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27th to 30th April 2015 – BIOGRAD, CROATIA

The 12th International Symposium

»MINE ACTION 2015«

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International Symposium "Mine Action 2015"

27 to 30 April 2015, Biograd, Croatia

Published by

HCR-CTRO d.o.o.

Sortina 1d, 10 020 Zagreb, Croatia

Tel +385 1 650 0020; Fax +385 1 652 0301

NOTE:

The material submitted by authors has not been revised.

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The book of papers of the 2015 Biograd Symposium has been published with the support from the TIRAMISU and D-BOX Projects

TIRAMISU and D-BOX are funded by the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreements n° 284747 and 284996.

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ISSN 1849-3718

Ključni naslov: Book of Papers (International symposium "Mine Action")

Skraćeni ključni naslov: Book pap. (Int. symp. "Mine Action ")

Contents

13th IARP WS HUDEM'2015

UAS deployment and data processing of natural disaster with impact to mine action in B&H, Case study: Region Olovo

Esad Avdic[1], Haris Balta[2], Tamara Ivelja[3]

ABSTRACT — In this paper, we present a case study report on how novel robotics technologies like the Unmanned Aerial System (UAS) and data processing methodologies could be used in order to support the traditional mine action procedures and be directly applied onto the terrain while increasing the operational efficiency, supporting mine action workers and minimizing human suffering in case of natural disaster with impact to mine action. Our case study is focusing on the region Olovo (Central Bosnia and Herzegovina) in response to massive flooding, landslides and sediment torrents in spring-summer of 2014. Such destructive impact of the natural disaster on the mine action situation resulted with a re-localizing of many explosive remnants of war which have been moved due to the flooding and landslides with significant negative environmental and security consequences increasing new potentially suspected hazardous areas.
What will be elaborated in this paper is the following: problem definition with a statement of needs, data acquisition procedures with UAS, data processing and quality assessment and usability in further mine action procedures.
KEYWORDS: Mine Action Support, Unmanned Aerial System, Natural Disaster.

1. Introduction

In the period between end of May and beginning of June 2014, Bosnia and Herzegovina, Croatia and Serbia were hit hard by a catastrophic massive flooding after abundant rainfall over a few weeks, causing floods and landslides. The countries suffered one of the greatest damages, as the rain has been the heaviest in the entire period of 120 years of recorded weather measurements. Only in Bosnia and Herzegovina, an estimated 1.5 million people were affected (39% of the population). Flooding has led to at least 57 deaths in Bosnia and Herzegovina and Serbia [1].
The EU Civil Protection Mechanism has been activated due to the catastrophic crisis 22 Member States have offered assistance through the Mechanism. In addition to destroying agricultural land, flooding caused thousands of landslides, displacing landmines and Explosive Remnants of War (ERW) buried during the 1992–1995 war conflict in that region. The change of the mine action situation created an extremely dangerous situation and resulted with significant negative environmental and security consequences for the local population and the relief workers [2, 3].
Natural disasters (floods, torrents, landslides, land shifting) have had intensive destructive impact on suspected hazardous areas (SHA) and mine fields in Bosnia and Herzegovina. According to the U.N., 70 percent of the flood-affected areas may contain landmines and unexploded ordnance (UXO) [1].
Only in Bosnia and Herzegovina, 831.4 km^2 were flooded, 37.48 km^2 of suspected hazardous area in 33 areas were under direct impact of torrents and landslides; by 4th July 2014, 1018 UXO, 92 mines and 3 cluster bombs were found, as well as 40.163 ammunition pieces. In addition, 80.2km^2 of new areas which previously had not been mine suspected became potentially hazardous (Northern part of Bosnia and Herzegovina). Bosnia–Herzegovina Mine Action Centre (BHMAC) have provided data and information about the affected regions, the kinds of influence, the impact intensity and the spatial distribution, as well as priorities [4]. In order to deal with such complex and dangerous situation, it

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was decided to deploy an Unmanned Arial System (UAS) for aerial assessment and mapping flights of the affected mine fields and new suspected hazardous, looking for indicators of where the minefields were shifted due to the floods and landslides [5].

2. Integration of UAS in mine action procedures

The use of Unmanned Aerial Systems for dangers and not easily accessible missions provides benefits for users due to their low cost, portability, and potential fields of use. In this context such systems can offer important support to human task forces in situation assessment and surveillance and in this way increase the situational awareness of the environment from the air. The UAS can be deployed without the need for extensive airstrips for take-off and landing. Operating costs are typically low, compared to conventional manned aircrafts. The use of small UAS may improve the response time and coverage for operations allowing search and ground teams to systematically survey and perform mapping and doing damage assessment of areas (high level of details and accuracy of ground pixel size 2-5 cm) of importance without any physical interaction within dangerous zones [2].

In the context of this mission we used a small vertical take-off aerial system UAS the md4-1000 from Microdrones as shown in Figure 1. Depending on the weight of the payload, state of the batteries, environmental and flight conditions, the UAS can fly for about 35-40 min. In addition, the overall UAS (system comprises of a field control base station with high gain antenna for providing command, control and data recording to and from the Unmanned Arial Vehicle (UAV). The UAV system is equipped with a Sony NEX-7 24.3 megapixel digital camera with an 18mm lens. The camera is mounted below the UAV on a 2-axis gimbal with high precision tilt and roll stabilization (because of the strong and multi-direction wind) in real time to provide better images for aero triangulation and mapping.

In general, two types of operations were performed:

- Manual Flights. End-users (demining teams) indicated points of interest they wanted to see investigated by the UAS, mainly for damage assessment and visual inspection. The flights were then executed by a trained operator.
- Waypoint-based mapping flights. An area to be mapped by the UAS was indicated by the end-users. A flight plan was then set up to map this area using an autonomous waypoint-based flight. Also under these conditions, a trained pilot always operated the remote control station.

A typical flight had a duration of 25 to 30 minutes, which enables to cover an area about few hundred sq meter. Multiple mapping missions were performed, maximum up to 500 images with a resolution of 24 megapixels and mapping areas not larger as 1sq km.
Figure 2 shows the complete workflow process of the UAS flight mission. Starting from the definition of the affected mine suspected areas, terrain reconnaissance, producing a flight plan, measuring D-GPS ground control points through flight execution with data acquisition and finally post-processing activities.

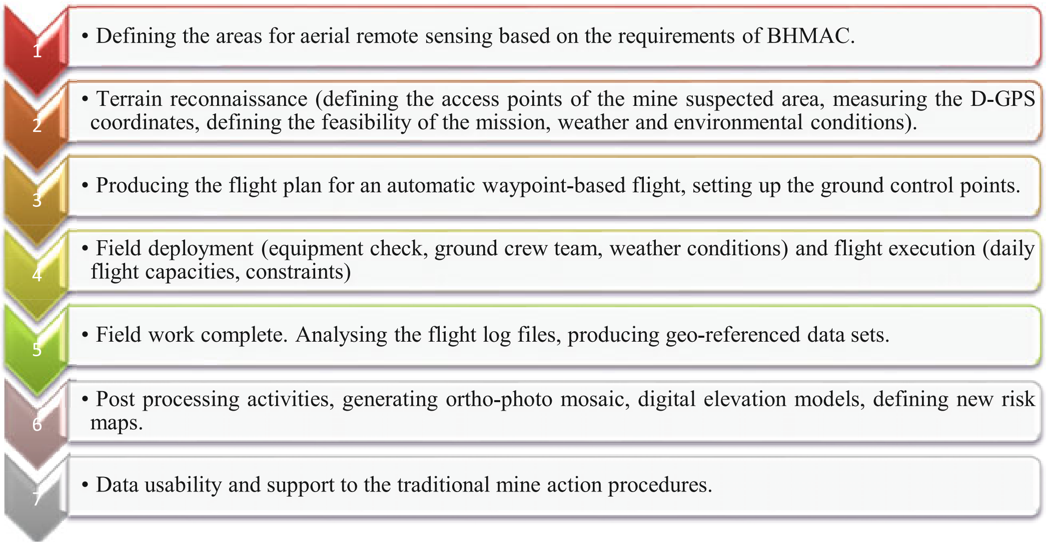

Figure 1 Workflow planning of the UAS flight mission

Figure 3 shows example images for an automatic waypoint-based mapping flight acquired by the UAS. Example of the landslide, which crosses the mine field from the region Olovo (Central part of Bosnia and Herzegovina).

Figure 3 Example of mine suspected area images acquired by the UAS

2.1 Problem defining - Region Olovo

Olovo Municipality is positioned within the central part of Bosnia and Herzegovina, 56 km N/E from the Capital Sarajevo and 75 km south from Tuzla. Before the Bosnian war[4], the Olovo municipality with its 44 surrounding villages counted 16.956 inhabitants. Nowadays, the municipality counts

4 The Bosnian War was an international armed conflict that took place in Bosnia and Herzegovina between 6 April 1992 and 14 December 1995. Source: http://en.wikipedia.org/wiki/Bosnian_War (web access: 21/3/2015)

approximately 13.000 inhabitants. The density of population is approximately 32 people per square kilometre, which is significantly below the region's average (approximately 128 persons per km2). Olovo is a medium-urbanized municipality with developed mining and forestry.

Our case study is focusing on the region Olovske Luke which belongs to the Olovo municipality. Location of Olovske Luke shows a clear mine situation, which is visible on mine situation map shown on Figure 4. During the war conflict, confrontation lines were steady and without significant movements. Combat lines were fortified and mine-explosive obstacles places with or without records, which is characteristic for this area. After the war activities in the period that followed, there have been operations of humanitarian demining in locations closer to objects relevant for infrastructure such as water line and elementary school of Olovske Luke (locations of number I priority), while locations of II and III category were marked with either semi-permanent fence or urgent signs of mine warning.

Due to the nature of combat, the location of Olovske Luke is mainly contaminated with a larger quantity of cluster bombs CB 1, fired from infantry weapons. At Olovo municipality area, since 1996 up to 2015, 31 mine incidents occurred; 22 persons were severely injured, with 9 fatalities, including two children.

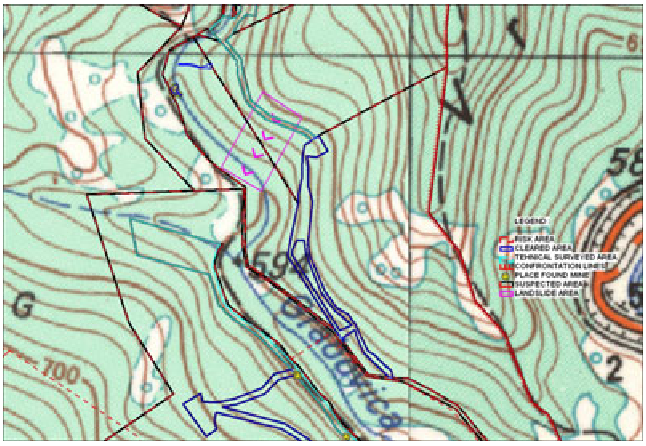

Figure 4 Location Olovske Luke – Topographic map (1:25000) and mine situation layers with influences of floods and landslides (Database BHMAC)

In May 2014 on location Olovske Luke, due to natural disaster that affected this area, a large landslide started off a previously marked mine suspected hazardous area. The landslide endangered formerly technically surveyed area that were partially demined due to restoration of the local water line. Since part of the landslide is situated in the mine suspected area, and it brought a large amount of slide material over formerly technically surveyed area, the demined zones within the landslide should be declared as mine suspected. Additionally, land erosion also brought a large amount of slide material onto Grabovica creek with great probability of mine-explosive materials displacement downstream in the direction of the urban areas.

Since the landslide is an active one and was not remediated, it is still a threat endangering the region with the risk of possible reactivation, expansion of the mine suspected area with significant negative environmental and security consequences for the citizens. Therefore, it was necessary to react urgently and it was decided to deploy the UAS for aerial assessment and mapping of the mine-suspected areas and to find indicators of where the minefields were shifted due to the floods and landslides. The data of the UAS mission was used for providing 3D-maps of the environment to analyze the effects of the landslides on mines. Fusing the obtained data from the UAS with pre-existing data (mine risk maps from the Bosnia and Herzegovina Mine Action Centre), it will be possible to predict the movement of the landmines and to generate updated mine risk maps and maps of mine-affected areas.

2.2 Data processing and quality assessment

Once obtained, the data acquired from the UAS were processed and new digital ortho-photo (DOF) mosaic and digital surface models (DSM) of affected mine suspected areas were produced. Main processing procedure was conducted in Agisoft Photoscan [6] software. The software generated the digital ortho-photo mosaic and digital surface models using an algorithm, which analyses all images of the aerial data set and searches for matching points. The best well-known feature matching algorithm is the scale-invariant feature transform approach. Those feature-matching points are combined with meta-data information from the autopilot (altitude, camera position and orientation) and are used in a bundle block adjustment in order to reconstruct the exact position and orientation of the camera for every acquired image. Based on this reconstruction, the matching points are verified and their 3D coordinates calculated. Those 3D points are interpolated to form a triangulated irregular network in order to obtain a Digital Elevation Model (DEM). This DEM is used to project every image pixel and to calculate the geo-referenced ortho-photo mosaic of the area. The reconstructed DEM and the resulting ortho-photo mosaic are shown in Figure 5. The quality of digital ortho-photo mosaic and DEM depends on the accuracy of the Ground Control Points (GCPs). If the quality of GCPs is excellent, therefore the result of digital ortho-photo mosaic and DEM can be anticipated accurately too. In this case we could reach an accuracy within few cm per pixel. Several processing procedures were tested due to large positioning error.

General processing procedure consists of the following steps:

I. Data import: Photos and corresponding GPS coordinates of the projection centres
II. Photo alignment
III. Defining Ground Control Points
IV. Alignment Optimisation
V. Build Dense Cloud
VI. Build Mesh
VII. Build Texture
VIII. Generate Result: DOF, DSM

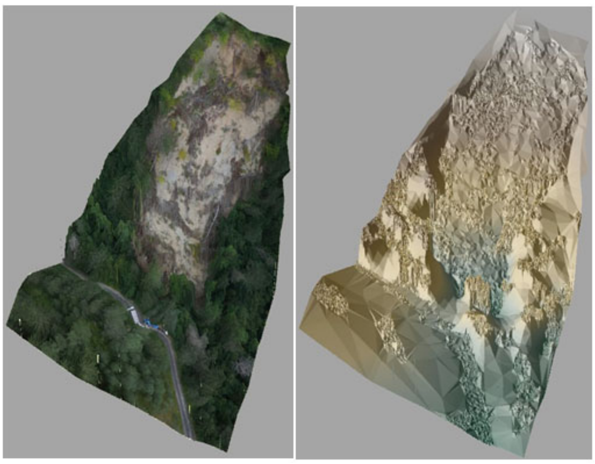

Figure 5 Left - Digital Ortho Photo mosaic of the recorded area Olovske Luke,
Right - Digital Surface Model
of the recorded area Olovske Luke

Applied processing procedures have not contributed to a significant reduction of positional error. Span of X coordinate positioning error is from 18.396 m to 15.685 m and for Y coordinate it varies from 21.164 m to 15.695 m. Position error was determined comparing well defined detail on both (official/state) DOF 1000 and generated micro DOF mosaic of this location. The best results were achieved after GCP ortho-metric height was corrected for geodetic undulation (difference between geoid and ellipsoid value) in the third processing step. Geodetic undulation value for this location was supplied from a web geoid calculator [7.].
Due to this reason it was necessary to conduct additional georeferencing of micro DOF mosaic on (official/state) DOF 1000. When applied, this procedure resolved the issue of large positional error. Achieved declared ground resolution of the DOF mosaic is 0.0174429 m/pix.

3. Data usability and support to the traditional mine action procedures

Once obtained, the data acquired from the air enables to define the estimated the size of the landslide and position it on cartographic and Mine Information System (MIS) database layers without further measuring on the ground, which diminishes the risk for the surveyors. It is also possible to estimate if ground erosion resulted in moving of the mine-explosive devices. In overlay of obtained micro ortho-photo mosaic with state/official DOF 1000 and MIS layers as shown in Figure 6, it is possible to assert that there has been ground erosion at places where mine-explosive devices are expected, thus it is necessity to re-declare the affected areas as risk areas.

Furthermore, it is possible to determine actual size of the phenomenon: the max length of the landslide is 142 m, it’s max. width is 55 m while total landslide area is 6650 m^2.
The obtained DSM will serve for better defining of geology and hydrogeology experts’ opinion on the possible problem expansion tendencies, landslides depth (in this case from 6 to 8 m), the urgency of remediating actions necessary, and the need for updating the boundaries of mine suspected hazardous area.

Figure 6 Left Figure: Ground situation before the natural disaster, overlay of DOF1000, technical surveyed area (green) and cleared area (blue),
Right Figure: Ground situation after landslide occurred, overlay of DOF1000, micro DOF mosaic, technical surveyed area (green) and cleared area (blue)

The use of UAS in mine action in Bosnia and Herzegovina is a new challenge towards more efficient and effective resolving of the problem of mine contamination. Based on the work and experiences gathered during the field missions, the direct and indirect benefit of UAS deployment in mine action procedures could be:

The data acquired from the air can enable identifying of mine presence indicators such as confrontation lines positions, combat facilities and reference points from minefield records in inaccessible areas. The data can also be used as quality control of created demining projects, in re-survey of risk areas processed within a demining project as well as in process of identifying areas without defined risk and in process of reduction of areas planned for systematic survey;

Also, it can be used for establishing facts of mine incidents by recording the mine incidents locations as proof of mine hazard, as well as recording technically surveyed area where remaining mines were found. Data obtained from UAS can also be useful in defining mine action procedure for future tasks, defining sizes of area intended for mechanical demining;

Gathering information on configuration, vegetation, soil type, infrastructure and establishing aggravating circumstances which might influence the conduct of planned mine actions;

In cases of mine accident the UAV data could be used for identification of the accident location in relation to the mine situation of the location, guiding deminers towards the indicators.

Documentation of activities conducted on the area of interest in mine action procedures (images and videos from the area).

4. Conclusion

In this paper, a report on the operational deployment of novel technological tools for mine action in an actual situation has been presented. An unmanned aerial system equipped with sophisticated 3D data processing algorithms was deployed to help with mine action efforts after the 2014 floods in the Bosnia and Herzegovina. The tools were used in support of ground teams for crisis assessment, and for helping in localizing landmine suspected areas affected by the natural disaster. The response from the response teams brought into contact with the unmanned tools was very positive. As a closing remark, one of the end-users (the BHMAC Technical operation officer), noted that the rapid mapping activities and the results we get from the UAS mission are crucial for damage assessment, and for re-localizing the many explosive remnants of war which have been displaced due to landslides and flooding water. In this case, we did not risk and put humans in the dangerous zones.

5. Acknowledgement

The work leading to these results has received funding from the Croatian Ministry of Foreign and European Affairs which recognized the contribution of the project to mine action cooperation in disaster/emergency response, technology development and capacity building and co-granted its realization. Especially cordial acknowledgments to the Coordinator of the project the HCR Centre for testing, development and training Ltd. The authors also want to thank the Bosnian Mine Action Centre (BHMAC) for their invaluable support during this operation. Additional thanks goes to the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement number 284747 TIRAMISU project.

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Mine Action after Natural Disaster, Emergency Response, Technology Development and Capacity Building

Milan Bajić[5], Nikola Pavković[6]

Abstract: The natural disaster (floods, landslides, torrents) in May 2014 caused huge consequences to mine action situation in Bosnia and Herzegovina, Croatia and Serbia. The Mine Action Centres from these countries initiated regional response aimed to assist the recovery, develop technology, build capacities, develop recommendations and standard operational procedures for future similar cases. CTDT was invited to propose approach, to derive and to lead the project. The importance of the project's objectives was recognised by Ministry of Foreign and European Affairs of the Republic of Croatia which decided to significantly support project's realisation. The main pillars of the project are: a) motivation and mobilisation of scientific resources, b) use of Remotely Piloted Aircraft Systems (RPAS) and helicopter for reconnaissance and mapping of afflicted regions, c) delivery of the outcomes to mine action centers and regional offices, d) development of the aerial survey technology suitable for mine action, e) building the initial capacities for operational use, f) derivation and verification of the recommendations and the standard operational procedures for mine action afflicted by natural disaster. Project duration is one year, started in September 2014, many persons participate in its realisation and total workload is 92 person months. The mapping by RPAS of the landslides, torrents's deposits was done in 2014 and the outcomes are delivered to Mine Action Centre Bosnia and Herzegovina and its Regional offices. The mapping in 2014. from the helicopter Gazela covered 95% of planned areas, processing is under way, while the remains will be mapped in spring 2015. Three workshop are realised in Sarajevo, with significant number of participants. Training of fourteen mine action surveyors (10 BH MAC and Regional offices, 2 from CROMAC and 2 from NPA Bosnia) was realised in February 2014. The use of RPAS for mapping of the afflicted mine suspected areas will serve for the operational validation of this technology for FP7 project TIRAMISU.

Key words: natural disaster, mine action, mine field, landslide, torrent, flooding, RPAS, reconnaissance, mapping, workshop, surveyor, BHMAC, capacity building

Introduction

The natural disaster (floods, landslides, torrents) in May 2014 caused huge consequences to mine action situation in Bosnia and Herzegovina, Croatia and Serbia. The Mine Action Centres from these countries initiated regional response aimed to assist the recovery, develop technology, build capacities, develop recommendations and standard operational procedures for future similar cases. CTDT[3] was invited to propose approach and to derive and lead the project [1]. The importance of the project's objectives was recognised by Ministry of Foreign and European Affairs of the Republic of Croatia which decided to significantly support project's realisation. Progress of the project after six months is presented in the paper. In realisation of the project participate mine action centre and Regional Offices of Bosnia and Herzegovina (BHMAC) Faculty of Civil Engineering University of Sarajevo, Bosnia and Herzegovina, Belgian Royal Military Academy (RMA) from Brussels, Geoarheo Ltd. Zagreb, Croatia, Helicopter Squadron of Air Forces Bosnia and Herzegovina. Ministry of Foreign and European Affairs of the Republic of Croatia grants 463.923 Euro for project, which lasts one year, workload is 92 person months (~ 70 persons). While 63127 Euro is not covered the project segments

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foreseen for Croatian Mine Action Centre (CROMAC) and cooperation with the Faculty of Geodesy University of Zagreb are not supported. The very large area is afflicted in Bosnia and Herzegovina by the considered natural catastrophe: 47 km2 of mine fields is directly damaged by 33 groups of landslides, torrents, new potentially suspected hazardous area is very large, even 82 km^2. Total mine hazardous area in Bosnia and Herzegovina was 1195 km2 on 20.01.2015 and 10.8 % of it was changed abruptly in several days in May 2024. There is also more than 100 km of long line of narrow mine fields on right bank of river Sava (border between Bosnia and Herzegovina and Croatia).

Goals and objectives of the project

- Assess the changed situation of the suspected hazardous areas, of the mine fields by the airborne mapping with two remotely piloted aircraft systems (RPAS) for smaller areas with moderate dynamic terrain and with helicopter Gazela for large areas and very changeable terrain, relief and vegetation, Fig.1.

Figure 1. RPAS-1 (RMA), RPAS-2 (Geoarheo), helicopter Gazela (Air Forces of Bosnia and Herzegovina).

- Develop initial models for spatial estimation of changes on the mine fields, on suspected hazardous areas, on new potentially hazardous areas, using airborne images collected by aerial mapping from RPAS and helicopter, Fig.2, Fig. 3.
- Apply initial models, describing destructive impact of the landslides, torrents, flooding on the mine fields, suspected hazardous areas, and assist projects of the marking the new hazardous areas, for the recovery of demining projects (if possible) which stopped due the considered natural disaster.
- Provide several smaller RPAS for Regional Offices and for BHMAC. Educate and train the surveyors of Regional Offices and BHMAC for application of RPAS in mine action.
- Provide multisensor RPAS to CTDT, which can serve in Croatia and in other countries.

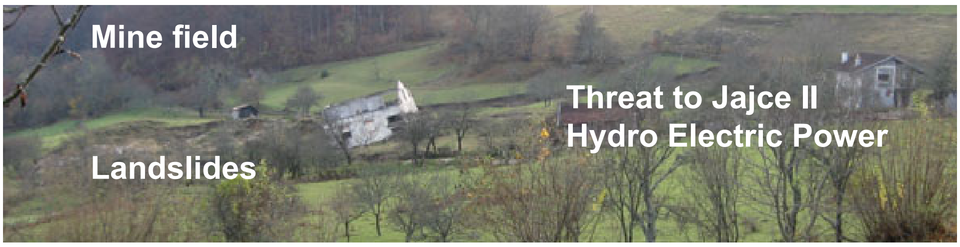

Figure 2. Example of very dangerous landslide, which demolished a village Barevo and threats the Hydro Electric Power Jajce II, Bosnia and Herzegovina.

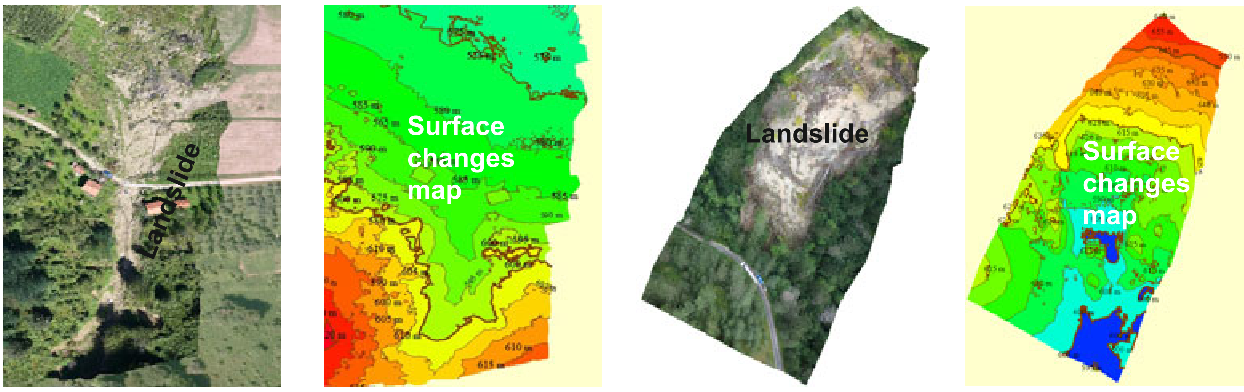

Figure 3. Examples of two landslides and digital surface models showing changes.

- Develop and apply (CTDT) a multisensor system for mapping from helicopter Gazela (Air Forces of Bosnia and Herzegovina), and match the system for application on helicopter Bell-206 (Croatian Air Forces). Provide availability for application in the case of natural disaster and short installation time. Note that in considered floods in May 2014 neither Croatia nor Bosnia and Herzegovina were able to provide airborne mapping of the large afflicted areas.

- Develop, evaluate and verify the recommendations and standard operating procedures (SOP) for behaviour of mine action system in the case of natural disasters, starting from project's results.

- Develop approaches for the advancement of the national mine action strategy for the case of the natural disasters influencing mine action.

- Establish a regional information network in CROMAC, BHMAC and mine action centre of Serbia for mine action during and after the natural disaster.

Project results on 30 March 2015

In 2014 are mapped 82 km^2 of new potentially suspected hazardous areas, more than 40 landslide groups, deposits of flooding, torrents on 47 km^2 of mine fields and suspected hazardous areas exposed to considered phenomena, long line of narrow mine fields on bank of river Sava. The images and data collected by RPAS-1 and RPAS-2 are processed, delivered to BHMAC and its Regional offices and to Faculty of Civil Engineering University of Sarajevo. Application is under way.

The multisensor system of CTDT was matched to the helicopter Gazela in October 2014. The mapping from the helicopter was accomplished 95% of planed area in November 2014. The rest will be mapped when meteorologic conditions become again suitable for mapping.

The processing of images and data collected by helicopter continues. The multisensor system was modified for the needs of FP7 project TIRAMISU [2], where will be used from helicopter Bell-206 of Croatian Air Forces, Fig. 4. The system was tested in flight on 17 March 2015 and is ready for exploitation. Installation on helicopter Bell-206 lasts 1:30 h, while for Gazela it was 2 h.

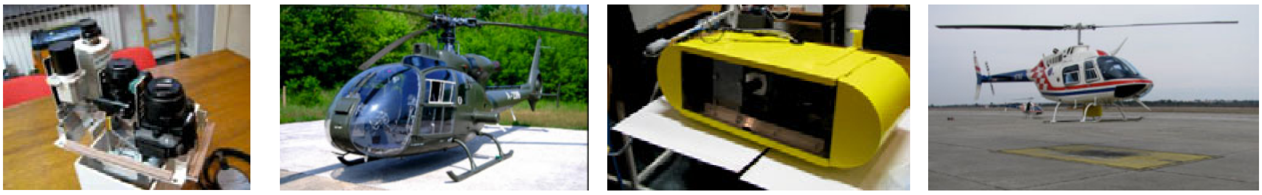

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Figure 4. a) Multisensor system for b) helicopter Gazela. c) Multisensor system in the pod for d) helicopter Bell-206.

Modernization of general survey in mine action by use of remotely piloted aircraft systems (RPAS) has started in Bosnia and Herzegovina and in Croatia. Fourteen surveyors, ten from BHMAC and its Regional offices, two from CROMAC and two from NPA Bosnia have completed a specialistic workshop training on application of remotely piloted aircraft systems (RPAS) in mine action (MA). The training was conducted 18-27 February 2015 in Vogosca, Bosnia and Herzegovina, as part of the project Mine Action after the Floods – Regional Synergy in Emergency Response, Technology Development and Capacity Building, [1], funded by the Croatian Ministry of Foreign and European Affairs. The training was prepared and conducted by Milan Bajić, PhD (CTDT), training on RPAS and the simulators was conducted by Haris Balta, Ir. MSc, from the Royal Military Academy (RMA) in Brussels.

Each participant had own selection of training area, a part of typical mine field with interesting problems. For this own case was conducted application of new methods presented at workshop: a) Analytical assessment for the process of collecting additional data [6]. b) Derivation of general and specific requirements for the airborne survey for own case area. c) Use of of software Global Mapper, ThermaCam Researcher, Panorama Maker, ImageJ, MapInfo. d) Application of programs for calculation of the area coverage with images for selected sensor parameters, altitude, velocity of flight, overlapping in flight direction. e) Calculating probability of airborne survey tasks (detection, classification, recognition, and identification). f) Operational ground resolving distance of system assessed by analysis of test bars. g) Analysis of long wave infrared (thermal) images. h) Geocoding of the airborne photography onto digital orthophoto map M 1:1000. i) Use of stereoscop for analysis of overlapped images. j) Hazardous risk analysis when use RPAS for mine action tasks. k) Mitigation of hazardous risk. The on the job training was conducted with small RPAS Phantom 2 and flight simulator, leaded by Mr. Haris Balta Mag. Eng. (RMA). Each participant had two flights by Phantom 2 and more than hour of training on the simulator.

Application of small RPAS in Mine Action

The presence of experienced mine action surveyors and their reactions when they were exposed to new technology produced a creative although realistic critical environment in which was possible to predict the application of small RPAS in mine action. Six surveyors participated in RPAS missions earlier in 2014 and they gained experience in very demanding conditions. The outcome of common work during the workshop is the variety of applications of small RPAS in mine action, which were identified in following groups.

a. Identify on images collected by RPAS, the objects mentioned in the mine field records. Identify the reference points of the mine field record. This is particularly important in regions with difficult (impossible) access.

b. Find and identify the investigating paths' for the Land Release missions. Checking the selected investigating paths'.
c. Reconnaissance by RPAS in the case of accidents or incidents in mine fields, suspected hazardous areas.
d. Identification of the separation lines.
e. Correcting the mine suspected area.
f. Quality Control (QC) of clearing process at working area.
g. Quality Control (QC) of project documentation by comparing with current status of the considered area.
h. Acquisition of images showing current situation in comparison to data known from former digital ortho photo maps (relief, Land Cover, Land Use).
i. Survey with RPAS of the mine fields, suspected hazardous areas which were damaged with natural disaster (landslides, torrents, deposits of floodings and torrents).
j. Use of small RPAS for quick survey of the marking tables.
k. Survey with small RPAS of the mine fields after the open space fires, detection of the location where exploded landmines or UXO.
l. Detecting of cluster ammunition bomblets by use of RPAS with longwave infrared sensors.

Conclusions

1. Project realised planned activities for first six months and started building of capacities from the second half of its duration.

2. The spin-off of the project is the training in a form of workshop for fourteen experienced mine action surveyors for deployment of small RPAS in mine action processes. The additional outcome of this workshop is a list of critically identified mine action functions where reconnaissance with small RPAS can provide significant benefits.

3. CTDT should continue building capacity for Regional offices in Bosnia and Herzegovina by providing small RPAS, simulators and stereoscops.

Acknowledgements

Croatian Ministry of Foreign and European Affairs recognized the contribution of the project to mine action cooperation in disaster/emergency response, technology development and capacity building and granted its realization. The mine action centers of Bosnia and Herzegovina, Croatia and Serbia supported project concept and its realization. Especially cordial acknowledgments to Regional offices and Mine Action Centre in Bosnia and Herzegovina, to many persons from this system who contributed and who participate in project realization, to pilots of Air Forces of Bosnia and Herzegovina.

The cooperation of partners from FP7 project TIRAMISU (RMA, CTDT) facilitated project establishment. The operational validation of RPAS (RMA) from [2] has been done in the frame of [1]. TIRAMISU has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 284747.

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Towards a Counter- Explosive Hazards Centre of Excellence focusing on the implementation of new mature Hardware and software Technologies

Yvan Baudoin[7], *F.Curatella*[8]

FP7 TIRAMISU, D-BOX Projects

1. Introduction

The year 1994 may be considered as the first decisive year in the long struggle with the use and the removal of anti-personnel (AP) mines throughout the world, followed in 1999 with the Entry into force of the OTTAWA Treaty adopted on September 1997, the Convention on the Prohibition of the use, stockpiling, production and transfer of AP-mines and their destruction.
Not all Countries signed the Ottawa Treaty: a political problem and many Countries are still affected by unexploded remnants of War and Conflicts
March 2009 was also the first deadline for completing clearance by the mine affected countries that ratified the Ottawa Convention before March 1999. Unfortunately, two thirds of them have not met this deadline [Ms Agnès Marcaillou, Director of the United Nations Mine Action Service (UNMAS)]
March 2013, new countries have been affected by the plague of disseminated unexploded devices, landmines but also cluster munitions (now directly concerned by the OSLO treaty). New dangers arise in some North African Countries, Middle East, Asian and African Countries, called Improvised Explosive Devices and slowing the difficult tasks of Deminers.
The need for rapid land release for economical purposes (agricultural and grazing, among others), is thus pressing. If a change towards less costly and time-consuming Mine Action practices has always been desirable, **it has now become imperative.**

In 2011, the European Commission confirmed its continued support for achieving a mine-free world by making important financial contributions (to Demining operations AND to R&D in support of such operations). The Commission will continue to consider landmines and explosive remnants of war (ERW) within a broader context of humanitarian assistance as well as long-term and sustainable socio-economic development programs.
The EC recently decided to fund two large projects including about fifty European organizations, NGO, Universities, SME and industrial partners. The RMA coordinates one of both projects, called TIRAMISU, the second one being coordinated by Airbus Defence and Space SAS and called D-BOX.
The TIRAMISU (Figure 1) and D-BOX (Figure 2) projects aim at providing the foundation for a global toolbox that will cover the main Mine Action activities, from the survey of large areas to the actual disposal of explosive hazards, including Mine Risk Education and Training. Obviously, as underlined in the presentation of M. Andy Smith (Fields and R&D synergy) no 'silver bullet solution' has to be expected from the projects, but new technologies (hardware and software) with high potential are ready for experimental validations and implementations in a process that has already started in close cooperation with the CROMAC (Croatia), the BHMAC (Bosnia Herzegovina) and the CMAC (Cambodia).
The system engineering work carried out in D-BOX through the expertise of Airbus Defence and Space, the demining experience of BACTEC, and the contribution of research institutions with expertise in demining, like the Swedish FOI, has generated the idea of an information management

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system of new conception, that glue together Information, best practices & procedures, and detection tools in a unique platform, to give better awareness to the End Users and reduces the possibilities of errors. D-BOX mission is to support End Users in the Land Release Process because this is the core activities of deminers. New tools will be plugged into the platform as soon as they become operational. The outputs of new tools and existing tools will be merged together to improve the quality of information provided to End Users.

Figure 1 Tiramisu Toolbox Content

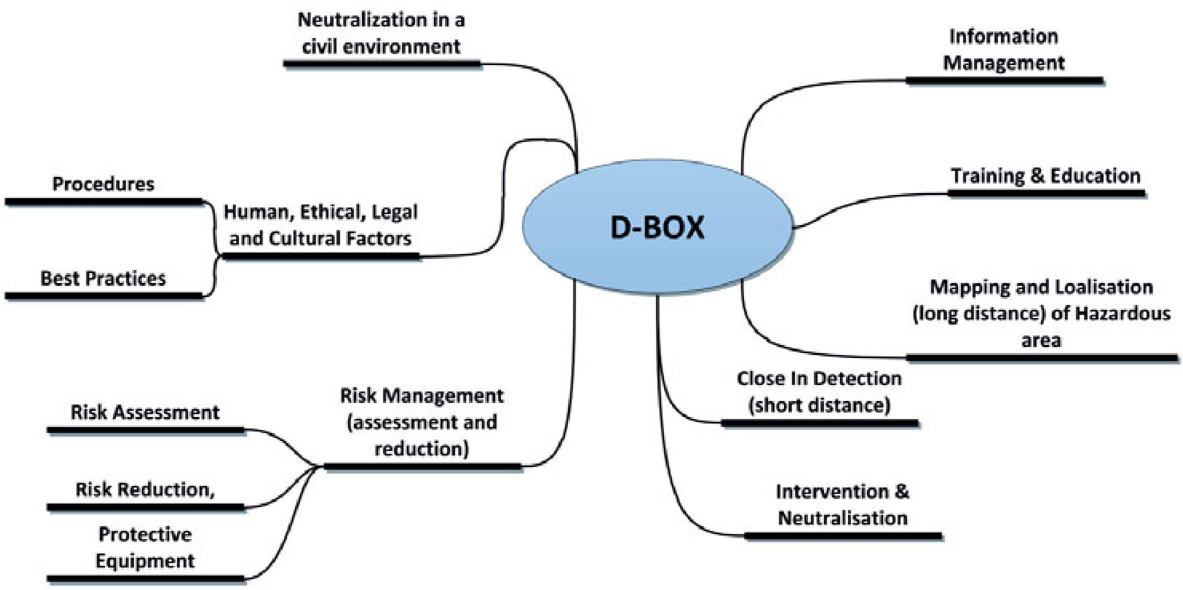

Figure 2.D-BOX Toolbox content

The development of our R&D is also supported by experienced De-mining services, some of them through Military Demining activities (the Swedish army, the Polish Military Engineering Centres), some of them active Members of International Centres of Excellence (the International Centre of Demining supported by the Spanish Ministry of Defence, the NATO-accredited Counter-Improvised Explosive Devices (C-IED) Centre of Excellence, the NATO EOD Centre of Excellence, the European Defence Agency).

Belgium has a long experience in the field: a lot of missions (Figure 3) have been entrusted to the Demining Service of the Belgian Defence. This experience has underlined the increasingly unsafe context of Mine Action in Countries affected by a periodic political, social and/or economic instability. Military Mine-clearing Actions often precede Humanitarian Demining activities entrusted to local entities or experienced Non-Governmental Bodies. Synergies with such Actions have to be improved as well

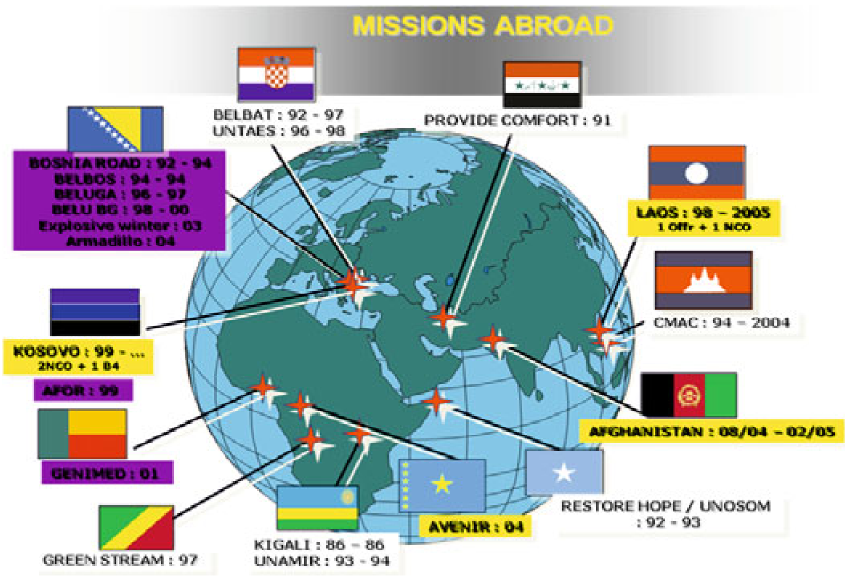

Figure 3. DOVO support in Humanitarian demining

2. Towards a European Counter-Explosive Hazards Centre of Excellence (C-EH CoE)

Our projects may not lead to successful results without the support of experts from the United Nations Services and the continuous cooperation of our consortiums with the Management System for Mine Action developed and maintained by the UNMAS and the GICHD since 1999.
From the GICHD point of view, the problems in HD will not be solved by the new technologies proposed in the FP7 TIRAMISU/D-BOX toolbox: technology is good enough, what is needed is capacity building (training), implementation support and appropriate prioritization. Nevertheless, the GICHD acknowledges the value of using images as an aid for the land release, but believes only low-cost solutions for image gathering should be envisaged.

The need to make a better use of existing tools is correct and understood; new tools and existing tools could be used together for improved efficiency and effectiveness of operations. Several of the solutions proposed in D-BOX and TIRAMISU do not require the user to enter physically in the Hazardous Area (0 risks for human life) and/or they allow scanning a large area in one shot. The real

challenge will be to make the End User to recognize and use the technology in the most safe and proficient way. To achieve this goal the tools shall be integrated in the processes used by End Users.
The Information Management Concept developed in project D-BOX is perhaps an answer to the doubts raised by the GICHD. D-BOX Platform reproduces the main activities of the Land Release process; Functional Tool Chains (including existing and new tools) are linked to the process tasks to realize the different activities, possibly with an increased effectiveness. The platform provides the means to transform raw data from the tools into information useful for the End Users.

GICHD: 'The data collection phase is directly included in Non-Technical Survey so that LIS (Land Impact survey) is removed from the demining process cycle'.

Advanced General Survey, based on Satellite Imagery at Country/Regional level must take into account the Sensor technology evolution (higher accuracy) and allow for the importance of community knowledge and the local perception of the social and economic impact of mined areas within their livelihood when planning mine clearance actions. To achieve this the EU projects therefore combine the former (but renewed) Impact Survey with the Non-Technical survey (from aerial manned or unmanned flights at local level) to derive efficient tools focusing on(i) the collection of quality data, (ii) the accurate geo-referencing of information and (iii) the use of analytical tools and methods for priority setting through the software development of interactive tools starting from expert, geospatial and contextual information and their exploitation to an Advanced Intelligent Decision support System optimizing the delineation of Suspected Hazardous Areas (SHA): tools that have been tested in close cooperation with End-Users.
The Information Management Concept developed in project D-BOX goes a long way towards answering the doubts raised by the GICHD. D-BOX Information Management reproduces the main activities of the Land Release process and implements Functional Tool Chains: the data provided by tools are elaborated, evaluated and merged with data provided by other tools to improve End User situational awareness.
The GICHD members were shocked to learn that the EU funded projects' efforts are focused mainly on the technological side, while from their point of view they should be on implementation.
Such implementation however requires technological R&D as well as study of the ethical and legal issues related to, for instance, unmanned flights. The GICHD has a global point of view: concerned by cost efficiency and by versatile applicability, so its focus is of course different from a research project funded by FP7. Moreover, the EU objectives are different from the objectives of the Centre. Referring to the Call for Security, TIRAMISU and D-BOX have to promote new technologies, ensuring dual use applications related to the whole program SECURITY of the Commission.
As a consequence, and taking the objectives of the European Union into account, it has been proposed to create a Centre of Excellence focusing on the exploitation of the toolboxes developed by the 50 partners of the FP7 Consortia, in close cooperation with existing Centres such as the GICHD, but also the NATO EOD Centre of Excellence, the NATO accredited C-IED Centre of Excellence, the International Centre of Demining located in Madrid, the International Centre of Humanitarian demining launched by Russia, the European Corporate of security Associations (ECSA), avoiding useless duplication and pursuing the HORIZON European objectives.
The CoE HUDEM will differ from other R&D resources by retaining the degree of honest scientific objectivity required in an academic institution and by pursuing practical and effective end-results without being subject to undue commercial influence. To promote the pursuit of rapid solutions that are not delayed by misinformation, constructive criticism and common-sense honesty will be required features in all reports.

3.

The following structure (Figure 4) will progressively be achieved by the end of the year, including four Technical Advisory Boards focusing on:

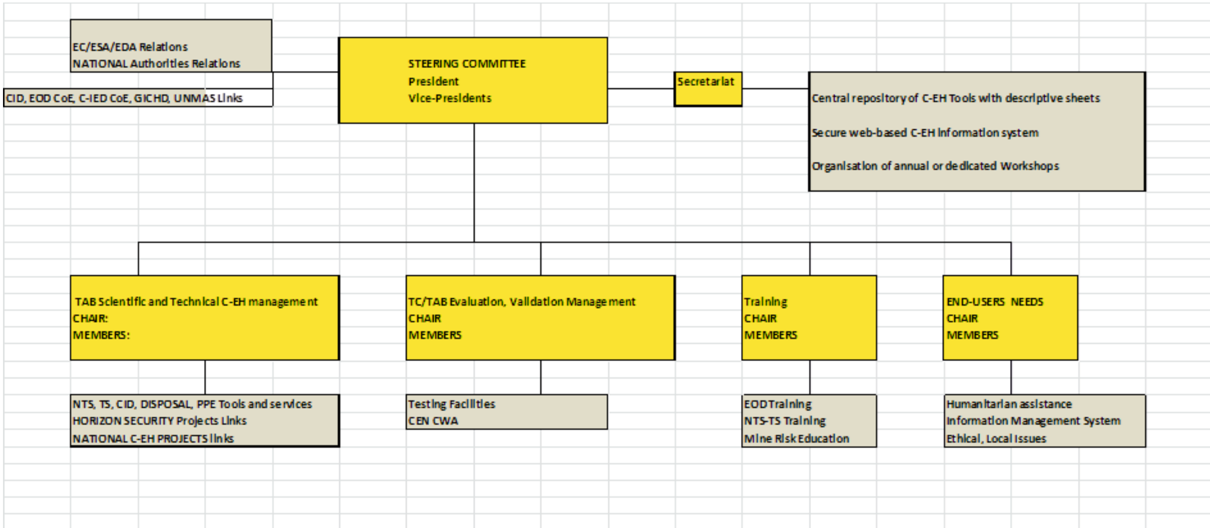

Figure 4. Intended C-EH-CoE Structure

3.1 R&D

It’s essential to improve new technologies through a continuous exchange of R&D information and results among the scientific Community and through an adequate policy of Technology Transfer. The handover of all Mine Action activities to local entities who can perform the majority of the work and can gain skills while participating to the creation and maintenance of **new technology** for area reduction is desirable and necessary.
The following R&D areas, among others, have been identified as impacting the fast release of suspected areas:

– **Sensors**: Chemical sensors, Metal detector arrays, GPR arrays, in particular, could improve the efficiency of technical Survey and Quality Assurance. In TIRAMISU, such sensors have been mounted on remote controlled platforms (unmanned EOD-like ground vehicles figure 5) – agricultural machines (figure 6).

Figure 5. TeODOR – VALLON Metal Detector Array

Figure 6. LOCOSTRA V2- LUCIFER GPR Array

- **Remote Sensing** : **RPAS** (Remotely Piloted Aircraft Systems) can also carry sensors and provide information used in Non-Technical and Technical Survey. Hyperspectral Sensing has provided essential data on Croatian infested areas, while the use of a classical camera combined with a Near-Infrared Sensor considerably helped the BH MAC in a country heavily affected by the floods destabilizing Mine action activities in 2014 (figure 7)

Figure 7. Detection of mines and UXOs after heavy floodsin Bosnia Herzegovina (2014)

- **Disposal and Personnel Protective Equipment**. In TIRAMISU, a novel technique for testing protective materials against fragment impacts was presented. Three projectile impacts within close space and time proximity were incorporated in order to simulate the effects of multiple fragment impacts on protective structures. A roller and and a transport trailer together with blast container vessel have been designed and tested, that could equip resistant platforms such as the LOCOSTRA V2;

The sharing of Expertise through dedicated Scientific Workshops and bi(multi) lateral work-meetings, in close cooperation with the above mentioned Centers will promote the implementation of such tools and their dual use, in particular in the current context of 'Terroristic threats' in Europe (European Program HORIZON focusing on the Security: the IED and Counter IED techniques are particularly developed by the NATO C-IED Center of Excellence and could lead to R&D cooperation in the domains of Terahertz technology, C-RCIED, Radars based on SAR principles, Multispectral spectroscopy, Bio-inspired sensors, etc.)

3.2 Evaluation, validation, certification (CWA)

The Centre would involve a dedicated area of permanent lab-space for baseline testing of performance – detection in air, detection "halo", battery life, signal clarity, reliable replication of results, etc. As far as possible, this would lead to a series of quantifiable, comparable and replicable results that manufacturers could not reasonably question. A full test would also involve field testing in dedicated test areas (Support of the CID in Spain and the CTRO Test Facilities in Croatia) leading to results that were semi-quantitative but still meaningful because the test context was the same for each test

(although weather variations, etc. would be noted). The field test would include a subjective assessment of ergonomics and ease of use for lengthy periods. The field results would not guarantee that the equipment would be suitable in the field in every country – but poor results would strongly imply that poor results might be expected elsewhere, which would be very useful to know when selecting equipment [2]
The Centre could thus re-initiate some activities of the former ITEP (International Test and Evaluation Program).

Between 2003 and 2008 several CEN Workshop Agreement were published and made available free-of-charge by CEN:

- CWA 14747 (2003):Testing Metal Detectors
- CWA 15044 (2004):Testing Demining Machines
- CWA 15464 (2005): Planning and Assessing EOD Competencies
- CWA 15832 (2008): Follow-on after Demining Machines
- CWA 15833 (2008): Quality management for mechanical demining
- CWA 15756 (2007):Testing PPE was initially published but was later withdrawn because some tests described in it were found out to be too demanding.

Four CWA were proposed by the Consortiums: (1) on 'PPE' (*The new CWA would* specify "*methods for the testing, evaluation, and acceptance of PPE for mine action against anti-personnel blast mines – this CWA is supported by the GICHD but complementary information has been requested by the CEN due to existing PPE standards in the context of dual Use of protective equipment (Fire-fighters, Police, etc.)*, (2) on ' better evaluation of mechanical assets for technical survey' (This CWA was not supported by the GICHD (IMAS Review Board) but fully supported by the CEN/BT – The GICHD supporting a TNMA[1]), (3) on 'ethical use of remotely piloted aircraft systems – also known as unmanned aerial vehicle (UAV) or miniature aerial photography plane (MAPP). This CWA was not supported by the GICHD (IMAS Review Board), but could become important in a near future because of privacy implications in RPAS operations as underlined by G.Voisin in [REF 3]: data protection where RPAS capture personal data, CCTV regulations where domestic law would regards video captured by RPAS as equivalent to CCTV, ad-hoc legislation regulating the use of specific instruments embedded in RPAS. (4) on Ethical Issues in humanitarian demining (D-BOX)

3.3 Training, Mine Risk education

During the project, E-tutors have been developed, currently evaluated by our Project advisory Boards, among which

- A E-tutor for Non-Technical Survey
- E-training tools for neutralization and clearance
- E-tutor for selection of protective equipment

With the progress of developments in information and communication technology, e-learning is emerging as a platform for modern education and training. E-learning is a general term referring to the use of digital technologies to support learning and teaching [4]. The Joint Information Systems Committee (JISC) defines e-learning as "learning facilitated and supported through the use of ICT".

E-tutoring can be defined as teaching, supporting, managing and assessing students on programs of study that involve the significant use of online technologies. An e-tutor is the interface between the learner and the learning resources.
The main advantages of e-learning are the following:

- E-learning is more cost-effective for the learner than traditional teaching methods because less time and money is spent travelling and the trainees have are able to study anywhere and at any time.
- E-learning is flexible and can be customized to meet the individual needs of the learner.
- E-learning enables money and time to be saved as traditional courses require more administration, preparation and organization.
- E-learning means that learners can work at their own pace and allows flexible training hours.
- The contents of an e-tutor can be continuously (and economically) upgraded and updated.
- The efficiency of the e-learning method is well-documented.
- E-learning provides a consistent message and eliminates the problems associated with different instructors teaching slightly different material on the same subject.
- There is evidence that e-learning methods can lead to increased retention, since many elements are combined to reinforce educational messages, such as video, audio, simulations, quizzes, interaction.
- E-learning enables learners to revisit or replay sections of the training course that might not have been clear the first time around.

As the e-tutor can be CD-ROM-based, it can also be delivered in some of the less developed countries that lack ICT infrastructure or have limited internet access. The very varied educational background of trainees around the world makes e-learning fairer and more inclusive than traditional classroom courses because well designed e-learning elements level the playing field by allowing trainees to start where they are, work at their own pace, and repeat the course elements as often as necessary.

In the last two years, CTDT (Croatian Partner of TIRAMISU) received about 35 requests for EOD Training I-V Level courses from several Countries in Europe, Asia and Africa, that also justify the development and validation of a EOD e-Tutor

Mine Risk education tools have also been developed and tested (TIRAMISU, in Cambodia and Western Sahara, among others) that could be added to the GICHD Risk education topics. We suggest improving such tools specifically for use in the Refugees Camps where a new need has arisen because of unstable and worrying situations in North Africa and the Middle East, and long term needs exist in places such as Myanmar/Thailand.

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

3.4 End-Users Needs, Information Management Systems

One of the most important characteristics of both projects lies in the development and validation of efficient Information Management Systems that allow a comprehensive use of the developed Mine

Action Tools. The figures 8 and 9 summarize these systems (introduced in other presentations of the 12th International Conference of BIOGRAD).
We are convinced that synergies have to be realized within a partnership of the Centers focusing on the Counter Explosive Hazards Actions, and that links could be improved between our Systems and Security challenges of the European Union (Surveillance of Borders, CBRN-E threats, Environmental Protection, etc.)

IMSMA provides a lot of domain knowledge, but the tool is obsolete with respect to the most recent web developments. IMSMA surely does not address the needs below and it is time to move on.

Information management should address two important needs of HD: the need to create and improve procedures, the need to provide the best information to all the chain of stakeholders of the domain, up to the United Nations and donors. One of the difficulties of the domain is to gather information from the field of operations and manage the quality of this information all along the decision chain.
Furthermore, conflicts that have generated the use of Anti-personnel mines, Sub-munitions and several kinds of explosive devices in the Countries affected by these plagues have dramatic consequences on the environment, and consequently on the health of the local population. Therefore it is important to ensure that the accumulation of explosive contaminants does not occur at levels that will result in adverse effects to the environment and the loss of the use of the range. In order to control these risks, it is important to know what kind of residues are released from different types of munitions and explosive devices, how the residues behave in the environment, and how they are distributed throughout the environment. This information will assist in calculating the environmental loads of constituents resulting from live-fire interventions.

In TIRAMISU, the spectral behavior of grass, and grassy types of the vegetation, the hyperspectral techniques for estimating grassland bio-physical variables have been analyzed, providing first satisfying background information that could be refined through continued hyperspectral survey of the grassy vegetation by ground based and airborne systems. As a consequence Humanitarian assistance (Health issues, among others) and Environmental Survey are still to be pursued.

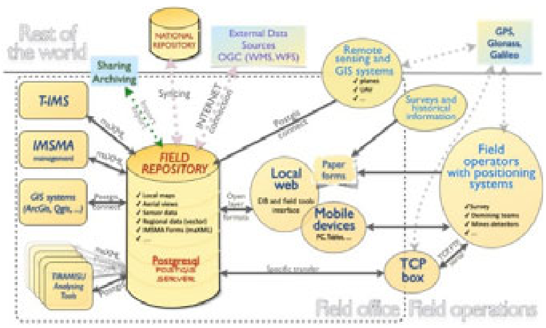

Figure 8. T-IMS and TRS TIRAMISU Management Information System

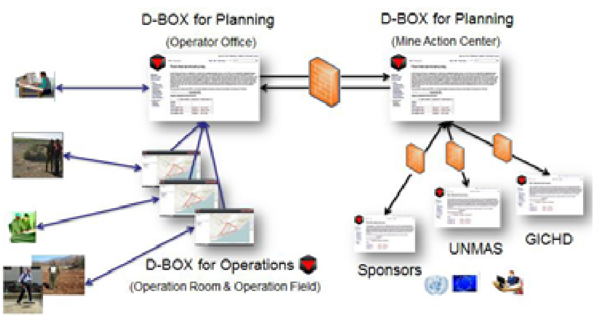

Figure 9.D-BOX Management Information System

4. Conclusions

The 'Humanitarian Demining projects have to reduce the lingering threat of landmines and cluster munitions for the population and would increase humanitarian security, while, at the same time, recreating an environment in which people can live safely, ensuring peace and stability, promoting a

sustainable social and economic development and alleviating human suffering of affected victims and communities.
The handover of all Mine Action activities to local entities who can perform the majority of the work and can gain skills while participating in the creation and maintenance of new technologies for area reduction and all aspects of Land Release is desirable and necessary.
The objective assessment and certification of tools remains a necessity, including a transparent record of their limitations as well as their strengths.
The development and validation of innovative technologies ensuring an optimal interoperability through Training related to the new technologies should replace the classical training courses with more accessible and appropriate training.
Also, taking full account of the opinions expressed by the GICHD which the project partners have assumed as a challenge, our efforts are now concentrating on selecting the most promising assets proposed in the two projects and then bringing them into use during operations.

5. REF:

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Human security perspective and mine action

Damjan Bergant[9]

ITF Enhancing Human Security (ITF) is a humanitarian, non-profit organization established by the Government of the Republic of Slovenia in March 1998 with the initial purpose to help Bosnia and Herzegovina in the implementation of the peace agreement and to provide assistance and support in post-conflict rehabilitation. Since its inception, ITF has been continuously developing and enhancing its mission, thus expanding the scope of its activities and geographic area of their implementation in order to address the problems of ever changing human security environment, the needs of beneficiary countries and the priorities of donor community. Altogether ITF has so far managed the clearance of over 129 million square meters of land, facilitated the treatment of more than 1,230 mine/ERW survivors and supported the development of national and local rehabilitation capacities in 12 mine-affected countries. None of this would have been possible without the generous assistance of ITF donors: 29 countries, European Union, UN agencies and numerous other public and private donors that have thus far altogether allocated more than 384 million US dollars for ITF activities.

The 2015–2020 ITF strategy has been introduced to recognize and implement the unique advantages, capabilities and experience of ITF across the spectrum of post-conflict recovery (including but not limited to humanitarian mine action and conventional weapons destruction (CWD)) such as: transparent and cost-efficient management and accounting, professionalism and integrity, coordination and collaboration of different stakeholders with focus on capacity building, strengthening of national ownership and regional cooperation, exchange of knowledge and best-practices, and quality procurement system. Donors' demand for better development outcomes of humanitarian mine action and the constant changing security environment inspire ITF to use and apply mine action methods, approaches and lessons learned to a broader set of activities, integrating mine action into a broader development and human security framework.

Humanitarian mine action and other forms of post-conflict assistance are proven contributors to human security and development. However, there is opportunity for translating the close relationship between such assistance and reconstruction, as well as development efforts into more concrete inter-linked approaches and programmes, broadening the areas of intervention. There is room for more and better all-encompassing coordination and collaboration between not only humanitarian mine action and CWD stakeholders, but also with other relevant developmental governmental and civil society actors. This approach increases efficiency, effectiveness and most importantly leaves a positive impact on conflict affected communities and thus enhances safety, socio-economic development and community empowerment, further ensuring that their right to a peaceful and dignified life is met. The human security approach is about changing the traditional, more technical, funnel-like mode of assistance thinking. It is about further mainstreaming of mine action and CWD issues into broader humanitarian, development and human rights issues, thus linking the holistic approach in mine action and CWD more effectively with development initiatives.

The human security approach creates a framework that mirrors the complexity of humanitarian and development interventions, and the crosscutting linkages and challenges encountered on the way

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to reaching the goal of mine/ERW impact free or CWD-completed country. It is a reminder of the impact of the war legacy on people and enables ITF to focus on efforts to not only save lives and limbs, but to build resilience and empower conflict affected communities. By applying a people-centered perspective as the central pillar of human security it becomes self-evident that humanitarian mine action and CWD is not just about clearance of ERW, risk awareness, or of stockpile destruction. Rather, the impact of mines/ERW and deteriorating and illicit munitions touches upon all faces of human security – health, personal security, livelihood, peace and the environment. Thus, the ITF will extend its scope of work beyond clearance and CWD, and will address the development phase of communities that have emerged from war.

Humanitarian mine action and CWD are about human security and restoring to human dignity. These two disciplines should not be limited to immediate relief, but should also address reconstruction and development. They both pave the way to peace and stability, make conflict affected communities safer, and set the stage for post-conflict recovery and development. However, long-term impacts of mines/ERW and other explosive hazards on people and communities remain even after they are removed. Therefore, ITF identifies **two main pillars** of its work, which will better support the efforts in building community resilience, addressing immediate and long-term impact of mine/ERW, risk arms and ammunition in conflict affected communities.

The following Strategic Pillars support a vision of future development of mine/ERW and conflict impacted communities and countries:

Strategic Pillar I
Reducing threats from mines, explosive remnants of war and other at-risk weapons and ammunition.

Strategic Pillar II
Facilitating safe, long-term development and building resilience of conflict-affected communities.

ITF will execute projects and activities within mentioned pillars through bellow mentioned intervention areas:

- **Clearance of landmines and ERW, including cluster munitions**.
- **Risk Education** enhancing safety of at-risk communities, thereby reducing the risk of injury and death.
- **Victim assistance** in support of socio-economic reintegration, health and psychosocial well being of ERW victims.
- **Capacity building**
- **Physical security and stockpile management** (PSSM) involving safe and secure storage of weapons and ammunition, and provision of professional training on best approaches and proper procedures to be applied for the effective management of stockpiles.
- **Destruction of surplus weapons and ammunition.** Destruction is a process of safe and final conversion of weapons and ammunition into an inert state, in which they can no longer function as designed.
- **Emergency response upon unplanned explosions** at munitions sites (UEMS).
- **Coordination, collaboration and mobilization of resources** in support of humanitarian mine action and CWD development for increased quality, cost efficiency and impact on conflict-affected communities. Focus will be placed on facilitating and promoting better coordination

and collaboration of not only mine action and CWD stakeholders, but also other relevant developmental governmental and civil society actors.

- **Advocacy work** generating publicity and raising awareness concerning mine/ERW impact, the dangers posed by surplus and deteriorating stockpiles of excess and aging munitions, and promoting rights of persons with disabilities.
- **Fundraising and donor matching mechanism** in which specific donors provide matching funds for the funds provided by other donors for selected projects of interest.

ITF will continue with its primary long-established focus in South East Europe, while further developing and expanding its programmes in Central Asia, South Caucasus, North Africa, and broader Middle East.

In its future work ITF will pay special attention on bellow mentioned **cross – cutting issues**:

Tendering procedure. Improving the transparency and cost-effectiveness of humanitarian mine action, CWD, and other areas of intervention by using ITF`s well established tender and procurement procedures.

Gender equality. ITF reaffirms its commitment to the equal participation and full involvement of women at all organizational levels and in all efforts promoting peace and security.
Respecting diversity. ITF values cultural, ethnic, racial, sexual, age, disability and religious diversity, and promotes the development of respectful relationships across these lines. ITF is dedicated to developing human rights-based, gender-responsive, and culturally sensitive programmes.

ITF will fulfil its mission of promoting enhanced human security in countries affected by landmines/ Explosive Remnants of War and other impacts from conflicts by following bellow mentioned **guiding principles**:

(1) Regional approach. Encouraging regional cooperation is an important confidence building measure, particularly in neighboring and nearby countries. A key element of ITF`s success in SEE has been its facilitation of a regional approach in mine action, as well as facilitation of and participation in the SEE Regional Approach to Stockpile Reduction (RASR) initiative.
(2) Partnerships. ITF shall continue to conduct its work in close partnership with donors, international organizations, national and local authorities, and public and private implementing organizations.
(3) National Ownership. ITF recognizes that the primary responsibility for addressing post-conflict challenges lies with the national authorities of an affected state.
(4) Humanitarian Focus. Post-conflict challenges are foremost a humanitarian concern and should be addressed from the humanitarian perspective. The humanitarian focus on mine action and CWD promoted and implemented by ITF is to save lives, prevent physical injuries, alleviate suffering, provide support to people in need, and thus enable the most vulnerable to preserve human dignity. In this view, the selection of the national programmes and local communities-oriented projects should reflect the fundamental humanitarian principles of neutrality, impartiality and humanity.
(5) Transparency. ITF is dedicated to full transparency of its work in SE Europe and other countries around the world. Such transparency as well as full accountability builds confidence that donor funds are being used effectively and as intended. ITF achieves transparency through its organizational procedures, strict adherence to proper accounting, and professional attitude of its staff.

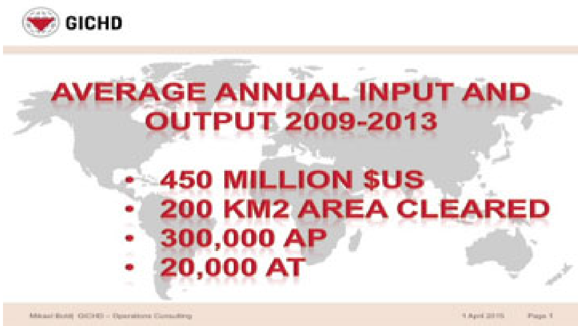
As conclusion, ITF will continue its mission of enhancing safety as well as to enable the recovery and development of conflict affected countries by addressing the immediate and long-term impact of mine/ERW and other hazards following armed violence. A human security approach is applied to all of the ITF's interventions as it provides a dynamic and practical policy framework for addressing widespread and cross-cutting threats. This human security approach supports the linkages between HMA and surplus arms reduction, as well as the nexus between security and development. It also upholds the development of essential preconditions, capabilities and capacities that pave the way to comprehensive development, and facilitate full national ownership and accountability in conflict affected countries.

Information Management and Technology Development in Mine Action

Mikael Bold[10]

There is an emergent consensus that an excessive use of clearance resources in areas that may not contain landmines and/or ERW represents an error in miscalculation rather than justifiable prudence. Nonetheless, in many countries contaminated areas consist of unpredictable patterns of hazards. Recently, more countries have been shifting towards ending large scale mine action operations, where a high proportion of remaining sites have a lower probability of containing hazards. To address such challenges, the mine action sector requires enhanced allocation of clearance resources and in particular improved technical survey techniques and methods for land release.

Global data collected by Landmine Monitor indicates, since the introduction of Land Release in 2009, that nothing has changed. From a country perspective we know that this may not actually be correct, at least for some countries. However, the overall statistics suggests that there is a massive gap between operations and information management. From an information management perspective operations should dictate the requirements, while information management shall reflect the reality and the activities undertaken. Blaming information management and/ or IMSMA only reflects poor operational management.



At least 450 million $US are spent annually and yet we have not a clear picture on what is remaining to achieve our conventional obligations.

What is the way forward to overcome these challenges? Our first conclusion is to invest time and money to bridge the gap between operations and information management. This does not necessarily have to be a very time consuming or expensive exercise.

Secondly, we need to invest in existing and up-to-date technology, allowing a one-time input of data and enabling decision makers to monitor agreed indicators in real time.

Finally, more efforts should be invested in technical survey to establish direct evidence of explosive hazards. New efficient survey approaches and new equipment should be looked at to reduce time spent in areas that don't contain a hazard. Are we interacting enough with our manufactures? Have we gathered enough evidence to promote innovation of new equipment? These are important questions to address one of the main challenges in survey and clearance – **FALSE INDICATIONS**.

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Libya Battle Area Clearance

INTRODUCTION

Muammar Gaddafi was in power until the Libyan Revolution of 2011 overthrew his regime. Protests in Benghazi on 15 February 2011 led to clashes with security forces and ultimately escalated into an armed conflict. The United Nations Security Council authorized the use of force in U.N. Security Council Resolution 1973. The subsequent intervention by NATO and some Arab states ensured the fall of Gaddafi. Since then, Libya has experienced instability and political violence which has severely affected both commerce and oil production.

Libya is governed by two rival governments since August 2014, one in Tripoli and one in Tobruk. The Council of Deputies elected in the June 2014 elections was declared unconstitutional by the Libyan Supreme Court in November 2014, but it rejected the ruling and has continued to claim legitimacy. However, its control of the country is severely limited by the current civil war against an Islamist rival government, which has controlled Tripoli since August 2014. The rival government presents itself as a legal continuation of the General National Congress, which was elected in July 2012 and was set to dissolve following the June 2014 elections, but reconvened after Islamists rejected the results. This new General National Congress meets in Tripoli, while the Council of Deputies meets in Tobruk. The Tobruk government is generally recognized internationally as Libya's legitimate authority.

MECHEM OPERATIONS

MECHEM was awarded a UN contract for the provision of a rapid response (BAC and EOD) capacity to support humanitarian operations in Libya. The contract was awarded and mobilisation was during May 2012. Operations were executed during the period May 2012 to end of June 2014.

BAC and EOD teams were deployed in Libya and huge amount of UXO and redundant ammunition were either destroyed or packed and handed over to the Libyan Army.

A combination of well trained and highly skilled international personnel as well as Libyan personnel were deployed in this project.

A presentation will be done to the symposium to show the magnitude of contamination and the current problem in the world after war or an intervention by a third party.

PRESENTER

Johan Coetzee: Chief Technical Advisor MECHEM

UAV Deployment in Survey with Hyperspectral Line Scanner

Tamara Ivelja[11], Milan Bajić[12], Goran Skelac[13]

1. Introduction

Research and development of TIRAMISU Light Hyper Spectral Imaging System (T-LHSIS) represents upgrade of existing Advanced Intelligence Decision Support System (AI DSS) and system for research of hyperspectral non-technical survey (T-HSNTS) tool. Historically, flying platform used for operation of AI DSS were helicopters Mi-8, Bell-206, Gazela, which did not match (yet) specific requirements for the purposes of vegetation research inside and outside the mine-contaminated areas. For T-HSNTS tool also blimp was tested as airborne platform. Main difficulties are consequence of line scanning sensor (Imspector V9) and low throughput od the acquisition computer.

The requirements for any platform that is used for hyperspectral survey with considered line scanner aimed to detect the vegetation spectral difference inside and outside the mine-contaminated areas are:

- flight velocity need to be as low as possible (< 10 m/s) above the area of special interest,
- flight altitudes need to be as low as possible (depending on the size of the observed object),
- roll and pitch shall be as small as possible,
- vibration should be minimal (to decrease blurring of collected data),
- controllability of platforms and possibility of navigating during a flight, respectively GPS tracking during the flight (flying according to the given routes and controlling the coverage area with images).

The airborne hyper spectral imaging scanners have limited throughput rate of raw data, which shall to be matched with the speed of the airborne platform otherwise appear losses in the flight direction. The flight altitudes need to be as low as possible so the desired spatial resolution could be achievable. The another difficulty with push broom spectral imaging is degrading influence of the aerial platform movements (roll, pitch, yaw) and vibrations on images geometry.

The main constrains that appear when considering the candidate airborne solution are: payload, endurance, roll, pitch, yaw, vibration, legal limitations.

By analyzing these requirements and available platforms, multi rotor unmanned aircraf system has been chosen as the most acceptable platform.

In order to deploy this kind of platforms, system (Figure 1.) was modified to be lightweight, romotelly contorolable and to operate on battery power supply (LiPo >2200 mAh).

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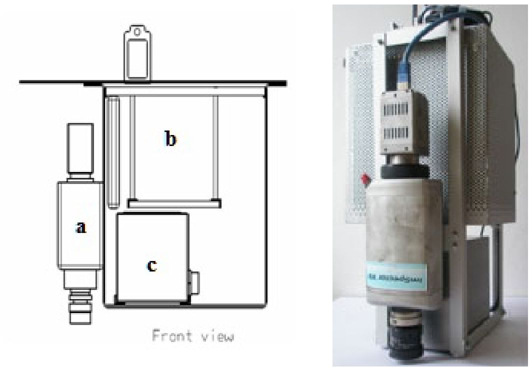


Figure 2. **Left** - Technical drawings of the structure of T-LHSIS; a) hyperspectral linear scanner (ImSpector V9, collects information in the visible and infrared part of the spectrum, 0.43 – 0.9 µm), b) PC, c) navigation devices (inertial measurement unit (IMU) - iMAR, GPS devices), **Right** - Photo of the T- LHSIS construction

2. Tested platforms

In 2014. with two unmanned aerial platforms provided by Georheo Ltd. [1.] (Figure 2.) were tested: UAV X8 MK and UAV 8 ZERO. UAV X8 MK was tested on several occasions at several locations in Zagreb, while UAV 8 ZERO was tested in the minefields Benkovac and Lički Ribnik.

Figure 3. Tested platforms. **Left** - UAV X8 MK, **Right** - UAV 8 ZERO (Geoarheo).

After testing operability of T-LHSIS on smaller UAV X8 MK in relation to given requirements this platform was discarded due to borderline payload (4560 g) and UAV's strougle to mantain stability. By analyzing the data collected during testing important experience was gained and it was found that most of the declared favorable flight parameters can be achievable:

- Low flight altitude (less than 30 m) and low flight velocity (about 2 m/s) are achievable. Velocity value varies from 1.155 m/s to 3.8 m/s.
- Vibrations didn't affect images quality,
- Flight routes should be prepared in advance bearing in mind several things: The length of flight segments shall be longer than 30 m, the mass of UAV and its payload shall have enough time to return to stable state after the shocks due to returns (prepare at least 10 m - 20 m long part of the route for the stabilization of the UAV before recording and 10 m - 20 m to exit the route),

- Although the ranges of roll and pitch values are acceptable; (span of roll varies from 2.8° to 4.5°, span of pitch varies from 1.2° to 2°) the consequence of the inclination around the longitudinal axis (roll) and around the transverse axis (pitch) has the great effect of winding of the recorded strip due to low flight altitude (30m). Based on the test results it follows that the deviation of the boundary line of the recorded stip from straight lines is 7.13% of 30 m altitude, which is too much. Higher altitude sould be used for recording in next survey.

2.1 UAV 8 ZERO

After the experiences gained during the testing of the UAV X8 MK requirements for UAV 8 ZERO were as folows:
- flight altitude from 60 m up to 300 m,
- flight range (radius) about 500 m,
- low flight velocity (about 2 m/s),
- insignificant swinging and vibrations.

Main restrictions of this particular UAV (before testing) were:
- short duration of the flight (battery capacity about 480 s).

First flight tests of a UAV 8 ZERO were conducted over test minefiled Benkovac in order to verify declared flight parameters, to establish operational ones and to establish UAV 8 ZERO's recording duration regarding T-LHSIS sensor's parameters and declared requirements.
Based on test results Geoarheo defined following operational velocities:
- Ascending velocity = 2 m/s,
- Descending velocity = 0,5 m/s,
- Maximal velocity = 5 m/s,
- Minimal "stable" velocity (recording velocity) = 3,6 m/s.

It is evident that short UAV 8 ZERO's duration of flight due to available battery capacity (480 s, 360 s) is very limiting for T-LHSIS (Table 2.). For example 300 m long strip could be recorded only from approximately 115 m to 60 m altitude). After conducted tests declared flight range as well as flight altitude and velocity were not confirmed.

Flight altitude [m]	Max. velocity - for continuous covering [m/s]	GRD* transversely to flight direction [cm]	GRD* in flight direction [cm]	Strip width [m]	Necessary time for ascending [s]	Necessary time for descending [s]	Time left for recording with bat. cap. 480s [s]	Length of recording strip (range) with bat. cap. 480s [m]
170	6,8	4,8	34	56,66	85	340	30	54
160	6,4	4,5	32	53,33	80	320	55	99
150	6,0	4,2	30	50,00	75	300	80	144
140	5,6	4,0	28	46,66	70	280	105	189
130	5,2	3,7	26	43,33	65	260	130	234
120	4,8	3,4	24	40,00	60	240	155	279
110	4,4	3,1	22	36,66	55	220	180	324
100	4,0	2,8	20	33,33	50	200	205	369
90	3,6	2,5	18	30,00	45	180	230	414
80	3,2	2,2	16	26,66	40	160	255	459
70	2,8	2,0	14	23,33	35	140	280	504
60	2,4	1,7	12	20,00	30	120	305	549

Table 1. UAV endurance calculation with operational parameters (*GRD - ground resolving distance)

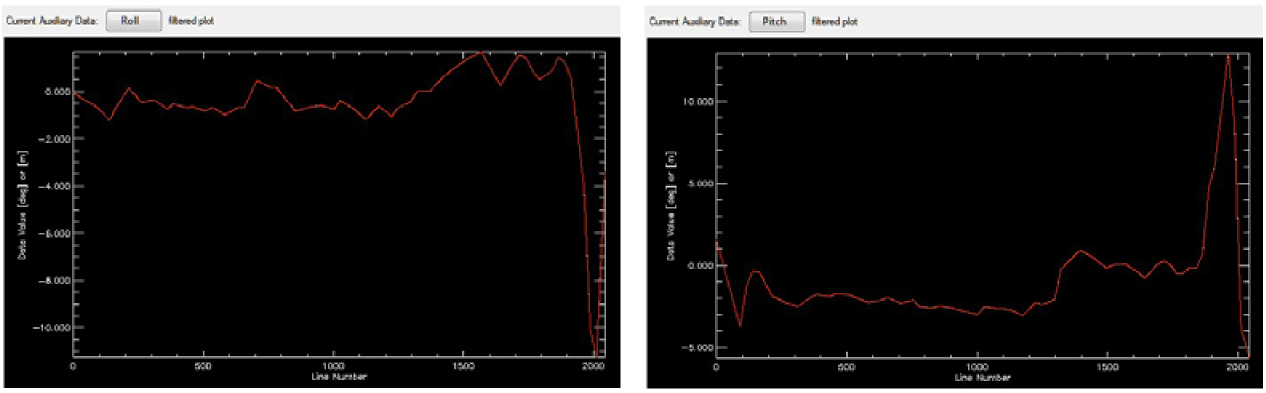
Further technical testing and evaluation has been done over minefield Licki Ribnik with these parameters:

- Flight altitude value around 120 m,
- Recording velocity around 3.6 m/s,
- Flight route length from 70 m to 350 m.

These are the conclusions after data set analysis:

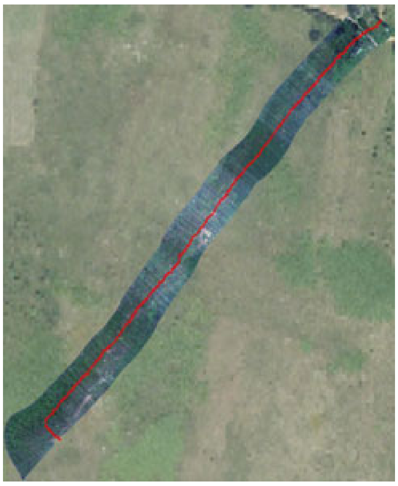
- Ranges of raw roll and pitch values are higher. Range variations of roll value are from 3.3^0 to 5.6^0 and around 6^0 for pitch value (Figure 4.),
- Executed flight route can differ from straight line (route meander) more than 15 m (Figure 5.),

Roll, pitch and especially yaw values significantly changed under operational condition. Reason for this significant change was due to stronger impact of gust of wind on higher velocity.



a b

Figure 4. a) Raw roll value: from - 1.5^0 to 1.8^0 (range 3.3^0). b) Raw pitch value: from 2^0 to -4^0 (range 6^0).



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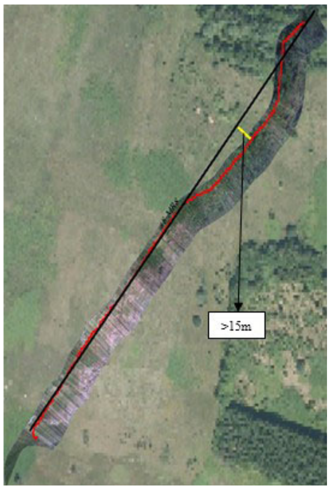

b

Figure 5. a) Example of parametric geocoded hyperspectral cube with corresponding GPS route (red line). b) Parametric geocoded hyperspectral cube with corresponding GPS route (red line) and marked deviation (yellow line) of route from straight line (black line)

The larger roll and pitch values of one processed and analysed sequences were manageable in pre-processing data stage of parametric geocoding procedure. These values did not have strong effect on quality of final result – parametric geocoded hyperspectral cube. Parametricaly geocoded HS sequences did not show significant losses in the flight direction and images were not blurred, but planned trajectory of the UAV was not achieved which caused significant differ of executed rute from straight (planed) route line (Figure 5. b).

3. Conclusion

After analysis it is concluded that the atmospheric conditions (wind gusts) strongly affect UAV's flight. Also, that UAV has strong limitation regarding flight and recording duration, flight velocities and altitudes. This platform has not proved to be particularly reliable for purpose of recording vegetation stress inside and outside the mine-contaminated areas, especially considering its other limitations (necessary visual line of sight, number of satellites).

4. Acknowledgement

These are people who have participated in these activities on a project TIRAMISU: Milan Bajić, Davor Cupar, Tamara Ivelja, Tihomir Kičimbaći, Marko Krajnović, Andrija Krtalić, Ivan Racetin, Goran Skelac. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 284747, project TIRAMISU.

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[1.] Geoarheo, http://www.fininfo.hr/Poduzece/Pregled/geoarheo/Detaljno/42067

Development of prodder for humanitarian demining based on tactile augmentation

A. Iwatani, R. Shoji, J. Ishikawa[14]

Abstract: This paper reports the development of a prodder system based on tactile augmentation. The proposed prodder, which is used to detect landmines by inserting it to the ground, is equipped with an accelerometer to sense vibrations and a piezoelectric actuator to amplify the measured acceleration and to generate tactile sensation to the operator. Preliminary experimental results showed that buried objects including landmine surrogates have their own features in vibrations excited when the prodder is contacting the target around a range from 100 to 400 Hz. Based on the fact, the measured acceleration is amplified laying stress on this frequency range by using two band-pass filters. To evaluate the validity of the proposed method, a classification test was planned based on the L18 orthogonal array, where a landmine surrogate and pieces of wood, stone and aluminum are used as targets to be classified. In the experiment, the operator scratches the target in the air and under the ground by the prodder in the condition that he does not know what the target is, and then he declares what the scratched target is. The experimental results were analyzed by the analysis of variance and evaluated by receiver operating characteristic (ROC) curve. Although the experimental environment is very ideal and no clatter, the evaluation results showed that compared with a conventional (normal) prodder, higher classification ratio around 90% and lower false positive ratio have been achieved by using the proposed prodder.

Keywords: Tactile augmentation, Design of experiments, Humanitarian mine detection

1. Introduction

It is said that there are about 70 to 100 million landmines left in conflict areas. Prodding work, which is in standard demining procedures, fully depends on deminers' proficiency [1], and many researches on improving prodders have been conducted. As examples, a prodding device to classify shallowly-buried objects based on vibration characteristics [2], an analyzing method to estimate the targets' stiffness by sensing the acceleration of a prodder excited during prodding work [3], and a device to detect landmine-like targets by analyzing ground vibration measured by a laser Doppler vibrometer [4] have been proposed. As well as these methods, there are also researches on adding another sensor to prodders [5]-[8]. Alternatively, there are researches on other sensors without using prodders. An example is dual sensor systems that are used both a ground penetrating radar (GPR) and a metal detector (MD). In [9]), Prof. Sato's team reported an evaluation result, in which a dual sensor named the advanced landmine imaging system (ALIS) has been tested in Cambodia.

In this paper, a prodder system for demining based on tactile augmentation is proposed. This research focuses more attention on deminers' assistance than on automatically classification. The proposed system augments a feeling (tactile sensation) when the prodder is touching the buried objects and aims to make the prodding work safer and easier.

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2. Frequency-shaped tactile augmentation

2.1 Analysis of vibration transmitted to prodder

As a preliminary experiment, acceleration in scratching the buried objects by a prodder was measured and analyzed based on the power spectrum density (PSD) estimate by the Welch method. In this experiment a landmine surrogate, a wood piece, a stone and an aluminum cylinder were used (Fig. 1). The targets were buried in the depth of 5.0 cm in a red soil. Figure 2 shows the PSD estimates acquired by the experiment. As summarized in Table 1, the accelerations in scratching the buried objects have features in a range from 100 to 400 Hz. From the results, the proposed system has been designed so as to emphasize the acceleration signal in this range and to transmit the amplified acceleration to the operator as a vibration via a tactile device.

Fig. 1. Four targets for classification test: from left, landmine surrogate, wood, stone, aluminum.

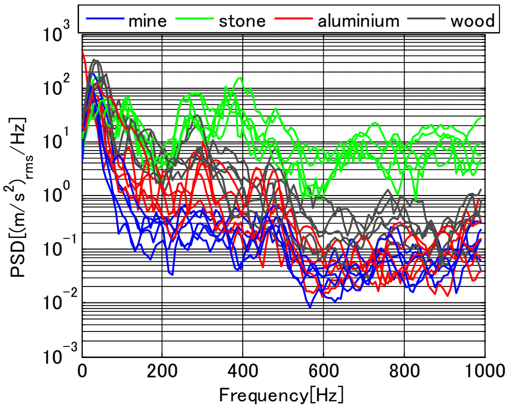

Fig. 2. Power spectrum density estimate of acceleration in scratching landmine surrogate, stone, aluminum and wood.

Table 1. Feature of power spectrum density in scratching landmine surrogate, stone, aluminum and wood.

Frequency [Hz]	Difference of PSD between four targets
0 - 100	Small
100 - 400	Large
400 - 1000	Middle

2.2 Band-pass filter

Figure 3 shows the whole configuration of the proposed system. In the proposed system, the acceleration signal in a specific range of frequency is amplified by two analog band-pass filters, and the signal is changed to vibrations by a tactile augmentation device as described in the next section (see Fig. 6). Figure 4 shows the circuit diagram of one band pass filter. The transfer function of the filter is given by

$$G(s)=\frac{V_o(s)}{V_i(s)}=\frac{-\frac{1}{CR_1}s}{s^2+2\frac{1}{CR_3}s+\frac{1}{C^2R_3}(\frac{1}{R_1}+\frac{1}{R_2})}. \qquad (1)$$

Base on the results in Table 1, the acquired signal from the accelerometer is amplified by the two band pass filters, the center frequencies of which are 100Hz and 300 Hz, and is summed up to the original signal as shown in the red square in Fig. 3. The frequency response of the whole filter system is shown in Fig. 5.

2.3 Tactile augmentation device

In order to transmit the tactile sensation to the operator's hand, a piezo actuator is used. For further enlargement of the vibration in the specific frequency range, a mechanism to augment the force utilizing a cantilever made of aluminum is installed. Figure 6

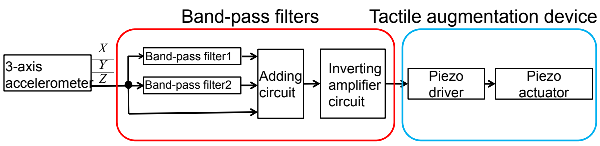

Fig. 3. Block diagram of prodder system.

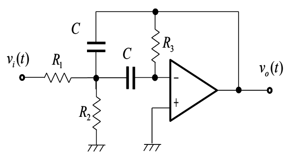

Fig. 4. Circuit diagram of band-pass filter.

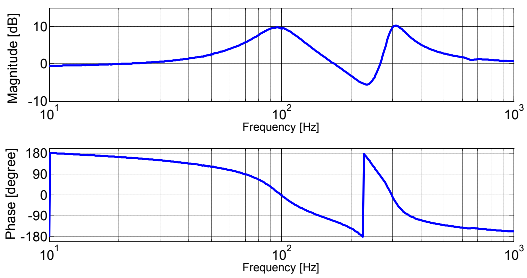

Fig. 5. Bode plot of signal amplifier using two band-pass filters.

shows the proposed tactile augmentation device, which consists of the piezo actuator, the aluminum plate and wood pieces. The design parameters are listed in Table 2. The resonant frequency of the device is given by

$$f=\frac{\lambda^2}{2\pi L^2}\sqrt{\frac{EI}{\rho A}}, \qquad (2)$$

and the parameters are adjusted as summarized in Table 2 to make the frequency to be 300 Hz.

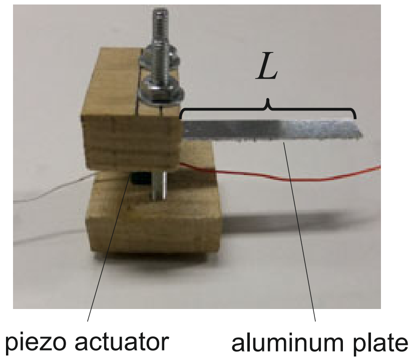

Fig. 6. Tactile augmentation device utilizing cantilever.

Table 2. Parameter of cantilever.

Symbol	Definition	Value and Unit
λ	Vibration mode	0.5π
L	Length of the plate	3.1×10^{-2} [m]
A	Sectional area of the plate	3.10×10^{-6} [m^2]
ρ	Density	2.70×10^{3} [kg/m^3]
E	Longitudinal elastic modulus	70.0×10^{9} [N/m^2]
I	Second moment of area	6.46×10^{-14} [m^4]

3. Prodder system

Figure 7 shows the experimental setup of the proposed prodder system that amplifies the measured acceleration in around 100 Hz and 300 Hz and generates tactile sensation to the operator. In the system, the 3-axis accelerometer is mounted in the middle of the prodder, and the only z-axis acceleration is measured since the z-axis is the dominant direction in the following scratching experiment. For the tactile augmentation device, a piezo electronic actuator (AE0505D08F, NEC-Tokin) and a piezo driver (M-265, Mess-Tek) are used.

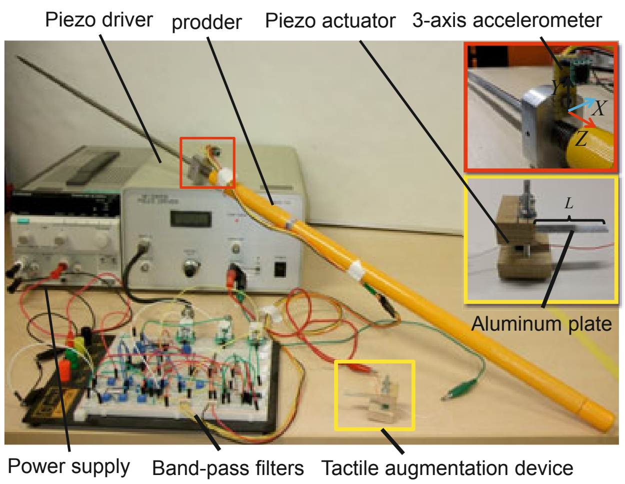

Fig. 7. Experimental setup of proposed prodder system.

4. Design of experiments (DoE)

In this section, a classification test is designed to evaluate the validity of the proposed method. The proposed prodder system is evaluated by analysis of variance (ANOVA), in which three factors are selected. The first one is target types (landmine surrogate, wood, stone and aluminum); the second one, prodder types (normal prodder, Prodder 1 and Prodder 2); the third one, environmental settings (in red soil, in river sand and on the ground) as shown in Fig. 8. The normal prodder is with no tactile augmentation. Prodder 1 is equipped with the tactile augmentation device driven by the original acceleration signal without frequency weighting. Prodder 2 is equipped with the tactile augmentation device driven by the frequency-shaped acceleration via the band-pass filters.

In order to impartially collect unbiased data for statistical analysis, reducing the total number of experiments, an orthogonal experimental design based on L18 (21×37) is used. As reported in [10]), the L18 orthogonal array is one of the most commonly used array for design of experiments. According to the L18 array, a combination of levels in every factor is designed as summarized in Table 3. Because the number of target types are four, the number of levels of the target types in Table 3 are reduced from 6 to 4 by dummy method [11].

Red soil River sand

Fig. 8. Experimental environment: from left, red soil, river sand.

Table 3. Experimental run based on L18 orthogonal array.

No.	Target type	Prodder type	Setting
1	Landmine	Prodder	In red soil
2	Landmine	Prodder 1	In river soil
3	Landmine	Prodder 2	On the ground
4	Wood	Prodder	In red soil
5	Wood	Prodder 1	In river soil
6	Wood	Prodder 2	On the ground
7	Stone	Prodder	In river soil
8	Stone	Prodder 1	On the ground
9	Stone	Prodder 2	In red soil
10	Aluminum	Prodder	On the ground
11	Aluminum	Prodder 1	In red soil
12	Aluminum	Prodder 2	In river soil

No.	Target type	Prodder type	Setting
13	Landmine	Prodder	In river soil
14	Landmine	Prodder 1	On the ground
15	Landmine	Prodder 2	In red soil
16	Wood	Prodder	On the ground
17	Wood	Prodder 1	In red soil
18	Wood	Prodder 2	In river soil

5. Experiment

5.1 Experimental procedure

In the experiment, two research participants (A and B) were asked to take a classification test based on only the tactile sensation as follows:

1. Eighteen experimental runs in Table 3 are chosen an in a random order.
2. The target is buried in the depth of 5 cm or put on the ground by the coordinator according to the condition of the selected experimental run.
3. Each research participant who dese not know the target type scratches the target without seeing it using one of the prodders specified by the condition.
4. Based on the tactile sensation in scratching, each research participant declares which the scratched target is and reports the confidence that the target is mine as 0, 20, 40, 60, 80, or 100 %.
5. Back to Step 1 until the number of each experimental run conducted is equal to seven.

5.2 Experimental result

A correct classification rate (CCR) is defined as a rate of the number of correct classifications for each target type with more than or equal to 60 % confidence to the total number of the declarations. Table 4 lists the correct classification rate for each experimental run based on L18 orthogonal array in Table 3, and Table 5 summarizes the result of ANOVA for CCR. Figure 9 shows the average of CCR for each level of the factor with 95% confidence intervals to evaluate the main effect of the factor. In Table 5, factors, the null hypothesis of which has been rejected at the level of significance of 0.05/0.01, are indicated by * (0.05)/** (0.01).

Table 4. Experimental result for 18 experimental runs.

No.	Target type	Correct classification rate of Participant A [%]	Correct classification rate of Participant B [%]
1	Landmine	85.71	57.14
2	Landmine	100	71.43
3	Landmine	100	100
4	Wood	71.43	71.43
5	Wood	71.43	71.43
6	Wood	100	57.13
7	Stone	71.43	71.43
8	Stone	100	100

No.	Target type	Correct classification rate of Participant A [%]	Correct classification rate of Participant B [%]
9	Stone	100	100
10	Aluminum	85.71	85.71
11	Aluminum	85.71	100
12	Aluminum	71.43	100
13	Landmine	71.43	42.86
14	Landmine	100	100
15	Landmine	100	100
16	Wood	85.71	57.14
17	Wood	71.43	85.71
18	Wood	71.43	71.43

The experimental results of ANOVA in Table 5 and the CCR in Fig. 9 showed that there were a significant dependence of CCR for the prodder types. This means that the proposed tactile sensation augmentation is effective for the CCR improvement. Regarding the difference between Participants A and B, Participant B has achieved the same CCR for both Prodders 1 and 2 although Participant A has achieved higher CCR with Prodder 2 than that with Prodder 1.

Figure 10 shows receiver operating characteristic (ROC) curves of Participants A and B based on the above described confidence. The vertical and horizontal axes of the ROC curves are respectively the true positive rate (TPR) and the false positive rate (FPR). The TPR is the CCR of the landmine surrogate calculated by changing the thresholds based on the confidences of 0, 20, 40, 60, 80, or 100 %. The FPR is also corresponding to the thresholds and is the rate of the number of declarations mistakenly-classified as landmines to the total number of the declarations for the target except the landmine surrogate.

As shown in Fig. 10, Prodder 2 has achieved higher TPR and lower FPR than those of the normal prodder and Prodder 1. This tendency was hold true for both Participants A and B.

Table 5. Result of analysis of variance for classification rate.

Source of Variation	Degree of freedom	Sum of squares	Mean of squares	Computed F statistic	P value
Target type	3	1592.97	530.99	3.96173	0.0179*
Prodder type	2	2392.29	1196.145	8.92445	0.0010 **
Setting	2	1575.96	787.98	5.87913	0.0074**
Error	28	3752.84	134.03		
Total	35	9314.06			

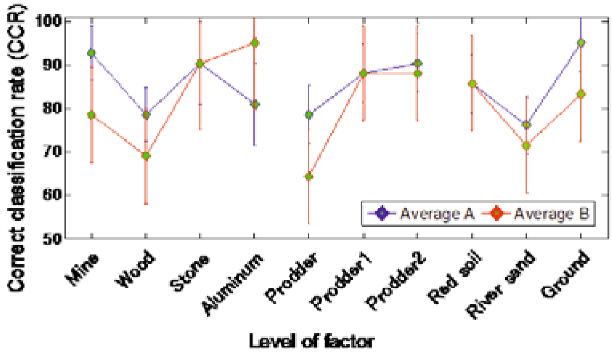

Fig. 9. Average of correct classification rate (probability detection) for each level of factor.

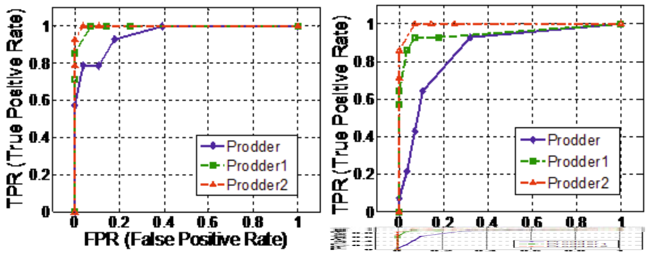

Fig. 10. Comparison of receiver operating characteristic (ROC) curves.

6. Conclusion

In this paper, a new prodder system that augments the tactile sensation in scratching buried targets by a prodder has been proposed. Although the experimental environment was very clean and ideal, the experimental results showed a potential that the proposed prodder can improve the prodding work.

7. Acknowledgement

The authors would like to thank Croatian Mine Action Center - Center for Testing, Development and Training (CROMAC-CTDT) for their support.

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Management of Residual ERW Risk Serbia Case Study

David GERTISER[15], Branislav Jovanovic[16], Dragan Jovanovic[17]

Abstract: Explosive legacies from past conflicts are still present in Serbia, even 100 years after the First World War. Subsequent conflicts, including the Second World War 70 years ago, the NATO bombings 16 years ago, and the clash on the southern part of Serbia 14 years ago, also left explosive contaminants.
Similar to most European countries, dealing with residual Explosive Remnants of War (ERW) is not new to Serbia. In the immediate aftermath of a conflict, and when faced with a great number of ERW, army, police and civil protection units performed urgent EOD and clearance operations. While this intense level of activity has subsided, ERW are still discovered on a daily basis. The Serbian EOD response averages between 5000-7000 pcs of different UXO found and disposed of every year.
Managing residual ERW increases the safety of citizens and enables a safe and secure environment for investment and development projects in Serbia. This is done by transparent risk management and prioritization. GICHD research has found that while ERW on the surface and shallow subsurface must be prioritized for humanitarian reasons, more deeply-buried ERW can be dealt with as they impinge on development. Risk management methods allow this prioritization to be conducted safely, thereby allowing more resources to be targeted to urgent humanitarian clearance operations. In the long-term, as the humanitarian problem of ERW is addressed, a residual capacity to continue to deal with risk management of ERW is present in all studied countries. GICHD has found that residual capacity takes many forms, from military and police, to Mine Action Centres or private companies.
The Belgrade Waterfront development project presents a unique case study in Serbia. It demonstrates large-scale investment and explosive risk management in an area with residual explosive contamination from several battles and both World Wars. Residual contamination is managed by the Serbian Mine Action Centre.

1. Introduction

The Future for Serbia, 2019 and beyond.

"Country without mines"

"Country without cluster munitions"

~~*"Country without ERW risk"*~~

"A Country managing ERW risk"

Explosive legacies from past conflicts are still present in Serbia, even 100 years after the First World War. Subsequent wars, including the Second World War 70 years ago, the NATO bombings 16 years ago, and the clash on the southern part of Serbia 14 years ago, also left explosive contaminants.
Risk from ERW and mines in Serbia can be split into two distinct groups:

15 Ammunition Technical Operations, Geneva International Centre for Humanitarian Demining (GICHD)
16 Director, Serbian Mine Action Centre-presenter
17 Deputy Director, Serbian Mine Action Centre

1. Direct threat to population (mine fields, cluster munitions, ERW on the surface or in the first layer of the ground)
2. Indirect threat to population – or residual threat – all existing threats that are so deep they cannot interact with everyday human activity.

Residual ERW risk is defined according to several principles:
Moment of risk:
1. First World War
2. Second World War
3. 1999 NATO raids
4. 2001 Conflict in south Serbia

Type of risk:
1. Small arms ammunitions
2. Artillery ammunitions till 76mm
3. Artillery ammunitions up 76mm
4. Air-dropped weapons
5. Rockets and missiles
6. Anti-vehicle and anti-personnel mines
7. River mines and torpedoes

SMAC focuses on direct threat to population and puts most of its efforts to solving the problem of SHA/CHA of minefield and group of mines, cluster munition and UXO explosions from army depot. Since the establishment of SMAC until the present, most clearance operations have been supported by the international community and donors mainly via ITF Enhancing Human Security (ITF) or independently. Main donors in the Republic of Serbia are EU, USA, Russian Federation, Norway, Czech Republic, Republic of Ireland and Spain.

2. Management of Residual ERW (MORE)

As other landmine and ERW-affected countries approach the completion of their mine and cluster munition clearance obligations under the Anti-personnel Mine Ban Convention and the Convention on Cluster Munitions, and battle areas are cleared of ERW in line with the Convention on Certain Conventional Weapons, attention is turning to the challenging tasks of residual contamination. Difficult to map and with no established baseline of contamination, deeply-buried bombs and widely-dispersed UXO pose a challenge that requires new policies and practices to support sustainable national responses. Modern risk management techniques can be used to focus efforts on addressing actual threats and supporting land release where only the perception of risk is present.
In the context of ongoing clearance from old and recent conflicts, GICHD has been studying the development of policy and the impact of deteriorating munitions. Based on experience and insight gained from the European experience, including that of the Republic of Serbia, Germany and Belgium, GICHD is working to develop appropriate approaches to manage explosive remnants in the long term. Many countries have learned to live with risk. They now operate on the premise that residual

explosive contamination cannot be totally eliminated, but that the risks are manageable if addressed swiftly when and where they occur.

3. MORE in Serbia

Similar to most European countries, dealing with residual ERW is not new to Serbia. In the immediate aftermath of a conflict, and when faced with a great number of ERW, army, police and civil protection units performed urgent EOD and clearance operations. While this intense level of activity has subsided, ERW are still discovered on a daily basis. The Serbian EOD response averages between 5000-7000 pcs of different UXO/AXO (Unexploded Ordnance / Abandoned Ordnance) found and disposed of every year.

Historically the Serbian Mine Action Centre (SMAC) has focussed on proactive measures: clearing minefields and cluster munitions as a way of reducing ERW risk. However, most of the EOD responses to ERW encounters indicated above are to the consequences when citizens unexpectedly encounter ERW: a residual response.

Managing residual ERW increases the safety of citizens and enables a safe and secure environment for investment and development projects in Serbia. This is done by transparent risk management and prioritization.

Residual contamination in Serbia poses numerous challenges and risks. SMAC is learning and adapting its methodology after every project.

Main projects were:

1. Oil refinery '' Novi Sad''- risk from 1999 raids
2. Corridors 10 and 11 – risk from WWII
3. Office building – New Belgrade – risk from WWII
4. Embassy of China – New Belgrade – risk from 1999 raid
5. Belgrade Waterfront – risk from WWI and WWII

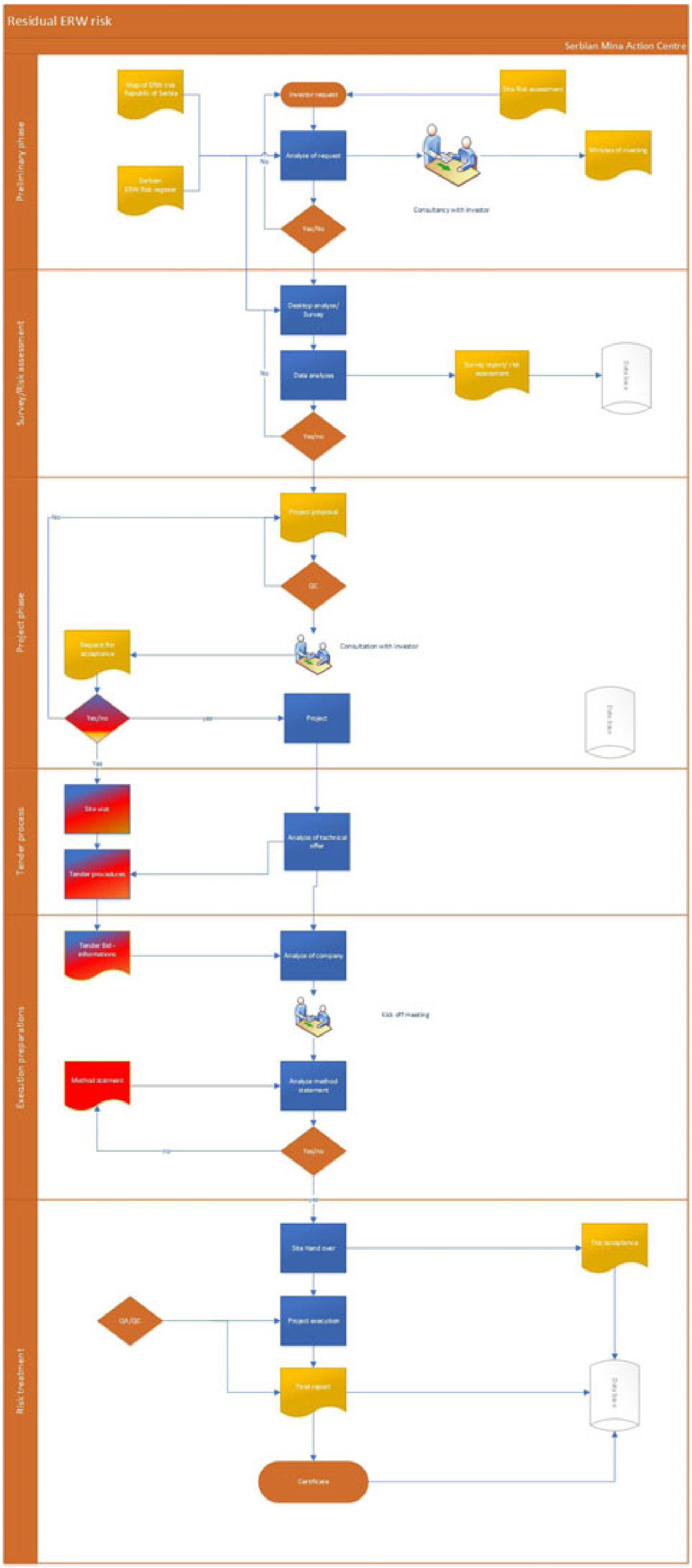

Figure 1: Process ERW risk management in Serbia

Risk Management is often equated with MORE. While good Risk Management is at the core of effective MORE, it also operates within a legal framework, with strategic planning, quality assurance and EOD/demilitarization processes. Together these define the overall context in which a residual response operates. Management of Residual ERW addresses concerns and restrictions in all these areas.

4. Legal frame

Serbia, like many countries, does not have specific legislation or a targeted law on residual ERW risk. But risk, including that posed by residual ERW, is mentioned in several other laws and regulations, notably:

Rulebook on Safety at work during construction Official Gazette of the RS, No. 53/97

When earthwork is carried out on old battlefields or in old warehouses, presence of residual ERW and other dangerous objects and substances shall be verified before starting work.

Occupational Safety and Health Law Official Gazette of RS, No. 101/05
Risk Assessment Act describes the work process with an assessment of the risk of injury and / or damage to health in the workplace in the working environment and measures to eliminate or reduce risk in order to improve the safety and health at work.

Also Disposal ERW actions link to other laws, regulations and EU directives.
For a listing of applicable laws and regulations see Annex I.

5. Social impact

In most cases, the local populations in Serbia are not aware of the presence of ERW risk in the ground or the attendant dangers. In cases when they do know about this risk, experiences from several conflicts in the country have made most people accustomed to the risk, and it is acceptable for them. Frequently the introduction of risk management processes regarding ERW is seen as an unnecessary nuisance. Even so, when ERW are discovered on site, the public is grateful and happy for the increased safety.
Investors and companies often approach the idea of risk management as an additional cost and burden which must be avoided. In defining acceptable levels of risk, it is common for both extremes to be reached. Some companies insist on certificates that the area is complete free of explosives (Free Explosive Certificate), while others maintain that all risks resulting from ERW are acceptable. In practice, the use of risk management often calls for a course of action between these extremes. GICHD’s research experience allows for country-specific assessments in order to help and advise those managing risk posed by ERW. Appropriate guidelines and clear national policies can contribute to an environment in which ERW risks are addressed appropriately, bearing in mind considerations of cost, safety, and efficiency.

6. Economic Impact

Economic development in the Republic of Serbia is one of the main objectives of the government, and investment is essential for this to occur. Given this priority, SMAC engages in all supporting activity free of charge.

However, investors must finance risk treatment. When investors choose or try to evade responsibilities in managing risks of ERW, they are essentially trading employee safety for increased profit margins. For this reason, insurance companies are an essential component in economic development and in alleviating investors' concerns. Further, adequate insurance procedures can help define how the investor must be compensated for cost. Targeted and appropriate measures in risk reduction can help reduce insurance premiums, thereby incentivizing investors to take appropriate action.

7. Serbia Case Study - Belgrade Waterfront

The Belgrade Waterfront project is located in the centre of Belgrade and is a project of nationwide significance for the Republic of Serbia.
Valid legislation regulates the need to initially assess the risk to all known or assumed risks and to take appropriate measures.
Due to the importance of the project, the Government of the Republic of Serbia instructed the Mine Action Centre (SMAC) to undertake the necessary measures within the valid regulations.

SMAC promptly started with project implementation.
SMAC has defined the following basic guidelines:

- No victims external to the project;
- Avoid operator victims;
- Reduce to the minimum incidental findings of UXO;
- Risk management activities of the residual ERW have as little influence as possible on preparation and construction of the project;
- Optimum definition of the risk reduction methods based on ALARP (As Low As Reasonably Practicable)
- Risk assessment matrix model
- The process is continuous and allows for constant improvement

The process is divided into 4 stages:

1. Preliminary risk assessment
2. Detail risk assessment
3. Risk reduction plan in relation to the purpose
4. Implementation of Risk reduction plan

8. Risk

Based on the preliminary risk assessment it has been determined that the entire area of the Belgrade Waterfront project was repeatedly the subject of conflict in the past one 100 years. Five time periods have been defined during which ERW would have resulted in the area in question.

- 28/29 July – 13 December 1914 – First World War battles
- 05 – 8 October 1915 – First World War battles
- 6 – 12 April 1941 – Belgrade heavily bombed by Nazi Germany
- 16 April – 3 September 1944 – Allied bombing of Belgrade
- 21 September – 22 October 1944 - liberation of Belgrade

Each of these periods was distinct because each time different types of ordnance were used and therefore the resulting risk is different.
Further complicating the process is the Sava river, which is an integral part of the project. Its river course has changed over the years, and seasonal flooding has covered former marshlands with layers of sediment. Underwater ERW pose separate challenges in the development project, especially with regard to the construction of bridges.

9. Risk assessment

There are several elements taken into account in risk assessment:

- ✓ complex risk (5 time periods on the same territory)
- ✓ Wetlands at the moment of risk and later backfilling of the area with construction materials from the bombed Belgrade
- ✓ Sava river as integral part of the project
- ✓ Non-systematic approach during previous EOD operations at this location.
- ✓ Construction system that includes dense piles and large scale earth works
- ✓

Taking all these into account, a risk analysis of each separate period shall be done, after which the worst case analysis defines the worst case in the overall risk.

Following a time-bound risk assessment for each period of conflict, the impact of risk on individual activities during construction is assessed and evaluated.

Thereafter a risk impact on each individual activity during construction has been defined.

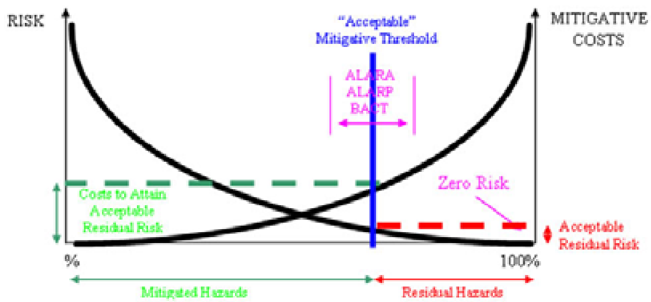

Figure 3: Risk assessments and ALARP

"ALARP" is short for "as low as reasonably practicable". Determining that UXO risks have been reduced to ALARP involves an assessment of the UXO risk to be avoided, of the sacrifice (in money, time and effort) involved in taking control measures to avoid or mitigate the risk, and a comparison of the two. The graph above depicts the varying levels of cost and benefit in meeting ALARP characterisation.

This process can involve varying degrees of rigor that will depend on the nature of the UXO hazard, the extent of the risk and the control measures to be adopted.

	1914 -1915	1941 German bombing	1944 Allies bombing	1944 Belgrade Operation
Small arms ammunitions	1	0	0	1
Artillery shell till 76mm	18	0	0	**36**
Artillery shell up 76mm	24	0	0	**32**
ADW	1	24	**36**	9
AP/AV mines	0	0	0	6
Torpedo/ river mines	8	0	0	1
Chemical munitions	0	0	0	0

Figure 4: Risk assessment for different munition types

Several sources of information are compiled in making these assessments. Quantitative data, including statistical analysis, is used when available. Qualitative assessments are used to supplement this information, including bombing data, national archives, military records, interviews and historical texts. Together these sources help paint a picture of the nature and degree of explosive contamination, and inform the appropriate risk management response.

Activity	Risk	Risk level
Shallow earthworks	Small arms ammunitions	1
	Artillery shell till 76mm	6
	Artillery shell up 76mm	12
	ADW	8
	AP/AV mines	8
	Torpedo/ river mines	8
	Chemical munitions	8
Excavation works	Small arms ammunitions	1
	Artillery shell till 76mm	36
	Artillery shell up 76mm	32
	ADW	36
	AP/AV mines	1
	Torpedo/ river mines	1
	Chemical munitions	0
Piles	Small arms ammunitions	1
	Artillery shell till 76mm	36
	Artillery shell up 76mm	32
	ADW	36
	AP/AV mines	3
	Torpedo/ river mines	0
	Chemical munitions	6
Underwater works	Small arms ammunitions	1
	Artillery shell till 76mm	1
	Artillery shell up 76mm	32
	ADW	36
	AP/AV mines	1
	Torpedo/ river mines	8
	Chemical munitions	0

Figure 5: Risk Assessment related to activity and munition type

10. Recommendations

A risk assessment should be based on collected data and their analysis.
Risk assessments show that the risk is directly connected to type of activity to be carried out on the location. Based on past experience and international recommendations and good practice, the level of risk in relation to NUS can be treated in the following manner.

Residual Risk Probability	Grading	Risk tolerance	Action
1-4	Low	Tolerable	Monitoring the risk. Pro-active educations of all personnel
5-12	Low-Medium	Partly tolerable	
13-27	Medium-high	Intolerable	Advance Mitigation Measures should be considered. Situation should be monitored. Risks to be mitigated subject to the mitigation being reasonable, practical and affordable. Mitigation Measures should / will be implemented. All risks to be mitigated.
28-82	High	High intolerable	

Figure 6: Risk levels and corresponding action

11. Conclusion

The residual ERW risk is not one that is often given much attention, leaving the risk uncovered. However, information management from the beginning of mine action for later adequate management ERW risk is essential.
The residual risk as such does not constitute a threat to the daily use of the land, but represents a real danger during development and investment projects. For this reason proper risk assessments and adequate response is vital for development projects.
SMAC still faces the challenge of educating the local population about residual risk. Of particular importance is presenting this information to investors and commercial companies.
In working together, the State, the investor and contributing organisations reframe management of ERW risk not as a cost but as an investment. Proper risk management ensures project safety, adequate timelines, and minimizes impact on personnel and equipment.
Ultimately the biggest decision is in the risk mitigation phase. The cost-benefit analysis will determine the extent and type of risk mitigation activities, ranging from elimination of the risk to changing the location of or even discontinuing the project (avoiding the risk).
Serbia has adopted the principle that SMAC manages the process of residual risk from the very beginning. Through collaboration with GICHD, risk management procedures in Serbia are not only clarified, but lessons learned are shared with other countries going through similar experiences. The Serbian example shows that the approach where the information from all projects flows into a central database is the most efficient and cost-effective, where it prevents duplicated clearance efforts in the same location.

12. Annex I

Law on Workplace Safety and Health

Decree on Safety and Health at Work at Temporary or Mobile Construction Sites

Pursuant to Article 123, item 3 of the Constitution of the Republic of Serbia, in relation to Article 7 of the Law on Safety and Health at Work ("Official Gazette of RS", No. 101/05)

The Code of Rules on Methodology of Risk Assessment at Workplace and in Work Environment

Pursuant to Article 13, Paragraph 4 of the Law on Health and Safety at Work ("Official Gazette RS" no. 1010/05)

Rulebook on Preventive Measures for Safe and Healthy Work Concerning the Use of Means and Equipment for Personal Protection at Work

Pursuant to Article 7, paragraph 2 of the Law on Workplace Safety and Health ("Official Gazette of the Republic of Serbia" No.101/05)

Rulebook on the Preliminary and Periodic Medical Examinations of the Employees Working at the Increased Risk Work Places

According to article 43 paragraph 2 of the Safety and Helth at Work Act ("The Official Gazette of RS", number 101/05)

Rulebook on Procedures for Work Equipment Inspection and Testing and for Testing Work Environment Conditions

Pursuant to Article 15 paragraph 2 of the Law on Health and Safety at Work (Official Gazette of the Republic of Serbia, No. 101/05)

Rulebook on Contents and Manner of Issuance of the Form of the Report on Workplace Injuries, Occupational Diseases and Work Related Diseases

Pursuant to Article 51, Paragraph 2 of the Law on health and safety at work (''Official Gazette of the Republic of Serbia'', number 101/05)

Rulebook on the Issuance Content and Manner of the Injury at Work, Professional Disease and Work-related Disease Report Form

Based on article 51 paragraph 2 of the Safety and Health at Work Act ("The Official Gazette of RS", number 101/05)

Rulebook on Safety at Work during Construction

Pursuant to Article 22a of the Law on Safety at Work ("Official Gazette of the RS" no. 42/91, 53/93, 67/93 and 48/94)

The Quick Reaction Force's Rapid Response Capabilities: USA – Serbia Case Study

Natalie Wazir[18], *Branislav Jovanovic*[19], *Dragan Jovanovic*[20]

Abstract: SMAC are established and equipped according to SHA/CHA in the Republic of Serbia. Also till present SHA/CHA seemed like a static problem with exactly defended border.
May 2014 completely changed such approach.

Floods, landslides and flash floods affected already known CHA/SHA. At one moment SMAC is managing the ERW and mine risk in the country, the day after completely different situations.
At that moment MACs are ready to share information and to perform joint risk assessment in the source of the risk. Main problem in SMAC was lack of capacity. SMAC at that moment have only 8 people with only 4 operational staff.

In four days following the floods, the U.S. Department of State Bureau of Political-Military Affairs Office of Weapons Removal and Abatement provided assistance to the SMAC in the emergency response phase by deploying the Quick Reaction Force, a team of EOD experts. A team performed initial survey of the whole area on behalf of the Republic of Serbia in 8 days only.

1. Introduction

The main tasks of SMAC are to coordinate activities in the field of humanitarian demining in the Republic of Serbia. In accordance with these it`s equipped and trained. With regard to the work methodology adopted in the Republic of Serbia SMAC has very limited operational capacities that consist of one team only that, among other, carry out survey and quality control in the field.

Also within the entire territory of the country there is a unique base SHA / CHA on the risks of EOR and mines. Accordingly, capacities are defined.

The situation has completely changed in May 2015. Heavy rainfall, floods, landslides and flash floods pass through already defined areas of both the RS and in the surrounding.

Following recent practice of cooperation between mine action centres, at the first hint that high precipitation may occur in the area Slovenia, Croatia, Bosnia & Herzegovina and Serbia an expert group has been formed (dated March 17, 2014) in order to monitor the situation and impact of rainfall on the risk EOR mines.

Preliminary assessment of risk based on assumptions of the flood wave development has been done immediately.

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Floods

In spite of appropriate preparation, the amount of rainfall exceeded expectations of relevant authorities. The situation imposed more activities that had to be performed simultaneously in a short period of time:

1. Mapping the situation in RS
2. Mapping the situation in the region - through regional expert team
3. Risk Assessment
4. Prevention of panic among civilians
5. Education of civilians and rescue teams on mine threat
6. Urgent marking of new/extended locations
7. Introduction of international organizations and DBP with the situation in the field
8. Preparation for emergency recovery

SMAC capacities were insufficient to adequately respond to the newly arisen situation.

On May 22, 2014, a meeting with representatives of the U.S. embassy was held in Belgrade to discuss in which areas the SMAC lacks adequate capacity to manage the emerging risks that have been presented.

Prompt response of QRF team

Two days following the floods, the SMAC was informed that the QRF team would arrive to Serbia to provide the urgent and needed assistance. Logistical preparations for the team and the planning of activities were immediately initiated.

On May 28 a three member EOD team arrived in Belgrade, where they immediately held a preparatory meeting.

A joint team was formed at the meeting, the methodology harmonized, and a plan agreed too. At the preparatory meeting, the QRF was provided and overview of the problem in RoS and the region, as well as types of risk. Team operation priorities were then agreed too.

Figure: QRF team priorities

Immediately after the meeting, the team began with site visits of the locations affected by heavy precipitation, floods, torrents, etc. It was found that more than 80% of CHA / SHA were affected and needed to be reassessed.

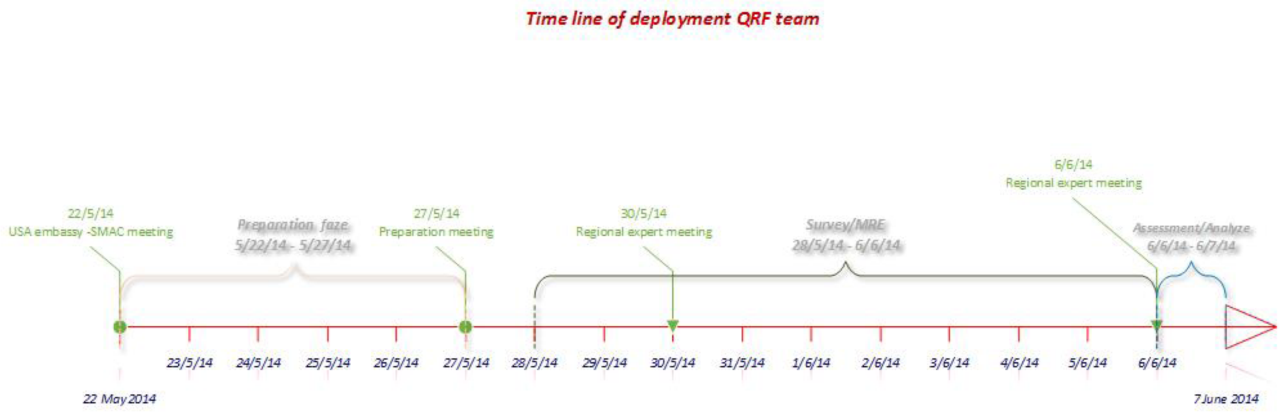
In conjunction with the site visits, a conditions assessment and modification of action plan was carried out. After inspection of all locations, it was found that the risk was greatest in the village Jamena.

Survey

MRE

Local medical staff with poster

Instead of conclusion



The quick response of the team was essential for the establishment of an adequate risk management strategy during the floods in May 2014. The mutual decision to establish a joint team of the QRF and SMAC proved to be beneficial because it eliminated that period of trying to educate the QRF on local specificities and it produced unique reports that the leadership of SMAC could immediately assess and implement.

In the case of RoS, the existence of the QRF teams was extremely helpful because the capacities of SMAC are insufficient for response in sporadic cases of crisis.

The material response of PPE against Dual Impacts: The Double Tap

Georgios Kechagiadakis, Marc Pirlot, Alain Doucet [21]

Abstract: Police and Armed Forces have reported Personal Protective Equipment failure against fast fired subsequent multiple shots within close proximity. This technique is well known as the double tap. Double tap is being used by the military because of its increased effectiveness in neutralizing an opponent. Currently, the ballistic performance of PPE is only tested under the condition of a threat of a singular impact. The interactions of multiple impacts have been considered negligible regardless of the application. In this article, the double tap technique is analysed thoroughly and its main characteristics are examined. 7 fragmentation vests from the Belgian Armed Forces were tested under dual impacts with the 9mm bullets. In total 26 double shots within a broad spectrum of time intervals were fired, with 8 of them being considered as infinite time between the shots. The distances between the impacts ranged from 44 to 78mm and the projectile velocities were measured with the use of a high speed camera.

The tests have shown that the first shots never result in perforation. The second shots, with decreasing time intervals, the probability of perforation is increasing up to 50%. Double shots within a few milliseconds exhibited intense penciling. In order to better understand the results a concept of proximity was created as a function of time and space intervals. The diagrams of terminal ballistics opposed to impacting velocities and proximity are submitted and discussed.

1. Introduction

Personnel working in public security are frequently exposed in life threatening risks. Often their lives depend on the personal protective equipment they carry. Fragmentation vests are a category of PPE which protect their users from multiple fragment impacts that are typically generated in an explosive event such as, an IED, a landmine, or a grenade detonating. Ballistic impact tests assess the resistance to perforation from fragments usually generated in an explosion and blast tests provide an insight to the structural integrity of the PPE [1-2]. In order to introduce controlled testing procedures for these tests many assumptions are determined. One of these assumptions is that the interactions of multiple fragment impacts are negligible and can be simulated with single impact tests. This hypothesis has not been investigated in depth by the scientific community due to the technological difficulties in realizing such tests. However a few attempts have been made to examine the ballistic response of a protective material under near simultaneous multi-site impacts [3-5]. Qian et al investigated the terminal effects of fragment cluster impacts on a metallic plate [3-4]. Norris developed a five steel cube launcher for hazard assessments for non-nuclear munitions [5]. Deka et al, developed an air gun triple launcher for realizing near simultaneous triple impact tests against S2-glass/epoxy composite laminates [6].

In this article, an insight to the interactions of subsequent multiple impacts is given. According to NATO's guidelines for testing PPE, the distances of the two impact points of every dual shot, were over 5 times the projectile caliber distance. The terminal ballistics results are categorized in groups

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based on the time intervals and distances between the impacts and the impacting velocities of the projectiles.

2. Experimental Setup

Four fragmentation vests of the Belgian Armed Forces were tested under dual impacts. Each vest was shot four times, two on the front and two on the back side. The projectiles chosen for the experiments were the 9mm lead core bullets as they combine low penetrability and increased mass. This design would allow a more global material response, thus more intense interactions between the impacts. The vests were placed tightly on a wooden box filled with preconditioned placticine in order to simulate the body behavior under impacts and incorporate it in the overall system response of human body/aramid fabric based vest. The plasticine was also used for measuring the indentation from the deflected aramid vest due to the projectile impacts. The weapon systems that were used were one laboratory 9mm barrel and a 9mm pistol. The triggering was manually actuated from the same operator. Due to the operator's random asynchronisation, small tolerance differences between the two weapon systems and variations between the two bullets, the two projectiles were launched with a time lag. The projectile velocity and the time lag were measured with the use of a Photron high speed camera which was placed normal on the projectile trajectories.

Proximity

Ballistics is a highly probabilistic engineering field in which the assessment of a phenomenal trend can be processed with the use of statistical tools. This chaotic behavior exacerbates in dual impact events as the overall result is a probabilistic interaction between two probabilistic phenomena.

Due to the fact that many of the parameters of the dual impact test were very difficult to control, such as the distances between the two points of impact, the time intervals and the velocities of the projectiles, the terminal ballistics effects were difficult to categorize and evaluate. A concept of proximity was investigated in order to recognize the conditions under which multiple impacts may alter the ballistic performance of a protective structure.

$$P = 1 - e^{-\frac{1000}{\Delta x \Delta t}}$$

Δx: distance between the two impact points (in mm)
Δt: time interval between the two impacts (in ms)

The results were categorized in three cases based on the terminal results.

Perforation: The projectile penetrated all the layers of the PPE .

Non Perforation: The projectile was stopped by the vest and the indentation created is expanded around the point of the impact

Penciling: The projectile was stopped by the vest and the indentation created is localized at the point of the impact with the protective layers penetrating the plasticine over 50mm deep. This material behavior is life threatening for the user of the vest even though the material is not penetrated by the bullet.

Fig.1 Three terminal ballistics results. Perforation, Non-Perforation, Penciling

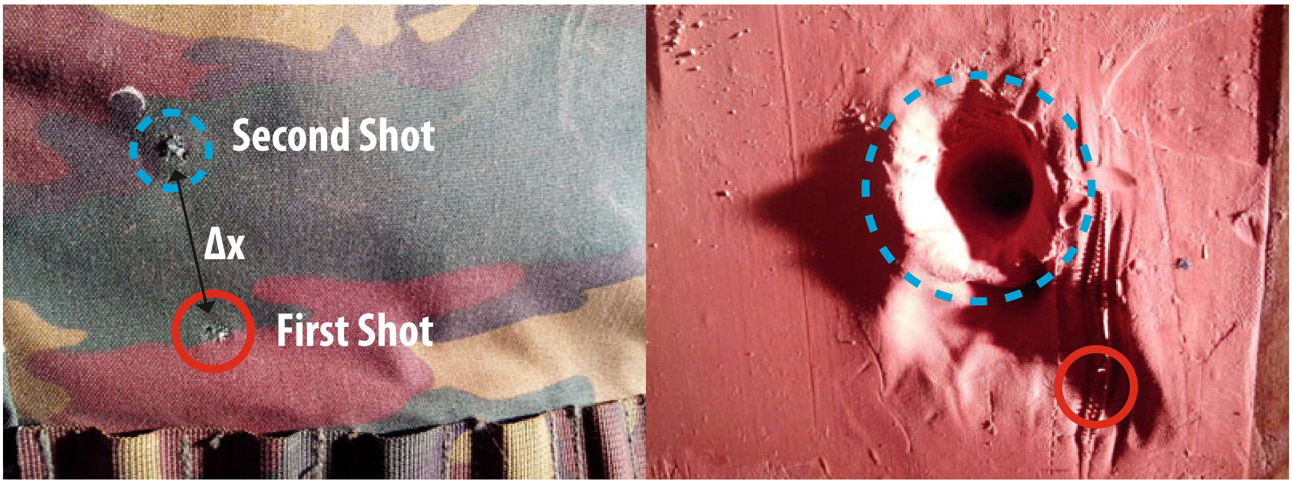

Fig.2 A double tap test resulting in perforation (of the second impact). The first impact point is circled with red and the second with dashed blue. Left: the fragmentation vest. Right: the plasticine backing.

3. Results

The characteristics of every double tap test were documented in order to form a diagram which links the impacting velocities, the proximity between the two impacts and the terminal ballistics results creating a point cloud. Within this point cloud, four distinct regions were identified. The terminal ballistics results represent only the second impacts.

1st Region – “Infinite” time. This region is situated on the horizontal axis of this diagram as the Proximity value is 0. The time interval of the dual shots of the tests represented in this region was in the order of minutes and considered to be infinite. There was no interaction between the two impacts as the material would not oscillate anymore from the first impact. However, due to residual damage from the first impact, an increased probability of perforation for the second impact was observed, reaching 25%.

2nd Region – Hundreds of ms. Within this region the dual shots had long time interval but the material seemed to oscillate during the second impact. Limited dynamic interactions between the two impacts were observed as the probability of perforations increased by 60%. The probability of perforation reached 40%.

3rd Region – Decades of ms. The time interval between the impacts of this region were increased by an order of magnitude. As a result, increased interactions between the impacts were observed with estimated probability of perforations for the second impact 50%.

4th Region – Units of ms – Penciling. This region was characterised by very short time intervals between the impacts. Penciling material response dominated this region instead of Perforation, as was anticipated. These results reveal a far more complex material behaviour. The interactions between the impacts exhibit alternating effects on the penetrability of the multiple impacts. It is difficult to interpret these results. Most probably the oscillation phase of the material plays an important role in the way the two impacts interact. Further investigation is required in order to fully address this phenomenon.

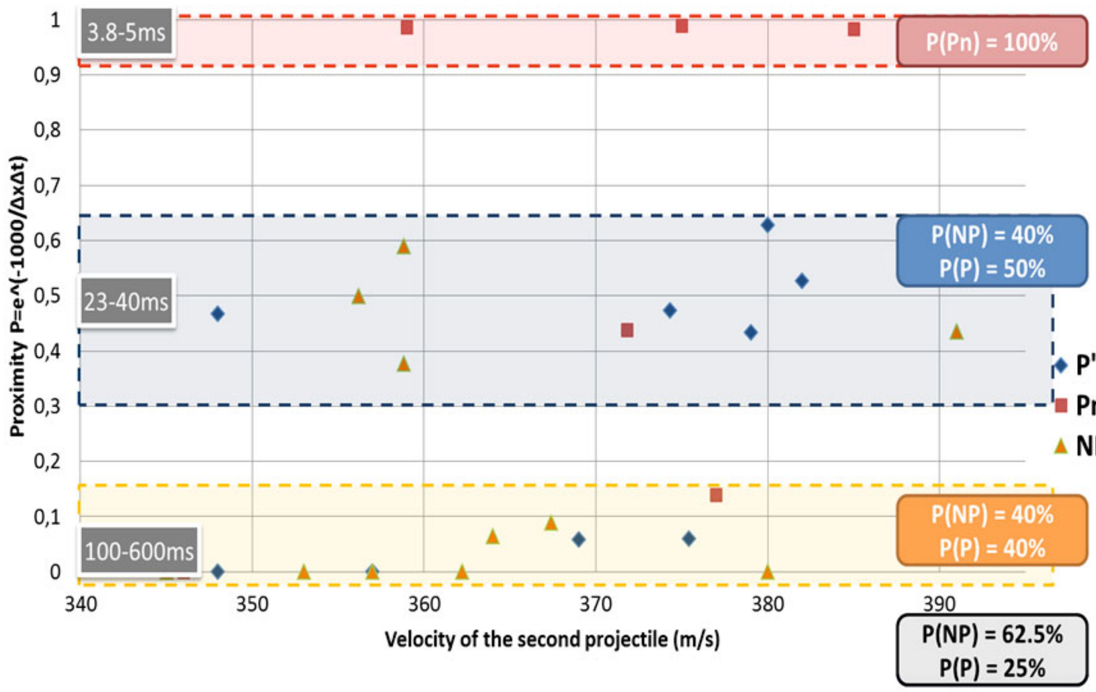

Fig.3 The results from the double tap tests. Four distinct regions of interactions are noticed.

Conclusions

In this article, an attempt to analyze the complex interactions that manifest in the case of multiple ballistic impacts on a protective structure was presented. Dual impact tests within different time intervals were performed with two 9mm barrels against fragmentation vests of the Belgian Armed forces. In 8 of these tests, the time intervals were over 5minutes, when the material would not have any kinetic energy left from the first shot (no oscillation), and their time intervals were considered as infinite.
The results have showed an increase of the probability of perforation as the time interval between the two impacts decreased. In very low time intervals, the material presents more complex behavior with penciling phenomenon dominating this region. The tests with infinite time intervals presented also increased probability of perforation compared to the first impacts, indicating that the first impacts had induced damage in the woven structure of the aramid fabrics which had propagated around the first impact points. The increase of the probability of perforation up to 50% in the faster dual impacts reveal the extent of the dynamic interactions between the impacts compared with the "infinite" time dual impact tests. The phase of the oscillation the material, due to the first impact, is altering the material response towards the second impact. Depending on the timing, the material may have been deflected towards the rear or front maximum or mid-minimum or every position in between.

The multiple impact phenomenon is interesting in many applications where multiple impacts occur on protective structures. The PPE for Humanitarian Demining are tested for their ballistic performance against primary and secondary fragmentation generated from anti-personnel mines. The standardized ballistic impact tests for testing PPE are single impact tests. The hypothesis that interactions between multiple impacts alter the material response, indicates strong discrepancies of the current methodologies compared to the actual physics of the phenomena that they try to replicate. These discrepancies must be investigated in order to further understand the material behavior in realistic conditions. New methodologies for testing PPE against multiple fragment impacts are required. This will result in a new generation of protective materials, more accurately optimized for these applications.

4. Acknowledgements

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

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Mine detection with conditioned free flying bees on the test mine field Cerovac CTRO

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Abstract: The development of methods for honey bee colony training to detect landmine odours in diverse conditions, including tests on the test mine-field has been carried out for last few years. Conditioning of honeybee colony is carried out within the mesh tent using sugar syrup and military-grade TNT scent. The results demonstrate high ability of bees to discriminate DNT (c=0.967), and to slightly less extent TNT (c=0.689) odour. Fourth day after start of the training, bees clearly recognize target odour. Conditioned honeybee colony is transferred to the test mine-field. At the new location, conditioning with target odour and food reward has to be repeated for one to two days. Offering of the food with target scent in the morning, followed with short periods with food reward during the day, can prolong interest of bees to search in the field for several days.

1. Introduction

Procedures with honeybee colonies in preconditioning period have key role in their ability to respond on training. Honeybee colony has to be carefully chosen and prepared. Colony has to have adequate food resources (pollen and honey). Before transfer of the colony to the tent for training, colony strength (number of bees) has to be checked, and if necessary adjusted by adding bees from other colonies. Training procedure (conditioning) takes place in the mesh tent, in controlled conditions, where the colony is physically isolated from surroundings (odours from surroundings present).

2. Material and methods

Trainings of the four colonies have been organized consecutively. When the first colony was introduced to CTRO test mine-field Cerovac, next colony was prepared at beekeepers premises and transferred to the apiary of University of Zagreb – Faculty for Agriculture for training in mesh tent. Size of mesh tent was 22 x 8 x 2,5 m, useful area of 176 m2, prior to transfer to the CTRO test mine-field Cerovac. Trainings were carried out during several days (four to seven days) from 6:00 to 19:00 o'clock. Counting of bees on targets and controls was followed for 15 minutes each hour. Training/ testing of honeybees was carried on military grade TNT odour. For the training and testing of bees, artificial targets with TNT and sugar syrup (1:1) and without TNT and syrup (control) were used. In glass dishes 20cm diameter, 1 g of TNT was distributed and covered with soil. The targets were prepared one week earlier and left to stabilise prior to use. When colony demonstrated ability to discriminate targets from controls within the tent, colony was transferred to CTRO test mine-field Cerovac for experiments in field conditions.

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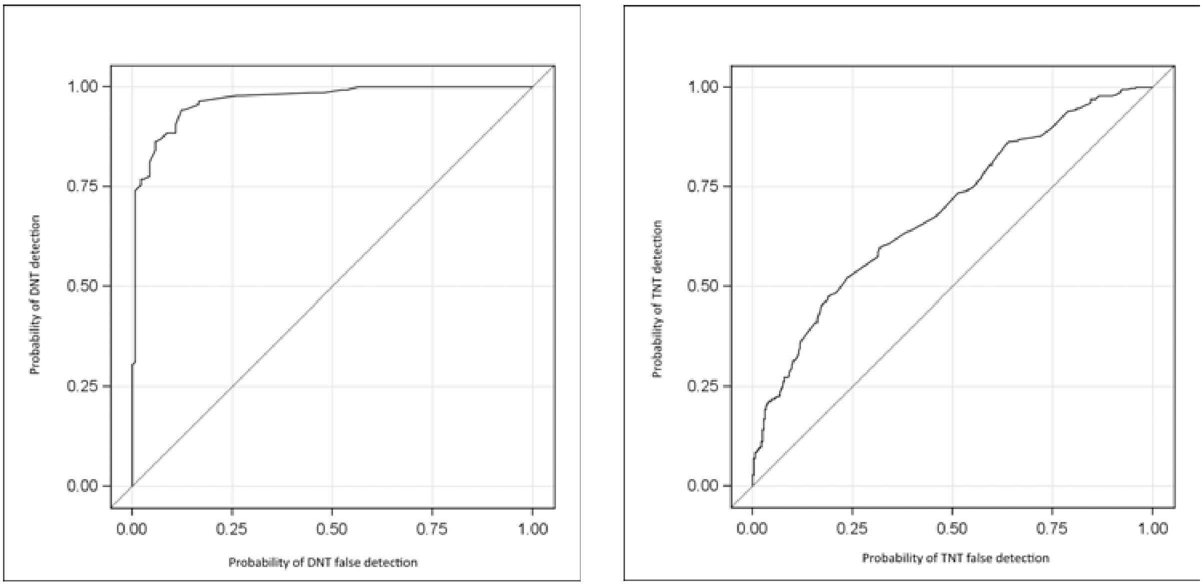
Method for following free flying bees in test mine field has been modified during 2014 to use acoustic signals produced by bees in flight to locate their position in the area. Recordings were performed during July and August, when weather conditions were suitable for trials. Audio Sensors were distributed over area to record honeybee activity in close proximity of expected mine position (target). In parallel, the same number of sensors was distributed in area with low chance of mine in proximate position (controls). Reading of acoustic data was transferred into numeric form for further statistical analysis. For statistical analysis proc Logistic (SAS, 2011) was used in SAS/STAT Software.

3. Results and discussion

Statistical analyses of data collected during the first and second year of the project, when DNT and TNT were used for training of the bees have been performed. According to literature review, bees were tested on DNT odour, and ROC curve produced (Bromenshenk, et al, 2003). To confirm training protocol, we calculated Receiver Operating Characteristic (ROC) Curve for the experiments conducted within the tent using DNT or TNT as training and testing components. The data were pooled over testing component for testing period.



a) DNT b) TNT

Figure 1. ROC curve for honeybees trained to associate the odour of DNT or TNT with food in semi-controlled conditions at the apiary of the University of Zagreb – Faculty of Agriculture. a) The area under the ROC curve is 0.9669 for DNT detection (c=0.967). b) The area under the ROC curve is 0.6890 for TNT detection (c=0.689).

The experimental conditions for these trials were influenced by environmental and climate factors. Trials were performed during spring and early summer when there were many flowering plants that could divert the attention of bees from the targets. Also, weather conditions were not constant over testing period. However, results demonstrate high ability of bees to discriminate DNT (c=0.967), and to slightly less extent TNT (c=0.689) odour. These results confirm correctness of conditioning procedures performed at the apiary of the University of Zagreb – Faculty of Agriculture.

During free flying bees testing on mine-field, colony was induced by offering TNT scent early in the morning (at sunrise) when bees start to be active. It enabled that the first foraging is from feeders with target scent. Feeders were removed two hours later. Food was offered in two hour cycles for 20 minutes. During periods when food was restricted, bees were prompted to actively search for trained scent in the area. These periods were used to record bees on targeted positions by acoustic sensors. Presented procedure prolongs bee interest to TNT odour for several days.

It is well known that bees respond to weather changes (Kezić et all. 2014.). During testing period weather conditions differed from dry and hot to periods with frequent summer storms and rain periods. Daily activity of free flying honeybees on CTRO test mine field Cerovac is given in Figure 2.

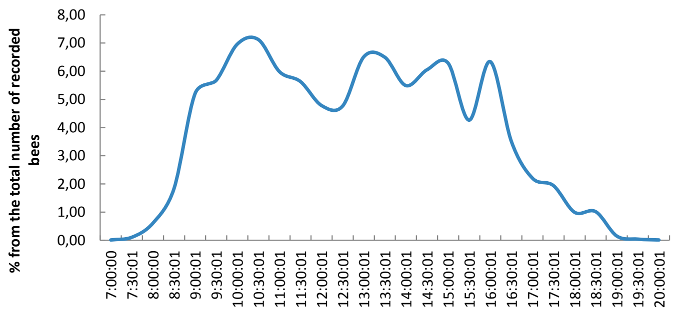


Figure 2. Daily activity of honeybees on CTRO test mine field Cerovac, based on acoustic signals (pooled data)

The analysis of the collected acoustical recordings starts with band-pass filtering (300 -3000 Hz), follows the statistical analysis of the amplitudes of detected bees (Figure 3) and time intervals of the appearance of bees near the acoustical sensor (Figure 4).

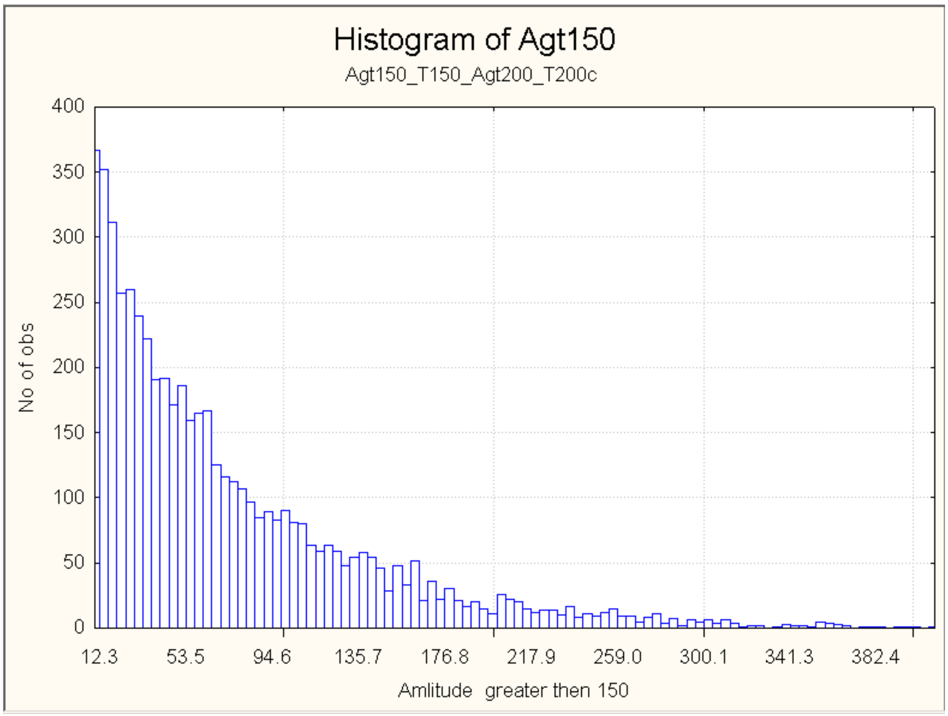


Figure 3. Histogram of the amplitudes of recorded signals of bees

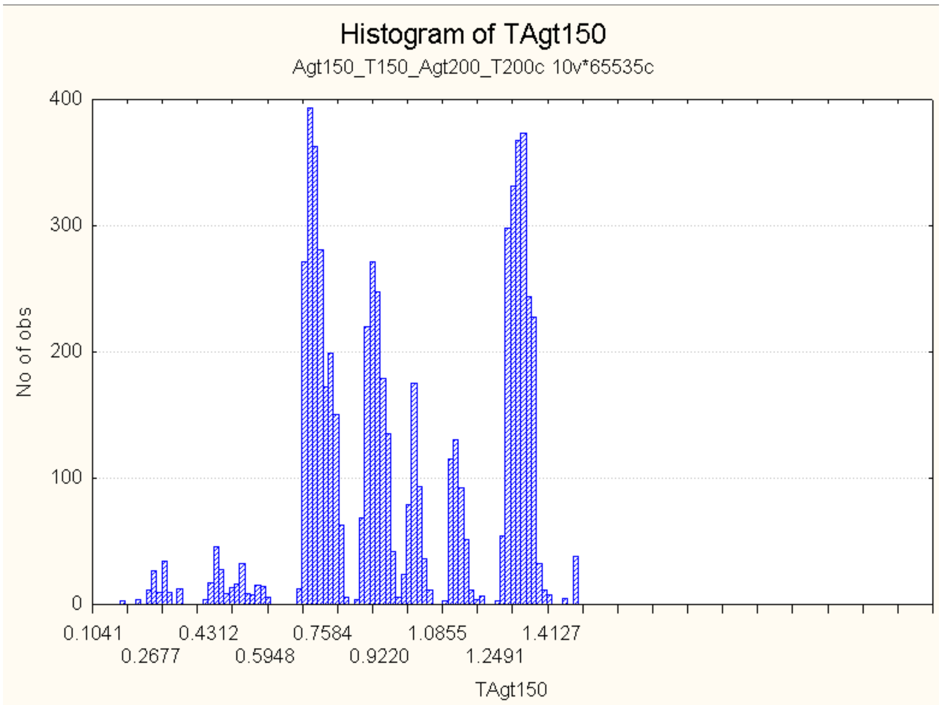


Figure 4 Histogram of the times when bees were recorded

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Integration of RPAS in mine action procedures of non-techical area survey that is under destructive impact of the landslides and sediment torrents - Case study: Krsno polje - Maglaj

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ABSTRACT: Non-technical survey of Suspected Hazardous Area (SHA) is a very complex procedure that is additionally hindered when the area is under destructive impact of landslides and sediment torrents.
Employment of Remotely Piloted Aircraft Systems (RPAS) in non-techical survey can be of great significance in such circumstances when, due to inaccessibility of the location and high risks connected to it, it is impossible to define the destructive impact of landslides and sediment torrents. Aerial survey of such area can provide substantial information on the impact of these destructive phenomena, its elements, placement and indication of its status, and sometimes also provide information of the MSA indicators (bunkers, trenches, roads and landmarks of the minefield records, etc.).
In the case study of the location Krsno polje (municipality Maglaj), there will be presented a complete integrated operating procedure: problem definition with a statement of needs, data acquisition procedures applied with such systems, data processing and quality assessment and usablity in further mine action procedures. At this location, greatly affected by a natural disaster that has befallen upon B&H in May of 2014., both mine endangerment and backfilling of civilian houses ocurred, including the potential risk of spreading onto the road between Maglaj and Zavidovići resulting in possible cut-offs in regional road communication. Demining activities were undertaken at the location, as well as the removal of deposited material that struck residential buildings and yards; however not the landslide that of which a significant part is situated in the MSA. The area has not been remediated and is still a threat endandgering the region with possible reactivation, expansion and mine displacement.

1. Introduction

Natural disasters (floods, landslides and sediment torrents) have had continuous impact on SHA in the region. The impact was intensified during 2014 in Bosnia and Herzegovina.
In order to establish the severity of the problem of mine contamination and to establish the size and boundaries of mine areas, after analysis of all available data, the process of non-technical survey (NTI) is applied. The process represents a number of activities that are mutually connected and synchronized, and that enable one to: gather data on possible contamination with mines/explosive remnants of war on a certain SHA. Furthermore, size and shape are determined, once the area has been confirmed as dangerous, level of danger and their characteristics are being determined, as well as the future mine actions and size of the land release occurring.
During this process, it is very important to gather information about any physical characteristics of the terrain, such as: walking paths, vegetation, soil type, topography, infrastructure, agriculture, safety of the local area, and all other factors that might be of relevance in the decision-making process. Alongside this, it is very important to gather information about physical changes in the environment that may influence the re-localizing of the explosive remnants of war with significant negative environmental and security consequences and enlargement of mine suspected area.

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In order to meet all quality demands and safety criteria for the surveyors, and to entice unbiased gathering of proofs and information, in cases when it is not possible to approach the location or certain areas of the location, introducing Remotely Piloted Aircraft Systems (RPAS) can be of incredible significance for the process of survey and surveillance of hazardous areas. Data acquisition from the air enables gathering various information on the physical characteristics of the terrains, physical changes in the environment, and even other indirect or direct proofs of mine existence when scenes allows. Once processed and geocoded data and corresponding surface models of the acquisition area can be overlapped with different layers of the mine information database, and from there onwards determine the boundaries od the high risk area and plan further mine action procedures and other activities.

2. Integration of RPAS in mine action procedures of non-techical area survey

2.1 Problem defining - Location: Krsno polje

The location Krsno polje in Maglaj municipality is one of very complex mine situation, as can be seen in the mine situation map (Figure 1.). Frequent moving around of confrontation line during the conflict, changing of battle units, establishing front lines and setting fortification and mine/explosive obstacles, both chartered and non-chartered, are the characteristics of this area. This situation resulted in several mine accidents in the area once war action had ended. In the period that followed, there have been operations of humanitarian demining in locations closer to inhabited areas and objects relevant for infrastructure (locations of number I priority), while locations of II and III category were marked with permanent or urgent signs of mine warning.

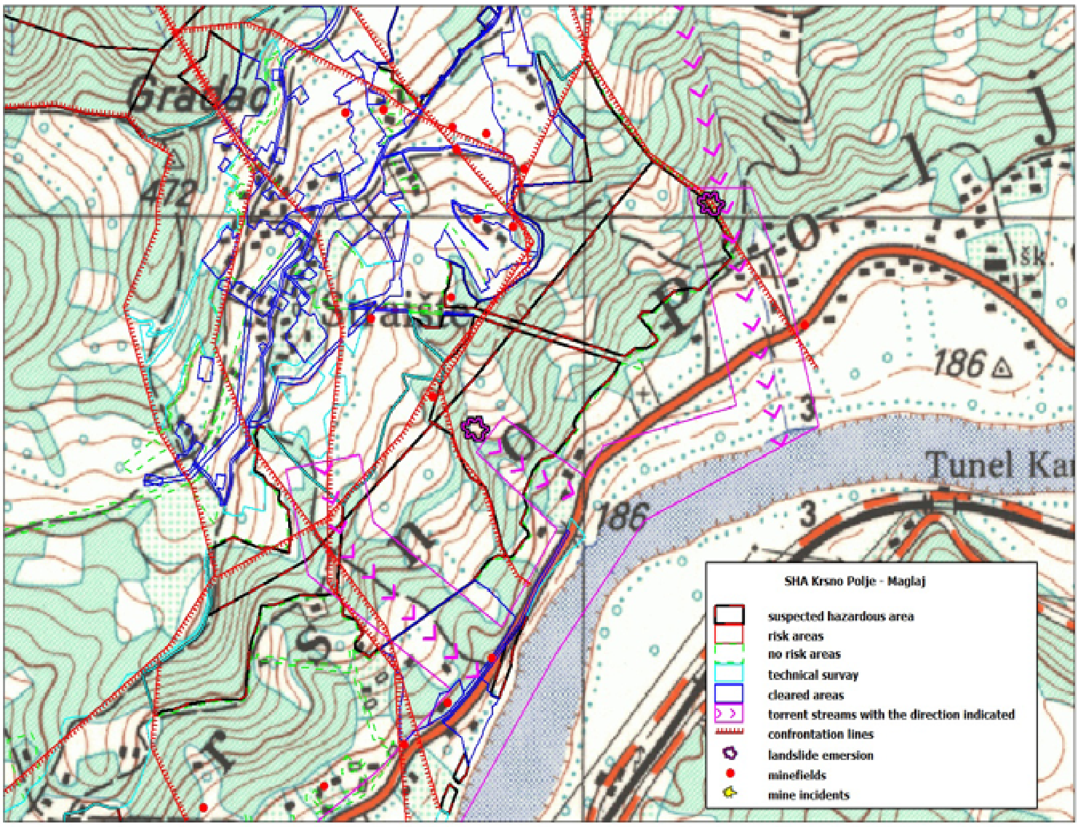

Figure 1.: Location Krsno polje – Topographic map (1:25000) and mine situation layres with influences of floods and landslides (Database BHMAC)

In the course of the natural disaster that affected this area, there have been two minor landslides and two torrent floods in SHA in May 2014. They caused land erosion and affected the regional travel communication on the road Maglaj – Zavidovići. Torrents were scheduled for air data acquisition as part of the project “Mine action after the floods - regional synergy in emergency response, technology development and capacity building”.
However, in August 2014 there has been another natural disaster, which has reactivated and started off a pre-existing landslide in that area. The landslide started off from previously marked hazardous areas, and it brought a large amount of slide material onto areas in use, houses and yards of inhabitants. The landslide directly endangered a housing object which could not be taken care of unless deposit material was removed. There was also indirect endangering of local water supply line, local cemetery, and regional road communication between Maglaj and Zavidovići. In accordance with the representatives of CroMAC - CTDT, considering the specificity of the situation, this location was an additional acquisiton area.
For the reconstruction and recovery of the endangered housing object, after a demand from Maglaj municipality and co-financing of UNDP in B&H, there was an emergency demining of one part of the location in stage one in October 2014. During this demining, dirt deposit that came from the high risk area due to landslide was examined and removed to level zero. This was made possible using appropriate machines and equipment on the total surface of 1575 m^2 with the deposit height of 0 - 5 m. However, not the entire landslide was remediated. A significant part of it is situated in the SHA, and is still a threat endandgering the region with the risk of possible reactivation, expansion and mine displacement.

2.2 Initial SOP for integration of of RPAS in mine action procedures of non-techical area survey

From experience gained through field work the initial standard operating procedure (SOP) for integration of RPAS, in mine action procedure of non-technical survey after natural disaster, was defined.
Once an initial acquisition areas have been defined, based on number of different mines action information database and cartographic layers, it is necessary to conduct coordination with BHMAC regional offices followed by reconnaissance of the area to gather precise poistioning information of the phenomenon and to determine feasibility to perform recording flights with RPAS taking into account the defined requirements for recordings and all the specific features of the location (access to the site, mine situation, relief dynamics, etc.).
Based on gathered information flight plans are made and recording flights conducted.
Next steps include: Data processing, assessment of the results quality and data integration in future mine action procedures and other activities.

2.2.1 *RPAS data acquisition procedure*

Aerial photography survey was conducted with RPAS model MRx8 (Figure 2.). MRx8 is the platform with eight engines and propellers placed in x8 configuration with four arms and coaxial position of the engines. For aerial photo acquisition it was used high-resolution camera Sony Alpha Nex 7, 24.3 MP which captures images with a resolution of 6000x 4000 pixels.

Figure 2. RPAS MRx8 and operator - preparation for aerial survey

The initial request was to capture the imagery of the area with landslides or other phenomena including wider zone of influence, and deliver all technical data on the flight. The sequence of photos should have a min. 80% overlap in the direction of flight and min. 60% of the side flaps when shooting more parallel rows of photographs. Another request was to shot photos in a uniform height of the recording i.e. flying. With photos it is necessary to deliver the GPS data the flight route and projection centers of individual photos.

Firstly it was conducted field survey and reconnaissance flight with a smaller RPAS (DJI Phantom Vision 2+), which determined the exact position of the landslide and feasibility to perform flight in the direction of the phenomenon. During this procedure it was also determined: the route length of 450 m, flight altitude of 240 m, due to relief height difference of 130m and take-off place with a good visual line of sight (VLOS) of the entire route.

Acquisition of the area, due to the mentioned conditions, was done in the shooting mode with intervals for taking pictures to give the desired overlap and resolution on the ground. It was recorded in a set of 14 photos. After reviewing the recorded material, additionally was recorded another series of six photos. When performing a flight and shooting, (slanted edge and modulation transfer function (MTF)) markers were set on the ground for the analysis of the ground resolution of the recorded images in additional post-processing procedure. Position of the Ground Control Point (GCP) was also measured and marked on the ground (to ensure visibility on the recorded photos).

After a successful recording, photos has been viewed with the aim to check the quality of images and visibility of the landslide.
The delivered data for processing are: photos, the GPS coordinates of the projection center of the photos , xml file with total route flight from takeoff to landing (taken from the navigation electronics of the RPAS) and coordinates of the GCP.

2.2.2 Data processing and quality assessment

After mandatory data were collected and delivered, main processing procedure was conducted in Agisoft Photoscan [1.] software. Digital Ortho Photo (DOF) mosaic and Digital Surface Model (DSM) of the recorded area are the results of this processing. Several processing procedures were tested due to data scale error and large positioning error.

General processing procedure consists of the following steps:

I. Data import: Photos and corresponding GPS coordinates of the projection centers
II. Photo alignment
III. Defining Ground Control Points
IV. Alignment Optimisation
V. Build Dese Cloud
VI. Build Mesh
VII. Build Texture
VIII. Generate Result: DOF, DSM

The best results (Figure 3.) were achieved after GCP orthometric height was corrected for geodetic unulation (difference between geoid and elipsoid value) in the third processing step. Geodetic unulation value for this location was supplied from a web geoid calculator [2.]. Position error was determined comparing well defined detail on both (official/state) DOF 1000 and generated micro DOF mosaic of this location. Positioning error of X coordinate was reduced from 36.789 m to 2.119 m and for Y coordinate from 27.851 m to 4.508 m. Achieved declared ground resoluton od DOF mosaic is 0.0418651 m/pix.

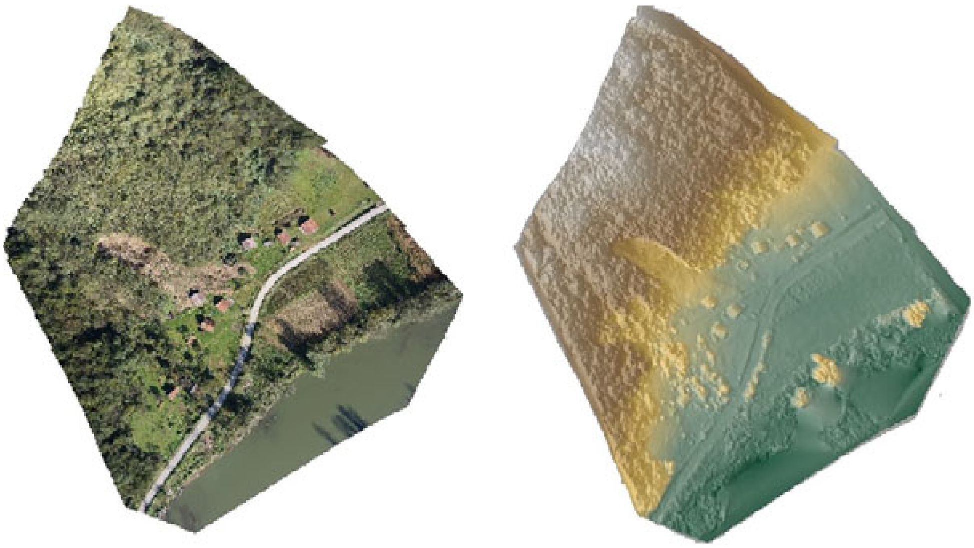

Figure 3.: Left - Digital Ortho Photo mosaic of the recerded area, Right - Digital Surface Model of the recorded area

2.2.3 Data usability for mine action procedures

Once obtained, the data acquired from the air in the further course of non-technical survey enables one to position the size of phenomenon on cartographic and Mine Information System (MIS) database layers without the need for further and more precise measuring and also enables to define the scope of the demining project. Furthermore, future overall mine action procedures can be better defined, and it is also possible to determine whether the landslide ocurrence with all the connected elements has influenced and started off shifting of mines and explosive remnants of war. It is clear on this location that the principal mark of the landslide has affected the area which, according to our knowledgeable sources on the field, is an area contaminated with PMR-2A mines (Figure 4.). A more objective evaluation of socioeconomical factors and risk factors was made possible, and they are essential when creating priority-based plans.

Data acquisition from the air enables a quality drafting for the project documentation for mine actions, and together with field analysis, surveillance and DSM will serve for better defining of geology and hydrogeology experts' opinion on the possible problem expansion tendencies, the urgency of remediating actions necessary, and the need for updating the boundaries od SHA.

Figure 4.: Overlap of DOF mosaic and boundary of the SHA on DSM of the location Krsno polje

3. Conclusion

Due to the speed of mobilization and access to areas that are not reachable from the ground RPAS are extremely useful in the implementation of field survey. In a short time it is possible to analyze the situation on the target area and carry out systematic recording of the field for further analysis. The current state of technology allows to capture micro sites - up to 1 km^2 with a tendency to increase operations and time of autonomy in the air.

The quality, quantity and high detail level of the proofs available in the process of non-technical survey with RPAS will greatly define the quality and reliability of the decision-making regarding further mine action procedures.

Non-technical survey procedures should be updated continuously, and continue to evolve in order to avoid biased estimates, to entice unbiased data proof and data acquisition, and meet safety standards. Only strictly documented, verified and well positioned geo - data will lead to a more efficient mine action procedures that will also have greater effect.

This process has been highly enhanced, as shown in the example of integration of RPAS in field surey on the location Krsno polje.

4. Acknowledgement

The project implementation leading to these results has received funding from the Ministry of Foreign and European Affairs of the Republic of Croatia (Project: "Mine action after the floods - regional synergy in emergency response, technology development and capacity building").

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The process of Targeted Investigation within Confirmed Hazardous Areas Case study: Avramovina, Gradačac

N. Kukuruzović[34]

Introduction

Bosnia and Herzegovina, as one of the most vulnerable countries to landmines in the region and in the world, faces a delay to implementation of Mine Action Strategy. This is mainly caused by the lack of funds and resources, as well as systemic inconsistencies since large suspected / confirmed hazardous areas were cleared where landmines weren’t found. Therefore, the goal of removing the danger of landmines has not been sufficiently achieved.
Resources for Landmine / ERW clearance are expensive, limited and insufficient to conduct Technical Survey and Clearance of all suspected / confirmed hazardous areas, as well as to confirm by non-technical survey that the local population uses an area, so that it could be cancelled.
Former experiences indicate a big discrepancy between the real needs for mine action in BiH and possibilities of the country. This reason has led to the development of the following idea and vision: to clean undoubtedly confirmed landmine /ERW contaminated areas; to confirm direct and indirect pieces of evidence on landmine existence using systematic and targeted investigation within technical survey and to ensure a reliable detection of landmine danger signs regarding remaining suspicion; to avoid conducting activities on the areas where landmines have not been found (to cancel the area). The concept and practice of restoring the area is the primary means of achieving the above mentioned goals, by which the greatest impact is accomplished for minimum price in the shortest time.
In December 2012, after the need for implementation of the Land Release project in BiH was established, the European Union in collaboration with BHMAC launched a pilot project using pre-accession funds (IPA 2011). The project aimed at conducting the activities of Land Release in BiH. Trainings and workshops were held in October 2013 and April 2014, and the pilot project started on the site during the demining season 2014. Four out of eight BHMAC’s regional offices were selected to manage this approach in order to determine whether it would be successful in BiH.
The European Union has signed an agreement with four NGOs on the implementation of technical survey and clearance activities using Land Release methodology in the way determined by BHMAC. Each NGO worked on one Land Release project within the area of one BHMAC’s regional office. After the four NGOs were engaged to work on pilot projects, Civil Protection of the Federation of BiH and the BiH Armed Forces expressed their interest in participating in this project. The two institutions are currently working on the activities of technical survey in the area of Tuzla and Mostar regional offices. Civil protection of the Republic of Srpska has also showed interest, but has not taken part in the project jet, while in 2015, the NPA is going to participate in the project in the area of regional office of Travnik.

1. The process and results of non-technical survey and the plan for operations of targeted investigation - the location of Avramovina, Gradačac

Non-technical survey represents a set of interrelated and coordinated activities to obtain information about possible landmine/ERW contamination within the default suspected hazardous area, to determine the size and shape, to identify the risk and characteristics of confirmed hazardous areas, to determine

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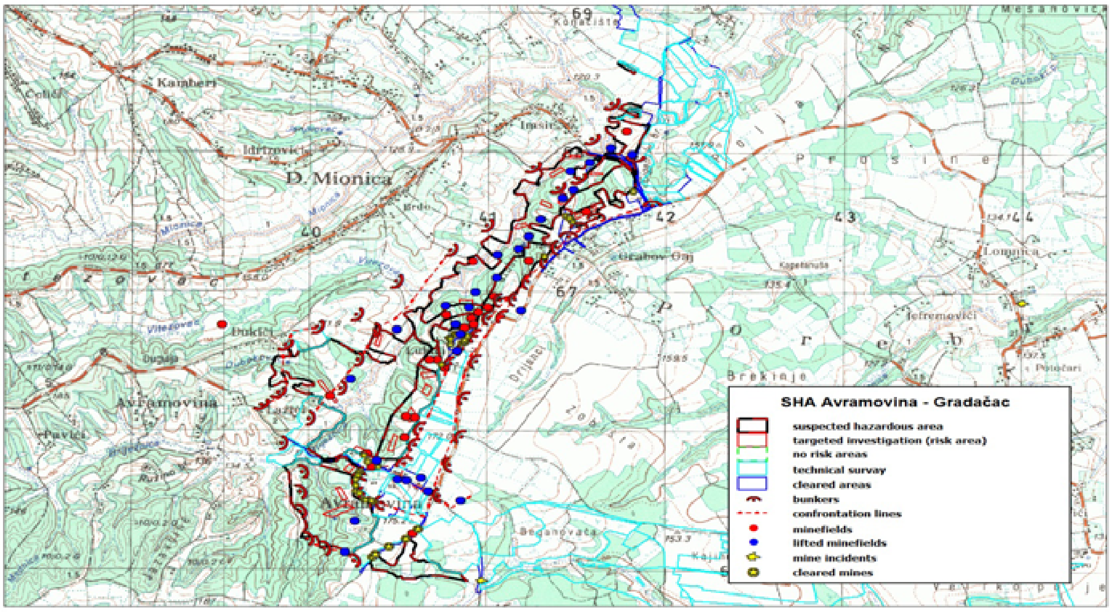
MA and define the cancelled area. The process of non-technical survey on SHA Avramovina was conducted in two dependent phases:

1st phase - Analytical and graphical data processing:
This phase included identifying, collecting, documenting and analyzing information, which represents the support for decision making process on further activities. The processing of all available data on suspicious and hazardous areas was performed (Mine-fields records, the information obtained from former members of the military, local residents and returnees, local communities, MA undertaken so far, accidents or landmine incidents, as well as all other information from available databases). All information has been processed on analytical and graphical surfaces.

2nd Phase - Non-Technical Survey (NTS): This phase included the field checks of all available data on suspicious and risk areas and gathering of new information, identification of indicators of landmine presence and specific areas for the targeted investigation. After completion of activities on the site, drafting operational plans and report on NTS was carried out. The result of quality non-technical survey is a concrete proposal of operational plans for the reliable identification of available information on the expected presence of landmines / ERW in the entire area that was the subject of non-technical survey.
Within the process NTS in the area of SHA Avramovina, Gradačac municipality, the following was defined:

- Total suspected area within SHA: 1.347 km^2;
- Area processed through demining projects (4 projects): 0.133 km^2;
- Total suspected area on which targeted investigation will be carried out: 1.214 km^2;
- Mine records removed from the database: 41 (confirmed military landmine removal)
- Evidence on landmine contamination to be treated through targeted investigation: 3 mine records, one scene of the accident (information from informants), 14 pieces of information and suspicions of informants;
- Defined number of locations for targeted investigation: 18 locations;
- Area planned for targeted investigation: 40,800 -50,000 m^2;
- Possible methods: manual;



Picture 1: Mine situation map SHA Avramovina, Gradačac during the process of NTS (BHMAC Database)

2. Process of targeted investigation - the location of Avramovina, Gradačac

Targeted investigation within technical survey is conducted when there is a high level of confidence that either dangerous items will be found in confirmed hazardous areas or reference points related to the information on landmine contamination, which results from the direct or indirect evidence of the landmines / ERW presence identified through non-technical survey, and additional information that is gathered by the purpose of quality planning survey.

Target investigation represents the entry into confirmed hazardous areas using technical methods (defined resources and planned procedures) by opening the investigation or working paths in order to identify landmines, their position and to define areas for clearance. The way of entrance using technical methods, choice of resources and scheme of investigation and working paths is given in the draft operational plan of targeted investigation in technical survey. Subject to the vegetation, metal pollution and topography of confirmed hazardous areas, type and position of landmines or information on the partial landmine removal, different means cause different levels of confidence in identification and possible reconstruction of the landmine position.

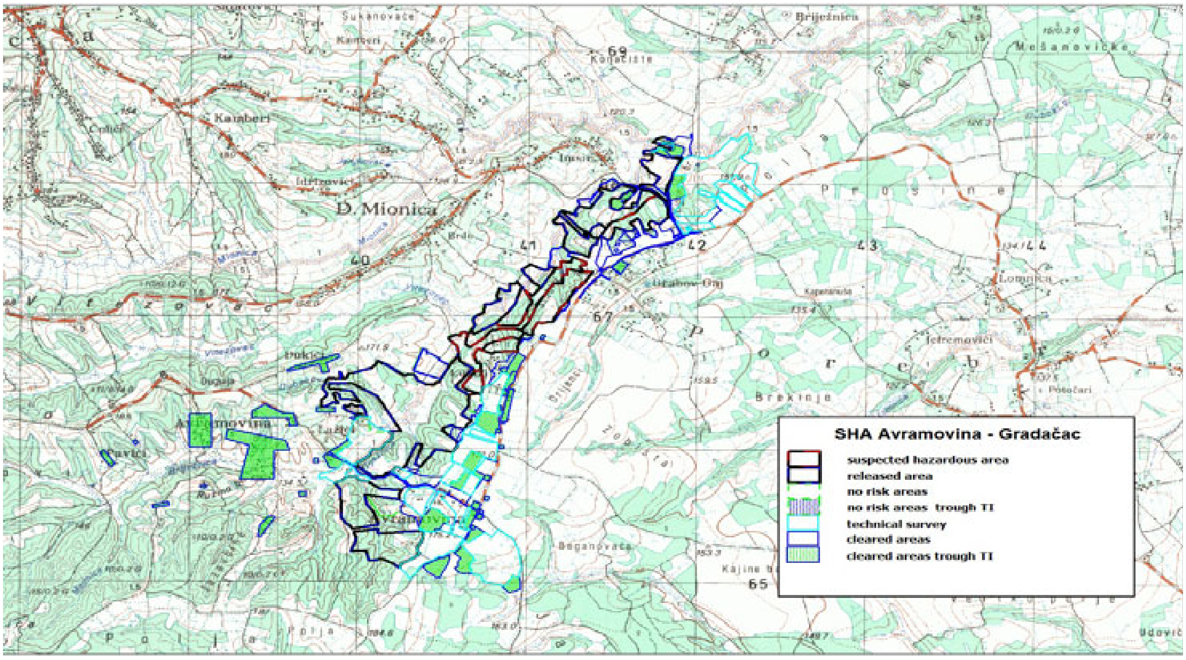
If the demining organization carrying out targeted investigations within technical survey continues to conduct clearance of defined hazardous areas and systematic technical survey of safe band around the cleared area, depending on the type and position of landmines found, such integration of technical survey in the clearance process potentially offers significant opportunities for increasing efficiency in releasing the area with confidence and responsibility. If clearance is not preceded after the completion of targeted investigation, task borders aiming at clearance will be defined as a separate task. Additional activities for systematic technical survey will also be defined as safety zones around the cleared area in case of finding landmines that are not expected or finding the expected type of landmines, or other position and the number of landmines.

The demining organization NGO Demira (funded by the Delegation of EU to BiH) successfully conducted this process on SHA Avramovina in the period from 11.06. to 22.07.2014., with constant supervision and operational guidance teams by BH MAC RO Tuzla. At this stage, all indicators of landmine contamination were treated through technical methods in the process of clearance and preparation of investigation paths. The clearance of the area was implemented around all confirmed indicators of landmine presence with a safety band of at least 10m from any items found, which is consistent with BiH Mine Action Standards. In addition, clearance through investigation paths of wider safety band was conducted around each thus treated area was carried out and cleaning investigative paths wider seat, in order to remove further suspicion. Additional information on landmine presence was gathered during the works while the existing one was reaffirmed.

Within the process of Target investigation in the area of SHA of Avramovina in Gradačac municipality the following was done:

- Area cleared through investigative paths: out of 18 planned locations for targeted investigation: 30,090 m^2;
- Area cleared: out of eight locations where landmines were found 19,975 m^2;
- Total cleared area: 50,065 m^2;
- Found and destroyed landmines / ERW-: 41 pcs. of landmines and 27 pieces of various UXO
- areas without identified risk where investigation paths were made: on 18 sites with the total area of 299,040 m^2;

– Areas without landmine presence indicators to be released : 797,500 m^2;
– Remaining risk area covered by demining projects: 4 projects with a total area of 132,336.73 m^2;
– Remaining suspected area: around demining projects - total area of 67,263.27 m^2;



Picture 2: Mine situation map SHA Avramovina, Gradačac during the process of target investigation (BHMAC Database)

3. Analysis of activities and outcomes and reduction of the area - the location of Avramovina, Gradačac

Analysis that provides reliable and efficient decision-making as well as the establishment and maintenance of confidence in the decisions made must be conducted after clearance and technical survey, together with the clearance and technical survey contractor, future users of the land, informants (those during non-technical survey and those before and during the technical survey), as well as those responsible for planning and prioritization of MA in the local community. It is necessary to meet all the needs of the above mentioned information users allowing for the achievement of the objectives of the technical survey.

Area can be released through reduction if it is possible to show that "all reasonable efforts" were used in identifying, defining and removing any presence or suspected presence of landmines / ERW, and that the application of additional effort would be unjustified in relation to the expected results. The application of "all reasonable efforts / resources" is based on an integrated system that covers all aspects and stages of planning, operation, control, documentation and decision-making.
Information management presents the key part of the process of land release. The correct management procedures, including adequate mechanisms of decision-making, making the records, training, internal and external control and adjustment, are crucial for the process. Documentation provides evidence that the procedures and systems are applied in the right way.
Residual risk is the risk remaining after the application of all invested (reasonable) efforts to identify, define and remove all existence and suspicion of landmines / ERW through non-technical, technical survey and / or clearance.

Residual risk is reduced when the process of releasing the area is carried out by competent organizations that follow approved procedures and processes. The remaining risk can be quantified over time by assessing canceled, reduced or cleared areas, through an interview with the user of returned area, in order to obtain information on presence of parts of the landmines / ERW, or other objects. The result of such assessment maintains confidence in the restored area system and serves to identify procedures and decisions that require improvement.

Results of activities can be analyzed using the example of implemented activities to SHA of Avramovina in Gradačac municipality where the following was done:

- Total treated area within a targeted investigation: 1,146,605 m^2;
- Total cleared area: 50,065 m^2;
- Percentage of treated area through technical methods: 4.4%;

By applying a rigorous, flexible, and constant non-technical and technical survey, less than 5% of suspected area is the treated through technical methods, resulting in enormous benefits of time and resources for the technical parts, which still represent the most expensive of activities. Even if the polygon has already been defined for technical survey or clearance, financial saving regarding technicalities of the process using this approach is approximately 1: 4 (ie. 25% of the cost) in comparison to conventional clearance project. This approach requires more commitment and responsibility reconnaissance and inspection resources, but it is a minor expenditure in the total costs of the project. If the clearance of defined hazardous areas is carried out along with targeted investigation, as in this case, it increases the efficiency and confidence in the returned area and assurance that all landmines were removed since deminers did not stop at the border of the original polygon from a project implementation plan.

Conclusion

The example of the completed activities on a pilot project applied on SHA of Avramovina in Gradačac municipality can show that the idea and vision about cleaning only confirmed contaminated areas without undertaking any technical intervention in areas where there is no indirect or direct evidence, is achievable and realistic. With all the activities undertaken during the non-technical and technical survey, it is possible to reduce the residual risk to a minimum so it can be acceptable to all stakeholders in the process.

What remains after the implementation of the pilot project is to improve the existing standards based on the entire process and lessons learned in the course of work, to adopt standard operating procedures for non-technical and technical survey and land release. It is necessary to conduct training and empower all resources for the implementation of these activities. Only in this way it is possible to realistically achieve the goals of the Mine Action Strategy in the shortest time period and with the most appropriate costs.

4. References

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Approach the modelling of transport processes in the case of floods

Nerma Lazović[35], Emina Hadžić, Željko Lozančić, Ajla Mulaomerović-Šeta

Abstract: Hydraulic calculations of flow in natural river bed are extremely complex due to the temporal and spatial variability of the amount of water (and sediment) that spread and the variability of the river bed geometry. Due to the complexity of the physical processes in natural watercourses, mathematical models that describe them in the form of differential equations handle this by applying numerical models, most often through the finished software packages, such as a HEC-RAS.
This paper will provide insight into the application program HEC-RAS to the define the flood lines for selected river section, with an analysis of the required input and boundary data required for modelling flow.
Key words: floods, open channel, hydraulic model, HEC-RAS

1. Introduction

In order to define the possible movements after the flood, mines and other explosive remnants of war (ERW) that are believed to be located in / in close proximity to the river bed, modeling of floods and transport processes was performed. The term transport processes in this paper includes the processes initiate and transport of alluvial deposits and material / sediment that reaches the aquifer flushing the soil with a water catchment area. Given the complexity of flow in natural riverbeds for flood modeling was used numerical model which is packed in the software package HEC-RAS.
Methodology for modeling transport processes is presented on example of Spreča River at location near the town Vukovina where there are two mined areas. In the considered part of the river Spreča was made hydrodynamic (HD) model for more different flows (medium and large water). The reason of analysing the medium water is to define the possible displacement of mines and ERW in the river bed during the smaller waters of the flood water. Results of HD models represent the input data for the modeling of starting and sediment transport (including mines and ERW).

2. General characteristics of the floodplain basin of the Spreča river

Spreča river is the right tributary of the river Bosna and belongs to the Sava River basin. It springs at the area between Zvornik and confluence Drinjača into the Drina. It runs north-westerly direction with a total length of 127 km flow and flows into the river Bosna near Doboj. The total area of the basin is 1947 km^2. Altitude of Spreča river source is 261.32 m asl, and the mouth is at 137.70 m asl. Height difference between the source and mouth is 123.62 m, and the mean lateral fall of the flow is 0.00098.
The total annual average precipitation in the valley of Spreča upstream of the reservoir Modrac based processing M.S. Tuzla, amount to about 895 mm.
Considered part of the river Spreča extends from the reservoir Modrac to the settlement Osmaci a length of approximately 36 km. It includes part of the valley with water stream - the upper Sprečko field. Elevation of the area is within the range of 253-198 m above sea level. The central longitudinal decline in the natural riverbed in this part is about 1.64 °.
Important tributaries of the river Spreča on the part of the flow upstream of the reservoir Modrac are: Mramorak, Vacetina, Bukovica, Bjelova, Međaši, Mala Spreča, Oskova and Gribaja.

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On the considered part of the river bed of the river Spreča is completely unsatisfactory situation. A narrow bed with low shores and a large number of meanders, and dense overgrown willow trees and shrubs caused frequent flooding of areas in the hinterland. Considerable damage caused by the tributaries of the river Spreča.

2.1 Basic hydrologic data

On the section of the river Spreča upstream of the reservoir Modrac are the following water stations: WS Đulović, WS Strasanj, WS Krivača, WS Osmaci. Table1. shows data on the characteristic discharges that are of interest to determine the flooding surface at the considered part of the valley of the river Spreča.

2.2 Basic hydraulic data

The length of River Spreča at section from its source to Modrac reservoir is 36.20 km. Average bed slope is 0.15% and at this section river Spreča has torrential character. River bed is unstable and prone to changes in the considered length. Because of the low coast, and low-capacity troughs are often present in the discharge of water hinterland.

2.3 Floodplain areas

According to hydrological analyses before floods form May 2014, for characteristic flows occurrence 1/20, 1/100 and 1/500 years, the level of high water and floodplain lines for flows with different time occurrence are determined. In Table 1 are presented the values of floodplain areas for characteristic flows.

Probability of occurrence	W.S. Đulovići Flow (m3/s)	W.S. Strašanj Flow (m3/s)	W.S. Krivača Flow (m3/s)	W.S. Osmaci Flow (m3/s)	Floodplain areas (ha)
1/20	258	175	138	68,20	4184
1/100	321	219	172	84,10	4787
1/500	378	256	198	97,70	5067

Table 1. Characteristic flows at water stations at Spreča river and floodplain areas

2.4 Mined areas location

In the valley of Spreča, at town Vukovina-Glavica, mined areas are defined at two locations: (i) P1 – Kalesija, Vukovina-Glavica (at hill Vis, total area 350938m^2) and (ii) P2 – Kalesija, Vukovina-Glavica (at estuary Bukovica river to Spreča river, 200 m upstream and downstream from the bridge, total area 107887 m^2). Figure 1 show locations of mined areas.

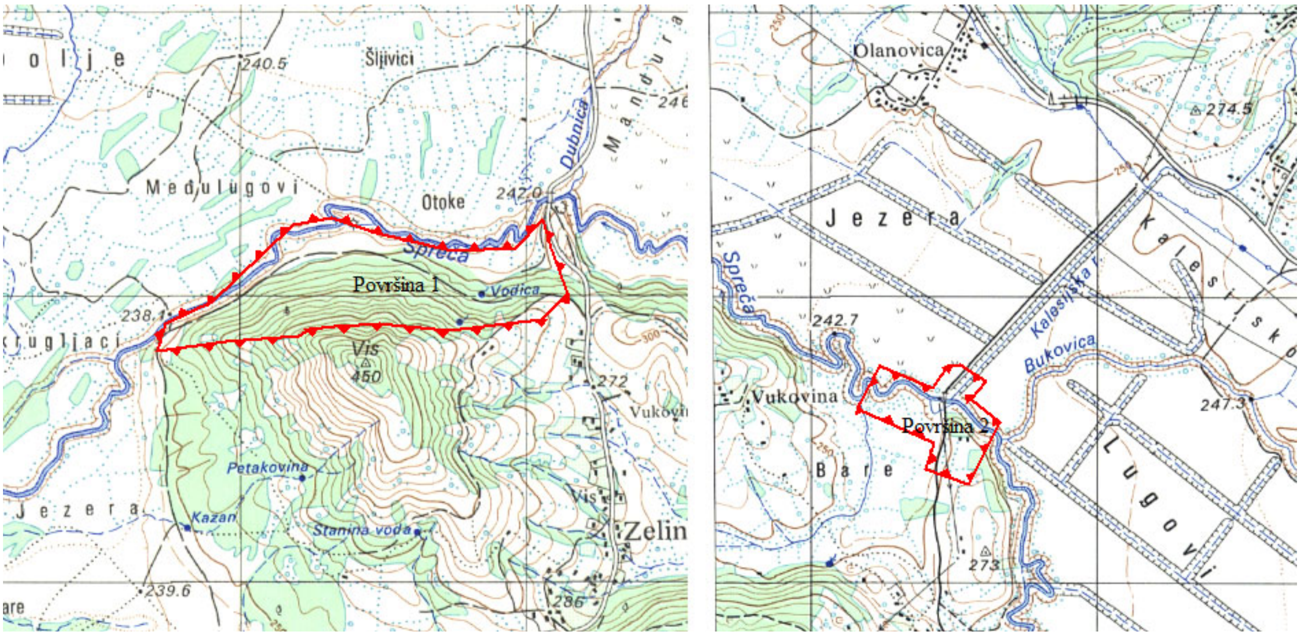


Figure 1. Locations of mined areas at town Vukovina-Glavica

3. Modeling of flood using HEC-RAS software

The program HEC RAS is developed in Hydrologic Engineering Centre – HEC which is part of the Institute for Water Resources. The software is designed for one-dimensional hydraulic analysis for the entire network of natural watercourses and constructed channels. The first version of the program came out in July 1995. Since then, came out the following versions: 1.1; 1.2; 2.0; 2.1; 3.0; 3.1; 4.0 and 4.1 version that came out in January 2010, Figure 2.

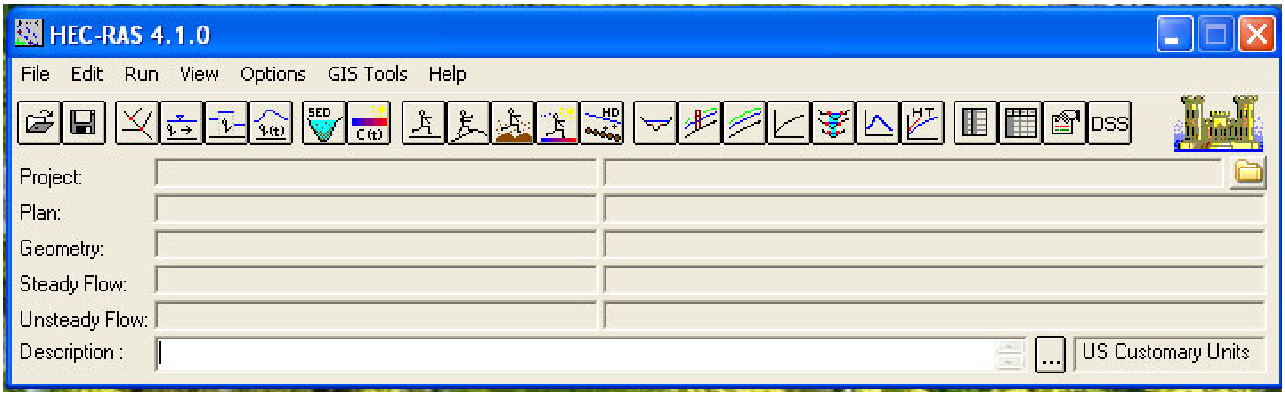


Figure 2. The basic HEC-RAS mask

The user uses the HEC-RAS through a graphical user interface (GUI). Interface offers the following functions: (i) file management, (ii) data entry and editing, (iii) hydraulic analysis, (iv) tabular and graphical representation of input and output data, (v) view reports.

HEC RAS system includes four components and one-dimensional analysis of river, which used the same geometrical data for the calculation. These components are: 1. the analysis of steady state; 2. the analysis of non-steady state; 3. the sediment transport analysis; 4. the water quality analysis.

Hydraulic calculations of flow in the river bed for stationary flow conditions is carried out by solving one-dimension equation of conservation of energy (Bernoulli's equation), taking into account local and friction resistance between the profiles. Input data required for hydraulic calculation are: (i) the geometric data (layout display of watercourses and cross-sections data); (ii) information about the roughness of the river bed; (iii) hydrological data (for defining upstream and downstream boundary conditions).

3.1 Geometry data

For consider section of Spreča River (shown in Figure 3) were available following data: (i) topographic map (TM) in scale 1: 25000, (ii) the digital terrain model (DTM) before the flood in May 2014, (iii) orthophoto and a digital snapshot of the field after the May floods.

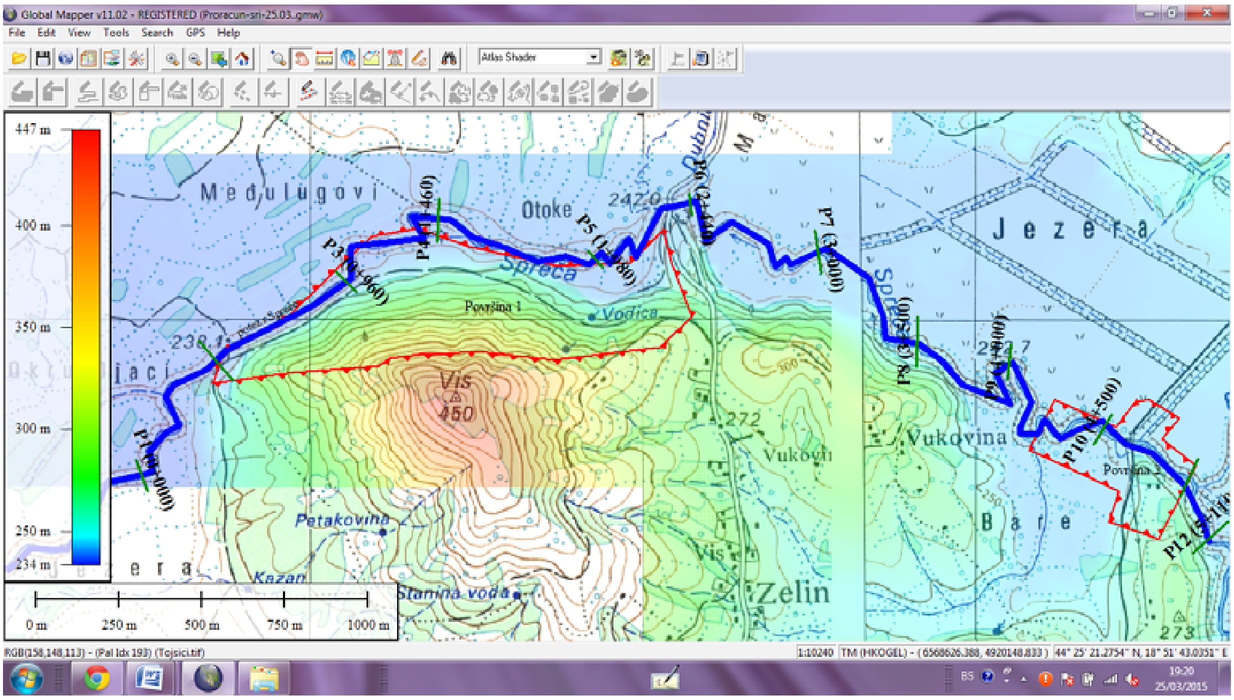


Figure 3. Layout display of Spreča river section at TM and DMT (programme Global Mapper 11)

Cross sections (P1-P12) showed at Figure 3 are collected from DMT using programme Global Mapper 11 and then are entered to software HEC-RAS. The roughness of the riverbed in the model infused over Manning's roughness coefficient, which is specifically prescribed for the main riverbed and inundation.

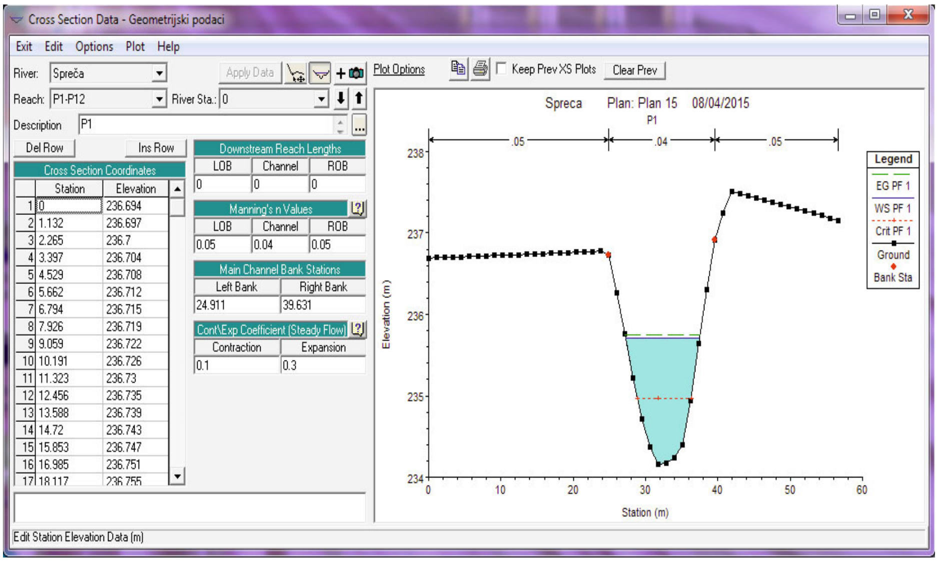


Figure 4. Cross-sections at HEC-RAS

3.2 Hydrological date – boundary conditions

After entering geometric data into the model, hydrological data are entered respectively upstream and downstream boundary conditions. In the case of stationary flow conditions, upstream boundary condition is the flow of high waters, while the downstream boundary condition can be produced in a number of ways, through: the water level for a given flow rate, flow lines, normal depth and critical depth, Figure 5.
To consider section of Spreča River was made hydraulic calculation of water level for flows 5, 10, 50, 100 and 200 m^3/s. These flows represent the upstream boundary conditions. The downstream boundary condition, i.e. the water level for a given flow is read from Q-h curve at profile P1 (synthetic Q-h curve calculated for profile P1 using Manning equation, Figure 5).

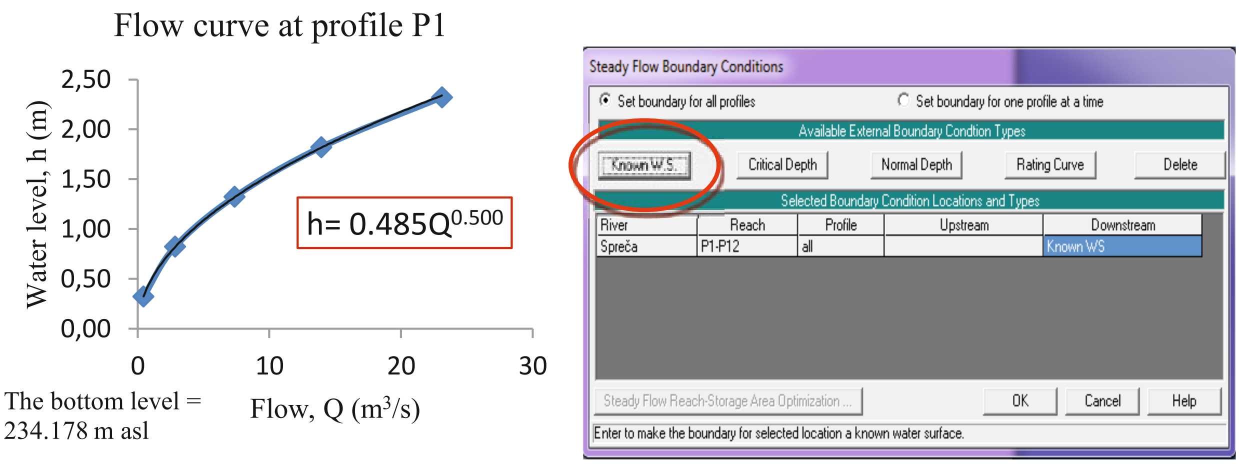
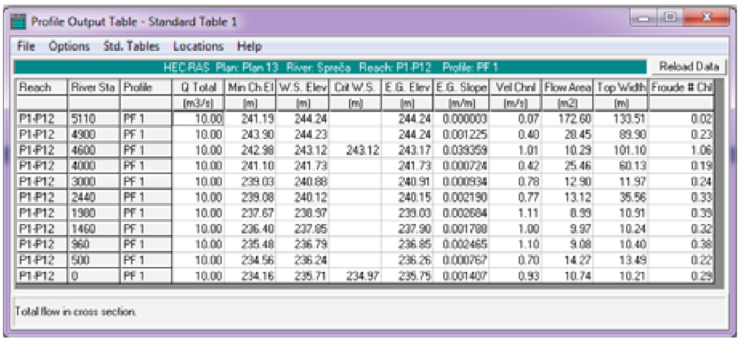


Figure 5. Downstream boundary condition

3.3 Results of calculation

The program HEC-RAS for the given input data and boundary conditions calculates water levels on each profile. In addition, for each profile account high speed, cross-sectional area, wetted perimeter, hydraulic radius, drop lines of energy, a velocity's height, tangential stress, etc. Results are displayed graphically (layout, longitudinal and cross sections) and tables (Figure 6).



Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: Plan 13 River: Spreča Reach: P1-P12 Profile: PF 1

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
P1-P12	5110	PF 1	10.00	241.19	244.24		244.24	0.000003	0.07	172.60	133.51	0.02
P1-P12	4900	PF 1	10.00	243.90	244.23		244.24	0.001225	0.40	28.45	89.90	0.23
P1-P12	4600	PF 1	10.00	242.98	243.12	243.12	243.17	0.039359	1.01	10.29	101.10	1.06
P1-P12	4000	PF 1	10.00	241.10	241.73		241.73	0.000724	0.42	25.46	60.13	0.19
P1-P12	3000	PF 1	10.00	239.03	240.88		240.91	0.000934	0.78	12.90	11.97	0.24
P1-P12	2440	PF 1	10.00	239.08	240.12		240.15	0.002190	0.77	13.12	35.56	0.33
P1-P12	1980	PF 1	10.00	237.67	238.97		239.03	0.002684	1.11	8.99	10.91	0.39
P1-P12	1460	PF 1	10.00	236.40	237.85		237.90	0.001788	1.00	9.97	10.24	0.32
P1-P12	960	PF 1	10.00	235.48	236.79		236.85	0.002465	1.10	9.08	10.40	0.38
P1-P12	500	PF 1	10.00	234.56	236.24		236.26	0.000767	0.70	14.27	13.49	0.22
P1-P12	0	PF 1	10.00	234.16	235.71	234.97	235.75	0.001407	0.93	10.74	10.21	0.29

Total flow in cross section.

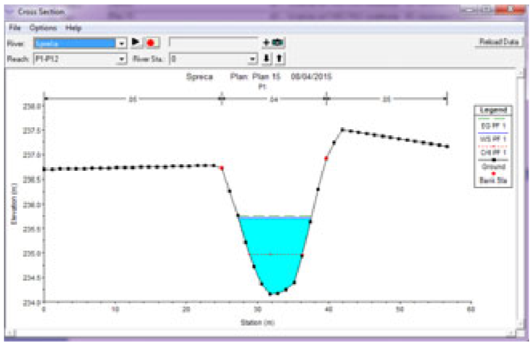


Figure 6. Calculation results display in HEC-RAS

4. Analysis of starting and transport of sediment

Analysis of sediment movement was performed by determining and comparing the values of tangential stress in the river bed and the critical traction stress to starting the sediment particles. The first stress is a function of the hydraulic characteristics of runoff, while the second stress is a function of the size and density of particles. The same approach was used in the analysis of starting mine, where they analyzed two types of mines - infantry and tank mines. Characteristics tank mines are: diameter 32.5cm, height 8.5cm, weight 8.65 kg, dimensions infantry mines are 14x7x3cm, weight 0.40kg. Equivalent diameter and density of mines, which are used in the expression for the calculation of the critical tangential stress, are determined based on the dimensions mine.

4.1 Tangential (tensile) stress and critical tangential stress

If we assume that in short intervals there is no significant change in flow in the watercourse and the bottom configuration, it can be considered that the flow is stationary and uniform. If in these circumstances watching one small element waterbeds (Figure 7), then the tangential stress in the bottom of the trough (tensile stress) can be obtained from the equation of balance of forces:

$$P_u + T = \tau_o \cdot p \cdot 1{,}0 + P_n$$

where: - tangential (tensile) stress at river bed bottom, G-water element weight, T- component of water element weight in the direction of the axle, p-wetted perimeter of riverbed on the part of the analyzed elements, Pu and Pn- forces of hydrostatic pressure.

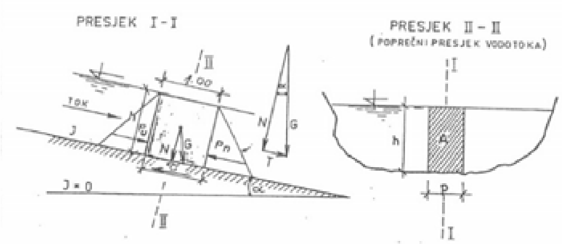


Figure 7. Analysis of unit volume of water in a watercourse

After substituting the expression for the force hydrostatic pressure and the weight of water following expression for tensile stress in the bottom of the trough:

$$\tau_0 = \rho_v \cdot g \cdot J \frac{A}{p} = \rho_v \cdot g \cdot J \cdot R$$

where: R- hydraulic radius, J-water level slope, ρ_v-density of water.
For the calculation of the critical tensile stress used empirical relation to the MPM method:

$$\tau_k = 0,047 \cdot g \cdot (\rho_n - \rho_v) d_{50}$$

where: g- gravitational acceleration, ρn-sediment density, ρv-density of water, d_{50}- median diameter.

4.2 Calculations results of starting sediment / mines

Calculation of starting of infantry and tank mine was made for flows 5, 10, 50, 100 and 200 m^3/s. Table 2 shows the results of the calculation for the discharge Q = 5m^3/s. The calculation shows that the value of tensile stress on individual profiles is greater than the critical value, which means that if there were mines in the river bed is possible that there may have been moved at much lower flow rates of the floodplain. At all other calculations carried out for higher flow rates, it has been shown that the tangential stresses exceeding critical to nearly all profiles, which in turn means and possible displacement of mines.

Profile	Chainage	h (m)	A (m^2)	V (m/s)	Tensile stress τ_0 N/m^2	Tank mines		Infantry mines	
						Critical stress τ_{cr} N/m^2	τ_0-τ_{kr}	Critical stress τ_{cr} N/m^2	τ_0-τ_{kr}
P11	**5+110**	2.91	115.2	0.04	0.02	12.46	-12.45	4.323	-4.30
P10	**4+900**	0.33	5.22	0.34	3.28	12.46	-9.19	4.323	-1.04
P9	4+600	0.33	5.22	0.44	6.47	12.46	-6.00	4.323	2.15
P8	4+000	0.4	12.17	0.41	4.07	12.46	-8.40	4.323	-0.25
P7	3+000	1.47	8.76	0.57	5.46	12.46	-7.01	4.323	1.14
P6	2+440	0.77	7.22	0.69	9.98	12.46	-2.49	4.323	5.66
P5	**1+980**	0.91	5.16	0.97	17.71	12.46	5.24	4.323	13.39
P4	**1+460**	1.08	6.47	0.77	10.55	12.46	-1.92	4.323	6.23
P3	**0+960**	0.91	5.15	0.97	17.87	12.46	5.40	4.323	13.55
P2	**0+500**	1.22	8.69	0.58	5.67	12.46	-6.80	4.323	1.35
P1	0+000	1.1	6.55	0.76	10.16	12.46	-2.31	4.323	5.84

Table 2. The calculation results of starting infantry and tank mines for flow Q=5 m^3/s

4.3 Sediment transport modeling

After the eventual starting, mines are moving in the river in the form of a mixture of sediment depending on the geometry and the slope of river bed and of the regime and flow condition in the river. On portions of the high gradient and flow velocities eroded the riverbed, while a lower gradient and low-velocities run begins to precipitate.
For the modeling of sediment transport is also used HEC-RAS software. The input data for sediment transport are geometric data, calculation of quasi-stationary flow and boundary conditions in terms of quantity and types of sediment. The calculation results are given in tables and graphs for each profile.

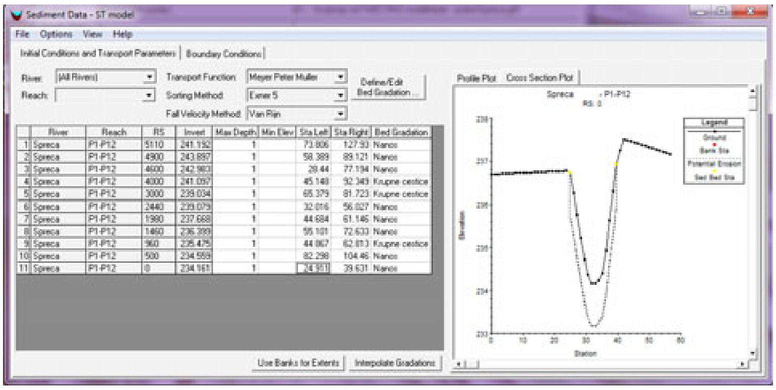


Figure 8. Initial and boundary conditions for sediment transport modelling in HEC-RAS

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Mine action technology and equipment - current situation and future perspectives

Abstract: Field and Research: promoting synergy

Andy Smith[36]

The author is a mine action specialist who has worked at all levels in Humanitarian Mine Action over twenty years. He has also developed improved demining equipment and worked as an advisor to government and academic research efforts around the world.

This paper suggests fundamental differences of approach between field workers and those conducting research and development in mine action. It identifies a temporal disjunct, dishonest performance claims and the unrealistic expectations of donors as intertwined reasons for the poor communication that has often led to disappointing results. Examples of R&D failure and success are used to illustrate improvements in collaborative approach and open communication that would benefit all parties.

Hundreds of millions of dollars have been spent on R&D for Mine Action over the last twenty years and it is easy to argue that there have not been enough results. That may be why managers in demining often have little patience with those engaged in Research and Development. Another obvious reason for impatience lies in the differing temporal perspectives between field people and researchers. The person responsible for clearance wants a tool he can use now, tomorrow, or next week at the latest. That desire for urgent practical solutions is in obvious conflict with the need to conduct research in incremental, proven stages, developing first the technology, then its practical application.

Another difference between the field and R&D perspective is the fact that a professional researcher should think that conducting the research professionally is the goal, not the development of an end-product. So Research and Development are two different things, not necessarily combined. Often, research ends with publishing papers, not producing a field-ready end-product. Publishing a result that shows that a technology is not viable is just as valuable as publishing something that seems to work – but any field people who have been involved are likely to think that they have wasted their time if the only result is paper.

These differences have been exacerbated by those responsible for R&D overselling the potential of their projects. When I first got into demining many technologies were presented as a "Silver bullet" solution but turned out to be of little or no practical value in the field. This is still happening.

Anyone who has been around in post-conflict countries knows that the contexts are so varied that there can never be a single solution that will work well everywhere. But even those with realistically limited expectations have often been disappointed and become cynical about the claims of researchers.

But those conducting R&D have to be funded – and their donors often want to fund solutions, not pure research. Although there is no way of knowing in advance whether a project with apparent potential will really deliver, the researchers have to pretend that it has a very good chance of doing so in order get funded. Worse, to please their funding sources, they sometimes have to pretend that

36 avs@nolandmines.com;

it has succeeded even when it has obviously not. In this instance the researchers often have the same temporal perspective as the demining manager – wanting to sign off this funding cycle as a “success” so that they can get funded again. Having been a field manager for INGOs and the UN, I think that field people should recognise that we all have the same pressure to overstate our achievements to please donors.

Let’s take hand-held dual sensors combining a metal detector and GPR as an example.

Sixteen years ago the first hand-held multi-sensor combining a metal detector and a Ground Penetrating Radar was under development as part of the U.S. Government’s support to HMA. When I first got to handle HSTAMIDS in 2003 it had already been presented as the solution to all demining needs. Conceived as a combination of five sensing technologies[37], the researchers for each had “talked up” the potential and then became trapped in a development cycle that could not work. The technologies were too under-developed, power hungry, and LARGE to be combined in anything that could realistically be hand-held. But the idea of a hand-held multi-sensor had been sold so the project continued, dropping several technologies while swallowing vast sums[38] from the US government’s R&D budget.

HSTAMIDS relies on the metal detector in the first instance. If it does not signal, the GPR results are not used. So the dual-technology detector can never find anything that a metal detector used alone would not have found. Despite this, an internet search still shows the claim that HSTAMIDS can detect non-metallic mines[39]. In theory, yes. In practice that is just another example of counter-productive R&D oversell.

However, if we forget the oversell, it is a fact that the HSTAMID R&D has inspired others and GPR has advanced because of it. Today, with a multiple GPR array combined with side-scanning it is credible to claim that a vehicle mounted system able to provide a 3D subsurface image at a useful resolution in real time will soon be available in the field. I can see this having great value on roads.

Other hand-held dual MD and GPR sensors, such as Minelab’s Mineshark and Vallon’s Minehound, are already available providing further evidence that the HSTAMIDS R&D was not wasted. While they all serve a primarily military use, as the technology is further refined I have come to believe that this it is inevitable that a hand-held dual MD/GPR sensor of real use in humanitarian demining will be available within the next decade.

If someone can combine the best metal detector with a real-time means of sensing explosive vapour that could change everything we do. I cannot see how that can be achieved, but no one should dismiss the possibility. A reliable hand-held explosive sensor would be of such value in so many security scenarios that the potential market will drive the R&D – and humanitarian mine action can benefit incidentally.

Humanitarian demining often does benefit incidentally. An example is the Minelab F3Ci metal detector – developed for the US marines. It is switchable between static and dynamic mode – which makes

37 From memory, the concept then presumed “sensor fusion” using IR, GRP, MD, MMW and Ultrasound technologies (this could be inaccurate).

38 J.Ishikawa and K. Furuta, Anti-Personnel Landmine Detection for Humanitarian Demining, Page 6: HSTAMIDS was developed “… at a cost of US$73 million”. A table breaks down costs into Research, prototyping, demonstration and validation, engineering and manufacturing.

39 http://www.globalsecurity.org/military/systems/ground/hstamids.htm: “… and improved metal-detection (MD) to provide a robust probability of detection (Pd) for both large and small metallic and non-metallic anti-tank and anti-personnel mines.

pinpointing shallow metal targets easier. It is the first commercial demining detector I have seen that can discriminate between some metal types with variations of tone – and it can also detect carbon rods. In some current demining scenarios, where IEDs are anticipated or in ammunition store kick-out areas, this could be a really useful tool. So this is an example of how R&D for a military customer can benefit Humanitarian Mine Action. The HMA market is so small that whenever possible researchers should aim for a bigger market to make it more likely that the development will be funded and a product can be made commercially viable.

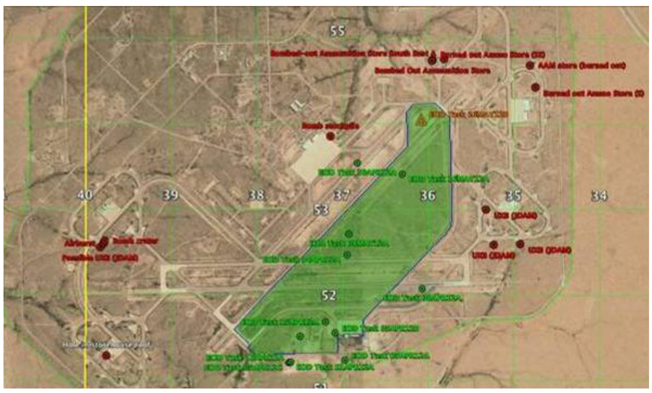
Leaving hand-held detectors aside, R&D into the extended use of satellite imagery, mapping and remote sensing has the potential to make the humanitarian task of clearing up after conflict simpler without reducing quality. On GIS, the HMA industry has become mired in IMSMA which combines limited GIS capacity with a complex management tool that is far from perfect. Most of us do not understand its programming or design, but many accept it because it is there and, presumably, those behind it knew what they were doing. A few have stepped sideways and use Google Earth in order to be in control themselves.

Slide 8.

Above, an instant overlay or an oil survey map in Google earth and below, the instant overlay of an old minefield record over a google earth image.

While the UN wasted time failing to introduce IMSMA in Libya, the INGOs just went ahead using Google Earth and overlays they put together themselves. A main advantage of this was that it could be shared with Nationals who did not have sophisticated computers and had no time for many months of IMSMA training.

Slide 9.



This Google Earth image of Sirte airport with hazards and work areas overlaid was produced by an INGO and shared widely in 2012.

The IMSMA developers probably achieved as much as anyone could have at the time, but developing alternatives that add value with self produced overlays that take advantage of emergent sensing technologies makes sense and need not take much time.

Another technology without a long development lead-time is remote explosive sensing. Denel Mechem from South Africa have been doing this using filters that are scanned by dogs in a remote laboratory

for a long time but, while I know it can work, it has a poor reputation. Developing refinements that allow inexpensive filters to be examined in the field would get a same-day result and greatly reduce the delays and potential for error. This would make a technology with known potential far more useful, reliable and widely applicable. R&D attempts to produce an electronic REST filter sensor were tested here in Croatia in 2003, but what happened next?[40]The manufacturer, NOMADICS, offers a machine they claims is as effective as a dog[41] and more cost effective, but I find this hard to believe because I have not seen it in the field. It probably works but is not reliable over open ground, not cost-effective, or not genuinely available for export to areas of need. Researchers and equipment producers really should state the limitations of their product *before* making claims for what it can do. More R&D work seems to be needed to produce a useful practical Remote Explosive Sensing tool.
New robots large and small have many potential uses in the ground and in the air. Their developed-world potential is high, and the spin-offs from their development should improve remote-control systems and robotic add-ons for field machines. New Camcopter designs already allow cost effective autonomous aerial survey and should be refined to carry a range of reliable sensors that add value to the risk-laden process of Land Release. The risk in Land Release is not to the deminer, it is to the end user of the land when they use land that is erroneously released.

My examples of desirable R&D need not have involved equipment at all. An area that is close to my heart is training. This is one in which the industry leaders have done little to encourage the application of current practices or refine training methods to make them appropriate to the trainees, whether deminers, MRE recipients, or demining supervisors. This is not the simple transfer of one training system to another place – it requires a paradigm shift in approach leading to flexible and context specific empowerment that is informed by local research, then developed with nationals in each context.

The same need for the engagement of end-users applies to all R&D. To fully achieve any of the potential in their project, those engaged in R&D must work closely with the end-users, understanding their strengths and limitations. They must take the trouble to start from where the end-users are, not where they think they should be. This is often difficult and it can be much simpler for the researchers to limit their engagement to people who speak their language and are easily available. If they do this, they will often be badly misled. They will get told what they want to hear – and sometimes told what they have effectively paid the person to say. Relying solely on unpaid advice from UNMAS or GICHD is also never enough. Often their people have the same temporal perspective as field managers and are dismissive or impatient. Sometimes they are professional bureaucrats and really do not know very much about demining or the people conducting it.

Organisations like HCR-CTRO – CROMAC - provide an excellent halfway house with events and resources that give an insight into the humanitarian demining around the world. But researchers should also get out there and spend time with the nationals in the countries they are trying to serve. Even then, success will depend on both being completely honest.

Honesty means that researchers should never oversell their project or claim that a useful product is just around the corner – unless it is, of course. Honesty also means that those in the field should never claim to know more than they do, or pretend that their experience makes R&D irrelevant. Too often, I have

40 The NOMADIC FIDO REST sensor tests are written up in Electronic Noses and Sensors for the Detection of Explosives, edited by J. Gardner, Jehuda Yinon, 2004, Holland: Kluwer Academic Publishers.

41 http://www.tha.co.th/en/explosive-detection-system/29-fido-portable-explosive-detector

seen internationals working as field managers who cling to their military training with a conservatism that precludes any change in their working practices. Many were encouraged to believe that their training was excellent and seem to believe that any criticism of it would be a betrayal of their team. I have seen others in the field with no knowledge but who pretend expertise by presenting the job as a "black art". The best in the field are not like this, but those who are bear some responsibility for shortcomings in past R&D efforts.

Meanwhile, donors and HMA industry leaders have to grow up and understand that R&D is worthwhile even when it may not result in a useful tool tomorrow. R&D is usually separately funded so it does not take money from field demining.

If twenty years in demining has taught me anything it is that there are no quick fixes that will make cleaning up after conflict simple and safe. There is no big silver bullet that will solve all problems. But there are advances to be made and R&D is an essential part of the Humanitarian Mine Action effort. If the industry leaders and donors would invest a little patience and politeness they might see that there really is a bandolier of small silver bullets that are either under development or just waiting to be worked on. If field managers in commercial and INGO demining organisations will take time to educate the researchers, we can all help to move this industry forward, one step at a time.

I am not an academic or an engineer, so what qualifies me to have an opinion that anyone should listen to? Most of my experience has been in the field in many countries over twenty years, but I have also been involved in R&D. I have worked with research groups and on my own initiative. My own R&D efforts have not been expensive and they have led to some minor improvements in the field. My work on blast resistant tools, frontal body armour and visors is fairly well known.

My designs of blast-resistant hand-tools are widely used. Any body armour that was used when I got into demining was heavy combat armour and often discarded, so I developed a simple frontal body armour that many other manufacturers have refined and which has became the standard. Then I devised and established an easy way of making visors cheaply. Anyone wearing a blast visor in demining today is probably wearing one made in the oven I made for the purpose in Zimbabwe. My visor work was initially conducted with the University of Warwick, UK, and it was a post-graduate student, Paul Sutton, who had the idea of making visors without moulds. I saw that idea through as an independent with support from a UK medical charity and the US government.

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Critically, it was not my effort that made any of this work a success. It was the sustained efforts of the manufacturer. While I have sometimes been paid to develop equipment, I have never taken any profit from its exploitation. Researchers with a field-ready product in mind should also have a manufacturer in mind because designing for production using available skills and resources is an essential part of product development. Teaching the commercial partner everything you know about the technology can help them to take ownership of the skills and develop the product. This is essential because, whatever the product is, it will almost certainly benefit from iterative development. Because Research is one thing and Development another, if researchers do not have the means to develop their results, they have only done half the work. If they have to give up ownership to get it developed, they should.

Taking advantage of having gained a lot of blast-testing experience during the design of tools and PPE, I have also done some work on making AP blast mine resistant wheels for at-risk vehicles. My first attempt was made in America in 2000, and my later attempts have been refined at the University of Genoa in Italy for use in one of their current projects. All I did was help show the researchers the forces they were working with and the crude parameters required for design success. They took ownership and moved the design forward. All researchers should allow for the fact that others will move their project forward and make that process simple by sharing what they know as openly and honestly as possible.

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I also shared my low-tech flexible ceramic armour work. My panels were shown to stop NATO combat rifle bullets in independent tests but I had hoped to design something wearable that could reliably stop all fragments from a PROM-1 bounding fragmentation mine. I failed because the end-product is too heavy for regular use in demining. So I published the results for everyone to use and have moved on. Publishing results regardless of success is essential. Someone far cleverer than me will eventually make a lightweight armour that meets the needs in demining and my work may help to get them started, or stop them making the same mistakes.

The reason for the success of my visor, armour and tool work is simple – they were not new or revolutionary. They were small incremental changes to the tools and equipment already in use, or to the way they are made. Those with open minds accepted them. But some demining organisations have ignored them because to make any change would be to admit that their equipment or procedures were less than perfect in the past.

That may be why some other demining tools have not been a success. A simple excavation tool was designed by post-graduate students at MIT[42] some years ago.

42 See it at: http://www.secdevinc.com/Excavator.htm also http://web.mit.edu/demining/

Slide 20.

It has never been adopted despite the fact that it is really useful for starting excavations in hard ground. Ergonomically clever, it is easy to use accurately and without strain, so is very popular with deminers. In places where heavy tools like pickaxes are routinely used to start an excavation this tool would be a real improvement in safety, but no one is using it today. I used it myself, got it tested in minefields and wrote a glowing report – but the developers at MIT graduated and disappeared as students do. Perhaps those organising their R&D should have taken more responsibility for seeing it through to field take-up?
In my view, the best example of truly revolutionary R&D that has changed demining almost everywhere has its roots here in Croatia. It is the DOK-ING mini-flail.

Today a mini-flail is thought of as conventional, but it was an entirely new development in the late 90s - combining remote-control with high mobility and versatility. Like all good R&D, today's DOK-ING version was originally developed to meet a recognised need in the field and has since been refined iteratively. Before it was invented, the most common cause of deminer death was the bounding fragmentation mine. A mini-flail can break or initiate these before the deminers have to go near, removing undergrowth and so making the demining process both faster and safer. But it cannot survive a tank mine blast, cannot handle wire entanglements and, like all remotely operated vehicles, can be severely restricted by unseen obstructions. Also, like all flails, it cannot destroy all mines and explosive devices – so it is not a single solution. That said, it is a really useful demining machine, helping to prepare areas and locate mine-lines when used with sensibly flexible SOPs. The factory also has a great reputation for providing all necessary field support and for having overcome many problems that its competitors have not – which probably explains why they have sold their products to the US army despite the US government having invested heavily in the R&D of its competitors. Small enough to be versatile and with good support, an MV-4 would be one of the small silver bullets in my bandolier almost anywhere in the world. And all R&D efforts could learn from its genesis – which had end-user need and commercial reality as driving forces.

For those who want something cheaper, there are alternatives such as the Locostra tractor which is smaller, highly manoeuvrable and can operate a range of tools on steep inclines. Conceived as a machine that would be cheap enough to leave behind with a community to promote use of the released land – and so promote peace-building – it has end-user needs and support for peace building as its driving forces. Seeing demining as an integrated part of building the conditions for peace may seem obvious, but to many in HMA it is a revolutionary concept. I would make daily use of Locostra if it were in my bandolier – doing many things that a mini-flail cannot including carrying wide-area detector arrays with GPS and data logging facilities during rapid BAC.

Another cheap machine I would use is the ARJUN rake and vegetation remover – converted from a second-hand backhoe. Using converted backhoes was pioneered in Afghanistan in the 1990s where they simply added some light armouring and used the conventional excavation bucket in damaged buildings and irrigation ditches. Conducting long-term and iterative research and development, the Indian NGO Sarvatra changed the tool and optimised it to both remove dense undergrowth and uncover the threats in its working area. This machine increased the speed of clearance in Sri Lanka so dramatically that there were more than twenty in use at one time, some leased to other INGOs working in the area. The tool must be adapted for the working conditions and explosive hazards in other countries but this can be easily done. Easy to maintain and operate, the machine also has the advantage of being readily converted back into a conventional backhoe for use in other post-conflict peace-building tasks. So, like Locostra, Arjun is more than a demining tool: it is a peace-building tool. The developers were deminers and their research was more empirical than theoretical, but the machine is an R&D success that underscores the need for R&D to involve field people as soon as an end-product is in mind. Its low cost, versatility and ease of use are good examples for those engaged in developing field tools. Perhaps the most important of those lessons is that it shows the advantage of adapting existing technology rather than reinventing every part of a new machine.

These examples should make everyone in demining realise that we benefit from R&D – and that the time and effort we invest in it is not wasted.

Currently, there are tools under development that could make a huge difference in the field. For this to happen, we need to work together with mutual understanding, respect, honesty and above-all patience. (I confess that I have not always met those criteria, but I try harder these days.) And then we need something truly revolutionary: we need donors and those in the field to be informed enough (and brave enough) to try something new when it is made available.

Finally, Brimatech gave a presentation entitled What makes Innovation in Demining Successful in Johannesburg last year. I saw it after writing this and was impressed because they made all the points I have raised in this paper and some others. The major difference is a change of emphasis in two areas.

First, those working in R&D have to take full responsibility for understanding field needs and restrictions. They must not rely on the field people to do their work for them.

Second, field people have to respect the efforts of researchers and give new tools and products a fair chance of achieving their potential.

Definition of SHA contaminated by cluster bomblets KB-1

Dražen Šimunović[43], dipl.ing., CROMAC

1. Description and technical characteristics of 262 mm missile M87 ''HURRICANE" and cluster bomblet KB-1

1.1 262 mm rocket M87 ''HURRICANE"

Length: 4,66 m; diameter: 262 mm; mass: 389,7 kg; number of KB-1 bomblets: 288 pcs (8% or 24 pcs are not being activated)
Performance along the straight line: 220°; Performance per elevation: -0,5° up to + 65°; Surface area of KB-1bomblets being scattered: around 2,3 ha (ellipse area: 180x165 m) ; Probable deflection along the straight line at maximum range: 300 m: Probability of deflection per distance at maximum range: 220 m; range: 5-50 km

Photo 1. 262 mm rocket system M87 , HURRICANE

Photo 2 . Cluster bomblet KB-1

1.2 The principle of action

At the height of 800 up to 1 000 m, the electronic timing fuse UTE M87 cuts the aluminium warhead cover of M87 in four pieces (Fig. 3) using detonation cutters. Then, it inflames the powder in the tube and the gases scatter cluster bomblets KB-1 in space. The process of KB-1's fuse armouring starts at the height of 400 m.

1.3 Technical characteristics KB-1

Length: 90 mm; diameter: 40 mm; mass of explosive: 35 g RDX; number of balls: 450; ball diameter: 3 mm; radius of wounding: 65 m; radius of deadly effect: 10 m (35 m); permeability of steel plate: 60 mm; effect on the target: fragmentation effect and hollow charge effect, Munroe **or Neumann** effect (penetrating).
Inside the warhead of a missile, cluster bomblets KB-1 are placed in four parts made of polyurethane: 24 pcs in the first part, 48 pcs in the second part, 108 in the third and fourth part (total: 288 pieces). The tube containing the powder used to scatter the KB-1 around is incorporated into the above-mentioned parts. (Fig. 3)

43 CROMAC, drazen.simunovic@hcr.hr

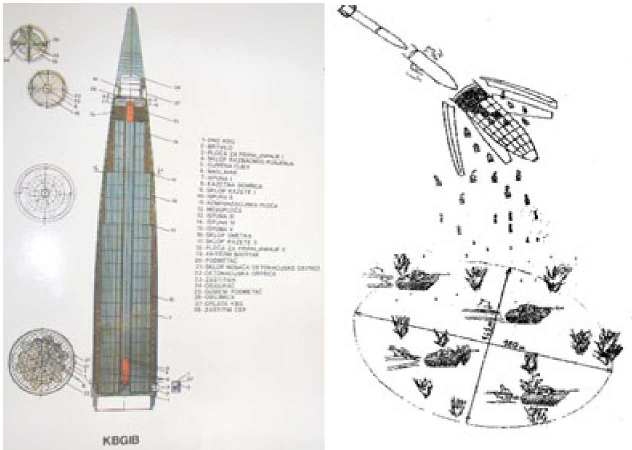


Fig. 3 The warhead of 262 mm missile M87, opening of warhead cover and dispersion of KB-1 (ellipse D1=180 m, D2=165 m)

Fig.4: armoured fuze of KB-1 (the slider is outside the fuze)

Fig.5: KB-1 fuze (not armoured)

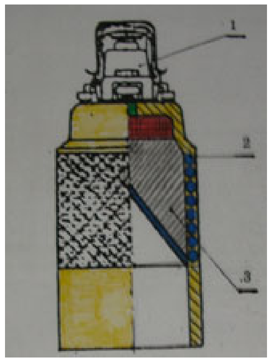


Fig.6: KB-1 (cross section)

Main parts of KB-1 are: fuze (1), body with steel balls (2) and explosive with conical liner (shaped charge) (3)

2. Area contaminated by cluster munition KB-1 in the Republic of Croatia

The counties contaminated by cluster munition KB-1 are as follows: Bjelovar-Bilogora, Sisak-Moslavina, Karlovac, Zadar, Šibenik-Knin, Lika-Senj and Split-Dalmatia County. It is estimated that 2,8 km2 of the territory of the Republic of Croatia are currently contaminated by cluster bomblets KB-1 covering the area of Karlovac, Lika-Senj, Sisak-Moslavina, Šibenik-Knin, zadar and Split-Dalmatia County.

3. The procedure of definition of areas where cluster bombs KB-1 have been identified

The areas contaminated by cluster munition KB-1 are defined by general survey methods in accordance with Standard Operating Procedures (SOPs). These are: data analysis, verification and collecting new data in the field, area definition, contamination estimate, preparation and verification of reports.

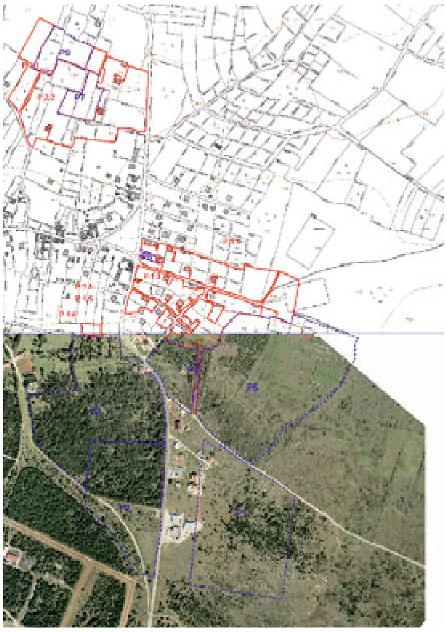


Fig. 7 Areas contaminated by KB-1

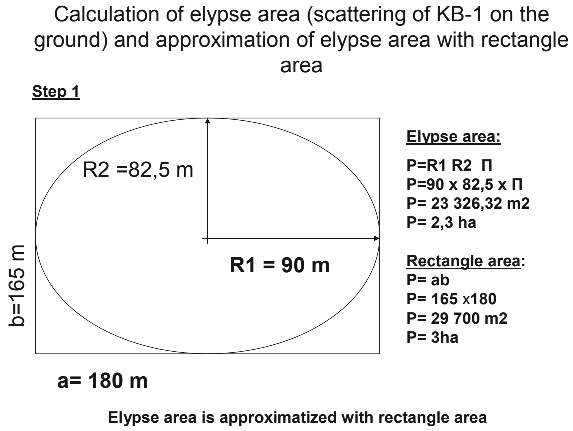


Fig. 8 Definition of KB-1 contaminated areas

4. Methodology of definition of boundaries contaminated by KB-1

4.1 4.1 Mathematical model of area definition in case of detection of KB-1

Methodology of definition of boundaries of KB-1 contaminated areas consists of:

a. Calculation of ellipse area of KB-1 scattering (P=2,3 ha); see Figure 8

b. Approximation of ellipse area with rectangle area (P=180x165 m, app. Pmax=3 ha)

c. Define the ellipse (rectangle) position in relation to the straight line and azimuth of launching the missile M87; see figure 9

d. Define maximum length L and width W of contamination area. Hypothesis: KB-1 could have been placed on 4 positions of the ellipse. Let's take maximum distance. Front, back and maximum left and right; see Figures 9,10,11

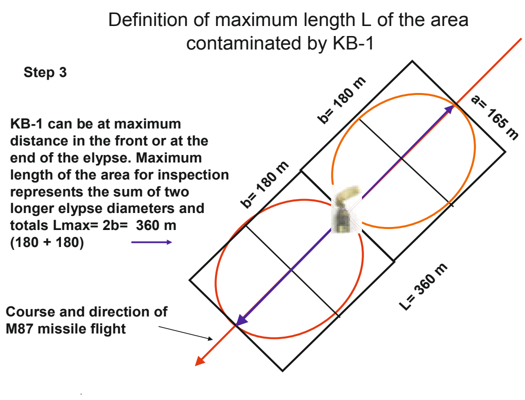


Fig. 9: Definition of maximum length L of the area

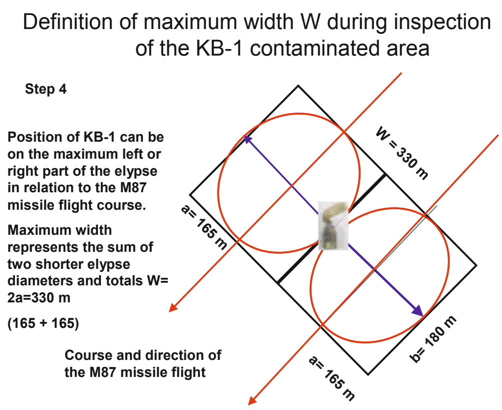


Fig.10: Definition of maximum width W of the area

e. Total area based on maximum length L and width W is 118 800 m^2 or app. 12 ha; see Fig.11

f. If more KB-1 bomblets have been found on the terrain, the position of the one in the middle is taken as a starting point of this calculation

g. If two KB-1 bomblets have been found on the area at the distance of 200 m and more (possibility as a result of 2 or more missiles M87) – the calculation is done for each bomblet separately (Fig.12)

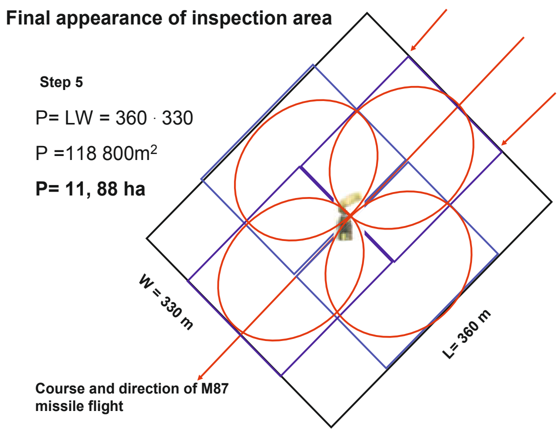


Fig.11: Total area for Lmax and Wmax

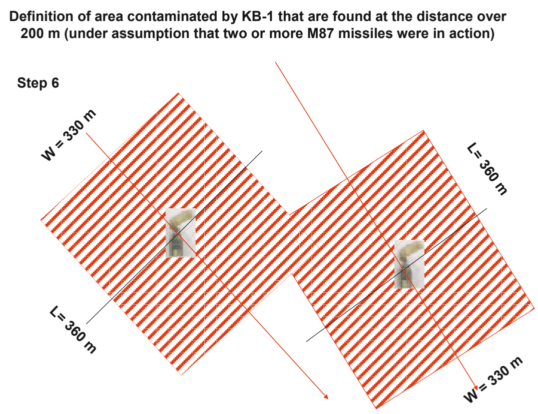


Fig.12: Areas contaminated by KB-1 as a result of several missiles

4.2 Definition of area in case of KB-1 detection with a fuze which is not armoured (hypothesis)

KB-1 bomblets with no armoured fuze can be found in the field. 8% of KB-1 or 24 pcs are not being armoured. Hypothetically, this could have happened for the following reasons:

a. The dynamics of the KB-1 bomblets flight. The bomblets are placed along the axis of the missile. The fuze is not armoured due to weak intensity of centrifugal and inertial forces that have an effect on releasing the slider in the fuze of a KB-1.

b. Construction-shaped bearing containing 24 pieces (8%) of KB-1. They are placed in the first part (top, nose) of the warhead. The pressure of propellant gasses (which should scatter KB-1 in space) did not break the first filling of KB-1 (24 pcs) so the fuzes have not been armoured.

The consequence in both cases is the free fall of KB-1 to the ground in the centre of the ellipse. In that case, the ellipse area i.e. rectangle 180x165 m (P= cca. 3ha).
This hypothesis should be checked and proven in real terrain conditions

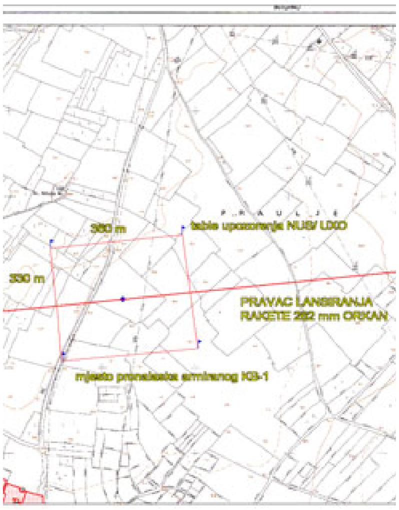


Fig.13: Definition of area on the map

Fig.14: UXO and cluster munition warning sign

5. Marking of cluster munition (KB-1) contaminated areas

After definition of maximum area contaminated by KB-1, the area should be marked by mine warning signs. The dimensions of the UXO and cluster munition warning sign are: 60x40 cm and consists of information about the possibility of running into the areas contaminated by UXO and KB-1. In tat case, they shouldn’t be touched.

6. Conclusion

This is one of the methods which can serve to define maximum area that could be contaminated by KB-1.

The conditions for implementation of this method are as follows: detection of unexploded KB-1, sufficient quantity of information about the spot the M87 missile has been launched towards the place of KB-1 detection and precise definition of azimuth in order to be able to properly form the rectangle that approximates the ellipses i.e. area of KB-1 scattering.

The method is not applicable in cases when it is established that the cluster bomb KB-1 has subsequently been brought or thrown to the area.

Mine Action in Turkey
(Border Management by the fields of landmines in 21st Century)

Kamil Murat Usun[44]

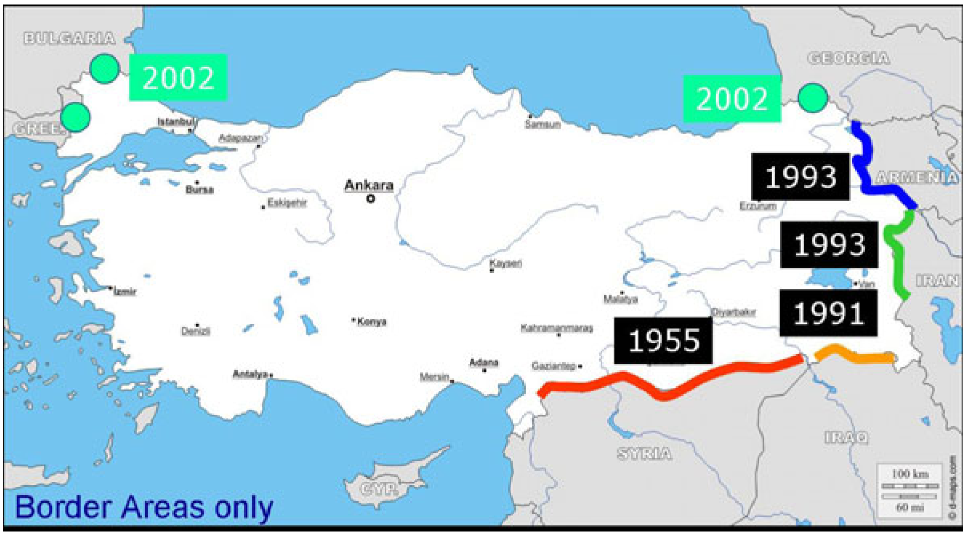
"I have seen the devastation caused by these indiscriminate weapons, which hamper reconstruction, damage the environment and cause grievous injuries and death for decades after conflicts end. My fervent hope is that the world will one day be free from the threats caused by landmines and explosive remnants of war."

Ban Ki-moon
UN Secretary-General

Mine Action in Turkey

- **History of Minefields**
- **The Impact Of Minefields On Border Management**
- **National Border Demining Projects**
- **Current Situation**

History of Minefields



44 Kamil Murat Usun TRANSTEC SA, Land Mine Clearing Expert, Technical Assistance For Mine Cleaning Activities Under 'Socioeconomic Development Through Demining and Increasing the Border Surveillance Capacity at the Eastern Borders of Turkey Phase 1' Project.

As it has been indicated in previous Meetings of the States Parties, Standing Committee meetings and Article 7 reports, a great majority of anti-personnel mines in Turkey are found along the borderlines. Turkey's western borders with Greece and Bulgaria, as well as the border with Georgia however, are mine-free.

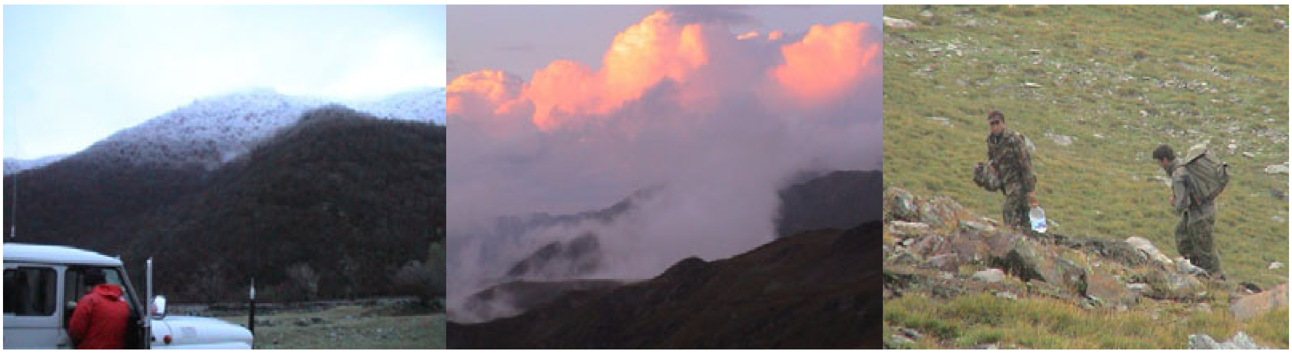
Following an increase in smuggling activities smugglers shot two Turkish customs agents dead in 1956 and the Turkish army laid landmines along Turkey's border with Syria. The anti-personnel landmines were meant to discourage the smuggling activity between the two countries.

Mines were laid along the borders and certain areas outside borders until from 1955 till 1998. The purpose of the emplacements was to reinforce security of the borders and military bases in fight against terrorist organization.

Location	Size of mined areas (app. square meters)	Number of mines[45]
Armenian border	1.291.500	20.430
Azerbaijani border	85.800	2.990
Iranian border	14.321.800	198.570
Iraqi border	5.917.500	69.050
Syrian border	190.500.000	615.450
Total	212.116.600	906.490

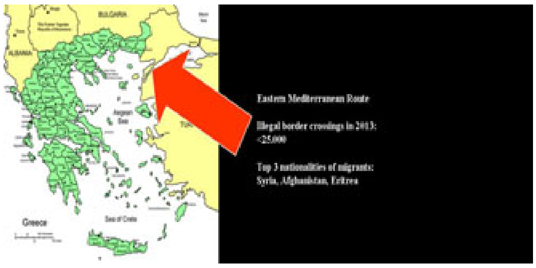
In addition to borders, a total of 637 mined areas containing 97.446 mines (2.615.648 square meters) are located around military installations throughout 11 Provinces.

The Impact of Minefields on Border Management



Mine contaminated areas make it difficult to patrol along the border for surveillance. The landmines had been used along the borders as a deterrent factor to prevent illegal migration within the context of providing border security.

45 http://www.apminebanconvention.org/fileadmin/APMBC/clearing-mined-areas/art5_extensions/countries/Turkey-ExtRequest-Received-29Mar2013.pdf



However, according to FORENTEX reports, illegal border crossings in 2013 are more than 25.000 from top 3 nationalities: Syria, Afghanistan, Eritrea by the illegal border crossing main route called Eastern Mediterranean Route through Eastern Borders (Armenian, Azerbaijan & Iranian borders) and Syrian border.[46]

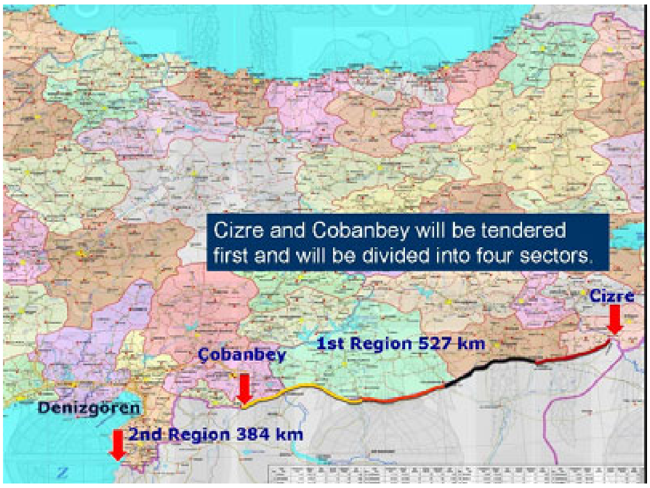
National Border Demining Projects

Two major demining projects:

- Turkey -Syria Border Demining
- Clearance on the Eastern Borders of Turkey

Turkey -Syria Border Demining

The project to clear the mined borderline with Syria, which is 911 kilometres long and on average 350 metres wide, is a major undertaking by any standard (total area is 190 mln. square meter).



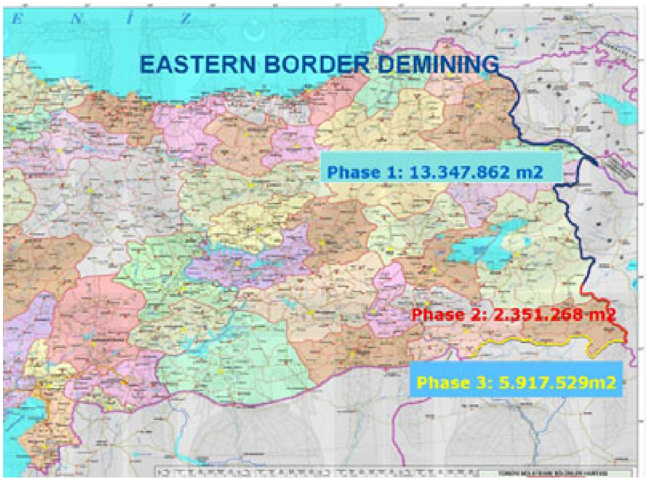
The Project planned to be financed from national resources. The project for the initiation of clearance was started in February 2011, with the signing of a "Sales Agreement" between the Ministry of Defense and the NATO Support Agency (NSPA). Turkish Ministry of National Defense announced 20 international joint ventures as finalists for bidding to demine Turkey -Syria Border in February 2012. The Ministry expected to finalize the selection process by Nov 15, 2012 but the worsening crisis in Syria affected directly Turkey -Syria Border Demining Bidding Process. Turkish Ministry of National Defense has cancelled the tender due to the

46 http://frontex.europa.eu/assets/Publications/Risk_Analysis/FRAN_Q1_2014.pdf

military clashes in Syria. New Tender process is expected to commence by the end of the conflict.

Clearance on the Eastern Borders of Turkey

The overall objective of the Project is to contribute to the social and economic development through demining and more secure borders in Eastern Turkey. Component 1 (service) of the project is to clear of 223 known minefields on the Armenian, Azerbaijan & Iranian borders with Turkey in the provinces of Ardahan, Kars, Iğdır, Ağrı &Van. Component 2 (Supply) of the project is to purchase the border surveillance equipment for the cleared regions.



Each phase is expected to take approximately 2 years to complete following the signing of the tender. The sum of the area that will be cleared of mines within the framework of the project is 21.616.659 m^2. The financial agreements for phase 1 and phase 2 were signed in December 2012. Two thirds of the total cost of the first two phases will be covered by the EU. Project will be overseen by the Ministry of Interior with active contribution by a project implementation group comprised of the Turkish General Staff, Ministry of National Defense and Ministry of Finance.

The draft tendering schedule to be carried out by UNDP:

Call for Expression of Interest	27th October 2014 (actual 17th November 2014)
Submission of Applications:	[by 10thNovember 2014]
Results of Prequalification:	[by 15thNovember 2014]
Request for Proposals:	[by 21stNovember 2014]
Submission of Proposals:	[by 2nd January 2015]
Evaluation of Proposals	[by 15thJanuary 2015]
Contract Award and Negotiation:	[by 30th January 2015]

Tender schedule is ongoing in accordance with the Project, "Preparatory Work for he Demining of the Eastern Borders of Turkey" between Central Finance and Contracts Unit (CFCU) and UNDP. The Expression of Interest (EOI) was released by 17th November 2014 but amended with 1 amendment notice & 6 announcements postponing the deadline and the announcement of the final EOI document.[47]Since UNDP had shared no revised schedule for tender, no clue for the next stages of the tender.

47 http://procurement-notices.undp.org/view_notice.cfm?notice_id=19418

Current Situation

Turkey acceded to the Ottowa Convention in 2003, and the Convention entered into force for Turkey on 1 March 2004. Turkey undertook to destroy or ensure the destruction of all anti-personnel mines in these areas as soon as possible but not later than 01 March 2014. In total, Turkey reported having destroyed nearly 3 million stockpile landmines. Turkey cleared 974 anti-tank mines and 25.047 anti-personnel mines including areas other than borders. On 28 March 2013 Turkey submitted a request to extend its mine clearance deadline. The request was granted and a new deadline was set for 1 March 2022.

The Ministry of National Defense has worked to establish a National Mine Action Authority (NMAA) and National Mine Action Centre (NMAC) which will supervise mine clearance activities, develop National Mine Action Standards and issue certificates for released areas in accordance with these standards. Recently,
Delegation of the Turkish Ministry of Defense visited HCR-CTRO on 5th December, a delegation of the Turkish Ministry of Defense, visited HCR-CTRO. The delegation had talks with HCR-CTRO Director Nikola Pavković, CROMAC Director Dražen Jakopec and Director of the Cluster for Humanitarian Demining, Oto Jungwirth.[48]

"The Law on the Establishment of a National Mine Authority and Mine Action Centre" is approved by parliament at 23 January 2015. The law includes details concerning the structure of the mine action centre, the responsibility and location of the mine action centre as well as a number of different issues.

Conclusion

Establishing a technologically supported border security system requires demining. The establishment of good functioning border surveillance systems leads to a decrease in the efficiency in the fight against illegal migration, cross-border crimes and smuggling. Demining is an indispensable part of the border management reforms. Clearing the mines will boost economic activity and create jobs in the agricultural sector and possibly in other industries.

However it takes time, Turkey is on own way to get rid of old fashioned border guards in 21st Century which consist of minefields.

48 http://www.ctro.hr/en/news/185-delegation-of-the-turkish-ministry-of-defense-visited-hcr-ctro-doo

TIRAMISU: Progress in Developing New Tools for Mine Action

Yann Yvinec[49]

Introduction

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

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

Progress in 2014

In 2014 important floods hit Bosnia-Herzegovina, Serbia and Croatia. Mines were moved and a new assessment of the situation was necessary in a short notice. An unmanned aerial system was deployed in Bosnia-Herzegovina in order to help BHMAC and various emergency organizations, such as the Belgian Fast Aid & Support Team [2][3][8].

Collecting data on suspected hazardous areas is a key activity to speed up the land release process. Some research is being done on methods to gather such additional information from remote sensing images and use this information to assess how likely an area is to be mined [13][18][19][27][28][36][41].

The development of the LOCOSTRA vehicle is continuing and an accreditation by CTRO is planned for 2015 [7][31].

The use of sensors mounted on unmanned ground vehicle for detection, technical survey of quality control and assurance is being investigated worldwide [35]. Some solutions developed in TIRAMISU were tested in particular in Belgium in July 2014. These systems include a multi-channel metal detector array [4][9], a densely-sampled ground penetrating radar array [33], among others. Some of these tools were tested in an international challenge [22]. A light-emitting polymer sensor to detect explosives for humanitarian demining is also developed [12][23][24][29][30][32]. It could be used for detection, technical survey and in coordination with the use of bees to detect explosives. Intelligent prodders are also being developed and evaluated for excavation and training [1][11]. A Field and Service Robotics backpack is also proposed [34].

When collecting a lot of data from different ways on the same areas, it is important to be able to manage all this information geographically. For this a repository system has been developed [20][39].

Training operators to the use of remotely-control vehicles in mine action may be a long process that may require the use of the vehicles, which therefore are no longer available for real work. This is one reason why we are working on computer simulation for training [5][21][24][25][26]. Methods to improve the training of operators to the use of hand-held detector are investigated too [10].

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Experiments show that several projectiles cause more damage when they hit a piece of personal protective equipment (PPE) almost simultaneously than one at a time. This is something that should be tested when evaluating the relevance of a PPE for a given mine action activity. This is one of the ideas behind new guidelines to test and evaluate PPE for mine action [16]. We have also proposed guidelines to evaluate demining machines [6].

Transporting explosive hazards to where they will be disposed of is sometimes as dangerous as finding them. A dedicated container has been designed and tested for that purpose [14][17]. Improving the efficiency of neutralization of explosive hazards is also investigated [40].

After a test in Algeria the radio-broadcast theater play "Billy Goat" was tested in a very different context in 2014: Cambodia [37][38]. The use of video games to teach children lessons on the risk of mines will be evaluated in 2015 [15].

Acknowledgment

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

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13th IARP WS HUDEM'2015

A DEMINERS WISH LIST

(Will emerging technology improve quality and reduce costs to aid efficient Landmine Clearance?)

The tools of Tiramisu and D-Box are reviewed against the author’s field and contract experience in an attempt to judge the likelihood of progress emanating from novel technology and the Seventh Framework Programmes. Whilst robots have a secure place in EOD, have they commercial value in Landmine Clearance? In 2015 improved access to satellite imagery, UAV imagery and GPR detections capture my interest.

Colonel (Retired) Stewart Grainger – ssgrainger@btinternet.com

INTRODUCTION

Advances in mine resistant vehicles, digital mapping, Google maps, GPS, fax, internet, e-mail, databases, digital cameras, smart phones, laptops and insurance have all helped deminers in recent years. However, we do have accidents and we would like to do better to help rid the world of the landmine menace. This short study is a personal attempt to ascertain what advances might be available soon to improve our practices and performance.

The views expressed in this report are those of the author. This Study is made as a Humanitarian Landmine Clearance Contract Manager. If promising tools or technologies have been overlooked, please let me know.

WHY TIRAMISU AND D-BOX?

These Seventh Framework Programmes are addressing the whole Demining process and seeking tools at various stages of development that can be demonstrated to show tangible improvements to performance, safety and cost. As such, both programmes are seeking to help deminers planning in the office and in their work in the field. Thus, a review of these programmes should indicate where and when advances might be achieved, soon. Both Tiramisu and D-Box are in their final year and both are due to demonstrate their findings towards the end of 2015. As such, advances may be forthcoming between now and the demonstrations that might affect the conclusions of this Study.

STUDY METHOD

This “Wish List” is generated from my personal experience and memory. D-Box has an End User Platform in which I am actively involved. Information regarding Tiramisu was gathered from the programme web site and through contacts with the Project Coordinator – Yann Yvinec, to whom I thank for his patience and time. The restrictions on the length of papers preclude a full documentation of my Study. Accordingly, I focus on key wishes and my conclusions on the tools that show promise, today.

MY WISHES

I suggest that my wishes, see Table 1, are self-explanatory except for these that I describe below.

Efficacy. This a general wish that pervades every aspect of my demining. The wish is to clear mines as cheaply and quickly as possible in order to:
Return land to the owners so that they can get on with their lives,
Give Donors Value for Money and,
Clear greater areas for the same funding.

Ethical Demining. It is evident that donors and some international and national agencies demand ethical demining. Thus to secure contacts NGOs and companies must work accordingly. The key topics are: equality, freedom of speech, openness and the respect of human rights. The key for me is to employ local people to give business to the area and the opportunity for people to feed their families.

Serial	Wish	Notes
1	Efficacy	General wish to clear more land, faster with less effort
2	Ethical Demining	Work in line with Humanitarian and Donor's demands.
3	Combat Major Distractions a. Accidents b. Religion c. Customs d. Terrorists	 Minimise errors/accidents. Respect festivals, holidays and sites. Respect local laws, behaviour and dress. Awareness and information of terrorist activities.
4	Information a. Access to all available hazard data b. Access to all available hazard information. c. Local process of assessing data and its conversion into information d. Best Geographic Data e. Best Geological Data f. Safe Routes g. Local Laws, Contacts and Suppliers	 All available and up to date data. NMAA/MAC assessments. Possibility of overlooked data. GIS and maps, weather, terrain and ground cover. Soil and subsoil. Weekly incident updates from NMAA/MAC. Employment Law, Traffic Regulations and local military, police, government, community and business contacts.
5	Satellite Imagery	Economic, useful and interpreted.
6	Aerial Photography	Economic aircraft, helicopter and UMA photos.
7	IMSMA	User Friendly and electronic links.
8	Clear display and handling of Data	Digital geographic based layers for reports and briefings.
9	Mine Risk Education	Contact with local organisation and availability of locally useable tools.
10	Remote Detection a. Detect ERW b. Detect Minefields c. Identify and locate Hazard Areas	Keep feet off contaminated land. Focus effort. Cancel and Reduce Land.
11	Close-In Detection a. Improve Probability of Detection b. Reduce False Alarms Rate c. Locate of Detections d. Identify buried objects	 Reduce Missed Mines. Reduce time spent on excavating rubbish. Printout to aid recording and neutralisation. Reduce False Alarms and aid selection of neutralisation tool.
12	Neutralisation	Economic tool for ease of shipment, storage and accounting. Remote Neutralisation.
13	Select Right Tools	Aid to select best tools for tasks.
14	Personnel Protection	Protection to match the threat. Priority for Hand/Arm protection.

Table 1: My Wish List

Combat Major Distractions. Work can be seriously upset by accidents; breeches in respect of religious sites and festivals; failure to observe national and tribal customs and clashes with terrorist organisations and their military locations. Demining managers must plan ahead and reduce the chances of such distractions happening. Individual deminers must be made aware of the problems so as to adjust their behaviour.

Satellite Imagery. Imagery may now be coming affordable and satellite sensors more attuned to demining. The detection of minefield indicators can help in the definition of hazard areas in the Land Release process.

UAV. Light UAV are incredibly stable and capable of carrying mine sensors. The work of TIRAMISU and D-Box is of great interest, and hopefully promise in detecting and locating hazard areas.

Remote Control/Robots. All tools that help keep "Feet off the Ground" are of interest for safety. As there are promising platforms now available for the deployment of sensors and ground preparation, my search is for the tools for use on these platforms.

POTENTIAL AND PROMISE

Tools Available.

T-AIDSS. Advanced Intelligence Support System – used in CROMAC.
T-Priority. On Line program to prioritise mine clearance tasks see the web site.
Mine Risk Education. Plays, artwork and videos.
Unmanned helicopters and remotely controlled platforms.

Tools with Promise. Promise is evident corresponding to my wishes as follows:

Ethical Demining. The Aide Memoire and Cultural Guidelines will assist managers and deminers in planning.
Combat Major Disruptions. The Aide Memoire, Cultural Guidelines, Error Reduction Methodology and Management Tools will help efficient and enlightened management and the capture of "best" information.
Best Information. Both D-Box and T-IMS should give managers the means to acquire and assess all available information.
Satellite and Aerial Imagery. Potential improvements in access and processing may aid the definition of hazard areas.
IMSMA. T-IMS and D-Box have potential to share information electronically and more easily by computer Users.
Displays. T-IMS and D-Box will provide clear images and georeferenced layers for records and briefings.
Remote Detection. Access to useful imagery and the remote transport of sensors should aid safe detections. The Manmade Camera could prove to be an asset in the detection and location of cluster munitions and ERW on the ground surface and in trees.
Close-in Detection. It will be interesting to see if ALIS proves to be a commercially viable humanitarian tool. The multi-channel metal detector is in a similar situation. As most accidents and injuries are caused during the excavation of ERW, the intelligent prodder must be monitored.
Neutralisation. Blast containers can help in the safe removal and disposal of ERW.

CONCLUSIONS

Whilst some of the TIRAMISU and D-Box tools are available now, the Technical Readiness Level of many of them is not sufficiently advanced for them to be commercially available or assessable. Probably the most critical factor, cost, was not available.

I am disappointed not to see programs to aid the selection of tools for detection and neutralisation.

As a Contract Manager I have particular interest in the potential of the management tools, T-IMS and D-Box, and the Aide Memoire and Cultural Guidelines to improve my planning, the capture of information and the execution of demining tasks.

I welcome an opportunity to attend the final demonstrations of D-Box and TIRAMISU, and also HUDEM 2015 to up-date myself and to check on the tools of promise.

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Table 1: TOOLS OF TIRAMISU AND D-BOX

SERIAL	TASK	TIRAMISU TOOLS	D-BOX TOOLS	PROMISE TODAY
1	Mine Action Management	T-IMS. T- Priority. T-A1 DSS.	D-Box Planning and Operations. Aide Memoire, Cultural Guidelines. Error Reduction Methodology. Mine Risk Analysis.	T-PRIORITY- Available T-A1-DSS - Available Aide Memoire. Cultural Guidelines. Error Reduction Methodology.
2	Advanced General Survey	T-IMS, T-SHA.	D-Box Planning	D-Box Planning.
3	Non-Technical Survey	T-IMS.	D-Box Operations	T-IMS. D-Box Operations.
4	Technical Survey	T-IMS.	D-Box Operations	D-Box Operations.
5	Remote Detection	T-IMAGE. MAV/UAV, Honeybees. Explosive Vapour Detector.	Satellite image acquisition and processing. Biosensor Laser. LWIR Thermal Camera, Man Made Camera. UAV. UGV.	T-IMAGE – with T-AI-DSS. Satellite image acquisition and processing. Man Made Camera. UAV/UGV - Available
6	Close-in Detection	ALIS. TRIDEM. CISC. LOCOSTRAv2 tEODor. Multi-channel Metal Detector. Densely Sampled GPR Array. Chemical Sensor. Intelligent Prodder.	3D Lidar. Acousto GPR.	Multi-channel Metal Detector. ALIS. Intelligent Prodder.
7	Identification of ERW	Spinator Ordnance Database - EOD IS	Hazard sources and Effects Database.	EOD IS – Available.
8	Disposal of ERW	Blast Containment Vessel.	Disposal Database.	Blast Containment Vessels.
9	Neutralisation of ERW	AP Neutralisation Set. RDX Disposal.	Laser. Neutralisation Database.	Note: The content of proposed databases has not been checked.
10	Protection	PPE Testing.	PPE Testing and Database	
11	Mine Risk Education (MRE)	Billy Goat Radio Play.	MRE Knowledge Base.	Available
12	Training	Training of End Users.		
13	Standards:	Machines for TS. Evaluation of PPE.	NTS Procedures. Cultural Guidelines. Taxonomy of Climate and Terrain.	

IA/00/089

Human Error in demining

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Abstract

The D-BOX project is funded by EU Framework Programme 7 to provide a Toolbox to assist in humanitarian demining. Uniquely it includes Tools directed at the human and societal issues encountered in such work. Human error is one such issue. The paper discusses error in the context of demining operations and describes its effects on safety, productivity and profitability.

Accident data from the Reporting, Analysis and Prevention of Incidents in Demining (RAPID) database maintained by GICHD were found to be of limited value, because in 46% of cases the causation was unknown. The independently maintained Database of Demining Accidents (DDAS) was more informative. From the number of records whose causation field contains terms related to human error, it was concluded that error has contributed to 83% of the accidents recorded.

The opinions of demining Subject Matter Experts (SMEs) regarding human error were gathered by e-survey, at Mine Action conferences (Šibenik, 2013 and Zadar, 2014) and from the D-BOX End-User Platform. In order of frequency, the principal causes of error identified were:

- Psychological (boredom, poor concentration, complacency, over-confidence, fatigue) – 39%
- Management (supervision, training) – 35%
- Practical (terrain, equipment) – 13%
- External pressures (funding, time pressure, targets) – 7%
- Socio-cultural (status, 'face') – 6%

To reduce the frequency of error, most SMEs suggested enhanced training and supervision – both activities being part of the management role. The third most frequently mentioned solution was to improve the demining procedures. This reflects the difficulty of procedure writing, particularly where the target audience has variety of first languages. Demining procedures should perhaps be developed by specialists.

The final output of the research is a methodology to support the identification and assessment of the sources of error arising from the D-BOX Tools. To be used within the 'Human HAZOPS' process, it consists of a spreadsheet with pre-determined keywords to elicit the credible errors and their mitigation. Use of the methodology should make it possible to reduce the frequency of errors on the minefield, mitigate the associated risk and improve deminer welfare and safety.

1. Human Error

People make errors throughout their daily lives. It is part of being human, and we are all familiar with what is involved. However, the concept of human error is difficult to define. Indeed, some analysts go as far as to deny its existence in industrial contexts, maintaining that if an action has an undesirable outcome it is the inevitable consequence of poor ergonomics, poor training or poor procedures [Ref 1]. Some of the more useful definitions are given below.

1.1 What Is Error

Many definitions of error have been used extensively in the published literature. We will adopt the following one: "Something done that was not intended by the actor, that was not desired by a set of rules or an external observer, or that led the task or system outside its acceptable limits" [Ref 2], because of its important inclusion of inadvertence.

Examples of actions that can be considered errors in the demining domain include:

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- Unintentionally disturbing an explosive device
- Misreading a map
- Using a misleading, unclear or offensive word in speech or writing
- Mishearing spoken commands
- Mistranslating written procedures
- Misreading a gauge, dial, clock-face or computer printout
- Entering incorrect data in a database or report.

It is important to distinguish the commission of an error from the occurrence of a hazardous event. Most errors are harmless; most are recovered immediately; most result only in delay. What is of interest is the tiny minority of errors whose consequences are serious.

1.2 What Is Not Error

It is also instructive to identify events that do not fall into the definition of error:

- **malevolent acts.** Deliberate actions taken by people with destructive effect, such as vandalism, sabotage and physical attacks.
- **deliberate departure from procedures**. These behaviours (sometimes called 'violations') are surprisingly common. They usually arise from poorly written procedures, in which the importance of carrying out a particular step is not made sufficiently clear. Often however the user will depart from a procedure because they believe it to be wrong – they consider it to contain pointless and time-wasting steps, perhaps, or they have little confidence in the abilities of its author.
- **equipment malfunction**: despite the all-too-familiar messages arising from fragile software, machines cannot be described as making errors – they malfunction or fail.

Events of these types can be expected to occur, but their frequency cannot be predicted. They can be prevented only by removing the human from the system. This is seldom practicable.

2. Predicting Error Probability

The most well-known and frequently used method of predicting HEPs is the Human Error Assessment and Reduction Technique (HEART) [Ref 3]. It is a phenomenological method: it has little theoretical underpinning but can nevertheless produce plausible results. Its popularity rests on its breadth of application and its simplicity.

The probability of error also depends on antecedent events. For example, an earlier error (whether by the same operator or another) might cause greater vigilance (reducing the HEP) or cause greater nervousness (raising the HEP). The concept of dependence extends to supervisory tasks, in which the probability of error depends on the relationship between the people involved. The effectiveness of supervision is reduced if both operators have had the same training, have the same cultural background, have worked together for many years and socialise outside work. They no longer act independently. The growth of trust between them – so important to the effectiveness of an organisation – can actually increase the probability of errors of supervision. HEART does not model dependence.

3. Current Error Mitigation in Demining

Over the years, the demining industry has developed hazard mitigation measures such as international standards, qualification and accreditation of individuals, and procedures.

3.1 Standards

The International Mine Action Standards (IMAS) aid safety and efficiency during many demining activities. They are maintained by GICHD. A team of experienced demining managers, based in Geneva, holds regular meetings with active demining managers to promulgate their work and to gather feedback to check that standards and procedures are kept in harmony with experience in the field.

3.2 PROCEDURES

Produced by the demining operators, the SOPs provide guidance on the conduct of specific actions to complete the demining project. They are derived from the IMAS in the light of the local conditions, the deminers, the ordnance and its location.

3.3 RECRUITMENT

Because managers plan and supervise training and operations, their quality, attitudes and experience greatly influence the efficiency and safety of demining projects. Many supervisors and team leaders, particularly from countries such as Lebanon, Mozambique and Zimbabwe, will have contacts with deminers from earlier contracts and they will offer lists of deminers to prospective employers. During mobilisation and accreditation, these individuals will be prepared for their tasks and their suitability and performance will be tested.

3.4 TRAINING

Normally, demining recruits will be selected from those having the skills of basic training and some experience. If the project includes local volunteers with no experience (in accordance with the Cultural Guidelines [Ref 4]), selection tests will be administered and basic training provided during the mobilisation phase.

3.5 SUPERVISION

Deminers must be focused, competent and confident to safeguard themselves and their teams against accidents. That demands good health and attitude and an absence of mental or physical distractions. Managers and supervisors will monitor the health, rest, feeding and accommodation of their employees to ensure they are fit for work. Once at work, the supervisors and team leaders will monitor the deminers in the field to check that they are working on the correct task, in defined areas and to the SOPs. Supervisors and team leaders will be nearby to provide advice and encouragement. Whilst risk assessments and SOPs will cover the threat, situation, procedures and inspections, it is unusual to find specific procedures to reduce human error. This matter is discussed further in Section 3.6.

3.6 SAFETY CHECK

It has been shown in many industries, from aviation to surgery, that the effectiveness of a safety check of this type is greater enhanced by the use of a checklist [Ref 5]. A checklist reduces the opportunity to omit items and allows the results to be recorded contemporaneously. The demining safety checklist must cover a broad range of subjects, but from the perspective of reducing error, it should include a consideration of any conditions that might affect the precursors to error, such as extreme weather, ground saturation, different ground cover or tight deadlines. It should cover the following subjects:

- The health and state of mind of the deminers
- The condition of the equipment provided for the tasks, its calibration, sensitivity and state of its power supply
- The availability and condition of the PPE
- The safe working distances between team members
- The presence, serviceability and readiness of medical support and evacuation vehicle
- Special conditions increasing the probability of error.

Insofar as the safety check must be conducted correctly and at an appropriate time, it should be enshrined in a SOP.

4. Database of Demining Accidents

The Database of Demining Accidents (DDAS) is a valuable resource of information on humanitarian demining accidents, maintained independently of the primary demining agencies [Ref 6]. It is an *Access* database with 804 detailed records (going back to 1999) that have been obtained from sources worldwide, including the United Nations Mine Action Service (UNMAS). The following deductions can be made from the DDAS data:

- Human error plays a part in most demining accidents
- AP mines cause the most casualties to deminers

- Most accidents occur during the excavation of AP mines
- Supervisors are involved in 12% of the recorded accidents.
- 10% of accidents are fatal and about 40% severe
- Surprisingly, only 2% of injuries are to the foot
- Most injuries are to the hands

5. RECOMMENDATIONS

The work carried out on this Task has given rise to the following recommendations for the reduction of error in demining:

- Demining managers should attend the courses run by GICHD (and other national agencies) to enhance their training skills. Where practicable, the courses attended should be accredited by a professional teaching body, such as the UK’s National College for Teaching & Leadership [Ref 7]
- Specialists in Human Factors and technical authorship should collaborate with demining managers in developing demining SOPs
- Research should be conducted into ways of mitigating the psychological sources of error when demining, such as boredom and over-confidence
- Funding should be made available for research and development into improved demining equipment,
- D-BOX Tool designers should follow the Human HAZOPS methodology to reduce the likelihood of error in the use of their Tools
- Research should be initiated into improved hand protection for demining activities
- The demining safety check should be based on the use of a checklist and contained in a SOP
- Safety checks should be considered an essential part of the operators’ SOPs and used every day (and whenever a new task is started) to help reduce human error
- Deminer training, particularly for managers, should include error identification and reduction techniques
- Signage in and around the minefield should meet recognised intelligibility criteria.

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D-BOX www.d-boxproject.eu

13th IARP Workshop on Humanitarian Demining and Risky Intervention

27-28 April 2015, Beograd, Croatia

Toward a multifaceted platform for Humanitarian Demining

Authors

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1 ABSTRACT

The D-BOX project aims to increase deminers' confidence in technology developing a web-enabled platform which allows them to better utilize existing technologies and foster the development of the use of new ones. The idea behind D-BOX is to create an Information Management System which incorporates the process of Land Release, whereby the use of technologies is part of the process. The system will be flexible to adapt to local needs but at the same time it will be compliant with the IMAS.

In a complex domain like demining, single technologies are rarely effective. The new platform will foster functional tool chains to realize complex tasks, information merging and synergies amongst heterogeneous tools to increase the effectiveness of the tool combinations. In the paper we establish the requirements for the new platform and give examples of Functional Tool Chain(s) and of Synergies among tools being developed by D-BOX partners.

Key-Words: Humanitarian Demining, Mobile Robotic Systems, Modular Tool-Kit Solutions, Sensor for Detection, Information Fusion, Networked Information Management, Cultural Guidelines.

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2 INTRODUCTION

Humanitarian Demining is a safety critical domain. Like in other safety critical domains (aeronautics, air traffic management etc.), the end users only make use of tools which are fully reliable and fully safe.

Information Management is also problematic because the information is shared among different stakeholders, remotely located, that in most of the cases are not willing to share information due to confidential, strategic, commercial or simply cultural reasons.

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Despite these difficulties, Demining Stakeholders should remain open to innovation as new opportunities come from new sensing technologies, from Spatial, Aerial and Terrestrial assets, and new information technologies (Content Management, Mobile and Web). Most of these technologies promise to increase effectiveness of demining operations without impacting human safety.

The project D-BOX, co-financed by the European Commission in the Call Security 2011 (Grant Agreement 284996), has developed a functional prototype and an innovative concept for Information Management which links together, information, procedures and tools.

This paper is structured as follow: Section 3 has a double role to discuss the needs of the demining stakeholders for a new platform for information management and to introduce the D-BOX solution; Section 4, introduces the concept of functional tool chains by using examples from D-BOX; Section 5 introduces the concept of sensor data fusion; Section 6 draws the conclusions.

3 D-BOX Framework

End User learning time should be dedicated to information management issues and not on learning technicalities of an information management system.

When the User learns how to use D-BOX, he learns how to manage the land release process. The Information Management tool suggests which information is required for each step of the process and which tool can be used to gather the information. Then intuitive GIS features enable the user to overlay geographical, historical and new detection provided by the tools and to define the boundaries of the hazardous. At each step, it is possible to record the baseline of hazardous areas for reporting, lessons learned and training purposes (Figure 1).

Most of the data will be provided by tools that cover large areas and that provide information on indicators of the presence of hazards without entering physically on the area, as it is discussed in Section 4.

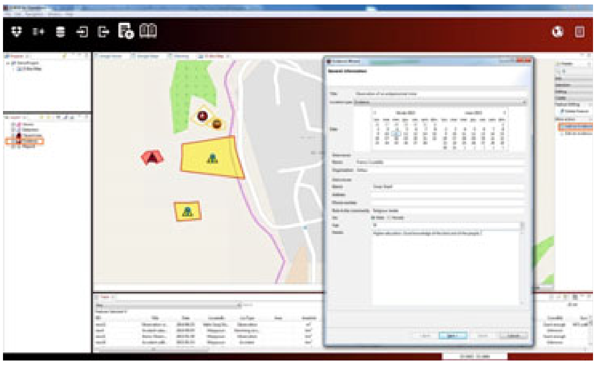

Figure 1 - Define the boundaries of a Hazardous Area with D-BOX for Operations. Baselines of Hazard Areas can be stored for reporting, lessons learned and staff training.

The places of demining span from international organizations, national offices, villages and remote regions in the countries affected by mine and ERW contamination.

Information Management has to manage the quality of the data and share the data between the correct actors.

The D-BOX architecture is composed of three main components; the first, D-BOX for Operations (Figure 1), is deployed on the user PC, provides GIS features and it is used to gather data from the source (humans or detection tool) no matter where the source is located; the second, D-BOX for Planning is a real knowledge management system and planning tool that enables collaborative decision making between stakeholders in the same organization (Figure 2); the third is the information sharing infrastructure that allows the different components to share information in a secure way. Information Sharing enables instances of D-BOX for Planning hosted by different organizations to exchange data.

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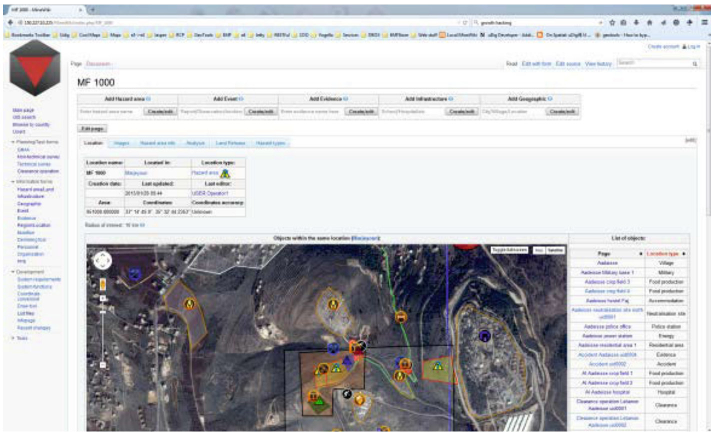


Figure 2 - D-BOX Planning Tool (knowledge management, collaborative decision making).

The objective of D-BOX is to create a value chain that includes all the stakeholders of Mine Actions irrespective of where they are located and the organization they belong to.

Data is collected from the operation field, elaborated, labelled with quality information and provided to the Mine Action Centre (MAC).

The Mine Action Centre verifies and confirms the information, defines the hazardous area and plans for the next step.

If required a report is sent to the international actors. The MAC can also share best practices and feedbacks with the GICHD. The mechanism is described in Figure 3.

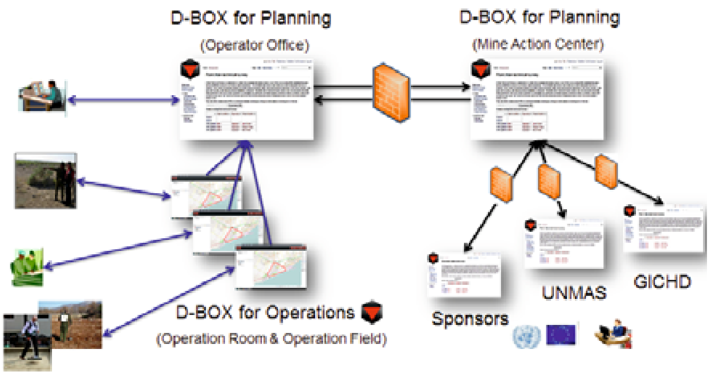


Figure 3 – A typical use case for D-BOX.

Several attempts have been made to create a global information management system for mine action. The SERWIS project, for instance, encountered the resistance of several Mine Action Programs concerned by the security of the data; they could not accept unrestrained public access to their full data base (c.f. [1]**).**

The D-BOX approach is different. D-BOX proposes the creation of a network of stakeholders that are willing to share data. Each stakeholder will select the actor(s) he wants to communicate with and the information he wants to share. The information is then exchanged in a secure way. Coordination is required on a bilateral base only.

4 D-BOX Tools

The approach proposed and adopted by D-BOX with respect to the detection tools is to arrange a functional chain of tools in a top-down fashion, where each tool supports a specific phase of the demining process (see fig. 4), starting from Long Range by satellites to close-in sub surface investigations. In particular, the following stages compose the tool of chain:

- **Long Range by satellite** aims at supporting the reduction of the scope of the investigation by exploiting Earth Observation techniques to exclude cleared area and focus on suspected area.

- **On Field Long Range** aims at acquiring detailed complementary information about the suspected area which cannot be retrieved by satellite imagery and/or which may be available by direct inspection of the investigation area (e.g.. shadowed by obstacles), by exploiting airborne platforms. In addition, airborne platform may become in the next future a sensor carrier for surface laid cluster munitions
- **Close-In Stand-Off** focuses on the suspected area(s), which has been confirmed by previous long range phases and aims essentially at close-in investigation by standoff methods, hence, without physically entering the minefield, in order to detect mines laid on the surface and swallowed or partially buried on the suspected areas, such as for instance cluster munitions. Essential tools at this stage are stand-off sensors such as thermal cameras, Man Made object detectors based on visible cameras. A detailed environmental mapping of the suspected area can be accomplished by means of unmanned ground vehicles (UGV) exploration tour equipped with high resolution terrestrial 3D mapping can be used for ground truth.
- **Close in Sub-Surface investigation** is the last stage of the tool of chain and focuses on the detection of the buried mines, by exploiting conventional commercial sensors such as Ground Penetrating Radar (GPR) and Metal Detector (MD). Indeed, one of the key points of the D-BOX approach is the compliance and the interfaceablity with respect to available technologies and currently used sensors. In addition, DBOX proposes enhancement of current technologies and novel sensing approaches which are beyond the state of the art. In particular, in DBOX the development of a prototype of an innovative autonomous multisensory system, based on the combination of a swarm of UGVs (provided with autonomous navigation capabilities) and sensor (MD, GPR, etc.) payload integration has been carried on.

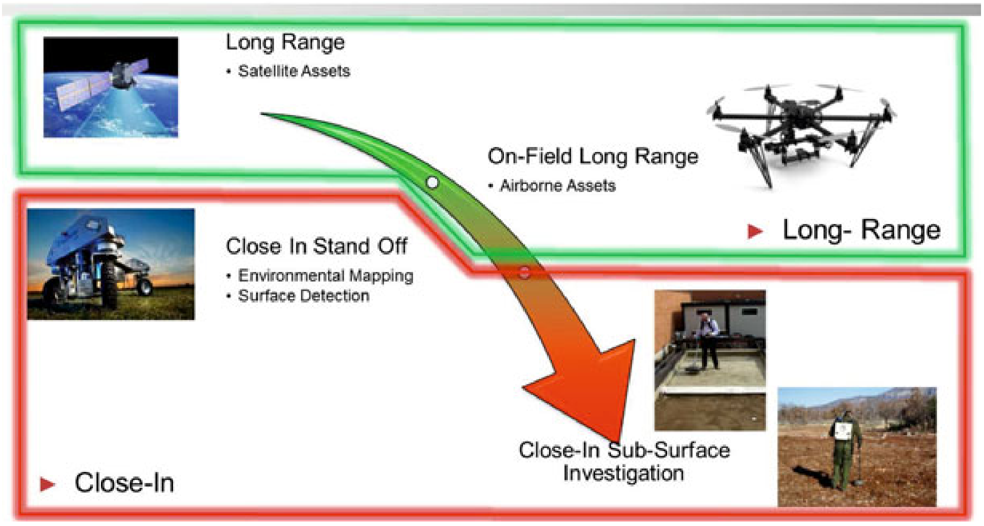


Figure 4 – Chain of Detection Tools

Information from different tools can be merged to improve the reliability of the detection (i.e. reduce the false alarm rate and improve the probability of detection), and in some specific cases sensor data can be applied. To use the above mentioned novel tools, the End User requires specific guidelines and procedures. D-BOX has also addressed these soft tools and, in particular, Error Correction Methodologies, Cultural Guidelines, Ethical Assessment.

4.1 Long Range Detection Tool

The Long Range Detection Tool aims at providing remote sensing mapping products, addressing the needs of the Mine Action (MA) community to optimize planning and preparation phases and to reduce the impact of demining activities, through long range detection techniques.

The use of Earth Observation (EO) is a promising technology, not yet fully exploited, in the framework of demining activities. In the last five years, the availability of radar images provided by the second generation of high resolution satellites such as COSMO-SkyMed (CSK) and TerraSAR-X, significantly increase the potential of EO based services.

Information obtained through space remote sensing, properly combined with ancillary information, can contribute meaningfully to several aspects of mine action planning, aimed to the reduction of land area for close-in analysis, through the detection of indirect indicators of mine presence.

With this respect, the tool developed within the D-BOX Project uses a methodology based on the combined use of different products obtained by the processing of COSMO-SkyMed data, such as a single image backscattering map or a Multi-Temporal with Interferometric Coherence image (MTC). MTC allows the generation of thematic maps and mine indicator layers supporting demining operations in their different operational phases (Planning, NTS, TS).

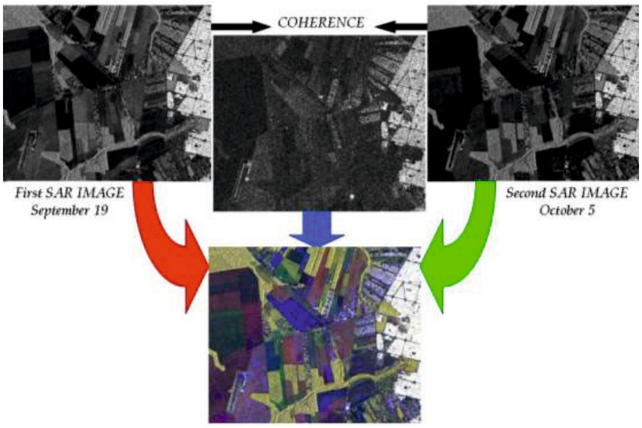


Figure 5 - Multi-Temporal with Coherence color composite methodology.

Starting from a single or multi-temporal series of COSMO-SkyMed SAR images and the aforementioned derived data as MTC, the following products are provided:

- Land Use Map
- Land Use Change Map

The scope of these maps is to provide and update the Earth observation-based layer, describing land cover and land use of areas of interest. In addition monitoring of territory evolutions and human activity through both amplitude and coherence change detection analysis.

Remote sensing and the derived products (Land Use and Land Use Change Maps) offer an economic advantage with respect to the "local" collection of information on large areas, supporting MA community during different hierarchical decision-making processes, starting from the definition of a Suspected Hazard Area, through prioritization of the intervention, to the post Land Release assessment.

Figure 6 - Example of land use map.

4.2 On-Field Long Range

On Field Long Range aims at acquiring detailed complementary information about the suspected which cannot be retrieved by satellite imagery and/or which may be available by direct inspection of the investigation area (e.g. not in line of sight or shadowed by obstacles) by exploiting airborne platforms.

An Unmanned Aerial Vehicle (UAV) adds the possibility of enhancing situation awareness within D-BOX by up-to-date high-resolution image data for environmental mapping. Unmanned Aerial Vehicles (UAV) are able to explore the hazardous area without safety risks. Another advantage is the ease of deployment when using small UAVs. Usually a single compact camera is mounted due to weight restrictions.

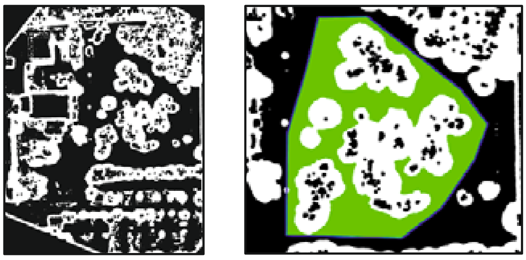
In order to cover a larger area, an UAV has and gather multiple images. These images can be merged into a combined representation by means of image processing methods, which are explained in the following. These representations allow further processing in order to assess relevant properties of the area.

Image mosaicking, where the images are stitched into a single high-resolution image is widely used. The resulting mosaic possesses a very high resolution of a few centimeters per pixel and provides a detailed view of the explored area (Figure 7) [2].

Figure 7: Image mosaic.

A geometric representation (3D point cloud and Digital Surface Map, DSM) can be acquired by photogrammetric methods like structure from motion and bundle adjustment.

Via discontinuity extraction from the DSM, the presence of buildings, obstacles, and bushes/trees can be displayed (Figure 8a). Possibly obstructive objects are shown in white while flat terrain is shown in black. Figure 8b shows a zoomed in view and an example of a referenced suspected hazard area from long range detection tools (blue line). Within this area an estimation of accessible areas (green) has been performed in order to give the operator a better insight to the area for planning and access.



(a) (b)

Figure 8: Extracted discontinuities and accessibility estimation.

The stitched image has a very high resolution but is not necessarily geometrically correct (it would be if the ground was totally flat). The orhtomosaic or 3D point cloud from the photogrammetric processing on the other hand is a geometrically correct representation, but does not have such a high resolution. So these two representations have opposite strengths/weaknesses and are both useful. The first for interpretation by a human, the second is more suited for algorithmic interpretation.

4.3 Close In Stand-Off

4.3.1 Platforms

An unmanned ground vehicle (UGV) equipped with sensors can be used for ground-based environmental mapping, detection of the minefield boundaries, and even for mapping of detected mines, if an appropriate sensor is attached.

Figure 9: 3D map over satellite image.

As all sensor measurements are influenced by noise, no single sensor is sufficient for reliable and precise localization in all situations. Thus, the UGV used in D-BOX incorporates multiple sensors for simultaneous localization and mapping (SLAM) which are combined by means of multi-sensor fusion for better robustness and higher precision. The methods and algorithms are explained in more detail in [3].

3D Light Detection and Ranging (LiDAR) is the main sensor used for 3D mapping. Since a GPS is incorporated in the fusion process, implicitly geo-referenced maps are generated (Figure 9). The figure shows the 3D map over a satellite image of the area. The elevation of the 3D map is color coded from red (deep) to purple (high).

4.3.2 Sensors

LiDAR – A LIDAR is an active sensor that measures distance to hard surfaces. There are several technologies available, one of which uses a narrow beam pulsed laser to measure the range by measuring the time of flight for the laser pulse from the laser to the target and back. By scanning the laser beam in a pattern a 3-dimensional point cloud (x, y, and z coordinates) of objects and surroundings is produced. With each point the reflected intensity is recorded. The range can be up to 300 m with 5 mm accuracy in all three dimensions. By collecting data sets from different views, and merging the point clouds, shadowing effects and drop-outs can be avoided.

The 3-D point cloud can be rotated and viewed from different aspect angels, hence revealing useful 3-D features to the deminer. Various algorithms can also be applied to detect objects behind vegetation and camouflage if multiple echo extraction is used. In a forested area, the trees can be "removed" to reveal the topography of the ground, i.e. to detect craters or trenches.

3-D LIDAR can be used to generate a 3-D map of the hazardous area, and to serve as an aid in documentation of the demining efforts.

Thermal Camera – With a passive optical camera in the long-wave infra-red (LWIR) spectral region (8-12 µm) the emitted and reflected infrared radiation in a scene can be measured. This means that objects lying on the ground can be detected as anomalies in the image. Buried objects can cause an anomaly on the ground surface, depending on differences in the thermal inertia between the object and the ground. Here, the contrast can vary with the time of day. Recording during a diurnal cycle may improve detection; in addition, differences in soil structure and vegetation above buried mines can be detected.

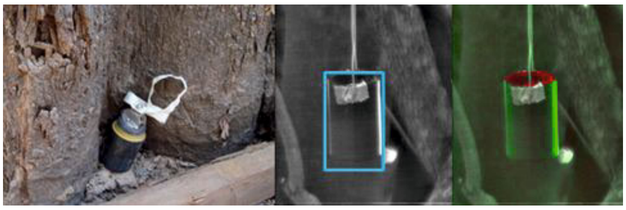


Figure 10 - Photograph of cluster munition bomblet scenario, ManMade Object detection camera automatic detection in reproduced scene, Image improved for visual confirmation of ManMade object.

ManMade Object Detector – The ManMade Object detector (Figure 10) is a novel camera design using different channels in visual light. The camera image provides the operator high contrast between man-made objects, e.g. plastic, rubber, casings and the natural vegetation in the background. Detection software is under development for automatic detection of cluster munition containers and bomblets.

Multi-camera user interface A user interface is designed for a ruggedized tablet PC that presents the images from multiple camera's (e.g. LWIR and ManMade Object detector), and allows an operator in the field to do a visual confirmation of automatic detections.

4.4 Close In Sub-Surface

4.4.1 Conventional Commercial Sensors

As mentioned above, the D-BOX is open to interface commercial off-the-shelf detection tools, which are typically used in demining activities, such as hand-held MD. Indeed, by means of a proper portable interface the data coming from the hand-held sensor can be automatically recorded and geo-referenced, in order to be easily integrated into D-BOX and merged with data provided by the other tools.

4.4.1 Beyond the State of the Art Sensors

Different novel sensor concepts and technologies have been proposed with the D-BOX.

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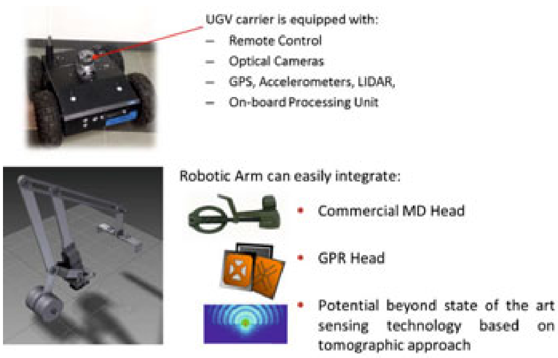

Figure 11: Distributed Sensor Network carrier.

Among them it is a multi-sensorial autonomous system, called the Distributed Sensor Network (DSN), which is based on a swarm of UGVs, provided with autonomous navigation capabilities, communication systems, and able to integrate on board heterogeneous detection sensors, such as a MD or a GPR or other possible, conventional and beyond the state of the art, detection system, by means of a proper electro-mechanical, moving, robotic arm (Figure 11). This prototype is able to autonomously explore the suspected area, without risks for the operator and leveraging on the multi-sensor payload. Different mission logics can be implemented by the swarm, according to the specific demining scenario at hand. The architecture of the system is flexible and customizable on the basis of the specific requirements of the mission.

4.5 Procedural (Soft) Tools

D-BOX contains several tools that are procedures, protocols and guides of various types. Two examples are described below.

4.5.1 Cultural Guidelines

Demining takes place in countries where there has been armed conflict or terrorist action. The contractors and NGOs employed to do it are usually from other countries with different cultures. The Cultural Guidelines provide a Tool to help demining managers assess and accommodate the cultural sensitivities of the people living in the affected area, thereby promoting the goodwill between the local community and the contractor that is vital for successful and efficient demining.

It is not feasible to embrace in a single set of Guidelines the religious and cultural requirements of all communities of the world. Instead, the Guidelines are intended to promote an awareness of cultural issues among demining contractors and to incorporate human development goals. The Guidelines are intended for use whatever the extent and effectiveness of national governance.

The following cultural topics are considered in the guidelines: Religion, Gender, Corruption, and Access to Land, Recreation and Social Life, Environment, detection technologies, Land Handover, Dress Code, employment and restoration.

Fifty-five guidelines emerged from the development process.

4.5.2 Aide Memoire

The function of an Aide Mémoire is to remind people to do things they know they must do, and know how to do, but (because they are human) they might forget to do. In the context of D-BOX, the purpose is to help demining employees to remember important points during a demining project. It should also limit any possible negative perceptions of the project or of the deminers within the local community and beyond. The Aide Mémoire Tool includes information from the Cultural Guidelines, the ethics assessment process and the human error reduction methodology

Each statement in the Aide Memoire:

Figure 12: Example page from D-BOX Aide Mémoire

- Is simply expressed, to accommodate the users' varying levels of education and familiarity with English. This reinforces the need for clarity of icons and of language.
- Starts with a positive verb – e.g. "Photograph only with permission" rather than "Don't take photographs".
- Is expressed in the active voice – e.g. "Respect accommodation boundaries" rather than "Accommodation boundaries should be respected".

It was decided to create an icon for each statement in the Aide Mémoire, because:

- Complex ideas can be conveyed with a single image.
- Concepts presented simultaneously as pictures and texts are more easily recalled.
- Icons bridge the language gap.

Figure 10 shows an example of the finished artwork.

4.6 Quantitative mine risk assessment

The Quantitative Mine Risk Analysis (QMRA) software tool supports users in estimating and analyzing the effects of intentional and unintentional explosions in individual demining scenarios. The graphical user interface of the desktop application (see Figure 13 on the left) provides functionalities which allow users to model the demining scenario to be analyzed in a virtual 3D environment. Objects such as explosive hazard sources (i.e. landmines and sub munitions), buildings and protective measures can be easily placed inside the 3D environment by using 'drag-and-drop'. Based on the generated scenario model the QMRA tool performs an automated calculation of explosion effects following the step-by-step risk analysis approach illustrated in Figure 11 on the right. Calculation results of each analysis step are displayed in the 3D visualization. In the hazard analysis, the QMRA tool calculates direct explosion effects such as the blast overpressure as well as fragment trajectories and densities. Based on this, the tool determines in the damage analysis effects on buildings and people in the form of probabilities for different types and severities of damage. Individual and collective risks for people are calculated by multiplying the injury probability with the event frequency of a possible explosion and the fractional exposure of the people to the hazard sources. To support the user in assessing the resulting risk values the QMRA tool provides existing thresholds for tolerated and accepted risks.

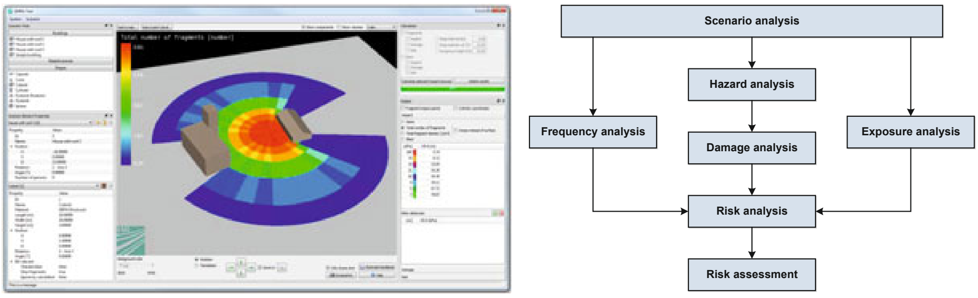

Figure 13: Graphical user interface with 3D visualization (left) and risk assessment procedure (right) of the Quantitative Mine Risk Analysis tool.

The output of other D-BOX tools can be used to facilitate the scenario modelling. On the one hand the QMRA tool provides an interface for the import of 2D pictures which show the top view of the demining scenario. Satellite images and maps, for instance, can support the exact positioning of objects, such as buildings, inside the virtual 3D environment (see Figure 14 on the left). Furthermore the QMRA tool allows the import of 3D point clouds which are generated by sensors like 3D LiDAR (see Figure 14 on the right). Beside the exact location of objects point clouds provide additional valuable information such as the height of objects.

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Figure 14: Import of satellite images (left) and 3D point clouds (right) into the Quantitative Mine Risk Analysis tool to facilitate the scenario modelling process.

The QMRA tool can be used for different purposes and in different demining phases. Basically it is an easy to use software tool to determine and visually display danger areas of possible explosions in individual demining scenarios. For instance, it can be applied during the process of clearance to check whether a building might be damaged by an explosion (see Figure 15) and whether additional protective measures have to be applied to reduce the possible damage. Furthermore, the tool can be used for educational purposes.

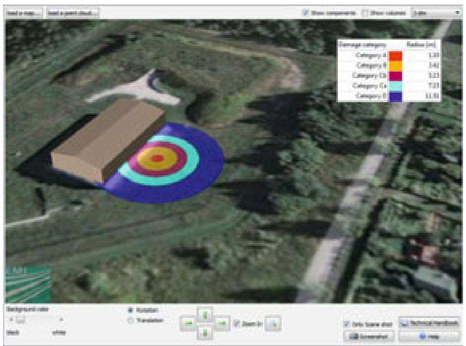

Figure 15: Expected building damage displayed in the 3D visualization of the Quantitative Mine Risk Analysis tool.

4.7 Ethical Review of D-BOX Tools

This is part of the D-BOX soft tools. D-BOX tool development process benefits by a thoroughly ethical advice and evaluation. As part of this process, *D-BOX Ethics Impact Evaluation of Tools Template* aims to inform and advice the tool developers of ethical issues relating to the design of the tools for future use in the field of operation. The methodological approach understands 'ethics' in a broader sense, as referring to *making decisions responsibly* based on *value sensitive design*. *Value sensitive design* evaluates and informs the development of technologies or procedures by taking into account human values [4]. A *value sensitive design* analysis will take into account the *technological characteristics of the de-mining technologies* and the impact on the core set of values proposed by the ECHR. In the context of de-mining technologies, the most important human rights that have to be considered are respect for private life and data protection (under the value of freedom), environmental protection (under the value of solidarity), and respect of health and safety. In terms of privacy, the robotic technologies used for environmental surveillance (UAVs, UGVs and sensor platforms) face issue strictly related to the large amount of the data collected, where also recognizable people are involved.

The Template is supplemented by the *D-BOX Ethical Impact Risk Assessment Form,* a practical tool that summarizes the ethics evaluation effort.

5 Multi-Sensor Data Fusion

The whole landmine detection task is divided into two sub-tasks - long-range image fusion task and close-range landmine detection task as shown in Figure 16. Sensors, such as satellite Synthetic Aperture Radar (SAR) imagers, will be used for mined area reduction. Data from close range sub-surface sensors, such as Ground Penetrating Radar (GPR), metal detectors and infra-red (IR) cameras will then be fused to identify mines in the reduced mine-suspect area.

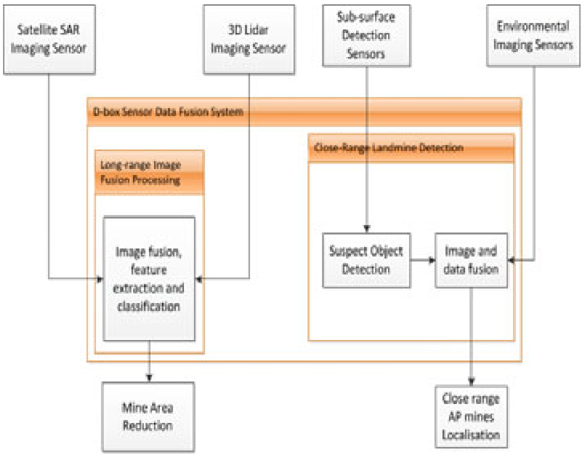

Figure 16 - Proposed D-BOX sensor data-fusion concept.

The long-range image fusion process reduces the mine suspect area through identification of key environmental indicators or geographical landmarks like rivers, roads, forests, landmine area marks, small towns, etc. Sensor data, such as satellite Synthetic Aperture Radar (SAR) and optical multispectral (MS) images as well as 3-D images e.g. 3-D Lidar, could be used as the input for that task.

First indicators of landmines could be recognized in 3-D images through feature extraction and classification algorithms.

Then 3-D images could be fused with satellite SAR and MS images to achieve reduction of the landmine area.

For the close–range landmine detection work sub-surface detection sensors could be used, such as Ground Penetrating Radar, Metal Detector and Thermal Infrared Camera as well as surface imaging sensors, providing information about the environment, e.g. man-made object detection camera, UAV mounted camera, etc.

Suspect object target recognition will be achieved by fusing the sub-surface detection sensors input at a feature level. Metal detectors are based on Electromagnetic induction (EMI) technology and are the dominant sensors in the nowadays demining practice. An induced magnetic field is measured over a target by using a time-varying magnetic field over the respective target. This technology is good for detecting buried mines in non-metallic soils, but it generates a very high rate of false alarms. Data fusion with other sensors, e.g. GPR and IR cameras, will help to discriminate between mines and other objects in order to reduce the false alarm rate of EMI sensors. GPR detects discontinuities in the ground including landmines with little or no metal content (high detection rates) but there could be also a high rate of false detections due to being quite sensitive to the type of soil and its condition, surface cover and terrain [7].

The suspect target recognition output could be fused with environmental data at a decision level to reach a final decision on the location of the landmine in the minefield. The fusion result will be superimposed on a GIS MAP to be used by the deminers for mine clearance.

6 Conclusions

Detection tools will be incorporated into the D-BOX system providing the means to transform the raw data into useful information for the End User. D-BOX will initially integrate existing tools (such as Metal Detectors) and some new tools with demonstrated capability to improve the situational awareness of the user and reduce errors. As soon as new technologies become available they will be plugged into D-BOX too. The concept of Functional Tool Chains will be extended to support the implementation of a variety of essential capabilities for mine action. It must be noted that D-BOX is not just a piece of software, but a system that is orientated to the needs of the End User, wo that the information is delivered as requested, providing procedures and guidelines to interpret and use the data. In summary D-BOX will be a comprehensive multifaceted platform which will be instrumental in creating links between the different stakeholders of mine actions, including technology suppliers.

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Our vision for the future is very simple: there are D-BOX Tools, there are TIRAMISU Tools, there are GICHD Tools and there are existing tools. Why not to converge them all towards a unique multifaceted platform for Mine Action?

Acknowledgements: the European Commission for financing and supporting D-BOX project; D-BOX partners: Terra Spatium (Greece), SELEX (Italy) and Astri Polska (Poland) for their contributions to the definition of the concept, Anders Torne (FOI, Sweden) for his contribution to D-BOX for Planning concept, to Stewart Grainger (BACTEC) for reviewing the paper.

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ERW transport container and mine roller – TIRAMISU project results

Marcin SZCZEPANIAK, Wiesław JASIŃSKI, Piotr KRYSIAK *

In the paper will be presented results of digital simulation explosion explosive charges inside the constructed for TIRAMISU project platform for transporting mines and unexploded ordnance (End Residues of War - ERW) and under wheelset of mine fail resulting in the same project. Will be presented stresses in the structure of these devices and the total effect of impact forces generated during the explosion. In the second part of the work will be shown a filed trials blasting explosive charges under real objects and the results recorded exposure: mechanical stresses arising in the construction, propagation of the shock wave and propagation of fragments. At the end of the work will be presented the conclusions from the comparison of the outcome of simulation and real results in relation to changes in the design of the proposed construction of devices. Will be presented the final version of the trailer to transport the remains of war, as well as the final version of the mine roller with a remote-controlled tractor engaged by Pierre Trattori.

1. SIMULATION OF THE EXPLOSION

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

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

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

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

The following parameters of TNT were accepted:

- density: 1640 kg/m^3;
- detonation rate: 6930 m/s;
- Chapman-Jouget pressure (PCJ): 27 GPa.

1.1. Simulation of explosion inside the container

As a result of numerical calculations, maps of displacements, strains, stresses and graphs of selected physical parameters in respect to the time were obtained.
This is presented in the figure below:
Maps of total deformations of the container body for t=2ms presented in Fig. 1.

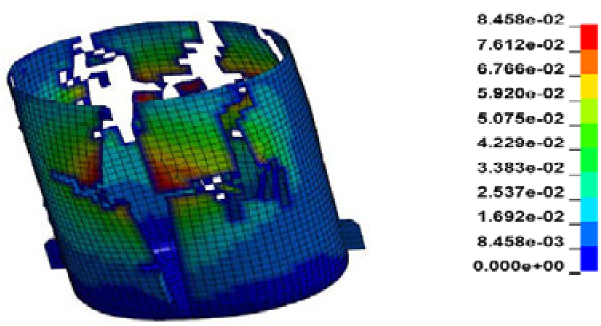

Fig. 1. Map of total deformations [m]

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Structural elements absorbing the energy of explosion (wooden boards, rubber) are completely destroyed. The container skin is deformed and there is the possibility of breaking the structure (Fig. 1).

1.2. Simulation of the explosion under the mine roller

The numerical model was built basing on the CAD geometric model. Then, the model was divided into finite elements and the physical characteristics were given by defining the materials, thickness and connections between different parts of the mine roller. Consequently numerical model of the mine roller was developed.
The explosion of 1 kg TNT applied under the middle wheel set was assumed for the computer calculations. The results are presented (Fig. 2) in the form of distribution of reduced stresses acc. to Huber hypothesis. The results are expressed in MPa.

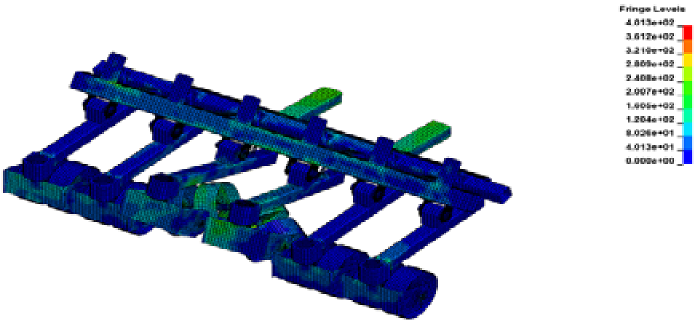

Fig. 2 Distribution of reduced stresses

It is possible that the roller which will be directly over the explosive charge can be completely destroyed. The whole mechanical construction of the mine roller will not be destroyed, because during the explosion the rocker arm together with the wheel set are to be thrown into the air (Fig. 2) and the energy is not transferred to the main part of construction. This phenomenon is confirms the design basis.
The damaged rocker arm should be replaced after the explosion. The mine clearance can continue.

2. EXPLOSION TESTS ON THE PROVING GROUND

The subject of the study were also the field tests of the container for transport and temporary storage of hazardous objects and the mine roller carried out on the proving ground. The subject is part of the TIRAMISU project.

2.1. Explosion tests inside the container carried out on the proving ground

The black foil placed on the ground and four control shields deployed around the container were used to assess the fragment scatter. The shield height was 3 m and its width was 2 m. The distance from the shields to the container axis was 6.5 m. The ICP 137A23 pressure sensors were used to measure the pulse and overpressure parameters at the front of the shock wave. The distance from the container axis to the first pressure sensor was 3.25 m, to the second sensor − 6.5 m and to the third sensor − 10 m.
The explosive charges used for testing included lethality enhancers. These charges were made of TNT pressed blocks weighing 75 g (11 elements) and a single 200 g block (1 piece). The lethality enhancers were steel balls (bearing balls) with the diameter of 6 mm. The total number of balls amounted to 2000. The 200 g TNT block has a body made of 2 mm steel sheet. The explosive charges were placed in the container and then armed with the "ERG" electrical detonators. Then they were connected to the measuring apparatus. The explosive charges were detonated by means of a TZK-100A electric blasting machine.

The effect of detonation of explosive charges is presented in Fig. 3. The container inspection was carried out after the trial and deformations of the container side surface in two areas were noted: larger, in the middle part and a minor one − of the container cover.

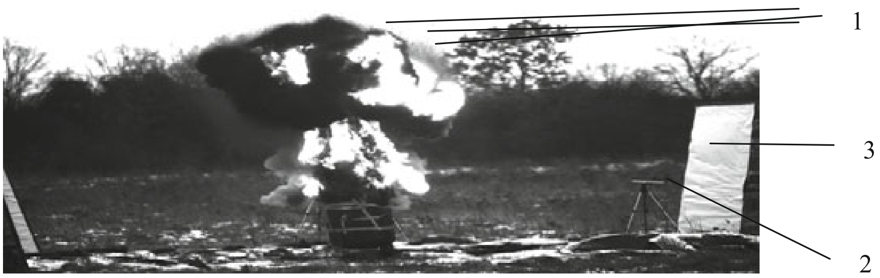

Fig. 3 Effect of detonation of explosive charges in the container
1-steel balls; 2-pressure sensor; 3-control shield

The inspection of the area covered with foil and of the control shields was carried out after the detonation. A dozen or so steel balls were found on the foil with a radius of 4.0 m from the container axis. Some wooden splinters of the damaged boards and of the cover of the cavity for explosive charges were present too. Not one steel ball had hit the control shields. The obtained results indicated that the substantial majority of balls remained in the container, only a few were ejected outside and fell around it. As a result of the impact of the high temperature of the post-explosion gasses, the wooden and rubber components inside the container had incinerated.

The experiment showed that the container was not damaged as a result of detonation of fragmentation explosive charges and that the explosion had no impact on the safety of its use. Tensile stresses of the side part of the container body, eye bolts and the frame of the container did not exceed the limit values for tensile strength. The probable cause of deformation of the container side surface in two places the impact of the 200 g block of TNT, which after detonation divided into two parts.

The maximum deformation values (Fig. 4) were 10÷11 mm and 4÷5 mm, respectively.

The courses of pulse and overpressure at the front of the shock wave registered by sensors.

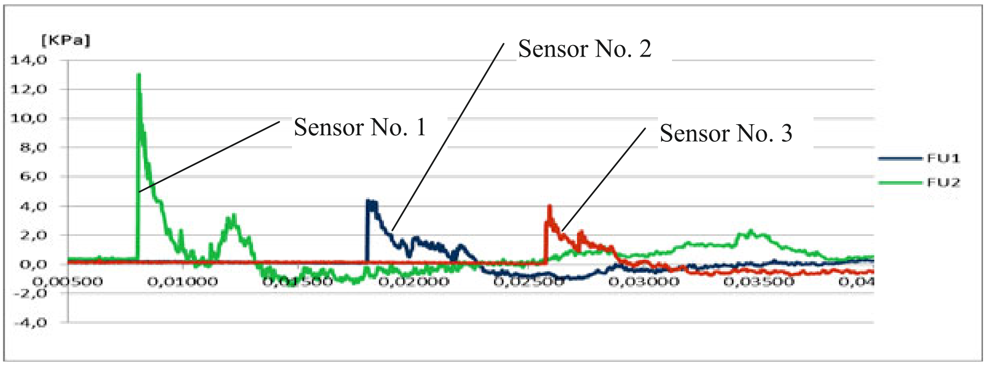

Fig. 4. The course of the pulse and overpressure at the front of the shock wave.

The peak values of the overpressure for the shock wave and reflected wave registered by separate sensors were as follows:

Sensor No. 1 – ΔP –max1 – 13.06 kPa; max2 – 3.45 kPa; (distance from the container axis – 3.25 m)
Sensor No. 2 – ΔP - max1 – 4.45 kPa; max2 – 1.74 kPa; (distance from the container axis – 6.5 m)
Sensor No. 3 - ΔP - max1 – 4.03 kPa; max2 – 2.14 kPa; (distance from the container axis – 10 m).

Area hazardous to human health and resulting from the impact of shock-wave (atmospheric pressure exceeding 0.1 standard atmosphere) measured from the centre of the explosion should equal:

a) from 0 to 6.5 m for a charge containing 2 kg of TNT,
b) from 6.5 m to 9.0 m for a charge containing 5 kg of TNT

according to the Ordnance of Ministers of Internal Affairs, National Defense, Finances and Justice (Journal of the Laws, No. 165, item 992 dated August 2nd, 2011).

Thus it can be concluded that the **hazardous area for the tested container carrying fragmentation explosive charges up to 1 kg of TNT ranges from 0 m to maximum 4 m, which is well below the Ordnance regulation**.

2.2. Mine roller tests on the proving ground

The test stand consisted of the mine roller mounted on the auxiliary frame loaded with the weight of 26.7 kN. Sequences of the selected registered images during the trial of dynamic load caused by the detonation of 8 kg cast TNT in form of 400 g 20 blocks placed indirectly under the mine roller wheel are presented in Fig. 5.

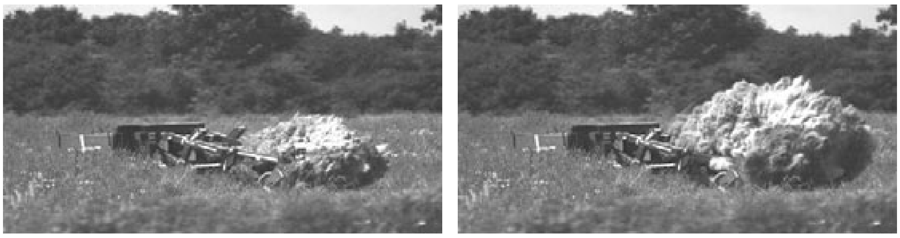

Fig. 5 Images registered during trial by the high speed camera

The above images were registered by means of a high speed camera.
Only a wheel set on the rocker arm directly over the explosive charge was destroyed. The remaining rocker arms and elements were in good condition.
The trial result confirmed earlier calculations.

3. Conclusions

The methods of digital prototyping and simulation of explosive phenomena were described in the paper. These methods were verified by experiments on the proving ground.
Generally speaking, the design basics were met. The assumed construction of the mine roller with modular structure consisting of quickly replaced elements which would be damaged as a result of explosion proved effective. In particular, the mine clearing elements (wheel sets) were designed so as to be placed on movable bars (the so-called rocker arms) which move back during the explosion thus minimizing the effects of the destruction on the device. Both the digital simulations and the proving ground tests indicate that this concept is sound and solid.
During the design of the container to transport explosives, it has been assumed that the part of energy of explosion should be absorbed by the material filling the container inside to protect the container against disintegration. At the same time, the overpressure of the shock wave will be released vertically upward through the shutter structure of the upper container cover. The design of the shutter/grate should not allow significant ejections of the solids from the container. Basing on the tests carried out, it can be concluded that the design basics have been met.
The designed container should comply with the legal document connected with the impact of the shock wave. In this paper, it has been shown that the hazardous zone for the tested container has a radius of 4 m, what is not only acceptable but well below the legal requirement.
On completion of the work, the following observations were made:

- calculations of explosion under the mine roller and the explosion on the proving ground confirm the accuracy of calculations;
- the explosion of the container on the proving ground did not confirm the calculations – the damage to the container was minor, while according to the calculations it should have been great.

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Acknowledgments

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

TIRAMISU Information Management Tool – T-IMS

Torsten Vikström, Stefan Kallin[1]

Abstract

The Mine Action Community Needs Integrated Tools and Standards

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

The European Union has, by the Project TIRAMISU, taken on the task to boost clearing of the deadly legacy left in countries plagued by war. One (cost-) effective and safe solution is the TIRAMISU Information Management System (T-IMS).

T-IMS is a GIS centric stand-alone software application supporting all Field Data Collection within the scope of Humanitarian Demining, following the steps of Non-technical survey, Technical survey, Clearance operations to Quality assurance and Reporting.

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

T-IMS integrates with the TIRAMISU Repository Service (TRS). This integration will be demonstrated hands-on during the conference.

T-IMS is fully operational late 2015.

T-IMS, a brief description

T-IMS is a stand-alone very user-friendly Field Data Collection tool (FDC) primary for the deminer's use out in the field. T-IMS is for use in the early stages of non-technical surveys through the phases of technical survey and mine clearance as well as the following quality assurance and reporting. Data caption with T-IMS is extremely easy. With T-IMS, hazard areas, mine fields and -lines, GPS-trackings, danger zones etc. can easily be defined and positioned in the GIS map module. Any type of attachment - such as georeferenced photos, images and documents – can be attached to any activity during a mine clearing operation. UXOs and other findings will easily be identified in T-IMS' ordnance database (CORD) with its intuitive search engine, and likewise be positioned with high accuracy in the map.

T-IMS is built for use under rough conditions as well as in extreme environments. The overall concept, design and usability have evolved by deminers with many years of use and great experience from earlier generations of like applications. It is built for use "out in the field" and its user interface is completely adapted to touch technology, meaning that it is fully usable without a touchpad or a mouse.
A clear indication of its ease-of-use is that test training indicates that after just half a day of training – or even less, a deminer in the field is fully operational with the application.

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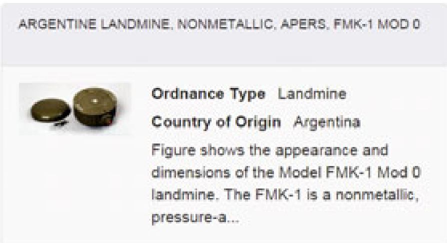
T-IMS handles…

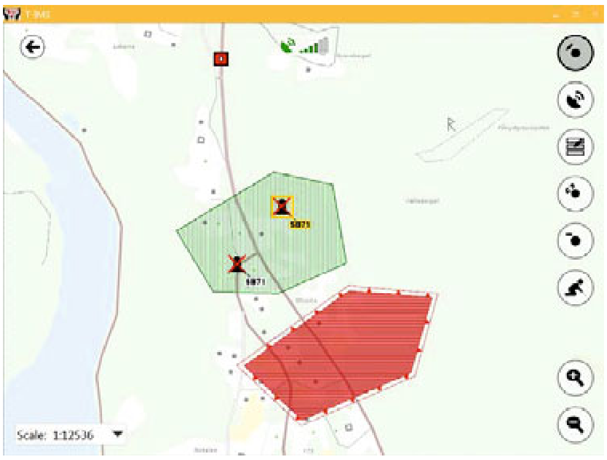
- The whole scope of Humanitarian Demining, following the steps of data collection through Non-technical survey, Technical survey, Clearance operations to Quality assurance and Reporting.
- Collaborative Ordnance Data – CORD.
  Ordnance database by James Madison University – JMU & GICHD
- Standardized interface for use of various map engines.
  Carmenta and Esri ArcGIS Runtime .NET, supported as of today
- Map Symbols for Humanitarian Demining
- maXML, for internal and external communication
  Communication and information standard by GICHD.
- Two way communication with Information Management System for Mine Action – IMSMA
  GICHD's IMSMA is currently in use in more than 80 % of all mine action programs around the world
- Reporting and communication with TRSD and using to the TCP-Box for high accuracy in positioning.
  WP526

Collaborative Ordnance Data – CORD



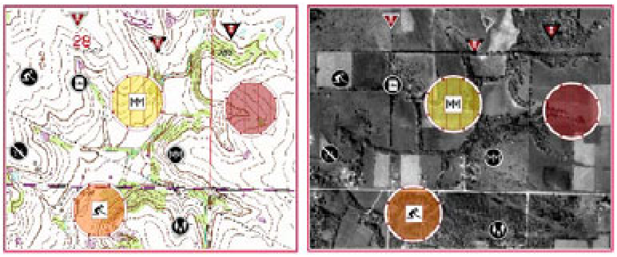
T-IMS contains off-line CORD ordnance data. This allows the deminer in the field to easily identify UXOs and other findings from the ordnance database with T-IMS built in intuitive search engine.

GIS centric



The user interface and interaction with T-IMS is very GIS centric for convenience and ease of use. When in the map view, you have access to all the information you need to know and all the actions you need to perform at that specific moment. For instance, identified (or unidentified/unknown) UXOs and other findings can easily be positioned on the map. This can be done either by "pointing them out" manually, or by letting the GPS position them at the place of your current position.
T-IMS can also communicate with the TCP-Box for higher accuracy in positioning.
In the map view you also have easy access to all the tools you need to draw and define objects, lines and areas, tools for zooming, panning, position photos, initiate a GPS tracking etc. etc.

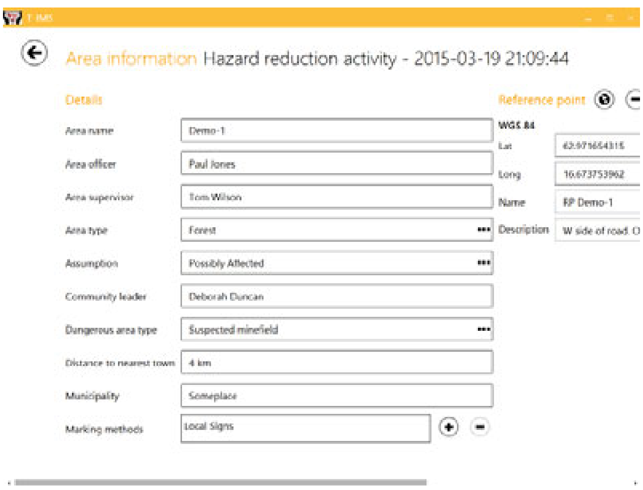
Map Symbols for Humanitarian Demining



"Maps and Geographic Information Systems (GIS) serve a valuable role in humanitarian demining for the management of geospatial information that is critical to safe and efficient operations. Symbols are necessary for representing the many categories of landmine hazards and mine action processes in graphic form on maps and in GIS. It is critical that these map symbols not be ambiguous, confusing, or otherwise unclear to demining personnel or civilians." [ref 1]

T-IMS follows *Recommendations for Humanitarian Demining Map symbols [ref 1]*, established by GICHD, and used in IMSMA [ref 2].

Mine Action XML – maXML



T-IMS uses maXML as a communication protocol, internally and externally, and for the definition of information elements as well as user input. All communication to and from T-IMS is done based on maXML. *As a result of this T-IMS also communicates with TRSD according to maXML.*

Information Management System for Mine Action – IMSMA

T-IMS is fully compliant in common parts with IMSMA. Thus this has enabled T-IMS to exchange information, both ways, with IMSMA [ref 2].

Demonstrations and more information

During the conference, outdoor presentations of T-IMS will take place as a part of the demonstration of the TRSD. During these demonstrations T-IMS will connect and upload data and reports to the "Field TRSD" and also connect to the TCP-Box for high accuracy in map positioning during data caption in the field.

Times for standalone T-IMS demonstrations will be announced during our common oral presentation with the TRSD.

More information about T-IMS is available at the TIRMISU booth.

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2. IMSMA Wiki
   http://mwiki.gichd.org/IM/Main_Page

Acknowledgment

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

Evaluation of the **E-tutor for humanitarian demining tasks managing staff**

Andrzej Masłowski*, Igor Ostrowski**, Paweł Musialik***

Abstract

E-tutor is an e-learning tool for humanitarian demining tasks managing staff. This tool is designed for checking the knowledge and try to solve tasks from area of site preparation. The tool is builded in two parts, one for Instructor and another one for trained . Trained person after 100% correct answered the test can try to solve exercise on map which is prepared by Instructor in his part ot the tool. Tool for trained is divided in two parts: checking the knowledge from area of humanitarian demining procedures, knowledge from area of task site preparation and second part which is work on the map. Exercise on the map is designed as graphical tool for dislocation of necessary facilities. Training assessment is performed by comparison of the prepared proposal with the reference values of necessary distances between facilities.

Introduction

Most important part of humanitarian demining task commanders is knowledge about Standard Operation Procedures which are part of every HD handbook. Another very important skill without which commander can not proceed is planning of task site preparation [1],[2]. E-learning will be use for improve this skills, this paper describe a tool designed in Institute of Mathematical Machines for this purpose. Tool consists of two part: checking the knowledge from area of humanitarian demining procedures and knowledge from area of task site preparation and second part which is work on the map.

First Part – Test

In the test correct answers for all questions have to be given to pass the exam. Without passing the test proceeding work on the map is unavailable.
Graphical layout of the test is presented in figure 1.

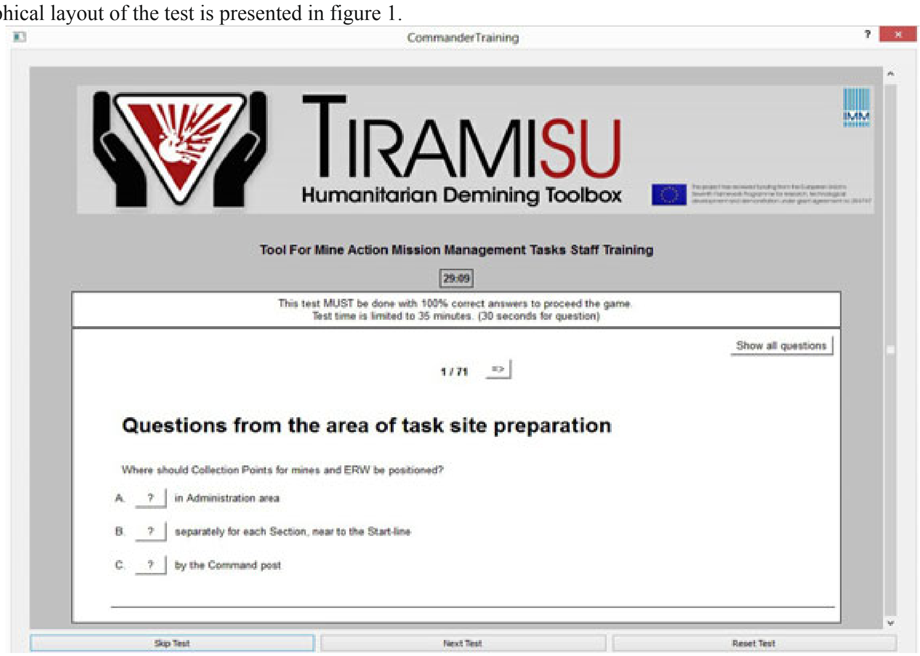

Figure 1 test graphical layout

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Examples of used questions from the area of safety and demining procedures:
(only answers "a" are correct)
The wide of demining line during manual demining is:
a - 1,2 m including two overlaps on each side of 0,1 m
b - 0,7 m
c - from 1 to 2 m depends on used demining method.
The overlap outside the demining line must be:
a - 10 cm on each sides
b - at least 10 cm on the right side
c - at least 0,2 m on the left side.
Efficiency of deminers using manual mine detection is:
a - 50 m^2/day
b - 500 m^2/day
c - 150 m^2/day.
If demining operations can be conducted when it is raining?
a - no
b - yes, if the rain intensity is low
c - it does not matter.
If demining operations can be conducted in low-light conditions, at the dusk?
a - no
b - yes, but appropriate lighting equipment must be ensured
c - it does not matter.
Is it allowed to conduct the demining process at low air temperature?
a - no, if temperature drops below 0º
b - yes, it has no influence
c - yes, but work efficiency decreases
How should deminer proceed after detection an unknown mine?
a - to call on EOD Operator by Section Leader
b - to try defuse the mine
c - to leave the mine on site of detection and to continue demining
Whether have the protection suites to be certified?
a - yes, must be capable of withstanding the blast effects of 240g TNT detonated at 30cm from the nearest part of the armour and shards within the velocity of 450 m/s
b - it is sufficient manufacturer's declaration of suitability for this type of work
c - it is not required
Minimum working distance between demining staff for the AP blast mines and HE containing more than 200g of explosives is:
a - 15 m in conditions of normal risk and 20 m in increased
b - 25 m
c - 60 m
Minimum working distance between demining staff for the AP fragmentation mines is:
a - 20 m in conditions of normal risk and 25 m in increased
b - 30 m
c - 60 m
Which distance to the base-line may rest-areas be placed if not all deminers rest at the same time?
a - safety distance - defined on the basis of recognized hazards
b - triple working distance
c - 100 m
If deminers can take off PPE in rest areas?
a - yes, because CP should be far enough from the working areas
b - yes, during the break
c - no, he should wear PPE

Knowledge test from the area of task site preparation

The purpose of this test is to confirm the acquired knowledge which is necessary to appropriate planning of the demining task and preparation of the technical-administrative facilities supporting demining process. Confirmation of the knowledge from this area is essential to begin next education level - planning of the demining. First level should enable learning - to acquire all essential information. The question and at least three answers (a, b ,c) should be shown but correct answer (highlighted) is in random place. Acceptance of the highlighted answer is requisite in order to go the next question. The questions are not in thematically related blocks. Trainees can repeat test unlimited times.

Final verification of acquired knowledge will be conducted within qualifying examination. The questions from whole thematic range are shown randomly and the time for answer limited to 30 s. Correct answers for all questions have to be given to pass the exam.

Examples of used questions from the area of task site preparation:

(only answers "a" are correct)

How wide must Access-lanes be?

a - at least 2 m
b - at least 5 m
c - at least 1 m

Where should Paramedic Post be positioned?

a - not be further than five minutes walk away from any working deminer by the Access line in safety distance from Working area
b - in Administration area
c - by the main access road

What should be provided in Rest area?

a - plenty of drinking water, latrine (if Administration area is far), simple seating and, when possible, racks to hold PPE and tools above the ground
b - TV, refrigerator, soft drinks and food preparation space
c - there are no special requirements defined

Which basic facilities should include Administration area?

a - a shelter with a table, means of communication and a display board with a Task map
b - social and office container equipped with fax and computer
c - basic office facilities and food preparation space

In which way should Access-lines be established?

a - should be straight whenever possible and use existing communication structures
b - parallel and perpendicular to the Start-line
c - existing roads should be avoided

It is necessary to conduct the demining of set out Access-lines

a - always if there are reasonable doubts
b - no
c - yes if there are in Platoon some not involved forces and means . [3]

Second Part – Exercise on map

The purpose of the practice test is to prepare the proposal of dislocation all necessary facilities in Task site and Access-lines, Start-line, areas of responsibility (Worksites) for each Sections. Theoretical knowledge of from the area of task site preparation should be applied. Training assessment will be performed by comparison of the prepared proposal with the reference values. The exercise tasks are prepared by instructor using specially developed tool named "Builder". Instructor prepare map with demining Task using OpenStreetMaps for choose place for exercise. After define DHA instructor can sketch some additional roads, obstacles or informations. Prepared task must have defined some additional information like "Safe distance" for this type of DHA, all of this necessary informations have to be given by instructor. Trainees using application named "Checker" can try to dislocate all necessary facilities in Task site. Trainees can look at the mission help which contains all important informations about task.

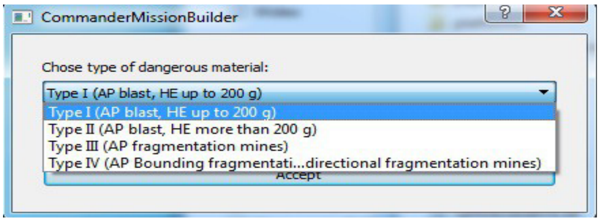

Figure 2 DHA choosing type of DHA window

Figure 3 example of mission help

Conclusion

Presented tool can be successfully use for improve knowledge and skills trainees for humanitarian demining tasks commander. Trainees will have ability to try solve problems from area of task site preparation using electronic map in convenient way. Instructors can prepare tasks which will be most useful from their point of view.

Acknowledgement

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

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Development and Programming of the Mobile Platform with Manipulation Arm for Rescue Operations

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Abstract— This paper deals with the design, construction and programming of a mobile platform with manipulator arm, which is able to move in restricted environments, detect all suspicious objects, and remove dangerous objects from specific areas in certain depth.

For the design of wheeled robot the rapid prototype methodology has been implemented, using fast techniques for processing the robotic parts of the Solid Works software tool.

Mobile robot with a manipulator arm is able to move with precision through dangerous areas to prevent the destruction from unexploded ordnance. Also, mobile robot is able to overcome most obstacles in its path or to avoid those obstacles that are not possible to be crossed above.

The robot chassis has the following features: aluminum hull design minimize magnetic signature and weight; watertight welded hull design enables foraging through standing water; integrated six degree-of-freedom inertial measurement unit with 3-axis magnetometer; integrated GPS accurate to one meter; two wireless Ethernet cameras streaming data from the front of robot and manipulator arm; one wireless Ethernet router; four wheel drives, with each wheel driven by its own motor and servo amplifier; encoder feedback on motors for precise velocity control and autonomous control with integrated algorithms in microcontroller or teleoperation through RF joystick; separate audible buzzer for COM and microcontroller for alarms; and model with 4-DOF robot arm.

Fully developed prototype of the mobile robot is ready to use software for control and navigation, data logging and sample codes, which can be proved by the results obtained from tests performed with RoboPlus and Matlab software.

Also, the performance of coordinated movements to control the robot from the distance has been evaluated giving satisfactory results.

Keywords—Robot platform, UXO Detection, Semi-Autonomous Control, Teleoperation, Programming

I. INTRODUCTION

Rescue robotics focuses on designing robots to help people after disasters. When time and equipments are limited, robots can be used to save lives, and emergency responders do not need to risk their own lives during the rescue operations.

One of the most common disaster for which rescue robots are being used is earthquake. The general requirements and expectations for rescue robots are given in refs. [1–3].

The main problem of rescue robot design is to have a mobile platform which can move through a rough terrain. The concept of rough terrain is described in refs. [4–6], where the damage to the building is described with different colors from yellow to red and illustration of the terrain difficulties from light to moderate is too complex.

In earlier studies, the problems encountered with mobile robots in a rescue field are explained, but the design process of the robot is not mentioned. This paper explains the mechanical design procedure and prototype stages of mobile robot which have been designed for a hazardous environment. Moreover, the robot was evaluated for its performance and the design challenges in the procedure of robot design have been summarized.

This paper deals with construction of the mobile robot that is able to move in constraint environment, to detect all suspicious objects, and to remove them from a specified area to a certain depth.

The mobile robot with manipulation arm named EMBOT is able to navigate accurately through the hazardous environment to prevent the triggering of unexploded ordnances. The mobile robot should be able to surmount most of the obstacles in its way while circumnavigating those which are impassable.

The mobile robot is able to have self-control by the usage of proposed algorithms that will be based on the microcontroller, but also by remote control from the computer panel according to the certain operations.

The second phase of mobile robot development was the installation of several sensors that would increase the intelligence rate by enabling the robot to monitor and adopt the actions for humanitarian purposes.

Most commercially available mobile robots consist of mainly custom made parts. The design and manufacturing of these parts make the robots very expensive. This fact reduces their attractiveness for rescue operations, as landmine affected countries cannot support expensive high-tech solution. A mobile robot has to be cost effective compared to local labor costs.

The paper goals are to demonstrate unmanned mobile robot under manual and semiautonomous control with advanced sensory awareness. The mobile robot has visual, proximity, positioning and object detection capabilities. The paper is dedicated for research purposes and for prototyping, involving developing of algorithms for complex smart systems.

The mobile platform with robotic arm is designed for indoor and outdoor operation requiring faster maneuverability. Wheel mobile platform is light weight (<60 kg), its payload capacity (carrying payload: max 1.5 kg). The integrated high resolution video/audio and IR sensor provide remote operator detail information of the surrounding.

II. The EMBOT Hardware

The EMBOT's dimensions are: 64 cm x 39 cm (length and width). Robotics platform height is 26 cm, while the distance from the ground is 13 cm. Circular line around the robot presents the greatest length that can be reached by the manipulation arm. Robotic arm is designed based on the type Pro-series ROBOTICA Arm. Type ROBOTICA Arm Pro-series consists of three MX-106 servo motors, one MX-28 servo motors, one servo motor MX-18, two servo motors AX and two flexible rods with a length of 21.11cm and 33.81cm.

A. Manipulation Arm Actuators

With the addition of a gripper, a manipulation arm can be used for many different applications, from doing routing tasks, detecting and ever defusing an explosive device. The manipulation arm includes the following servo motors identified by ID numbers.

B. Distance Sensor

Shield CM-700 controller offers flexibility so that besides connecting Dynamixel servo motors, it enables the connection of different sensors and actuators. In our case we've installed two sensors both are based on the infrared waves. First one is an IR distance sensor that measures the distance accurately, but the range of distance measurement is short. The second sensor is DMS-80 which is also distance sensor but has wider range of distance measurement. These sensors have the transmitters transmitting infrared waves towards the obstacle (object), and also have receivers which receive these reflection waves of the obstacles that lie ahead of sensors. In this way sensors are able to measure the distance of the object.

The maximum sensitivity of the IR sensor is at distance 1.5 cm, below that distance the IR sensor starts to lose the sensitivity, until there is no sensitivity at all in distance closer to zero. In this way the purpose of IR sensor application is to detect the range of distance from 1.5 cm and longer, figure 1.

The DMS sensor effective sensitivity lies between 6-80 cm. The maximum sensitivity of this sensor is at 6 cm. DMS sensor is not such accurate as IR sensor, and it is not affected by colours as IR sensor.

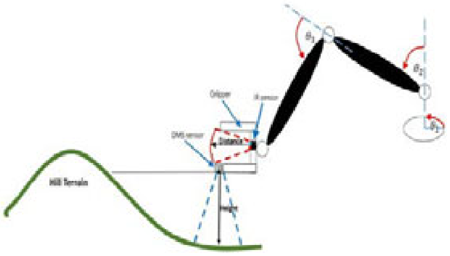
Besides the IR sensor used in arm gripper, another sensor called DMS has been used. The purpose of using the DMS in our case is to avoid the collision of arm gripper with the hill terrain. Once the platform is moving and hill terrain comes the DMS will measure the difference between the arm gripper and ground. In application it is set the fixed distance 12 cm from ground, at this fixed distance DMS will show the value 400. Whatever distance that DMS measure besides the fixed distance it will influence by increasing and decreasing joint 3 - servo motor ID[4] or theta3.

III. EMBOT Structure Diagram and the System's External Hardware

The block schema of EMBOT manipulation arm is based on certain modules that in general enable the realization of different tasks, at the same time increase the flexibility of a mobile platform, figure 2.

Movement of the platform module consists of a main board which controls the movements of the platform, taking the task from Laptop (Integrated PC). This task is processed further by sending commands (desire speed) to the Servo (Servo Driver 1-4). Each servo driver is connected with one servo motor for each platform wheel.

For example, Servo Driver 1 is connected with the first Servo motor to the left-front side of the platform. At the same servo motor is connected an encoder, which follows the motor displacement and the direction of motion. This displacement is forwarded to the certain servo driver in order to close the feedback loop.



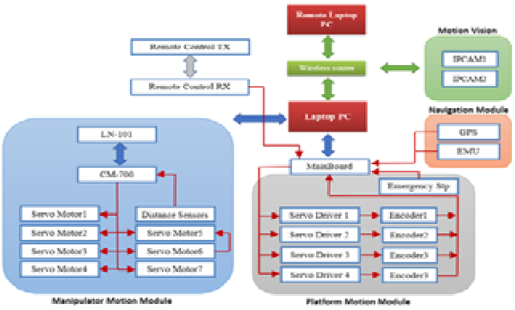


Fig. 1. Application of IR and DMS sensor in Arm Gripper   Fig. 2. Block schema of EMBOT’s modules

A. Configuring of IP Cameras and Wireless Router

To access remotely the cameras that are located at robotic arm and at robotic platform, it is necessary to set a wireless router to establish the connection.

Motion Vision represents the part that connects two IP cameras of the type D-Link 930L. For accessing these cameras remotely, first there should be physical connection between IP cameras and wireless router. Then the wireless router should be configured in order to define static IP’s for each IP camera. Once the router is configured, IP cameras can be accessed through remote laptop connected in that local network.

IV. Programming the Robotic Arm through RoboPlus Software

Defining physical constraints for each joint is one of the first steps before passing to the programming section. To begin with programming section, first an algorithm flow of program needs to be designed. The algorithm of EMBOT manipulator is divided in two parts.

The first part offers possibility to control the robotic arm manually by making the displacement of each joint. The manual mode offers the possibility of using the EMBOT for various tasks application.

The second part of the algorithm offers the possibility of using the various combinations of motions configurations, offering the flexibility to perform complex tasks depending from the application.

Once the sequential program starts, it will call the function named “initial_position”. The robotic arm is meant to go in the initial position by calling this function, in order to be able to perform any possible motion from that position. In this manner the possibility of the physical collisions with the environment are avoided.

There is also used an infrared sensor to measure the distance of the obstacle, once the obstacle or the target object is reached in certain distance where the sensitivity threshold is passed, then the robotic arm grippers are closed to catch the target object.

If none of the condition is reached within the program, then it will remain in the endless loop and wait to receive next instruction from the human, since one of the conditions for sure will be reached. Otherwise the program is corrupted, and needs to restart the program again.

A. Creating Robotic Arm Motions through RoboPlus Motion Software

While describing the algorithm it is mentioned that in the second part of the algorithm there are used configured motions. These motions are created by using software called RoboPlus Motion.

The motions are configured according to the task that is design to pick up and drop a bottle. For completing a full task it is needed to create seven different motions. The motions are illustrated with numbers fields that have to be configured. A motion may consist of one step or it may consist of couple of steps sorted in appropriate form to complete a full complex task.

For each joint (ID) there is the page parameters, where can be defined parameters such are: speed rate, inertial force control, joint softness etc.

The next step is to select which joints will be included in actuating the certain motion, and their joint displacement for each one of them needs to be defined.

B. Creating Robotic Arm movements through RoboPlus Task Software

The EMBOT robotic arm program is written in RoboPlus Task as part of RoboPlus package which allows write the code in C+ language.

Program code of EMBOT Robotic arm is not included in the paper because of paper expansion; just a short part of it is presented in the figure 3.

The top view of EMBOT Robot Mobile is presented in figure 4. Wireless network is used to connect to control computer mounted on the top of EMBOT and remote base computer. Its main purpose is to follow the swiped area of the robot. The cameras can monitor the image for the range of 100 meters. The cameras are controlled from the master computer that enables the person to have the view of the detected field from distance. The mobile platform can be operated under autonomous operation and master-slave tele-control. The mobile robot is steered by a four channel FM Radio Transmitter. The remote controlled operation identifies the existing movement of the mobile platform and paves the way for a potential future upgrade to full autonomous navigation. The gripper attached to manipulator is intended to grasp suspicious objects while mobile robot traverses the infected area.

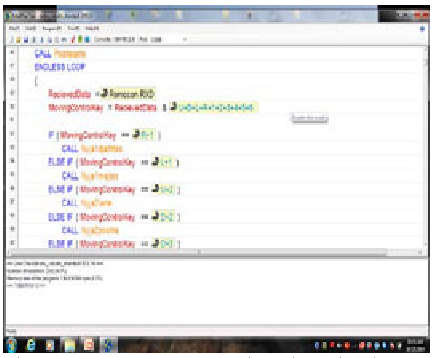


Fig. 3. EMBOT program written in RoboPlus Task

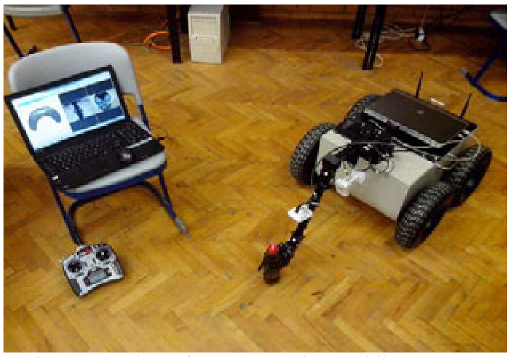


Fig. 4. Top view of EMBOT Robot Mobile

Performance of the mobile robot is being evaluated with a large number of experiments to test its motion performance, long running reliability and application in the mine field. The prototype tests have shown promising results.

CONCLUSIONS

The wheeled robot with manipulator called EMBOT is ready to use software for navigation and control, data logging and model codes, which can be seen the initial results obtained from tests carried RoboPlus software.

Also the robot is assessed in terms of the performance of coordinated movements to control from a distance, where satisfactory results were obtained.

Robotics programming platform and manipulator arm allows realize various complex tasks, depending on the requirements presented to the robot.

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DESIGN OF A HUMAN MACHINE INTERFACE FOR TRAINING ACTIVITIES WITH PRODDERS

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Abstract

This paper presents the Human Machine Interface (HMI) that has been designed for improving the training activities of demining operations carried out with prodders. The proposed HMI will contribute in gathering, analysing, presenting and consolidating the information acquired with an intelligent feedback prodder that has been especially conceived for interacting with this application. The friendly graphic user interface will present the data received in an efficient format, maximizing the instructor's ability for monitoring, processing and assessing the trainee performance. The different components, features and functions of the HMI are described in detail through this document.

Introduction

Humanitarian demining is difficult and dangerous, as it requires the complete removal of all mines and the return of the cleared minefield to normal use [1-3]. Metal detectors and prodders are still the most important tools for humanitarian demining. Prodders are mainly used as complement to the metal detectors, so that once a possible target has been detected, the prodder permits to locate it in the terrain. Finding mines with a prodder involves pushing tool into the ground and relaying on tactile feedback to identify an obstruction that maybe a mine [4]. Prodding on antipersonnel mines is a major cause of demining accidents in some countries, especially where the soil is hard or rocky. Some studies [5] involving field measurements of the force exerted by the operators showed that deminers, and even senior training staff, had no real idea of the force they were using and consistently underestimated the force they were exerting by large amounts. To alleviate this situation, an intelligent prodder, which gives to the deminer information about the amount of force exerted and alerts him when the prodder's angle is approaching or exceeding a certain limit, has been designed and implemented. The emphasis in this article will be put on the description of the proposed HMI. The interface will be responsible of collecting the data acquired by the instrumented prodder, processing and analysing the measured performance variables, and presenting the essential information required during the training sessions. The rest of the paper is organised as follows. Section 2 briefly introduces the intelligent feedback prodder responsible for acquiring the performance data during the training sessions. Section 3 describes the screen components, links and functions of the HMI and finally, Section 4 summarises major conclusions.

Intelligent feedback prodder

The intelligent feedback prodder for training consists of a HMI, an instrumented prodder, a data acquisition module and an electronic module for signals conditioning. All basic parts of the instrumented prodder (sensors, a rod with a sharp spike, a handle and an extension) are separable with the ability of replacing different extensions in order to obtain different versions of the prodders, depending on the demining training needs. For the design of the instrumented prodder, two main types of sensors have been evaluated and selected: a load cell and an Inertial Measurement Unit (IMU). Table 1 and 2 summarise the main technical specifications of the selected compression load cell and the IMU, respectively.

The electronic module for signals conditioning is responsible of filtering and amplifying the force sensor output in order to meet the requirements of the next stage, in which the data acquisition module converts the resulting

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analog signal into a digital one for further processing. The sampling frequency was chosen to be 100 Hz for the IMU signals and 500Hz for the force signal.

Table 1. Main technical specifications of the compression load cell.

Parameters	Values
Thickness	3.81 mm
Diameter	25.4 mm
Non-linearity	± 1% FSO
Hysteresis	± 1% FSO
Deflection at "FS"	< 0.013 mm nom.
Thermal zero shift	± 2.5mV/50ºC
Thermal sensitivity shift	± 2.5%/50ºC
Operating temp.	(-40 to 120)ºC

Table 2. Technical specifications of the IMU.

Parameters	Orientation Performance	Parameters	Angular velocity	Acceleration
Dimensions	3 axes (pitch, roll, yaw)	**Dimensions**	3 axes	3 axes
Full scale	±180 deg	**Full scale**	±1200 deg/s	±1600 m/s^2
Angular resolution	0.05 deg	**Linearity**	0.1% FS	0.2% FS
Static accuracy	0.5 deg	**Noise**	0.05deg/s/√Hz	0.003m/s2/√Hz
Dynamic Accuracy	2 deg RMS	**Alignment error**	0.1 deg	0.1 deg
Bandwidth	100 Hz (max.)	**Bandwidth**	100 Hz (max.)	100 Hz (max.)

HMI console

The HMI console, also called graphical user interface for the Intelligent Feedback Prodder Monitoring, is the principal mechanism through which instructor supervises the performance of trainees. The HMI console is divided into several sections that are described below (see Figure 1).

Initialisations
This section encloses two radio buttons mutually exclusive named "New Session" and "Load Session" for initiating a new session or loading an existing one. "New Session" enables resetting all data contained in the interface, while "Load Session" allows replaying a recorded session.

Configuration
This section encloses three radio buttons mutually exclusive that permit loading a predefined configuration file for modifying the objectives of the training session according to the soil type, the soil conditions and the kind of target to be detected.

Session Info
This section contains two different elements that enable to introduce the session ID and the name of the operator that is being monitored with the proposed tool. These texts entries will facilitate the orderly storage of the data and the reporting phase.

Controls
Two different buttons are included for starting or ending the interface activities. Thus, the "Start" button initiates the acquisition, visualisation and recording of data, and finally the "Stop" button halts all the functions of the HMI.

Intelligent Feedback Prodder Status
Two different text messages are included in this section, the first one for informing about the status of the IMU and the second one for describing the status of the force sensor. Thus, these messages notify if sensors are connected or disconnected, if measurement process is being carrying out properly or not, and if some error takes place.

Prodder Monitoring
This VRML graphic reconstructs in real time the orientation of the prodder carried out by the human operator. The graphic enables the instructor to check if each prodding is being performed with a proper angle of insertion.

Force and Orientation Graphics
These two graphics display in real time the force exerted by the human operator while prodding, in N, and the roll, pitch, yaw angles in degrees, describing the orientation of the prodding during the training session.

Force and Angle Data
In this section, data acquired by the intelligent feedback prodder is turn into useful information that will help the instructor to monitor the current situation. Two performance variables are utilised for this purpose: the force exerted by the human operator while prodding in N, and the angle of insertion of the prodder in degrees. Analogic representation of these values, indicating their position relative to normal, abnormal and alarm conditions are displayed. The alarms included for each variable enable the operator to quickly detect values outside the safety range, so he doesn't have to relay in his memory and mentally compare each value to its corresponding defined range to discover deviations of trainee objectives. In addition, colours are utilised in two bar graphics to indicate if the performance is holding or not within the training objectives: green is used for indicating that all the evaluated variables are within the training objectives, yellow for warning that the values are starting to deviate from the goals and red for values out of the defined safety ranges.

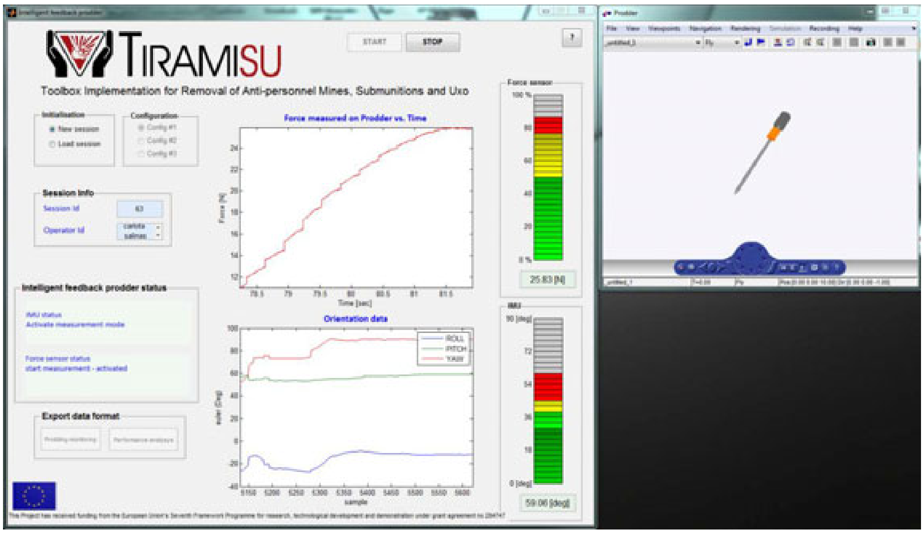

Figure 1. HMI console for the Intelligent Feedback Prodder.

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Export Data

This section encloses two buttons called “Prodding Monitoring” and “Performance Analysis”. The first one saves all data acquired by the intelligent feedback prodder during the active session. Lastly, the second button links with an external application that conducts the performance evaluation of the operator and generates the corresponding evaluation report. The performance analysis can be done from the last active session, or from any other session that has been previously stored.

In addition, the interface provides the possibility to modify the limit values of the performance variables (maximum force and maximum angle of insertion) depending on the characteristics of the mission for which the training is being conducted. This feature is achieved through the configuration options. The interface also exhibits ability to record long data-runs without data loss.

Discussion

In this work a HMI has been proposed as part of a training tool for improving the deminers’ skills during close-in detection tasks carried out with prodders. An outline of its main features, functions and components has been described in detail. The proposed HMI has the advantage of providing an overview of the entire operation conducted with the prodder and a limited number of well-defined alarms. In this way, the instructor, or the trained operator can see the entire operation almost at-a-glance. Therefore, it is envisioned that the graphical user interface will improve the instructors’ ability for monitoring, processing and assessing the performance data of the training, reducing the total cognitive load required.

Conclusions

The authors acknowledge funding from the European Commission under 7th Framework Programme (TIRAMISU Grant Agreement Nº 284747) and partial funding from the RoboCity2030-III-CM project (Robótica aplicada a la mejora de la calidad de vida de los ciudadanos. Fase III; S2013/MIT-2748), funded by Programas de Actividades I+D en la Comunidad de Madrid and cofunded by Structural Funds of the EU. Dr. Héctor Montes also acknowledges support from Universidad Tecnológica de Panamá.

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International Symposium "Humanitarian Demining 2015" - 28 April 2015, Biograd, Croatia

Geospatial analysis of the conflict landscape for supporting Non-Technical Survey

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Abstract

In this paper, we explore the potential of geospatial analysis for supporting Non-Technical Survey. Several datasets are used for reconstructing the historical conflict landscape that forms the context of ERW contamination. This analysis aims at verifying and refining units' positions derived from military archives, for then inferring the location of mine obstacles based on contextual information and expert knowledge. Preliminary results indicate that the method offers interesting perspectives and that it should be refined by integrating additional datasets, processing and expert knowledge.

Introduction

The analysis of digital geo-information in Geographic Information Systems can support Mine Action at different stages. The GICHD, with the University of Geneva, has produced an issue brief on the topic (Lacroix et al., 2013). The possibilities range from simple overlays of geographic layers to complex geospatial analysis combining various datasets for modelling and mapping, e.g., the ERW contamination density, the potential displacements of mines caused by water runoff, the populations most exposed to the risk, the accessibility of an area, etc. The output of such analyses can be used in the survey process, in the priority-setting phase and for planning and reporting operations.

Our purpose here is the application of geospatial analysis to the reconstruction of the historical conflict landscape that forms the context of ERW contamination, in support to the Non-Technical Survey. The research is being carried out in the framework of the project TIRAMISU, for the development of a tool called T-SHA. This potential application seems to have been little explored up to now in Mine Action. Beside, in the field of conflict archaeology, literature on the use of geospatial information for the reconstruction of ancient battlefields mainly reports the implementation of feature extraction from aerial photos or satellite images (Kaimaris, 2011; Passmore et al., 2013), sometimes in combination with simple GIS functions (Nolan, 2009).

In a book published recently (Matić et al., 2014), CROMAC-CTDT authors highlight the elements that should be taken into account when carrying out a military-oriented interpretation of a Suspected Hazardous Area. They underline the fact that information extracted from available military archives should be completed with other elements such as topography, hydrography, communication networks (e.g. roads and tracks), vegetation, soil properties and land use. In this paper, we explore the potential of remote sensing and GIS for supporting the work of the expert in this perspective.

Study area

The Region of Interest (ROI) that was selected for developing the method is located in the Dinaric Alps, in Croatia. It is a mountainous zone characterised by irregular karst topography. The terrain is rugged and rocky and it displays little trace of human activity, beside ancient dry stone walls enclosing grassy areas used for grazing (typically in sinkholes), and dilapidated shepherd's huts. Mine laying took place in the early 1990s, during the Croatian War of Independence. Two decades after the end of the conflict, traces of military activity have become difficult to pinpoint. Fortifications were erected using mainly natural materials present in the environment, or they were covered with stones to remain inconspicuous, and earthwork-digging possibilities were limited due to the nature of the soil. The constructions are generally small and have been damaged by time and weather events, making them sometimes hard to spot, even in the field.

Data

Expert analysis of military archives by CROMAC surveyors resulted in the production of layers of polylines (vectors) representing the positions of units of both warring parties that were active in the area. These polylines have a set of attributes characterizing notably the reliability of the source and the date of occupation of the positions. Since, in a first stage, no piece of information should be discarded, the polylines were provided to us unfiltered (one polyline per source and per position), which means that a single unit position at

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a given time is likely to be represented by several polylines. Positions where fortifications were erected were also derived from archives and provided as layers of points. Surveyors also provided a list of places where they expect that additional information can be extracted thanks to earth observation.

Topographic maps on the scale 1:25000 and 1:5000 are available from the WMS of the Croatian Geodetic Institute.

The remote sensing data used in the study are:
(i) 3K colour aerial photographs (RGB) shot during a flight operated by DLR in autumn 2013 (Kurz et al., 2012). They were radiometrically calibrated, atmospherically corrected, orthorectified and mosaicked by DLR. The final product has a spatial resolution of 15cm
(ii) a raster Digital Surface Model (DSM) that has a spatial resolution of 30cm. It was generated by DLR using the 3K data. A DSM is an elevation model that includes the objects present on the terrain (vegetation and man-made features such as buildings).
(iii) WorldView-2 satellite images shot in April 2013. These images have a panchromatic band and eight multispectral bands; their spatial resolution is 50cm after pre-processing and pansharpening.

Data collected in the field during a survey carried out under guidance from a surveyor were also used in the analysis.

Methods and preliminary results

1. Feature extraction

Referring to the recommendations made by CROMAC-CTDT experts, features that are relevant for the analysis are being extracted from earth observation data:

- Sections of the tracks present in the area and that are not included in the topographic maps could be extracted automatically from WorldView-2 data by adapting a line detection algorithm initially developed for the extraction of trenches (Lacroix and Vanhuysse, 2014). Since these tracks hardly stand out from their background, the extraction had to be completed by Computer-Assisted Photo Interpretation (CAPI).
- The semi-automatic extraction of forests is ongoing, using all available remote sensing sources. Ideally, historical images should be used since the forest edges do not remain stable in time if they are not maintained.
- Some of the features that could have influenced the operations are absent from the area, i.e. mainly watercourses and water bodies.
- Feature relating to the land use that could be a consequence of mine laying are also absent, e.g. abandoned/used cultivated land.
- Features that indicate military activity and that can be considered as Indicators of Mine Presence (IMPs), e.g. bunkers, shelters, linear fortifications, etc., are small and unlikely to be extracted using (semi-)automated methods. To avoid the tedious process of screening the whole area visually and to increase the chances of finding IMPs, the photointerpreter's understanding of the conflict landscape can be leveraged by geospatial analysis so that CAPI can be intensified in places where IMPs are most likely situated. The identification of favourable locations is explained in the next section.

2. Geospatial analysis

The requirement expressed by CROMAC surveyors is that units' positions derived from archives are verified and refined so that mine contamination can then be inferred using contextual information and expert knowledge.

Polygons representing the areas to investigate more closely were digitized based on the list of places provided by surveyors and topographic maps.

The Digital Surface Model was resampled to a resolution of 9m. It was used for computing a Topographic Position Index (TPI) in a neighbourhood of 500m. The Topographic Position Index compares the elevation of each cell in the DSM to the mean elevation of a specified neighbourhood around that cell (Weiss, 2001). Positive values indicate areas that are higher than their surrounding, whether negative values indicate areas lower than their surroundings. An image of slope was also computed using the DSM. The TPI was classified into four classes, taking into account relative elevation compared to the surroundings (lower, about the same elevation, higher, much higher). The slopes were classified into five classes. The combination of classified TPI and slope values allowed the identification of landforms that are favourable for positioning units for observation or firing purposes, i.e. areas that are quite flat and higher or much higher than their surroundings. This was verified by overlaying the points representing expected locations of fortifications derived from archives and observations made in the field on the map of landforms. CAPI was then performed, focussing on these favourable locations, for finding traces of military activity that can be considered as IMPs. Several fortifications (mainly shelters) could be extracted; the result will be submitted to an expert for validation.

The next steps were developed using one of the units' positions that were identified. Virtual observers were positioned in places where fortifications were located, and their field of view in the direction of the other warring party was computed using a directional viewshed algorithm. The combination of this new layer with the layer of landforms allowed us to refine the search for other candidate units' positions. A rest camp (confirmed by field observations) could notably be identified just outside the limit of the viewshed.

Areas that are quite flat and that are also lower or much lower than their surroundings are not favourable for observation or firing, but rather for military logistics installations, provided that they are not visible for observers from the other side and that their accessibility is reasonably good. Some candidate IMPs could be located by examining the landforms, the field of view and a track extracted from satellite imagery.

Once units' positions have been located, potential mine contamination "hotspots" can be identified. This involves military knowledge relating to mine laying and to the temporal dynamics of the conflict, but also fine-scale topographic analysis, information on the land cover/land use, trafficability analysis, etc. A first rough hotspot was mapped using a directional buffer algorithm. It should be refined thanks to interaction with experts.

Future developments

The preliminary results will be cross-checked thanks to interaction with surveyors. Results will then be refined thanks to the integration of additional data (e.g. a map of forests), processing (e.g. trafficability analysis, fine-scale topographic analysis) and expert knowledge (e.g. distance between fortification and mine obstacles, temporal dynamics of the conflict).

Conclusion

Geospatial analysis of the conflict landscape offers interesting perspectives for supporting Non-Technical Survey. It allows leveraging the analytical capabilities of the expert, who should remain the lynchpin of the interpretation of a Suspected Hazardous Area. In a mountainous environment, terrain plays a major part in the analysis even in modern warfare, as combatants are likely to seek natural cover and dominant positions. The applicability of the method to other types of environments should be assessed and the necessary adaptations should be considered. The method is not applicable to contexts where mine laying was not planned according to a strategy. In Cambodia for instance, many nuisance mines were laid, resulting in an unstructured spread of mines in large suspected areas.

Acknowledgements

This work was carried out in the framework of the project TIRAMISU, funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant n°284747.

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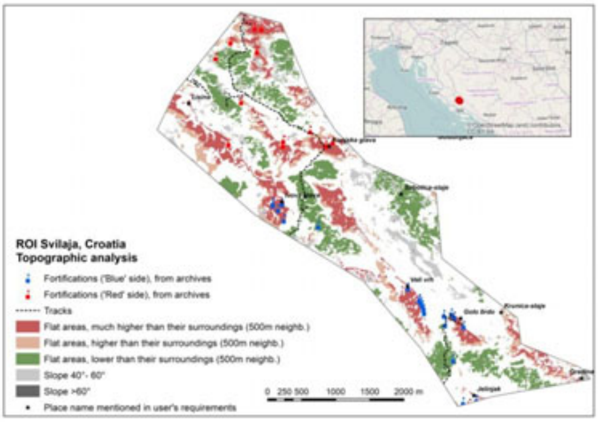

Figure 1: Fortifications mapped from archives confirm that a number of flat dominant areas identified by semi-automated topographic analysis (in light and dark brown) have been occupied by combatants. Other fortifications are located on lower ground, in the vicinity of the track extracted by CAPI.

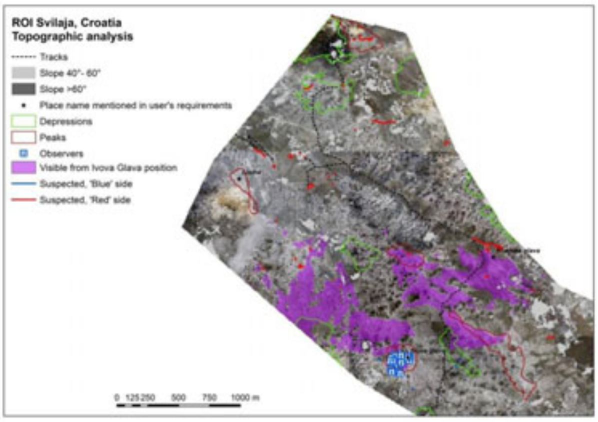

Figure 2: The field of view of virtual observers placed on one of the unit position is shown in purple. Certain positions of the other warring party can be found just beyond its limit. The base layer is 3K aerial photographs**.**

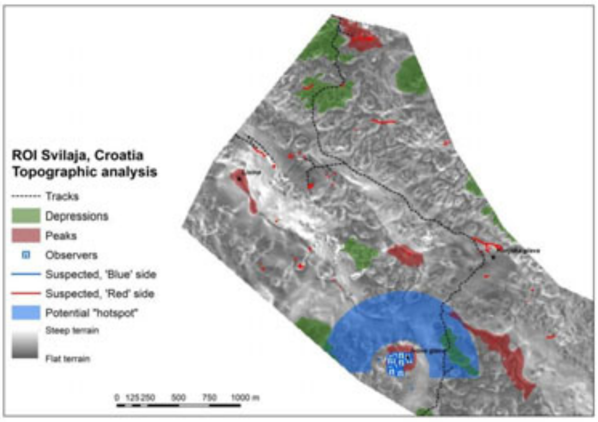

Figure 3: Once units’ positions have been found, ‘hotspots’ of contamination can be delineated. Here, a rough delineation (in blue), to be refined thanks to additional datasets and processing, and also expert knowledge. The background is a slope image.

International Symposium **"Humanitarian Demining 2015"** - 28th April 2015, Biograd, HR

Centralised data management in the demining world : The Tiramisu Repository Service

Didier Peeters [1] , Dirk Schmidt [2] , Gerd Waizmann [3] , Josef Riesch [4]

1. Introduction

Information systems play a more and more important role in modern demining actions. They enable effective, collaborative and secure management of demining actions. They also improve the human interface for more and more complex tools like sensors and detectors and enable the usage of new technologies like Geodata, GIS mapping and sensor fusion or modular toolkits. But these systems also have to be usable in remote areas with poor infrastructure and without expert knowledge available. This brings new challenges for data management, data communication and data security.

Several cooperative tools have been developed by the EU funded project TIRAMISU, that can help to solve these demands. These tools give support for the demining workflow starting with pattern recognition on satellite or aerial images, support for sensor data management enabling sensor fusion, infrastructure for precise navigation and flexible data communication even at remote places of demining up to support for decision makers, report generation and documentation.

The tools for these purposes will be presented and also the cooperation between them on the basis of a demining workflow scenario:

* The Tiramisu Repository Server (TRS) acts as a data repository that serves either through internet or by a rugged field server device the data storage and retrieval needs. It is based on open standards and popular internet technologies. Through MA-XML, data exchange with actual demining data systems like IMSMA is under development.
* Infrastructure for precise positioning using multi satellite navigation systems like GPS, Glonass and Galileo, flexible ad-hoc data communication infrastructure including connecting to the internet through satellite communication can be provided by the TCPbox. The TCPbox also supports vehicles like robots or drones with position and communication capabilities and also enhances demining sensors and detectors with a genuine interface for automatic data transfer into the TRS data repository for further evaluation.
* For interaction with humans there are several tools cooperative. A QGIS based system with support for more detailed sensor and image data processing cooperates with the TRS. The Decision Support Client DSC can be used for easy information queries and presentation of the data involved. The T-IMS system can also be used for generating reports and supports also interfacing to IMSMA based systems.

To demonstrate the actual developments, an integration of the TEODOR robot vehicle, equipped with a Vallon sensor array and a TCPbox delivering data to a TRS server system, detailed analysis and computation of sensor data through the FDS, display mission data on the DSC and reporting with T-IMS is planned to be demonstrated during the conference.

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2. General description

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

Practically, the Tiramisu Repository Service (TRS) is a database with geographical capabilities, working in a client-server architecture, in which different tools store and read data. The inner structure is made of data tables allocated to divisions (the schemas) covering each a specific main functionality. It will be hosted in an office on a desktop computer or as a server in a computing centre and will have its robust, battery-driven lighter version for accompanying the field missions. So the TRS centralises the information and makes it available to all the tools whenever and wherever they need it.

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

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

- the National-TRS hosted in the national demining headquarter,
- and the Field-TRS which is hosted on a rugged Unix-box and used outdoors on the demining site.

The figure below gives an overview about the basic software and hardware components of the Field-TRS. All the software components are based on popular open source programs and give a comprehensive computing environment. even if no (or a very limited) internet connection is available. The hardware components are assembled in a single ruggedised metal box, which can operate independent of external power supply and internet connection.

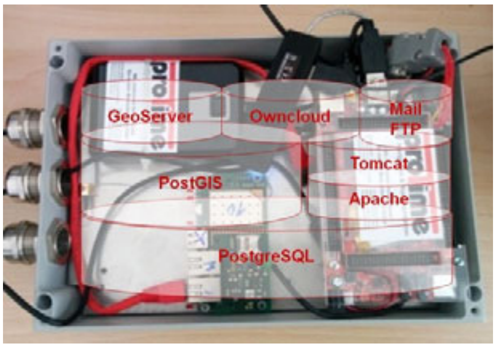


FIG 1. THE FIELD TRS

3. The final user first

The demining world is currently evolving with the release of many software tools aiming at supporting the whole chain of operations. Tiramisu and D-Box projects are illustrating perfectly this tendency. Hence, many software are proposed to the demining community with an ever growing redundancy, which can be seen as a better chance for the final user to find better solutions. Yet, it is seldom easy for the demining actors to switch from one solution to a new one even if the latter fits more their needs, because this switch would mean either the loss of previously collected data or a difficult and expensive effort to transfer them to the new system. This transition stress could be lowered if the different software were sharing some standardisation, and this is possible by the adoption of free standards, such as those on which the TRS and its current partner tools are based, i.e. the OGC protocols, Openlayers, HTML5, ODBC, SQL, PostGIS, …. If the different proposed systems share the same elementary building bricks that don't belong to any specific company, then the final users will always find solutions to eventually transfer their precious data between different systems, and escape from a probable captivity where they become gradually more and more dependent on a single actor. And forward-looking it is a question of sustainability to think about solution, which keeps the growing number of data accessible and usable for other people or companies next month, year or even in ten or twenty years.

4. *The data flow*

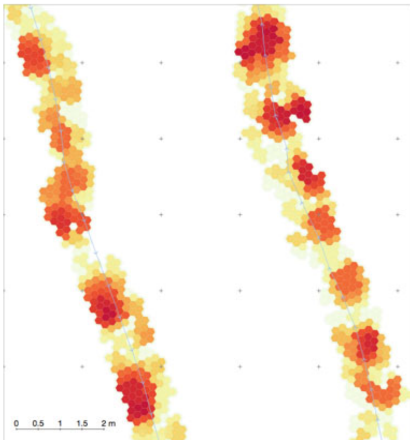
We consider that tools benefitting from the data repository can be seen either as data providers, as data users or as both. The data producers are the sensors, the remote sensing and consequent GIS operations, the surveyors, the general geographical regional data, the UXO databases. The data users are the decision makers, the deminers themselves, the MAC's management, the donors, the engineers developing new tools.

Internally the TRS has schemas devoted to the reception of data and others to present the data, with different access rights predefined and controlled by the server, so that a tool sees only what is necessary to itself. Automatic functions stored within the database and developed accordingly to the specific needs of some tool can perform additional tasks like add some metadata or achieve a complementary data processing. These stored procedures allow different tools to benefit.

5. *The current developments*

The development of the TRS is an extra task in the framework of the Tiramisu project and had to be done with a small budget having led to the limitation of the features currently available. At the moment we can propose the following:

- Support of a metal detector. Here the field TRS is connected to a TCP-box, which in turn is connected to a metal detector array mounted on the robot 'Teodor'[5], all tools are developed within Tiramisu. The array generates data (positioning and time stamps provided by a TCP-Box and detectors signals) that is fed into the TRS every minutes where a complementary process transform them into map layers that can be visualised in a GIS tool also connected to the TRS, such as the DSC[7] tool or QGIS[6]. The GPS tracks and all the geo-positioned detectors signals are stored in the database for further use.



Metal Detector signal intensity as viewed with the TRS. Test realised in July 2014 in DOVO centre, Belgium, with Vallon MD array mounted on robot Teodor. Intensity of the reds related to the intensity of the signal.

FIG 2. METAL DETECTORS SIGNALS

- The TCPbox implement a flexible infrastructure for a distributed ad-hoc data communication infrastructure and support for precise navigation using multiple satellite navigation systems like GPS, Glonass and Galileo (GNSS). Different versions of the TCPbox can act as communication hubs and equipped with different GNSS receivers they also support precise positioning using realtime kinematic algorithms (RTK). In areas without internet infrastructure they can serve as a gateway to a (satellite) internet connection and also act as a local reference station for correcting GNSS signals.

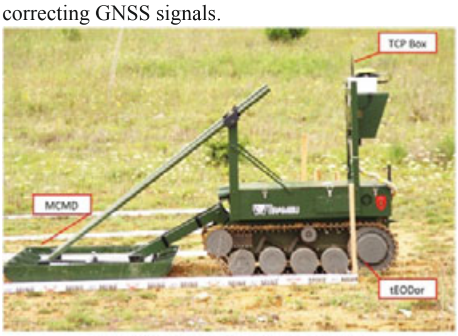


Figure 1 tEODor mobile robot platform with the MCMD and TCP box

FIG3. TEODOR WITH MD AND TCPBOX

- Survey data collected by T-IMS[2] are transferred by MaXML files. T-IMS is a mobile app used to collect data in the field and it uses MaXML (an XML formalisation of the Mine Action data created by the GICHD and enhanced during the Tiramisu project) as a transfer file format. The TRS has an input schema designed to receive the MaXML data loaded by a side module to T-IMS.
- Similarly a module developed in QGIS with a live connection to a TRS instance has been developed in the framework of the Non Technical Survey (NTS) for Mine Presence Indicators (MPI). It allows the user to identify on a ground image - obtained from public sources or from aerial engines such as UAV's - the MPI's that are used to describe the past war activities and consequently locate the possible mine fields. This module can be used in a semi-mobile way on the field with a laptop and a GPS positioning or in the office.

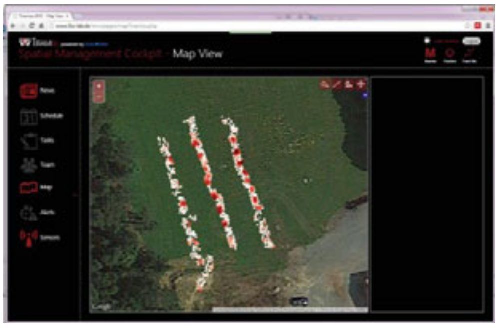


FIG 4. THE DSC USER INTERFACE

- The Decision Support Client (DSC) is probably the Tiramisu tool that takes more advantage of the TRS. It is a web-based interface fitted for a tablet that allows to display data from the TRS, such as the one generated by the tools described above, with a wifi connection to the TCP-Box field network. The DSC is based on HTML5 and can be used independently of the hardware. It is the TRS keystone for the decision makers, presenting on the same display the different types of data related to one area. It also provides access to collaboration tools like group calendar, task lists, shared documents and other management services hosted by the TRS.

6. *The next developments*

The Tiramisu project is still ongoing and even if the plans for the TRS are almost reached, we may have the opportunity to add some useful functionality.
The TRS has a modular structure and is progressively augmented with different tools developed inside the Tiramisu project. This allows us to consider the addition of other functionalities not yet implemented:

[5, 7] See project Tiramisu

[6] See http://www.qgis.org

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- The TRS would be a perfect place to implement the T-Priority, a tool to compute the priorities among the different areas to care for.
- The T-PCH is a tool used to delineate the different suspected hazardous areas based on the indicators previously collected. A functionality designed to delineate PCH along linear feature like trenches or defence lines is already available but there is much more work still to do and we might integrate other algorithms already developed separately
- Additional sensors as data sources should be added to make the TRS a real universal data management tool. In addition to the storing of sensor data, functionality for setup and control of sensors to support mission planning is a helpful extension.

Obviously the more tools are integrated with the TRS the best.

7. Scalability / Openness / Adaptability

Because of the openness of the TRS and with attention to favour end-users, it is possible and highly desirable that other actors, among which the MAC, develop their own functionalities to enrich the TRS capabilities and to customise it to their specific needs. As it is said in last year's paper [1] there are different ways to interact with the TRS and as long as the authority in charge of operating the system allows it by defining the access rights, many things are possible. Moreover the add-ons developed by third parties could easily be shared between the different users in the HD community.

8. Demo scenario

To illustrate the role of the TRS for integrated demining data management, here's a simple scenario of hypothetic successive demining operations:

1. Limited-size satellite images or aerial photos over a mine contaminated suspected area and/or vectorial delimitations/characterisations of PCH (= Potential contamination hotspot resulting of the remote sensing analysis) are processed by analysts using Land Impact Survey Tools, and are stored in the **National TRS**. *[Result: A PCH is identified]*
2. The relevant PCH data are loaded on mobile field devices (tablet or laptop) of a Non-Technical Survey Team for on-site exploration purposes. Additional geo-referenced observations (photos, videos, notes) are collected via **T-REX.MPIC** (Mine Presence Indicator Collector) or **T-IMS** *[Result: A PCH is further validated by on-site observations and a field-report is generated (with **T-IMS**) and stored in **National TRS**.]*
3. The geographical material and the field report are used for further analysis at the MAC. The analysis result with the map(s) – now probably augmented with drawings/markings from the analysis staff – is stored in the **National TRS**. *[Result: Material for decision support is prepared and provided.]*
4. Based on the analysis result, decision makers from the MAC task a Technical Survey Team (TST) to enter the area. The task is defined in an order based on data stored in the **TRS** and it is also stored and shared on the TRS. *[Result: Decision is made and TST-Task is defined, stored and shared.]*
5. A “snapshot” with the data relevant for that specific area is transferred from the **National-TRS** to the **Field-TRS**. The **Field-TRS** will be set-up and connected to all **TCPboxes** installed on the different sensor platforms, and additional computers or mobile devices on site via the **Wifi Field Mesh-Net**. *[Result: Field-TRS, TCPboxes and Wifi Mesh-Net are up and running.]*
6. During Technical Survey, the sensor data of the mine detector(s) with position and timestamp are stored on the **Field-TRS**. *[Result: Documentation of geo- and time-referenced measurements]*
7. Map layers are generated to show a spatial visualisation of sensor measurements (‘heat map’) and the position tracks of the sensor platforms on the **DSC** tablet PC of the Head of the Technical Survey Team. (Previous measurements of other sensor surveys on the same area can be visualised as map overlays.) *[Result: Map visualisation of the measurements on the DSC]*
8. Periodical reports will be generated summarising the collected data and activities for the PCH. They are stored as PDF in the **Field-TRS**. *[Result: Shared PDF documents via the TRS-D owncloud service]*
9. When all the work in the PCH is done, the **Field-TRS** will be synchronised with the **National-TRS** *[Result: All data referring to that specific mine action site are backed up and available for further investigations – whenever needed]*

9. Conclusion

As more and more demining tools need input data from other tools and produce more data that might be input for others, a centralised data management gets more and more a urgent need also for deminers. During the Tiramisu project, the Tiramisu Repository Service TRS was developed and integrated with several other Tiramisu tools from sensor data to decision support to demonstrate an open approach for data handling along the demining workflow from satellite image analysis to technical survey and documentation. We are open to cooperate with further tools for a real comprehensive support along the demining process to make demining more efficient, results more reliable and well documented also for future use.

Open source hardware for mine action

E. E. Cepolina, S. Cepolina, E. S. Carrea [1]

Abstract

The mine action community suffers from a lack of information sharing among stakeholders. Although the problem has been highlighted long time ago by different practitioners such as [Lokey, 2000], it seems it hasn’t been solved yet with reluctance in sharing basic data such as machine purchasing cost still actual (see the GICHD catalogue of mechanical demining equipment[2]).
An idea investigated and originally developed in 2004 with the Participatory Agricultural Technology (PAT) machine project is now revisited and re-proposed to promote a dramatic shift in paradigm: the development of open source hardware, especially mechanical technology for mine action.
Positive examples of business models already exist in open design. Learning from experiences by successful pioneers such as Arduino[3], a new philosophy is proposed in which demining technology is designed in a way that aims at making it suitable to be produced, or when this is not possible, to be assembled, in not specialized workshops around the world, and the detailed technical drawings are published on the internet under creative commons licenses, free to be downloaded by everybody interested in building the hardware.

The market of demining machines

The market of machines for demining is definitely of niche type, with less than 750 units currently operating worldwide. According to the Catalogue of Demining Equipment Catalogue[4], an electronic database hosted by the Geneva International Centre for Humanitarian Demining (GICHD) and continuously updated directly by machine producers, among the 43 different models of demining machines of all types produced, the majority (53,49%) are operating worldwide in five or less units (see fig.1). Nine different machine models have only one unit currently operating. Therefore, the market is characterised by a relatively high number of machine producers (29) each one with a limited number of machines in use in the field. Among the four companies with the highest number of units in use, the one with highest number (220) have them operating predominantly within the military (see fig.2).
Given that there is widespread consensus on the benefits machines bring to a faster release of suspected hazardous areas to local communities, there is huge potential for the market to expand. On the other end, clearly, some limitations to its expansion also exist and they should be looked for in the unique nature of this very particular type of market.
According to [GPC International, 2002] the market for humanitarian demining technologies is anything but traditional and does not respond to standard market approaches. The main reason for this is that it’s small and donor-driven. Since the volume of the market is low and donors are asked to purchase the equipment users need, it is generally inefficient and conservative; decisions not necessarily reflect a cost-benefit analysis, instead favouring the use of well-known equipment, generally high cost.
The negative effects of a donor-driven market are also highlighted by [Bilec-Sullivan, 2007] who suggests that mine action personnel may only consider new technologies when it has been developed by a benefactor or a partner organization of a benefactor. For example, if a mine action operation is funded by a specific donor, the donor may require the use of a specific close-in detection technology developed by a partner organization. The potential result could be that technologies are sometimes adapted by demining organizations as a result of political or strategic partnerships versus increase in productivity or cost-effectiveness.
Another factor hampering the opening of the market is highlighted by [Lokey, 2000] who reports general reluctance by “experts” to share the information they have : information that could be used to benefit the entire community is frequently held by the expatriate and international workers who feel they're experienced experts and don't deem the hordes of

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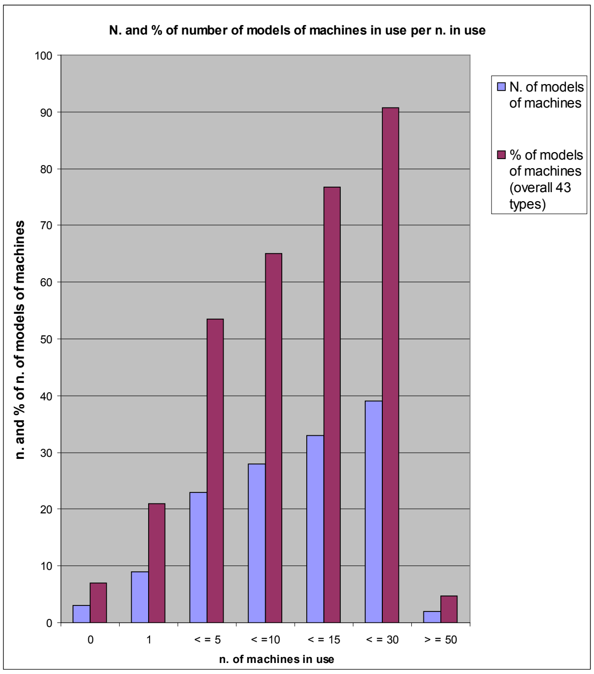
[2] [4] http://www.gichd.org/mine-action-resources/equipment-catalogue/#.VQg9htLF_1E
[3] http://www.arduino.cc/

newcomers worthy of their time and [Carruthers and Littmann, 2001] who observe that there is a great amount of potentially useful information being generated, but it is treated as proprietary and not open for dissemination.
The lack of information sharing and transparency is also responsible for keeping the gap between scientific and operational mine action communities very large and for making research into new technologies for mine action useful only if carried out after an extensive and deep personal analysis of end-user needs, that generally require important resources to be committed to the cause.



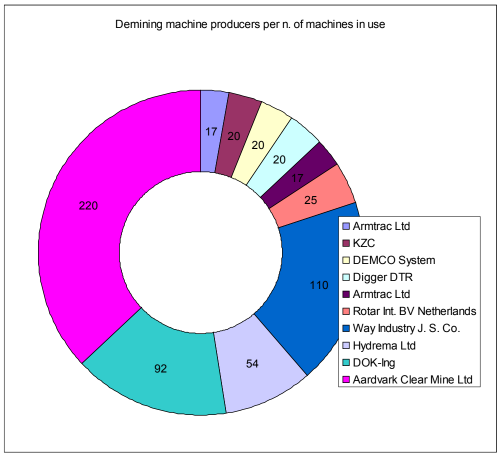


Fig. 1 and Fig. 2. Analysis of data published in the Catalogue of Demining Equipment published by the GICHD as of 12/03/2015.

Therefore, in order to create a favourable environment for more technologies to enter the demining technology market and then ultimately helping releasing mine affected land to local communities for a safe use including food production faster, there is need to change approach and create a more transparent, less donor depending and more cost-efficiency oriented market. While changing the market is a huge effort at which Snail Aid together with other partners is working on within TIRAMISU[5] project, creating a new business model for a new technology is easier. The hope is that the new model can work as provocative and pioneering example for other technology designers.

Disarmadillo approach

Snail Aid is a research and development not for profit organization that had the rare chance to have the time, resources and aptitude to gain the necessary experience in the field to achieve a fairly good understanding of the needs for new mine action technology. After having visited more than 30 organizations working in the field and having interviewed representatives of them at different levels in the context of different studies and visits during personal free time, Snail Aid staff has decided to suggest again an idea investigated and originally developed in 2004 with the Participatory Agricultural

[5] Toolbox Implementation for Removal of Antipersonnel Mines, Submunitions and UXO (TIRAMISU), is an EU co-funded integrated project (under grant agreement n. 284747) whose purpose is the creation of a comprehensive toolbox for humanitarian demining (TIRAMISU.http// www.fp7-tiramisu.eu/).

Technology (PAT) machine project [Cepolina E.E., 2008]: the development of open source hardware, in particular mechanical technology for mine action.

As PAT machine, also its newer version Disarmadillo is aimed to be an upgrade kit that can be mounted on every type of powertiller (a two wheeled agricultural machine used as prime mover) to transform it into a demining machine supporting manual deminers in their work, by helping them cutting vegetation and smoothing the soil before they start working. Instead of being designed to clear mines, it is designed to assist manual deminers or dog handlers (whoever follows the machine) by processing the ground in front of them with the double aim of making their work safer and lighter, but without pretending to detonate or crush all mines. Thanks to their low cost, more units can be used at the same time, helping releasing land to local communities faster. When not used in demining operations, Disarmadillo can be reconverted to its original agricultural use and help securing food production.

While COTS (commercial off the shelf components) needed by the kit will be listed with price and suggested purchasing sites, all components that need to be custom made will have their technical drawings available for free downloading from the internet. Potentially, a new machine could be built around any powertiller by anyone interested, with as little modifications as possible.

Similar approaches are being successfully used by projects targeting electronics (Arduino) and heavier hardware (open source ecology[6] or Do It Yourself (DIY) Vehicles[7] or Drones[8]). As in these well known cases, the community of users would be asked to provide its feedback on experiences with the machine and contribute to future developments.

The idea of revisiting PAT machine follows a stream of thoughts generated by the recent interest in a new standardised test protocol on demining machines other than machines designed to detonate mines. The current CEN Workshop Agreement (CWA 15044) regulating the test and evaluation of demining machines is openly biased towards demining machines designed to detonate hazards and clearly states that "there is need to expand future work to address a number of issues, including appropriate testing for ground preparation devices". In the attempt to bridge the gap left by the current CWA, research into new protocols for testing and evaluating demining machines, other than machines designed to detonate hazards, has started and the possibility to take this opportunity also to integrate a cost-efficiency evaluation of such machines has been considered. To push the focus on cost-efficiency to an extreme, the idea of suggesting again a machine at near to zero purchasing cost, built around a typical available machine in rural communities, arose. Besides having negligible initial cost, Disarmadillo is characterised by being simple and modular. If required by customers, all parts needed could also be produced and bought in Italy by the producer and delivered in a box to the customer. If, necessary, upon request from the customer, assembly of all components can also be offered as a service locally (as knowledge transfer) in the mine affected country together with training on the use of the machine. Thanks to its modularity, if new tools or components are devised by the community, old machines can be upgraded without having to throw away what works.

The kit adds to the original powertiller a frame that has the dual aim of hosting two additional wheels at the front with respect to the original driven wheels and of embedding a track tensioning system. Agricultural tyres are replaced with special wheels designed to transmit motion to and support the tracks along their width. The frame added to the power tiller is designed to host a winch and a sort of three point linkage system, allowing different tools to be mounted at the front. The power take off at the back of the machine can be used to power implements requiring an actuating torque. Being reversible, the machine can be used indifferently forward or backwards. The machine is remotely actuated and is driven by an industrial remote control unit, allowing major functions to be controlled remotely. The remote control system is not substituting original manual controls; therefore, once reconverted to agricultural activities, the machine can go back to manual control.

Disarmadillo is aimed at hosting a range of different implements such as vegetation cutting and ground processing tools such as the rake (fig 5) that has already been tested in operating environment in Jordan with inert mines, while explosive tests have taken place in Italy [Salvi M. et al., 2005].

Disarmadillo has been designed in accordance with circular economy philosophy [Ellen McArthur Foundation, 2013]: the mature technologies it is based on are well known everywhere in the world as well as the skills needed to repair it. The machine uses components that are either available off the shelf or easy to manufacture in non-specialised workshops.

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6 http://opensourceecology.org/

7 https://www.osvehicle.com/

8 http://diydrones.com/

Fig3 – 4 - 5. From left: DISARMADILLO built around a Grillo powertiller and DISARMADILLO built around an old Pasquali powertiller, rake implement under test in Jordan.

Thanks to the fact that it is based on mature agricultural technology also its maintenance and running costs are minimized.
The ambitious project idea is to make humanitarian mine action (HMA) end-users closer to technology providers, to allow end-users to choose and buy the technology they need without having donors as intermediate and to make them owner of the technology they use. By focusing on cost-efficiency of machines, the project aims at bringing sustainable technologies to developing countries to serve both humanitarian and food security.
The idea to adopt an open design business model for a mine action technology is clearly provocative and against the flow considering the HMA market trends highlighted in the previous part of the work; nevertheless, it is feasible and in line with Snail Aid's nature and mission.
This approach aims at challenging the traditional lack of information sharing of mine action, at increasing active participation of end users to the design and decision making process. Positive implications, as better explained in the following paragraph, are expected in terms of gap reduction between scientific and operational HMA communities, increased competition level, cost reduction and possibly promotion of a more close integration with development.

Open source hardware business model

Although it might seem controversial, open source philosophy can be a viable business model.
Open source could improve enterprise's performances by different perspectives. It could be seen as a development methodology to implement the open innovation paradigm, allowing the opening of the company's boundaries to the external environment, "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation" [Chesbrough, 2006]. Sharing problems and ideas, promoting collaboration and cross fertilization contribute to boost innovation, collecting inputs from all over the world, actively involving end users from the first design phases and at the same time it allows to save critically scarce resources like time and money.
The open source approach allows producing better products: an open product can be easily tailored and personalized, thanks to continuous consumer and technicians interaction; openness makes products adaptable and flexible (to local contexts, needs and budget) and easier and cheaper to maintain, to repair and individual parts easier to be reused [Gibb, 2015]. At the same time, products are available at low price or even for free. Based on the DIY Drones and Arduino case studies [Gibb, 2015], people can download free hardware design, the complete list of all the components (with relative prices) and the instructions on how to put them together to obtain the final product. Customers can decide to pay the company to make the product for them, to buy components by different suppliers and assembly autonomously or to do it by themselves.
Thus, open design has interesting positive implications in terms of sustainability mainly linked to the modularity of the products, the distributed manufacturing model [Wittbrodt et al., 2013] and postponement supply chain management strategy [Chang et al., 2010], resulting in close to zero waste manufacturing processes, compressed supply chain and long lasting of products life.
Finally the open source model seems to be actually coherent with the nature of Snail Aid, a no profit social enterprise researching and implementing technologies for sustainable development, both in Italy and abroad, especially in developing countries. The open source model tends to distribute wealth to the populace rather than to concentrate it [McKnight, 2010] and it works as business accelerator, encouraging business start-ups for new applications, minimizing barriers to entry.

Apart from the well known cases of Arduino and open source ecology, there is a great amount of other positive examples of application of open source models applied to hardware production. A plethora of DIY examples exist such as the already mentioned drones and vehicles.

Conclusions

The paper addresses the problem of lack of information sharing and transparency in the mine action technology world. A new paradigm is provocatively presented and a new business model suggested through the example of Disarmadillo, the first open source mechanical demining technology that would soon enter the market.

Acknowledgments

The research leading to these information and results has received funding from the European Community's Seventh Framework Programme (FP7/2007 - 2013) under grant agreement n° 284747. While Disarmadillo has not been subject of structured funding, its development has kept on going with volunteer contributions of many partners interested in the project we would like to thank here : Grillo Spa, the company producing the powertiller the current version of Disarmadillo is based on, Edoardo Del Bianco, recently graduated from the University of Genova in Italy with a thesis on the remote control of Disarmadillo, I.p.s.i.a. Odero, a technical high school in Genova, Italy, where students have been involved into the re-design of the machine, and in particular prof. Gigi Acquilino, and many other companies who provided their products and consultancy for free such as Isibond S.a.s., producing brakes and many others.

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Pilot MRE campaign in Cambodia using Billy Goat Radio System

L. Scapolla[1], E. E. Cepolina[1], S. Aresca[1]

Abstract

After the first evaluation of Billy Goat Radio System, which took place in October 2013 in the Sahrawi refugee camps settled in Algeria, in October 2014 Snail Aid carried out another in-field test in the north west of Cambodia. Aim of the mission was to finalise the research work started in January 2013 by implementing an actual pilot campaign held during an in-field mission aimed at evaluating all the main aspects of the tool. The combined use of tradition and technology is a constant characteristic in Billy Goat Radio Project: on one side, the traditional story telling proposed in form of a radio broadcast serial drama, and on the other side an adaptability system which uses in parallel a simple software and a system of cards to adapt the serial drama's story and the mine risk educational messages embedded in it to any context. Both the broadcasting and the adaptability system have been tested first with experts from different local and international organizations working on mine action in Cambodia and later on among several mine affected communities; results and feedbacks have been used to tune Billy Goat Radio system toward its final version.

Introduction

Billy Goat radio is a Mine Risk Education tool, developed by Snail Aid – Technology for Development, in the frame of TIRAMISU[2], an EU co-funded integrated project. It consists of a modular and adaptable system aimed at enabling local end-users to write and produce educational short serial dramas, whose episodes should be broadcast by radio and live performed inside mine affected communities.

In September-October 2013 Snail Aid took the preliminary version of Billy Goat Radio to the refugee camps of Sahrawi people settled in the south west of Algeria. This version had been conceptualized and implemented since January 2013 and already included the main basic features of the project, built on the basis of entertainment-education theories:

1. an educational serial drama in six episodes, to be both broadcast by a local radio and performed live by teams of actors travelling among mine affected communities,
2. a simple and cost-efficient recording equipment (suitable to itinerant plays) to record the episodes.

The third fundamental characteristic of Billy Goat Radio project is the possibility to use the tool in very different situations and contexts without the need of a long and expensive re-writing process and without needing professional writers: this possibility is achievable through the Adaptability System. Still missing during the first implementation in Algeria, this system had been anyway already considered and foreseen, and the experience made there with local mine affected communities, gave Snail Aid researchers the instruments to create the

3. Billy Goat Adaptability System, which, in its original form, consisted of a simple system of cards.

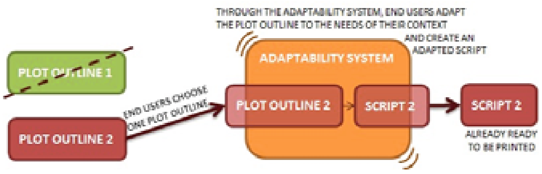

Figure 1 - the writing process: from plot outline to script

These three main points have been elaborated and integrated during 2014 by Snail Aid researchers, and a new, more complete version of Billy Goat Radio was taken to Cambodia in order to test its potential and its drawbacks. The precious collaboration and exchanges with experts from different local and international organizations working on mine action and later on the experiences among several mine affected communities lead Billy Goat Radio toward the actual and final version.

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[2] Toolbox Implementation for Removal of Antipersonnel Mines, Submunitions and UXO (TIRAMISU), is an EU co-funded integrated project (under grant agreement n. 284747) whose purpose is the creation of a comprehensive toolbox for humanitarian demining (TIRAMISU.http//www.fp7-tiramisu.eu/).

In October 2014, Billy Goat Radio project already included two different educational serial dramas, both organised in six episodes, whose different stories and characters make each of them more suitable for one or another context. For each drama, Snail Aid proposes a *plot outline*, which is basically the storyline of the drama without any local characterisation in terms of social life, environment, mine or UXO threat. The local end –users should choose one of the two *plot outlines*, then adapt it to their context's needs through the Adaptability System: this way they generate their local version of the chosen drama, automatically creating a *script* which is the final step of their writing work.

The first serial drama, "Billy Goat: the story of Mariam and Yahdi", was tested in Algeria, while the second one, "Billy Goat: life of Mliss", was the one Snail Aid brought to Cambodia.

Billy Goat Radio in Cambodia – Phnom Penh

Billy Goat landed in Cambodia well prepared: a complete serial drama already translated from English to Khmer, well established contacts with local and international organizations operating in the country and a team of local experts made kindly available to Snail Aid staff by the Cambodian Mine Action Centre (CMAC) for the entire duration of the mission, which took place mainly in the Pailin region, in the north west of the country.

Before starting with the recording and the broadcasting of the drama and moving all the staff to Pailin, the tool passed through a careful and accurate evaluation in the capital city, Phnom Penh. In two different occasions, the whole project was presented in front of delegates from organizations active in mine action in Cambodia: the Cambodian Mine Action and Victim Assistance Authority (CMAA), CMAC, the Cambodian Self Help Demining (CSHD), UNICEF and HALO Trust. After an explanation of Billy Goat Radio's aim and functioning, the focus of these meetings shifted on the testing of the Adaptability System, at that time still consisting only of a system of cards. The system is made up of two separate parts: the first one regards the social aspects of the everyday life of the context where the MRE campaign takes place (from social, religious, gender discrimination, moral and traditions points of view). The second one is aimed at defining which MRE educational messages, among the several proposed by the system, actually fit to the real needs of the local affected communities in terms of threat (presence of mines, UXO, category of victims) combined with local features such as orography, environment, vegetation, etc.

Figure 2 - Test of Billy Goat Adaptability System in CMAA offices, Phnom Penh

Figure 3 - the Adaptability System cards in use

Figure 4 - Delegates of CMAA, CMAC, CSHD, UNICEF and HALO Trust in CMAA offices

Experts from organizations were asked to collaborate creating a new version of the story starting from the fixed *plot outline* Snail Aid prepared. Using the cards and answering a series of simple questions regarding everyday life inside mine affected communities in north-western Cambodia and the different threats, they gradually built around the *plot outline* a series of slight changes and different details which should be able to make this version of the serial drama (we call it "*version B*") very adherent to the needs of the local context.

The same operation, after extensive research, had been previously carried out by Snail Aid staff who created a *version A* of the drama, whose script was used as official script of the serial drama for the MRE campaign in Pailin. The comparison of versions *A* and *B* should stress differences and consistencies between them, in order to check if the Adaptability System was effectively able to guide resident operators (without any experience in literary creative work) in generating a story version which could seem written directly in the local context by local writers. As a result, it was noticed that the Adaptability System part regarding the social features of the story was quite easy to understand and to use for the end-users, who seemed to be amused by the intuitive practice of the cards system. The part about the educational messages, instead, was difficult to understand and not clear in terms of results: among the several available educational messages, some were judged by the local experts as too general or vague, while others, in reverse, were perceived as too specific. However, at the end, version *A* and *B* diverged only by few details, and Snail Aid and the local experts chose the same educational messages, unless few exceptions. The main drawbacks of the system were thus seen by the local experts as relying more in the difficulty of the use than in the proposed messages.

Similarly, a difficulty in the use was evident when Snail Aid researchers tried to explain how to proceed from the story version created through the Adaptability System to the effective writing of the final text in form of a script (organized as a series of dialogues, without descriptive parts). Not yet fully developed, this step of the system was still very complicated and confused, virtually impossible to be comprehended by non-specialists in one afternoon. Feedbacks and comments of the delegates helped a lot in enhancing and above all in simplifying this transition.

Billy Goat Radio in Cambodia – Pailin

Pailin region is one of the most heavily mined areas in the world and among the five most mine affected provinces in Cambodia [CMAA, 2014] [I]. Despite a positive trend recorded in the latest years, in the first half of 2014 the number of accidents of mines and ERW in Pailin region increased by 52% compared with the number reported in the previous six months [CMAA, 2014] [II]. For this reason, this area was chosen by CMAC as target for Billy Goat pilot campaign; the campaign benefited from CMAC good network of salaried and volunteer workers well integrated in the communities, coordinated by Mr Khim Thorn, CMAC Training/Monitoring Officer, native of Pailin, who supported Snail Aid's work for the entire length of the campaign.

After a necessary adjustment of the Khmer translation of the script to adapt the language to the slang spoken by local farmers with the help of local CMAC staff, a team of actors belonging to the local O Torng Pailin Radio Station[3] started recording the six episodes of the drama. Meanwhile, Snail Aid researchers with CMAC staff started a campaign through the countryside with the double aim of interviewing local farmers living and working in at-risk areas and meet local organizations working on development in the area. During one week of intensive travelling around Pailin, Snail Aid reached seven different rural villages and was able to interview 30 dwellers, submitting them the KAP1 questionnaire prepared in collaboration with Brimatech[4] to assess the knowledge about mine risk and safe behaviours of local people before the MRE campaign started. In the same time, it was planned to meet all the local based organizations dealing with development, in order to better understand the reasons of the recent increase in mine casualties. Unfortunately, the area's underdevelopment and isolation resulted evident by the number of organizations reached: only Buddhism for Development, a confessional organization aimed at encouraging and providing support and training to rural people [Mansfield et MacLoed, 2004], and the governmental Department of Agriculture of Pailin Province, could be reached. Both these meetings confirmed how institutions are aware of the local situation, but unfortunately highlighted a lack of structured plans and strategies to improve in any way the quality of life of local rural workers. As in many mine affected areas in developing countries, it is the hunger that pushes needy people to risk their lives cultivating contaminated land, and there is no governmental policy trying to convince poor farmers not to move to the area, where many (but most likely contaminated) parcels are still available [National Institute of Statistics et al., 2014]. However, the results of KAP1proved that most of the population of Pailin region is not uninformed about mine and UXO threat in the area: on the contrary, many interviewed people showed a quite good knowledge of the principles of safe behaviours, in contrast with the high number of accidents still happening in the area. Snail Aid researchers' feeling was that all this accumulated knowledge, result of frequent MRE traditional sessions (achieved in form of oral presentation, with one lecturer speaking in front of a passive audience), had been memorised and repeated by the villagers as a theoretical lesson, without a real or deep understanding of the practical value and the potential impact of messages on their daily life. This encouraged the staff in going on with Billy Goat Radio project, whose aim is precisely proposing MRE messages in an entertaining way which shouldn't be passively perceived by the target as something extraneous or imposed form the top down [Scapolla et Cepolina, 2013], but actively assimilated through identification with the drama's characters and their lives [Bandura, 1977].

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[3] O Torng Pailin Radio Station, available on FM 97.5 MHz, is one of the two radio stations broadcasting from in Pailin. The other one is National Radio of Kampuchea, which transmits from the same studios on FM 90.5 MHz.

[4] TIRAMISU partner as well, Brimatech is an Austrian market research and consulting company specialised in supporting projects development, which worked with Snail Aid since the beginning of Billy Goat Radio project with the aim to evaluate the effective impact of the tool on the target audience (www.brimatech.at).

Once the actors concluded the recording work, the six episodes of the serial drama started to be broadcast by O Torng Radio, an episode a day, at 10am, as previously agreed with the radio station. Simultaneously with the broadcast, Snail Aid staff started the new phase of the work, travelling every day to a different village to propose each drama episode in a live form to the audience of affected communities. The plan was to perform each episode in front of a group of resident spectators, at the same time of the radio broadcast of the drama. This was a way to present the project to affected communities and their local authorities, to create attachment to the story, to better convey the educational messages and to generate the conditions for community liaison, accomplished by Snail Aid through group discussions carried out after the episode show.

In the first campaign (Algeria 2013), the actors travelled with Snail Aid team from village to village performing every episode in front of the audience: this time, the actors could not participate and the live shows consisted of a projected video whose images followed the rhythm of the recorded episode, which was diffused through a system of loudspeakers. Although it was for sure not as fascinating as a real live performance with actors, the audience reacted to the show in an interested and concerned way, demonstrating to follow the story and the educational messages during all the length of the episode. The active listening of the audience is demonstrated by the fact that out of more than 70 answers to "rapid questions" asked at the end of the live shows to record the level of message and story understanding only 7 were wrong, therefore less than 10%.

Figure 5 – audience in a rural village

Figure 6 – actors recording an episode

Figure 8 – KAP1, interview with a villager

Figure 7 – mine victims among the audience during a group discussion

Figure 9 – MRE game, a moment of the group discussion

Among other activities aimed at fostering community liaison, during the group discussion sessions Snail Aid proposed those people who accepted to answer another questionnaire, KAP2, prepared in collaboration with Brimatech and intended this time to evaluate the effective impact of the educational drama on the listeners.

Billy Goat Radio after Cambodia – Conclusions

Snail Aid learned a lot during two years of research and two testing and evaluation missions in different parts of the world, diverse for society, environment and educational needs.
The results obtained through the first evaluation carried out in collaboration with Brimatech, showed that Billy Goat reached a very good level of acceptance and comprehension by the listeners [Scapolla et Cepolina, 2014]. This left Snail Aid researchers free to concentrate on the Adaptability System and particularly its part concerning the choice of the best fitting educational messages, on which the second evaluation mission focused on.

Results and feedbacks obtained during the MRE campaigns of 2013 and 2014 are currently being used to tune Billy Goat Radio system toward its final version, in which the Adaptability System will be improved and made more flexible. Key word of this last phase is simplification: Snail aid decided to work toward a final product simple and easy going in terms of both end-users comprehension and ease of use.

Remembering the difficulties Cambodian delegates (on average probably more educated than the effective future end-users of the tool) encountered in understanding how to use the Adaptability System's parts regarding the MRE messages and the step proceeding from the plot outline to the final script, both these issues have been radically streamlined.
The MRE key messages have been corrected and more simply schematised. Thanks to new inputs and a division in categories of topics, they cover now a more ample spectrum of general and particular situations of mine / UXO threats and the cards can guide the end-users to formulate alone those MRE messages they can't find among the proposed ones. The transition from the adapted plot to a ready script has been dramatically simplified and automatized: before, the end-users were required to remember and manually write down the details and changes they obtained through the Adaptability System, and then to organize them relatively freely in a coherent script. In the new version, after having used the Adaptability System, the end-users will automatically get a script, already perfectly organized and detailed, ready to be print. This necessarily implicates the use of a computer, whose elementary knowledge is one of the basic requirements the end-users must have to use Billy Goat Radio tool, together with adequate English language skills. However, considering the fact that mine affected areas are often in developing countries and in rural areas, where computer literacy may be quite small, every step involving computer use has been conceived to be easily used by operators with very low computer literacy.
The use of a computer has introduced enhancements also in the Adaptability System, which has been renewed too: always in the perspective of a simplification of the whole structure, the already mentioned cards have been juxtaposed with a software system, whose use requires only an elementary knowledge of computer technology and which automatizes the process sparing repetitions and memory exercises to the end-users. The local end-users will be free to choose between the paper and the software system, and through different but analogous processes they will always get to the final adapted version of the story, already written in form of a drama script and ready to be printed. Currently, Snail aid is preparing the updated cards and software versions of both the stories ("The story of Mariam and Yahdi" and "Life of Mliss)" available in Billy Goat Radio system.

Acknowledgments

The research leading to these information and results has received funding from the European Community's Seventh Framework Programme (FP7/2007 - 2013) under grant agreement n° 284747. All pictures are courtesy of Silvia Aresca, photographer and researcher of Snail Aid.

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Unmanned aerial vehicles in chemical, biological, radiological and nuclear environment: Sensors review and concepts of operations

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ABSTRACT

Recent crisis like the use of chemical warfare agents in Syria and the Fukushima accident, presents a need for new technologies, which may lead to the deployment of unmanned aerial vehicles (UAV) to detect chemical, biological, radiological and nuclear (CBRN) threats in the future. Unmanned aircrafts are an ideal choice when operations are required in environments that would be hostile to a manned aircraft or its crew. Airborne sampling or observation missions related to CBRN threats would be ideally suited to unmanned aircrafts. Sensors can be fitted to a range of types, from a small man-portable system for local tactical use, to large aircraft-sized systems for global monitoring.

This review aims to describe some trends on CBRN sensors and integration on UAV platforms and also to identify concepts of operations involving the use of UAV in a CBRN scenario. From the technical perspective the biggest challenge is to combine the avionic flight system of the UAV, the sensor systems and the wireless communication link while guaranteeing the absence of any mutual interference. Another issue that is addressed is related to the need for decontamination of the platforms after an operation in a "*hot zone*". Modular approach with disposable components or the use of low cost systems could be a solution where smaller systems can be disposed in a safe area once data has been gathered rather than having to recover to an airfield where it would have to be decontaminated, or risk contaminating personnel and other equipment.

The knowledge of CBRN sensor technologies, future trends and concepts of operations are some of the main issues that should be addressed for identifying research and development (R&D) opportunities for further development of UAV for CBRN operations.

Introduction

Current developments in unmanned aerial vehicles (UAV) trace their beginnings to World War I. Efforts during the Interwar Period, World War II, and afterward ultimately led to the development of cruise missiles, aerial targets, and the current family of UAV. The UAV have the ability to transmit to the battlefield commander real-time intelligence, surveillance, and reconnaissance information from hostile areas. They can also act as communication relays, designate targets for neutralization by other assets, or attack the targets themselves with onboard munitions and then loiter while streaming real-time battle damage information back to friendly forces, all without risking the lives of an aircrew.[1]

The use of UAV is crucial in highly contaminated environments, having several advantages including: reduction and/or elimination of life loss risk; access to inhospitable and inaccessible environments; incorporation of several advanced technologies, complementary and coordinated with each other, increasing the efficiency and speed of missions; enables greater maneuverability, mobility, flexibility, versatility and autonomy over conventional means; involves lower maintenance and consumables costs; increases survivability due to small size and possibility of coupling highly differentiated technologies that make UAV virtually undetectable.[2]

There are three types of UAV: (1) pilotless target aircraft that are used for training purposes (such as target drones); (2) nonlethal aircraft designed to gather intelligence, surveillance, and reconnaissance (ISR) data; (3) unmanned combat air vehicles (UCAV) that are designed to provide lethal ISR services.[1]

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Unmanned aircraft can also be divided into categories based on an aircraft's maximum gross take-off weight and normal operating height or altitude. Categories start with weight classes, which are further divided on the basis of the operational altitude of the unmanned aircraft as follows: class I (<150kg) further sub-divided into micro-UAV (<2kg), mini-UAV (2-20kg), small-UAV (20-150kg); class II (150-600kg); class III (>600kg) further sub-divided into MALE (medium altitude long endurance), HALE (high altitude long endurance).[3]

An unmanned aerial system (UAS) can be divided into five distinct elements: (1) the air vehicle element consists of the airframe, propulsion and the avionics required for air vehicle and flight management; (2) the payload element is comprised of payload packages, these can be sensor systems and associated recording devices that are installed on the UAV, or they can consist of stores, e.g., weapon systems, and associated control/feedback mechanisms, or both; (3) the data link element consists of the vehicle data terminal (VDT) in the air vehicle and the control data terminal (CDT) which may be located on the surface, sub-surface or air platforms; (4) the UAV control system (UCS) element incorporates the functionality to generate, load and execute the UAV mission and to disseminate useable information data products to various comand control communications computers and intelligence (C4I) systems; (5) the launch and recovery element incorporates the functionality required to launch and recover the air vehicle.[4]

CBRN Sensors and detectors

The CBRN sensors and detectors integrate the payload element of a UAS and consist of a wide range of sensors and detectors comprising different technologies related to the specific scenario and threat.

As a radioactive isotope decays, it emits a variety of types of radiation, including alpha particles, beta particles and X-rays, suffer from self-absorption within the source, resulting in different emission characteristics for different source shapes. Therefore, radiation detection instruments rely on impingement of gamma rays.[5]

Several types of detectors like dose rate meters or scintillation detectors can be used as payload in UAV. The radiological detectors require good sensitivity, whereas good energy resolution is needed for identification of nuclides. On the other hand, a very sensitive detector may be saturated inside an active plume. In that case at least dose rate measurement must be carried out. For dose rate measurement a Geiger-Müller counter is robust and reliable and a detector can combine low and high dose rate sensors. The use of several detectors gives additional operational reliability in the case of a failure in one detector there may still be available data from another one.[6]

Chemical detectors should ideally present capability detection such as good selectivity and sensitivity, lower response time, low rate of false alarms, and good performance and portability allowing to operate under a variety of environment conditions in short time (for set up, warm up and reset), with lower power requirements and lower use and maintenance costs. Presently there is no single detector with all the desirable capabilities and performance functions. Moreover, in most cases it does not specify the chemical, but classification within a chemical group instead.[7]

During identification process there are three levels according to order of confidence, quality and length time: provisional, confirmed and unambiguous identification.[8] Provisional identification allows the location and classification of chemicals, whether through detectors with photoionization, flame ionization, electrochemical or catalytic sensors for location purposes, or through reagent-based tests such as papers and detection kits or colorimetric tubes, flame spectrophotometry, traditional ion mobility spectroscopy, surface acoustical wave for location and classification purposes. Also, there are still orthogonal detectors which have more than one technology mentioned above, allowing lower rates of false alarms and consequently more reliable results. Generally, all these technologies present high sensitivity, fast response time, portability, and power supply autonomy. However, there are some use restrictions: higher number of false positive results, location and classification without specification and poor performance in the analysis of complex and trace samples.

Detection of biological agents used in bioterrorism or as warfare agents poses many challenges to detection platforms. Environmental detection of biological threats face two main obstacles: the ubiquity of microorganisms and the complexity of the environment. Bacteria, virus and other microorganisms are widely present in the environment, constituting a large and complex environmental biological community background, from which pathogenic biologic agents must be distinguished from non-pathogenic agents. Nevertheless, biologic agents are associated with diverse types of complex matrices such as air, water, soil, biological fluids, among others.[9] The identification of microorganisms in different matrices is also an additional challenge to detection platforms, and these systems must be able to identify specific targets characteristic of pathogens, rejecting signals originated from non-pathogens or matrix backgrounds.

Concerning the complex nature of biologic agents and the necessity to process samples by an operator, before running an assay in a biologic detector, the integration of these devices into mini UAV is quite limited. Nevertheless a great diversity of small aerosol collectors, consisting of a small vacuum pump and filter cassettes are available. These simple air sample collection systems can easily be mounted in a UAV and employed to collect air samples inside a suspect aerosol cloud. The air samples could then be processed by an operator (in the field on a reach back laboratory) using commercially available point detection systems, or conventional laboratory diagnostic systems to evaluate the nature of the collected samples.

Concepts of operations

CBRN defence is divided into five enabling components: (1) detection, identification and monitoring; (2) information management; (3) physical protection; (4) hazard management; (5) Medical countermeasures and support. The main objectives of the detection, identification and monitoring component are to detect and characterize CBRN incidents, identify the agents and hazards, to delineate areas of contamination, and monitor the changes. This is acomplished by performing several tasks in the contaminated or suspected area increasing the risk of exposure of personnel. These tasks include surveillance, reconnaisance, survey, sampling, identification and monitoring.[10]

In CBRN response, control zones are established to ensure the safety of all responders and control access into and out of a contaminated area. The three zones established at a chemical, radiological, nuclear, and some biological incident sites are often referred to as the "hot zone", the "warm zone", and the "cold zone".[11]

The main area of operations with a UAV equiped with CBRN sensors is the "hot zone", and that could imply the contamination of the UAV during the process. This aspect poses a problem related to the recovery of the platform after the mission. To adress this issue there must be developed concepts of operation to minimize the risk of exposure of personnel to the contaminants.

In a real CBRN scenario the response teams leave the contaminated area after performing thorough decontamination procedures. To minimise the risk of contamination outside the "hot zone" only a minimum ammount of equipments leave the contaminated area. The "use and drop" approach applied for UAV deployment in a CBRN scenario is based on establishing a landing zone within the "hot zone". As the CBRN sensor systems and the core components of the UAV are valuable items, and also the need to recover data for analysis, the development of UAV for CBRN operations should consider its modularity, including the main components designed for decontamination procedures combined with other disposable components or the use of low cost systems that can be disposed in a safe area.

The use of UAV in CBRN scenarios with its main purpose for detection or sampling tasks, combines the advantages of manned and aerial approaches. This aspect is maximized with the use of vertical take off and landing (VTOL) platforms. The main issues that should be addressed in these type of aircraft are the possibility of cross-contamination, and the interaction with the environment due to the "downwash" of the propellers that could pose some problems of dispersion of contaminants and affect the detection performance.

The integration of multiple UAV should also be considered in a CBRN scenario. Compared with single UAV, the cooperative UAV system can perform with more safety and efficiency. It could reduce the time for tasks, lower the demand of capacity for one UAV, and is operated in a distributed manner, which increases the redundancy and robustness of the entire system. Moreover, multiple UAV can share information with each other by wireless communication, so some advanced and optimal algorithms can be implemented such as gradient searching and contour mapping of contaminated areas.[12]

Conclusions

Due to the rapid advancement in UAV and experience that has been gained by many nations involved in contemporary operations worldwide, CBRN detection in its current form is very likely to experience a fast transition towards a decade of new capabilities. Generally in the past the main focus has been concentrated around mounted and dismounted CBRN reconnaissance. With the emergence of new technologies and the focus on force protection in all operations, capability requirements are now addressing a new topic of unmanned platforms as part of CBRN defence operations.[14]

The UAV continue as the most dynamic growth sector of global aerospace industry this decade, Teal Group's 2012 market study estimates that UAV spending will almost double over the next decade from current worldwide UAV expenditures of $6.6 billion annually to $11.4 billion, totaling just over $89 billion in the next ten years. This study provides 10-year funding and production forecasts for a wide range of UAV payloads, including electro-optic/infrared sensors (EO/IR), synthetic aperture radars (SARs), signal intelligence (SIGINT) and eletronic warfare (EW) systems, C4I systems, and CBRN sensors, worth $2.7 billion in 2012 and forecast to increase to $6.0 billion in 2021.[15]

The CBRN market settled around $8.8 billion at the end of 2013. Several reports and studies estimate an increase in the CBRN defense market. The Strategic Defense Intelligence report "The Global CBRN Market 2013-2023 – Competitive Landscape and Strategic Insights: Market Profile" predicts that the market will have stable growth at approximately 4.2 percent compound annual growth rate and surpass $13.69 billion by 2023.[16]

The merge of these two growing markets configure many opportunities for research and development (R&D) and the knowledge of CBRN sensor technologies, future trends and concepts of operations are some of the main issues that should be addressed for identifying opportunities for further development of UAV for CBRN operations.

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E-TUTOR FOR TRAINING IN ANTIPERSONNEL LANDMINES IDENTIFICATION

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Abstract

This paper will present the development of an e-Tutor that shows several characteristics of some antipersonnel mines. The main objective is the basic training of people that work in humanitarian demining tasks. It has been considered the development of an e-Tutor, because it can be used in Mine Action Centres from different countries for training of people that require a preparing in this activity. Additionally, the learning based on e-Tutors presents some advantages with respect to the face-to-face training, which are related with training in any time and in any place.

1. Introduction

Landmines represent a great problem since many years and they remain a problem today, due to the large number of them which are still buried in farm fields or areas that can be travelled by innocent children and adults [1]. The main problem is that the landmines do not distinguish between a soldier and a child, killing or wounding indiscriminately both soldiers and civilians or humanitarian workers. They present a serious threat to the safety of the population during the conflicts, and are transformed in a greater danger after the end of the fighting. For example, in a study in 2010 conducted by Landmine Monitor [2], it is mentioned that one in four accidents caused by mines had as a victim a child.

Military academies carry out specific training regarding with any type EOD including the antipersonnel landmines. Also, these institutions use surrogates landmines and real landmines in the training process. However, it is very difficult for humanitarian demining groups the access to the surrogate landmines and other relevant information about this type of EOD, for safety reasons. Some information related with surrogate landmines and/or characteristics of training process can be seen in [3-8]. The training process that is described briefly in [3-7] is face-to-face teaching.

This manuscript presents a new e-Tutor which expects carry out a first training in landmines identification in any moment and in any place without trainer. This training is for novel students in this field with the aim to show the main characteristics of the some landmines, as well as the arming and disarming procedure of them. This e-Tutor is accompanied by four surrogate landmines designed and manufactured by mean of 3D printer by CSIC-UPM. Also, this e-tutor has two first e-Tutor (sub-e-Tutors) related with a general introduction about the antipersonnel landmines and humanitarian demining, and general concepts about the neutralization by external agents.

2. Design and manufactured of the surrogate mines

The criteria that were considered and evaluated to select the anti-personnel mines that were designed and manufactured by mean of a 3D printer were as following: activation mechanisms, shape of the mines, data availability, and mines requested by a member of TIRAMISU consortium. Antipersonnel landmines designed should have different mechanisms of activation, different shape, and very important, the measurements availability of the landmines because the data of a lot of mines are not freely available. The landmines selected were PMA-1, Valmara-69, VS-50 and PPM-2. Figure 1 shows the surrogate antipersonnel landmines designed and manufactured by CAR CSIC-UPM. In Figure 1 the component parts of each one of surrogate landmines are presented.

Figure 1. Surrogate antipersonnel landmines designed by CAR CSIC-UPM.

The arming and disarming procedures used in the e-Tutor of each landmine were carrying out in the design stage by mean of Autodesk Inventor Professional 2014. Several pictures and video were used to recognize the component parts of the landmines. Figure 2 shows only four photograms of one video about of the arming process of the PMA-1 landmine. The trainee can control the video in order to reinforce the learning of each of the parts and the sequence of the assembling.

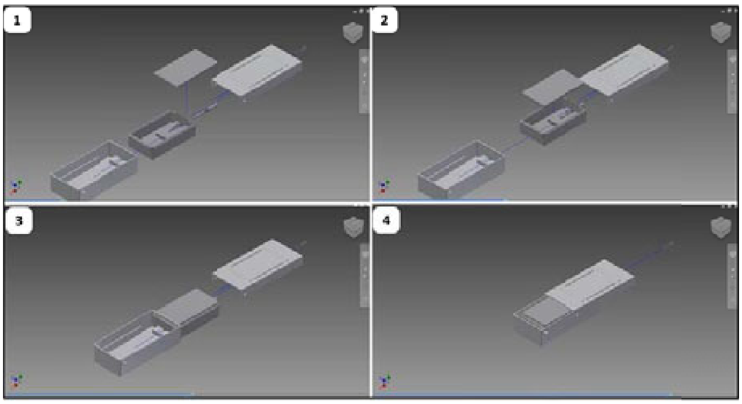

Figure 2. Photographic sequence of the assembly of the PMA-1 (from left to right and up to down).

3. Development of the e-Tutor

This e-Tutor has been developed in order to be used in Mine Action Centres from countries who need it. The idea is training civilian people to learn about of the identification in antipersonnel landmines, and that require preparing to work in this activity. The training can be realized in any time and in any place, because the base of the information is through of the electronic learning.

The learning based on e-tutors presents the next advantages with respect to the face-to-face training [8-9]: (i) personal learning rate, (ii) training in the time that is needed, (iii) it can reach a greater number of students. However, an important disadvantage is the non-availability of all necessary resources to carry it out.

The e-Tutor developed by CAR CSIC-UPM consists of six lessons or sub-e-Tutors, which are listed follows:

1. General description of the antipersonnel mines
2. Description of the common demining methods
3. Description of the PMA-1 landmine
4. Description of the Valmara 69 landmine
5. Description of the VS-50 landmine
6. Description of the PPM-2 landmine

The two first lessons of this e-Tutor present the main concepts of the antipersonnel mines and the landmines neutralization by external agents, respectively. The other sub-e-Tutors show the main characteristics of each mine, the procedure of arming, disarming and disabling of each mine, and the procedure/theory about of mine neutralization by mean of external agents. The last four sub-e-Tutors are accompanied by their respective surrogate landmines designed and manufactured by the CAR CSIC-UPM, as has been mentioned about. The idea is the trainee can manipulate the mines while he is following the electronic lesson. These surrogate landmines have the main internal parts in order to be compared with its parts in the sub-e-tutors. Each lesson has a simple video of arming/disarming of each landmine with the name of each part. Figure 3 shows the two first pages of the e-Tutor, which are the registration of the trainees and the presentation by mean of video of the e-Tutor for training in antipersonnel mines. Figure 4 shows the first pages of the sub-e-Tutor related with the identification of the landmines PMA-1, Valmara 69, VS-50, and PPM-2. Additionally, this figure shows the page where the video of assembling is carried out.

Figure 3. Main pages of the e-Tutor. Pages of registration and presentation of the e-Tutor.

Figure 4. Main pages of the sub-e-Tutors and video slides of the landmines PMA-1, Valmara 69, VS-50 and PPM-2

4

Finally, in the end of each sub-e-tutor a respective test is presented, which must be approved to pass to the next sub-e-tutor. In this case the grade of pass is 85%; however this grade can be changed depending on the evaluation required. Figure 5 shows two pages related with the test of the e-tutor of VS-50 landmine.

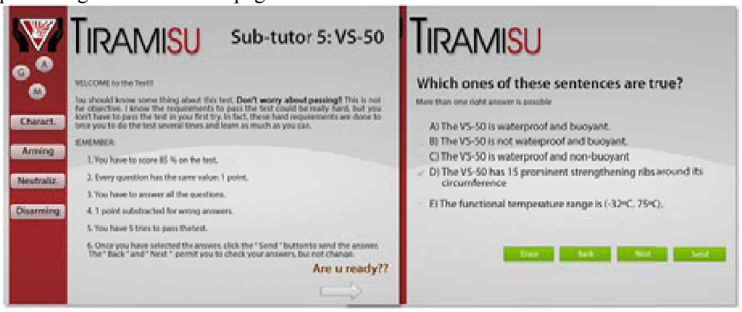

Figure 5. First page and one question of the test of the sub-e-tutor of VS-50 landmine.

4. Discussion

In this work an e-Tutor for training in antipersonnel landmines identification has been briefly described. The main objective of this work is that novel trainees can have training in this field in order to they may be helpful to carry out works in this activity. Additionally, trainees can use this e-Tutor in any time and any place, and can count on with surrogate landmines to support the learning. Besides, trainees may take the necessary time to learn the lessons of suitable way.

Acknowledgment

The authors acknowledge funding of this work under TIRAMISU Project - Grant Agreement Nº 284747 of the 7FP, and partial funding from the RoboCity2030-III-CM project (Robótica aplicada a la mejora de la calidad de vida de los ciudadanos. Fase III; S2013/MIT-2748), funded by Programas de Actividades I+D en la Comunidad de Madrid and cofunded by Structural Funds of the EU. Dr. Héctor Montes also acknowledges support from Universidad Tecnológica de Panamá.

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Confidence of indicators of mine presence

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ABSTRACT: Indicators of mine presence and absence are the main objects on the scene that need to be detected and spatialy positioned for the purpose of conducting quality aerial non-technical survey of suspected hazardous areas (SHA). Detection of these indicators on the images of the observed scene and positioning of the existing indicators from the mine information system (MIS) enables creation of danger map. Danger map is the result of the fusion of all existing data about mine indicators. Experts of warfare and mining in a particular area can bring conclusions on potential areas that are contaminated by mines on the basis of danger maps. However, the possibility of recognition and extraction of mine presence indicators on aerial and satellite images greatly depends on the image quality and corresponding ground sampling distance, as well as contextual knowledge and experience of mine scene interpreter. Therefore, due to the fact that the experts draw conclusions about SHA based on position of indicators in space and their zones of influence on the environment, it is necessary to add a level of confidence (the level of reliability with which the interpreter evaluates its decision) for each extracted indicator. This information is essential for a more realistic appearance of danger map depending on the available data on the observed scene and from MIS. The confidence of the decision that has been detected and extracted indicator of mine presence affects the level of danger of an area on the danger map. Tools used to automatically extract indicators on the mine scene can be validated in this way. Validation is done based on the true data about mine scene. Internal validation can be carried out by an experienced interpreter of mine scene, while operational validation will be performed after demining of the observed scene.

Key words: confidence, indicator, data fusion, validation

1. Introduction

The TIRAMISU Advanced Intelligence Decision Support System (T-AI DSS) is a tool to support decision about the status of suspected hazardous area. The input includes data from mine information system (MIS), expert knowledge, airborne and satellite data, contextual data, etc. The outcomes are detected and proved positions of indicators of mine presence (IMP) in space, reconstruction of battlefield (in time and space), better (re)definition of SHA, proposals for exclusion from or inclusion in the SHA (thematic maps). T-AI DSS is the unique Mine Action technology that combines remote sensing with advanced intelligence methodology into successfully operational system. It is the heritage of the SMART (EC IST SMART, 2000) generic methodology, implemented and advanced in the operationally validated system that improves risk assessment for greater efficiency in land cancellation and release. The main characteristic of the T-AI DSS is compatibility and operability with the processes and main functions in Mine Action Centres (MAC) (Bajic *et al.*, 2011). The main limitation of the Advanced General Survey by T-AI DSS is the collection of data above the forested regions (because of requirement that trees should have no leaves, in the case of the deciduous forests), undefined indicators of mine presence or absence of them.

2. Analytical Assessment

The crucial document for the success of T-AI DSS application is the analytical assessment of the SHA based on data and information that are available in MIS of MACs. The outcomes of this analysis are the general and specific requirements for the airborne and space borne collecting (non-technical survey) and producing new, additional data, information and evidences about the former situation in SHA (Bajic *et al.*, 2011). New data, information and evidences are position of indicators of mine presence within the SHA in this case.

Analytical assessment comprises the following procedures:

- investigation of existing data and phenomena,
- examination of their content, comparison, systematization and gradual integration according to military activities and order of battle in a certain area.

In doing so, it is important to explore the chronology of military activities during the war, with a special emphasis on relocations of units and other indicators of organization and implementation of defensive and offensive activities that influenced the construction of barrier minefields. These activities are different for different countries (method of warfare, terrain type, etc.). The analysis made so far has been conducted by experts in the field of methods of warfare and mining in a certain territory (with the data from the CRO and the BH MAC (ITF (2008), ITF (2010)).

3. Image Interpretation and Confidence

The possibility of recognition and extraction of mine presence indicators on aerial and satellite images greatly depends on the image quality and corresponding ground sampling distance, as well as contextual knowledge and experience of mine scene interpreter. Therefore, due to the fact that the experts draw conclusions about SHA based on position of indicators in space and their zones of influence on the environment, it is necessary to add a level of confidence (the level of reliability with which the interpreter evaluates its decision) for each extracted indicator. The experience from the projects undertaken led to the conclusion that the human eye of an interpreter (of mine scene) can hardly be replaced by automatic methods of digital image processing. Therefore, the basic idea of interactive methods of semi-automatic interpretation of digital images of SHA (Racetin *et al*., 2014) is to provide assistance to the interpreter in the interpretation of digital images rather than to replace him. The confidence of the claim that it is an indicator (level of confidence interpreter or module that detected the indicator) is given to all identified objects in the scene, regardless of the way of detecting. The possibility of recognition and extraction of mine presence indicators on aerial and satellite images greatly depends on the image quality and corresponding ground sampling distance. The image evaluation is conducted by interpreter and carried out on the basis of NIIRS (Irvine, 1997) and IQM (Nill and Bouzas, 1992) parameters.

4. Data Fusion

All founded and extracted indicators and the data from MIS (known indicators, mine records, mine accidents, office reconstituted position of the minefield) are going to the data fusion. Any input data in the data fusion must be analyzed and should have a level of confidence, at least to the extent available from the source which provided information that suspicious object is an indicator. (barem do razine dostupne od izvora koji je dostavio informaciju da je sumnjivi objekt stvarno indikator). Contextual information and expert knowledge about the conduction/procedures/rules of mining (expert) make fuzzy set that depends on the type of terrain and expert judgments related to the method of mining. The expert determines the zones of influence on the environment for each indicator (object). For each zone of influence expert determines the control points (risk starts at, high risk from, high risk to, no risk beyond). The experts estimated the parameters of membership functions (control points) on the basis of information, data, acquired knowledge, experience in mine clearance and weapons that were used in the conflict. Physical objects on the ground can be linked with their impact on the environment based on these contextual data. In order to link the impact of indicators on the environment and indicators themselves, membership functions are used. Membership functions describe the appearance of influence of each indicator of the mine presence on their surroundings and the neighboring indicators. Control points define the shape of membership function.

Danger map (Vanhuysse et al, 2004) is a thematic map produced in order to provide support to competent persons in the process of humanitarian demining, the experts from the national MAC's, in making decisions about the reduction of SHA, in confirming suspicions, or its extension (Krtalic, 2011). This information is essential for a more realistic appearance of danger map depending on the available data on the observed scene (images) and from MIS. The confidence of the decision that has been detected and extracted indicator of mine presence affects the level of danger of an area on the danger map.

5. Validation

Different methods of multicriteria analysis are used to calculate the weight of indicators in order to design a danger map. Two types of danger maps are produced for each type of indicator (separately for IMP and IMA, because of displayed contradictory information). One type displays only the surface of all zones of influence of indicators. The second also shows the surface of all zones of influence of indicators but also pictures the weighted sum of factors derived from the IMP or IMA. The proposals of reduction maps are also be produced. Scenario-oriented testing and evaluation are conducted on the basis of multi-criteria analysis. Different methods shall yield different design of thematic maps (danger maps).

The evaluation and verification of the statements on thematic maps shall be expressed by MAC experts. Operational evaluation and verification of the statements on thematic maps will be expressed by elements of the confusion matrix due to the ground truth from MIS data after mine clearance. Extraction of IMP's by mine scene interpreter and tools used to automatically extract indicators on the mine scene can be validated by analyzing a danger map. Internal validation can be carried out by an experienced interpreter of mine scene, while operational validation requires true dana about mine scene and is performed after demining of the observed scene.

6. Acknowledgement

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

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Towards Autonomous Landmine Detection Using Mobile Robots and Metal Detectors: A Case Study

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Abstract

Automated landmine detection using robots as mobile scanning platforms is an emerging application field and as such presents an important effort towards safer and more efficient humanitarian demining. In this paper, we present a target classification concept that was developed and tested as a case study within the framework of the Humanitarian Robotics and Automation Technology Challenge event (HRATC 2014). We first briefly introduce the HRATC event and describe its competition rules, objectives and the main features of the mobile platform used in the experiments. Next, we present the process of developing a robust model-based algorithm for classifying metallic targets based on their shape. The algorithm was experimentally evaluated on a dataset collected from a test site containing surrogate mines (metallic spheres) and clutter targets. Initial results indicate that the algorithm correctly resolves the target shape from a limited amount of sensor data.

1. Introduction

Detection of buried landmines is a crucial and most dangerous part of the humanitarian demining process since it normally involves human deminers performing hazardous tasks in the field. At present, the prime tool for close-in detection of landmines is a handheld metal detector (MD). Conventional MDs used in humanitarian demining feature high sensitivity to extremely low quantities of metal, such as those found in low-metallic content landmines. On the other hand, enormous false alarm rates (up to 1,000 alarms per mine) are introduced, due to detectors inability to discriminate between metallic parts of a mine and non-hazardous metallic clutter [1].

Automated landmine detection using robots as mobile scanning platforms is an emerging application field and as such presents an important effort towards safer and more efficient humanitarian demining. Several research and development attempts have been made in automating or assisting human deminers in the scanning process by applying different mobile robot and sensor designs [2]. One of the most difficult tasks leading towards automated demining is developing a robust approach to automatic target detection, characterization and classification. Current research work in this field has mainly been focused on data fusion algorithms that utilize different sensing modalities, such as metal detectors (MDs), ground penetrating radars (GPRs), infrared (IR) sensors, odour sensing devices, etc. [3]-[4]. While such approach provides robust information, it also raises complexity and system integration issues related to specific aspects of different sensing technologies.

In this paper, we present a different concept based on electromagnetic induction (EMI) modality only, that aims to extract information on target position, as well as its geometric and electromagnetic properties. The work presented here is a continuation of previously reported activities of our research group in the field of metallic target characterization (MTC) [5]. In this paper, we further develop the MTC concept and apply it for usage with a commercial, three-coil pulse induction metal detector mounted on an autonomous mobile robot. We use the field data, acquired by a metal detector during the test trials with a mobile robot to validate the proposed target classification algorithm.

2. The HRATC 2014 event

The Humanitarian Robotics and Automation Technology Challenge (HRATC) event was organized by the IEEE Robotics & Automation Society –Special Interest Group on Humanitarian Technology (RAS – SIGHT), with a support and partnership from the FP7-TIRAMISU Project and Clearpath Robotics, Inc. It took place at the 2014 International Conference on Robotics and Automation (ICRA) in Hong Kong and remotely in Coimbra, Portugal. The aim of this robot competition event was to promote the development of new strategies for autonomous landmine detection using mobile ground robots [6].

Initially, 14 teams from eight countries submitted their entries. Based on their description papers where teams were asked to describe their experience and strategies, ten teams were short-listed to move forward with the competition. The University of Zagreb ACROSS team was chosen to participate in the challenge together with 13 other teams from all over the world. In the simulation phase, ACROSS team won the first place, and received the award at ICRA 2014 conference for reaching the finals together with two other teams from USA, and one from Germany.

2.1. Objectives and rules

The HRATC 2014 event was organized as a three-stage robot competition including a simulation phase, (Figure 1), field trials and the finals. The following evaluating criteria were considered: exploration time and environmental coverage; detection and classification quality and landmine avoidance.

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Figure 1. HRATC software framework (simulation stage).

Figure 3. A three-coil metal detector (Vallon VMP3).

The following evaluating criteria were considered: exploration time and environmental coverage; detection and classification quality and landmine avoidance. In the framework of HRATC, there are two main tasks that the robot needs to perform: the navigation task and the mine detection task. The goal of the navigation task is to autonomously navigate in an unknown area so that the robot covers all the reachable positions in the area while avoiding obstacles detected by its sensors. In robotics literature this problem is called the complete coverage of an area [7]. In this paper we focus primarily on the mine detection part, whose role is to detect, locate and classify buried metallic targets.

3. Mobile metal detection platform

2.2. Mobile robot

The Clearpath Husky A200 robot was used as an autonomous scanning platform, Figure 2 [8]. The robot comprises sensing systems for localization, navigation and obstacle avoidance, such as stereo cameras, laser range finder, real-time kinematic global positioning system (RTK GPS), inertial measurement unit (IMU) and odometry sensors. A 2DoF robotic arm is used for sweeping the MD over the target area. The pose of each coil is updated at the rate of 50 Hz and is synchronized with the MD readings.

Figure 2. The Clearpath Husky mobile robot with the Vallon VMP3 metal detector.

2.3. Metal detector

A central part of the mobile detection system is the Vallon VMP3, a pulse induction (PI) three-coil metal detector, Figure 3 [9].

In general, PI EMI sensors transmit a primary magnetic field of pulse waveform and detect a weak, time-decaying secondary field induced by eddy-currents in the metallic target after the transmitter has been shut-off. MDs usually sample data at multiple time instances (gates) along the pulse decay curve. Such temporal information may be used for better detection of different target types or simple size-based discrimination.

For each of the three coils of VMP3, data corresponding to induced voltages sampled at three different time gates are made available to the robot. Raw sensor data are filtered within the VMP3 and updated at the rate of 10 Hz per channel. A basic block diagram depicting main parts of the mobile landmine detection platform and the signals used for target classification is shown in Figure 4.

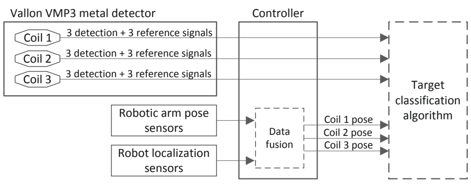

Figure 4. Block diagram of the mobile landmine detection system.

3. Target characterization and classification

The process of automated landmine detection is normally carried out in three consecutive steps: initial target detection, spatial mapping and target classification. In this paper, we focus on the classification part, assuming that the target is detected (for instance by using a signal tresholding technique) and a spatially relevant sensor dataset is obtained. In our model-based approach, we firstly characterize the target by means of its position and the magnetic polarizability tensor [5], and then use these parameters for target classification.

3.1. Metal detector modeling

The first step in a development of a model-based classification algorithm is to derive a forward model describing the EMI response of a small metallic target illuminated by the sensor's magnetic field from an arbitrary location above the target. For that purpose, an exact coil geometry must be known. However, such data are often unavailable when dealing with commercial MDs, such as VMP3. Therefore, we use a simplified model that approximates each of the three sensor coils with an octagonal current loop. The benefit of using such an equivalent coil geometry is that the spatial distribution of its magnetic field is described with an analytic expression (found by direct application of the Biot-Savart law), which is convenient since the inversion algorithm can be implemented in a computationally efficient manner.

3.1. Inversion algorithm

Model-based characterization of a metallic target leads to a problem of estimating its position and the six elements of its magnetic polarizability tensor (MPT) from a set of induced voltages measured at known sensor poses. The inversion problem is linear in terms of the MPT and non-linear in terms of the target position [5].

The actual algorithm is realized in two steps. In the first step, an initial target location is estimated directly from the measured dataset by simply finding sensor coordinates that correspond to the maximum signal value. Based on this initial estimate, initial values of the MPT elements are found by solving a corresponding linear inversion problem. In the second step, initial estimates of MPT and target position are used as starting points in an iterative non-linear optimization algorithm based on the Levenberg-Marquard method. After the optimization procedure is finished, the MPT is decomposed to its eigenvalues, and these values are evaluated at different time gates and combined into a single, shape-based classification parameter - the signature matrix. The method is described in more detail in [10]. A simplified block-diagram of the whole procedure is given in Figure 5.

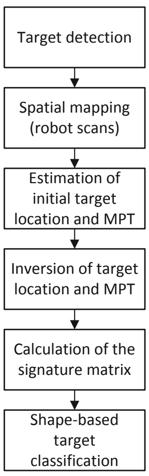

Figure 5. Target classification algorithm.

4. Experimental validation

In order to validate the proposed classification method, the algorithm was tested with a dataset obtained as a result of field trials of the mobile scanning platform. Metallic spheres with a diameter of 1 cm, placed inside the plastic package and buried at random locations near the soil surface were used as surrogate mines, Figure 6.a. Other metallic objects representing metallic clutter items, such as screws, cans, etc. were also placed within the test area as potential sources of false positives, Figure 6.b.

Figure 6. a) Metallic spheres as landmine simulants, b) landmine simulants and metallic clutter items.

Sensor readings corresponding to voltages induced in the left sensor coil in response to a buried metallic sphere are given in Figure 7. An estimated sensor response (i.e. response reconstructed from inverted MPT and target location, at a given time gate) is also shown in order to validate the model-data fit. Figure 8 shows the x-y trajectory of the sensor coil during scan, with the estimated initial and final target location.

For different datasets representing mine simulants and clutter targets (similar to those given in Figure 7 and Figure 8), signature matrices were calculated and used for target classification. All the landmine simulants were correctly recognized as spheres and discriminated from clutter items by their shape.

In our future work, we plan to test the algorithm with more sensor data corresponding to metallic targets of different shapes. We also plan to realize the real-time algorithm on a mobile robot featuring ROS operating system [11]. Such algorithm is feasible due to the use of relatively simple and computationally efficient analytic forward models and inversion procedures.

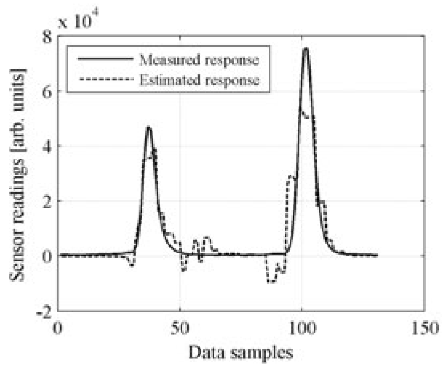

Figure 7. Measured and estimated sensor response to a buried metallic sphere.

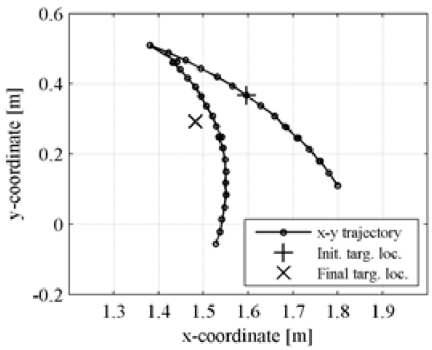

Figure 8. Trajectory of the sensor coil during scan and the estimated metallic sphere position (initial guess and final inverted position).

Conclusions

We presented a case study, in which we investigated the possibility of using metal detectors and mobile robots to perform autonomous detection and classification of buried metallic targets. For that purpose, we developed a robust model-based algorithm that uses the sweeping motion and certain spatial-temporal features of metal detector response to characterize the target by its shape and then use this information for classification purposes. The proposed algorithm was evaluated on a real dataset obtained from the robot field trials and containing sensor responses to different buried targets. Initial results obtained for the case of metallic spheres indicate that the algorithm correctly resolves the target shape from a very limited amount of sensor data. This leads to a conclusion that next-generation landmine detection systems incorporating autonomous robots, field-proven metal detection technology and novel metallic target characterization concepts are feasible.

Acknowledgment

The authors would like to thank Dr Marija Đakulović and Kruno Lenac, members of the ACROSS team participating in the robot competition event, for their help in preparation and interpretation of the testing datasets.

This work has been supported by the European Community Seventh Framework Programme under grant No. 285939 (ACROSS).

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Development of polymer-based sensor systems for explosives vapour detection

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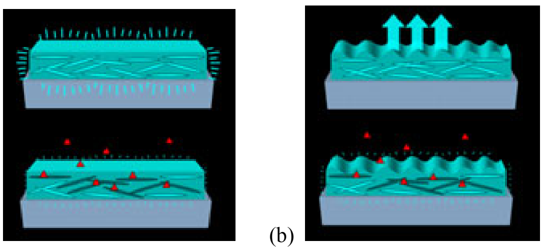
Abstract

This paper presents an overview of progress towards the development of compact polymer-based explosives vapour sensors for the detection of landmines. The sensors, under development within the TIRAMISU project, work by detecting a change in the light emission from a semiconducting polymer film when exposed to the vapours of TNT and related materials. The response of the sensor films to vapours of TNT, DNT, RDX and other relevant materials is presented. Portable, robust instrumentation for in-field explosives-vapour sensing integrating these semiconducting polymer films has been prototyped and results of initial tests in a simulated landmine environment are presented.

Introduction

New technologies are required by the humanitarian mine action community to address the many challenges associated with the removal of buried landmines. Close-in detection of buried landmines commonly uses metal detectors, though these can suffer from high false alarm rates due to innocent fragments of metal. Combined use of metal detectors with ground penetrating radar and prodders can help to reduce false detections, but it would be very desirable to detect directly the chemical presence of the buried explosive itself.

Chemical detection of explosives in humanitarian demining is currently mostly based on the use of trained dogs, to detect vapours of the explosives. The animals are used in two main modes of operation: firstly by walking detection dogs across a section of a minefield, to determine whether that section should be selected for systematic close in detection with metal detectors. Secondly, they are used in a technical survey operation called remote explosive scent tracing (REST) [1], in which a target area of ground is surveyed by sampling air and dust in a filter, which is subsequently presented to the animal to detect vapours of explosives. The REST approach has been successfully implemented with animals by Mechem and others, but there could be advantages in using a sensitive electronic detector that can quantify the explosive residue in the filter, or even identify the constituents. Commercial vapour detection technologies, e.g. the fluorescence-based Fido sensor (Flir Systems) and ion mobility spectrometers, are used in military and airport applications but have not so far been adopted for humanitarian demining.



(a) (b)

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

Within the TIRAMISU project, we are developing novel polymer-based sensors for detecting explosive vapours from landmines. These sensors work by detecting a change in the light emission from a semiconducting polymer film [2]. When exposed to very dilute vapours of TNT-like compounds, the explosive molecules are sorbed into the film and turn off the light emission due to a reversible electronic interaction between the molecules (Figure 1). The speed of response and sensitivity to TNT can be increased by generating laser light in the polymer film instead of fluorescence to detect explosives [3-6]. In this paper we describe progress towards the development of a compact polymer-based explosives vapour sensor that could be used for on-field mine detection. We describe the response of the polymers to nitroaromatic explosives and other relevant materials, and implementation of compact prototype sensor systems for single sensor and array detection.

Polymer Response to Explosive Vapours

We have studied the response of a number of light-emitting polymer sensor materials to a selection of explosives and related materials including TNT, 2,4-DNT, 1,4-DNB, RDX, DMDNB and PETN. Figure 2 shows the change in light emission observed on exposure to ppb-level concentrations of DNT and TNT for example films from two groups of polymers (based on poly(para-phenylenevinylene) (PPV) and polyfluorene backbones). The sensing elements were films of approximately 50 nm thickness, deposited on silica substrates. Each film was exposed to the vapours for 180 s while the light emission was monitored, before being purged with nitrogen gas to remove the surrounding vapour. Each of these polymers significantly responded to the nitroaromatic vapours, with a measureable drop in the light emission within a few seconds after exposure. After removal of the DNT vapours, the light emission recovers as the DNT molecules are desorbed from the film. For the case of Merck "Super Yellow" polymer, no recovery is observed at room temperature, but the sensor can be 'reset' by heating the film. We observe that TNT molecules more strongly bind to the films but also show recovery of light emission at room temperature in some materials (e.g. PFO).

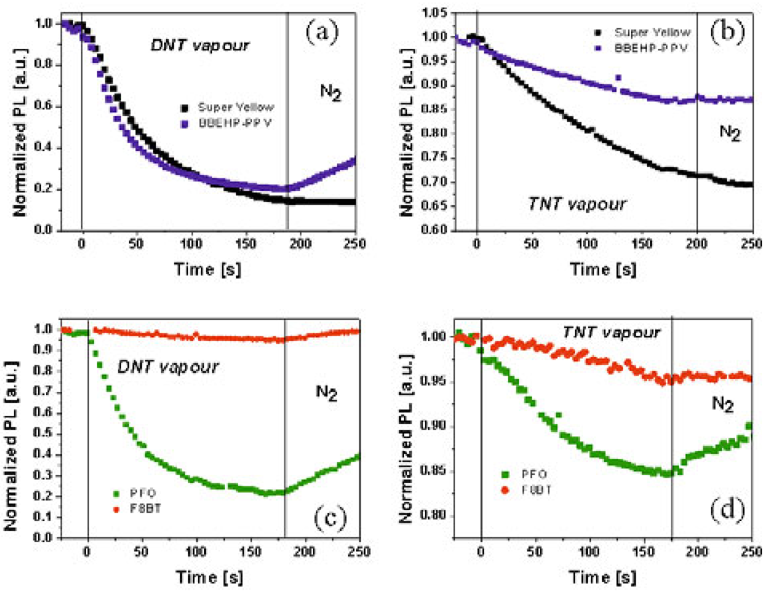


Figure 2 Change in photoluminescence (PL) of four sensor polymers to vapours of (a), (c) DNT and (b), (d) TNT. The response of PPV-group polymers BBEHP-PPV and Merck "Super Yellow" are shown in (a) and (b) and the response of polyfluorene-group polymers PFO and F8BT are shown in (c) and (d).

The response of these polymers to a wider set of explosives is summarized in Table 1. These show fast response to ppb-level vapours, with measurable changes within a few seconds. One interesting result to note is that F8BT has much higher response to DNB than to DNT molecules, despite DNT having higher vapour pressure. Such variations in sensitivity to different explosives could be exploited to distinguish the detected chemicals.

Table 1: Summary of the response (percentage change in the light emission output) of a selection of polymers following exposure to vapours of different explosive-related materials. 1,4-dinitrobenzene (DNB); 2,4-dinitrotoluene (DNT); trinitrotoluene (TNT); cyclotrimethylenetrinitramine (RDX).

polymer	polymer type	DNB	DNT	TNT	RDX
BBEHP-PPV	phenylene-vinylene	50%	80%	13%	5%
Super Yellow	phenylene-vinylene	77%	86%	29%	12%
F8BT	fluorene	35%	5.2%	5%	0%
PFO	fluorene	50%	79%	15.5%	11%

Instrumentation Design

The explosives vapour detector is intended for deployment in two main scenarios: close-in detection of individual mines (in support of metal detector / GPR) by a deminer or robot, and for wide-area technical survey in combination with REST filters in a side-of-minefield configuration. A simple "yes/no" configuration allows the system to be stand-alone with a visual or aural alert if explosives are detected, while the full system has real-time monitoring of sensor emission via laptop or PC. For these two applications we have designed a modular system with the option for different vapour delivery to the sample chamber. However, the principle of the detection instrumentation for both applications is the same. In the laser/PL configurations the basic tool consists of the following elements:

- A thin-film polymer sensing element deposited on a glass/plastic substrate;
- A laser or LED excitation source that illuminates the luminescent polymer film;
- A light-detection module that monitors the intensity of the light emission from the polymer;
- A method to ensure satisfactory vapour/polymer contact;
- Control electronics/software for the light source and detector;
- Stand-alone operation with interface for computer communication.

(a) 

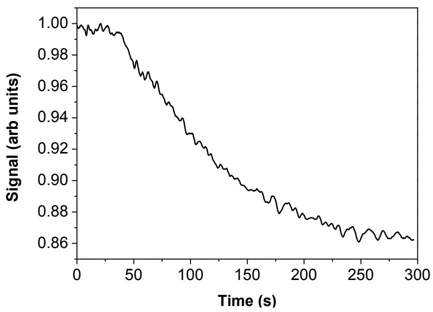
(b) 

Figure 3: (a) α-prototype of explosive vapour detector with laser head; **(b)** Detection response of α-prototype to DNT vapour (using a Super Yellow polymer film); vapour source switched on after 50 s.

The general principle of operation of the instrument, sees vapour drawn through a gland at the front end of an IP67 enclosure, passed through an air-tight chamber containing the polymer film sensor, and out an exhaust gland at the back. The system is shown on the left in Figure 3, with the lid off to show the components inside the box and laptop in the background for data capture and display. The sensor is excited by incident light from a Philips LED or compact pulsed laser, and the emission response is monitored by a Hamamatsu photodiode interfaced to an Arduino microprocessor which converts the signal from analogue to digital. The microprocessor sends the data via USB to LabView hosted on a laptop with real-time display, data saving options, and laser control software.

The sensor system has been used to detect vapours at ppb levels, and also for initial tests on buried vapour sources where a positive detection to DNT has been made. Measurements are ongoing to test for buried samples of TNT, DNT and RDX. For simulated REST samples, the sensors have detected vapours from particles of TNT with masses as low as 250 ng, and made initial positive detections on contaminated REST filters.

CMOS Image Array for Selective Detection

As discussed above, the sensor system responds to a range of nitroaromatic materials and other target explosives. To improve the selectivity of the sensor, a CMOS camera-based system for multi-sensor array detection is in initial development stages. By monitoring multiple sensor films in parallel this detection module should offer the possibility to "fingerprint" the explosive, enhancing selectivity. The imaging system approach should be low-cost, low footprint and give future potential to integrate the hardware and software with smartphones. Since each polymer material has a different response to each explosive, a combinatorial approach using multiple materials can yield a selective measurement to try to identify the particular explosive and give information about its concentration. Ultimately, a database could be built for explosives, pesticides, and other in-situ contaminants by mapping the unique pattern obtained from multiple sensor spots. The imaging sensor has been tested with the polymers listed in table 1 to successfully detect DNT vapour. We have also developed composite films based on molecularly imprinted polymers in which binding sites for DNT are specifically imprinted into a film of the light-emitting sensor polymer. These imprinted materials show a preferential response to DNT, TNT over potential interferants including some agricultural pesticides.

Conclusions

Polymer-based explosive vapour sensors for mine / UXO detection have been developed which use sensing mechanisms based on both spontaneous emission and lasing in thin polymer films. A portable, compact version of the vapour sensor has been developed and the initial prototype is currently being tested. An input stage suitable for outside use has been made and following initial tests on buried explosives is currently being redesigned. Studies to optimise the sensor material response time and sensitivity have been undertaken. Approaches to optimise the design and processing of sensing materials for target vapours of TNT, DNT and RDX have been explored and evaluated. We have also developed strategies to increase the chemical selectivity including use of a multiple sensor array and light-emitting materials incorporated in molecularly imprinted polymers. The chemical sensors have successfully detected vapours from very small particles of explosives and detected vapours above sources that had been buried for several weeks. Assessment and validation of performance is ongoing and will continue into 2015, including measurements of response speed, range and limit of detection of nitro-aromatic vapours, and detection of buried explosives for use in realistic field conditions.

Acknowledgements

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under agreement no 284747. We gratefully acknowledge provision of materials from Prof Peter Skabara and Dr Alex Kanibolotsky at the University of Strathclyde.

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ETHICAL IMPACT RISK ASSESSMENT FOR ROBOTS AND CARRIED SENSOR SYSTEMS FOR ENVIRONMENTAL SURVEILLANCE IN A HUMANITARIAN DEMINING CONTEXT

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Dominic Kelly[2]

Abstract

The aim of the paper is to provide a practical tool supporting the ethical risk assessment process for the use of robots and carried sensor systems for environmental surveillance in a humanitarian demining context. The ethical assessment process is developed as part of the FP7 European Research Project, *Demining Tool-Box for humanitarian clearing of large scale area from anti-personnel landmines and cluster munitions* (D-BOX). European policies with regard to emerging security technologies are considered keeping in mind the EU legal instruments applicable both at the R&D stage as well as during the deployment phase. These include privacy and data protection norms, fundamental rights provisions, EU safety standards on dual use and export control regulations. In light of the above, the development and employment of robots and carried sensor systems for environmental surveillance should encourage respect for the ECHR core values and fundamental rights. Most importantly, compliance should be pursued at the R&D stage where ethical and societal issues can be considered and appropriately handled.

In this context, the ethical framework for the analysis of robots and carried sensor systems for environmental surveillance presented in this paper is constructed by application of European Convention of Human Rights (ECHR). This approach allows technology developers to consider the ethical issues from the outset of the R&D stages, and to maximise the ethical compliance of robots and carried sensor systems for environmental surveillance during the deployment. The ethical framework is supplemented by an *Ethical Impact Risk Assessment Template* which is a practical tool summarising the entire analysis effort. The *Template* is useful for technology developers and operational decision makers and aims to support ethical governance of robots and carried sensor systems for environmental surveillance both during R&D stages and the deployment phase.

Key-Words: Humanitarian demining, robots, carried sensor system, ethical impact risk assessment.

Introduction

Mobile robotic systems have many applications relating to security and environmental surveillance, including humaniatarian de-mining campaigns. The reason is obvious as robots can carry out dangerous tasks associated with landmine detection and de-mining activities. As mentioned by Baudoin and Habib [3], robotics solutions that are properly sized with suitable sensors, modularized mechanical structutres, autonomus or semi-autonomus navigations systems that are well adapted to the local conditions of the field can improve the safety and the security of personnel as well as their work efficiency and flexibitity. However, the rapidity of growth within the robotics industry in the security and environmental surveillance domains is leaving a gap between the effective use of the technology and its ethical application.

There are different EU legal instruments relevant and applicable both at the R&D stage and in the deployment phase[4] of robotics technologies across the fields of security and environmental surveillance. These include privacy and data protection norms, fundamental rights provisions, some EU safety standards on dual use, export control rules, as well as other specific legal instruments. The legal instruments depend on the specific context of the technology being employed.

In light of the above, the development and employment of robotics technologies used in de-mining activities should encourage respect for the ECHR core values and fundamental rights; most importantly, compliance should be particularly encapsulated at the R&D stage where ethical and societal issues can be considered and appropriately handled. Unlike other means of environmental surveillance (e.g. CCTV and satellites), robotic vehicles are mobile, flexible and have 24/7 capability uses[5]. If they are platforms for sensors or sensor fusion technology they can hear as well as see. The potential for data collection is extensive in quantity but also in accessing and assembling different kinds of information to be networked and used. This requires consideration of the possible uses of the appropriate technology. It should also take into account the actors that have potentially involved in its use; in particular, the individuals or category of individuals that may be affected by its use. The potential effects that it may have on their fundamental rights and the associated risks or problems must also be considered. Once these risks and problems have been identified it is necessary to consider and adopt measures aimed at their elimination or mitigation. These measures may concern the governance of these technologies or be technological innovations themselves. This means they may consist of technical solutions that inhibit the possibility that a technology will be employed that might jeopardise the fundamental rights of an individual (value sensitive design approach)[6]. Once adopted, the consistency and effectiveness of these measures have then to be validated and monitored.

Ethical framework – The European Convention on Human Rights (ECHR)

ECHR is the first Council of Europe's conventions and the cornerstone of all of its activities. It was adopted in 1950 and entered into force in 1953. Its ratification is a prerequisite for joining the Organisation[7]. The Convention has a great symbolic importance because it expresses the "European community of values"[8]. These values ground European identity and should be reflected in the actions promoted by the EU. The values are: respect for human dignity, freedom, equality, solidarity, democracy and the rule of law. Each of these values should be realised by enforcing specific human rights. In particular:

- **Dignity:** human dignity, the right to life, the right to the integrity of the person, prohibition of torture and inhuman or degrading treatment or punishment, prohibition of slavery and forced labour.
- **Freedoms:** the right to liberty and security, respect for private and family life, protection of personal data, the right to marry and found a family, freedom of thought, conscience and religion, freedom of expression and information, freedom of assembly and association, freedom of the arts and sciences, the right to education, freedom to choose an occupation and the right to engage in work, freedom to conduct a business, the right to property, the right to asylum, protection in the event of removal, expulsion or extradition.
- **Equality:** equality before the law, non-discrimination, cultural, religious and linguistic diversity, equality between men and women, the rights of the child, the rights of the elderly, integration of persons with disabilities.
- **Solidarity:** workers' right to information and consultation within the undertaking, the right of collective bargaining and action, the right of access to placement services, protection in the event of unjustified dismissal, fair and just working conditions, prohibition of child labour and protection of young people at work, family and professional life, social security and social assistance, health care, access to services of general economic interest, environmental protection, consumer protection.

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[5] Report to COMEST of Workshop on Ethics of Modern Robotics in Surveillance, Policing and Warfare* (University of Birmingham, United Kingdom of Great Britain and Northern Ireland, 20-22 March 2011, p. 3;
[6] Value sensitive design is an approach that aims at integrating values of ethical importance in a systematic way within engineering design; see Freiedman, B., Kahn, P.H. Jr. and Borning, A., 'Value sensitive design and information systems', in *Human-Computer Interaction in Management Information Systems: Foundations* (Eds P.Zhang and Galletta D.), M.E. Sharpe, Armonk, pp.348-372
[7] http://human-rights-convention.org/ last accessed on 20.03.2015;
[8] Mordini E., Bonfanti M.E., *Op.cit*. pp. 4-6

- **Citizens' rights:** the right to vote and stand as a candidate at elections to the European Parliament and at municipal elections, the right to good administration to be enforced also with the European Ombudsman, the right of access to documents, the right to petition, freedom of movement and residence, diplomatic and consular protection.
- **Justice:** the right to an effective remedy and a fair trial, presumption of innocence and the right of defence, principles of legality and proportionality of criminal offences and penalties, the right not to be tried or punished twice in criminal proceedings for the same criminal offence.

In the context of robotic technologies used for environmental surveillance and de-mining activities the most important human rights to be considered are respect for private life and data protection (under the value of freedom), environmental protection (under the value of solidarity), and respect of health and safety. In terms of privacy, the robotic technologies used for environmental surveillance face issues strictly related to the large amount of the data collected where recognizable people are involved. However, these issues are comparable to those relating to existing security systems with data storage capabilities. Recently the European Parliament discussed the issue of automatic security systems and underlined the necessity for further action and regulation for privacy-related issues in relation to machine vision systems as technology develops (e.g. of automated algorithmic surveillance such as facial recognition or intelligent scene monitoring)[9].

Ethical impact risk assessment template for robots and environmental surveillance technologies used in de-mining operation

For whom is this template for**?** This ethics template is aimed at supporting the assessment of the ethical impact inherent in the R&D and deployment stages of robotics and environmental surveillance technologies used in de-mining operations. It should be used both by technology developers (R&D stages) and operational planners (deployment phase). The same template is used in all phases (R&D and deployment): the ethical issues will differ according to the context or situation.

For what purpose? This ethics template serves as a heuristic tool. In other words, it provides the user with a framework to identify potential ethical risks associated with robotics and environmental surveillance technologies. This is important because robots and environmental surveillance systems used in de-mining activities have been treated as primarily a technical challenge where technological advances are either generally understood as something positive or seen through purely consequentialist ethical lens[10] (that is: means and right are secondary as long as the outcome is positive). However, robots and environmental surveillance systems raise a wide range of issues touching the values of safety, privacy and data protection and environmental protection.

What's in it? The template consists of a matrix[11]: In the rows of which a catalogue of rights and norms are identified. In the columns of the matrix there are the categories of risk assessment processes as follows:

- Designation of risk related to a specific right or norm (respected, applicable, non-applicable). An earlier designation of a risk as "Not Applicable" should not be treated as definitive.
- The 'Controls' to be described in the Template are the mechanisms in place to mitigate the risk. Examples of Controls are (a) compliance with legislation & regulations, (b) the inclusion of advice on the issue in the training of the users, (c) an explicit reference to the issue in SOPs or (d) reference to the process of ethical governance.
- The 'Residual risk' (High, Medium or Low) is the level of risk that remains, based on a reasonable assessment of the effectiveness of the specified Controls. For example, training can be forgotten under stress and therefore it cannot fully mitigate a risk. However, if a particular ethical issue is of little concern locally, the initial risk will already be Low and training might suffice to reduce it to As Low As Reasonably Practicable (ALARP).
- Actions should be specified in the Template to reduce the risk to ALARP, whatever the level of residual risk. Evidence of the resolution of the Actions should be appended to the Template.

How to use it? Read through the different rights/ethical categories that might be affected. Consider what your tool is designed to do, what issues emerged when you deployed it and which emerged as you developed the tool. Try to complete as many boxes of the table below as possible and identify key ethical challenges. The results of the ethical impact risk assessment should be discussed by the team and decision makers. The completed Templates should be retained for the record and review.

When to use it? It is important to engage with ethical issues as early as possible in the R&D process. Beyond consulting this Ethics Template, it is advisable to seek advice from ethics specialists.

Origin and limitations of Template: This check-list was developed as part of the EU-FP7 funded D-BOX project. It is an initial attempt to systematically account for and manage ethical issues that have been identified during the D-BOX tools development process and discussions within the Ethics Committee.

Ethical Impact Risk Assessment	
Name	
Position	
Robot/environmental surveillance technology in de-mining activity context	
Date	
Please circle the stage to which the impact assessment refers:	
Research & development (R&D)	Deployment

Ethical issue (values and principles)		Respected/Applicable/ Non-applicable	Instance	Control	Residual risk (High, Medium, Low)	Action
Freedom	Respect for private and family right					
	Protection of personal data					

[9] See 'D3.2.1 Ethical Legal and Societal issues in robotics', FP7 project' euRobotics The European Robotics Coordination Action', available at: http://www.eurobotics-project.eu/cms/upload/PDF/euRobotics_Deliverable_D.3.2.1_ELS_IssuesInRobotics.pdf

[10] Krieger K., Stănciugelu I., *Ethics checklist for CBRNE tool developers and suppliers, users and trainers*, FP 7 PRACTICE project available at: http://www.practice-fp7-security.eu

[11] The matrix has been created with support of Nigel Hale and Dave Usher, CBRNE Ltd.

Environmental Protection	Use of materials/substances/ processes that are not highly polluting					
	Generation of minimal environmental pollution as possible.					
Safety	Use of material/substances/processes not dangerous to human health					
	Safety standards & regulations					
	Generation of minimal health risk as possible.					
Care	Validated in trials					
	Compliance with ethical & legal standards for trials (including informed consent)					
	Effectiveness					
Respect of legal export rules and other legal provisions that might apply						
Provision of training for users						

Conclusions

The institutions supporting research and development of robots and environmental surveillance technologies should undertake an effort to educate and sensitise programme managers toward ethical issues. They should seek advice from external experts because properly addressing ethical concerns requires a depth of knowledge that cannot realistically be expected of programme managers or scientists[12]. Research-performing institutions should provide assistance for researchers addressing ethical issues in their work on security technologies.

Many institutions performing R&D activities already have in place policies and procedures to address a variety of ethical and legal issues that arise in S&T research. For example, institutional ethics review boards are common. Where policies and procedures already exist to address ethical concerns, new ones should not be created to address them.

[12] Mordini E., Bonfanti M.E., *Op.cit*.

Semi-Automated Detection and Extraction of Unexploded Ordnances using the Object Based Image Analysis Approach

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ABSTRACT: This paper describes application of methodology for semi-automatic interpretation of digital multisensor images for the purpose of detection and extraction of unexploded ordnances developed within the EU FP7 TIRAMISU project on the site of exploded ammunition depot in Padjene, Croatia. Process relies on combining the advantages of the both radiometric and object based image analysis using the statistical tools where lessons and rules learned on the test image are then applied on other images of the same scene but different location. In this case methodology has been applied on aerial images acquired by consumer DSLR camera mounted on helicopter flying at average height of 300 meters above ground level. Prior to this application perspective preliminary result was achieved for aluminum objects. During the further application, image processing for improved detection and extraction of corroded objects was defined and evaluated. Achieved results of methodology application on different scenes at same location (exploded ammunition depot). At the end, perspective of further research and analysis of this methodology is stated.

Key words: Remote sensing, Image processing and analysis, OBIA, UXO

1. Introduction

In September 2011 severe forest fire caused the explosion of ammunition storage depot in Padjene, Figure 1. For addressing these situations, ground teams of demining experts are engaged for clearance and recovery tasks. In scope of ongoing EU FP7 TIRAMISU project an idea of research and development approach to this problem was initiated. This idea resulted in deployment of data acquisition module of TIRAMISU Advanced Intelligence Decision Support System (T-AI DSS) – multisensor imagery acquisition system (Bajic, 2010) for aerial survey of wider area of ammunition storage.

Density distribution of the scattered ammunition and parts was estimated by the Task force of Croatian Ministry of Defense for recovery: inside the radius of 800 m form the ammunition storage center 70 % of the pollution was expected, while additional 20 % in the radius of 1000 m (Bajic, 2012). The results of this catastrophe were scattered unexploded ordnances (UXOs) varying from rifle ammunition to the cluster bombs. Nonetheless, due to the explosion UXOs were found in various forms: intact, slightly or significantly deformed, burned, corroded or with the original paint preserved.

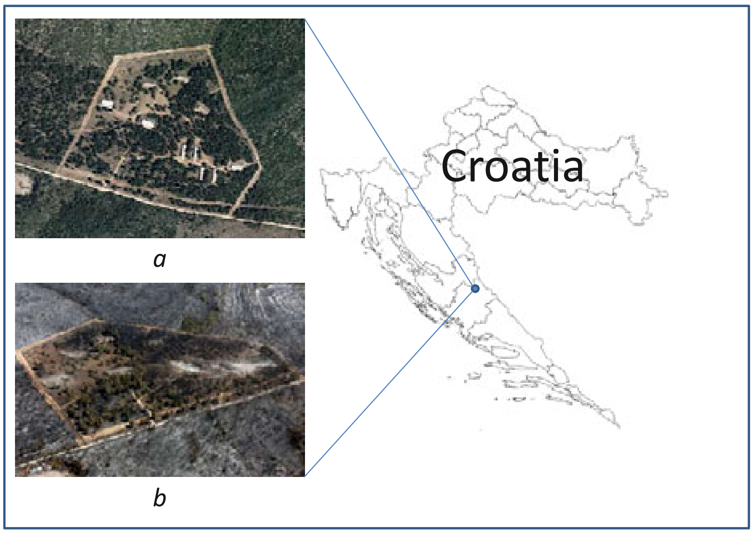

Figure 1 Images of ammunition storage depot Padjene: a) digital orthophoto before the explosion (available at URL 1), b) oblique aerial image after the explosion (available at URL 2)

2. Methodology

Data used for UXO detection and extraction at the exploded ammunition depot were aerial RGB images made by commercial Nikon D90 camera. Methodology used for data processing is methodology for semi-automatic interpretation of digital multisensor images for the purpose of detection and extraction of unexploded ordnances (Racetin and Krtalic, 2014), Figure 2. Process relies on combining the advantages of the both radiometric and object based image analysis (OBIA) using the statistical tools where lessons and rules learned on the test image are then applied on other images of the same scene but different location.

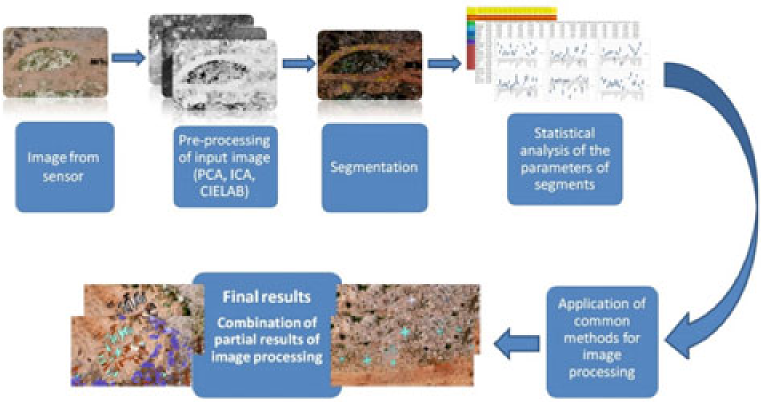

Figure 2 Shematic Representation of Methodology for Semi-Automatic Interpretation of Digital Multisensor Images (Racetin & Krtalic 2014)

3. Results and discussion

Prior to this application perspective preliminary result was achieved for aluminum objects (Racetin et al, 2014). During the further research, image processing for improved detection and extraction of corroded objects was defined and evaluated. Thresholds for pixel values in every layer (R, G, B, Principal components, Independent components) were defined for delineation between classes for the test image which contained most of the UXOs found in the ammunition depot. These thresholds are not something that is directly applicable on any image; they represent more a kind of guidelines to the interpreter. A simple classifier which ranked the highest possibilities according to the already defined thresholds was programmed. In the "Sample" column mean values of certain segment are inserted. If the mean value of segment in specified channel (Red, Green, Blue, 1st Principal Component, etc.) is occurring in the defined interval for some class (UXOs, Vegetation, Stone, etc.) value 1 is set, in opposite 0 value is placed. Upper and lower threshold values for class in specified channel are defined on the basis of statistical analysis (Racetin and Krtalic, 2014). Sum of row is the sum of occurrences of sample value in different classes which can be regarded as weight. Simple possibility of occurrence is calculated by dividing the one occurrence with the weight for that channel. Weighted sum is the sum of these probabilities. Higher values of this weighted sum for specific class indicate the greater chance of this sample belonging to it.

Table 1 Example of sample classifier, only few classes are presented here. Mean values of specific segment are exported from software supporting OBIA and then pasted in "Sample" column. Classifier then calculates the weighted sum of occurrences according to the thresholds calculated using the statistical analysis.

	Sample	BL755 Container	BETAB 500	RBK 250	SAB 100	STURM	MR 120	AS 130	R100 M69	WARHEAD OF S-24B	SUM
B	46.25	0	0	0	0	0	0	0	0	0	0
G	45.19	0	0	0	0	0	0	0	0	0	0
ICA_1	0.337	0	0	0	0	0	0	0	0	0	0
ICA_2	-1.177	0	0	0	0	0	0	0	0	0	0
ICA_3	-0.861	0	0	0	0	0	0	0	0	0	0
Lab_a	7.959	0	1	0	1	0	0	1	0	1	4
Lab_b	1.666	1	0	1	0	0	0	0	0	0	4
Lab_L	28.25	0	0	0	0	0	0	0	0	0	0
PCA_ICA_1	0.2162	0	1	0	1	1	0	1	0	1	5
PCA_ICA_2	-1.259	0	0	0	0	0	0	0	0	0	0
PCA_ICA_3	-2.052	0	0	0	0	0	0	0	0	0	0
PCA_1	-129.6	0	0	0	0	0	1	0	0	0	2
PCA_2	-4.47	0	0	0	0	0	0	0	0	1	1
PCA_3	-10.89	0	0	0	0	0	0	0	0	0	0
R	58.55	0	0	0	0	0	0	0	0	0	0
	W_SUM	0.25	0.45	0.25	0.45	0.20	0.50	0.45	0.00	1.45	

Although the exact values of these thresholds are hardly a rules for direct delineation of targeted objects, the ratios between classes should stay preserved on whole set of images. Between the thresholds one showed great results and repeatability with the exact value. Values in channel ***a*** from transformation to CIELab colour space which are higher than 15 strongly correlate with the corroded UXOs. Examples of achieved results are presented on following images (Figure 3), on black and white images white pixels represent object of interest.


a

b

Figure 3 a) Input RGB image b) Result of processing

4. Conclusion

Implementation of procedures presented in this paper does not require any specialized knowledge or proprietary software to be applied. Although statistics behind it are complex, the procedure itself is not computationally demanding and it is easy to execute. This implementation is designed to be semi-automatic, meaning that it should serve as a help to the human interpreter rather than a replacement for him. It is clear that no matter what accuracy and reliability image processing and classification algorithms achieve, ground clearance teams will definitely watch their steps instead of walking directly to the coordinates exported from computer software.

Concerning the future steps, potential of object based image analysis has not yet been exploited to its limits. Because of the nature of the shape of targets – UXOs (some of them preserved their original shape, some suffered only minor damage and deformations, while some are in completely unrecognizable form) it is difficult to set geometry values for classification using the OBIA. Considering that one object can appear in different conditions (burned, corroded or with the original paint preserved), or it can be located in the sun or in the shadow additional resources will be invested in the research of textures parameters.

Acknowledgement

The research leading to these results has received funding from the European Union's Seventh Framework Programme under grant agreement no 284747, project TIRAMISU.

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Evaluation of the computer game for children MRE: "Great Rally on the back of electronic turtles"

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In the paper evaluation of the computer game for children MRE "Great Rally on the back of electronic turtles" has been presented.
"Great Rally" is an educational computer game under development in the TIRAMISU project. This is a multiplayer board-game for school-like use with teacher-instructor participation, designed for implementation on Internet-connectable mobile devices, with rally on the backs of electronic turtles through a terrain with mine risks as its content. Pre-tests of the game with children participation will be conducted in Poland, and full tests in Croatia. The paper argues evaluation of the game by means of these tests. The following issues, related to the "protocol of the test", are discussed:
- enrolment of children with their parents' consent;
- content and schedule of the test;
- organization of the test in a school - administrative and personnel aspects;
- instructive preparation of the test participants;
- regulations of the test games course;

Spatial Situation Statistical Models of the UAS's survey of the mine suspected areas damaged by landslides, torrents and floods.

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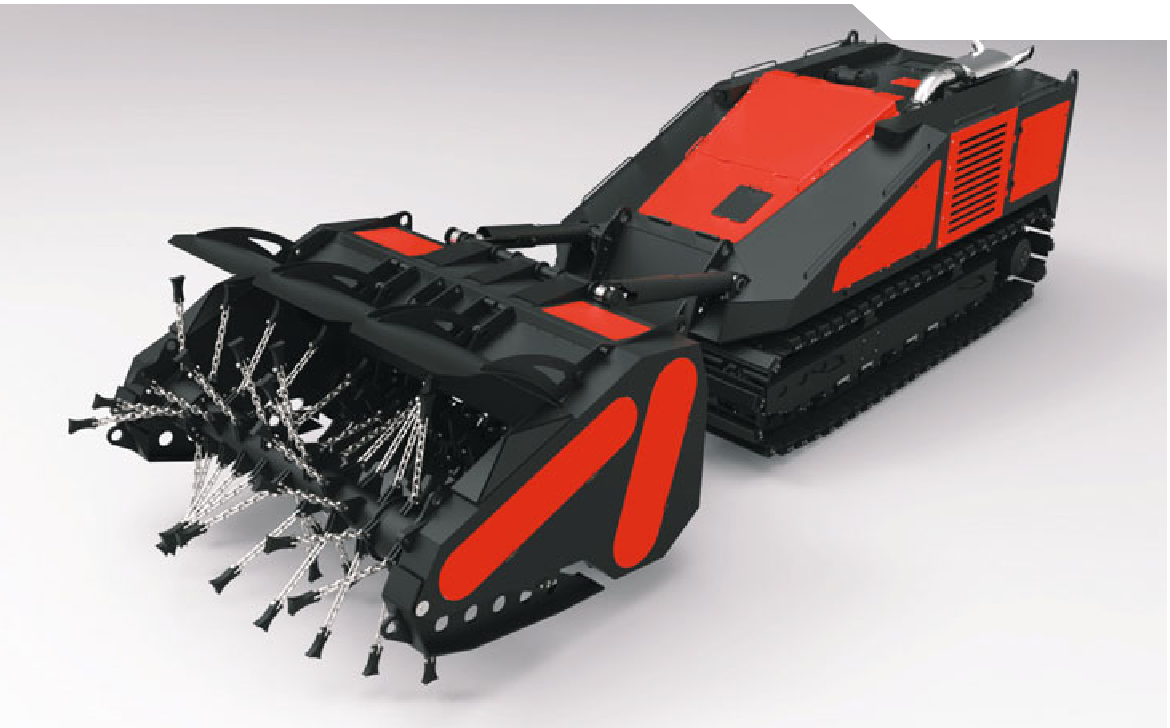
The use of the unmanned aircraft systems (UAS) for humanitarian mine action is comming technology. There is a large discrepancy between very simplified offering of UAS industry and the needs of the mine action. The misunderstanding between the potentials and operational needs is a main obstacle for deployment of UAS in mine action. The own experience of the application of UAS in a large mine suspected areas, influenced by severe natural disaster in 2014 motivated us to consider this topic deeper. In considered cases UAS were exposed to the variety of extreme requirements, the situations, terrain, relief, vegetation, hazard level, acces, GPS satelite availability. Our goal is to derive situation spatial statistical models and explain impact of majority of the mentioned variables. Aerial mapping of the affected mine suspected area damaged by landslides, torrents and floods was conducted with two different UAS, we use only one data set. Once obtained, the data acquired from the UAS were processed and new digital orthomosaic and digital surface terrain models of affected mine suspected areas were produced. When the initial evaluation of spatial accuracy was done it was found that the value of spatial positional error varies, considerably from 1m to 45m, regardless of the uniform processing procedure. Due to various factors that could affect the data to oscillate in positional accuracy so greatly it is clear that simply understanding of this phenomenon is not possible and it is necessary conduct deeper analysis of the data. For further analysis one data set of 11 recorded locations was selected. In this paper will be presented different statistical models of the various factors influence on the realization of spatial accuracy.



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