10 MHz and Δf is set to 1 kHz then the extending ratio is $f_0/\Delta f = 10{,}000$. In practice, a 300 *ps* pulse is extended to 3 *µs*. This corresponds to an equivalent sampling rate of 100 Gsamples/s. We modified the sampler from [9] in such a way that we used fabricated balun from Mini-Circuits with bandwidth of 8 GHz instead of microstrip to slot line balun. As a strobe generator we used the previously described picosecond generator. The sampler is based on a two-diode bridge configuration. We used fast Schottky mixer diodes (Infineon BAT2402) which have small capacitance and serial resistance and forward voltage of 0.23 V. Rest of used elements (resistors and capacitors) are the same as in original research [9]. Fig. 9 shows the schematic of the sampling mixer.

The experimental setup is shown in Fig. 10. On the left the operational amplifier fed with $f_0 \pm \Delta f$ clock is shown. The strobe generator is connected with the amplifier and produces strobe pulses with repetition frequency $f_0 \pm \Delta f$ at the output. The balun is in the middle, which divides the input pulse into two opposite pulses. The opposite pulses then open the diodes on the sampler. On the right side of the figure, we can see the pulse generator fed by f_0 clock and attenuator, which attenuates the sampling RF pulse. Sampler stretches the signal from the pulse generator and sends it to the IF port.

5. Experimental results

The time domain radar was tested using educational AT landmine. The land mine was buried into a laboratory polygon of size 3 m x 2 m x 1.5m,25 cm

Fig. 10. Experimental set-up of generating and sampling UWB signals.



a) b) c)

Fig. 11. (a) AT landmine above ground surface, landmine diameter is 27 cm and height is 13 cm. (b) B-scan obtained using SFCW radar. (c) B-Scan obtained using time domain radar.

below surface. The radar platform was moved continuously over the polygon and data was acquired. Figs. 11(a) show a tank landmine, which was observed using developed radars. Figs. 11(b) and 11(c) show the B-Scan obtained using SFCW radar and time domain radar, respectively. Clear parabola can be spotted using both radars. Using fine inspection, it can be concluded, that time domain radar has greater bandwidth and can detect smaller objects.

6. Conclusion

This paper presented small range and small radars using Steeped Frequency Continuous Wave (SFCW) radar design and time domain radar design. The SFCW radar works in the frequency domain and its bandwidth depends on the highest frequency component generated by the transmitter. The time domain radar was based on SDR diodes and a principle of transmitter and receiver were presented. The experimental results showed that both radar can efficiently detect small objects under ground.

Acknowledgment

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Testing of unmanned aerial vehicles with a thermal camera to detect explosive devices at contaminated areas and development of a methodology for survey and risk assessment

Darvin Lisica[1], Milan Bajić[2], Braco Pandurević[3], Saša Džinić[4]

Abstract

Through September to November 2018, Norwegian People's Aid (NPA) performed the first phase of field testing of unmanned area vehicle (UAV) DJI Matrice 200 with thermal camera Zenmuse XT, 640 × 512 pixels digital image format or analog video 30 Hz (NTSC 720x480 pixels) and 9mm lens. Another used sensor was color camera Zenmuse w/X4S CMOS 1" 20MP, 5472x3648 pixels. Testing thermal cameras on UAV for detecting the explosive devices on the ground and development of the survey and the risk assessment methodology is based on following pillars: 1) Matching parameters of the survey to features of the targets and the environment; 2) Provision of needed detecting probability for the considered targets and the environment; 3) Optimizing the UAV based thermal acquisition for non-technical/technical survey. 4) Quality monitoring of demining operations, and risk assessment of ammunition storage sites. Evolutionary design of the standard operating procedures, verified in several totally different environments and situations. The first phase of testing included use of UAV for thermal detection of known explosive items at three locations: NPA training areas in Blagovac, then areas contaminated with landmines at locations Kamena and Rotimlja, Mostar, Bosnia, and Herzegovina, designing survey process for applied flight techniques and development of standard operational procedures. The article summarizes the result of the first stage and lessons learned and enables the continuation of the testing in the real conditions. The second phase of testing will include investigation with UAV in Montenegro for purpose of a non-technical/technical survey on locations contaminated with cluster munition remnants, different unexploded, abandoned or dropped explosive ordnances, and for risk assessment of populated places in the vicinity of ammunition storage sites.

Keywords: unmanned aerial vehicles, thermal camera, survey, risk assessment, Norwegian People's Aid

Introduction

Through September to November 2018, Norwegian People's Aid (NPA) performed the first phase of field testing of unmanned aerial vehicle (UAV) DJI Matrice 200 with thermal camera Zenmuse XT, 640 × 512 pixels digital image format or analog video 30 Hz (NTSC 720x480 pixels) and 9mm lens. Another used sensor was color camera Zenmuse w/X4S CMOS 1" 20MP, 5472x3648 pixels. Testing thermal cameras on UAV for detecting the explosive devices on the ground and development of the survey and the risk assessment methodology is based on following pillars: 1) Matching parameters of the survey to features of the targets and the environment; 2) Provision of needed detecting probability for the considered targets and the environment; 3) Optimizing the UAV based thermal acquisition for non-technical/technical survey. 4) Quality monitoring of demining operations, and risk assessment of ammunition storage sites. Evolutionary design of the standard operating procedures, verified in several totally different environments and situations.

First phase of testing included use of UAV for thermal detection of known explosive items at three locations: NPA training areas in Blagovac as key testing field due to various items there, then areas contaminated with landmines at locations Kamena and Rotimlja, Mostar, Bosnia and Herzegovina, designing survey process for applied flight techniques and development of standard operational procedure (SOP). The PIX4D and DJI GO 4 software suite are used for analysis of images. In total, 960 thermal images were recorded. The targets are recognized on 70 images, Tab.1, while 113 images require additional analysis since targets are expected. Other 777 images are rejected since don't contain data on the explosive threat. Target 6 was recognized also in area Rotimlja.

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Id	Target	Material	Blag-ovac
1	UXO, MB M:62 mm	Aluminum	6
2	Fuse, M:125 mm	Steel-brass	3
3	UXO, TTM RP	Aluminum-plastic	4
4	UXO, Hand grenade	Gus	4
5	UXO, Hand grenade	Iron	2
6	AP, PMR capljinka	Plastic	7
7	UXO, Bullet 20 mm	Brass-plastic	4
8	Bullet 30,2 mm	Brass-plastic	18
9	AP, PMR 2A	Gus	36
10	UXO, MB M:82 mm	Steel	5
11	AP, PMR 3	Steel	7
12	UXO, TTM RP	Aluminum-plastic	4
13	UXO, Bullet 40 mm	Brass-plastic	1
14	UXO, Bandoleer for 7,62 mm bullets	Copper-brass	-
15	UXO, BR M75	Plastic	-
16	UXO, PMA 2	Plastic	-
17	Minefield record ID 10.262		-

Table 1. Targets recognized in Blagovac

Matching parameters of the survey to features of the targets and the environment

The targets of interest are the land mines, the explosive remnants of war (ERW), UXO, AXO, the improvised explosive devices (IED), the parallel plate and crush wire switches, the cluster munition remnants, a hazardous suspected area (HSA), a hazardous confirmed area (HCA), the remnants of the battle field (trenches, shelters, bunkers, armament shelters, damaged bridges, roads, buildings, railways, etc.), the exploded ammunition depots. In the paper we are focused on the landmines, UXO, AXO, IED, and the switches, cluster munition remnants and their survey by thermal sensors on board of the UAV. The main trade-off shall be done between the reliable detection and the identification of explosive targets and the magnitude of the surveyed area. The actual UAV based systems with advanced color visible (very high spatial resolution) and long wave infra red (thermal) imaging sensors, enable programming the automated survey missions which shall be matched to targets and environment. This shall be done for each new situation and environment and be included in the standard operation procedures (SOPs).

Provision of needed survey probability for the considered targets and the environment

The outcomes of the thermal imaging are aimed to provide evidence for the non-technical survey (NTS), the technical survey (TS), in office reconstruction of the battle field, for area excluding from list of SHA, CHA, for the area including in SHA, CHA, for the risk analysis. In dependence of the aim, the survey shall provide the data and the evidence which have high reliability for the statements of target detection and very high reliability for statements that there is no dangerous (explosive) target. In our testing activity in 2018, the acquisition of thermal data was done in the analog video format MP4 (30 panchromatic images/sec, 720x480 pixels) or in the digital image formats JPEG, R-JPEG (radiometry JPG), each 640x512 pixels. Digital images have been acquired with the selected overlapping in flight direction, while the video images continuously overlap in dependence of the speed of the UAV flight. Test areas have been imaged also by the sequence of the very high-resolution color images (5472x3648 pixels). The lens of a used thermal camera has the focal length 9 mm and the viewing angles 69°x56°. The mapping area for tests at the height 15 m above the flat terrain is 44x27 m, pixels are 6,87x5,27 cm. This spatial resolution is too coarse for typical explosive targets. For example, we considered the land mines PMR-3, PMR Čapljinka, the mortar mine 82MM M68P1, the cassette bomblet MK-1 of a cluster bomb BL755 MK3. For the larger targets (trenches, bunkers, shelters etc.) this lens can be useful, but for the small explosive targets, another lens would be more suitable. While the main request for the imaging sensors is to provide reliable detection – identification of the explosive targets, tending to 90 % probability, it is necessary to fly at the height above

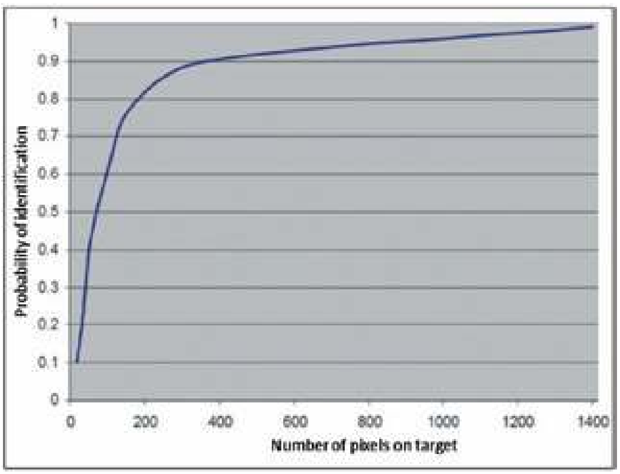


Figure 1. The probability of target classification depends on a number of pixels on target

the target which will provide at least 300 and more pixels on the target area, Fig. 1. This condition is very important and shall be fully satisfied, especially for a thermal survey.

Optimizing the UAV based thermal acquisition of targets on the ground surface

Thermal sensing of the targets is based on the measurement of the electromagnetic waves radiated by each material if its temperature is higher then 0°K (-273°C) in the wavelengths 7,5 to 13,5 mm. It is influenced by the emissivity E of the target, E<=1, by target's reflectance R (R=1-E), the attenuation of the atmosphere and the measurement angle. Emissivity E is the ratio of the target temperature measured by the thermal camera T_m and the real physical temperature of the target T, E = T_m/T. Before the survey, it is recommended to estimate the emissivity Ee of the typical samples of targets and use the estimated emissivity E_e and to calculate real temperature from measured T=T_m/E_e. If this is not done, the targets seem colder. If the target reflects certain energy by R=1-E, the measured target can be also seen colder. This can be mitigated by matching the flight route in dependence of the position of Sun. Each of the mentioned factors decreases the probability of the accurate measurement of the target radiation and lowers the probability of target detection and identification via the thermal measurement. The most critical is the influence of the atmosphere attenuation which is dependent on the weather conditions (humidity, air temperature) and the distance from the thermal camera onboard the UAV and the target. Therefore arises a simple but very useful recommendation, do the thermal survey of small targets (landmines, UXO, AXO, cassette bomblets) from the heights up to 10 m and lower. The next influencing factors which determine the thermal survey are the thermal contrast T_t/T_n of the target T_t and the neighborhood T_n and the daily changes of T_t/T_n. The thermal survey shall be planned in the suitable environment conditions when this ratio is high enough to provide reliable target identification. The minimum thermal difference which could be detected by a considered sensor (Sensitivity) is <50mK. Combined with contrast T_t/T_n the camera thermal sensitivity determines the probability of target identification.

Measurements which were done for 14 different targets around 9 h and 14 h, show the contrast changes, Fig. 2.

The SOPs for thermal survey shall include a selection of suitable parts of the day when the needed

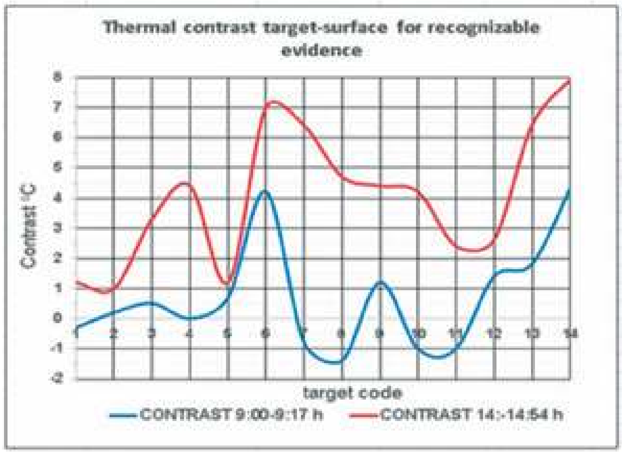


Figure 2. Measured thermal contrast T_t/T_n of 14 targets in two times of the day.

contrast T_t/T_n can be achieved. Besides the general request about the needed number of pixels on target from Fig. 1, the application of modified Johnson's criteria links the probability of target identification – detection and needed spatial resolution, [1], example Fig. 3. After application of the described steps, the acquired thermal data (video or digital images) can be used in many ways of interpretation. The most suitable are functionalities for computer-assisted photography interpretation (CAPI), for example, Fig. 4.

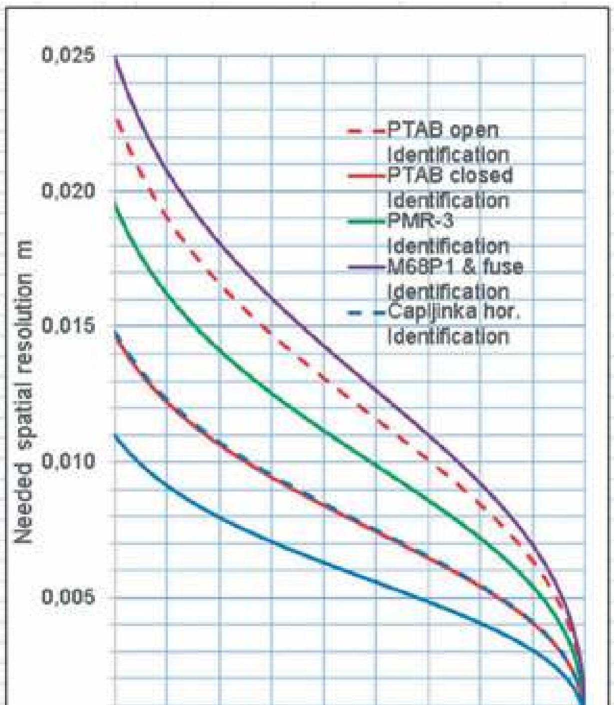
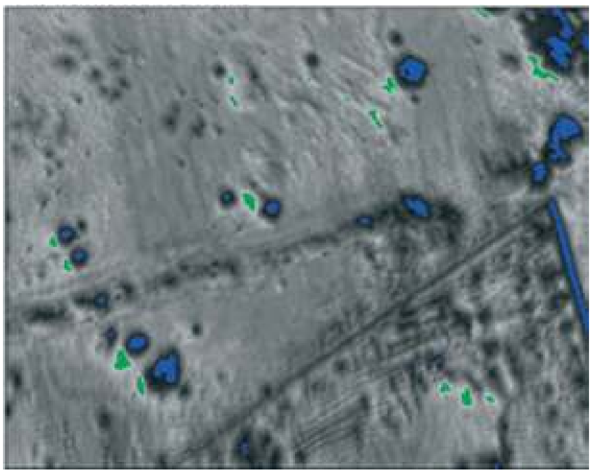
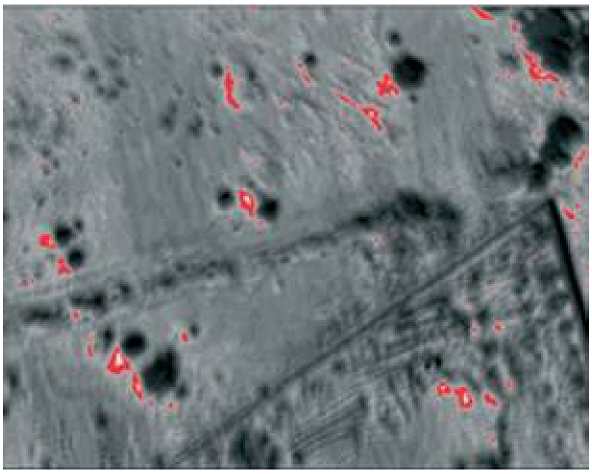


Figure 3. The needed spatial resolution depends on the defined probability of the target identification.



Selection of areas bellow lower threshold level (blue) and above the higher threshold level (green)



Selection of areas which have a temperature in the selected interval (red).

Figure 4. Search of thermal anomalies while watching continuous imagery in the flight direction.

Conclusion – designing the survey process for applied flight techniques and development of SOP

The second phase of testing of UAV DJI Matrice 200 with thermal and color camera in the real ground conditions requires standardization of UAV investigation processes developed through performed activities. UAV could be used for various techniques of survey, risk assessment and quality monitoring of areas contaminated with explosive items. NPA has been working on SOP for Data Collection and Assessment Using Unmanned Aerial Vehicles. Besides, Scope, General Principles, Terms and acronyms, SOP contains chapters: Classification of unmanned aircrafts for performing flight operations and flight areas; Categorization of UAV flight operations; Safety measures; UAV techniques for survey, risk

TECHNIQUES FOR DATA COLLECTION AND ASSESSMENT USING UAV ACCORDING TO NPA SOP

Non-technical (NTS) and technical survey (TS):

A. Investigating evidence through a visual check of the physical existence of explosive threat;

B. Investigating areas in the given directions that may provide additional data on explosive contamination, environmental and operational condition for further interventions;

C. Re-distribution of suspected hazardous areas (SHAs) and/or their cancellation.

Quality monitoring of different type of demining operation:

D. Monitoring of team movements during operations;

E. Monitoring of the site condition during operations (marking, the layout of the work site, etc.);

F. Monitoring and security control of the area during explosive ordnance disposal (EOD) operations;

Risk assessment related to ammunition storages sites (ASS):

G. Survey after an unplanned explosion of ASS;

H. Risk assessment of populated places in the vicinity of ASS.

Table 2. Classification of techniques for data collection and assessment using UAV

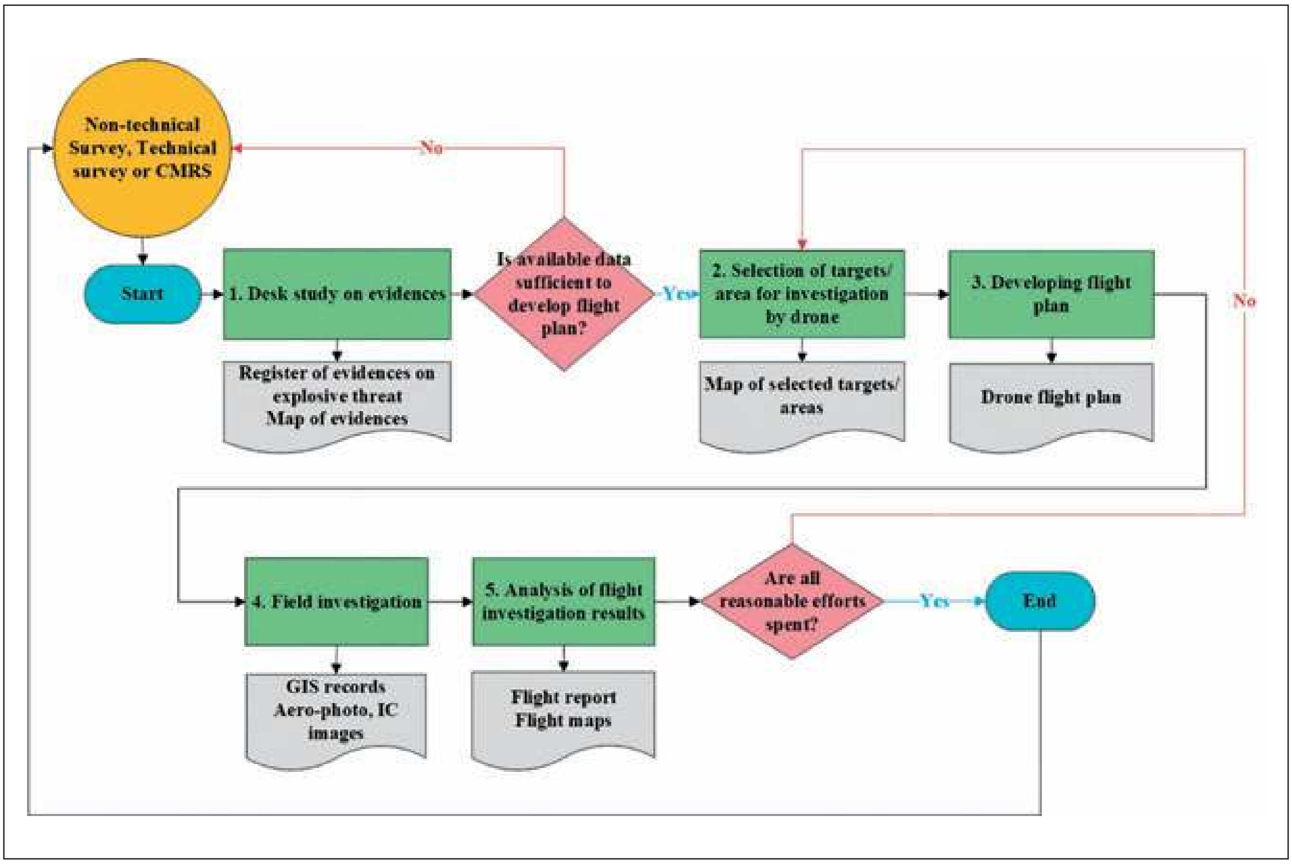


Figure 5. The process of investigation with UAV for non-technical and technical survey

assessment and quality monitoring; Description of flight mission type for software PIX4D; Recording with UAV; Procedure in the event of forced landing of an UAV; and Annexes with templates for planning, reporting, recording of evidences and mapping. SOP includes techniques for use of UAV for the purpose of NTS and TS; quality monitoring of different type of demining operation; risk assessment related to ammunition storages sites (ASS), Tab. 2.

One of the key processes described in the SOP is an investigation with UAV for NTS and TS and deserve short explanation here, Fig. 5. This is an evidence-based activity, fully integrated with other NTS and TS techniques for data collection and assessment. The process consists of five process steps: (1) Desk study on evidence; (2) Selection of targets/area for investigation by UAV; (3) Developing flight plan; (4) Field investigation; and (5) Analysis of flight investigation results. In addition to the aforementioned, processing and analyzing of images and videos can serve to assess the operational conditions for carrying out technical survey and clearance operations. In case of indications and some additional information and knowledge, after analysing the characteristics of the SHAs, analysing the missing data, working on the collection of new data through observation and interviewing, UAV team could perform additional flights with UAV for the purpose of collecting additional data with the aim of redistributing the SHAs and cancellation or increasing SHAs. The second phase of the testing of UAV DJI Matrice 200 with thermal and color camera includes also testing of SOP in the real operational conditions and its review.

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Testing of Digger DTR GPS Smart for MDD in Norwegian People's Aid Global Training Centre for Mine and Explosive Detection Dogs

Darvin Lisica[1], Kenan Muftić[2]

Abstract

Digger's SMART MDD system is an innovation developed by The Digger Foundation, in collaboration with the Geneva International Center for Humanitarian Demining and with the financial support of the Foundation World without Mines. A system includes GPS harness for of mine detection dogs MDDs, embedded with an electronic system aiming to improve efficiency of MDDs and overall land release interventions. In August 2018, Norwegian People's Aid (NPA) decided to conduct extensive testing of the system with the aim to contribute to better understanding of the system and to support further development of the equipment, working techniques and procedures. NPA Global Training Centre for Mine and Explosive Detection Dogs provided MDD team with three dog handlers and six MDDs. The four testing fields were selected to provide a variety of configuration and terrain features. The objective of the testing was primarily to identify external factors affecting the accuracy of the SMART GPS, to explore capabilities of the integrated camera, software, and other equipment in the kit, compare them with alternatives available on the open market, and provide inputs for the improvement of the system to the producer. Over a period of two months, the MDD team for testing conducted 103 searching sessions and recorded 500 tests. In addition to the data collected by the SMART system, the team recorded time frame, weather conditions, area configuration, ground conditions, and the distance from the SMART GPS receiver to the indicated spot. The article summarizes the result of the first stage of testing in the training areas including statistical analysis of the SMART GPS error and enables the continuation of trial in real operational conditions.

Keywords: Digger's SMART MDD, mine detection dog, testing, Norwegian People's Aid, Geneva International Center for Humanitarian Demining, Foundation World Without Mines

Introduction

Digger's SMART MDD system is an innovation in the mine action aiming to improve the efficiency of mine detection dogs (MDD) and overall land release interventions. The Digger Foundation undertook this project in collaboration with the Geneva International Center for Humanitarian Demining.

Foundation World Without Mines funded development of the system. It includes GPS harness for of mine detection dogs MDDs, embedded with an electronic system aiming to improve efficiency of MDDs and overall land release interventions. In August 2018, Norwegian People's Aid (NPA) decided to conduct extensive testing of the system with the aim to contribute to better understanding of the system and to support further development of the equipment, working techniques and procedures. NPA Global Training Centre for Mine and Explosive Detection Dogs (NPA GTC) provided MDD team with three dog handlers and six MDDs. The four testing fields were selected to provide a variety of configuration and terrain features.

The objective of the testing was primarily to identify external factors affecting the accuracy of the SMART GPS, to explore capabilities of the integrated camera, software, and other equipment in the kit, compare them with alternatives available on the open market, and provide inputs for the improvement of the system to the producer. In two months, the MDD team for testing conducted 103 searching sessions and recorded 500 tests. In addition to the data collected by the SMART system, the team recorded time frame, weather conditions, area configuration, ground conditions, and the distance from the SMART GPS receiver to the indicated spot. The article summarizes the result of the first stage of testing in the training areas including statistical analysis of the SMART

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GPS error and enables the continuation of trial in real operational conditions. The testing of Digger's SMART MDD system should be conducted in three stages: (1) Testing in a controlled environment (MDD testing and training areas); (2) Testing in operational conditions; and (3) A trial period of SMART MDD deployment. The first stage includes testing of accuracy and evaluation of contributing factors in a controlled environment. The test areas are selected to provide different conditions, while the exact location of the target is known. Results of testing in this stage should provide the answer if the SMART System is sufficiently accurate to be used operationally.

Digger SMART System, equipment, software, MDD team, and testing field

The Digger SMART system consists of dog harness unit and IT equipment for transmitting and data logging (wireless station, and laptop). A dog harness is made of a 3D printed plastic saddle with integrated camera, GPS antenna, and microphone with the speaker. The GPS receiver, as well as the camera and microphone, is embedded into small plastic saddle shaped to fit the curves of a dog's backline, Fig 1.

Accompanying IT equipment is PC notebook (Lenovo Thinkpad 11e), smartphone (LG Nexus) and the antenna with radio/ wi-fi link (Bullet M 2, Ubiquity Networks).

MDD team

The team consists of two dog handlers and a team leader. The team leader is responsible for setting up the system, monitoring the whole process, and exporting reports from the SMART software as required. One SMART set includes two harnesses (dog units) supported by one wireless link and PC.

Figure 1: MDD equipped with Digger SMART

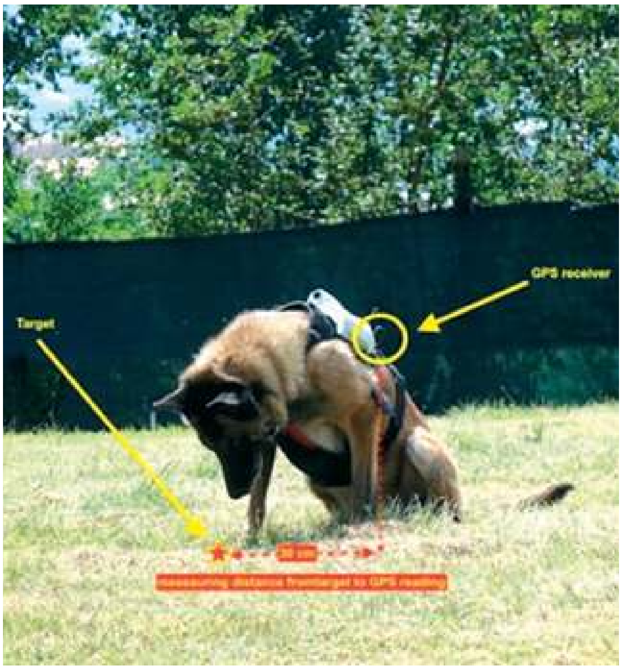

Figure 2: Position of GPS, target, and dog, when dog indicate

Name of dog	Age	Dog height (cm)	Distance from a target (cm)
Flora	8	59	25
Choy	10	59	45
Xena	4	54	35
Cuma	2	62	50
Mustang	2	60	60
Jaica	4	50	40

Table 1: Dogs used for testing

All dogs, Tab 1, are trained to search straight lines ahead from the handler until they are called to search back. However, the speed, moving pace, intensity, and the indication style varies from dog to dog. Dog speed is earlier identified to be a parameter affecting the accuracy of the GPS, which again may depend on the individual dog. The indication distance is also depending on the dogs, and it varies due to dog size and focus.

It is measured as a length of the horizontal straight line from the point of GPS receiver, which is located right behind a dog's withers, projected on the ground, to the center of the target (Fig 2). This distance is measured in advance for each dog and considered for the calculation of the actual indication point coordinates.

Set–up of testing fields, environmental conditions

The four testing fields were selected to provide a variety of configuration and terrain features, Tab 2. The polygons' turning points and the coordinates of actual target locations are taken with differential GPS Topcon GR-3. Key testing polygon in the NPA GTC is located in settlement of Blagovac, Vogosca. The field contain buried AP and AT mines, cluster munition, and hand grenades. The testing field in Rajlovac is located within a military base. It contains similar targets as NPA GTC. Radica Potok is a 60 m long stretch of the forest road, fenced with woods of medium height. At this location, temporary targets were used, such as pieces of explosives and mines. The testing on the mount Motka was conducted below, as well as along the mountain ridge. Similarly to Radica Potok, temporary targets were used at this location as well. The searching boxes were determined for each searching session with the aim to include a variety of ground configurations. The searching has been conducted from at least two directions for each box. Such an approach provides different angles when reaching targets while movement of the SMART GPS devices must be different due to variety. The mine detection dogs, trained to search in straight lanes to a minimum distance of 30 meters, were equipped with the SMART system kit.

The designated areas are in the controlled environment, where targets are known, and the chances for false alarms are minimal. Humidity, temperature, wind speed and wind direction have been recorded for each session.

Conditions/Area	GTC	Rajlovac	Radica potok	Motka	Total
Codes	P BA1 A,B,C	P BA4 DD	P BA6 Z	P BA5 AA	
Altitude	550	480	795	1100–1250	N/A
Configuration	Hilly, slopes	Flat	Slope	Mountain ridge	N/A
Ground	Short grass	Short grass	Gravel	Grass	N/A
Features	Trees, ditches	no	Road, trees	no	N/A
Number of sessions	50	42	4	7	103
Number of targets	222	212	24	42	500
Area covered (m^2)	11344,3	9362,5	331,8	1667,8	22706,4

Table 2: Overview of locations with the number of tests conducted

Statistical analysis of Digger SMART GPS errors

Digger SMART GPS error (SGE) is a difference between GPS coordinates of actual target locations measured with differential GPS Topcon GR-3 and coordinates measured with Digger Smart GPS, corrected for the distance between harness on dog and target, Fig 2. The results of statistical analysis of Digger SMART GPS errors (SGE) point to the following conclusions:

(1) Results on SGE were with Gaussian distribution, in the form of a normal curve. The curve is symmetric with a slightly larger distribution of results in a positive direction. Some more errors are larger than the average, but not significant from the standpoint of analysis. A total of 500 tests were enough to conclude on tested indicators through statistical analysis.

(2) The average size of SGE was M = 2.416 m, with a standard deviation of SD = 1.143 m. SGE range was from 0.190 m to 5.949 m. The SGEs related to MDD team includes an analysis that is based on descriptive statistics values calculated separately for: harnesses, dogs and dog handler (Table 4). Harness 2 has recorded larger average size of SGE (M = 2.626 m) then Harness 1 (M = 1.609 m,) Harness 2 also has recorded larger standard deviation of SGE (SD = 1.140 m) then Harness 1 (SD = 0.714 m). Between dogs, the largest average size of SGE was recorded for Mustang (M = 2.912 m), whereas the smallest one was obtained for Xena (M = 1.563 m),. A difference of SGE between dog handler was not significant.

(3) The average size of SGEs derived for all combinations of harnesses, dogs, and handlers show that

Digger SMART GPS error means for MDDs, handlers, and harnesses	Search unit and dog handler					
	Dragan Dzajic		Namik Dzanko		Nedzad Mujkanovic	
Dog	Harness 1	Harness 2	Harness 1	Harness 2	Harness 1	Harness 2
Xena	1.563					
Flora		2.850	1.975	1.466		2.556
Choy						1.925
Cuma	1.399	2.890	1.781		1.757	
Mustang		3.105	1.706	2.630		3.307
Jaica		1.797		2.853	1.100	

Lower scores (orange) — Upper scores (green)

Table 3: Digger SMART GPS error means for MDDs, handlers and harnesses

the higher SGEs values are mostly related to data recorded with Harness 2, Tab 3. They are not related to any particular dog or dog handler significantly. In most of the scenarios SGE was lower on Harness 1 than Harnes 2. The obtained results indicate that there is a difference in performance between Harness 1 and 2.(4) A correlation matrix was performed for variables: temperature (°C), wind speed (km/h), humidity (%), pressure (hPa), time of day and SGE, Tab 4. All variable has a statistical significant linear correlation with SGE. Three of them have linear correlation on medium level and two of them insignificant linear correlation (wind speed and time of day). Those who have positive medium linear correlation with SGE are temperature ($r = 0.303$) and pressure ($r = 0.355$). It means that increasing the temperature and pressure increases the error and vice versa. Humidity has a negative medium linear correlation with SGE ($r = -0.312$) which means that with increasing humidity decreases SGE and vice versa. (5) Multiple regression analysis includes temperature (°C), wind speed (km/h), humidity (%), pressure (hPa) and time of day as the predictive value, whereas the criterion variable where SGE. The obtain regression model has shown there are two statistically non-significant predictors – temperature and time of day. They are excluded from the regression model. The new regression analysis, Tab 5, also yielded statistically significant result ($F = 54.968$, $p < .001$). Wind Speed (km/h), humidity (%) and pressure (hPa) as predictors were in a moderate relationship with SGE (Multiple $R = .500$). Also, they accounted for 24.5% of its variance (Adjusted R Square = 0.245). In this case, all the predictors were statistically significant. The strongest predictor of SGE was humidity ($\beta = -1.964$, $t = -8.026$, $p < .001$). The regression equation (where SGE' is the estimated value of SGE) is:

$$SGE' = -36.019 - 0.078WS - 1.964H + 0.041P$$

For example, if wind speed (WS) is 4 km/h, humidity (H) 60% (that is, 0.60 which is the format that should be used in this equation for the percent of humidity), pressure (P) 965 hPa, the estimated value of SGE is SGE' = 2.056 m. To decrease SGE, the following conditions have to be met: stronger wind speed (WS) but limited with dog ability to scent target, greater humidity level (H), lower pressure (P). These results should, however, be taken with caution because the influence of all possible predictors on the error is not tested. It should take into account that there may be latent variables that have a significant impact on the error.

Opinion on tested equipment and recommendations

The harness is well designed ergonomic dog vest, easily mountable on a dog. The GPS signal is emitted from the harness and tracked on the smartphone through a locally installed wireless link. Task setup is conducted on the PC through the software where gathered data are stored as well.

One of the tools within the SMART system kit is the 160° wide-angle video camera embedded into the saddle on the harness. Its primary purpose is the quality assurance of the dog work through real-time screen monitoring.

The camera is located at a dog's right shoulder providing a view in front of the dog. As the dog's head is bent down, the camera view usually is not obstructed by a dog's neck. However, the camera does not provide a view on the ground, an area that is being searched by a dog or the indication spot. If the dog sits, which is the required trained indication response, the camera points up in the air. Therefore, it is not possible to observe the indication spot through the camera live feed.

The resolution of the camera is 640x480 (0,3 megapixels) with a recording rate of 60 frames per second. For the reviewing details, such resolution is insufficient, particularly in scenarios of landmine suspected areas. Most of the time the handler has a better view from the actual standing point that it is a live-video on a smartphone screen. The camera becomes useful when the view becomes obstructed by vegetation and obstacles, but due to the low resolution, the picture is not adequately clear.

The live feed from the SMART camera sometimes freezes for a few seconds, probably due to the signal transmitting performance of the SMART antenna. Nevertheless, in cases of camera shaking or physical obstacles between the SMART harness and the antenna, screen freezes are often reported. Such problems are unacceptable if the camera is considered as a control tool for ensuring a dog's safety.

It is not possible to take photos or capture videos through SMART cameras. If for some reasons handler or operator wants to record the photo, the only option is to take the phone screenshot using the phone features or an external application. The photos taken on this way cannot be stored in the SMART software, nor imported later for reporting purposes. However, it is possible to take photos by the phone camera and store them in the software. Photos taken from the phone are georeferenced, and comments can be added in the software. Nevertheless, although photos are stored in the software, they cannot be included in exported reports or .kml files for preview.

Today, there are several compact action cameras available on the market. Most of them provide high-quality videos and photos with adjustable settings like resolutions, frame rate, or lens angle. They are popular amongst the extreme sports and outdoor enthusiast, as well as for the dog owners and trainers. There are also various camera holders, and harnesses designed for the dogs. The best-reviewed harnesses provide camera mounts on the dog chest and elevated holders on a dog's back. Some harnesses provide holders for two cameras.

Latest models of 360^{O} cameras provide high-quality videos with possibilities to review videos after recordings. The videos recorded by 360^{O} cameras provide possibilities to zoom in the details, as well as to look at the scene from a different angle.

The testing team has reviewed a budget 360^{O} cameras, and results are at the quiet satisfactory level.

The main issue with action cameras, especially 360^{O} is the image stabilization. There are hand-held image stabilizers available on the market commonly used with different camera models. However, such stabilizers cannot be used for dog mounted cameras. The solution might be camera-integrated stabilization system which is the still-developing feature in the production of these devices. Good results are already achieved with the GoPro Fusion and Insta360 one x.

Next steps of testing of Digger DTR GPS Smart for MDD

The first stage of testing of Digger DTR GPS Smart for MDD on known targets and analysis performed were provided valuable inputs and lessons learned for operational use of the system. Through 2019-2021, NPA intent to continue the next stages of testing including operational use.

The second stage includes testing Digger DTR GPS Smart for MDD in operational conditions, as a secondary or additional tool for data gathering and indication recording. In this stage, it is not only essential to confirm accuracy but to evaluate operational efficiency in terms of speeding up the indication recording and information management processes and its overall impact on operational results primarily in targeted technical survey operations.

The third stage or trial period of SMART MDD deployment focuses on this tool as a main operational asset for selected hazardous area and results in comparison with other available alternatives. The combination strategies and toolbox approach are also to be developed during this stage. Norwegian People's Aid Global Training Centre for Mine and Explosive Detection Dogs remains the leading implementer and will continue close cooperation with Geneva International Center for Humanitarian Demining.

Embedding target discrimination capabilities into handheld detectors for humanitarian demining

A. J. Peyton[1], W. van Verre, X. Gao, L. A. Marsh, F. J. W. Podd and D. J. Daniels, D. Ambruš, D. Vasić, V. Bilas[2]

Abstract

Metal detection (MD) remains a dominant detection technology for humanitarian demining and the decades of its use have brought steady improvements in sensitivity and the ability to discriminate in increasingly uncooperative soils. Recently, dual mode MD and ground penetrating radar (GPR) systems have been deployed in increasing numbers. The radar is typically used to verify indications from the metal detector in order to reduce false alarms. Reports indicate that this can reduce the false alarm rate from metal clutter by over an order of magnitude.

This paper considers the technical framework for moving hand-held detectors to a point where they can discriminate what the detected object might be.

1. Introduction

Over the past decades, the equipment available for demining operations has improved. Modern metal detectors offer good rejection of interference from mineralised soil, although they still suffer from problems with metallic clutter and with the most uncooperative soils.

GPR has emerged as a key technology for improving detection equipment, and dual-modality sensors are now in use in large numbers in NATO forces. Dual mode detectors [1,2] are now finding use in humanitarian demining operations with reports of significant improvement in the false alarm rate [3].

The performance of current sensing technology has reached the stage where detection capability is proven but does not yet provide classification by recognising and identifying targets. The benefits of real-time recognition and identification of targets are potentially significant as this capability will not only improve the Probability of Detection [PD] of targets but also reduce the false alarm rate per unit area [FARa] experienced by the operator. By providing information on the nature of the target, safety and speed of target excavation could be also increased. Ideally a sensor would have a PD of 1 and a FARa of 0. The goal of increasing the PD to 0.99 but reducing the FARa to 0.001 per m^2 is the underlying aim of improving target recognition and identification. This paper considers some of the techniques now under investigation.

2. Metal Characterisation

Landmine or improved explosive devices (IED's) may contain metals for switch, detonator or fragmentation components. In minimal metal landmines, this is typically the detonator and possibly small associated components. For IED's, conductive components such as carbon rods have also been employed, e.g. switch components. These metallic / conductive components can potentially be detected by metal detectors. However, detection alone is insufficient in situations where the ground is contaminated with items of metal clutter or is heavily mineralised, as the number of false positives would be prohibitive. In these situations, metal characterisation (MC) rather than simple MD is needed. In addition the MC data could be combined with other sensor modalities, in particular GPR and wire detectors to further improve discrimination.

Over the past decades [4], considerable progress has been made in the understanding of the response of a metallic or conductive object to applied AC magnetic fields. A concise and accurate description of the res-

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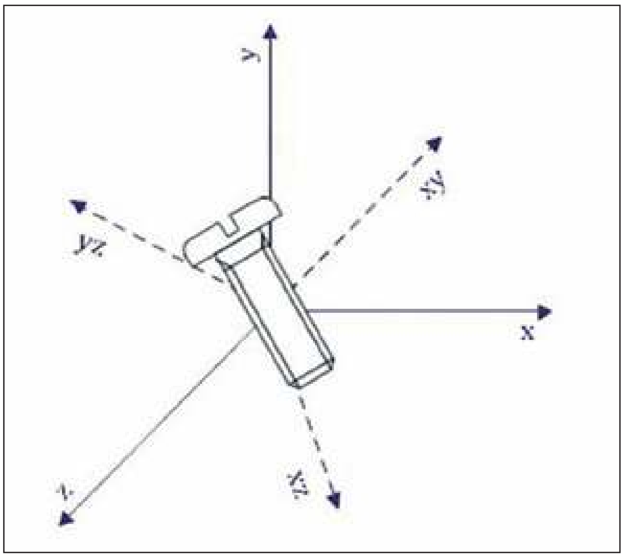

Figure 1. Representation of the tensor components for a screw in an arbitrary orientation.

ponse is given by the electromagnetic tensor spectra of the metal object.

The tensor describes the object response to an incident primary field in all axial directions and cross-diagonals as displayed in Figure 1. It is symmetrical in nature due to electromagnetic reciprocity; containing only 6 unique frequency values (for frequency-domain or continuous wave sensors using sine-wave excitation) or temporal values (for time-domain or pulse induction sensors employing pulse excitation).

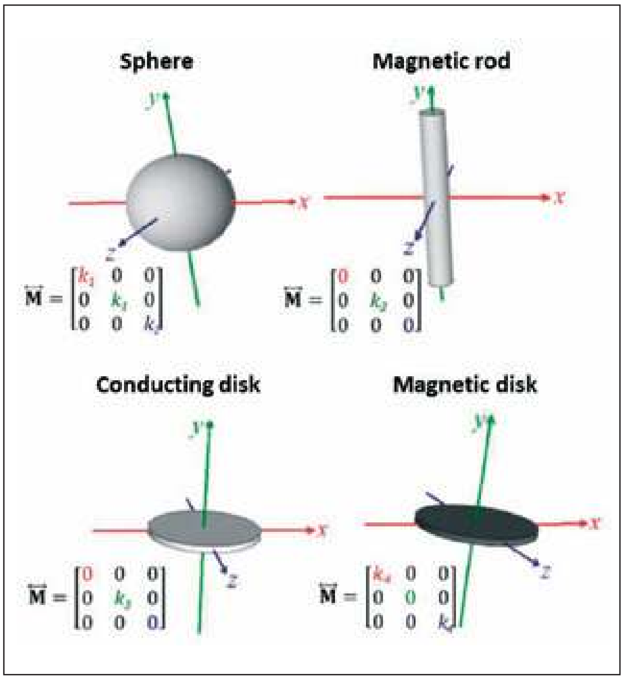

Figure 2. Example single frequency tensor components for a sphere, magnetic rod of negligible diameter, non-magnetic and magnetic discs of negligible thickness

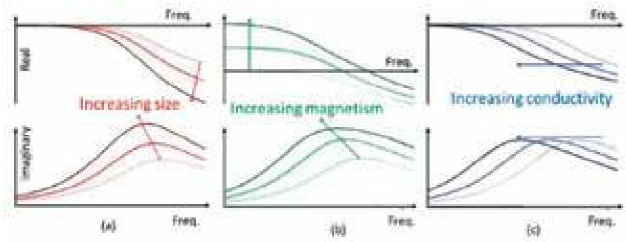

Figure 3. The variance in the spectroscopic complex tensor with a change in object properties; increasing object size (a), increasing object permeability (b) and increasing object conductivity (c).

It may be evident from Figure 1 that the tensor is orientation dependent; a change in orientation would result in different tensor components. In order to perform classification of objects, orientation independence is required to ensure that the same tensor would be obtained for an object regardless of its orientation. Therefore, the eigenvalue matrix of the tensor is used instead for classification.

The means by which object properties can be inferred from the tensor involves the consideration of a number of tensor features. Some shape characteristics of the object can be inferred in terms of relative object dimensions by comparing the relative tensor components as shown in Figure 2.

In frequency-domain sensors, the complex nature of the tensor implicitly describes the phase shift exhibited between the primary (transmit) field and the induced dipole or secondary field of the object. This depends on a number of object attributes, mainly the object's electromagnetic and geometrical properties. Consequently, the spectroscopic tensor can reveal information about the object's material and size as illustrated in Figure 3, showing the effects of size, magnetism and electrical conductivity [5].

In practice, the detector is swept over the ground and a series of voltages are recorded. The tensor is determined from a sequence of measured voltages, quantities derived in this manner are known as the inverse solution. A sufficiently large dataset is required to the inversion, taking numerous fields of view to ensure the correct tensor is obtained. This is achieved by moving the detector with respect to the object, i.e. as the detector is swept over the ground. Alternatively a detector containing an array of detector and receiver coils can be used. The eigenvalue data can be used for classification. Classification techniques are well established throughout decades and the Kth nearest neighbour (KNN) classifier is one of the simplest and most well-known algorithms for this.

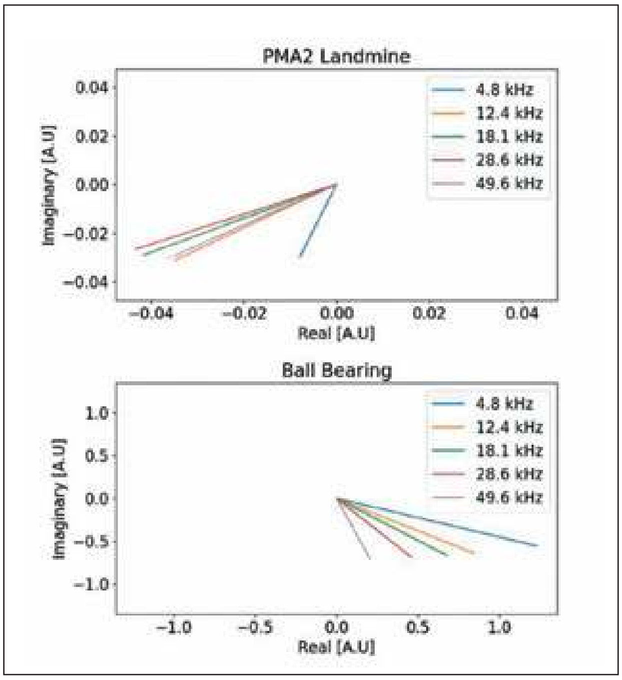

Figure 4. Spectra of two objects as measured in air

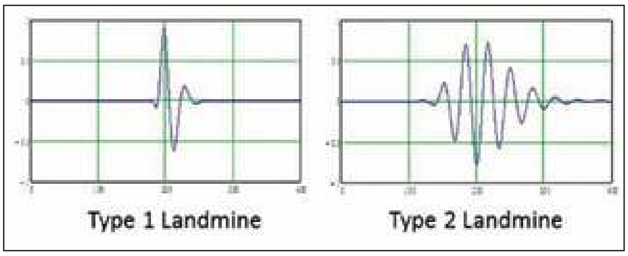

Figure 5 - Simulated time domain [amplitude v time] signatures of two landmine targets

Figure 4 shows two examples of the spectra taken with a prototype multi-frequency sensor for a PMA2 landmine and a small ferritic steel ball bearing. Here, the spectra are shown in phasor form and the objects were positioned approximately 7.5 cm away from the sensor, giving a clear signal. The spectra are apparently different to each other and this information can be used to discriminate between objects.

3. Ground Penetrating Radar

GPR has the ability to image the subsurface, offering the facility for detection based on the bulk material of the landmine, rather than just the metallic components inside it. The operating principle of GPR has been well-described in literature and is based on the detection of energy backscattered from the mine.

GPR suffers from its own sources of clutter, particularly at short ranges, due to the presence of rocks, air and water-filled cavities and undulation of the surface. Furthermore, due to the small amount of energy coupled into the ground and the losses in the soil, the amount of backscattered energy received by the GPR is very small, requiring a high signal-to-noise and clutter ratio. Designing the GPR sensor to be robust to these conditions is a significant technical challenge.

To alleviate the problems with clutter at short ranges, it is important for the signal radiated by the antennas to be well controlled in order to achieve best range resolution and minimise self-generated clutter.

In the first instance GPR can be used to validate positive detections from the MD, purely based on the presence of targets with typical landmine characteristics. This analysis could be based purely on the amplitude of the received signals. However, it is also possible to include the GPR in the target discrimination and identification process. Similar to the MC system, different objects will have different spectral features in their GPR response. Figure 5 shows the simulated response of two different landmines to illustrate this point.

Techniques such as the short-time Fourier transform (STFT) and the discrete wavelet transform can be employed in embedded target discrimination routines.

Other research has focused on the use of neural networks (NNs) for the task of discriminating between buried objects; however the availability of training data remains a concern [6]. NNs require large input datasets for training purposes, which can be difficult to assemble in the case of buried landmines. It may be possible to use numerical modelling tools to increase the size of the training datasets available.

4. Dual Modality Sensing

Figure 6 demonstrates the richness of the data which can be gathered using dual-sensor detectors. Figures 6a and 6b show the STFT of the GPR response from two landmine surrogates, while Figure 6f shows their electromagnetic induction spectra. For comparison, the spectrum of a coin is shown in Figure 6d. Figure 6e shows the imaginary component of the metal detector response at 14.3 kHz, as a top-down view. Figure 6b shows an analogous image based on the GPR measurements, made through a summation of the C-scans. Finally, Figure 6g shows a three-dimensional reconstruction of the subsurface based on the GPR data, together with models of the targets.

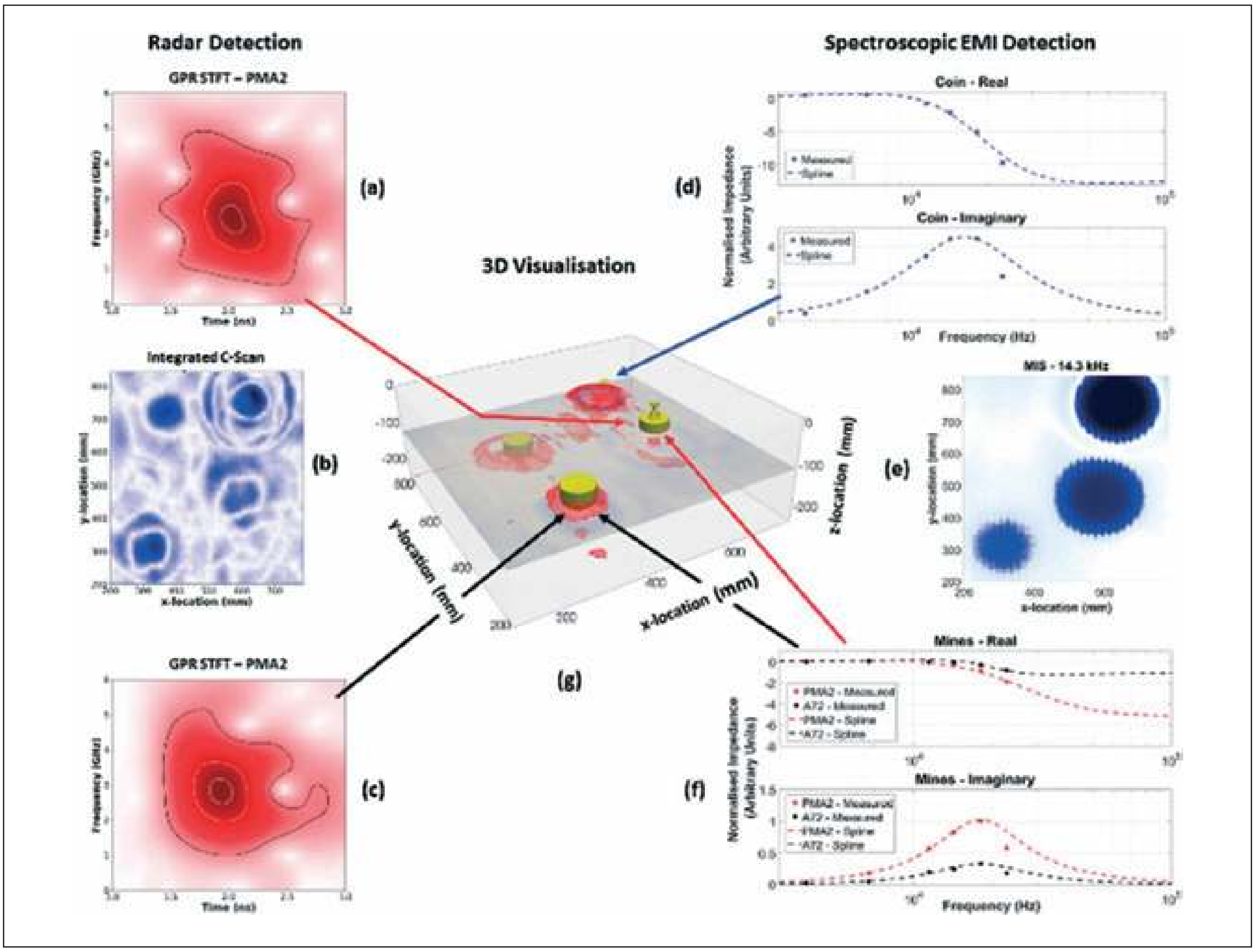

Figure 6. Data Fusion of GPR and EMI data (3D visualisation)

5. Conclusions

This paper has provided a brief description of some of the techniques that can be used to classify landmines. The aim of this work is to further reduce the system false alarm rate while improving the probability of detection at the same time as providing information on the type of target.

Acknowledgments

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Swabbing for explosives with organic semiconductor explosive sensors

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Abstract

Swabs taken from the surface of a suspicious object are a standard method of identifying a concealed explosive device. These are often tested for explosive residue using methods such as ion mobility spectroscopy or chemical colorimetric tests. Although these perform well, ion mobility spectrographs are expensive and require specialist training and colorimetric tests can require micrograms of explosive to be collected on the swab to be effective and rely on the operator's judgement to identify a colour change. Here we present preliminary experiments using organic semiconductors to detect small amounts of explosive deposited on a substrate to demonstrate the suitability of organic semiconductors as sensors to test explosive swabs.

Introduction

Organic semiconductors are more commonly found in high-end consumer electronics such a iPhones and OLED televisions. The same type of materials which form the emitting layers can be used to detect explosives through fluorescence quenching[1-6]. These materials can be made to emit light using a laser or LED. Due to the chemistry of the materials the presence nitroaromatic explosives such as trinitrotoluene (TNT) result in a drop in their light emission. This drop in light emission can be used as a signal to indicate the presence of explosives. The amount of explosive needed to cause a detectable drop in light emission in these sensor materials is comparable to what is detectable by sniffer dogs[7]. In this paper we explore the application of these sensors in the testing of explosive swabs.

Testing swabs with organic semiconductor sensors

Organic semiconductor sensors are currently being used in the NATO SPS project "Biological methods (Bees) for explosive detects (Bee4exp)" to detect small amounts of explosives collected by bees foraging on minefields[8]. The method used in this project has been modified to test for small amounts of explosive which would be collected on a swab.

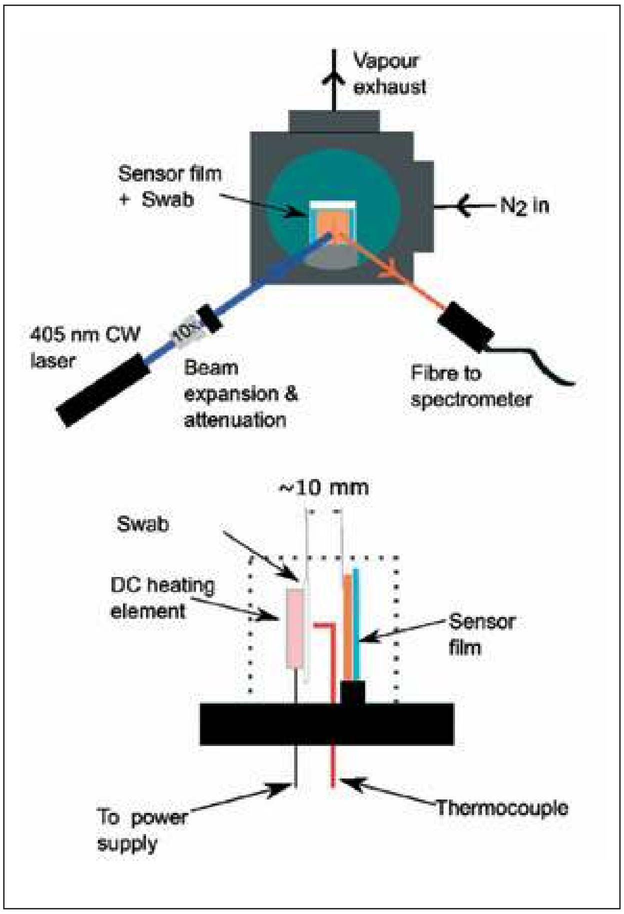

Figure 1: Experimental setup used to test the pre-dosed swabs.

Polyester canvas was dosed with known small amounts of model explosive material (2,4-DNT). A stock solution was created by dissolving 2,4-DNT in acetonitrile to create a stock solution which was diluted stepwise to create dosing solutions which were used to deposit 5 and 50 ng of material onto 2.5 x 2.5 cm polyester canvas substrates and left to dry in an extracted fume hood. Merck PDY-132 Super Yellow conjugated polymer sensors were prepared by dissolving the polymer in tolu-

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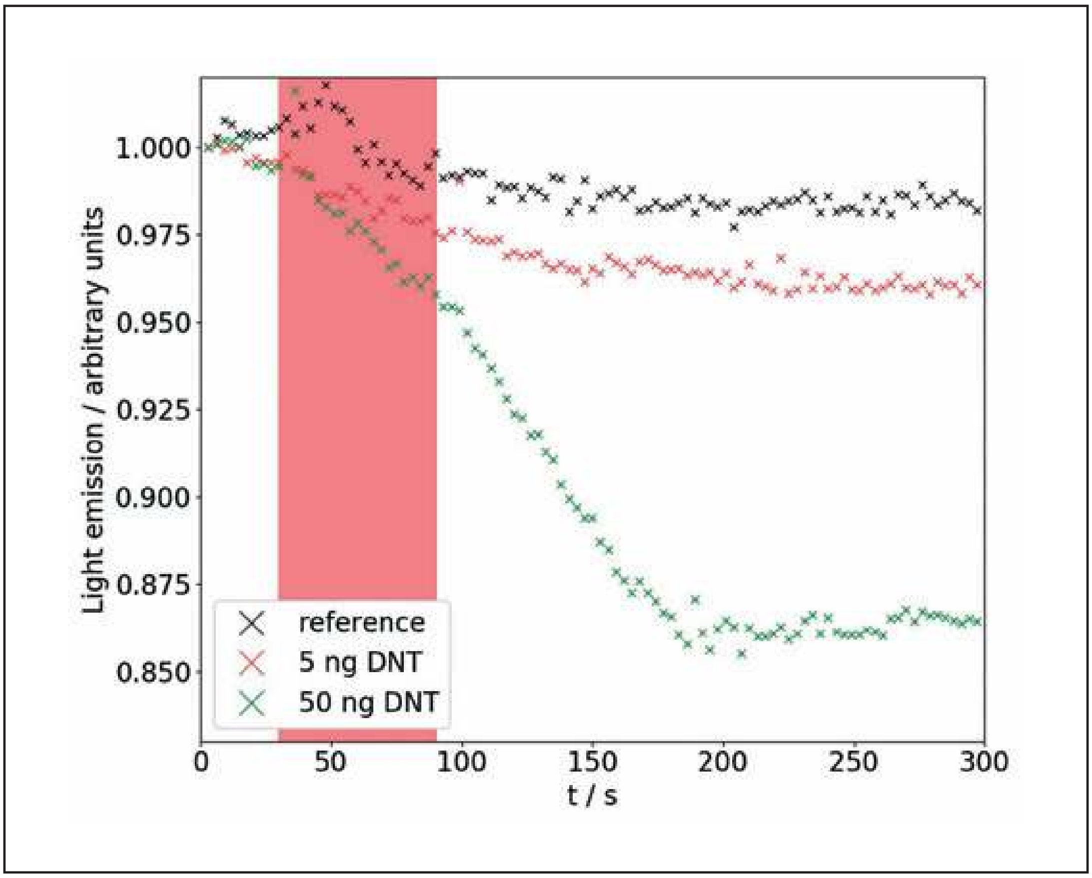

Figure 2: Response of sensors to swabs pre-loaded with 0 ng (black crosses), 5 ng (red crosses), and 50 ng (green crosses) of 2,4-DNT. Red shaded area indicates when the swab is heated.

ene at a concentration of 6.5 $mgml^{-1}$ before spin coating onto 2.5 x 2.5 cm glass substrates at 2000 rpm to produce films of ~ 100 nm thickness. The swabs and sensors films were then placed in the setup shown in Figure 1. The chamber was flooded with nitrogen for 2 min and then sealed. The sensor film was excited with a diode laser and its light emission monitored by a spectrometer for 30 s before the heating element was switched on until the swab reached a temperature of 100°C (approx. heating time 60 s). The photoluminescence of the sensor was recorded for a total of 300 s. The chamber was flushed with nitrogen for a further 2 minutes to cool down the heating element before removing the swab and the sample. Reference measurements were taken by performing a measurement without a swab. If any drop in fluorescence was observed in these measurements the setup was decontaminated by holding the heating element at 100°C and flowing nitrogen through the setup for 5 min. The spectra collected in the measurement were then integrated to give the sensor response. Figure 2 shows the responses of super yellow sensors to the pre-dosed polyester canvas swabs. From the responses shown in Figure 2 at least 50 ng of 2,4-DNT collected on ~6 cm^2 polyester canvas is detectable using our method.

Comparison to colorimetric tests

Pre dosed swabs were also tested with a colorimetric test to compare how our method to more standard tests. Polyester canvas cut into ~2.5 x 2.5 cm squares were pre-dosed with 0-500 ug of 2,4-DNT in the same way as the samples tested with organic semiconductor sensors. Potassium hydroxide (KOH) was dissolved in ethanol absolute at a concentration of 1 gml^{-1} which was used as the colorimetric test solution[9]. The test solution was added dropwise to the pre-loaded swabs until the surface of the substrate was covered in test solution. The presence of 2,4-DNT is indicated by the alcoholic KOH test by the appearance of a blue colour when adding the test solution. Figure 3 shows the result of the alcoholic KOH test performed, A strong colour change indiciative of the presence of 2,4-DNT was seen on the substrates dosed with 500 µg. A lighter blue colour was observed with the 50 µg sample and no colour change seen for the 50 ng, 500 ng or 5000 ng samples.

Discussion & Conclusion

Preliminary experiments have shown that the sensor system developed for testing remote explosive scent tracing (REST) style samples in the Bee4exp project

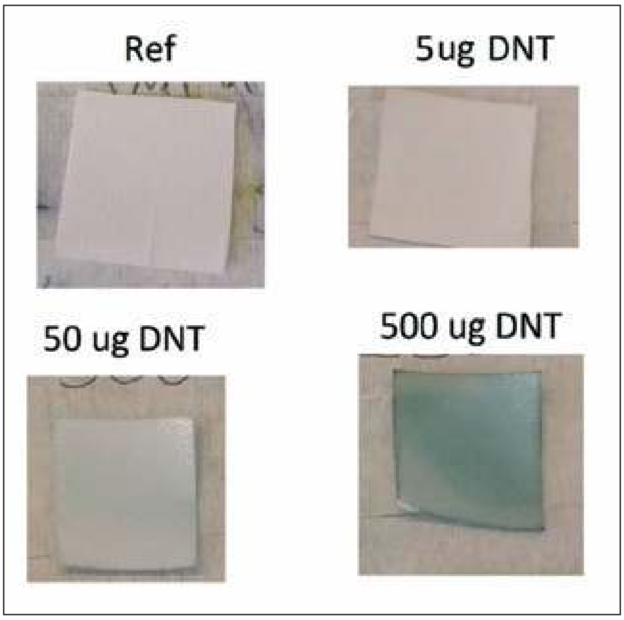

Figure 3: Alcoholic KOH test performed on polyester canvas swabs pre-dosed with 50 - 500 µg of 2,4-DNT.

can be adapted for use with swabs for explosives. We have shown the method can detect a swab-style sample containing little as 8 ngcm^{-2} of 2,4-DNT. The colorimetric alcoholic KOH test was shown to be able to detect 8 µgcm^{-2}. The increased sensitivity offered by the organic semiconductor sensors could be used to create a quick and simple test device for identifying the type of explosive used from swabs taken post-blast. The type of explosive can be identified by comparing the response of an array of different sensor materials exposed to the same sample[10-11]. This could be easily integrated within the experimental setup shown in Figure 1. Further experiments with more realistic swabs and different types of explosives are in progress.

Acknowledgements

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Biological Method (Bees) for Explosives Detection

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Abstract

Two novel methodologies, under the Biological Method (Bees) for Explosives Detection project, aim to develop innovative procedures for the detection of legacy landmines. The first, the Passive Method, uses bee colonies in conjunction with organic semiconductor-based explosive vapour sensing films. In the Active Method, UAVs with high-definition and thermal imaging cameras, with image processing and analysis software, are used to track trained honeybee colonies. The initial results indicate that honeybees collect enough material to be sorbed onto pre-concentrating materials prior to optical detection; and that camera-equipped UAVs can distinguish free-flying honeybees in real-time localising around a suspected buried mine. Bee activity monitoring in-situ can also feedback and inform the data from both surveying methods. The use of these methods together is intended to sample an area to confirm the presence or absence of explosive materials, and subsequent active identification of landmine locations.

1. Introduction

Novel technologies and methodologies are required to add efficiency, confidence, and cost-effectiveness to the demining toolkit. The wide range of terrains, climates and vegetation across landmine-contaminated areas gives need for flexible techniques in area surveying and landmine identification.

Honeybees have been used in the past as sentinels for environmental contaminants including explosives [1, 2]. The fact that honeybees can collect particles on their body-hair while free-flying, and that they can be trained to associate a particular smell with food, means they are a very useful tool for a two-pronged approach to landmine clearance. The Passive Method exploits the passive collection of explosive materials from a set area prior to analysis of hive contamination, while the Active Method uses honeybees that have been conditioned to sniff out TNT, which can be tracked in the field by camera-equipped UAVs and subsequent image processing.

2. The Passive Method

Light emitting organic semiconductors can be used to detect explosive vapour because the explosives decrease the amount of emission from the material [3, 4]. However, applying these materials in a real-world environment is challenging. Polymers to enhance preconcentration of explosives, which increases the amount of detectable material, have been adapted for this purpose based on the commercial fluoropolymer Aflas, which can sorb explosives to the surface in a manner similar to REST sampling [5].

In the context of the passive method, the honeybees are untrained and allowed to free-fly in a given area to collect explosives electrostatically on their body hair while foraging. Aflas-coated filter papers are inserted into 1 cm^2 cartridges and placed in the hive entrance and exit, as shown in Figure 1. As the bees return from foraging, any explosives are transferred to the preconcentrators for subsequent analysis by thermally desorbing the explosives from the Aflas surface and

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exposing them to a light-emitting polymer sensor. Results indicate that this method is promising [6], with hive entrances giving a stronger response after one day, suggesting that on the first day the bees fly more randomly searching for food, and thus collect a relatively high amount of explosives. On following days the food source is more directly accessed, and so less material is deposited on the preconcentrator substrates.

The passive method is intended for surveying a wide area for explosive contamination, and for post-clearance analysis.

Figure 1 - Preconcentrators in hive entrance

3. The Active Method

Since it is known that honeybees can be trained to associate the scent of explosives with food native to a particular area where suspected minefields are located, this gives us a possibility to mark the most frequently visited places by the bees as suspicious areas. However, tracking trained bees over a variety of terrains on potentially dangerous ground has previously been challenging. The active method relies on accurate capturing and localization of honeybees flying outside a hive and over a terrain that potentially contains mines. Honeybees are specially prepared to carry on the task of detecting explosive vapours (scent) of explosive substances contained in landmines. To locate honeybees flying or hovering over a patch of the field, we use ultra-high definition video (UHD) and a thermal camera (TC) video attached to a UAV. Since this is a rather demanding task, parameters of acquisition are precisely tuned so that each honeybee covers the area of 15-20 pixels. Considering the behaviour of honeybees outside a hive, a small object motion is a good marker for their detection and tracing. Video pre-processing includes stabilization and splitting into smaller spatial segments. A modified Gaussian Mixture Model is used for background subtraction and morphological image post-processing to generate a space-time density map. Preliminary results obtained with deep learning are also encouraging. It is planned to combine these two methods to increase the probability of detection.

Figure 2 - Training honeybees for the Active Method

4. Bee monitoring

To correlate bee activity per colony with results obtained by both passive (e.g. stronger response from one particular hive due to a more active colony) and active (e.g. weather affecting bee activity for trained flight) methods, a bee monitoring system has been developed based on an infrared sensor which counts individual bees as they enter and exit the hive. Additionally, environmental sensors for factors including wind speed, rain, and temperatures can be integrated to provide a full understanding of bee behaviour in the field. The hardware is designed to sit on the entrance preconcentrator cartridge, with the backbone of the system based on a credit-card sized ATmega2560 microcontroller.

Initial results from this system show high exit activity in the morning as bees begin to forage, in conjunction with rising temperature and decreasing humidity, and high entrance activity in the evening. In future this correlated, integrated data approach is expected to provide robust parameters for optimal deployment environments, and supporting information for analysis of both passive and active method results.

5. Conclusions

This multidisciplinary project has shown very promising results using both free-flying and trained honeybees in the development of novel methods for landmine detection. Field trials have indicated areas for improvement with the technologies, and together are anticipated to help in area surveying, identification of specific landmines, and in post-clearance Quality Assurance.

Acknowledgements

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ALIS Dual Sensor Evaluation Test in 2018

Motoyuki Sato[1]

Abstract

ALIS (Advanced Land Mine Imaging System) is a dual sensor, which combines EMI sensor and GPR. Tohoku University has started the development of ALIS in 2002, and after tests in Cambodian land mine fields, it is now ready to be deployed in mine affected coutries. An evaluation test of ALIS was conducted by CMAC (Cambodian Mine Action Centre) for a certificate to use ALIS in mine fields in October 2018. We trained 4 deminers of CMAC, and they demonstrated that ALIS can images typical landmines in Cambodia including PMN-2 and Type-72 in various types of soil very clearly. The EMI sensor can pin-point the location of the buried objects, and GPR can image the targets, which can be used by the deminer to judge the buried object. The test results was good, and the certificate was given to ALIS in January 2019. Since January 2019, two ALIS systems have been deployed in mine fields in Cambodia. In this paper, we introduce the technical performances of ALIS, and then reports the recent activities of ALIS in Cambodia.

Keywords: ALIS, Dual sensor, Cambodia, Humanitarian Demining

1. Introduction

Dual sensor is an innovative mine detection sensor, because it has a capability to discriminate buried mines from metal clutters. We expect this performance will shorten the time for mine clearance, especially in humanitarian demining activities, because it can simplify the prodding procedure for metal clutters.

A few types of dual sensor have been introduced in humanitarian demining, however, the number of dual sensors which have replaced conventional EMI sensors are limited. We think it is because the operation is different from conventional EMI sensors, and the system is heavier and more difficult to operate compared to the conventional EMI sensors, although the advantages of using dual sensors are still limited. Ground Penetrating radar (GPR) provides rich information about the buried objects, but the understanding or analysis of the GPR information is too complicated for deminers, who has to judge the information immediately. Therefore, most of the dual sensors do not to show the original GPR information to the deminer, but provide only simplified final results from GPR information, to simulate the operation of conventional EMI sensors. It makes the operation simple, however, rich information contained in GPR was not fully used.

ALIS (Advanced Landmine Imaging System) has been developed by Tohoku University, Japan since 2002[1][2][3]. The concept of ALIS is visualization of GPR information which will provide full information of GPR to the deminer. 3-D image of buried objects is shown on a display of the sensor, and the deminer can understand the shape and the depth of the buried objects. Combined with the visualized EMI sensor signal, deminers can discriminate mines from metal clutters. This procedure is very different from other dual sensor systems.

ALIS prototype has been tested in Cambodia since 2009[5][6], and ALIS deployment started in Cambodia in 2019[8]. In this paper we introduce the basic technical properties of ALIS and then describes the training of deminers for ALIS operation, and then show tests and activities of ALIS in Cambodia.

2. ALIS System

Based on our experience of operation of the prototype of ALIS in mine affected countries including Croatia and Cambodia[4][5], we have continued hardware development of ALIS and it was completed in 2017[8]. ALIS is composed from one unit, which include EMI and GPR sensor head and its electronics and batteries, and an Android tablet which is used for SAR processing and data display. ALIS is using accelerometer equipped within the sensor head for the sensor position tracking. For the signal processing, we use a tablet

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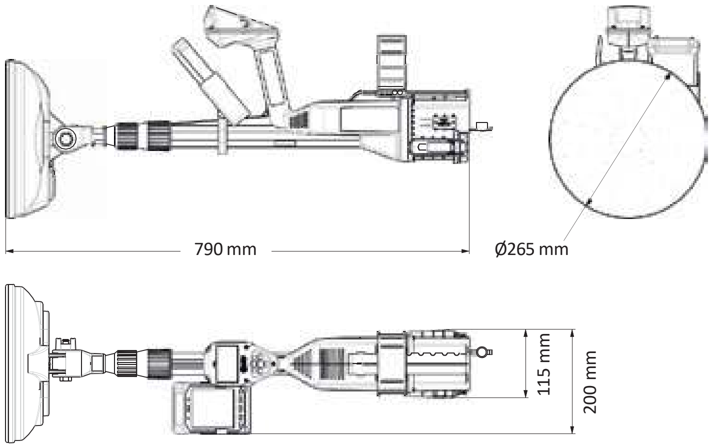


Figure 1. Advance ALIS (Size for transportation is shown).

Figure 2. ALIS system.

PC(Panasonic Toughpad), which works on Android. Other technical specifications of the advanced ALIS including EMI and GPR performance have not been charged from prototype ALIS. Therefore, we believe that the technical performance of the advanced ALIS has already been validated by ALIS prototype operations in mine fields.

The system is powered by Ni-MH rechargeable battery, and works more than 6 hours. The size of the system is shown in Figure. 1, and it is not much different from conventional EMI sensors (metal detectors) used for humanitarian demining. The total weight of the equipment including the battery is 3.1 kg. Data acquisition starts by pushing a button on the sensor handle, and after finishing the data acquisition by pushing the button again, Synthetic Aperture Radar (SAR) signal processing automatically starts and the EMI signal and 3-D GPR reconstructed image will be displayed on the window of the tablet. The operator can change the depth of the 3-D GPR image and can identify the buried mine and its depth. Semi-automatic landmine detection software will also be implemented for assistance of the mine recognition.

ALIS GPR is using 2 cavity back spiral antennas. The radar system is a FM-CW operating at 800MHz- 2.3GHz.

3. Tests at CAMC Test site

3.1. Test Site

The first test of ALIS in Cambodia was conducted in 2006 at CMAC (Cambodian Mine Action Centre) Research and Development facility located near Siem Reap, North Cambodia[4]. The facility was prepared for evaluation of dual sensors, under the support of JST (Japan Science and Technology Cooperation). Inert mines and, metal fragments together with wood pieces have been buried in 6 different types of soil, which are commonly found in Cambodia. All the buried targets were kept unchanged until now(2019), therefore it is a very good site for evaluation of sensors, because the disturbance of soil is minimum, and very close to the situation of real mine fields. It should be noted that, if we bury any targets in soil, even after a few months later, the moisture in soil is inhomogeneous around the dug area, and in many cases, GPR sees not the targets, but the disturbed soil. We obtained much experience in this test and developed this system.

After many modifications of the system, prototype of ALIS was evaluated by CMAC in 2009 using the same test site, and CMAC gave certificate to use the porotype of ALIS in mine fields in Cambodia[5]. However, this is a trial stage, and all the detected objects have to be plodded, even ALIS operator thinks the object is a metal clutter. This test continued until 2017[6], and we could obtain rich scientific data sets, because all the ALIS data recorded on ALIS system was recovered, and it could be used for detailed analysis. In this test, the plodded objects were recorded with the judgement of the deminers.

3.2. Evaluation test

The purpose of the performance trial ALIS dual sensors detector is to:

1. Determine the capable detection against trial target as mine type 72 buried at various depths and soil.
2. Determine probability of detection and false alarm rate based on use within the test lanes as simulated minefield.
3. Measure capability of GPR scanned images of detected objects telling as mine or metal.

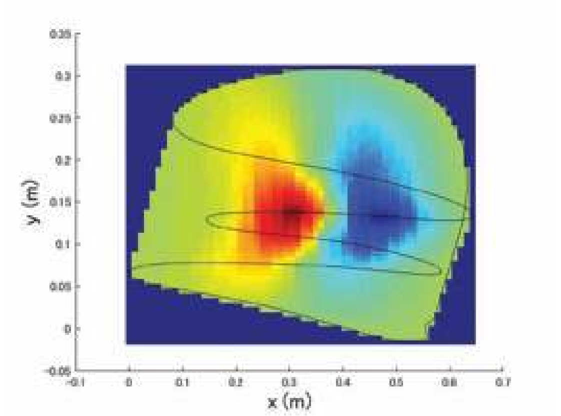
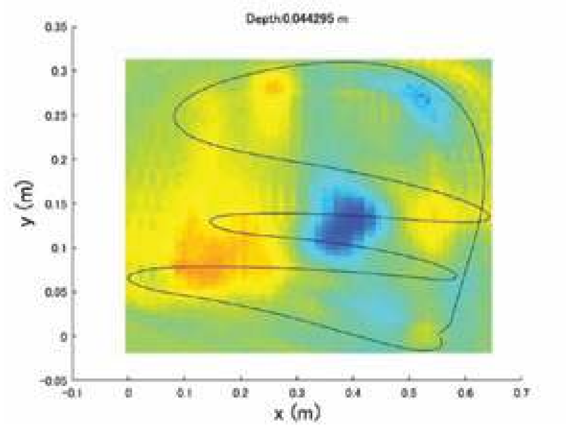
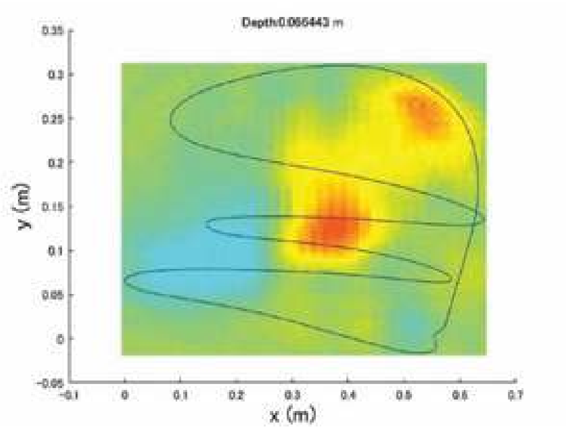


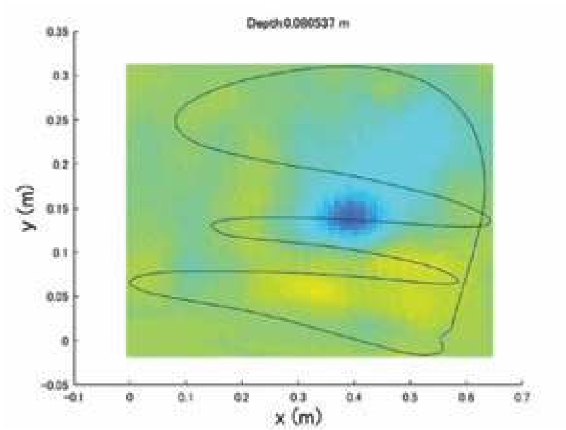
Figure 2. EMI sensor image.



(a) 4.4cm



(b) 6.6cm



(c) 8.0cm

Figure 3. GPR images. (Data ALIS #1 1544, PMN-2 depth=10cm Lane #4 acquired on 26 October 2018)

Figure 2 and Figure 3 show a typical ALIS image obtained in this test lane. Figure 2. shows the visualized EMI sensor image. This is a differential type sensor, and red and blue color indicate positive and negative response. The metal object is located at the boundary of the red and blue signal. The black line in the image shows the trajectory of the sensor head. GPR image has 3-D structure, and the images are shown as horizontal images at different depths. Figure 3 shows 3 images at 3 different depths. The image area for GPR is the same as for EMI sensor, and we can confirm that the round shape of the mine (PMN-2) is located at the exactly same position of the EMI sensor. At first, a deminer detects a signal on the EMI image, and then try to find the shape of mines at the same location of the EMI sensor. It has important meaning, because GPR image is strongly affected by clutters. GPR image contains many images caused by clutter, which is caused by a inhomogeneity of soil moisture or small gravels and grass roots, and if EMI signal location is consistent with the GPR image, the deminer can judge it as a mine. If a deminer has no EMI information, determination of mines from string clutter is difficult.

4. Operation of ALIS in Mine fields in Cambodia

Currently (as of April 2019) Tohoku University has rented 2 sets of ALIS to CMAC. One of the units is used by NPO organization IMCCD, which is located in Japan. The deminers of IMCCD belongs to CMAC and they are working at Battambang province, Northwest part of Cambodia. We visited there in January 2019.

The operation of demining starts by brush cutting. This operation is required to scan EMI and GPR sensors at an appropriate distance from the ground surface. Normally, ALIS GPR search head should be about 2-3cm above the ground surface to have the best images.

The area to be cleared is set as 1.5m width, and a red wooden bar is set as the starting position. Until the area 50cm beyond the wooden bar will be surveyed by the EMI sensor of ALIS. If no metal object is detected, this area is judged as safe and the red wooden bar will be placed 50cm beyond the original position. If any metal object is detected, the deminer uses the GPR function of ALIS. 50cm by 50 cm are will be scanned by ALIS sensor head, it will takes less than 1min. The data processing starts automatically after the scan on the area, and in a few second the EMI senor and GPR images will be displayed as shown in Figures 8 and 9. Then the deminer will judge the buried object by using these two images. If the deminer thinks it can be a mine, he will put a red tag on the suspected object position, and if he thinks it is not a mine, he will put a blue tag on the position.

If the deminer thinks it is a mine, the deminer will prod it. Prodding procedure has to be carried out very carefully, and it can take several minutes. If the deminer can judge the buried objects before the prodding, the procedure can be simplified. We propose that if the suspected object is judged as non-mine object, the prodding process can be simplified, for example by using a brushing cutter, so that the time of prodding procedure can be shortened.

By using the acquired ALIS data sets at real mine fields, we are continuing the development of the software of processing ALIS data. For example, we are trying to introduce CS(Compressive Sensing) algorithm of high-resolution target imaging, and applying the algorithm to the data sets acquired I Cambodian mine fields, we could find good results[7].

Figure 4. Landmine detection by ALIS.

5. Conclusion

The development of ALIS hardware is almost completed. 2 units of ALIS are operated by CMAC and data sets will be acquired and stored. Now we are continuing the development of software for ALIS signal processing.

Currently, we are trying to test ALIS in different soil types and different targets, different types of mines.

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EDS - EXPERIENCES

AND METHODS OF APPROACH

Situational awareness system for civil IED Disposal and Mine Action in a risky post–conflict environment

Domagoj Tuličić[1], Milan Bajić[2]

Abstract

In recent years, the influence of improvised explosive devices (IED) changed the humanitarian mine action (MA) scene. The attention of this paper is focused on the concept of the intelligent situational awareness system (INTELSAW) for security support the civil organizations doing MA and IED Disposal (IEDD) in a post-conflict environment. INTELSAW is aimed to contribute to the safety of civil users: ground vehicles convoys (logistic, humanitarian, search and rescue); group of MA, IEDD vehicles moving from base to working areas and back; emergency vehicles MA, IEDD moving from working location to hospital; surveillance perimeter of MA, IEDD working area etc. The main groups of technologies for advancement in MA and IEDD: modern RPAS platforms, for programable automated reconnaissance, surveillance, photogrammetry mapping and production of digital surface models and digital elevation models; digital sensors, hyperspectral, longwave infrared (LWIR), non-linear junction detectors, very high-resolution color images; machine learning and methods for cognitive decision support by situational awareness. The AIDSS (advanced intelligence decision support), is based on the airborne data acquisition, expert knowledge formalization, contextual data acquisition, terrain analysis, multi-criteria data fusion and on providing the risk assessment maps for land release (danger maps). The INTELSAW uses the majority of solutions of AIDSS but processing has to be in the real-time and the outcomes shall be dynamic and not static, the system shall provide situational awareness and cognitive training for the user (decision maker). Several versions of INTELSAW are offered.

Keywords: IED Disposal, Mine Action, situational awareness, cognitive decision support, iMMAP-IHF, INTELSAW, AIDSS, coordinated machine learning

1. Introduction

In recent years, the influence of improvised explosive devices (IED) changed humanitarian mine action (MA) scene and this process continues in different directions, an overview derived by GCIHD [1] presents status estimated by end of 2016. The comprehensive insight into the current situation in Iraq from August 2017, [2], enables a more realistic understanding of this process. Similar situations can be expected in Jemen, Lybia, Afganistan and possibly once in Syria. We will consider civilian aspects of MA IED Disposal (IEDD) relations while military response can be perceived via the example of NATO technology detection programme [3], via a description of current needs expressed by the military and/or security forces, e.g. [4]. Two different approaches to the military and/or security search in IED environment defined in [4] can be seen in [5], [6]. In [5] is analyzed the application of several ground-based sensors and procedures for detection large home-made explosive IED below the road surface. In [6] is presented the concept of the intelligent situation awareness system based on multisensor surveillance, via remotely piloted airborne system (RPAS) and ground vehicle, for support decision making to the vehicles convoy behavior in the risky post-conflict environment. The general relations between MA and IEDD from a civil humanitarian point of view are considered in [7], [8], [1] where IED is subject for MA only if the IED is not active. In standard operation procedures is often stated: The clearance of "active" command IEDs can be interpreted as making the IEDD operator a party to the conflict, it also has far greater physical security and equipment requirements and necessitates different SOPs and methodologies. Despite to such attempts to exclude active IEDs from humanitarian MA, the situation described in [2], illustrated by novel electric switches for IED (crush wire and parallel pressure plate) [9], warns that humanitarian needs can not be satisfied with described simplification. It is worthy of note several directions of technology solutions which

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support MA combined with IED, e.g. [10], [11], [12]. We focus our attention on the concept of the intelligent situational awareness system (INTELSAW) to support the civil organizations doing MA and IEDD in a post-conflict environment. Note that despite the risky and dangerous environment, personnel in humanitarian civil organizations is not permitted to have any arms for own protection.

2. Intelligent situational awareness system

INTELSAW is aimed to contribute to the safety, by providing in a real-time the situational awareness to civil users:

- *Ground vehicles convoy* (logistic, humanitarian, search and rescue, etc.), several logistic companies in Iraq send daily 20 convoys.
- *Group of MA, IEDD vehicles* moving from base to working areas and back.
- *Emergency vehicles* MA, IEDD moving from working location to hospital.
- *Surveillance perimeter* of MA, IEDD working area etc.

The INTELSAW system is aimed to provide continuous situational awareness in mentioned cases, environment, and to support decision making in actual risky situations. Background for considered system solutions is developed and implemented from our MA R&D [13], [14] as well as from other sources [15], [16], [17]. The main promising and verified groups of technologies for advancement in MA and IEDD are:

- *Modern RPAS platforms*, for programmable automated reconnaissance, surveillance, photogrammetry mapping and production of excellent digital surface models and digital elevation models, e.g. [12].
- *Digital sensors*, hyperspectral, longwave infrared (LWIR), [18], non-linear junction detectors (harmonic radar), very high resolution color images, [11], [10].
- *Machine learning and methods for cognitive decision support by situati-onal awareness,* [15], [16], [17], [19].

The seed of the INTELSAW are the contribution to MA made by developing and implementing the Advanced Intelligence Decision Support System for Non-Technical Survey (NTS) [13], [14], based on the airborne data acquisition, expert knowledge formalisation, contextual data acquisition, terrain analysis, multi-criteria data fusion and on providing the risk assessment maps for land release (danger maps). The INTELSAW uses the majority of solutions of AIDSS but processing has to be in the real-time and outcomes shall be dynamic and not static, the system shall provide situational awareness and cognitive training for the user (decision maker), Fig.1. The variability of IEDs is enormous and continuously grows, therefore INTELSAW provides the functionality for permanent advancement based on the initial historical and on the recent operational and empirical data. A very important function of the system is situational, spatial simulation of IED distribution, which is aimed for the cognitive training for IEDD and other users and for operational research.

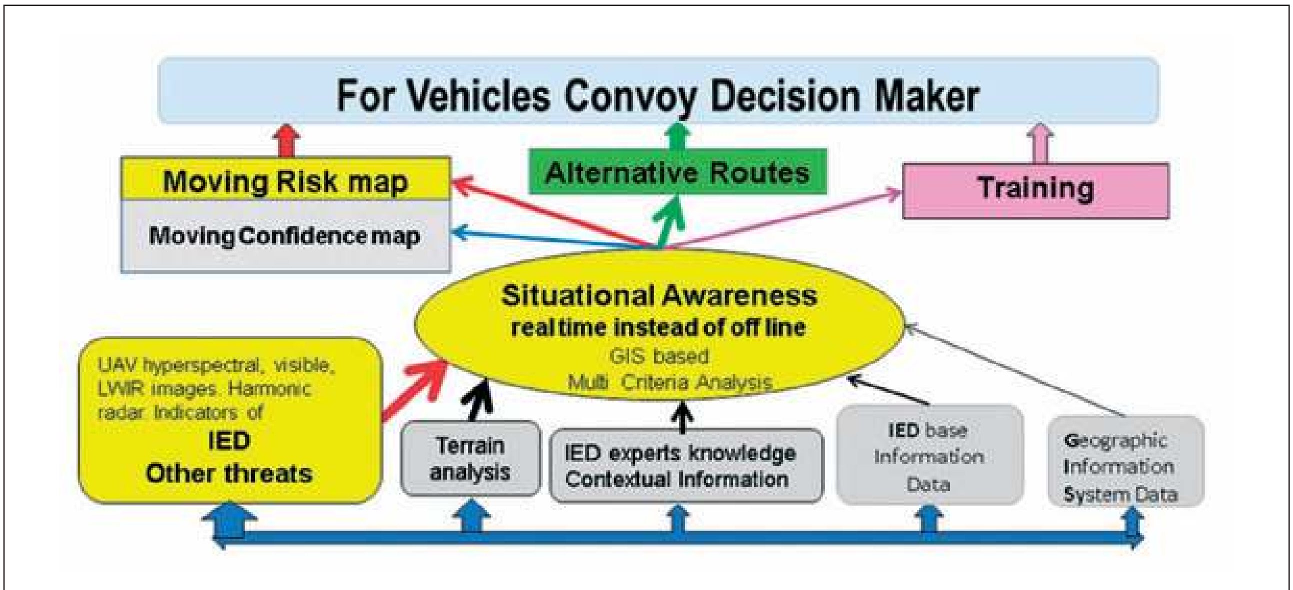

Figure 1. The situational awareness system for civil ground vehicles conwoy, [20, p. 51].

3. Coordinated Machine Learning and Decision Support for Situation Awareness

In a former mentioned system for situation awareness (INTELSAW) just like in other similar systems, by their very nature of things, threat analysis has a big role. J. Roy, R. Burton, and R. Rousseau [19, p.55] threat analysis define as:

„The analysis of the past, present and expected actions of external entities, and their consequences, to identify menacing situations and quantitatively establish the degree of their impact on the mission, the intents, the plans, the actions, and the human and material assets of some valuable units to be protected, taking into account the defensive actions that could be performed to reduce, avoid, or eliminate the identified menace.“

They have not stopped just on the definition of threat analysis and explanation of that definition, but they went further and illustrated the threat analysis concept and its relation to response planning. But before we provide explanation and computing realization of the concept of threat analysis let's shortly explain what preceded that, Fig. 2.

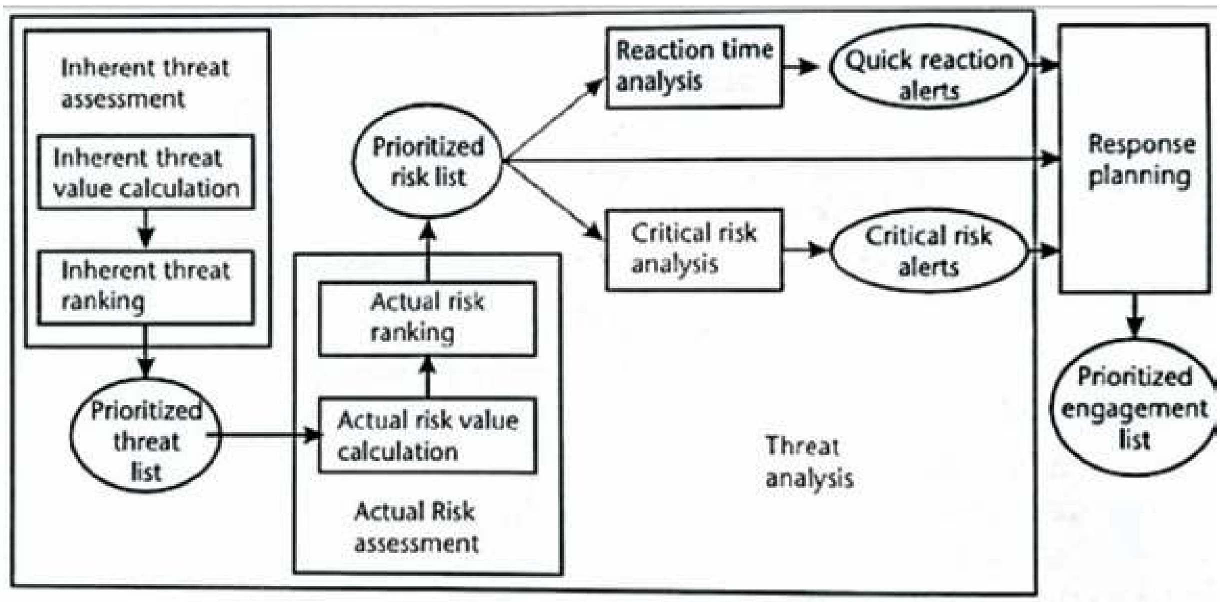

Figure 2. Threat analysis and response planning, [19, p. 55]

Every system as this described one (INTELSAW) relies on information - better said on a lot of pieces of information, knowledge, data. There are several general-purpose technologies which could be used for information, knowledge, data fusion. In the previous R&D for the static situation in mine action, we have used GIS-based Multi-Criteria Analysis (MCA), Fig.1. For considered dynamic IEDD, MA situation we found a promising solution in »Coordinated Machine Learning and Decision Support for Situation Awareness« research conducted by SANDIA laboratory, [16]. In this research work very clearly is described how to use and coordinate supervised, unsupervised and reinforcement machine learning - all three types of machine learning for the purpose of information, knowledge, data fusion. They successfully demonstrated how situation awareness system could be improved during operational use due to reinforcement learning and neural networks based on Adaptive Resonance Theory (ART) technology.

To achieve that INTELSAW system is effective in changing the environment we decided to utilize reinforcement learning and concept of threat analysis and response planning (Fig. 2). Therefore, we adopted the concept of threat analysis which is consisted of two processes – process of inherent threat assessment and process of actual risk assessment, as our model for situation assessment. For both processes, it is necessary to get information through information fusion. From the results (information, data, knowledge) obtained in information fusion for inherent threat assessment and actual risk assessment, we would use partially observable Markov decision process (POMDP) formulation to calculate a probability distribution over a state space. This newly generated information presented us the confidence level that the system is in a certain given state. With this we are achieving functionality which we wanted to get through the model of threat analysis - this is prioritized risk list obtained after mentioned above processes. Then from the prioritized risk list reaction time analysis and critical risk analysis could be derived. Because INTELSAW system preferred to be so-called »human in the loop« system, the human operator gives the final decision about the prioritized risk list. Such system setup provides changes during operation which is accomplished with reinforcement learning signal which essentially could be positive or negative. There could be several reasons why the signal should be back-propagated through the system. For example, one of the reasons could be that the operator disagrees with the prioritized risk list of the current state. In that case reinforcement signal is sent to a part of the system for information fusion and a new mapping of data is activated during operation. This is the way for system adaptation in any environment. It is an important point that the final action decisions are fully the domain of the human operator and are not automated. This system is an aid to the human; it is not a replacement. It remains to explain why we used a partially observable Markov decision process (POMDP). Using a Markov chain for sequential decision making is justified for many cases and this kind of model is called the Markov decision process. System for Markov decision process (MDP) needs to have Markov property. This means that every information about future state should be known in the current state but sometimes it is not possible because of the uncertainties of our environment. In that case, a probabilistic description of the current state is used which is called a belief space, this concept is the core idea of a Partially Observable Markov Decision Process (POMDP). Because of the performance of the system, it is good to know that POMDP takes a massive amount of computer power. To avoid this problem Bayesian Filter is used transforming POMDS into an MDP.

4. Versions of INTELSAW

Station for IEDD Non-Technical Survey, Targeted survey, Situational Awareness Assessment. Located in the premises of user of the INTELSAW, MA IEDD, MA or in civil convoys company. Two persons and hardware station. *The mobile module of SAW* for ground vehicles civil convoy leader. One operator hardware station for control of RPAS, for real-time risk changes assessment (fusion of static and dynamic risk data), a subsystem for Dual sensor RPAS control. *Dual sensor real-time warning RPAS flying in front of the first vehicle.* Flight at a distance which provides time for reaction after detection of the IED or the ambush. One operator of RPAS in the ground vehicle.

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DEMINING OF FORESTS

– CHALLENGES AND SOLUTIONS

The utilization potentials of demined forest areas in the Republic of Croatia

Đurđa Adlešič[1], Adela Zobundžija[2]

Abstract

The paper presents guidelines for possible potential use of demined areas that open up the possibility of restoration and protection of forests and forest land, strengthening the value of ecosystems in protected areas, enhancing public awareness of biodiversity, ecosystems and the importance of sustainable forest management and forest land. The idea of access is to provide the education of the population by members of the Homeland War, professional and competent staff from the tourism sector, and experts from the field of environmental protection who will, through their experience, knowledge and authority, influence the target groups to be educated. The survey shows the result of several thematically different successfully completed projects implemented by the Association for Support and Encouragement of Community »Croatia Helps«. The purpose of the work is to emphasize the continuity of further mine action activities on mine risk areas and the potential of using the forest area after demining that will enable the acquisition of accurate information needed to undertake actions and the possibility of activating sites on future mine clearing areas.

Keywords: education, demining, forest areas, potentials, environmental protection;

Introduction

According to available reports, more than 2.1 million hectares of forests and forest land with which the Croatian forests are managed can not be used due to the suspicion that it is mined and there are about 48 thousand hectares that is available for work. Forests and forest land cover 43% of the land area of the territory of the Republic of Croatia, of which 81% are state-owned. The rest are private or forests of special purpose and others. Mines or mine suspected areas make damages not only in the forests management but also in the overall business, but in relation to the war itself, and the period just after the war, the situation is now incomparably better. In the years from 1991 to 1997, the forests that were occupied during the war did not work. Nobody could safely say what the surface was, because there was no validated data. Mines are often prevented from extinguishing forest fires. For example, in the biggest fire in Croatia, in 2012, 6 952 hectares hawks of oak and hornbeam, beetroot, grass and low plants burnt down. Forests and forest land still make most of the remaining mine suspected areas in the Republic of Croatia.

This paper presents the potential for utilization of forest areas after mine clearing, through education of the local population in the Republic of Croatia. The idea of access is to provide the education of the population by participants of the Homeland War, professional and competent persons from tourism and environmental protection, who will with their experience and authority convincingly influence the target groups that they will educate.

The development guidelines presented are the result of several projects implemented successfully by the Association for Support and Encouragement of the Commonwealth »Croatia Helps«, and co-financed by the Ministry of Croatian Defenders, under a public tender called »Psychological and Social Empowerment and Raising the Quality of Life of Croatian Defenders, Croatian Defenders with disabilities, HRVI, victims and members of the family of a mortally forcible, detained or missing Croatian war veterans from the Homeland War.« Specific objectives of the project were the psychological empowerment of Croatian veterans, former

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members of special police forces and the reduction of social exclusion through their active inclusion in the community by raising competence for population education on the dangers of mine suspected areas, reintegration of areas and potentials for exploitation of the mine clearance area. One of the results of the project is the interest of the general public on the continuation of education activities, in particular on what to do and how to dispose mine suspected areas and which are available to launch new activities (agriculture, tourism, public use, production, processing and similar). It should also be emphasized that, in the context of the mentioned guidelines for the development of the demined area, the implementation of the first largest environmental protection project in which the Croatian Forest is being carried out, and the partners of the Croatian Mine Action Center, the Ministry of Mine Action of the Government of the Republic of Croatia, Croatian Waters and Public Institution » Nature Park Kopački rit ». The project was named »Demining, Renovation and Protection of Forests and Forest Land in Protected and Natura 2000 Areas in the Danavsko-Dravska Region-NATURAVITA«.

It is a strategic project aimed at demining, restoration and protection of forests, forest land and water resources in the project area which is still contaminated or suspected of mines explosive devices and unexploded ordnance for warfare, and which is why it is not possible to adequately manage forests. The project is implemented in the Osiječko-Baranjska County and covers forests and forest land in Natura 2000 and protected areas. By realizing this project, 597 ha of forest and forest land in the area of Nature Park »Kopački rit« and 1,937 ha in the Mura-Drava Regional Park will be cleared of mine explosive and unexploded ordnance. In addition, the Podravlje forest house will be reconstructed and the Educational and Visitor Center »Podravlje« will be set up with four educational and recreational paths and classrooms in nature. This is an excellent example of good practice of exploiting demined forest areas with redirected to publicly available land allocated to the general public.

Work goal

The aim of this paper is to show the potentials of forests on the territory of the Republic of Croatia, which through the restoration and improvement of the fire protection conditions and the reconstruction of war-degraded forest areas through various design models enable usability in specific sectors of activity. By model of preparation of project proposals for exploitation of forest and forest habitat potential, it is possible to implement operational programs and strategic development projects in the areas of regions where there are still major mining threats, which are demining areas of strategic importance for the region and placed in function according to the previous local community decisions and the resources or potentials available to them.

Methods

Although, through the projects implemented annually by the Croatia Association, it has educated more than a hundred different target groups from Croatian veterans, former members of the special police, 100% HRVI, representatives of Homeland War veterans' associations and others through several cycles of dangers education from mines, psychosocial empowerment, forestry education, hunters and other target groups, there are potential for continued implementation of education on the theme of challenges and possible solutions for exploitation of demined forest areas. According to the above, analyzes were carried out with a preliminary survey conducted in the field from the 8th to the 29th of November 2018, in which hundreds of subjects from the three counties (Sisačko-Moslavačka, Karlovača and Ličko-Senjska) participated, based on which conclusions were made regarding the subject. The first part of the research included the definition of a target group interested in exploiting the forestry:

a) Local population - objective: an interested community for the management of forest areas in order to maintain the biodiversity of the area;
b) Private Sector - Objective: The observed opportunity and the potential to start a private business aimed at strengthening the tourist offer of the region;
c) Public Sector - Goal: Challenges and Opportunities of Local Policies aimed at strengthening the potential of arranging, equipping and maintaining socially and publicly accessible facilities and spaces;
d) Physical persons - small entrepreneurs - the goal: by working in their crafts or family farms, they want to use part of the forest areas for development;

The second part of the research involved exploring the possibilities and the usability of available programs, measures and project proposals that would provide the necessary resources for successful implementation of the planned:

a) The development of the tourism sector and the potential encompassed by strengthening competitiveness of Croatian tourism;
b) Investments in conservation of forest habitats and forest revitalization;

c) Investments in strengthening ecological production, processing and marketing of Croatian products;

The third part of the survey covered potential sources of funding, suggestions and observations of the local population of the regions where research was conducted - 3 counties in which the largest number of forest areas under mines (Sisačko-Moslavačka County, Karlovačka and Ličko-Senjska County).

The Results

After processing the collected data of the research and the effect assessment carried out, the results obtained were significant for further work on the subject.
Research Phase:
F1: Specificity of the target group;
F2: Challenges and Opportunities for Use of Forest Potential - Demined Areas;
F3: Needed resources to achieve the goal;
The interest in the opportunities offered by the use of forest areas after their demining was shown by almost all target groups with different interests of activity as shown in Table 1.

F1: Target group	1. Karlovačka County 2. Sisačko-moslavačka County 3. Ličko-senjska County
Local population	Preservation of biodiversity, maintenance of educational paths, sources and forest habitats;
Physical persons	Purpose of investment in the tourism sector, biodynamic, ecological production – small entrepreneurs;
Public sector	Sustainable forest management, preservation of biodiversity – public useful objects and spaces;
Private sector	Legal entities interested in starting a business related to the forest area – tourism;

Table 1: Overview of target group specifics

The opportunities that we observe by using demined forest areas for planning new activities (Table 2) are invaluable for timely launching strategic decisions of the local community in the case of state ownership of forest areas, ie activation of land by owners if they are privately owned. In both cases, it is certainly useful to put the forest areas back into function, according to the available resources.

F2: Forest potentials:	1. Karlovačka County 2. Sisačko-moslavačka County 3. Ličko-senjska County
Local population; physical Persons; Public Sector; private Sector;	– Tourism sector development: hunting and fishing tourism, adventure tourism, mountain lodges accommodation capacities, camps; – Conservation in conservation of forest habitats and forest revitalization: nurseries, educational paths and the like; –Relation to strengthen ecological and biodynamic production: untreated land ideal for eco-production, compost production, woodcutter processing and similar;

Table 2: Potential for the use of forest areas after demining

To start each planned investment, it is important to determine the potential / resources and possible sources of funding (Table 3), which are tailored to the investor, or to whoever initiates any initiative.

Discussion

Because of the consequences of war operations during the Homeland War, Croatia faced a significant security problem, pollution of living space by mine explosive and unexploded ordnance. The consequences of the security vulnerability of the population, as well as the inability to use minefields, have been strongly influenced for many years to develop areas

F3: Financing sources	1. Karlovačka County 2. Sisačko-moslavačka County 3. Ličko-senjska County
Local population; The physical persons; Public sector; Private sector;	–Financing from own sources: a) budget funds of local government units and self-government units; b) the assets of the enterprise realized from the realized profit; c) resources of physical persons aimed at initiating activities to achieve revenue / profit –National funding sources: a) public calls and tenders at the level of ministries, agencies and funds; –Financing from EU Funds: a) Structural Funds (ESF, EFRR, EPFRR) b) Union Programs (eg LIFE) c) Cross-border / International Programs (Interreg); b) Union Programs (eg LIFE) c) Cross-border / International Programs (Interreg);

Table 3: Resources - sources of funding activities

affected by war events, and thus to the development of society as a whole. The consequences are multifaceted: security, economic, ecological and social. According to the priorities of the implementation of the remaining mine clearance, demining of agricultural areas, national parks, nature parks and protected areas of natural and cultural heritage and forests and other areas (meadows and pastures) is ongoing. According to the National Mine Action Program of the Republic of Croatia3, in the period 2009-2019, five strategic objectives are planned, one of which foresees the development and implementation of a program of education for the entire population living and / or working in the mine suspected area or gravitating to it. Therefore, the problem of the use of mine-cleaned forest areas is one of the thematic program activities that need to be informed and educated to the population, and the cleaned area should be put into operation as soon as possible.

Conclusion

Due to the unavailability of mine suspected areas it is impossible to use their economic potential (agricultural areas, forest complexes, etc.), the implementation of fire protection, the surveillance of the state border, the implementation of various actions, the implementation of flood protection measures and the treatment of technological accidents have been prevented. It is concluded that mining has an immediate impact on the implementation of measures for the protection of life and property of citizens and that it is necessary to develop and upgrade a system that will successfully solve the mine problem and clean up the areas again. In addition, it is important to carry out activities of population education on the potential of the forest area after demining as well as existing resources to inform target groups about the possibilities of using technical assistance in projects to be financed by the EU funds from the financial perspective of the programming period by 2020 and further in future operational programs for future periods. The above results of the research aimed at launching new project activities are aimed at restoring and protecting forest and forest land and strengthening the value of ecosystems in protected areas, enhancing public awareness of biodiversity, ecosystems and the importance of sustainable forest management and forest land. At the same time, they are prerequisites for sustainable management of natural resources in protected areas, which means that the Republic of Croatia has significant quantities and are necessary in the process of planning the economic development of the same areas.

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INFRASTRUCTURE

SECURITY WITH REGARD TO EXPLOSIVE ORDNANCES

The influence of explosive remnants of war to infrastructure: new perspective for Serbia and WB region

Vojkan Krstić[1]

Serbia´s mission and strategic aim for EU membership should be followed also with antimine actions. That certainly undertakes raising the level of network quality as well as raising the quality of cultural, cities and economic resources in infrastructure on sufficient level, which will provide its undisturbed usage. Good infrastructural basis is mandatory precondition, that will create very fruitful ground for further construction of objects, necessary for the functioning of state and its economy.

Serbia, as country with various different networks of international, regional and local ways, is also obliged to provide security and safety of passengers who are passing through the country.

On the another hand, looking at the rural and city development in all regions of Serbia, as two equal components of its economic development, especially having in mind the high contamination of explosive ordnance that are left behind from war period, there is a high need to take close attention of decomission of ammunition, and to take all necessary actions of possible threat elimination.

In line with the world trend of fulfilling UN SDGs, the mandate of every state to take the responsibility of care and protect human lives, the need od personal contribution, with international assistance and support is imposing, in order to help the pollution reduction or/and to protect the health environment. This will definitely contribute to equal infrastructural development, which is among highest priorities of every democratic state.

Basic problems that may appear after armed conflicts, based on pollution from explosive ordnance from war, could successfully be removed, by taking joint actions in which all society subjects and international actors need to be involved.

As it was described in the New UNMAS Strategy 2019-2023, "ongoing crises and conflicts create increased contamination, particularly in urban settings, giving rise to new challenges and risks. Worldwide, mine action programmes continue to make progress in addressing risks associated with explosive ordnance, but increased contamination has resulted in higher civilian casualty rates and damage to civilian objects and critical infrastructure and created new challenges for the protection of civilians. These crises and conflicts also contribute to population displacement, loss of livelihoods, impeded or obstructed access to essential infrastructure and services, and increased vulnerability. Moreover, while there has been progress in the development and implementation of the normative framework pertaining to mine action, calls for strict compliance with international humanitarian law (IHL) and human rights law remain necessary."[2]

In 2018, Serbia has adopted the Law on downsizing the risks and managing the emergency situations, where is also clearly defined the term of explosive ordinance remnant. With new strategic framework, Serbia is making a serious progress in adoption of international terminology and standards and its implementation into national legislation.

New Law has defined the explosive ordnance remnant as explosive or unexploded tool, with or without lighter, prepared for use or already used (fired, launched or expelled).[3] It is a realistic expectation that the National Strategy for downsizing the risks from catastrophe and managing the emergency situations will develop the guidelines for protection from explosive ordnance remnants. In order to raise awareness of citizens and legal authorities how important this issue must be, the State had defined the measures and the circumstances for the ones who disobey state orders of immediately reporting in case of discovery explosive remnant.[4]

1 Serbian Rescue Center, Republic of Serbia,
e-mail: vojkan.krstic@gmail.com.

2 https://mineaction.org/sites/default/files/documents/un_mine_action_strategy_2019-2023_-_final_for_online.pdf.

3 See more in Zakon o smanjenju rizika od katastrofa I upravljanju vanrednim situacijama ("Sl. glasnik RS", br. 87/2018).

4 See more in Zakon o smanjenju rizika od katastrofa I upravljanju vanrednim situacijama ("Sl. glasnik RS", br. 87/2018).

Having in mind that protection measures are the part of civilian protection, the inclusion of civil society and non-governmental organizations is a strong recommendation. In that context, it could be perceived as complete process of antimine action and its components, which would directly benefit to further development of infrastructure in Serbia.

According to actual statistics of the Mine Action Centre of Serbia, as independent governmental institution, from the period of 2008. till February 2019, total area that was cleaned is 6.727.439 m^2, and it was removed 13.276 different types of unexploded ordnance remnants.[5]

Source: http://www.czrs.gov.rs/lat/vesti.php

5 http://www.czrs.gov.rs/lat/vesti.php.

Hence, following the infrastructural development, there is a need for synchronized action of humanitarian disarmament projects and the process of planning, coordination and managing the infrastructural projects. In order to make an comprehensive approach to the development of infrastructure in the service of economy development on a state and possibly regional level, it is highly recommended to prepare new proposals for antimine cleaning of all suspicious and risky surface, after which it will be submitted to their owners/users. Key significance for the enhancement of labour market competitiveness of the region lays down in developing the positive climate and good preconditions for the development of infrastructure. With high level of contamination of explosive ordnance remnants and still locations that needs to be discovered, there is a high risk of additional expenses for new investments, which will then result with the lower quality of life standards.

With the aim of promotion the integrative approach in the system of sustainable development of local municipalities, in order to facilitate state aid and international support, it is highly necessary to monitor and overview the situation in the field, to register the suspicious/risk fields and to take the action of cleaning. „Priority has that surface in inhabited areas, frequent roads, construction sites, processed agricultural surface and other resources“.[6]

Looking at the actual situation of the ground pollution, affected by nonexplosive ordnance remnants, in Serbia there are some factors that contributed this situation. For instance, between 1941. and 2006. there were several cases of ammunition stores explosion. According to the official datas, the area of 22 km^2 in12 different sides in 9 municipalities were under unexploded ordanance, as a result of ammunition storage explosion.“.[7]

Therefore, it is highly recommended to seek for cooperation among civil society organisations, with the international assistance and support, which may significantly contribute to anti-mine actions, with the aim to achieve better effect in developing the infrastructure and overall better life conditions.

6 Žnidaršič, Vinko (2009) “Primena GIS-a u protivminskoj delatnosti na teritoriji Republike Srbije” OTEX 2009, Vojnotehnički institut Beograd.

7 Jovanović, Dragan (2011) »ERW in the Republic of Serbia,«The Journal of ERW and Mine Action : Vol. 15 : Iss. 1 , Article 18.

By that, though the system of civil protection it could be identified different organizations, among which Serbian Rescue Center, as non governmental organization and registered subject of specific significance in reaction in the emergency situations. Basically, this Center contributes by providing support in the field by raising awareness on anti-mine actions. Besides actions in the field, certified personnel is capable to provide trainings and education on anti-mine actions, and to assist nationally and regionally, where needed.

Furthermore, the latest activities shows that Serbia is working hardly on the incorporation of international mine action standards into national standard operative procedures, in order to be capable to raise the level of security and better life standards. „Mine action is a continuously evolving field of assistance relying on over two decades of diverse and multi-sectoral partnerships, established communities of practice and lessons learned.“[8]

In the following period, it will be most appreciated to use the already existing experience, combining with the priorities from the New UNMAS Strategy, obtained into one comprehensive approach how to contribute the fulfilment of UN SDGs and in the same time how to achieve the goals from the anti-mine action components. „During the 2019-2023 period the UN will strengthen and expand its partnerships at international, regional and national levels in order to enhance coordination and synergies across countries on specific thematic issues and challenge.“[9] This would also be the framework in which The Serbian Rescue Center will continue to work and to develop, strengthening the cooperation with civil society organisations, governmental institutions, regional and international actors whose activities are dedicated to anti-mine actions with full respect of international standards.

8 https://mineaction.org/sites/default/files/documents/un_mine_action_strategy_2019-2023_-_final_for_online.pdf.

9 https://mineaction.org/sites/default/files/documents/un_mine_action_strategy_2019-2023_-_final_for_online.pdf.


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

- testing and certification of:
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  - mine detection dogs
  - metal detectors, PPE and prodders
- field testing and operational validation of technologies used for mine contaminated area detection and mine suspected area reduction
- training and issuing certificates for the use of metal detectors
- training of EOD officers, worksite managers, demining teams and monitoring personnel
- organizing workshops, conferences and other gatherings on the subject of mine action
- system establishment and training for remotely piloted aircraft systems (RPAS) survey in mine action
- aerial non-technical multisensor survey after natural disasters
- aerial survey of scattered UXO after explosions of ammunition depots
- lease of test sites
- implementation of research and development projects in the field of mine action

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