GOVERNMENT OF THE REPUBLIC OF CROATIA

OFFICE FOR MINE ACTION

HRVATSKI CENTAR ZA RAZMINIRANJE

HCR CENTAR ZA TESTIRANJE, RAZVOJ I OBUKU
CENTER FOR TESTING, DEVELOPMENT AND TRAINING

The 13th International Symposium

"MINE ACTION 2016"

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Contents

Application of targeted technical survey in Bosnia and Herzegovina: Development of advanced techniques for data collection and assessment, standard operational procedures and building of national capacities

Darvin Lisica Ph.D.[1]

Targeted technical survey is "missing chain" in concept of land release in Bosnia and Herzegovina (BiH). In October 2014, Norwegian People's Aid (NPA) presented to BiH national authorities its framework for development of process and procedures of targeted technical survey. Testing of standard operational procedures, including advanced techniques for data collection and assessment are conducted through pilot project conducted by NPA in the area of Middle Bosnia through 2015.

During the implementation of the pilot project NPA, together with BiH Mine Action Centre were faced with several challenges/objectives: (1) Establish a process and to develop techniques for data collection in targeted technical survey that ensure improved assessment of the remaining mine suspected areas with very limited use of resources for clearance; (2) Achieve a strong interaction between the non-technical survey and targeted technical survey; (3) Targeted technical survey should be used instead of systematic technical survey wherever possible; (4) To improve the efficiency of mine clearance through targeted technical survey; (5) To increase the area for mine clearance on the way that minefield confirmed through targeted technical survey are prioritize for clearance; and (6) Provide good working conditions for all demining organizations, governmental-and non-governmental organizations and commercial companies.

The test results of procedures and applied data collection techniques were presented and discussed at three workshops that were attended by representatives of international organizations and organizations from Southeast Europe countries.

NPA develop capacity building plan 2016-2017 in order to fit targeted technical survey to regular operational activities in BiH. NPA's efforts on targeted technical survey have been supported by the Kingdom of Norway, Republic of Korea through ITF Enhancing Human Security and Swiss Development Cooperation.

Context for Application of Land Release Concept into Bosnia and Herzegovina Mine Action

Twenty year after the war, landmines, cluster munitions and other explosive and toxic remnants of war still have serious social, economic, environmental and security impact in Bosnia and Herzegovina (BiH). More than 1,450 communities have been affected by mines and cluster munitions (25% of

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all communities). On beginning of 2016, the estimated size of the areas contaminated by landmines mines is 1,177 km^2, and size of the areas contaminated by cluster munitions remnants is 8.7 km^2. According BiH Mine Action Centre (BHMAC) data base, 8,350 victims were registered. Since the war there have been 1,732 casualties, of these 603 fatal. Approximately, 650,000 people are affected by landmines, cluster munitions and other explosive remnants of war in BiH. In global context of contamination, BiH belong between countries with high density of contamination, impact and consequences comparing with other affected countries.

BiH became a State Party to the Mine Ban Treaty in 1999 and following an extension granted in 2009 must complete the clearance and destruction of leftover anti-personnel mines by 2019. As a State Party of the Convention on Cluster Munitions, BiH has to complete clearance of all contaminated areas by 2021. According extension of deadline for fulfilment of obligations as State party of both conventions, Council of Minister adopted BiH Mine Action Strategy 2009-2019.

Through 2000-2004, BHMAC has been developed first mechanism for the reduction of areas suspected to be contaminated with leftover mines, today called "land release". The mechanism was included two activities related to non-technical survey, technical survey and clearance. Non-technical survey included procedures called "systematic survey" as tool for continual assessment of all available data and measuring of result on land release on country level, and procedures of general survey which were more oriented on detail assessment of micro-location and defining confirmed hazardous areas (CHA) for technical survey and clearance. Technical survey was based on systematic investigation only, without targeted investigation, and was applied fully in humanitarian demining operation through 2004-2005. Already in 2005, this mechanism improved efficiency of work, both in terms of released land and the number of mines found on cleared areas. It increased donor confidence in the commitment of local authorities to address the problem of mines and meet the obligations under Mine Ban Treaty. Results of Mine Action in BiH show that the applied land release model was efficient in the period 2005-2009. However, lack of its continuous improvement through adaptation to new challenges, such are: (1) application of advanced techniques of data collection and assessment and (2) insufficient information on remaining contamination have created difficulties for implementation of BiH Mine Action Strategy 2009-2019.

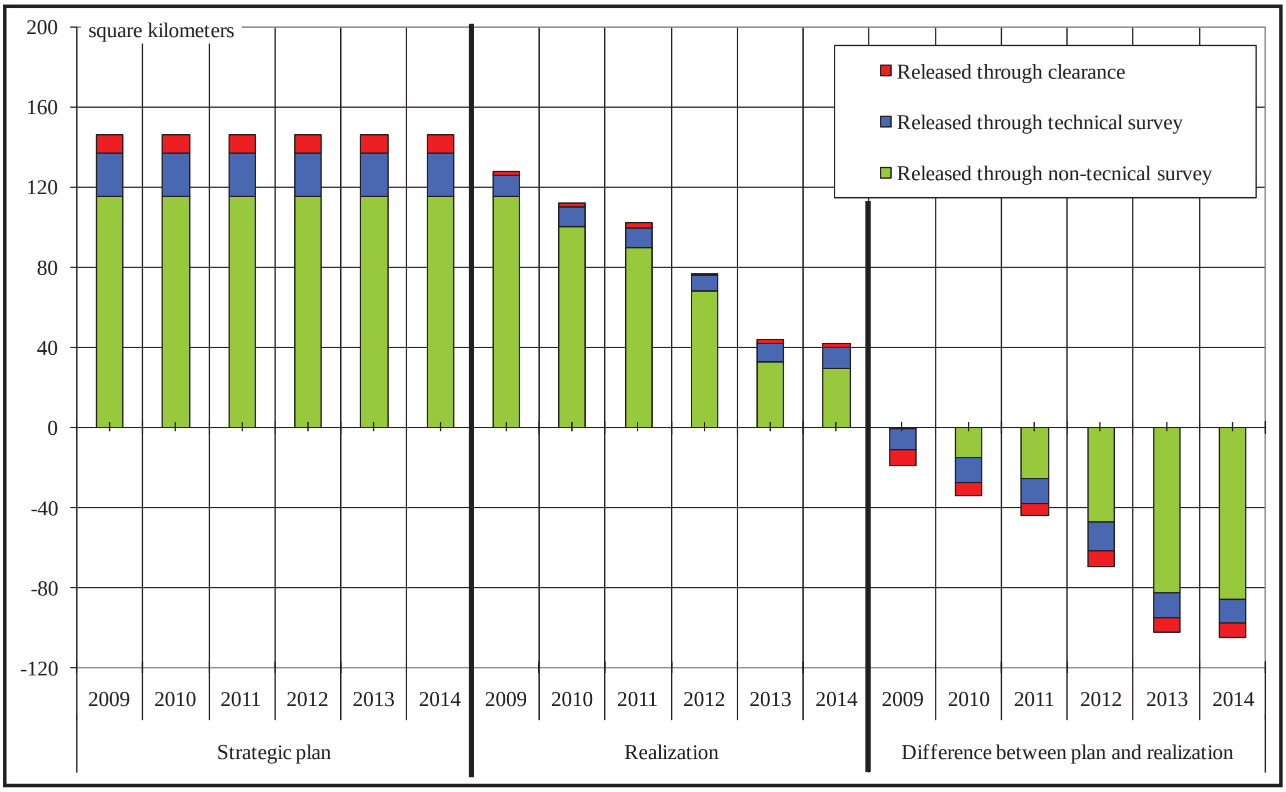
The analysis of the strategic concept for Mine Action in Bosnia and Herzegovina shows five phases in the implementation of the Strategy. The first phase of the implementation of the strategic concept refers to the period 2007 – 2008 and implies certain preconditions for the beginning and progress of the successful implementation of the Strategy. In the first phase it was also anticipated that the new Mine Action Law would be issued. Preparation of the new Law on Mine Action lasted too long and did not anticipate appropriate obligations for financing of mine action. Also, the public and the relevant experts were not involved enough in the process of review of the draft Law and thus had no chance to actively contribute to its improvement. The Parliamentary Assembly of Bosnia and Herzegovina didn't accept Mine Action Law until 2015 which created unfavourable legal environment for implementation of Strategy. Without these necessary preconditions that were supposed to provide by national authorities, the strategy has been brought into question at the beginning of its implementation.

Through 2009-2014, releasing of land was implemented on the level of 57.6% of strategic plan. According components of the releasing of land it looks like this: 63.0% of non-technical survey plan, 43.6% of technical survey (systematic investigation only) plan and 22.3% of clearance plan.

Implementation of strategic plan was also based on increased contribution of national, entity and local authorities in BiH, as well as companies for the purpose of releasing of land. Besides contribution of external donors with 115 Mill BAM, BiH Council of Ministers accepted obligation to provide 362.1 Mill BAM for implementation of Mine Action Strategy in the period 2009-2014. Reports shown that external donors implemented their "side" of financial plan on level of 104.3%, while national authorities secured 34.1% of adopted budget.

TABLE 1: Concept applied in BiH Mine Action Strategy and its implementation

Milestones	Time	Strategic assumptions	Imple-mented
		- Local budgets need to ensure the beginning of progressive increase of their share of funding in 2009.	No
		- Issuing of Mine Action Law will ensure additional and continuous funding through local budgets, which will represent an additional incentive for the interest and trust of donors.	No
		- Significant support of current donor countries until 2015.	Yes
Beginning of implementation of the Strategy	**2009**	**Achieved preconditions**	No
		- High level of relation between non-technical survey, technical survey and clearance in order to prepare the first revision of the Mine Action Strategy.	Yes
		- BiH Mine Action Centre needs additional survey teams for finalization of activities on non-technical survey of the areas from the first and second category of priorities **(NPA secured additional survey teams).**	Yes
		- 30 km² of clearance and technical survey annually (2 times more than in 2008).	No
First revision of the Strategy	**2012**	**Completed non-technical survey of suspected areas from the first and second category of priorities**	No
		- Non-technical survey, clearance and technical survey of risk areas from third category of priorities based on the improved surveying techniques.	No
		- 30 km² of clearance and technical survey annually	No
Second revision of the Strategy	**2015**	**Since 2015 demining done mostly out of local funds**	No
		- Increase of the role of non-governmental organizations, Armed Forces of BiH and Civil Protection	Yes
		- Non-technical survey, clearance and technical survey of risk areas from third category of priorities	No
		- 30 km² of clearance and technical survey annually	No
Third revision of the Strategy	**2017**	**Exit strategy of the BiH Mine Action Centre**	?
		- Gradual decrease of non-technical survey activities.	
		- 30 km² of clearance and technical survey of remaining suspected areas from third category of priorities annually	
		- Exit strategy of non-governmental organizations	
End of implementation of the Strategic Plan	**2019**	**Fulfilments of obligations from the Anti-personnel Mine Ban Convention**	



GRAPH 1: Implementation of strategic plan on releasing of land in BiH

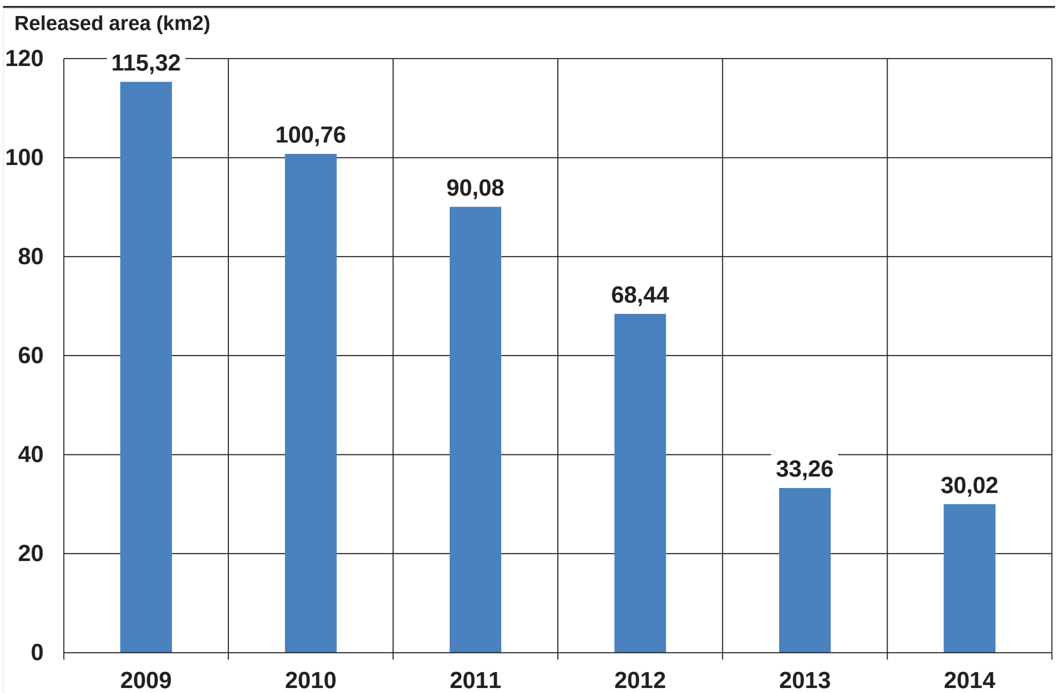
TABLE 2: Support to Mine Action in Bosnia and Herzegovina 2009-2014

Year	Budget according BiH national mine action strategy			Realization			Lost
	National funding	External donors	Total	National funding	External donors	Total	
	Millon BAM	Millon BAM	Millon BAM	Millon BAM	Millon BAM	Millon BAM	Millon BAM
2009	53,4	25,0	78,4	21,7	26,0	47,7	-30,7
				40,6%	103,9%	60,8%	
2010	54,2	25,0	79,2	26,5	17,5	44,0	-35,2
				48,9%	70,0%	55,6%	
2011	60,0	20,0	80,0	20,1	20,5	40,7	-39,3
				33,5%	102,7%	50,8%	
2012	60,2	20,0	80,2	16,9	16,7	33,6	-46,6
				28,1%	83,5%	41,9%	
2013	65,0	15,0	80,0	16,69	18,77	35,46	-44,5
				25,7%	125,1%	44,3%	
2014	69,4	10,0	79,4	21,50	20,49	41,99	-37,4
				31,0%	204,9%	52,9%	
Total	362,1	115,0	477,1	123,4	120,0	243,4	-233,7
				34,1%	104,3%	51,0%	

Therefore, the most important strategic and legal preconditions which would enable successful implementation of the BiH Mine Action Strategy have not been fulfilled. Due to extent of contamination and impact with leftover explosive hazard, lack of sufficient financial resources and past and current dynamic on implementation of strategic plan, it is obvious that BiH has been unable to meet this obligation under Mine Ban Treaty by deadline on 1st March 2019. Request for a reasonable extension of deadline to fulfil Mine Ban Treaty obligations is necessary. Assistance to national authorities in BiH towards fulfilment of the Mine Ban Treaty and the Convention on Cluster Munition obligations should remain a primary goal for donor countries, international organisations, specialised agencies for mine action and non-governmental organisations. BiH national authorities also have shown political initiative, as well as demonstrate will to meet the remaining obligations under both Conventions. The political will should be transformed into improved national mine action legislation and increased financial participation on a national level.

Targeted technical survey is "missing chain" in concept of land release in Bosnia and Herzegovina

Last five years, non-technical survey slightly lost efficiency in the releasing of land in BiH. Decreasing trend in the size of area that can be released through non-technical survey is result of circumstances that some key criteria cannot be applied more. Criteria are "spent" through their long-term application in non-technical survey in BiH. This is unstoppable process because some attempts to increase accuracy with aero-photo and satellite images have not desired effect. It means, non-technical survey needs to be supported and combined with very limited use of clearance techniques to collect data entering in suspected hazardous areas through application of targeted investigation in technical survey.



GRAPH 2: Efficiency of land release in BiH – non-technical survey

Accuracy of CHA estimated through non-technical survey was also serious problem for efficiency of both technical survey (systematic investigation) and clearance. Through 1996-2003, clearance procedures have been used in BiH only. There were sporadic attempts to bring in technical survey but without success. BiH adopted procedures for technical survey (systematic investigation) in 2004-2005 which increase efficiency, number of found mines per cleared areas and speed-up process of land release using non-technical survey, technical survey and clearance. Applied mechanism was efficient because BiH still "had" sufficient number of known minefields.

Since 2009, it was obvious that the mine situation becomes more blurred, with a smaller number of known mine fields than it was before. Non-technical survey as an independent activity performed by BHMAC, could no longer provide enough accurate data to define hazardous areas that should be treated by technical survey (systematic investigation) or clearance. Through 2009-2015, areas designated for technical survey (systematic investigation) "produced" 2.5% area for clearance only.

TABLE 3: Result of technical survey (systematic investigation) 2009-2015

BHMAC Regional office	Area treated through technical survey (systematic investigation)	Cleared mined area within technical survey tasks (CHA desiganetd for clearance through technical survey)	
	km^2	km^2	%
Bihać	5,7	0,1	1,80%
Mostar	5,6	0,2	3,60%
Sarajevo	6,5	0,4	6,20%
Travnik	2,9	0,2	6,90%
Tuzla	9,7	0,2	2,10%
Banja Luka	5,8	0,2	3,40%
Pale	3,7	0,1	2,70%
Brčko	19,6	0,1	0,50%
BiH	59,5	1,5	2,50%

Currently, technical survey dominate with annual contribution of 80-85% while clearance contribute with 15-20% which is not acceptable in future. Through development of land release concept in BiH, technical survey (systematic investigation) has to be significantly reduced. Its application has to stay an integral part of land release cycle, if "all other reasonable efforts" to confirm or refuse presence of mines are spent only.

Defining of CHAs designated for clearance through non-technical survey becomes also questionable. An example is analysis of found mines per hectare on NPA tasks in BiH through 2011-2014. It is important to emphasize that NPA investigated clearance tasks produced by BHMAC non-technical survey additionally and very often asked BHMAC for reduction of clearance task once minefields are identified. These kind of requests to BHMAC to reduce task areas is not practice of operators contracted through bidding process. Although NPA pay attention on such tasks for clearance, analysis show tremendous discrepancy between CHA defined through non-technical survey and technical survey (systematic investigation). NPA found 6.17 mines per hectare on CHA defined through non-technical survey while 46.98 mines per hectare on CHA defined through technical survey (systematic investigation). In practical sense, accuracy of CHA defined through non-technical survey is 7.5 time less than defined through technical survey.

TABLE 4: Mines found on NPA tasks 2011-2014

Year	Found mine/hectar (mine/ha) on NPA tasks	
	Clerance taks defined through non-technical survey (mines/ha)	Clearance tasks defined through techncal survey (systematic investigation) (mines/ha)
2011	4,6	37,14
2012	11,03	87,8
2013	0,74	44,68
2014	8,47	36,65
2011-2014	6,17	46,98

Obviously, current CHAs defined through non-technical survey which are designated for clearance will create serious problem for efficiency of clearance in BiH. In same time, previous analysis show that traditional BiH model of technical survey based on systematic investigation is not solution because poor result on definition of CHA for clearance. In addition, the existing model of technical survey consumes 20-30 percent of resources for clearance which is big financial cost for the country. Solution could be introduction of cheaper and more efficient techniques within land release that could replace technical survey (systematic investigation) substantially.

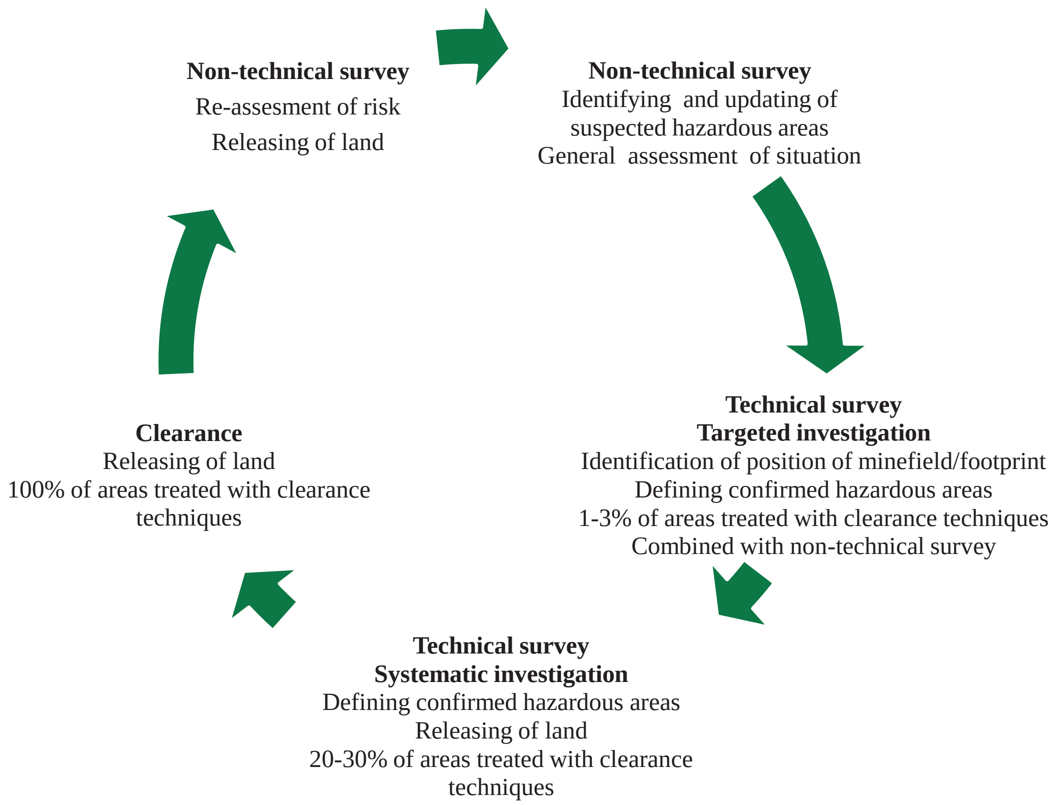


FIGURE 1: Land release cycle

Technical survey (targeted investigation) or targeted technical survey becomes "missing chain" in whole land release cycle in BiH. Through 2015, its development was oriented on application of advanced techniques for data collection and assessment and standard operational procedures.

Development of procedures and testing of techniques for targeted technical survey by Norwegian People's Aid

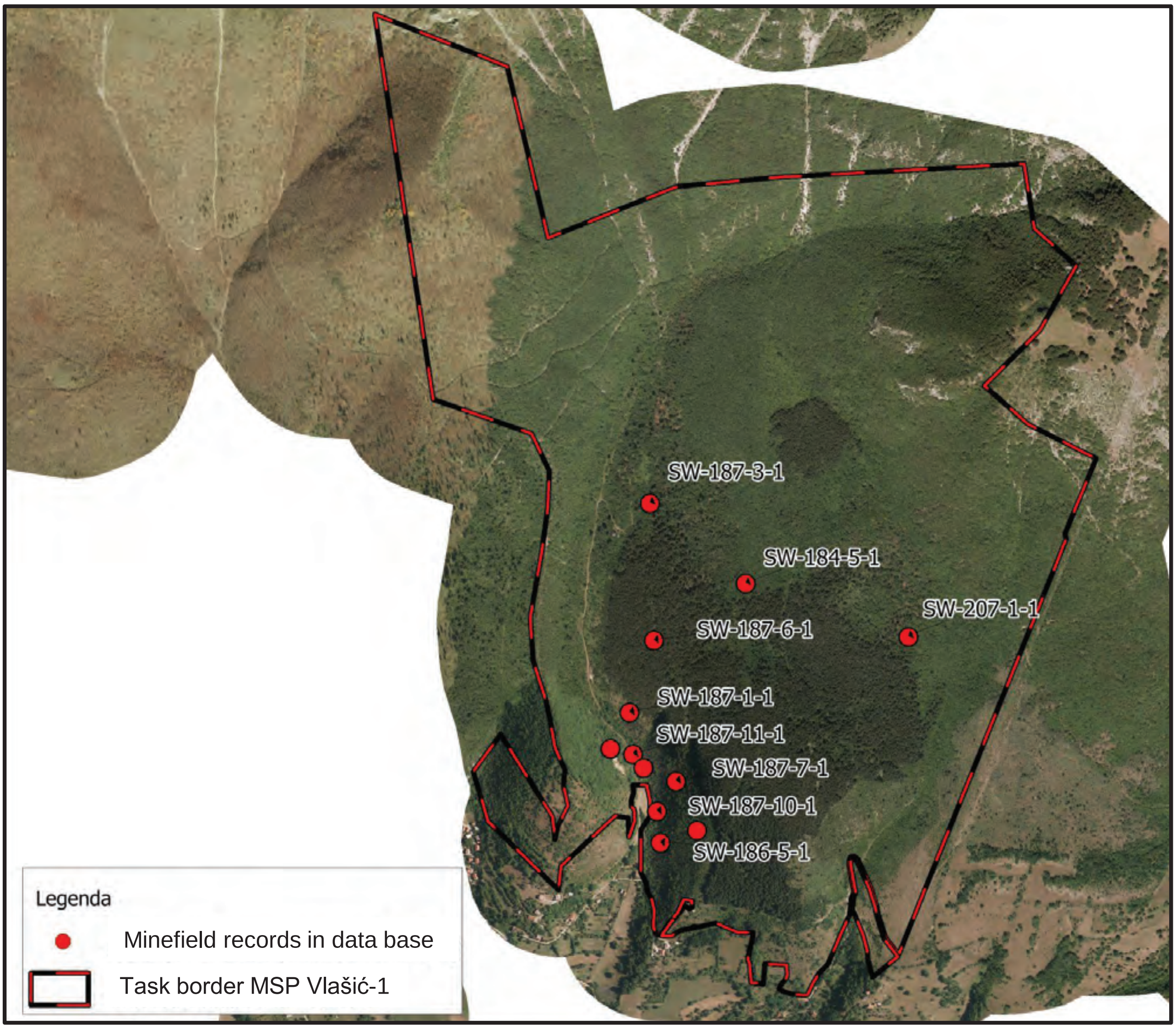
In October 2014, Norwegian People's Aid (NPA) presented to BiH national authorities its framework for development of process and procedures of targeted technical survey. Testing of standard operational procedures, including advanced techniques for data collection and assessment are conducted through pilot project conducted by NPA in the area of Middle Bosnia through 2015. During the implementation of the pilot project NPA, together with BiH Mine Action Centre were faced with several challenges/objectives: (1) Establish a process and to develop techniques for data collection in targeted technical survey that ensure improved assessment of the remaining mine suspected areas with very limited use of resources for clearance; (2) Achieve a strong interaction between the non-technical survey and targeted technical survey; (3) Targeted technical survey should be used instead of systematic technical survey wherever possible; (4) To improve the efficiency of mine clearance through targeted technical survey; (5) To increase the area for mine clearance on the way that minefield confirmed through targeted technical survey are prioritize for clearance; and (6) Provide good working conditions for all demining organizations, governmental and non-governmental organizations and commercial companies.

Pilot project is implemented through three phases. First phase (January-June 2015) included: (1) Drafting of standard operational procedures for targeted technical survey and development of pilot project and their approval by BHMAC; (2) The approval of a pilot project by the Demining Commission; (3) Visit and survey of locations where pilot project will be implemented in cooperation with BHMAC Regional Office Travnik; (4) Preparation for field activities: (a) Processing of all available data obtained from non-technical survey; (b) Development of execution plan for targeted investigation; and (c) Selection and preparation of personnel and resources for field work. Second phase (July –October 2015) included: (1) Opening of the task and the organization of monitoring of the pilot project by the BHMAC; (2) Application and testing of planned techniques and methods in a targeted investigation; and (3) Held technical workshop for analysis and evaluation of methods during project implementation. Third phase (November-December 2015) included: (1) Analysis of the results achieved during execution of the pilot project; (2) Analysis of standard operational procedures in accordance with results achieved by NPA and BHMAC; (3) Redefining of process for targeted technical survey following result of pilot project; (4) Workshop on the results and findings of the pilot project and future application of targeted technical survey in BiH for governmental organisations, representatives of international organizations and other organizations from Southeast Europe countries.

Initially, targeted technical survey applied by NPA was designed as process with seven process steps: (1) Analysis of direct evidences on existence of mines and explosive remnants of war; (2) Assessment of indirect evidences on existence of mines and explosive remnants of war; (3) Selection of the targets for investigation; (4) Development of the execution plan for targeted investigation; (5) Field targeted investigation; (6) Analysis of targeted investigation outputs; and (7) Assessment of confirmed hazardous/released areas and reporting. The techniques applied in targeted investigation enabled additional collection of data which confirms the existence of the hazard from mines and other explosive remnants of war, and which could not be collected through the methods of non-technical survey.

NPA pilot project is implemented through targeted technical survey on suspected hazardous area "MSP Vlašić-1", Community Potkraj, Municipality of Travnik in size of 1,825,000 m^2. Investigation team consist of: project manager/operational officer, assistant for non-technical survey, site manager/team leader, six deminers, two dog handler with two special detection dogs and medial team.

First four process steps before targeted investigation are conducted together with BHMAC Regional Office Travnik. Preliminary analysis to identify all available data on evidences on existence of mines



MAP 1: Status in BHMAC data base before targeted technical survey

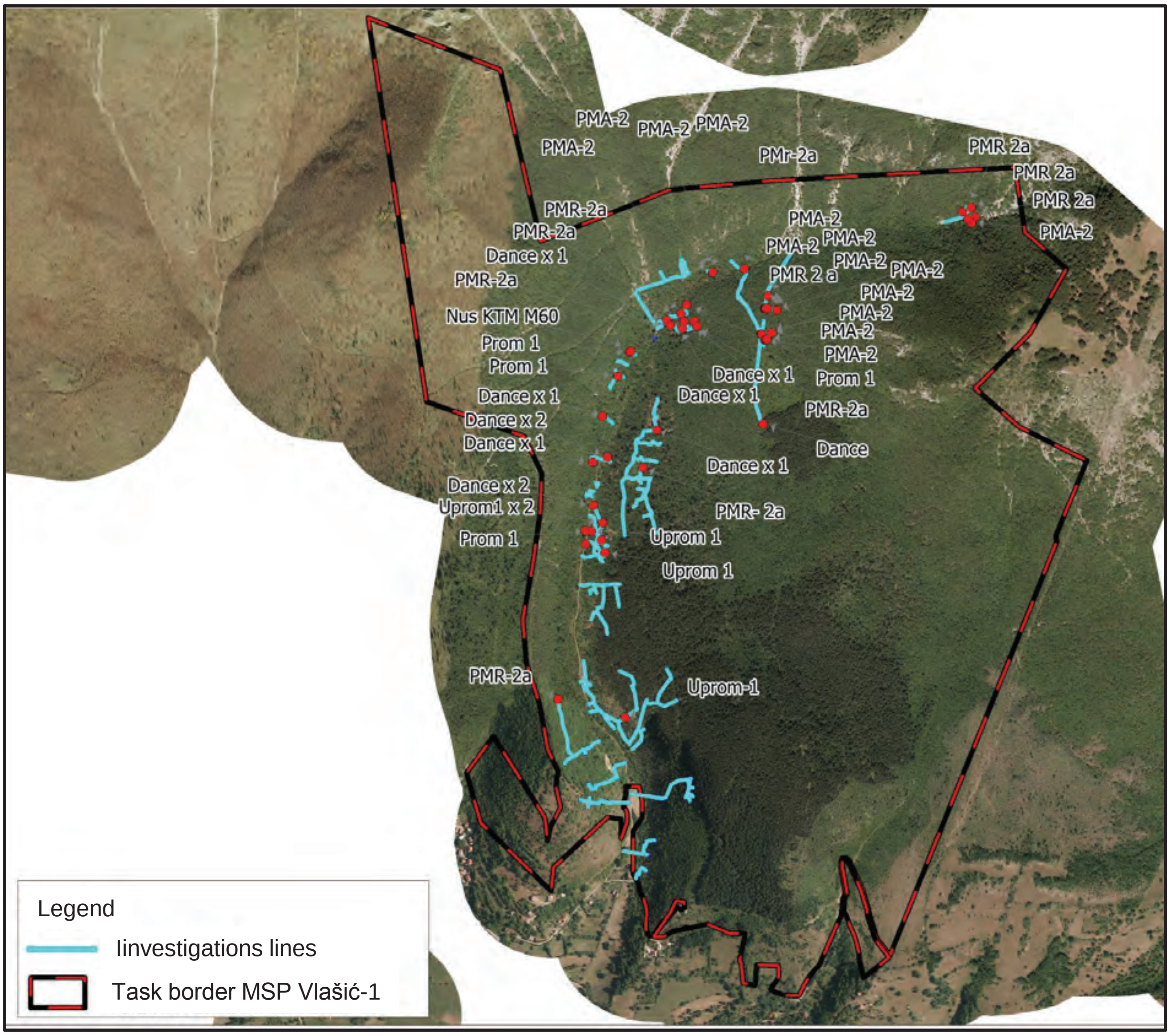
shown that "all reasonable efforts" are not spent through non-technical survey. BHMAC and NPA identified new sources of information (former soldiers and commander, local population) who provided valuable data on mine contamination. It is necessary to continue non-technical survey parallel to targeted technical survey. Their mutual connection and data sharing could improve efficiency, save resources and speed-up work.

In total 11 evidences are selected and "transformed" to target by which it is supposed to check the presence of mines and characteristics of minefields. During the targeted investigation in the field the following techniques have been applied: (1) Manual clearance leading working lane/working lanes towards a specific target; (2) Special detection dogs search towards a specific target: (a) leading a dog on a leash up to 30 m and (b) leading dogs without a leash by focusing on target, (c) leading working lane in traditional way – one working lane/two dogs; (3) Recording (and observing) using drones: (a) directing the drone to target for visual verification of the existence of mines and (b) setting directions of drone search, which can give additional information that could not be collected through non-technical survey. Selection of techniques for each target was carried out according to the analysis of the characteristics of indirect evidence examined, environmental conditions (configuration of the terrain, dense vegetation).

TABLE 5: Clearance resources spent for targeted investigation

Applied techniques and procedures	Investigation of the targets			Definition of the geographical characteristics of targets			**Total**	
	Number of targets	Cleared area		Number of targets	Cleared area			
		m^2	%		m^2	%	m^2	%
Manual clearance	11	2.555	25,7%	6	2.882	28,9%	**5.437**	**54,6%**
Special detection dogs	6	1.790	18,0%	3	2.734	27,4%	**4.524**	**45,4%**
Total	**11**	**4.345**	**43,6%**	**6**	**5.616**	**56,4%**	**9.961**	**100,0%**

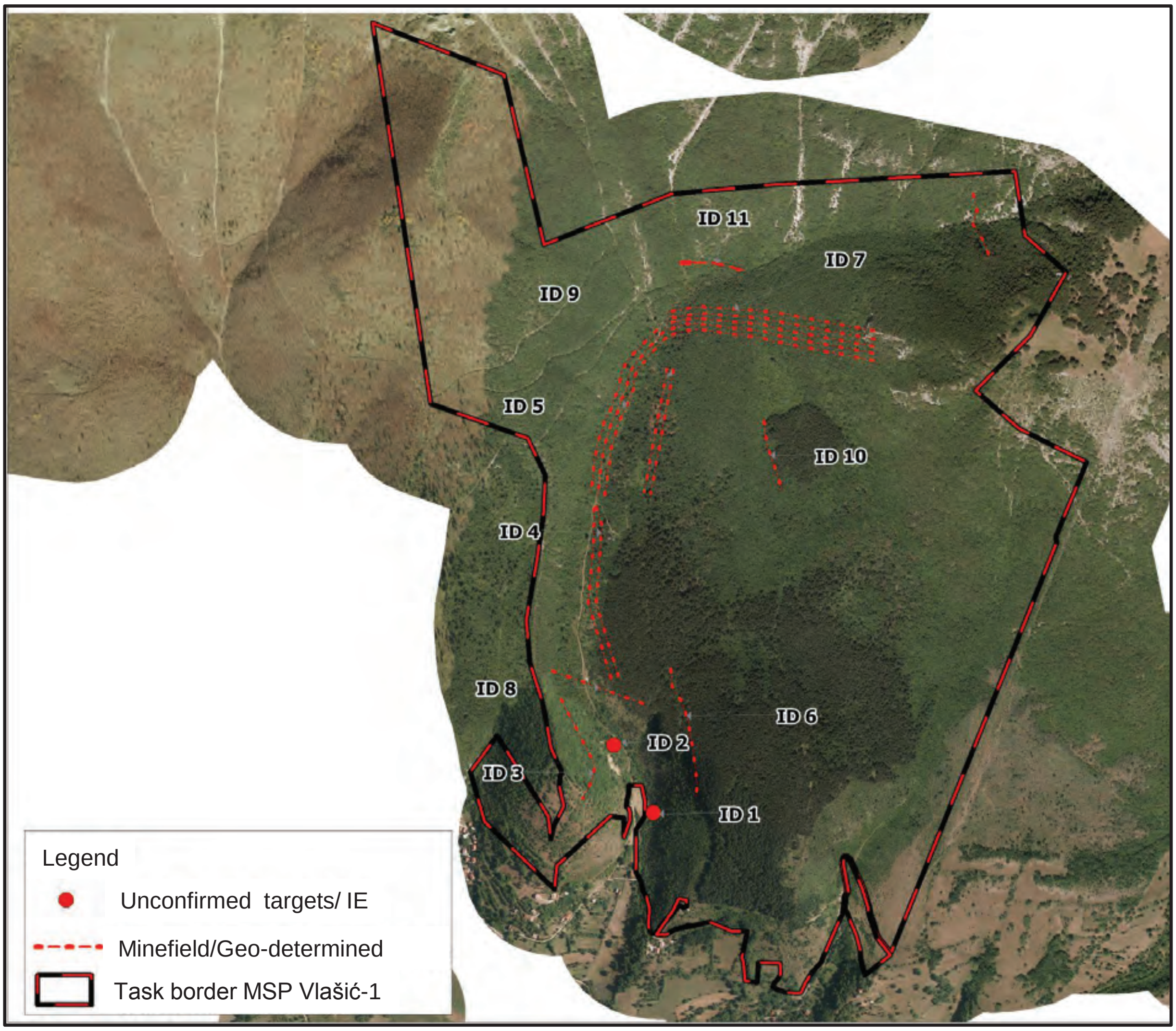
On a total of five targets manual method was applied only. On residual six targets special detection dogs for technical survey were also engaged. Additionally, these techniques are used for purpose of definition of geographical characteristics of minefields. On a total of three targets manual method was applied only. On residual three targets special detection dogs for technical survey were also engaged.



MAP 2: Targeted technical survey conducted by NPA and findings

Field investigation also confirmed that for the purpose of selection of targets the significance and likelihood of the presence of mines is more important criteria than favourable operating conditions and terrain for work. The order of applied methods should be used in consideration as an important question during development of execution plan for targeted investigation. Special detection dogs should be introduced first, as the fastest means for detecting of presence of mines on a relatively larger space than manual teams can do.

Analysis of targeted investigation outputs shown that presence of mines was confirmed on nine targets while no evidences of mines on two targets. Investigation team was also able to identify exact position end characteristics of minefields.



MAP 3: Confirmed targets and positioned minefields

The new assessment of the situation included the entire area of the task/SHA in size of 1,826,000 m^2. Team determined CHA designated for mine clearance in the size of 39,000 m^2 (2.14% of task area). The area the size of 129,100 m^2 (7.07% of task area) is planned for technical survey (systematic investigation) since there was not enough evidence to confirm or reject the existence of mines. It is expected that the remaining area of the task/SHA in the size of 1,657,900 m^2 (90.79% of task area) will be released without additional interventions after the end of clearance and technical survey (systematic investigation) on area defined through targeted investigation.

It can be concluded that strong interaction between the target technical survey and non-technical survey is achieved. Targeted technical survey has enabled the collection and analysis of new data that were not available to non-technical survey. It was done with a limited use of resources for clearance in size 9,961 m^2 (0.55% of task area) for purpose of investigation of selected evidences. The introduction of targeted technical survey will change current practice release of land in Bosnia and Herzegovina. Previously, SHAs where there are incorrect records of minefields have been treated by traditional technical survey (systematic investigation with use of 20-30% of the clearance resources) only. This pilot project shows that the same kind of SHAs can be successfully treated by means of targeted technical survey with the use of 1-3% of the clearance resources).

Review of the process of targeted technical survey after field testing

As a result of the testing, the process of targeted technical survey applied by the NPA is partially modified to six process steps. Through first process step "Desk study on evidences identified through non-technical survey" implementer of targeted technical survey analyse all available data received through non-technical survey or other sources of information. "Selection of the targets for investigation" is second process step of targeted technical survey in which a certain number of evidences is determined as targets for filed targeted investigation. The final number of targets are defined on the basis of available resources, geographical and other environmental conditions and targets layout. "Development of execution plan for targeted investigation" is the third process step of targeted technical survey. The plan shall be made for a natural geographical area of such dimensions that allows the implementation of safety measures, medical evacuation from one place and management of targeted technical survey operations. Execution plan includes an overview of selected targets that should be checked and contains methods for targets checking and engaged resources for checking of each target individually. "Field targeted investigation" is the fourth process step of targeted technical survey at which task is conducting. "Analysis of data gathered through targeted investigation" is the fifth process step of targeted technical survey where the estimation of usability of the data, collected by targeted investigations methods is performing, and confirms certain targets as new evidences. Assessment of CHA for clearance is the fifth process step of targeted technical survey. Implementing organizations is analysing the results of previous process steps and evaluate whether the drata is sufficient for definition of confirmed hazardous areas designated for clearance.

Targeted technical survey could be combined with non-technical survey or technical survey (systematic investigation) or clearance. Targeted technical survey in combination with non-technical survey may result with land release when the collected data and evidences allow it in accordance with the set criteria. Targeted technical survey in combination with systematic technical survey or clearance may result in the land release when is performed as an integral part of/at the beginning of a systematic survey/clearance for better positioning of the mined area. It leads to changes in the borders of the task and the partial release of the task on which systematic technical survey/clearance operations have not been applied.

Conclusions

The results of pilot project on testing of procedures and applied data collection techniques were presented and discussed at three workshops that were attended by representatives of international organizations and organizations from Southeast Europe countries: (1) Technical workshop on testing of techniques and procedures and field presentation held in Travnik on 16 October 2015; (2) Regional

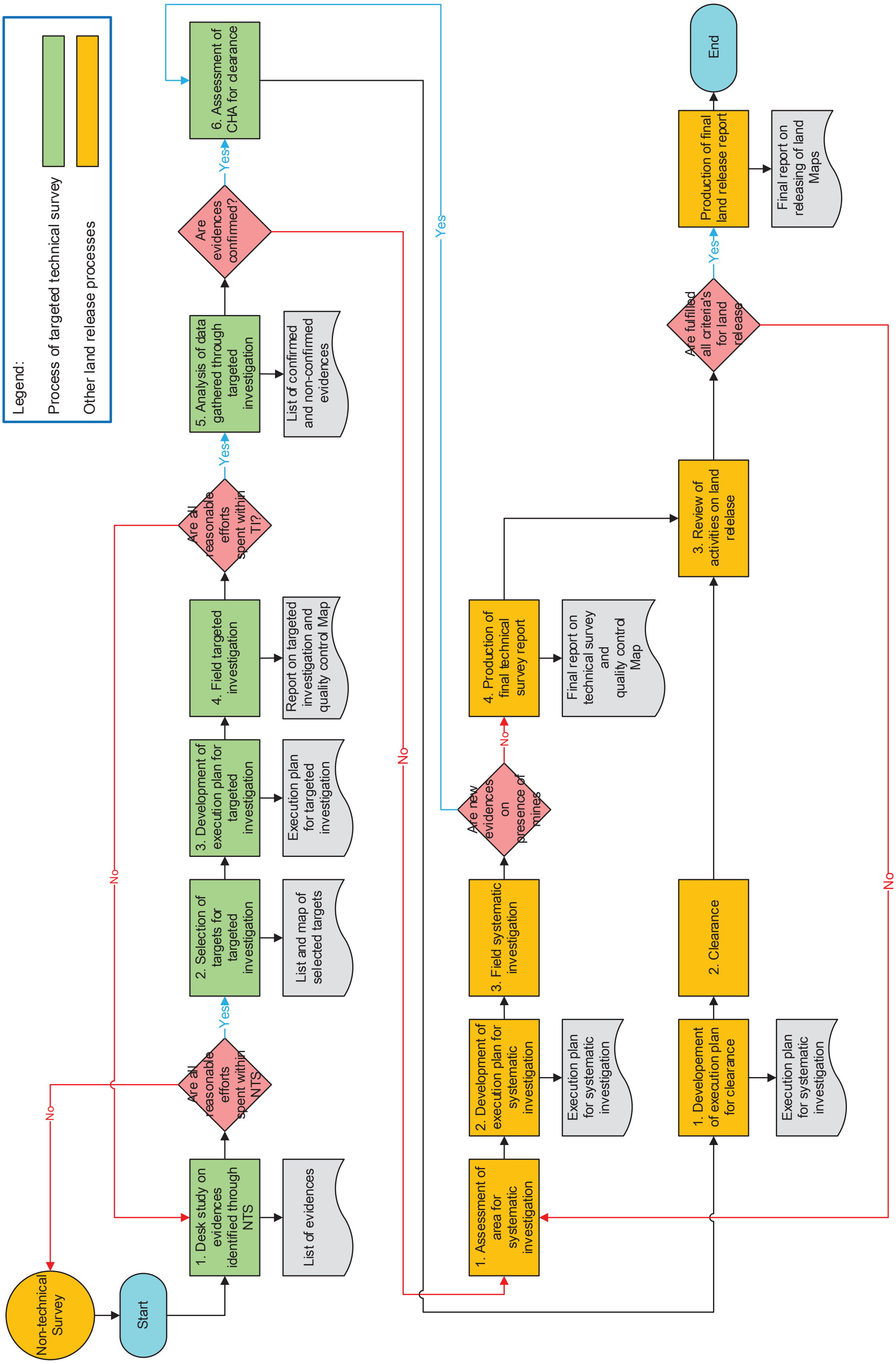


FIGURE 2: Process of targeted technical survey integrated to releasing of land

Workshop: “The state of the cluster munitions contamination in Bosnia and Herzegovina. Toward the First Review Conference of the Convention on Cluster Munitions” on final result of pilot project held in Sarajevo on 15 December 2015; and (3) Workshop on development of standard operational procedures for targeted technical survey and its application in releasing of land contaminated with landmines held in Mostar on 9-11 March 2016. During this workshop Demining battalion, entity Civil Protections and NPA presented findings on their pilot projects and, together with BH Mine Action Centre, find agreement on common approach in implementation of targeted technical survey.

Besides work on development of process and procedures for application of targeted technical survey, workshops defined next key conclusions and recommendations.

National Standard for the Land Release needs to provide a framework for the standardization and implementation of the targeted technical survey including its connection with non-technical survey as well as systematic investigation and clearance. Application of advanced working methods, with traditional methods used in demining in BiH, creates the conditions for increasing efficiency and effectiveness of targeted investigations.

It is necessary to continue with workshop and training on application of procedures and techniques for targeted technical survey and its operational and quality management for governmental organization and other interested organizations (NGOs, companies) in BiH in future: (1) Transfer of knowledge and lessons learned is necessary for efficiency and successful application of targeted investigation (survey) in BiH land release practice; (2) Results of targeted technical survey strongly depends of management skills and ability to lead with such operations; and (3) Improving of national information management system for land release and training of operational management for its use is precondition for good understanding and assessment of available data.

There is needs for equipping of governmental organizations with necessary equipment for application of methods for targeted investigation. It is necessary to include targeted technical survey in regular land release operations in BiH and speed-up work on accreditation of organisations who already implements targeted technical survey tasks using temporarily standard operational procedures or guidelines.

Areas for mine clearance where minefields are confirmed through targeted technical survey need to be included in priority list as urgent tasks. Early planning of targeted technical survey operation for 2017 is necessary to start in 2016. It is important that BHMAC prepare sufficient number of task areas for targeted technical survey and delegate such tasks timely to stakeholders. Early start on analysis of information provided by BHMAC is crucial for successful start-up of operations.

Liaison with local communities and their inclusions in work before, during and after targeted technical survey is essential: (1) Lessons learned shown that communities provided valuable data on new minefields before and during operations as well as knowledge on vulnerable groups affected by presence of landmines; and (2) Targeted technical survey promote elements of mine risk education. Besides community liaison, it promote informing of population at risk and improving their awareness on presence of mines.

Through targeted technical survey implemented in 2015 and 2016 Demining battalion, entity Civil Protections and NPA have to provide sufficient indicators on land release that could be useful for BiH Mine Action Centre during revision of BiH Mine Action Strategy in 2017. It is necessary to reaffirm work of IPA Land Release Board as governmental forum for coordination of all efforts on land release in BiH.

Background International Mine Action and Humanitarian Demining

Dr. Ken Rutherford[1]

Presentation Synopsis

The Center for International Stabilization and Recovery

Founded in 1996, The Center for International Stabilization and Recovery at James Madison University remains one of the world's leaders in addressing post-conflict research and management of landmines and unexploded ordinances (UXO) through education and training. In 2008, the center increased specific activities to support victims of conflict and disaster. This work entails on-the-ground support in more than 12 countries spanning across the globe from Peru to Vietnam.

Landmines as Humanitarian Issue

The late 1980's and 1990's marked the emergence of landmines as a major threat due to their unconventional and conventional use as new-age technological terror weapons in asymmetrical warfare. Consequently, refugees were frequently met with unusable land, high risk of death or injury, and the destruction of country infrastructure upon their homecoming. These humanitarian challenges incited milestone development in mine action, notably with The Convention on Certain Conventional Weapons (CCW) in 1980 to regulate landmine use and the International Campaign to Ban Landmines (ICBL) with numerous NGO participants in 1991. Humanitarian demining initiatives took an institutional hold with the Afghanistan Mine Action Program (MAPA) in 1988, the Cambodian Mine Action Center in 1992.

During the first phase of MAPA planning, the United Nations established their Office for the Coordination of Humanitarian Affairs (UNOCHA), who trained 15,000 Afghanis in manual mine clearance with mixed results of success and opportunities for improvement. At this time, efforts primarily focused on reducing risks as refugees rebuilt their homes and resettled their communities. This included mobilizing donor support and resource acquisition to provide support services and technical assistance for operational activities. In phase two, between 1988 and 1990, non-governmental organizations (NGOs) entered the field with significant participation. MAPA contracted NGOs like HALO Trust and International Rescue Committee to develop full-scale activities for mine clearance, awareness, surveying, training, monitoring, and mapping data to collate. Norwegian People's Aid also became a key contributor by contracting with a Cambodian mine clearance program in 1992.

United Humanitarian Response

Global participation heightened in the following years. The United States established the U.S. Humanitarian Demining Program in 1994, and the United Nations Children's Emergency Fund

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(UNICEF) established Mine Awareness Guidelines in 1996. The same year, the Government of Demark hosted an International Conference on Demining Technology in Copenhagen. The United Nations Mine Action Service (UNMAS) started in 1997 while the Ottawa Convention to Ban Anti-Personnel Landmines was accepted and open for signatures. To formalize and unite the mine action conversation, CISR began the *Journal of ERW & Mine Action*, which continues to circulate in over 160 countries in an updated form. In 1998, the ICBL established the "Landmine Monitor Report" to document landmine issues for the public eye and the government of Switzerland established the Geneva International Center for Humanitarian Demining (GICHD).

Notable developmental studies occurred in 1999, such as the U.N. review of "International Standards for Humanitarian Mine Clearance Operations," the United Nations Development Programme study of "Management Training Needs," and UNMAS development of The Information Management System for Mine Action. The following year, a Deminer Injury Study and the first Landmine Impact Survey in Yemen continued this momentum toward the creation of mine action knowledge. The international community gathered again for the First Review Conference of the States Parties to the Ottawa Convention in 2004. The 2005-2009 Nairobi Action Plan provided a focus on mine action completion through risk management, mine action mainstream awareness, a comprehensive approach for victim assistance, and a clearance system that prioritized projects with the highest impact.

The Legacy of Mine Action

Mine action effort itself created a legacy with worldwide implications. The cause implored unprecedented international cooperation among civil governments, NGOs, military, the United Nations, private-sector organizations, and popular sentiment. New procedures for mine clearance often call for innovative technology while organizations become increasingly multifunctional by adapting to the many needs – awareness, victim assistance, legal, diplomatic, mine clearance – of mine action. The campaign to ban landmines strongly influenced the creation of the 2008 Convention of the Rights of Persons with Disabilities and the 2010 Convention on Cluster Munitions. More recently, researchers have found improvised explosive devices (IEDs) to be a primary cause of casualties for victims of armed violence. The field of mine action and conventional weapons destruction is poised to address IED use as it becomes a burgeoning humanitarian issue.

Humanitarian Demining National Capacity Strengthening

Ejército Nacional de Colombia

Rodrigo Cepeda Ascencio[1]

Background

The systematic, preconceived, generalised and indiscriminate use of Explosive Ordnance (Antipersonnel Mines, Improvised Explosive Devices and Unexploded Ordnance) by the illegal armed groups has changed Colombia into one of the most affected countries during the last decades. With a total report of 11.408 victims (6.979 of them are public force members and 4.429 are civil population members)[2], Colombia is the second country in the world with the highest number of antipersonnel mine victims, added to this, there are 31.000 events registered in IMSMA (with a total area of more than 50 million square meters) that require an exhaustive intervention in order to cancel, confirm or clear.

In order to face this problem, the Military Forces have led a comprehensive strategy to develop the capacity, acquire the experience and the knowledge to assume the responsibility for clearing the mine affected areas and supporting the communities during the land resettlement process and in advance of social development projects.

To fulfill the international obligations in the subject, accepted by the Colombian Government through the signature and adherence to the Convention on the prohibition of the use, stockpiling, production and transfer of antipersonnel mines and on their destruction (AKA Ottawa Convention) in its article 5, it was necessary to request for an extension until March 1St /2021 that was approved by the 10th Meeting of States Parties.

What we are doing to face the problem

Nowadays, the Colombian Government is leading the necessary efforts to get to know the real level of contamination with Explosive Devices due to the lack of a stablished methodology for installing, common laying patterns or even the location of antipersonnel mines already laid. This has caused that much of the available information is not accurate enough and all the technical efforts should be focused on update the available records.

On that matter, the military forces were assigned to implement these technical processes by the approval and put into force of the article 18 included in the Law 759/2002, in which the Ministry of National Defense shall "*designate the military personnel specialized in humanitarian Demining Techniques in order to implement detection, marking, mapping of hazardous areas, clearance and elimina-*

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2 National database. DAICMA.

tion of antipersonnel mines". As a result, the General Command of the Military Forces has pointed out the need to improve planning, implementation and monitoring processes of humanitarian demining projects led by the military units in the country.

As a result, the Army developed and train the required personnel to activate the Demining Battallion Nª 60 " Cr. Gabino Gutierrez" (BIDES) that has been operative since 2007 and implemented Non Technical Survey, Technical Survey and Clearance tasks through Mechanical, Canine and Manual Clearance techniques. During this period, it is implementing Humanitarian Demining in 14 mine affected municipalities and 4 of those have already been released to the civil population in order to support land restitution processes and resettlement projects along with social development and national policies. These municipalities are San Francisco and San Carlos in Antioquia, El Dorado (Meta), Zambrano (Bolivar) and San Vicente del Chucuri in Santander. Some other results of the interventions of the Battallion are: 2'461.438 square meters of released land; 4.613 antipersonnel mines and 537 UXO destroyed.

The municipalities under current interventions are: Cocornà, Granada, Guatape and San Luis in Antioquia; El Carmen del Chucuri and Sabana de Torres in Santander and Samana in Caldas. The technical and Non-technical interventions in these municipalities by BIDES have positively impacted families and communities that were affected by the internal conflict and were forced to displace and abandon their lands and houses by the illegal armed groups and the risk that mines posed to their daily activities. One of the best examples is the support to families and communities to come back to their lands in a safe environment free of mines and UXO.

Another important result of the humanitarian demining interventions by BIDES is the support to the peace agreement in La Habana (Cuba), where both negotiating parties have agreed on start humanitarian demining activities under a joint methodology, with the participation of Norwegian People`s Aid, BIDES and member of Farc who have information on the possible places where mines were installed during the conflict. There are two areas that were selected and are currently under technical intervention: Briceño municipality in Antioquia and Mesetas municipality in Meta.

Our objective

Committed to the emerging challenges and added to the initial objectives, the Colombian Government and the General Command of the Military Forces have jointly outlined and worked on the national strategy for strengthening the humanitarian demining national capacity, led by the Army, through the activation of two Humanitarian Demining Brigades in order to broaden the deployment capacity so that interventions will be more effective and address the high impact areas.

In one hand, The 1st Humanitarian Demining Brigade will be fully activated by 2016 and will have as a main objective to stablish the real level of impact and affectation by mines and UXO. At the end of that stage, the 2nd Humanitarian Demining Brigade will be in charge of fully cleared the mine affected areas and support consolidation processes in the municipalities that most require the interventions by 2018.

On the other hand, this process will also allow the Army to support effectively and efficiently the implementation of national policies focused on social development and consolidation, as the National Policy for Land Restitution and the subsequent resettlements activities, warranting that land is now safe for intended use.

Opportunities for Cooperation with the NATO Science for Peace and Security Programme

Dr Eyup Kuntay Turmus[1]

ABSTRACT: The NATO Science for Peace and Security (SPS) Programme is one of the most relevant, effective and flexible partnership tools of NATO. In the spirit of cooperative security, SPS provides concrete, practical opportunities for cooperation to NATO's wide network of partner countries based on security-related civil science, technology and innovation. The SPS Programme is guided by a set of key priorities that are aligned with NATO's strategic objectives. Accordingly, the Programme promotes cooperation, scientific research and innovation to address security challenges, such as counter-terrorism, defence against CBRN agents; to support the development of security-related advanced technology as well as to address capacity building projects on mine and unexploded ordnance clearance and countering improvised explosive devices. Over the years, NATO has acquired much valuable expertise in the domain of explosives management through several multi-year capacity building projects to help partner nations with this significant threat.

The Science for Peace and Security (SPS) Programme is an established brand for NATO based on three pillars – science, partnership and security – and has been contributing to the core goals of the Alliance for many decades. It is a partnership tool that forges connections among scientists, experts and officials from Alliance and partner nations, who work together to address shared security concerns. The origins of the SPS Programme date back to the 1950s and its outlook has been adapted to the changing security environment over the decades. The Programme provides funding and expert advice for security-relevant activities in the form of workshops, training courses, or multi-year research projects.

All activities funded under the SPS Programme address one or more of the programme's key priorities and have a link to security. The SPS key priorities are based on NATO's Strategic Concept, agreed by Allies in the 2010 Lisbon Summit and the Strategic Objectives of NATO's Partner Relations agreed in Berlin in 2011. These priorities focus principally on emerging security challenges such as counter-terrorism, energy security, cyber defence, defence against CBRN agents, border and port security, support the development of security-related advanced technology as well as mine and unexploded ordnance detection and clearance. The SPS Programme also responds and adjusts to the changing security context to support NATO's strategic objectives and political priorities in its relations with partners.

The SPS Programme contributes to the Alliance's increased efforts to provide support to partner nations in meeting these non-traditional risks and challenges. Under the SPS framework, several tailored projects have been launched that further capability development in the area of explosives man-

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agement. These include countering improvised explosive devices (C-IED), unexploded ordnance (UXO) disposal, mine detection and clearance as well as other explosive remnants of war (ERW). The aim of SPS activities is to set a working model often by providing an initial operational capability that could then be expanded through national and/or other resources. Train-the-trainer approach is a significant component of SPS activities enabling cascading training partner countries.

NATO can draw on expertise in these domains through its significant access to Centres of Excellence (CoE) such as the C-IED CoE in Spain as well as the EOD CoE in the Slovak Republic. The SPS programme has collaborated with these renowned institutions on several occasions. The following section will outline a selection of SPS initiatives in the domain of explosive management.

Increasing the Clearance Capacity for Unexploded Ordnance (UXO) in Montenegro

A multi-year SPS project to support the clearance of UXOs in Montenegro was initiated in 2013. Following the unsettling years of war in the 1990s, UXOs are still found in unsecured areas in the country, posing a considerable risk to the local population. However, as the national UXO clearance team largely lacks the technological know-how and equipment, assistance is provided to Montenegro in acquiring and developing state-of-the-art technologies and methods of UXO clearance.

The main goals of this project are to equip the UXO clearance team under the Ministry of Interior of Montenegro with advanced means for detecting UXO, protective equipment, means for safe transport and destruction of UXO, and, provide the team with technical and management training. The project aims to provide several deliverables to enhance and speed-up the clearance of UXO in Montenegro. One outcome will be new means for detecting UXO in the ground, such as metal detectors, magnetometers, data loggers, evaluation software and dedicated computers including the introduction of new detection technologies.

SPS Demining Projects in Egypt

Egypt is regarded as one of the most contaminated countries in the world in terms of the number of mines and explosive remnants of war scattered across its territory. As a result, large swathes of land are rendered unsafe and unusable. This issue not only poses a serious security challenge for local populations, but also hinders economic development and investment. In a coordinated effort to tackle this issue, the SPS Programme and Egypt have launched two successful demining projects in the country to introduce advanced detection systems suitable for demining in the Egyptian desert.

Launched in 2012, the first SPS flagship project "Advanced Detection Equipment for Demining and UXO Clearance in Egypt" was successfully implemented and completed. Building on its success, the new initiative "Enhanced Explosive Remnants of War (ERW) detection and access capability in Egypt" was kicked-off in 2014 with the aim to provide Egypt with an enhanced operational detection and clearance capability. The project is composed of two phases – detection and access. The first phase includes the use of enhanced Ground Penetrating Radar (GPR) detection systems capable of identifying and discriminating anomalies (plastic/metal) buried at greater depths in order to accelerate clearance in those areas affected by the presence of sand build-up over ERW. In the second phase, the use of suitable excavation and associated equipment to physically support the area and enable safe access to the exposed anomalies identified by the detection system(s) in soft sand will considerably improve safety among clearance teams. Provision of this enhanced capability will greatly improve the safety of

Egyptian de-miners, thereby reducing the number of casualties from ERW clearance, and improving individual confidence and the credibility of the Egyptian de-miners to address the problem. This will have an immediate effect on the safety and security of the local population, reducing the threat from ERW and releasing land for economic development.

Support to Humanitarian Demining in Ukraine

This new multi-year SPS project was kicked-off in May 2015 and will provide equipment and training for humanitarian demining in Ukraine, where landmines are a major problem. The project was initiated based on a request for assistance by Ukraine in identifying and destroying explosive remnants of war.

An SPS fact-finding mission organised in cooperation with the NATO Support and Procurement Agency (NSPA) identified a need to replace equipment that ERW clearance teams lost as a result of the current conflict. During that visit it was determined that the immediate requirement was to replace equipment lost by four Civil Defence State Emergency Service of Ukraine (SESU) demining teams from the two Pyrotechnic Groups in Donetsk and Luhansk Oblasts. This multi-year project therefore aims to provide the SESU with modern technologies to detect and clear ERW and offering technical and operational training to their teams allowing the local population to return to their homes safely.

Holographic and Impulse Subsurface Radar for Landmine and IED Detection in Ukraine

Recognizing that the detection of buried explosives is a vital security issue, the development of techniques that enable rapid detection with a low number of false alarms is crucial. This project is developing a remotely-operable, robotic, multi-sensor device for detection of UXO, mines, and IEDs. This device will enhance the detection of dangerous targets and diminish the number of false alarms by means of new techniques combining holographic and acoustic methods. The enhanced radar will make possible the demining of larger areas of land in a safe and efficient manner, open new possibilities in demining in a range of soil conditions, help diminish the number of casualties among demining personnel and civilians and reduce the overall cost of demining. Scientists from the University of Florence, the National Academy of Sciences of Ukraine and the Franklin & Marshall College in the United States are working together to create this first prototype.

Options for Cooperation with the SPS Programme

Drawing on NATO's significant experience in the domain of explosive's management, the above mentioned projects are only few examples of the SPS Programme's success in the field. By connecting scientists, experts, government representatives and civil society on key issues of security, the SPS Programme is able to make a significant positive impact upon society and achieve tangible and lasting results. It further looks at engaging partners in civil science, technology, innovation and beyond.

Interested parties can always submit an application for funding. Proposed projects must be led by project directors from at least one Allied and one partner country as well as address the SPS key priorities that have a clear link to security. The developed collaborative activity must fit within one of the

SPS grant mechanisms that is multi-year projects, training courses or workshops, as mentioned above. Applications received by the SPS Programme will undergo a comprehensive evaluation and approval process, taking into account expert, scientific and political guidance.

For more information and the latest news about the SPS Programme please visit our website (www.nato.int/science) where you will also be able to find detailed application guidelines and forms. Alternatively, you can e-mail us under sps.info@hq.nato.int.

MORE from micro and macro point of view – Angola case study

Branislav Jovanovic[1] and David Gertiser

Background and Introduction

Angola has gone through several armed struggles over the last forty years, with a liberation movement against Portuguese in 60s, through several stages of civil war in 80s, 90s and 2000s. Today, Angola is peaceful country with great prospects, but the legacy of four decades of war is still visible with every step.

According to the Mine Action Monitor, the Republic of Angola has almost 129 km^2 of confirmed hazardous areas (CHAs) containing mines and a further 356 km^2 of suspected hazardous area (SHA). It also has a significant problem with unexploded ordnance (UXO).

The Angolan government believes that they will need another 5 years just to determine the extent of the mine problem in the country. To date, more than 80.000 peoples in Angola have been killed or injured by landmines. It is estimated that still affected 14% of the country or approximately more than 2.4 million peoples are still exposed to risks from ERW. In 2014 Angola recorded 11 mine/ERW casualties; the lowest numbers since 1990.

Engaging with the ongoing risks posed by explosive contamination requires a tailored approach, one which benefits from Risk Management and systematic analysis. This paper will look at the Management of Residual ERW (MORE) from a more global perspective, and then investigate the application of MORE principles in a case study in Angola.

Macro point of view

Management of Residual ERW (MORE) refers to the comprehensive approach to dealing with the risks posed by explosive remnants of war (ERW). The approach is long-term; dealing with ERW and mine contamination even long after general proactive clearance operations have ceased and a country has complied with its international treaty obligations.

The typology of a MORE system is different than a standard mine-action approach, though many of the same considerations are present in both. For this article, MORE will be discussed in terms of Risk Management, Long Term Solutions, and Varied Actors.

Risk Management[2]

Risk Management consists of a coordinated set of activities to direct and control a project, organisation, programme or national system with regard to risk. Risk is generally understood as "the effect of uncertainty on objectives," but here is directly linked to those risks arising from or related to ERW.

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2 for a more detailed discussion of Risk Management in a MORE context, see "Management of Residual ERW (MORE) – Risk Management" in GICHD's Issue Brief series on MORE)

The Risk Management Cycle

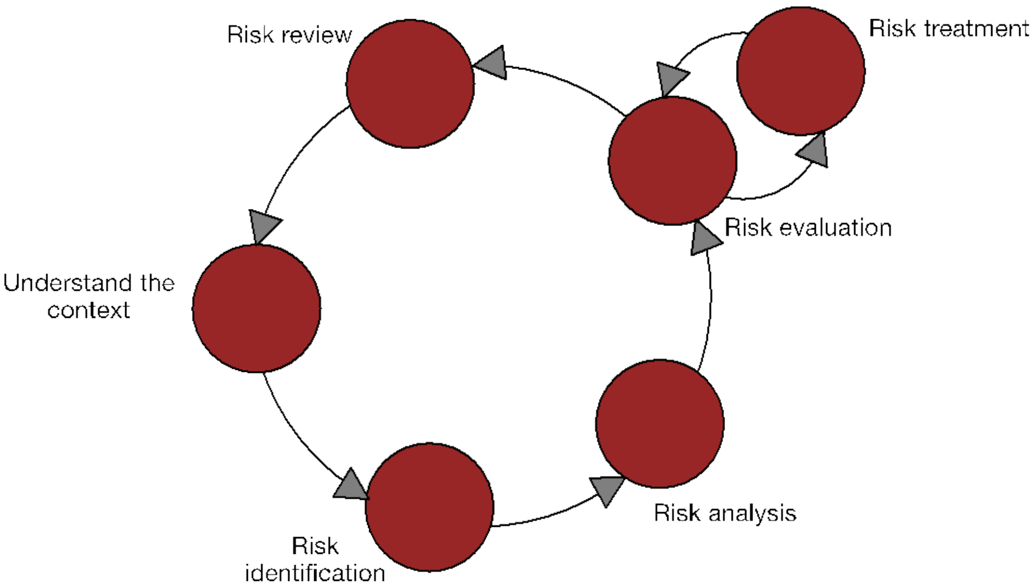


FIGURE 1: Risk Management as a Cycle

As with most management systems, MORE Risk Management is conceived as a cycle, shown below as an excerpt from the GICHD Issue Brief on Risk Management:

"It starts with analysis of the context, within which MORE is carried out, before identifying risks that may be present. Risk analysis is based upon quantifying, or otherwise assessing, the likelihood and consequence of the risk should it become reality. Once risks have been analysed they can be evaluated against risk criteria established at the MORE policy level (in essence to decide whether they matter or not). The results of the evaluation determine the need to treat risks, using a variety of potential controls, to ensure that they remain at a tolerable level. All risks are then reviewed at appropriate intervals to ensure that the MORE system remains relevant, effective and efficient."

Real vs Suspected Risk

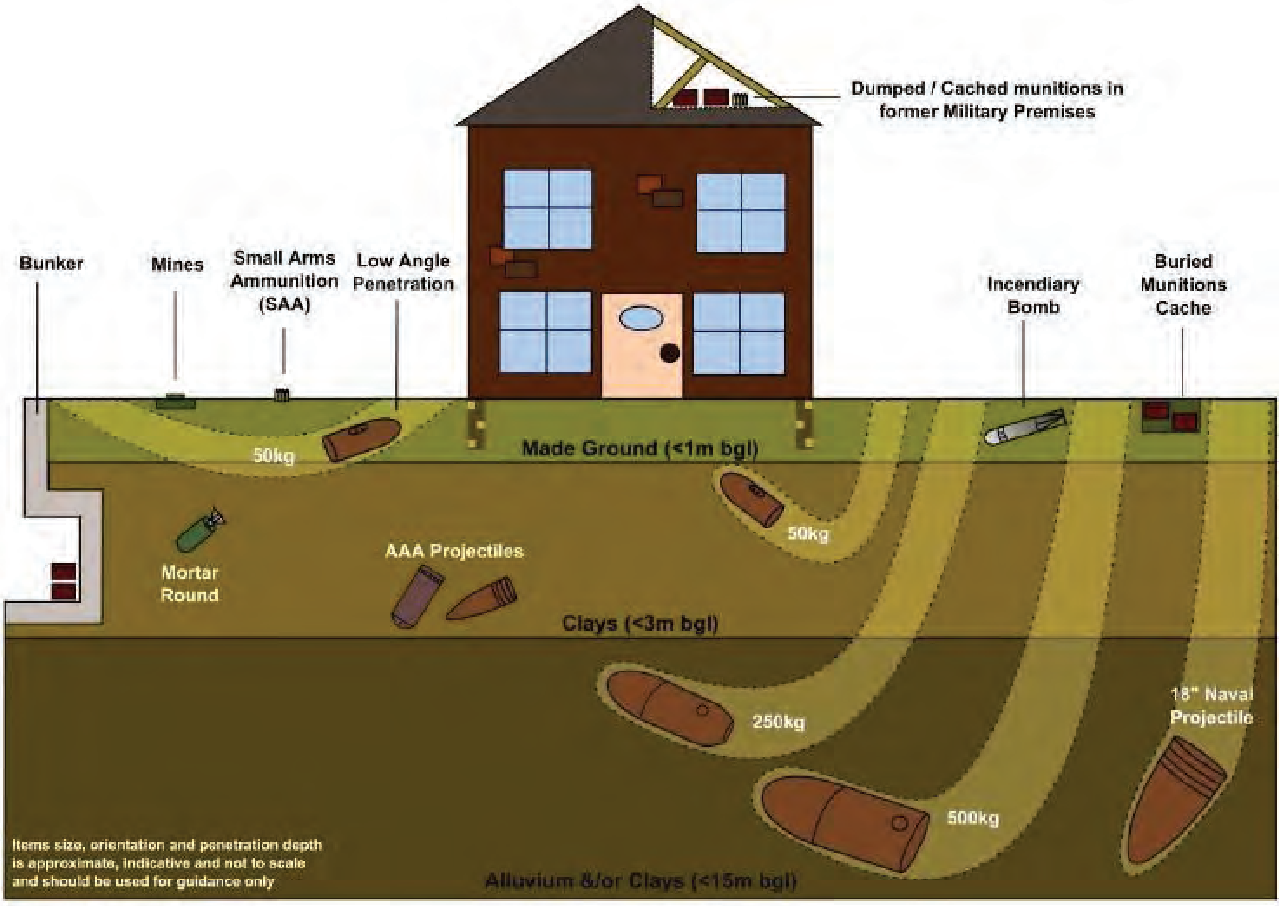
ERW risks actually exist only when three associated factors combine: ERW contamination must be present at a location where activity (capable of interacting with the contamination) is taking place, or will take place.

In the MORE risk diagram (left) a real risk only arises in the central red zone of the diagram. All three contributing factors need to be understood when identifying MORE risks.

Perception of risk may extend well outside the red zone. Mechanisms for addressing the different areas of perceived and potential risk are discussed below.

The **location** of possible ERW contamination must be understood in three dimensions, as opposed to the prevalently mapped "2D" maps of mine contamination. The history of the conflict (aerial bombardment, mechanized warfare, artillery barrage) can help indicate how deep

FIGURE 2: MORE Risk Diagram



Approximate depth of penetration for various UXO[2]

munitions might go. Geological considerations, including substrata of hard rock or gravel, can also affect "munition swim" and render search below a certain depth unnecessary.

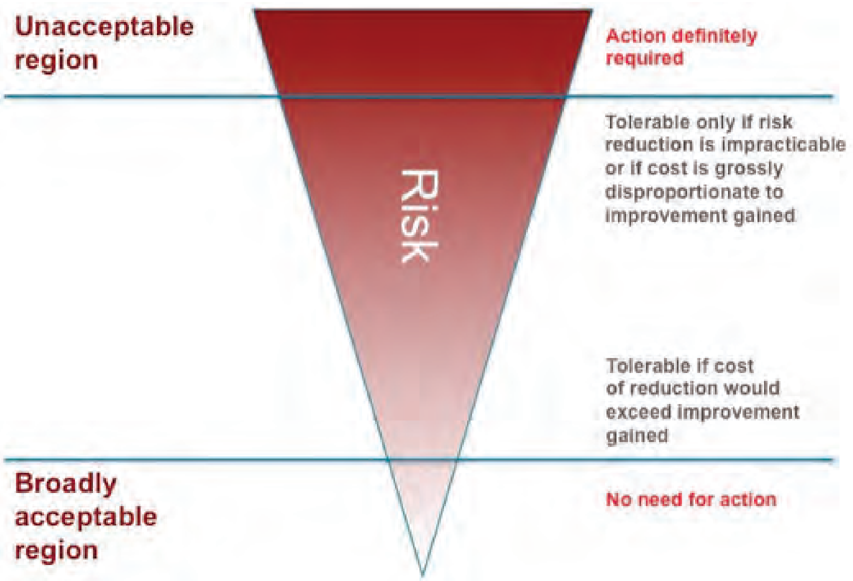
The type of **contamination** also weighs into risk management decisions. "An abandoned, unfuzed air dropped weapon is likely to present a lower risk than a fuzed and armed anti-personnel landmine, but over time a range of factors change the risk profile. After thirty years out in the open the landmine may have become non-functional as key components rust, seize up or become obstructed by the ingress of sand, plant roots or other debris. At the same time the abandoned air dropped weapon may have become a good deal more dangerous, especially if it contains other hazardous materials such as rocket propellants." (Source: GICHD IB Risk Management)

Finally, the type of **expected activity** factors into determining the overall level of risk. The cornerstone of good Land Release practice[4], the interaction of activity with munitions governs the level of risk. Land suitable for grazing need not be cleared of ERW to the same depth as land intended for laying deep foundations. In each instance, measures to assess and respond to risk are tailored to the intended land use.

3 https://www.linkedin.com/in/rory-o-brien-97b37141?authType=name&authToken=OtOf&trk=hp-feed-member-name

4 see GICHD's guide to Land Release, and an upcoming animation

ALARP



The concept of a risk being 'as low as reasonably practicable' (ALARP), has parallels with the principle of application of all reasonable effort found within concepts of land release in mine action. ALARP is often used as criteria in relation to ERW.

Risk is usually treated using one or more of the following options:

- **Avoiding the risk** – not starting an activity, or avoiding an area associated with the risk. A developer may choose not to proceed with development on an area contaminated with ERW. Government may restrict public access to areas suspected to contain ERW. Government may choose to make certain activities illegal (such as in Vietnam where the collection of ERW for scrap is forbidden).
- **Removing the risk source** – typically by clearing the ERW, although it is important to recognise that it may be possible to remove the risk source from one combination of location, contamination and activity, while leaving in place contamination that may present a risk to a different activity at some stage in the future – a MORE example might be the removal of shallow ERW to allow agricultural activity to take place, while accepting that deeper buried ordnance may remain in place, but would only present a risk if major civil engineering activities were to take place at some stage in the future.
- **Changing the likelihood** – adopt procedures or policies that make it less likely that ERW will be a problem. Improve desktop risk assessments and provide awareness training to plant operators for instance.
- **Changing the consequences** – by providing protection or by seeking to keep people away from areas of risk. The encroachment of civil population areas on old ammunition storage areas may represent an increase in the consequences of an unplanned explosion in a munition site (UEMS); moving the weapons to a more remote storage area, or implementing more rigorous housing controls may ensure that the consequences of an adverse event remain tolerable.
- **Sharing the risk** – the most widely used risk sharing mechanism is insurance, although it is also possible to share risk through contractual terms and risk financing. Government policy on residual liability (an important aspect of many mine action programmes) also provides an opportunity to detail how different parties within a MORE system share risk.
- **Retaining the risk** – in many cases it may be acceptable to accept the risk as it is and 'retain' it. Such an approach may be entirely valid, if it based on appropriate identification, analysis and evaluation of the risk, but it is important to ensure that risk review takes place at appropriate intervals so that any decision to retain a risk remains valid.

BOX 1: Extract on ALARP from GICHD Issue Brief: Risk Management and MORE

Long Term Solutions and the importance of Information Management

Using MORE as a system is most beneficial when looking at extended time horizons. It is only over the protracted time-scale of ERW response that a cyclical approach makes sense; otherwise simpler project implementation plan would be used.

Even after comprehensive clearance efforts, contamination has been shown to remain an ongoing problem even seventy years (Second World War) or one-hundred years (First World War) after a conflict ends. It is therefore important to keep the long term nature of the problem in mind, and ensure national policies support sustainable practice.

Perhaps the most important factor in dealing with long term problems is appropriate record-keeping. Information Management (IM) should not only record details that are of interest today, but also incorporate reporting for analysis in the future. Several key aspects of reporting are a useful addition to standard reporting in light of long time horizons: depth, condition of munition, and eventually munition viability.

Several studies have been conducted on Ageing of Munitions[5]. Munitions degradation is important to track as time progresses to be able to evaluate the evolving nature of risk. While many munitions become more stable over time, some do not. A good desktop survey can reveal where certain munitions where used during a conflict, perhaps indicating zones where munitions who degrade toward instability may be found. It may also generate zones where the likelihood of finding this unstable munition is low. Properly identifying these risks helps make sure that the response is tailored to the actual threat.

Varied Actors

In the context of MORE, many actors will play important roles. The individual actors involved may also vary over time. For example, demining conducting during and immediately post-conflict might be conducted by military units. The intent is to secure transportation routes, access critical infrastructure, and regain confidence from a distraught population. A more general post-conflict response to ERW contamination may be dominated by International Humanitarian NGOs. The focus of effort will be to relieve human suffering and save life and limb. With the progress of time, development projects may begin to usher in commercial companies to clear specific land for specific use. The entire country may also be served by a national capacity which responds to ERW finds when and as they occur. Common features of this capacity often include hotlines for reporting, mobile response teams, and central demolition centres. The exact constellation of these actors varies by country as well as over time.

Micro point of view

Like many countries, the unique history and nature of conflict in Angola has resulted in a particular profile of explosive contamination. Forty years of conflict, with involvement of many countries, brings a huge diversity of ERW risk to the country.

In last the last decades, an oil boom has brought a new moment in Angolan development. The real estate, energy and oil sectors are the dominant economic drivers in the country. With rapidly expanding development, especially in the above sectors, construction sites are increasingly entering into areas which contain SHA/CHA as well as areas with residual ERW risk.

[5] GICHD's Issue Brief on Ageing of Munitions, and the George Washington University / CISR / Fenix Insight study on Landmine ageing

"Line projects" like roads, pipelines, electrical power lines and seismic research pose great challenges to companies operating in the sector. Complex logistics engage with different risks and in different sectors. This complex array of variables poses a great challenge to companies and organizations trying to manage the risk of explosive contamination.

On this specific project, National Oil Company of Angola, conducted preliminary studies of a geological structure located to the south of the Kwanza (Onshore), in order to determine the oil potential in that field. The studies are initially based on a seismic survey of the region. Company has a task to enable safety of all personnel related to ERW. Maavarim Group has opened about 1,600 km' seismic lines in varied terrain (from savannah to dense vegetation and jungles) through highly cliffs, deep ravines and many rivers.

FIGURE 3: Map of Project Area

The terrain topographically and geographically varied, posing various engineering challenges. Further, the route crossed through various types of conflict zones, including mined areas, ground battles and skirmishes, and locations of air-dropped weapons. Treating the risks posed by these munitions needed to be tailored to the specific location and weapon type. It was not reasonable to search for deeply-buried large aircraft bombs along the entire route, for example.

Maavarim Group concluded that the management of residual ERW approach was a best-fit on this kind of project. This was due to several reasons:

1. Different risk on different part of the project
2. SHA/CHA existing on some part of the project
3. Client awareness about ERW problem, but lack of technical knowledge
4. Best cost/benefit result

In this case the process of risk management was conducted in line with guidance described under MORE, going through all the elements of the risk management cycle. Here, though, the focus is just on a more specific set of locations, risks and inputs.

Understanding the MORE context

Local circumstances in Angola are quit challenging for a company which is working for the first time in-country.

Legal and regulatory aspects are something that is quit demanding in Angola, but with time it is possible to gain an understanding and apply this in all phases of the project.

Financial and Economic aspects of the project are more specific on the case-study level. Contract price, budget and cost means it is relatively easy to determine all cost on the project. On the commercial project, finances are planned well in advance and are set. Using MORE allows for a realistic approach to addressing ERW risks while meeting financial constraints. In this instance, it was the only possible way for the development project, similar to other projects in energy or oil sector, to move forward.

Information aspects: on the power line project involves assessing and crossing a huge area. Knowing all risks individually is almost impossible. Non-Technical Survey (NTS), therefore, is very important for gathering information and adequately planning future activity. All information generated in the course of the project will over become an integral part of CNIDA database, and can be used to inform future projects after this one is done.

Capacities and capabilities: Company relocate significant asset for this project. From survey teams, manual demining till mechanical team with armored bagger and demining machines.

Identifying ERW risks

The risks posed by ERW in Angola are quite significant, meaning that it is very hard to determine all risks on the project from the early beginning. Applying NTS from the early beginning of the project together with ongoing review and analysis lead us to the successful end of this project.

FIGURE 4 AND 5: Examples of mine and ERW contamination in Angola

All three of the MORE ERW risk factors combine on this project: Locations was exactly defined by the project scope, including the area and depth required for assessment. Not all locations required assessments to the same depth, thereby enabling significant cost savings. The entire spectrum of Angolan explosive contamination was present, from mined SHA/CHA in some areas to residual ERW risk on other parts.

Analysing ERW risks

Analysing ERW risks was a very important part on this project. It was impossible to define one standard risk assessment for the whole project. The assessment was broken down by the length of the project, with depth determined by intended land use. Additionally, the management team performed analysis day by day with new information's coming from the field. This continual feed-back loop enabled the project to proceed with risks being addressed by the most appropriate method.

The matrix method was a more basic method for assessing risk, which was used initially. Additionally, all information was augmented by statistical analysis of historical data and Structured What If Techniques, giving the possibility of using the most appropriate method for treating the risks.


FIGURE 6 AND 7: Examples of Anti Vehicle mine accidents

Evaluating ERW risks

Risk evaluation is the process of deciding which risks require treatment and to prioritise treatment action. Risk evaluation involves the comparison of the results of risk analysis with risk criteria identified as part of the context analysis.

This project contained several criteria, varying from conditions required to begin developing the area, to the most important one of keeping people safe.

Because the specificity of area these criteria were very demanding. With set deadlines and a defined budget, it was important to choose the appropriate tools and methods in order to keep people safe.

Applying ALARP method was for us totally reasonable solutions, but for Client that was not initially understandable. In most cases the client makes generalized demands/requirements. Usually this is voiced in the form of a requiring a "contamination free guarantee," or other assurances that guarantee both safety and project completion.

Through the course of the project we were able to convince the Client that the ALARP method is not only the best possible risk-mitigation technique on this type of the project, it also forms a basic tenet of Risk Management in general. Approaches requiring complete survey and clearance of the entire area would not be possible from a cost/benefit perspective.

Treating ERW risks

Our fundamental suggestion was avoiding the risk where possible. This was done by including the possibility of re-planning or re-designing the project in order to avoid risks. The primary method of redesign was either rerouting the planned power line path, or adjusting the locations of planned support structures to an area of decreased risk.

Removing the risk source this was also a very common way on the area where information confirmed the presence or risks from mines and ERW. A wide array of equipment was used, from mine detectors, UPEX® 740 M Large Loop metal locator (LLD), ground probes, and even remotely piloted aircraft systems (RPAS). Not each tool was used for each job, for example ground penetrating radar or probes were not used to clear confirmed mine fields. Nor were metal detectors used to clear the areas around pylons.

Another method – changing the likelihood of a negative event – was employed through the entire project. For example, workers and engineers were educated about ERW risks, and informed about how to report ERW finds. Adopting appropriate procedures, from SOPs to general management, was another method. These procedures were also periodically evaluated to make sure they were still fit-for-purpose.

Changing the consequences of an event was employed on the project by wearing appropriate Personal Protective Equipment, when necessary. Another example is moving all non-essential personnel from an area where munitions were being cleared. Specific to this project was its great length (over 1600 km) but relatively narrow width (just 60m).

FIGURE 8 AND 9: Treating ERW risk on the project

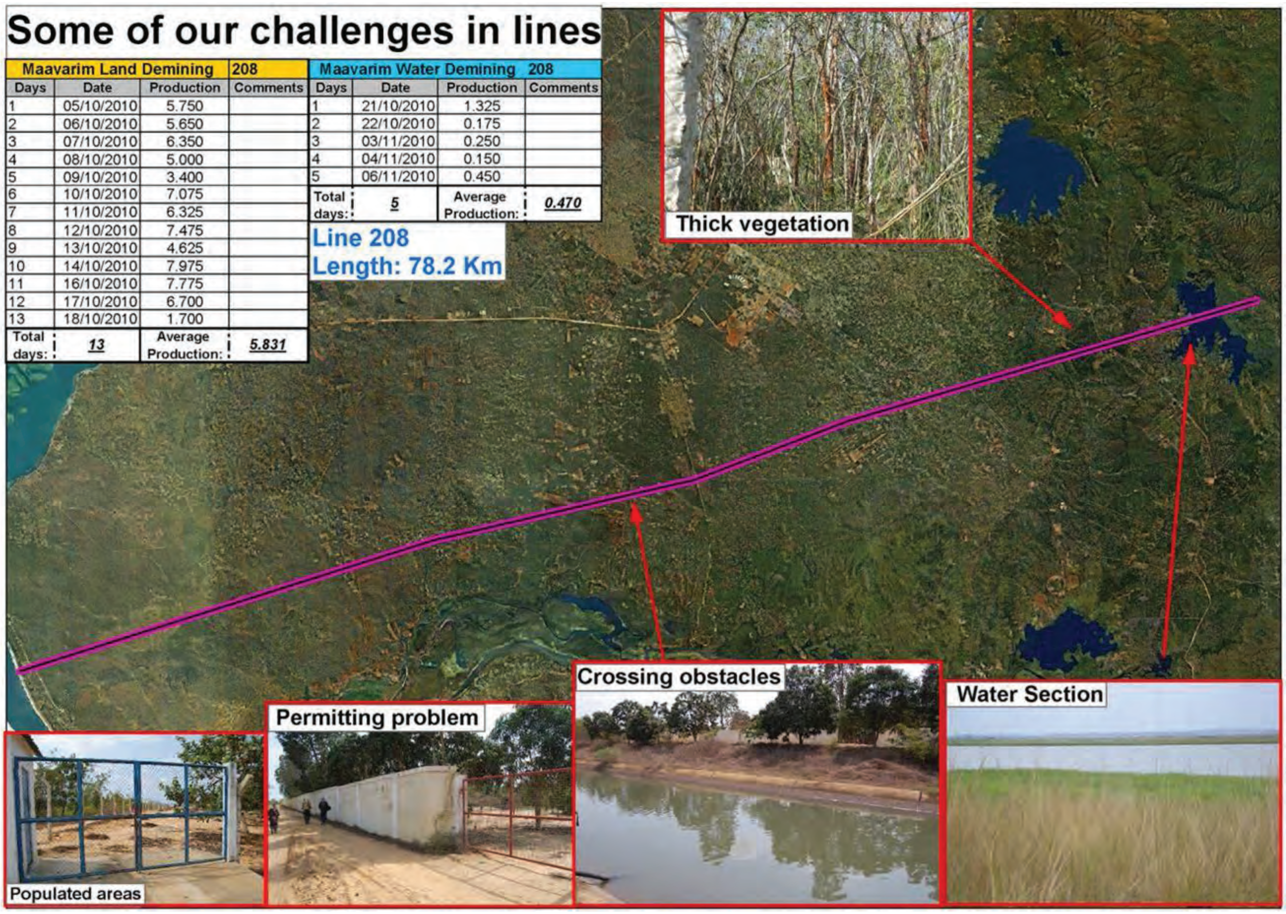


FIGURE 10: Challenges encountered during the project

Risk Review

After finishing the project, the company performed several internal evaluations in order to update existing procedures to incorporate all what we learned on this project. As a result we now put more focus on information management and GIS on all spheres of project. This change helps provide a totally new perspective of decision making and project management.

Conclusion

This project gives us possibly to apply really whole cycle of Management of Residual ERW. The 1600 km project was very demanding. The main challenge proved to be how to best define risk for every small location and then how to treat that risk in the most efficient way.

Targeted Technical Investigation of Suspected Mined Areas

Colonel Refik Fazlić[1]

Introduction

Fulfillment of obligations under the Convention on the prohibition of the use landmines; increase of work efficiency and demands for increase of timesaving sets new challenges for development of con-termine actions. This is especially manifested in the domain of land release of areas contaminated by mines, cluster munition and other explosive reminets of war. There is a need to improve the classic and introduce new methods and techniques for the land release and, at the same time, ensure their standardization at the international and national level.

Considering the size and characteristics of the mine problem, efficiency of methods and techniques in mine action applied in BiH so far, it is evident that there is a need for a change in the approach. This change involves the application of the concept of Land Release according to the International Mine Action Standards (IMAS), through the inclusion of targeted technical survey as a lacking method in the process of land release applied in BiH.

Through International Standards for Humanitarian Demining IMAS 2009, Land Release has been introduced as a new approach to the resolution of a mine problem.

Land Release is a process of applaying all resonable effort to identify and remove any presence and suspicion on the presence of mines through non- technical survey, technical survey and land-clear-ance.

Terms and definitions

Suspected Mine Hazardous Area is an area consisting of suspected hazardous areas and confirmed hazardous areas of one or more mine-affected communities (included in the whole or in part), which is selected to be treated through the process of Land Release as one logical unity.

Technical survey

Technical survey is a process of collecting and analyzing data about the presence, type and arrange-ment of mines, using appropriate technical methods, in order to determine more clearly where the mine contamination is present and where it is not. Technical survey is implemented through targeted and/or systematic survey.

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Targeted investigation

Targeted investigations is an activity of investigating signs of mine contamination based on the confirmed local evidence of the presence of mines in SHA and CHA using technical methods.

Systematic investigation

Systematic investigation is an activity of pursuing signs of mine contamination based on unspecified local evidence of the presence of mines in SHA/CHA, using technical methods.

Direct evidence of mine presence

Direct evidence of mines is such an evidence which are positively pointing to the existence of certain mines in the areas to which they relate.

Indirect evidence of the mine presence

Indirect evidence of the presence of mines are such an evidence which are unconclusively syptomatic of the presence of mines in the areas to which they relate.

Note: From the standpoint of the certainty of finding evidence of mine presecne to which evidence of their potential existence in the area are pinpointing to, they can be divided into direct and indirect evidence. This division on direct and indirect evidence has one sole purpose, which is – a classificacion of mine suspected areas as SHA (direct evidence) and CHA (indirect evidence).

Cancelled area

Cancelled area (m^2) is a defined area for which it has been concluded that it does not contain evidence of mine/ERW contamination after the implementation of non-technical survey of a suspected and/or confirmed hazardous area.

Note: It pertains to those areas for which it has been determined that they do not contain mines, but which has not been treated by techical methods, which does not mean that for a conclusion stating this area does not contain any mines information from contiguous techicaly surveyed or cleared areas have not been used. Those areas which have been previously declared as areas without confirmed risk shall be treated as cancelled areas.

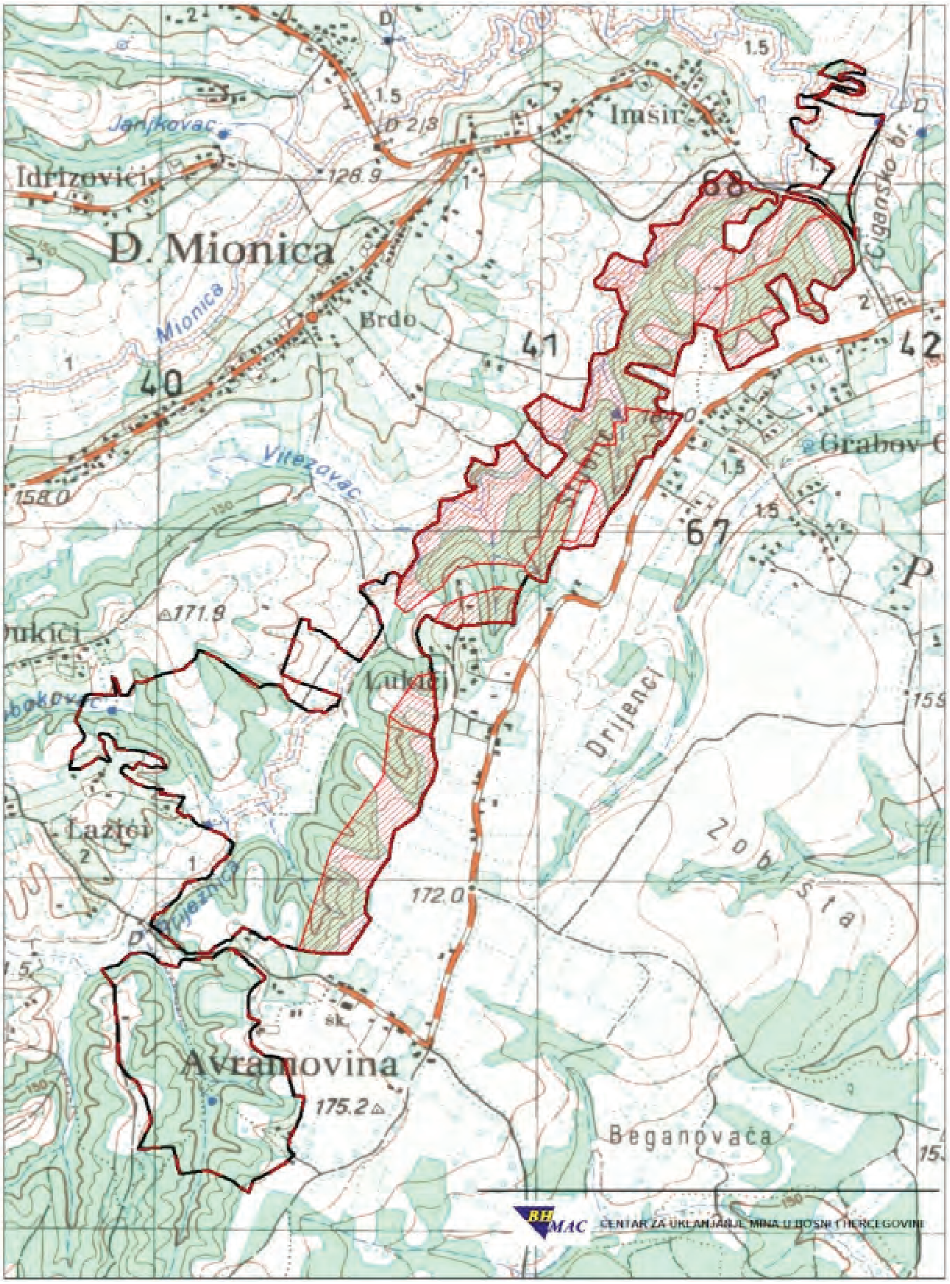
Reduced land

Reduced land (m^2) is a defined area for which it has been concluded that it does not contain evidence of mine/ERW contamination after the implementation of non-technical survey of a suspected and/or confirmed hazardous area.

Note: Those areas which have been previously treated through technical survey, as well as areas determined as those without confirmed risk through targeted investigation shall be treated as reduced land.

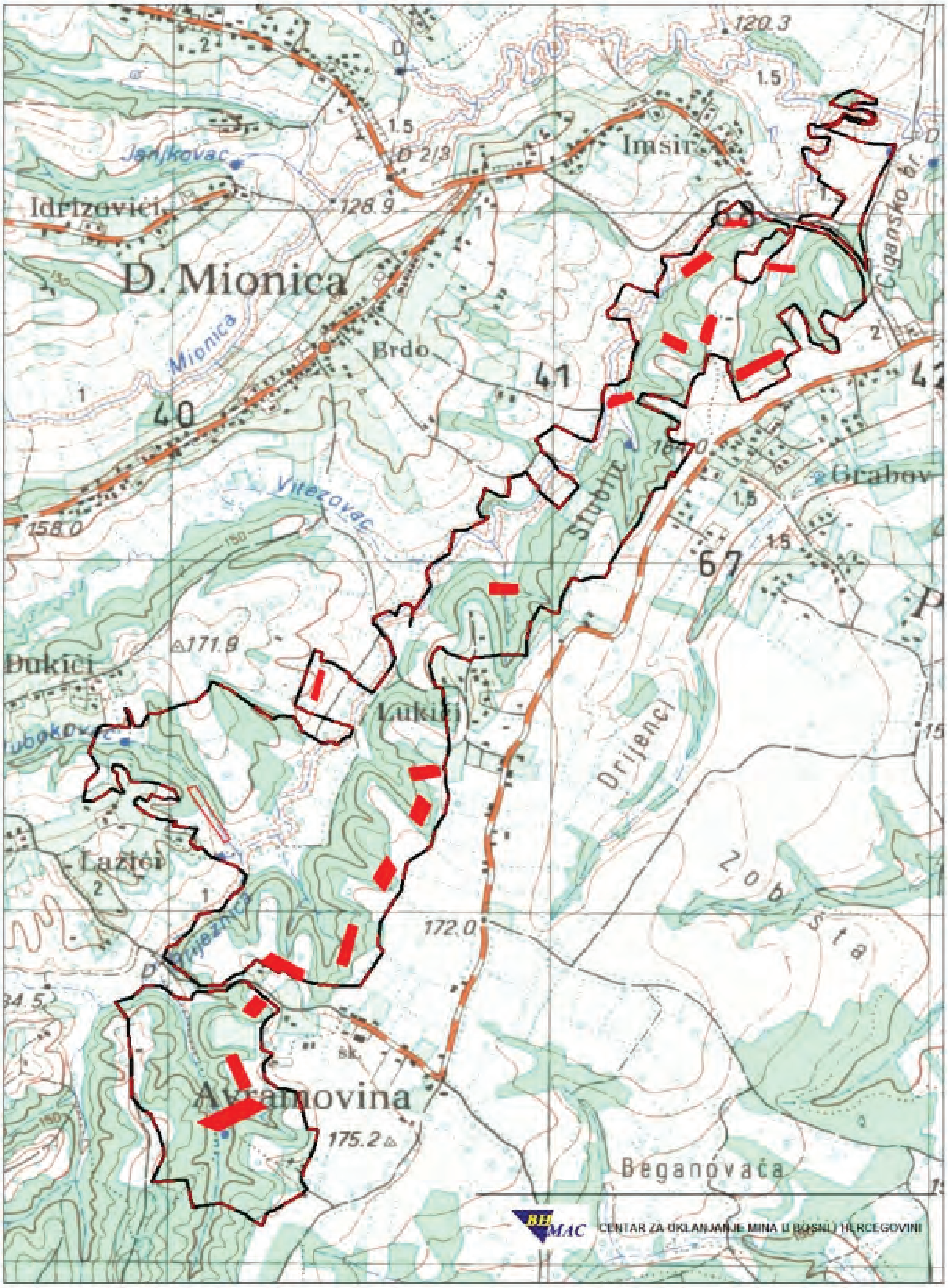
Comparison of the classical and the Land Release approach in the resolution of a mine problem

Classical approach



Total area of **1,31 m²** will be released after **19.975 m²** of clearance and **30.090 m²** of clearance throug working lanes in a targeted and systematic survey.

Land Release



Total area of **1,31 km²** would be treated through projects of mine clearance and technical survey.

Technical survey aims, through technical methods and procedues on the field, to locate evidence of mine/ERW contamination, to determine boundries of a mined are, if it exists, or to eliminate any doubt about the presence of the mines in the area to which these evidence pertains.

In tehchical survey three methods can be applied, which are: manual mathod, manual method with mechanical ground preparation and manual method along with the use of DDTs.

Techical survey is conducted through targeted and systematic investigation.

The Changing Risks Facing Deminers – Field Experiences

Ashley Williams[1]

Introduction

1. Traditionally humanitarian demining has been seen as a noble and altruistic task, respected by most governments, rival groups and the population at large. Demining under the auspices of the United Nations almost gave demining operations an immunity against any aggressive interference from any source. The biggest risk facing deminers was actual operational accidents and incidents which could mainly be ascribed to the non-adherence to SOPs, NTSGs and other safety guidelines. However over the past 6 to 7 years this scenario has drastically changed and demining operations face many new risks and threats, mostly totally unrelated to the actual task of demining.

2. Most of you present here will be able to attest that most casualties over the years where a direct result of safety regulations being transgressed, either negligently or purely by accident. From our own experience in Mechem we have been fortunate to have last had someone fatally injured in a work-related incident in 1998. In this incident, which happened here in Croatia, a Dog Handler was killed when his dog accidentally activated a POM-Z tripwire mine. I would like to think that this was really a tragic accident and something that no-one could have foreseen and thus prevented.

3. On the other end of the scale I can mention an incident in 2007 when an International Team Leader removed the mechanism from a Type 72 mine and the detonator of the mechanism exploded in his hand, resulting in the loss of the tip of a finger. Another incident occurred in 2014 when a Local Libyan Deminer entered an uncleared area during a lunch break and picked up a detonator which went off in his hand, also resulting in the loss of a fingertip. Both these incidents are examples of gross negligence and the transgression of the most basic and standard safety regulations.

4. Those of us who have been working on United Nations projects will recall how up until approximately 2010 one almost had immunity against any form of aggression. The so-called “blue helmet” gave one a sense of safety and as a South African company, we at Mechem still had the “Mandela factor” on our side as well. Working on the ring road in Afghanistan from 2003 to 2005 I remember our teams on the road staying in temporary tented camps along the road. Once one of our teams pitched camp next to a police station, just to discover the next morning that the police station had been attacked by the Taliban during the night. We presumed that the United Nations and South African flags ensured our safety.

The new risks

5. Today, new equipment, better procedures and stricter adherence to safety SOPs and NTSGs, has reduced the number of accidents amongst deminers to a minimum. However the nature of intra-state

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wars and asymmetrical warfare have created a new and even greater threat to deminers across the globe. While demining safety related incidents are within the demining organization's ability to eliminate, or at least reduce, these new threats facing them are not really within their ability to eliminate or even reduce.

6. A number of field experiences will be used as examples of what demining organizations are presently experiencing as risks and threats. This is not intended to be an exhaustive list, but rather just examples to stimulate discussion and possibly assist in formulating mitigations.

7. A very real threat facing demining institutions in countries with intra-state conflicts, is the laying of new landmines. In 2011 South Sudan gained independence from Sudan and became the world's newest state. However since that date there has been numerous ongoing conflicts between various groupings and very little peace. This has inevitably led to especially roads that were cleared many years ago, being re-mined. Of course in such an eventuality the demining organization originally responsible for the clearance of that road or route is immediately placed in the dock as the accused. Fortunately good record keeping can assist one in proving which methods and tools were used for the clearance as well as the exact boundaries of the areas cleared. A proper investigation and analysis of the mines or craters found will also assist in proving that the mines were newly laid.

8. Mechem has been the victim of asymmetrical warfare in countries such as Somalia where extremist groups are constantly trying to topple the government and international forces. One such incident occurred on 19 June 2013 when the UNDP Compound in Mogadishu was attacked first by a vehicle borne IED which blew open the gate to the compound and then 6 Al Shabaab fighters who managed to kill 3 Mechem employees, 2 International and one Local, before being neutralized by the AMISOM forces. This was the worst loss Mechem has ever had in our 56 year history. Similarly 2 of our Local Somali's were killed on 26 July 2015 in the Al Shabaab attack on the Jazeera Hotel in Mogadishu. The two members were on their way home on their motorcycle when a truck borne IED detonated right next to them, killing them instantly. In both these cases the Mechem members were not the intended targets, only in the wrong place at the wrong time.

9. In late June 2012 one of the Mechem teams operating out of Bentui, near the border between South Sudan and Sudan, was tasked to clear a road north-east of Bentui so as to afford the UNHCR safe passage to the refugee camp at Yida close to the border. On 28 June 2012 the UN Operations Manager for the area indicated that he and member from a NGO who had accompanied him, wanted to return to Bentui earlier. Mechem was instructed to send one of the support CASSPIRS not directly involved in operations back to Bentui with the UN Land Cruiser. With the CASSPIR we sent an International Driver/Mechanic and a Local Deminer. Under command of the UN member this small convey then left for Bentui using a route that had not been cleared by the UN Security, but was deemed to be in a better condition and thus faster. Fortunately the Mechem Team Leader on the ground informed the UN Base in Bentui that the 2 vehicles were on their way back. When the members had not arrived back at Bentui by late afternoon, the alarm was raised and it was discovered that a group calling themselves the SPLA-North had captured the 4 members and taken them across the border to Heglig from where they were flown to Khartoum and paraded as rebels who had illegally crossed the border. A tense 3 weeks followed and only after intervention by the South African Government, the members were released. With the African borders being so porous, it is still unsure whether the members were captured in South Sudan or Sudan. Obviously the senior UN Manager reckons they were still well within South Sudan, whilst the Government of Sudan reckon they had transgressed the border and were captured within Sudan. Two of the important lessons learnt here are firstly that when working in dangerous areas one should adhere to the safety and security advice supplied by organizations such as UNDSS and secondly one should always ensure that the operations room at one's destination has a good idea of your expected time of arrival.

10. While the above is an example of kidnapping in a mix between an intra- and inter-state conflict, there are other examples of kidnapping for purely criminal as well as political purposes. In May 2013 Mechem had 12 local deminers, 3 women and 9 men, kidnapped in Senegal by members of the FDC, a rebel group operating out of Guinea Bissau and Gambia. The main aim of the FDC is obtaining independence for the Cassamance Province (between Gambia and Guinea Bissau) and the kidnapping was done to try and force the Government into negotiations with them. The kidnaped deminers were all locals out of the Cassamance Province and were well treated by their captors during the one (women) and 2 month (men) periods they were in captivity. The kidnappers made it clear that they had no problems or fights with either Mechem or the kidnapped members and allowed us to regularly take in food and fresh clothes for the captives. This incident all but halted the demining program in Senegal as well as a number of development programs in the Cassamance Province. Unfortunately a demining company does not have the authority to force a government into talks with a rebel group, but one should make a good study of the socio-political circumstances in the country one is operating in.

11. In an act of pure criminality Mechem had 3 members, one International and 2 Locals, kidnapped in Eastern DRC during May 2015. The kidnappers demanded a ransom and were constantly in communication with both Mechem and the UN under whose auspices we were working. Whilst the UN requested that no ransom be paid as it could set a very difficult president, the organization also withdrew at a certain stage stating that since we were contractors it was our problem to sort out. Fortunately the men were released after a week, badly beaten up, but alive. While most companies do have some form of insurance against ransom demands, it will really open the flood gates internationally if just one company gives in to the criminals and decides to pay. It was also quite a shock being told by the UN that we were suddenly on our own in an African country thousands of kilometers away from home and with very weak and sometimes corrupt police and judicial systems.

12. In Libya all contractors were contractually forced to fit tracking devices to their vehicles. However when our Local driver was robbed of a Land Cruiser a very interesting scenario played itself out. With the tracking device we could fairly easily track down the vehicle's location as well as initially shut down the engine. However when we took both the Police Chief as well as a senior Army Officer to the location where we could see the vehicle standing, they both refused to take any action. Apparently the compound where the vehicle was taken to, belonged to a notorious warlord and neither the Police nor Army were prepared to confront him. Fortunately our insurance was prepared to pay us out for the vehicle.

13. Unfortunately when one does demining in countries coming out of many years of conflict there is often no functioning banking system in place. This leads to demining companies having to transport and hold large sums of money at their local head offices. It seems as if criminal elements, often with insider information, are now starting to target demining companies so as to get their hands onto large sums of cash. December 2015 was an exceptionally active period and Mechem had an attempted break in on our head office in the DRC which was successfully thwarted, but our office in Nairobi as well as the offices of two other demining companies in Juba, South Sudan, were robbed of huge sums of cash. In one instance in Juba, the perpetrators held the guards at gunpoint and fled with the whole safe! While all of us learnt some lessons out of these incidents and continually try to see where we can do electronic banking, the sad reality remains that the deminers in most African countries still want their salaries in hard cash.

14. Arguably the greatest threat facing demining organizations in post-conflict and developing countries today is road accidents. Minefields and UXOs are usually found in areas with little to no infrastructure making road and route movement very difficult and dangerous, especially in the rainy season. The other side of the coin is also true, namely that with successful landmine and UXO clearance

new roads are often built, presenting their own set of problems with high speeds and irresponsible driving. In most African countries the "law of the jungle" exists on the roads and many people tragically die each year as result of road traffic accidents. Over the years we have learnt that it is the best to always appoint local drivers, no matter how recklessly they drive, since in any accident involving an expatriate, the expatriate is always wrong and large sums of money are always required to make the incident "go away". With the local driving skills, road and vehicle conditions, it is just a wonder that demining companies do not lose more people due to road accidents.

15. In Africa Tropical Diseases such as malaria remain a real threat. Even though there are prophylaxes available for malaria, it remains almost impossible to ensure that members actually use them, especially once at home for leave or at the termination of the contract. During 2003 Mechem had 2 members pass away from cerebral malaria while on vacation leave. Registers kept by the medical staff to ensure the members are given the necessary prophylaxes remains the only way one can have a measure of control.

Summary

16. Landmine and UXO clearance in itself is a difficult and thankless task thwart with danger. However in many post-conflict areas there are today many other risks that demining organizations have to take into consideration. Unfortunately the world has also changed and humanitarian and aid workers are today seen as legitimate targets by both rebel groups and criminals.

17. The few examples given above are by no means exhaustive and mainly just a few of the examples drawn from actual events experienced by Mechem over the past few years. Hopefully this short paper will lead to the sharing of experiences between demining and other humanitarian organizations and the finding of mitigations to reduce the risks faced by our employees.

Commercial Landmine Clearance: Management of Quality, Finance and Risk

Colonel (Retired) Stewart Grainger[1]

Colonel Grainger trained as a Civil Engineer and served a full career in the Royal Engineers. Since then he has led a landmine research project in the United Kingdom and humanitarian landmine clearance contracts in the Kuwait, Mozambique and Lebanon. When not working in the field he has participated in research projects for NATO, the EU and BACTEC International Limited.

Summary

Colonel Grainger relates how, as a technical adviser to the Emirates, he put in place processes to manage contracts in South Lebanon. Subtle and routine measures secured the investment of the Donor and met his wishes to standard and cost.

Background

On the withdrawal of the Israeli military from South Lebanon in 2000 the Emirates wished to help their Muslim "brothers" get back to normality by clearing the minefields and remnants of war. They set-up a Memorandum of Understanding (MOU) with the Government of Lebanon and promised 50million US$ to fund the clearances. The MOU gave deminers the right to enter and work in Lebanon without paying custom's dues and local taxes. The Emirates appointed a Project Director, a Colonel in Emirates Military Engineers. Colonel Stewart was engaged as the landmine clearance technical consultant.

In the briefing in Abu Dhabi in 2001 the Donor relayed three objectives:

a. The safe and timely return of contaminated land to the people of Southern Lebanon.

b. Best Practice demining to International Mine Action Standards (IMAS).

c. Value for Aid.

The Emirates negotiated arrangements with UNMAS to reinforce the Mine Action Centre South Lebanon (MACC SL) with staff to coordinate demining with other agencies and to supervise Quality Assurance procedures and checks. Support was concentrated to the South of the River Litani. The employment of local people was encouraged as was the local purchase of food and fuel. A bid for funds to build an Office in Beirut was declined.

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The Challenge

The task was massive, and of a scale beyond our experience. It involved the clearance of the land from the Mediterranean, along the borders of Israel and Syria and South of the River Litani, some 460 square kilometres on the map. The UN has been present along the Lebanese/Israeli border since WWII and more recently with the United Nations Interim Force in Lebanon (UNIFIL) that was supported by the MACC SL. There were numerous minefields around former Israeli positions, protective minefields, and remnants of war wherever actions took place and where shells and bombs fell. The minefields mainly comprised anti-personnel mines, Israeli No 4 AP. This meant that the mines were shallowed laid and readily detected by commercially available detectors. It was known that booby traps were used but many had been removed by local terrorists. Villages and farms free of hazards were occupied and most roads and tracks were safe and passable. Obstacle maps were available through the Information Management System for Mine Action (IMSMA) of the National Mine Action Office. Known minefields and hazards were fenced and marked.

The Contracts

An early task was to decide how to set-up contracts for the clearance of such a large area. Fortunately the Lebanese Officer in the MACC SL, Major (now Brigadier General) Kassem Jammoul, was an engineer and had worked in the area. With his knowledge of the land four areas were defined on the map. They became known as Operation Emirates Solidarity Areas 1to 4. IMSMA had records of the contamination but they were by no means 100% accurate or complete. They were a good starting point.

Tight contracts were sought to protect the Donor from disputes about the clearance work done for which payment would be due. Contracts could not be tied solely to the IMSMA data because of its incompleteness. In order to cover all eventualities it was decided to solicit bids for all the work involving:

Known Minefields: The minefields, booby traps and UXO recorded in IMSMA as at 28 February 2002.

Encountered Minefields: The minefields, booby traps and UXO encountered by the Contractors during their demining work in their Contract Areas.

Reported Minefields: The minefields, booby traps and UXO reported to the MACC SL and the Contractors by the local population during the period of the Contractors' demining operations in their Contract Areas.

Some 31 internationally renowned demining agencies expressed their interest in the clearance. The contenders were scrutinised against the following criteria:

Knowledge and expertise in working to IMAS,

Recent UN demining accreditations,

Capabilities with manual, mechanical and mine detection dog teams,

Proven capability to plan and execute contracts with mixed demining assets.

10 companies were selected to bid and to attend a briefed in Tyre:

BACTEC International Limited	UK
EMERCOM DEMINING	Soviet Union

European Landmine Solutions	UK
Frontier Works Organisation	Pakistan
MECHEM Consultants	South Africa
MINETECH International Limited	UK/Zimbabwe
National Demining Company	Jordan
RONCO	USA
SOGELMA	Italy
UKROBORONSERVICE	Ukraine

After the briefing the areas were toured with the guidance of the MACC SL and the information provided from IMSMA.

The ten bids delivered were technically assessed in the presence of the Director of MAC SL and 4 contractors were summoned to Abu Dhabi for financial negotiations with the Emirates Officers. The result was that BACTEC International won Areas 1 & 2 and MINETECH International Limited Areas 3 & 4.

Quality

The Contractors were engaged to clear geographical areas defined on maps and as described in the Briefing. Boundaries were the centreline of well-defined roads and tracks. Contractors were responsible for all the demining in their contracted areas until the whole area was certified by MACC SL as cleared to IMAS and Technical and Safety Guidelines (TSG) Lebanon.

A QA failure of an area was defined as when the QA Manager of MACC SL, after inspection of the area, reported it as "NOT Satisfactory". Failed areas had to be re-cleared and QA inspected.

Finance

The Contracts were at a Fixed Price and for a maximum term of 2 years.

A Performance Bond of 5% was arranged and payable on 1 May 2004 or 90 days after the handover of the Area as accepted by MACC SL, whichever was the earliest.

On contract award an "Advance" payment of 25% was paid plus a 10% mobilisation fee. The balance was paid in equal monthly amounts.

Risk

CONTRACT TASKS. The situation of incomplete hazard information meant that disputes could arise about the extent of clearance to be completed in the contract area over the period of the contract. The solution was to define the contract areas and including requirements to deal with encountered and reported munitions and suspect areas. The bid price for the work reflected the survey and clearance expertise of the bidder.

QUALITY. This was contracted to MACC SL. United Nations Mine Action Service (UNMAS) sponsored and staffed the Centre giving it world class status. The coordination of work and the inspection of completed tasks were conducted in a thorough and professional manner by international staff.

FINANCE. The Donor's investment of the Advance and Mobilisation were at risk but suitably covered in the screening of bidders with the required expertise and experience. The contenders had their reputations to maintain that help them secure future demining contracts. Again, monthly payments might be at risk but the contracted "Fixed Time" would secure continued progress and effort. As much of the land to be cleared was arable, the period of the contracts and the time limitation of the Performance Bond was considered to cover the time when famers getting back onto their land might encounter missed hazards.

Donor's Objectives

Both, BACTEC's and MINE-TECH's contracts were completed to time and quality in 20 months. The clearances dealt with:

Minefields	Booby Traps	Area m^2	UXO	AP	AT
265	**67**	**4,315,130**	**3,261**	**34,862**	**1,533**

The reported landmine victims were:

LANDMINE VICTIMS IN LEBANON		
Year	**Mortalities**	**Total Number of Victims**
2000	12	101
2001	14	90
2002	4	42
2003[1]	2	15

(Source: Landmine Resource Center, Balamand University, Lebanon)
(**Note: 1.** Total figures for 2003, up to and including September.)

The figures in the table cover the whole of Lebanon, a far greater area than the contract areas to the South.

These results suggest that:

- Land was returned to the people in South Lebanon as quickly as resources permitted.
- Best practice was achieved through the work of MACC SL.
- True measurable value was given for the Donor's Aid.

Conclusions

This Paper has outlined the processes used to control Quality, Finance and Risk in the contracts of Operation Emirates Solidarity Phases 1 & 2. Many of the processes were standard in the demining business but special arrangements were demanded to protect the Donor in such a large undertaking and with no Technical Survey results to define the contamination for clearance. The boundaries of the contract areas defined the extent of each contract. The contracts ensured that the clearance of the known contaminations were covered with any new hazards encountered or reported were the responsibility of the contractor. The work of MACC SL secured the best quality standards and the financial risks were mitigated by simple controls and the expertise and reputations of the successful contractors.

FIGURE 1: Operation Emirate Solidarity area.

FIGURES 2: Typical fenced minefield with evidence of detonated AP mines

FIGURE 4: Rock booby trap

FIGURE 5: Job Done

Benefits and advantages of using modern mobile technologies for field data collection in mine action

***Torsten Vikström**, Stefan Kallin*[1]

ABSTRACT: Mines and unexploded ordnance all over the world are still taking its toll as lifelong suffering or death. It strikes blindly and effects innocent civilians. The European Union has, by the Project TIRAMISU, taken on the task to boost clearing of the deadly legacy left in countries plagued by war. One effective and safe solution is the TIRAMISU Information Management System, T-IMS.

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

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

T-IMS combines easy-to-use computer software with the use of standards for information storage, data exchange and increased interoperability. By following and adapting to widely accepted and used standards, 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 has been operationally validated by CTDT and CROMAC.

Introduction

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

M. Bold – GICHD

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Technology Development

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

Mine action would benefit immensely allowing it to shift away from the traditional hierarchical command and control structures and hence opening up for horizontal networks and co-operative teams. Consequently, this would enhance the ability in decision-making, monitoring and evaluation in parallel with continuous improvement. In consequence, this will increase efficiency but at the same time will also provide scope for growing transparency along with the national capability to bridge mine action with human security.

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

The importance of standards

By combining easy-to-use computer software with the use of standards for information storage, data exchange etc. increased interoperability is enabled. By following and adapting to widely accepted and used standards, for instance standards developed and maintained by the Open Geospatial Consortium (OGC), the Geneva International Centre for Humanitarian Demining (GICHD) and the International Mine Action Standards (IMAS), we 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.

Advantages of using mobile technology in the field

Still as of today a lot of the information collected in the field by surveyors and deminers is captured by hand with the use of pen & paper, separate GPS-units and hand drawn maps over the current area and situation. Over time, this is a very time and effort consuming way – often combined with high risk – to collect sensitive information. Information that often need to be passed several steps by hand to finally end up in an IM-system, where it is consolidated and make basis for new and improved manual maps to be drawn.

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

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

T-IMS – TIRAMISU Information Management System

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

With T-IMS' intuitive search engine, findings such as UXOs or landmines will easily be identified and can likewise be positioned with high accuracy in the map. T-IMS is optionally equipped with off-line CORD (Collaborative ORDnance data repository) which is a result of the cooperation with the James Madison University – JMU). This database consists of approx. 5 000 ordnance objects.

Any type of attachment – such as geo-referenced photos, voice recordings, videos, images and documents – may be attached to any activity.

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

More information about T-IMS is available at the [Spinator] T-IMS booth. T-IMS also will be a part of the field demonstrations Thursday April 28th.

The TIRAMISU project

The European Union has, by the Project TIRAMISU, taken on the task to boost clearing of the deadly legacy left in countries plagued by war. The project, funded by the European Union's Seventh Framework Program (FP7), aimed to provide the Mine Action community with a global toolbox to assist in addressing the many issues related to Humanitarian Demining, thus promoting peace, national and regional security, conflict prevention, social and economic rehabilitation and post-conflict reconstruction. This toolbox cover the main mine action activities, from the survey of large areas to the actual disposal of explosive hazards, including mine risk education. To reach the level of expertise needed the TIRAMISU team included organizations that were involved in some of the most important European and international research projects in mine action of the last fifteen years. The TIRAMISU consortium consisted of 26 partners from 12 different countries, with a total budget of approx. EUR 20 million. The TIRAMISU project started up in 2012 and was ended by December 2015.

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

ACKNOWLEDGEMENT

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   By Mikael Bold [article for counteriedreport.com July 2015]

Advances in Signal Processing for QR-based Explosives Detection during Demining Operations

Weihang Shao,[1] Blaž Zupančič, Jamie Barras, Kaspar Althoefer, and Panagiotis Kosmas

ABSTRACT: Humanitarian demining must be unequivocal–all suspicious objects must be detected, and at the same time false alarms due to various clutter sources must be minimal. We believe that the best way of ensuring this is to have a fast technique that can detect suspicious objects with high probability, e.g. metal detector, followed by a confirmation sensor which can reduce false alarms by providing complementary information, such as searching specifically for the chemical signature of the bulk explosive content of the mine, or looking for trace quantities of explosives.

The AQUAREOS project sponsored by Find A Better Way [1] is designed to develop just such a confirmation sensor based on the radiofrequency spectroscopic technique Quadrupole Resonance (QR). Its basic detection concept is particularly simple: a pulse or series of radiofrequency pulses is applied at a particular frequency for the explosives of interest, and the presence (or absence) of a return signal is sought [2].

The QR signal can be effectively captured with an echo train system. And the corresponding algorithms, the well-known ETAML (echo train approximate maximum-likelihood) and FETAML (frequency-selective ETAML) [3], have been proven to be very precise in detecting the existence of the QR signal when the levels of the noise and the interference are limited. However, as the signal to noise rate (SNR) comes down, and even worse, the data is polluted by strong and complicated interference, methods which can help suppressing the noise and cancelling the interference should be introduced or present algorithms (ETAML/FETAML) will markedly lose performance. So, by summing up the datum of each echo, an effective datum which has higher SNR can be acquired.

By using the proposed algorithm called ESICAML which is a combination between the AML (approximate maximum-likelihood) method [4] and a novel interference cancelation method [5], the existence of the QR signal can be detected efficiently from the effective datum in situations of high radiofrequency interference and/or low SNR common to demining operations.

Both simulated data and real data are used for testifying the validation of the new algorithm and meaningful results have been obtained.

I. INTRODUCTION

Explosives, such as trinitrotoluen (TNT), usually contain quadrupolar nuclei which can be resonant with external electromagnetic (EM) waves and emit eigen EM signal subsequently [6]. Quadrupole resonance(QR)-based Explosives Detection is prevailing in Humanitarian demining recently, as de-

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tecting the QR signal is a very effective way to identify the presence of the explosives. Compared to the traditional demining method whose principle is to search metal components only, QR detection can even detect plastic made landmines, and does not suffer false alarms of metal objects in soil.

QR signal decays rapidly with time. For acquiring sufficient long data, a system called pulsed spin locking (PSL) sequences or "echo train" need to be used in the measurements [7]. This system can echo the QR signal periodically. The intensity of QR signal is almost restored at each echo except for suffering a weak decay. Using the data acquired by this system, the well known ETAML (echo train approximate maximum-likelihood) and FETAML (frequency-selective ETAML) algorithms can identify the presence of the explosives by estimating the QR signal parameters including frequency and decay coefficients based on the maximum likelihood (ML) theory [3]. The ETAML and FETAML algorithms are very useful. However, they demand that the noise and interference are limited.

For data of low signal-to-noise ratio (SNR) and of strong interference, one need to process the data in prior for effectively suppressing the noise and canceling the interference before applying a detection algorithm. It is noted that, at each echo, the QR signal does not only restore its intensity but also its initial phase. Hence, if one sums up the datum of each echo, the QR signal can be added coherently while stochastic noise can not. Data summing is an effective way to increase SNR. However for interference, since it may be very strong and deterministic, it is not easily suppressed like noise and it may also be added coherently like QR signal. Interference needs to be canceled specially.

In this paper, we propose an algorithm suitable for data containing high noise and strong interference. The procedures of this algorithm for processing data are 1. Get the echo summed data. 2. Use a novel method to cancel the interference in the summed data. 3. Estimate QR signal parameters for the interference canceled data based on ML theory in order to identify the presence (or absence) of the QR signal. This algorithm is called ESICAML (echo summing–>interference canceling–>parameters estimating based on approximate maximum-likelihood theory).

II. THE THEORY OF THE ESICAML ALGORITHM

Considering an echo train detection system, the QR signal which consists of total d components can be well modeled for the mth echo as [3]

$$y^m(t) = \sum_{k=1}^{d} \alpha_k e^{-(t+m\mu)/T_k^e} e^{-|t-t_{sp}|/T_k^* + j\omega_k t}, \tag{1}$$

where $t=t_0,...,t_{N-1}$ is the echo sampling time with the symmetric center to be t_{sp}, $\mu=2t_{sp}$ is the echo spacing, αk, T_k^e, T_k^*, and ωk are the amplitude, echo train decay time, damping time, and angular frequency of the kth component, respectively. To sum up all the echos, we have the model of summed QR signal.

$$\overline{y(t)} = \sum_{m=1}^{M} y^m(t) = \sum_{k=1}^{d}\left[\sum_{m=1}^{M} \alpha_k e^{-(t+m\mu)/T_k^e}\right] e^{-|t-t_{sp}|/T_k^* + j\omega_k t} \simeq \sum_{k=1}^{d} \overline{\alpha_k} e^{-|t-t_{sp}|/T_k^* + j\omega_k t}, \tag{2}$$

where M is the total echo number and $\overline{\alpha}_k$ is a constant representing the summed amplitude, respectively. The approximation in Eq.(2) is reasonable since T_k^e, is large compared to the time length of a single echo. The structure of the summed data $\overline{z}$ can be divided into three parts: the summed QR signal $\overline{y}$, the summed noise $\overline{n}$ and interference $\overline{r}$.

$$\overline{z(t)} = \overline{y(t)} + \overline{n(t)} + \overline{r(t)}. \tag{3}$$

The summed data can be rewritten in vector as

$$\mathbf{Z}_N = \mathbf{Y}_N + \mathbf{N}_N + \mathbf{R}_N, \tag{4}$$

where $\mathbf{N}_N$ and $\mathbf{R}_N$ are the noise and interference parts, respectively, and the signal part $\mathbf{Y}_{NM}$ satisfie

$$\mathbf{Y}_N = [\overline{y(t_0)}, \overline{y(t_2)}, ..., \overline{y(t_{N-1})}]^{\mathrm{T}} = Q_N\mathbf{A}, \tag{5}$$

where $(.)^{\mathrm{T}}$ denotes the transpose,

$$\mathbf{A} = [\overline{\alpha_1}, \overline{\alpha_2}, ..., \overline{\alpha_d}]^{\mathrm{T}}, \tag{6}$$

is the amplitude vector, and

$$Q_N = \begin{pmatrix} e^{-\frac{|t_0-t_{sp}|}{T_1^*}+j\omega_1 t_0} & e^{-\frac{|t_0-t_{sp}|}{T_2^*}+j\omega_2 t_0} & \dots & e^{-\frac{|t_0-t_{sp}|}{T_d^*}+j\omega_d t_0} \\ e^{-\frac{|t_1-t_{sp}|}{T_1^*}+j\omega_1 t_1} & e^{-\frac{|t_1-t_{sp}|}{T_2^*}+j\omega_2 t_1} & \dots & e^{-\frac{|t_1-t_{sp}|}{T_d^*}+j\omega_d t_1} \\ \dots & \dots & \dots & \dots \\ e^{-\frac{|t_{N-1}-t_{sp}|}{T_1^*}+j\omega_1 t_{N-1}} & e^{-\frac{|t_{N-1}-t_{sp}|}{T_2^*}+j\omega_2 t_{N-1}} & \dots & e^{-\frac{|t_{N-1}-t_{sp}|}{T_d^*}+j\omega_d t_{N-1}} \end{pmatrix}, \tag{7}$$

is the parameter matrix.

We use a novel method for canceling the interference in the summed data [5]. This method first searches out the main frequency components of the interference. For any frequency component f_k (k=1,2,...) of the summed data $\mathbf{Z}_N$, its cost function is defined as

$$C(f_k) = \mathbf{Z}_N - \mathbf{F}(f_k)\mathbf{F}^{\dagger}(f_k)\mathbf{Z}_N, \tag{8}$$

where $\mathbf{F}(f_k)$ is the Fourier vector $[e^{j2\pi f_k t_0}, ..., e^{j2\pi f_k t_{N-1}}]^{\mathrm{T}}$ and $(.)^{\dagger}$ denotes the Moore-Penrose pseudo-inverse. The main components of the interference are those who have extremely small cost function values compared to other components of data $\mathbf{Z}_N$. Assume that the main interference components/frequencies we pick out are $(f_{m1}, f_{m2}, ..., f_{ml})$. The interference canceled data $\mathbf{Z}_C$ can be acquired

$$\mathbf{Z}_C = \mathbf{Z}_N - (\mathbf{F}(f_{m1}), \mathbf{F}(f_{m2}), ..., \mathbf{F}(f_{ml}))(\mathbf{F}(f_{m1}), \mathbf{F}(f_{m2}), ..., \mathbf{F}(f_{ml}))^{\dagger}\mathbf{Z}_N. \tag{9}$$

This method is very useful if only the interference frequency is not the same as that of the QR signal.

Using the data $\mathbf{Z}_C$, one may identify the presence of QR signal by estimating parameters $\overline{\alpha}_k$, ωk, and T^*_k, based on maximum likelihood theory. The procedures are 1. The amplitudes $\overline{\alpha}_k$ (or A) are expressed based on the least square theory.

$$\mathbf{A} = Q_N^{\dagger}\mathbf{Z}_C, \tag{10}$$

so that $\overline{\alpha}_k$ (or A) is treated as a function of ωk, and T^*_k. 2. The likelihood function for ωk aand T^*_k, and T^e_k can be written as

$$L(\omega_k, T_k^*) = \mathbf{Z}_C^{\mathrm{H}} Q_N Q_N^{\dagger}\mathbf{Z}_C, \tag{11}$$

where $(.)^{\mathrm{H}}$ denotes the conjugate transpose. To estimate the parameters ωk and T^*_k is equal to find the ωk and T^*_k values which satisfy $|L|$=max($|L|$). For calculation efficiency, one should determine suitable search scales of ωk and T^*_k. A choice is to refer to the related QR theory[8], which helps calculating the value scales of the QR signal parameters in prior. Once the estimated ωk and T^*_k are acquired, by substituting them into the test statistic [4]

$$T(\mathbf{Z}_C) = (2N-1)\frac{\mathbf{Z}_C^{\mathrm{H}} Q_N Q_N^{\dagger} \mathbf{Z}_C}{\mathbf{Z}_C^{\mathrm{H}}\mathbf{Z}_C - \mathbf{Z}_C^{\mathrm{H}} Q_N Q_N^{\dagger} \mathbf{Z}_C}, \tag{12}$$

the existence of the QR signal can finally be identified. By predetermining a threshold value γ, one can make decisions like that the NQR signal is deemed present if and only if $T(\mathbf{Z}_{NM}) > \gamma$, and otherwise not.

III. Numerical tests for the esicaml algorithm

Both real data and simulated data are used for testifying the performance of the ESICAML algorithm. The results are compared with that output by the ETAML and FETAML algorithms. We choose the QR source to be the sodium nitrite $NaNO_2$. In our experiments, for imitating the landmine environment, there are two starch solution portions respectively sealed in two plastic boxes which are buried under soil separately. One has $NaNO_2$ dissolved inside while the other has not. The QR source is excited by EM waves which are transmitted from a coil. And a spectrometer with an "echo train" system records the data. The sampling frequency is f_s=1/16μs. The measurements suffer high noise and strong interference. The interference is nonstationary and its frequency is very close to that of the QR signal. The data structure is N=128 sampling points × M=4 echoes. We have acquired 100 runs of data. According to the QR theory, it can be calculated that the QR signal frequency is about $f \simeq 1.0365$MHz (single frequency) with an uncertainty about ±600Hz, $T \simeq 1.74$ms, and $T^{e} \simeq 88$ms. In the measurement, the technique of frequency modulation is applied. The real available frequency band of the recorded data is $[f_c - f_s/2, f_c + f_s/2]$, where f_c=1.0365MHz is the frequency center of the modulation. A run of the real data is chosen as an example in order to see the effects of echo summing and interference cancelation. We sum up the echoes and show the frequency spectra of this summed data as well as the corresponding interference canceled data in Fig. 1. One can see that 1. The QR signal part at the middle outstands due to echo summing. 2. The interference is still serious after echo summing, but is well canceled by ESICAML algorithm. Continuing the ESICAML calculation, the receiver operating characteristic (ROC) curve can be obtained. Fig. 2 shows the ROC curves output by ESICAML, ETAML, and FETAML. It is obvious that high noise and (or) strong interference can make ETAML and FE TAML lose performance. The ESICAML well confines the noise and interference so that it is able to identify the presence (or absence) of QR signal precisely.

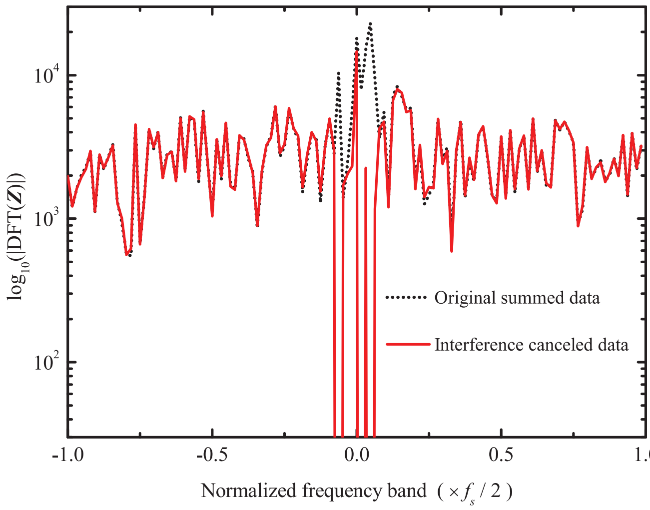

FIG. 1. (Color online) The frequency spectra about a run of the real data. The DFT means digital Fourier transformation. **Z** represents the data vectors.

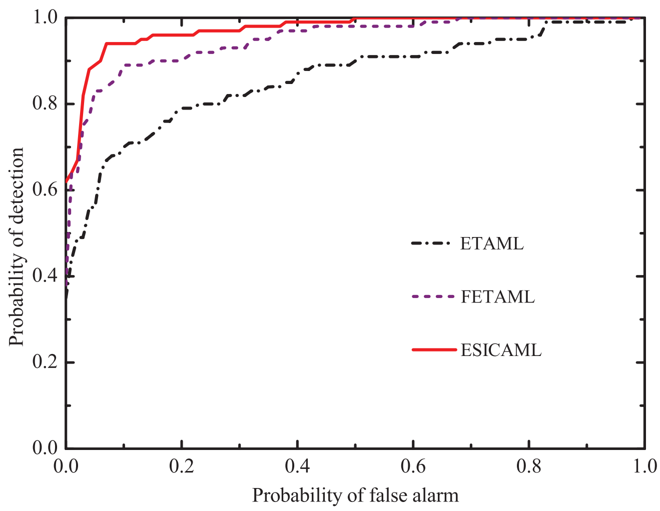

FIG. 2. (Color online) The ROC curves obtained by by ETAML, FETAML, and ESICAML for the real data.

For further theoretical discussion, we also analyze simulated data which have lower SNR and stronger interference. The simulated data are created by imitating the real data: the frequency and amplitude of the QR signal are $f=0$ (modulation considered) and $|A|=1$; the noise is Gaussian white, and its amplitude is |A|=6. Regarding the interference, we consider two cases. Case l. The interference is stationary and it has 5 frequency components which are $[2.4,2.5, 2.6, 2.7,2.8]\times f_s/N$. The amplitude of each component is |A|=12. Case II. The interference is nonstationary. It has 2 time-varying frequency components $f_a(t_{nm})=(1.2+0.6t_{nm}\times f_s\ /(NM))\times f_s/N$ and $f_b(t_{nm})=(2.8\text{-}0.8t_{nm}\times f\ s\ /(NM))\times f_s/N$, where t_{nm} represents the $N\times M$ points of sampled time. Their amplitudes are both |A|=12. All the other conditions or related parameters are copied from that of the real data of our experiments. Figs.3 and 4 are the ROC curves of Cases I and II, respectively. The ETAML and FETAML, according to the results, are unsuitable for dealing with "high noise and strong interference" data, especially for the nonstationary interference case. The ESICAML algorithm shows its good performance in both cases. It is worth putting ESICAML into real life use.

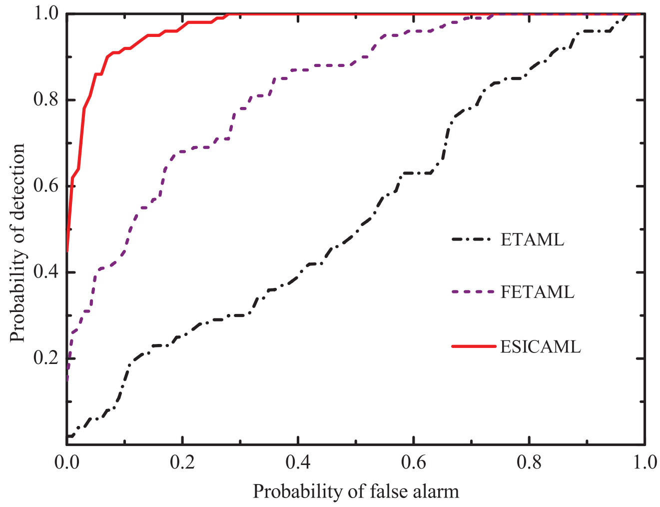

FIG. 3. (Color online) The ROC curves obtained by by ETAML, FETAML, and ESICAML for the simulated data of stationary interference case.

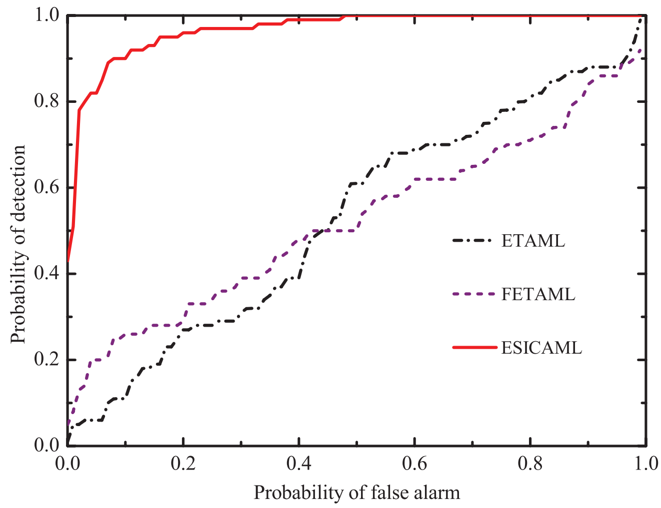

FIG. 4. (Color online) The ROC curves obtained by by ETAML, FETAML, and ESICAML for the simulated data of nonstationary interference case.

IV. Conclusion

We propose a QR signal detecting algorithm called ESICAML which can be suitable for "high noise and strong interference" case. In this case, the algorithm can effectively suppress the noise, cancel the interference, and precisely identify the presence (or absence) of QR signal, while the classical ETAML and FETAML algorithms inevitably lose performance.

ACKNOWLEDGMENTS

We thank Find a Better Way for supporting this work.

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QR-based Intelligent Prodder for Demining Operations

Blaž Zupančič, Jamie Barras, Weihang Shao, Panagiotis Kosmas, Kaspar Althoefer[1]

We propose a new type of confirmation sensor which can be seamlessly integrated into the existing workflow in humanitarian demining, i.e., it becomes a part of the prodding operation. Unlike other indirect methods, the sensor employs quadrupole resonance to directly detect the explosive compound. The two key innovations of the proposed sensing technique are the use of non-resonant detection which significantly simplifies the detector operation, and the integration with existing prodders which brings the sensor in contact with interrogated object and thus avoids low signal return, the main problem that was hindering the use of quadrupole resonance in demining.

1. Introduction

Humanitarian demining must be unequivocal – all suspicious objects must be detected, and at the same time false alarms due to various clutter sources must be minimal. We believe that the best way of ensuring this is to have a fast technique that can detect suspicious objects with high probability, e.g. metal detector, followed by a confirmation sensor which can reduce false alarms by providing complementary information, such as searching specifically for the chemical signature of the bulk explosive content of the mine, or looking for trace quantities of explosives.

The AQUAREOS project sponsored by Find A Better Way [1] is designed to develop just such a confirmation sensor based on the radiofrequency spectroscopic technique quadrupole resonance (QR). Its basic detection concept is particularly simple: a pulse or series of radiofrequency (RF) pulses is applied at a particular frequency for the explosives of interest, and the presence (or absence) of a return signal is sought [2].

Unfortunately, the return signal intensity varies rapidly when the distance to the target is changed. Since in demining operations the landmine depths are not precisely known, this presents a problem for the QR detection. In addition, currently available hardware is not well suited for field use since it requires frequent re-tuning of the resonant circuit which is used for enhancing both transmission and reception.

We propose a solution to these deficiencies by dispensing with the cumbersome frequency- tuning elements in favour of a broadband non-resonant device with the sensing element mounted at the end of a conventional prodder. Prodding, an operation carried out in current ConOps, brings the sensor in contact with the target thus solving the problem of decreasing signal intensity. Although other attempts of producing intelligent prodders can be found in the literature [3], they are mostly based on methods which can help in recognizing the surface of the target but fail to detect the actual explosive materials. A critical advantage of QR is the ability to reduce false alarms significantly by directly detecting the explosive compound.

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2. Quadrupole Resonance

QR spectroscopy is a non-invasive and non-destructive analytical technique that is highly suitable for detection of different chemical compounds. About 50% of atoms in the periodic table contain so-called quadrupolar nuclei that generate QR signals. Specifically, almost all explosives used in military or improvised landmines contain QR-active nuclei such as nitrogen (^{14}N), which is the main isotope of nitrogen with 99.635 % natural abundance and thus the most suitable nucleus for landmine detection. Since QR provides unique information about the electronic and molecular properties of solid state explosives, it has the potential for unique detection and thus minimization of the number of false positives.

QR spectra are generated by resonant transitions between nuclear energy levels. Only nuclei with spin quantum numbers $I \geq 1$ are quadrupolar, i.e., have the asymmetric charge distributions required to generate non-zero quadrupole moments and thus QR spectra [2]. The resultant resonances occur in the radio frequency (RF) part of the electromagnetic spectrum, as shown in Figure 1 for ^{14}N ($I = 1$), the resonances typically occur in the 0.1 – 5.5 MHz range.

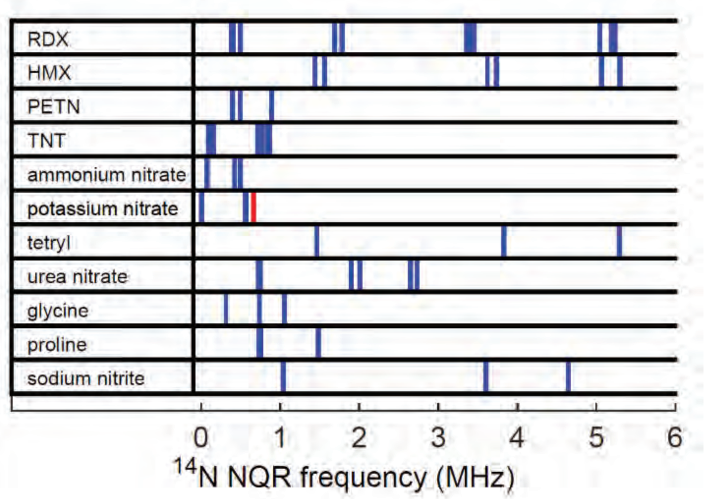

FIGURE 1: ^{14}N QR lines for common explosives and phantom materials used for testing QR explosive detection capabilities.

QR experiments are carried out by alternately perturbing a large number of quadrupolar nuclei away from thermal equilibrium and detecting the sum of the resulting responses as they gradually return to equilibrium. The perturbing signal (excitation) is known as a pulse sequence and consists of one or more RF pulses with frequency ω_0 that are generated by a transmitter circuit. The most common pulse sequence used for QR experiments is known as the spin-locked spin echo (SLSE) or pulsed spin-locking (PSL) sequence schematically shown in Figure 2. The pulses are applied to the sample by a transmitter coil that generates an oscillating magnetic field which excites the nuclei when ω0 is close to one of the QR transition frequencies, e.g., frequencies listed in Figure 1.

As a result, the excited nuclei generate an oscillating magnetic dipole moment M(t) within the sample. A macroscopic receiver coil converts this time-varying magnetization into an oscillating voltage $v(t) \propto dM(t)/dt$ through Faraday induction. In many systems the same physical coil is used for both transmission and reception; in this case a transmit/receive switch (duplexer) is used to control access to the coil. The detected voltage is amplified and digitized by a low-noise RF receiver circuit.

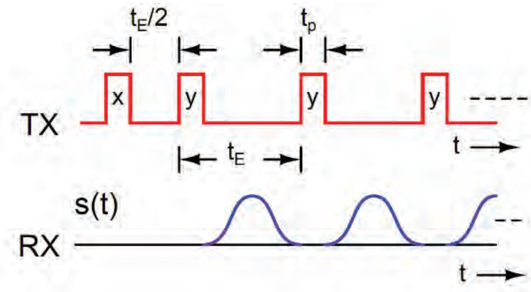

FIGURE 2: Spin-locked spin echo sequence consists of an initial excitation pulse and a long train of refocusing pulses separated by the echo period tE. The pulses have the same length tp, but are denoted by x and y to emphasize a relative phase shift of 90° between them. s(t) denotes the signal which can be acquired between the pulses.

The acquired QR signal can be analysed in the frequency domain by taking the Fourier transform to obtain the QR spectrum. The spectrum contains narrowband features (lines) centred around the QR resonance frequencies. Both the frequencies and widths of these lines contain unique information about the chemistry and structure of the sample.

3. Broadband QR

The default approach which is to date adopted by all groups that have trialled QR-based detection systems in realistic environments, is the resonant (tuned) transmission and detection. It relies on the resonant circuit comprising additional capacitors and/or inductors to provide for both transmission and detection gain, defined by the quality factor of the circuit. It is an approach that has, within the confines of the applications it has been applied to, been relatively successful. Its principle weaknesses are well-known and linked: the complexity, bulk and fragility of the electro-mechanical systems needed for retuning the resonant circuit elements to the frequency of the investigated material. This is particularly true when searching for new materials, e.g. new explosives, in the face of the need to then be able to retune to yet more frequencies. It is fair to say that the most successful (and also most compact) QR systems for detection applications to date have been those that target a single material e.g. the entirely handheld system designed by the Osaka group for the detection of ammonium nitrate-based improvised landmines in conflict areas of Colombia [4].

To overcome the electro-mechanical problems of tuned detector systems and to allow for acquisition of QR signals at all frequencies with a single circuit, we have used the broadband non-resonant system recently developed by Schlumberger-Doll (SLB) [5]. This transceiver has been successfully employed for both NMR and QR measurements at Nitrogen-14 frequencies [6] and therefore perfectly matches the requirements for landmine detection.

The SLB non-resonant transmit/receive system is designed as an add-on to standard commercially available NMR consoles. The console provides for low-power RF pulses which are used to drive the transmitter, and for amplification and digitization of the detected RF signal from the receiver. The system contains all other required electronics to run wide-band QR experiments: RF power amplifier, power amplifier driver, active duplexer, step-up transformer, and low-noise preamplifier (see Figure 3).

The system is designed to run experiments in the 0.1-3 MHz frequency range when a detection coil with L=15 μH is used. Two input channels (CH1 or CH2) accept pulse sequences with maximum amplitudes of 0.3 V. The pulses amplified by the RF driver/amplifier part of the circuit are then directed through an actively-switched GaNFET-based duplexer to the detection coil. On the receive side, a 1:N step-up transformer is used to increase the signal to a suitable level that can be amplified with 70dB gain preamplifier. The signal is then further amplified and digitized by the NMR console. The main feature of the system is that no tuning or matching capacitors are necessary, i.e., the coil is connected directly to the output of the non-resonant device.

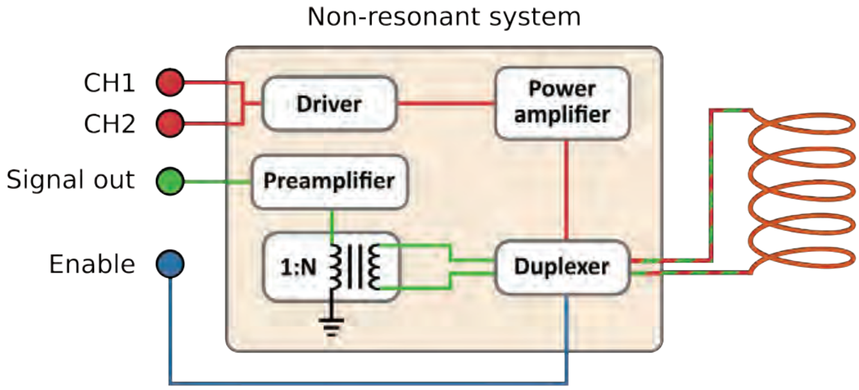

FIGURE 3: Block diagram of the non-resonant system.

The amplitude of the current in the coil during RF pulses, and therefore the RF power generated, depends on the transmitter supply voltage V, coil inductance L, and the operating frequency $\omega_0 = 2\pi f_0$ as $I_{coil} \propto V/(\omega_0 L)$. The challenge with non-resonant systems, then, is in matching coil inductance to the frequency range of operation to achieve the RF power desired.

This is because, contrary to resonant system, where there is gain in RF power transmitted and receiver sensitivity associated with the quality factor of the coil [7], the voltage across the non- resonant coil is the same as that generated at the output of the power amplifier and the sensitivity is a function of coil resistance and the performance figure of the step-up transformer.

4. Non-resonant acquisition

The SLB transceiver was coupled with a 13 μH solenoid coil and tested with two materials: Sodium Nitrite, our standard surrogate, and 1,2,4-triazole, a material with a great multiplicity of ^{14}N QR lines allowing for rapid testing of performance of the transceiver across a wide frequency range (Table 1). Two modes of signal capture were studied: (i) sequential excitation, sequential acquisition (SESeqA) and (ii) sequential excitation, simultaneous acquisition (SESimA). These acquisition modes were chosen to demonstrate multi-line detection capabilities of the non-resonant transceiver and are either not possible or need complex hardware to work automatically on resonant systems.

TABLE 1: Targeted QR lines of studied materials.

Material	^{14}N QR frequencies (kHz)
$NaNO_2$	3603
1,2,4-triazole	2257, 2406, 2503, 3787

In SESeqA mode (Figure 4a) separate measurements were performed sequentially at 4 frequencies of 1,2,4-triazole. There was no need to change any hardware setting in between the measurements since, the excitation frequency was simply changed in the software. The advantage of SESeqA is that, each time, a very narrowband acquisition centred on the single frequency of interest can be performed, limiting the amount of extraneous radiofrequency interference (RFI) that reaches the receiver. This can be clearly seen from the measurements where the noise exists only in narrow regions around the lines and no data was acquired at the frequency regions between the lines.

In SESimA mode (Figure 4b) a single measurement was performed that included sequential excitation at two frequencies of two different materials, 3603 kHz line of $NaNO_2$ and 3787 kHz line of 1,2,4-triazole, followed by a single, broadband signal acquisition. As with SESeqA, there was no need to change any hardware setting. The multiple lines covered can be at a remove from each other far in excess of the bandwidth that could be covered by a single radiofrequency pulse. The advantage of SESimA is that the multi-line signal capture takes places in a single event resulting in a spectrum that has multiple features that can be fitted to for improved signal processing certainty.

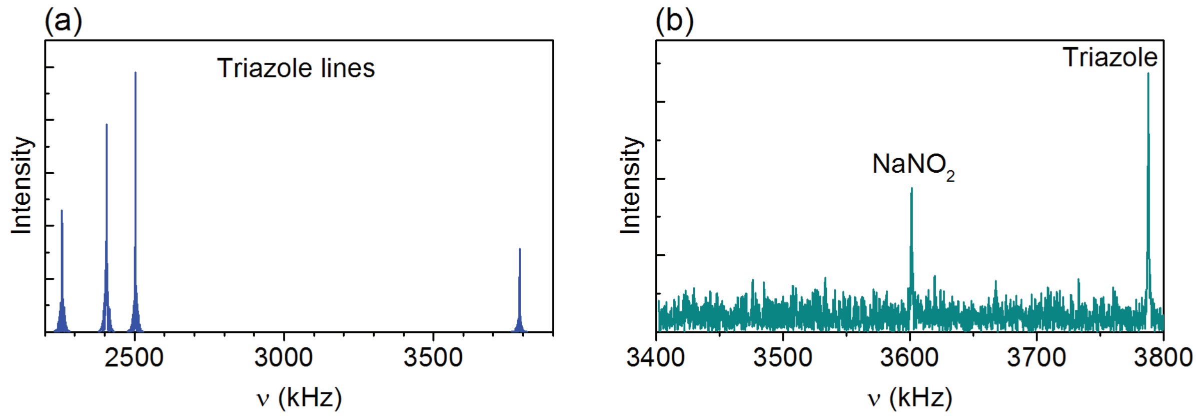

FIGURE 4 (a) Sequential Excitation, Sequential Acquisition covering 1.6 MHz of spectral range and capturing 4 triazole lines. (b) Sequential Excitation, Simultaneous Acquisition of 2 spectral lines from different materials ($NaNO_2$ and triazole).

5. Intelligent prodder

The testing of non-resonant system was performed with a standard coil to allow for comparison between resonant and non-resonant approaches. In the next step we have investigated the possibility of miniaturizing the detection coil in order to integrate it with prodders used in demining operations.

Since the modifications of coil shape and size significantly change the transmitted RF pulse power, we have performed magnetic field simulations for different geometries with the freely available FEMM package [8]. Even though only static magnetic fields were simulated, the results presented in Figure 5 allow for us to determine the coil parameters needed to obtain the excitation field strength equivalent to the one of a standard coil. All the calculations were performed with the coil current of 1 A and the absolute field densities were plotted to allow for relative comparison. From the simulation results, the active regions for different prodder geometries can be determined where the magnetic field density is of the same order of magnitude as inside the standard solenoid coil (marked with white rectangles in Figure 5). The key advantage of the prodder approach is that it works in contact mode, i.e., the distance between the sensing coil and the investigated object is limited to a couple of mm. In this way remote QR detection can be avoided thus leading to more reliable results.

The numerical results were verified by constructing prodder coils and running the same pulse sequences as with the standard solenoid. A typical acquisition on NaNO2 phantom is presented in Figure 6, demonstrating the detection capability. As was expected, the noise level is higher and additional RFI peaks are appearing since prodder coils cannot be shielded. The problem of RFI in prodder coils and the discrimination between real and RFI lines can however be overcome by employing advanced data processing techniques [9].

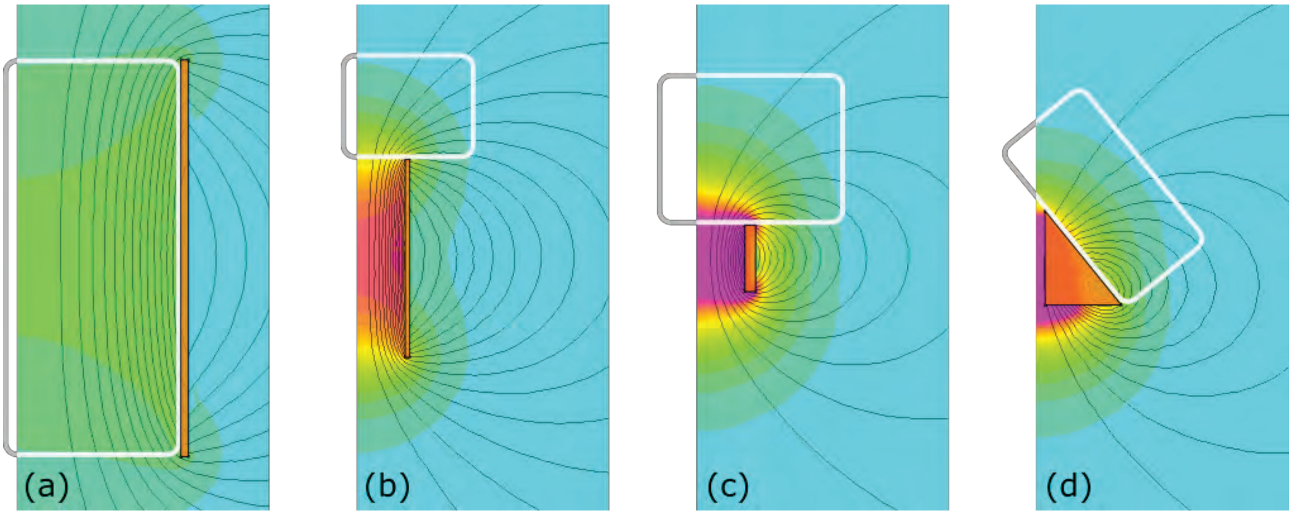

FIGURE 5 The simulated magnetic field densities shown in cylindrical coordinates for various coil geometries: (a) standard solenoid (ϕ50 x 60 mm, 20 turns, 16 AWG copper wire), (b)-(d) different prodder configurations (45 turns, 21 AWG copper wire). The interrogated sample volume is marked with white rectangles and the coil cross-sections are shown in orange.

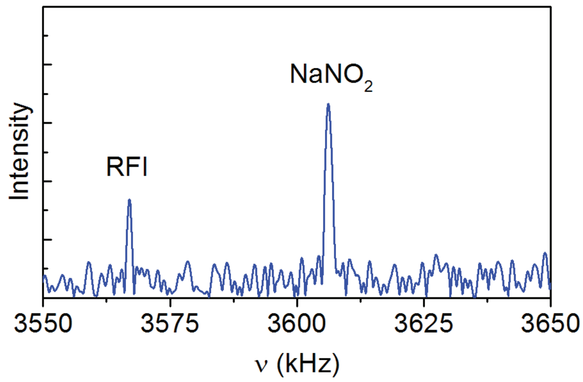

FIGURE 6 The spectra acquired with the prodder coil of type shown in Figure 5c.

6. Conclusions

An intelligent prodding approach was presented which intends to solve two main issues present in existing QR detection methods: (i) the complex frequency-tuning hardware and thus difficult use of detectors and (ii) the low signal return due to large and unknown sensor-target distance which limits the reliability or even prevents detection altogether. The use of non-resonant acquisition technique allows for simple software-controlled frequency selection, making simultaneous acquisition of multiple lines possible which can significantly increase detection certainty. We show that the integration of this kind of sensor with existing prodders is possible and could give demining personnel important additional information about the actual material present with negligible additional training cost.

ACKNOWLEDGMENTS

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Lessons learned through partnership between Ministry of Defence of Bosnia and Herzegovina and Norwegian People's Aid on implementation of capacity building for Demining Battalion of Armed Forces

Darvin Lisica Ph.D.[1]

From 2010 Norwegian People's Aid (NPA) has been supporting Demining Battalion of the Armed Forces of Bosnia and Herzegovina development of its capacities for mine action in country. First capacity building plan was developed for period 2010-2014 and was based on common donor and NPA criteria for selection of national partner organisation for capacity building, on needs assessment, exiting structure and potentiality for land release of Demining Battalion.

NPA has been implementing capacity building plan in partnership BiH Ministry of Defence. Key objectives of Plan includes: (1) Transfer of knowledge through improvement of operational planning of mine action (common training of NPA and Demining battalion managerial staff, training for team leaders, dog handlers and machine operators, workshops etc.); (2) Increased efficiency of Demining battalion through NPA direct operational support on their land release task and; (3) Procurement/handover of assets to reduce disparity between human resources of Demining battalion and other demining assets such as mine clearance machines, mine detection dogs and other tools required for demining. The Kingdom of Norway, the Swiss Confederation, the Kingdom of the Netherlands, the Federal Republic of Germany and Digger Foundation have been supporting cooperation between Ministry of Defence and NPA on building of national mine action capacity within Armed Forces.

The result-based and formative evaluation of NPA Capacity building of the Demining Battalion of the BiH Armed Forces covers the period 2011-2014. The main objective of evaluation is to better understand implemented activities through partnership between a non-governmental organisation and military, achieved results, impact and sustainability, limitations, as well as recommendations and lessons learned.

Introduction

Building national capacity for mine action is integral part of a global policy of Norwegian People's Aid (NPA), so that it was not a novelty for the time when its development started in Bosnia and Herzegovina (BiH) in 2008. However, the novelty was multi-year partnership between nongovernmental organization (NGO) and the military to strengthen a military unit to carry out mine action. In 2009, NPA and Ministry of Foreign Affairs of Kingdom of Norway were set next criteria for determining of the national organization whose building of capacity would be supported: (1) Existence of the mine

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action organization until fulfilment of obligations under Mine Ban Treaty; (2) Operation of chosen organization should be in accordance with the goals of the national Mine Action Strategy and the priorities set by the authorized BiH government body; (3) It must be a non-profit organization; (4) Abiding by international and local mine action standards and operation in accordance with the standard operational procedures that exclude what is usually referred to as "military demining"; (5) Full monitoring by BiH Mine Action Centre over activities on mine clearance and technical survey, including testing, certifying and other quality management measures; (6) Support in implementation of strategic goals set by the NPA strategy; and (7) Guarantee that the granted assets will be used only for demining in Bosnia and Herzegovina.

From 2010 NPA has been supporting Demining Battalion of the Armed Forces of Bosnia and Herzegovina (BiHAF) development of its capacities for mine action in country. First version of capacity building plan was developed for period 2010-2014. For each year of implementation of the Plan, Memorandum of Understanding between the BiH Ministry of Defence and the NPA was prepared with obligations and responsibilities of the signatories of the Memorandum. Implementation of the plan is followed by Coordinating Body consisting of representatives of the BiH Ministry of Defence, the Operational Command BiHAF, Demining Battalion and the NPA. In January 2015, Coordination Body has decided to establish of an evaluation team composed of representatives from the Operational Command BiHAF, Demining Battalion and the NPA. Through February-March 2015, team selected techniques and instruments for evaluation and creates evaluation matrix together with evaluation measures and indicators for the period 2011-2014 (year 2010 was already evaluated through previous evaluation. Through March – October 2015, team collected and analysed data, then through workshops verified applied evaluation techniques. Evaluation report was published in December 2015.

Capacity building plan 2010-2014 and its implementation

On the beginning of 2009, Demining battalion had 10 year field experience in humanitarian demining with available staff of: 34 manual teams with 68 team leader/deputy of team leader, 238 deminers; 9 mechanical teams with 9 team leaders and 18 machine operators; 9 MDD teams with 9 team leaders/dog handlers and 9 dog handlers; 6 non-technical survey teams with 6 team leaders/surveyors and 6 surveyors; 34 medics. Beside above mentioned operational resources. Demining battalion had also educational/training team and internal quality assurance team. Basic equipment, machines and MDD's, were: 125 metal detectors, 6 mine clearance machines and 18 mine detection dogs. Demining battalion was the biggest demining organisation with the highest potential to increase outputs, but also with distinct problems in terms of capacity

(1) Inadequate age structure of the Battalion staff and needs to recruit and educate new professional soldiers in short time. It was necessary to replace 190 deminers-soldiers that crossed the legal age limit of 35 for soldier year. In 2011 battalion was reduced on 17 teams available only. Additionally, 75 deminers-soldiers was replaced in 2013 and 2014, so the Battalion staff reached their full number at the beginning of 2015.
(2) Insufficient number of equipment, demining machines and mine detection dogs were also serious problem that are not in balance with available human resources. Battalion had 50% of metal detectors, 50% machines was operative. Insufficient number of mine detection dogs including 50% of old dogs for replacement.

In fact, the Demining battalion had human resources to even double its output. Increase in productivity was limited because of imbalance between human resources, equipment, mine clearing machines and mine detection dogs, and the lack of logistical support. It was not possible in the short term to increase productivity due to imbalance between the human resources, equipment, of machines and mine detection dogs. Problem was also the cost price and should apply the techniques and procedures of work that will increase the efficiency of the battalion.

TABLE 1: NPA Capacity building plan for Demining battalion BiHAF

Objectives	2010	2011	2012	2013	2014
Partnership and cooperation	Coordination body MoU between MoD and NPA BiH	Coordination body MoU between MoD and NPA BiH	Coordination body MoU between MoD and NPA BiH	Coordination body MoU between MoD and NPA BiH	Coordination body MoU between MoD and NPA BiH
Transfer of knowledge through improvement of project management, operational planning of mine clearance and technical survey operations	**Workshop:** Procedures of MDD clearance on technical survey tasks, Level I (dog handlers and team leaders) **Practical exercise:** MDD activities on technical survey tasks on mechanical ground prepared area	**Workshops:** Procedures of MDD clearance on technical survey tasks, Level II (Site managers), Lessons learned during implementation capacity building plan"	**Workshop**: Lessons learned during implementation of capacity building plan **Training course:** MDD trainer course	**Workshops:** Evaluation of capacity building plan Relation with donors **Training courses:** Operating machine MV-4" Clearance and TS of areas contaminated with cluster munition remnants	**Training courses:** Operating machine Mini MineWolf Operating and servicing Digger D-250 machine Course for surveyors **Workshops:** Evaluation of Capacity building plan
Increased efficiency of BiHAF Demining battalion through NPA direct operational support on their clearance task.		Mechanical ground preparation: 414,600 m^2 Batteries: 1,400	Mechanical ground preparation: 245,500 m^2 Batteries: 3,000	Mechanical ground preparation: 525,600 m^2 Batteries: 4,000 Mine tape. 1600 kg Veterinary support Food for 18 dogs Support to Dem. Battalion operation in Krupa	Mechanical ground preparation: 786,634 m^2 Support to Dem. Battalion in Srebrenica Region Support to Dem. Battalion in flooded areas
	GPS device support	GPS device support	GPS device support	GPS device support	GPS device support
Handover of good quality equipment	Metal detectors: 15	Metal detectors: 25			
Procurement new equipment and dogs	Mine detection dogs: 5	Mine detection dogs: 2	Mine detection dogs: 3 Metal detectors: 20	IT equipment for non-technical survey 54 protective flak jackets, 300 visors	Mine detection dogs: 7 Metal detectors: 20+10 Locators: 12 Trimmer: 5; Motor saws: 5 Digger D-250 mine clearance machine

One of the first tasks in the implementation of the plan was to increase the productivity of teams for manual cleaning. By 2011, the NPA has submitted 40 detectors demining battalion who were in excellent condition. NPA has purchased spare parts needed for their maintenance. Later purchased new detectors from donations of Switzerland, Norway and Germany. Procurement of new dogs to replace the existing and increasing their total number in the Demining Battalion is done gradually. It was in line with the dynamics of training on the use of mine detection dogs for clearance and technical survey. In addition, NPA ensures quality food and veterinary support for these dogs and other dogs of Demining battalion. Also, the NPA was able to alleviate some logistical problems demining battalion who questioned his productivity. It should be noted that the NPA supported demining battalion with its mine clearance machines.

In total, NPA delivered Demining battalion: 90 metal detectors (80 metal detectors type CEIA MIL-D1 and 10 metal detectors type VMH-3 CS) including spare parts; 12 magnetic locators type Schonstedt; 17 mine detection dogs, dog food and veterinary support; 54 protective vests and 340 protective visors; 8 motor saws and 8 trimmers; 7,400 batteries for metal detectors; small demining tools and marking materials and fuel for machines, vehicles, motor saws and trimmers.

Training was one of the most important elements in building capacity. Procurement of equipment and dogs was important because of the existing imbalances in relation to the available human resources. This plan was not just a mere investment in equipment. The transfer of knowledge and skills was one of the important goals in its implementation. It may seem strange that a non-governmental organization trying to train military unit. However, it should be noted that the NPA engaged in mine action since the beginning of the 90s and currently operates in 24 countries in the world by removing mines, cluster munitions and other explosive means. The NPA is the accumulated knowledge and experience that should be shared with others. It should be emphasized that in the part of the plan related to dogs Demining Battalion achieved significant results. This was confirmed by its accreditation for greater participation of dogs in clearance. From the first permit that dogs may only be used on 30% of the site in 2009, demining battalion now has the ability to dogs used in 70% of the demining site.

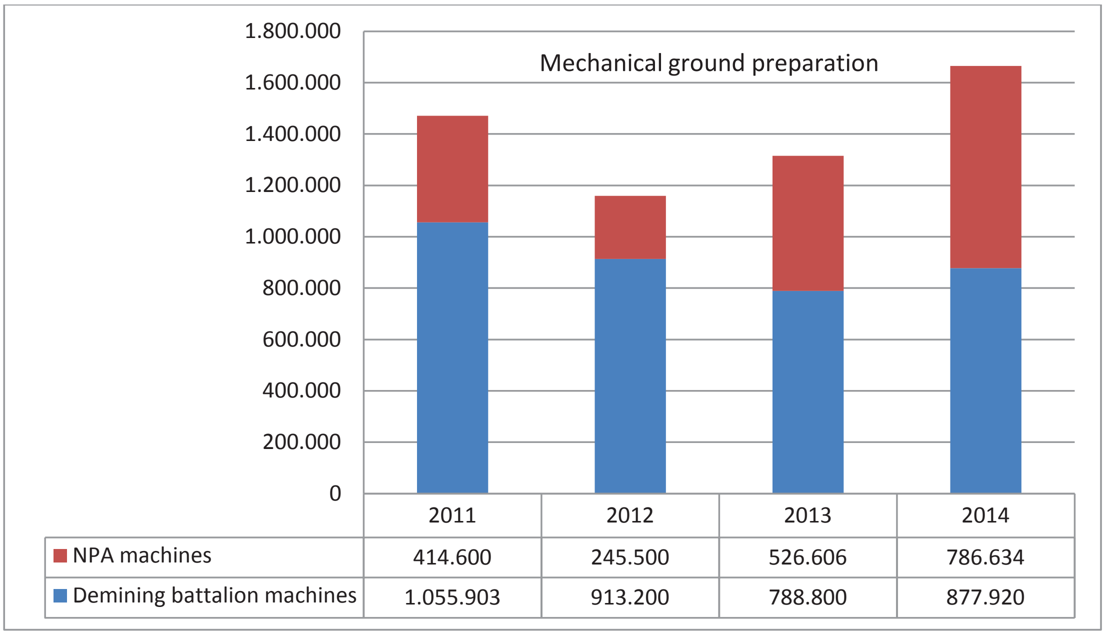
Through 2011-2014 NPA conducted 6 workshop on increasing efficiency in application of working methods 7 training courses, 2 re-training courses and 1 practical exercise for members of Demining battalion. Training was focused on better planning and use of demining resources as well as improved techniques for use of mine detection dogs. Training and equipping for activities of land release contaminated with cluster munition remnants was conducted in 2013. In total, 63 members of Demining battalion upgraded their skills through trainings and courses organized by NPA.

Mechanical ground preparation

NPA support with mine clearance machines to the Demining Battalion was conducted on 29 demining task, total area of 1,973,340 m^2. Mechanical ground preparation on Demining battalion demining tasks was conducted with four Demining battalion machines and three NPA machines.

NPA contributed with 35.18% of all mechanical ground preparation on Demining battalion demining tasks. Unfortunately, a few Demining battalion machines were inoperative during the period of implementation of NPA capacity building plan, which forced NPA to increase support with NPA mine clearance machines in 2013 and 2014, as support to manual teams and MDDs.

Having in mind that the mechanical ground preparation will be a significant factor in the effective land release of areas contaminated with mines in Bosnia and Herzegovina in future, and that the existing capacities for mechanical ground preparation within the Demining Battalion largely worn out and outdated, it is necessary to include in the medium term plan replacement of two machines from the composition of Demining Battalion with the new, whose specifications match the medium size machines and have greater manoeuvrability. The existing maintenance services system of machines for mechanical ground preparation that is reflected in the slow procurement of spare parts and their installation, negatively effects on productivity of machines, and should be improved. In regard to this it is necessary to establish a timely and continuous maintenance.

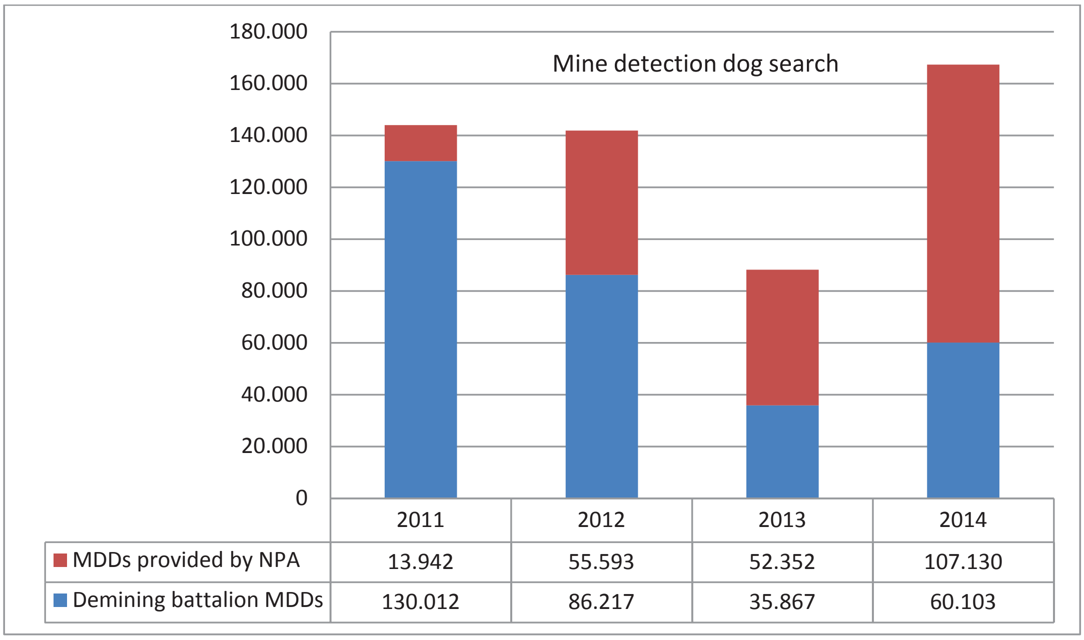


GRAPH 1: Mechanical ground preparation on AF BiH demining tasks

Mine detection dogs search

Since 2011, NPA provided 17 mine detection dogs in order to increase MDDs capacities within Demining battalion. NPA also organized several workshops and trainings for Demining battalion staff on applying of methods of technical survey with a significant use of dogs. In 2014, Demining Battalion of Armed Forces Bosnia and Herzegovina has 22 mine detection dogs.

The greatest reversal of the situation there is in the results Demining Battalion who were reached with mine detection dogs. In period 2011-2014, 42.31% of total MDD team’s productivity was realized with mine detection dogs provided by NPA. Percentage of contribution of mine detection dogs was



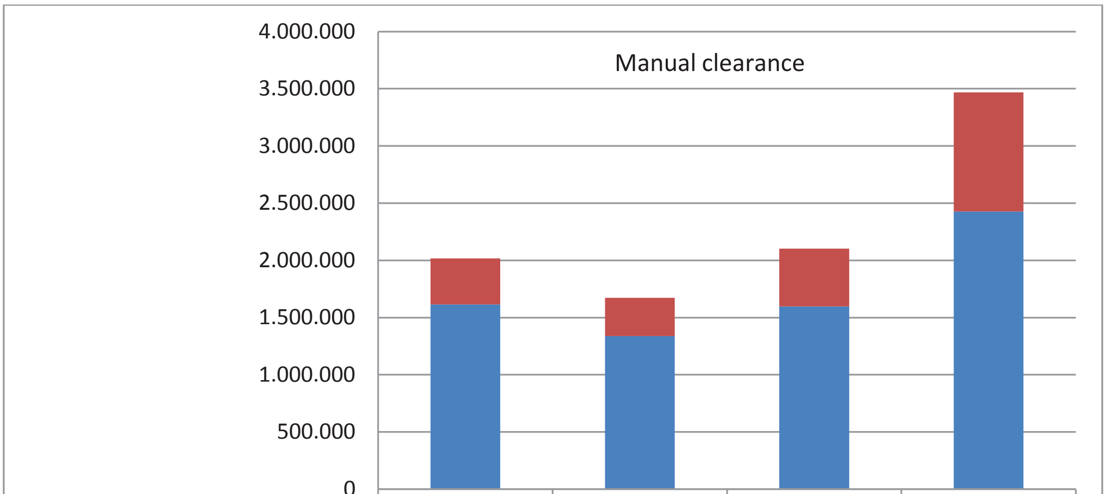
GRAPH 2: Mine detection dog search

growing from year to year and reached in 2014, 64.06% of whole productivity. The greatest reversal of the situation there is in the results Demining Battalion who were reached with mine detection dogs. Through 2011-2014, dogs provided by the NPA searched 229,017 m^2 on tasks Demining Battalion representing 42.3% of total results. Although contribution of dogs are in increasing trend in 2014 and 2015, total contribution of dogs are still poor comparing with manual clearance. There is biggest potential for increasing of productivity and efficiency of Demining battalion. With 17 NPA dogs fully operable Demining battalion continues increasing of productivity in 2015 but total outputs depend of logistical support from Ministry of Defence of Bosnia and Herzegovina.

According NPA field experience in BiH, optimal balance between human resources and dogs are: 1.3 mine detection dogs per demining teams (NPA has 8 dogs and 6 demining teams). Additionally, NPA use 2 special detection dogs for targeted investigation within technical survey. It is obviously that Demining battalion needs more dogs in order to reach good balance and increase total outputs on more cost efficient way.

Manual clearance

Analysis of manual clearance method included results of Demining battalion manual teams achieved with metal detectors/locators. The number of manual teams within Demining battalion varied form 17 in 2011, to 34 in 2014. Demining battalion has 266 metal detectors, out of which 102 is defective. At the end of 2014 the number of fully equipped metal detectors in Demining battalion were 164 out of which 90 was provided by NPA. The contribution of mine clearance with use of NPA detectors increased from year to year, so that in 2014 was 30% of whole contribution.



	2011	2012	2013	2014
Detectors provided by NPA	403.517	334.522	504.452	1.040.289
Demining battalion's detectors	1.614.068	1.338.088	1.597.435	2.427.341

GRAPH 3: Manual clearance with use of metal detectors

Land release

Regarding quality of Demining battalion clearance and technical survey work on demining tasks the evaluation team analysed number of mines and explosive remnants of war (ERW) found. A total of 896 mines and 434 ERW were found on Demining battalion technical survey and clearance tasks in the period 2011-2014. In 2013 and 2014 Demining battalion significantly increased its contribution in total number of found mines and ERW in BiH.

TABLE 2: Landmines and other ERW found on demining sites

Year	Mines and ERW found		
	Demining battalion		Total in Bosnia and Herzegovina
2011	180	**2.4%**	7,551
2012	96	**5.9%**	1,615
2013	379	**13.8%**	2,741
2014	675	**15.4%**	4,378
2011-2014	**1,330**	**8.2%**	**16,285**

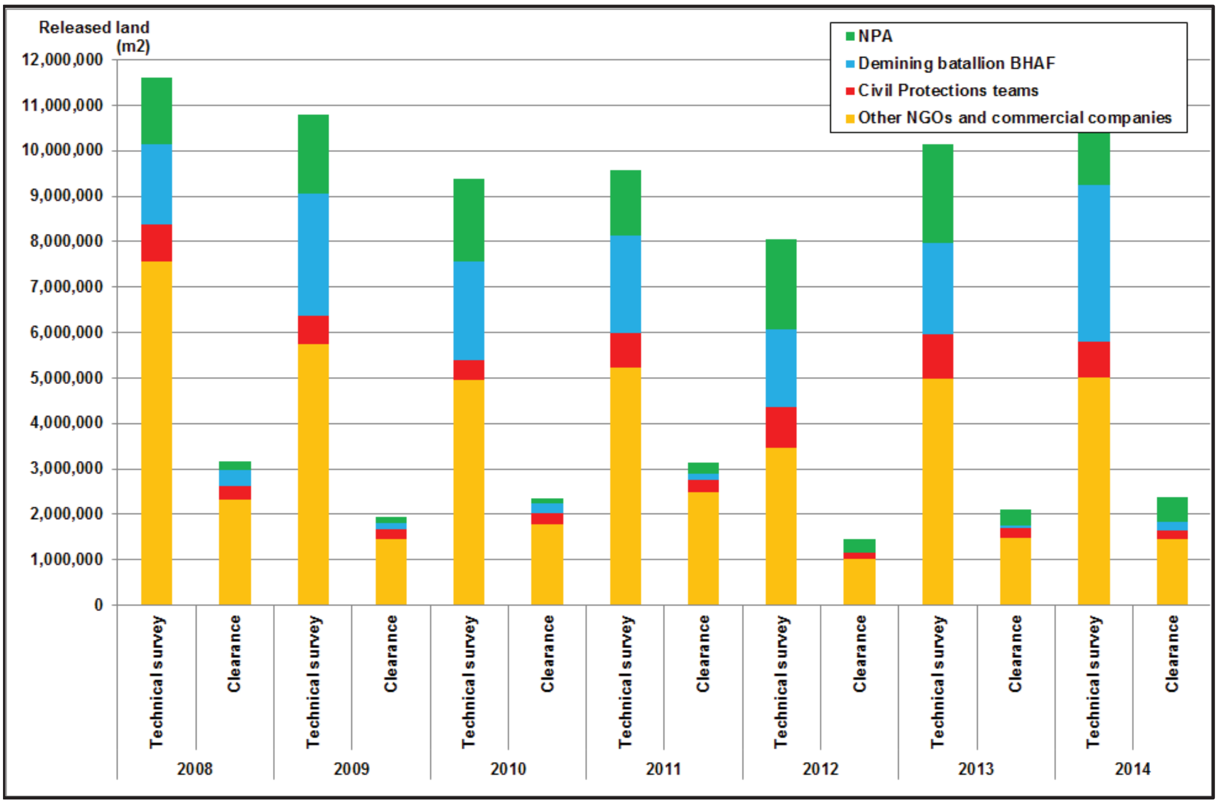
Average number of mines found on Demining battalion demining sites comparing to the national average also indicate improved quality on selection of tasks and hazard assessment. Average number of found mines on Demining battalion tasks is between 2.5 and 3 time bigger than national average in the period 2012-2014.

TABLE 3: Average number of found mines on demining tasks per ha

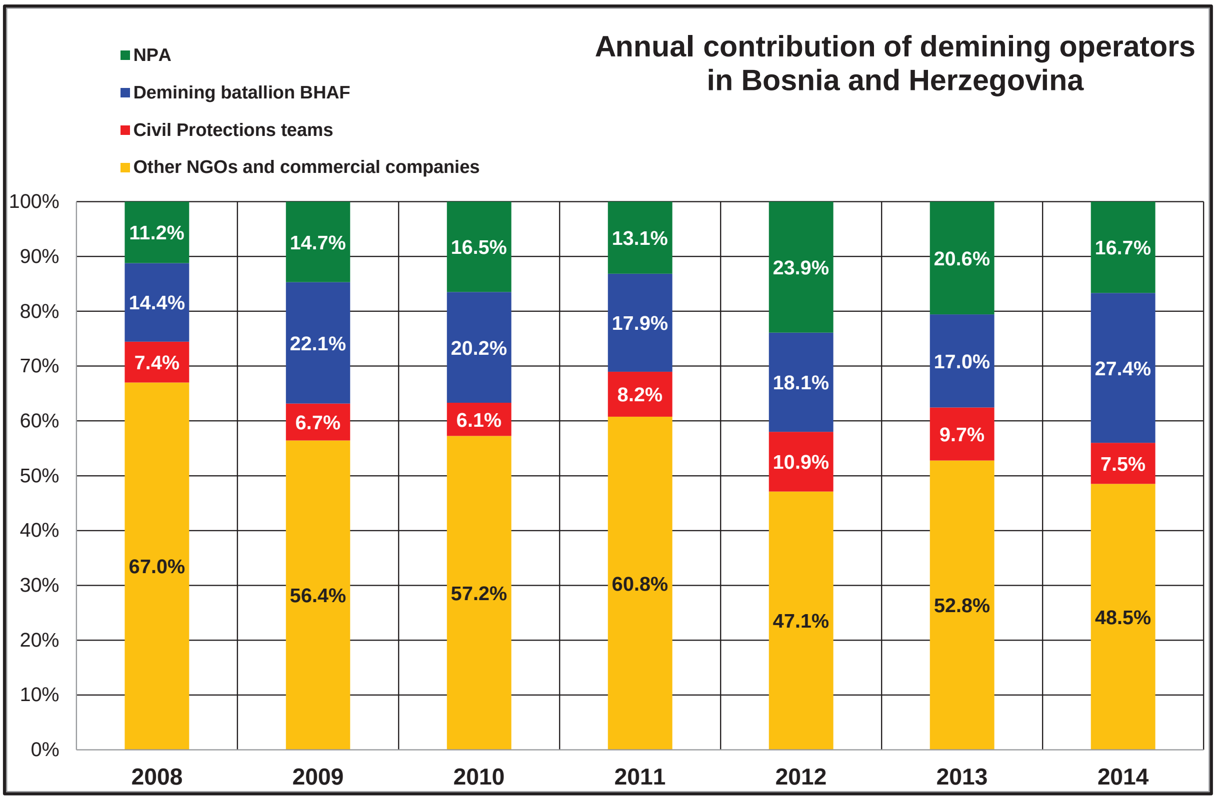
Year	Average number of found mines on demining tasks per ha	
	Demining battalion	Total in Bosnia and Herzegovina
2011	8.55	7.04
2012	18.37	7.50
2013	31.26	9.52
2014	21.47	10.99

Based on the both indicators above the evaluation team concluded that quality of Demining battalion work has been improved. In the period 2011-2014 Demining battalion had no demining incidents or accidents even though the operations were conducted on the sites where it has been found twice more mine than the average in Bosnia and Herzegovina.

According to the results of land release through technical survey and clearance in 2014, Demining Battalion is positioned as the biggest demining operator in Bosnia and Herzegovina, in comparison with other operators. In relative figures, Battalion contributed with 27.4%, NPA with 16.7%, and Civil protection teams with 7.5%. Other 8 NGO's and 5 private companies funded through commercial tenders contribute with 48.5%.



GRAPH 4: Contribution of Demining battalion, NPA and other organisations in land release through technical survey and clearance in BiH



GRAPH 5: Relative annual contribution of Demining battalion, NPA and other organisations in land release through technical survey and clearance in BiH

Conclusions

On 4th of June 2015, as part of the evaluation, a workshop "Evaluation of results of the Capacity Building of the Ministry of Defence – the Demining Battalion of the Armed Forces of Bosnia and Herzegovina 2010 – 2014", was held. The key findings and recommendations of the evaluation team were confirmed on the workshop. Their brief overview is given below.

Reduction of demining staff of demining battalion due to age limitation had negative impact on clearance productivity. Since 2011, the number of teams within the Demining battalion was significantly reduced due to the discharge of soldiers over 35 years, resulting that average deminer productivity in 2012 was 62.5% of previous year. Until the end of 2014, Demining battalion reach full capacity of 34 manual teams. Young deminers had reduced productivity in the first year of work, but after gaining some experience they achieved better results than the old deminers.

The existing Demining Battalion capacities for mechanical ground preparation are largely worn and outdated. In the medium term, it is necessary to plan the replacement of two machines. The existing system of maintenance of machines for mechanical ground preparation reflects negatively on machines productivity. The existing maintenance services system of machines for mechanical ground preparation that is reflected in the slow procurement of spare parts and their installation, negatively effects on productivity of machines, and should be improved. In regard to this it is necessary to establish a timely and continuous maintenance.

Since 2011, NPA provided 17 mine detection dogs in order to increase MDDs capacities within Demining battalion. NPA also organized several workshops and trainings for Demining battalion staff on applying of methods of technical survey with a significant use of dogs. It is obviously that Demining battalion needs more dogs in order to reach good balance and increase total outputs on more cost efficient way.

Occupancy of Demining Battalion with metal detectors / locators, is inadequate and prevents the full involvement of human resources. A significant number of existing detectors is obsolete. Priority procurement is 100% occupancy of demining teams with metal detectors / locators, and renewal with new detectors.

It is necessary to reinforce the capacities within the Demining Battalion for technical survey and clearance of areas contaminated with cluster munition remnants in order for Bosnia and Herzegovina to fulfil obligations under article 4 of the Convention on Cluster Munitions, as announced. Demining Battalion has three trained team for technical survey and clearance activities of areas contaminated with cluster munition. It is necessary to equip a team with magnetic locators in order to create conditions for the full involvement of all three trained team, which would lead to increase of productivity.

Transfer of NPA knowledge has positive impact on operational planning, application of working methods and productivity of Demining battalion. In total, 63 members of Demining battalion passed trainings and courses organized by NPA and upgraded their skills. It was concluded that NPA successfully transferred knowledge through improvement of project management, operational planning of mine clearance and technical survey operations, introduction of more efficient approach to use mine detection dogs and organizing various workshops and trainings for the members of Demining battalion.

Lack of synergy between different efforts on building of capacities of Demining Battalion provided by international organization and NGO's in Bosnia and Herzegovina. There is a need for improved coordination mechanism between all partners of Ministry of Defence that are included in building of mine action capacity within Armed Forces of Bosnia and Herzegovina.

Through NPA direct operational support and procurement of equipment Demining battalion was able to recoup partly reduction of staff and imbalance between human resources, mine clearance machines and mine detection dogs. Internal (Army) logistical support of field operation has serious negative impact on Demining battalion land release productivity in 2013 and 2014 and remains key obstacle for full utilisation of Battalion resources. Regardless lack of logistical support, Demining battalion is stable the biggest demining operator in BiH and capable to reach annual productivity on 5 km^2 with available human and material resources. With additional investment in equipment, machines, dogs and adequate logistical support and infrastructure, Battalion has potential in human resources for annual outputs more than 7 km^2 in two years.

Investment in Integrated Demining through Development Cooperation towards Sustainable Development

Jenny Oštarić Vunjak[1]

In the past two decades, the world has witnessed a significant increase in the number of natural and man-made disasters and crises. More often than not, these disturbances have mostly affected developing countries, from Latina America, Asia, Africa, the Middle East to our neighbourhood and Croatia itself through the Homeland War. In this time, development cooperation is faced with the challenge to fulfil its task in the context of crises, conflict and disasters, and it has become increasingly difficult and problematic to distinguish between sustainable development cooperation and emergency aid in international development cooperation. The mere fact that twelve United Nations Departments and Offices of the Secretariat, specialised agencies, funds and programmes have raised awareness of the interdependence of humanitarian demining and sustainable development through their programmes[2], should also be reflected in the way donor countries approach the goals set before the international community in achieving the 2030 Agenda[3]. Since 2010, in an effort to overcome these issues, Croatia has through development cooperation, commenced with the concept of Integrated Demining both through development cooperation and humanitarian aid together with the Croatia Mine Action Centre and the Croatian Mine Action Centre for Testing, Development and Training.

In many developing countries, landmines and explosive remnants of war[4] has grown into a significant obstacle to development, more particularly due to the manner in which landmines have been used in recent years that have an adverse effect on civilian populations. Their use ever increasingly deprives the civilian population of access to infrastructure facilities, schools, medical facilities, water resources, fisheries, waterways, agricultural past lands and deprives refugees of possible return to their homes. Developing countries, especially those with agricultural and agrarian infrastructures have been seriously confronted with development problems. However, the real extent of mining becomes visible after a conflict has ended, but as we have seen after the May 2014 floods, which affected

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2 These include: the United Nations Mine Action Service of the Department of Peacekeeping Operations, the Office for Disarmament Affairs, the United Nations Development Programme (UNDP), the United Nations Office for the Coordination of Humanitarian Affairs, the Office of the United Nations High Commissioner for Human Rights (OHCHR), the Office of the United Nations High Commissioner for Refugees (UNHCR), the United Nations Children's Fund (UNICEF), the United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women), the United Nations Office for Project Services (UNOPS), the Food and Agriculture Organization of the United Nations (FAO), the World Food Programme (WFP) and the World Health Organization (WHO).

3 A/RES/70/1 Transforming our World: the 2030 Agenda for Sustainable Development

4 Explosive remnants of war (ERW) refer to ordnance left behind after a conflict. Explosive weapons that for some reason fail to detonate as intended become unexploded ordnances (UXO). An abandoned explosive ordnance (AXO) is explosive ordnance that has not been used during armed conflict but has been left behind and is no longer effectively controlled. ERW can include artillery shells, grenades, mortars, rockets, airdropped bombs, and cluster munition remnants. Under the international legal definition, ERW consist of UXO and AXO, but not mines.

Bosnia-Herzegovina and Serbia, landmines and explosive remnants of war, can also affect the provision of humanitarian aid due to their dislocation. There is a clear connection between the necessity to clear landmines and other explosive remnants and measures to alleviate actual poverty of populations in mine-affected areas.

The mathematics is very simple in this case. In many instances, mines are very affordable – anywhere from $3 to $50, whilst to remove the same landmine it could cost 50 times as much. However, this is not the only cost: land cannot be used, traffic infrastructure cannot be used and hence there is a loss of trade at a national, regional and international level, and not to mention the cost of treating injured people from landmines. And then there is the social cost…Landmines are found along roads, in fields and forests, near wells and river banks. As a result, they can cause serious economic problems limiting movement of the population. If one were to take the case of Afghanistan or Cambodia, without the contamination of mines and explosive remnants of war in agricultural areas, agricultural production could more than double. On the other hand, Libya before the Arab Spring, had a contamination level of 27% of agricultural land due to the mines and unexploded ordnances left after the Second World War. What will be the final percentage after this conflict we are yet to find out. In Somalia, a country with one of the largest number of refugees and migrants coming to Europe in the last 10 months, mines have badly damaged grazing lands and water resources, leading to an out flux of working age civilians and placing a burden on donor countries in Europe.

And there is the case of delivery of humanitarian aid to countries. Usually, it would cost international humanitarian organisations approximately $150 to deliver a tonne of humanitarian relief in Africa[5]. Cases have shown that delivery humanitarian aid to Somalia and Sudan was well in excess of $2,000 per tonnes due to the fact that aid deliveries could not be done by roads or railways as they were mined and had to be replaced with air shipments.

And finally there is the medical cost. According to the Landmine Monitor 2015[6], 3,678 casualties were recorded in 2014, which represented an increase of 12% compared to 2013. Of these victims, 80% of the recorded landmine and explosive remnants of war casualties where civilian, of which 39% where children. Furthermore, women and girls made up 12% of all casualties in 2013. The highest casualties of which were recorded in Afghanistan, Colombia, Myanmar, Pakistan, Syria, Cambodia and Mali[7] [8].

Providing medical care when there is a war is very difficult, but landmine injuries create even greater problems bearing in mind that the surgery, which is required, is very difficult and expensive. Add to this problem additional costs if the injured victim is a growing child who may need artificial limb, or limbs, replaced every six months. Many developing countries have already very few facilities let alone facilities which would assist victims to lead normal lives let alone take care of their psychological problems due to their injury. In effect, landmine injuries place a great strain on a country's whole health system. Victims of mines need many types of assistance but if you consider only the cost of medical care, the cost associated with treating mine victims is very high. Victims need more antibiotics, more dressings, more blood transfusions, they need to stay longer in hospital and need rehabilitation programs. Resources needed to treat landmine victims can also take resources from other serious problems, such as transmittable disease which are creating chaos in the country. So if the Government cannot assist the victims in providing elementary health, families have no other resort than to go into

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5 Using the principle of the nearest point for purchasing relief items to the affected region.

6 Landmine Monitor 2015, International Campaign to Ban Landmines – Cluster Munition Coalition (ICBL-CMC), November 2015, pp.1 – 2; 25

7 Ibid, p. 26

8 Afghanistan recorded 1,296 casualties, Colombia – 286, Myanmar – 251, Pakistan – 233, Syria – 174, Cambodia – 154 and Mali – 144 casualties.

debt with probably very high interest rates. And what if the injured victim is the primary income producer for the household? The family goes further into debt, under aged children are forced into child labour instead of attending school, recruitment into terrorist groups or illegal activities, to the point when they migrate to other countries as refugees in a hope for a better life.

The financial and budgetary constraint to Government can be overburdening. What is even more distressing is that many countries confronted with the most landmines and explosive remnants of war are classified as Highly Indebted Poor Countries[9].

Moreover, this is where the international donor community should and must step in to end this downward spiral.

Integrated demining should become an integral part of rehabilitation and reconstruction efforts in development cooperation projects and are selected in accordance with development cooperation priorities, such as alleviating poverty, education, health, economic growth or even environmental protection. Though development cooperation objectives are at the forefront, demining components should never be independent but should be complimentary – a cross-cutting issue to say the least, and should be incorporated within specific framework conditions for implementation. If the presence of land mines or other unexploded ordnances hinder the implementation of development projects, special project components must be incorporated into the original concept to solve the problem. Such components may include mine risk education to populations, mapping of minefields or even mine removal actions.

Furthermore, it is often the case that demining activities are the prerequisite for refugees or displaced persons to return to their homes: it makes reconstruction possible after a catastrophe or war, establishes a supply structure, it makes it possible to the cultivation of farmland, assists local populations to develop self-assistance and overcomes their dependence of the population on the donor community.

Therefore, the main goal of integrated demining is to reduce the number of accidents caused by mines and other unexploded ordnances, reduce the permanent threat to life and health, create the necessary measure to allow freedom of movement (especially in emergency cases), increase self-help structures and reduce the dependencies for food aid through demining agricultural fields and/or irrigation.

In order to ensure success in Integrated demining, it is necessary to have active participation of the local community in the supply of information, the planning, organization and the implementation and the willingness of national, regional and local governments to resolve the mines issue. The latter is of significant importance to ensure that new landmines are not placed and that these levels of government assume the political and administrative responsibility of mine-cleared regions. Such cooperation is essential to ensure incorporation of such components in development cooperation projects and programmes. In effect, in the case of the after conflict, it is firstly necessary to clear transport infrastructure route (primarily road and rail) which is important to establish in order to provide possible humanitarian assistance to populations, and secondly, to clear minefield, especially those in the vicinity of villages and towns in order to prevent human casualties and immediate threats posed to communities.

9 Framework for action to resolve the external debt problems of heavily indebted poor countries (HIPCs) that was developed jointly by the IMF and the World Bank and was adopted in September 1996. The Initiative envisaged comprehensive action by the international financial community, including multilateral institutions, to reduce to sustainable levels the external debt burden on HIPCs, provided they build a track record of strong policy performance. Following a comprehensive review of the HIPC Initiative, a number of modifications to the Initiative was approved in September 1999 to provide faster, deeper and broader debt relief and strengthen the links between debt relief, poverty reduction, and social policies.

Sustainability and cost reduction can be reached through participatory and co-ordinated planning and distribution of tasks during the preparation, implementation and control of demining projects, training and employment of local mine-clearance personnel, and the use of adapted technologies.

In providing emergency assistance which is development orientated, it should comprise of all measures, initiatives and responses to emergency situations in crises, conflicts and disaster, as well as preventative activities in these fields and it takes action before, during and after crises, conflicts and disasters. It should seek key areas of work which are in key duel areas of prevention and recovery. Furthermore, in providing emergency assistance which is development orientated technical cooperation should be an integral part which observes technical cooperation guidelines and quality standards in its operations. In this manner, development orientated emergency assistance works in target related groups and participates in a manner in accordance with technical cooperation quality standards and promotes self-help by supplementing the efforts of the people and the governments in a sustainable and development orientated manner. It should be done with cooperation with third parties at both the national and international level, with government and non-governmental organisations (NGOs), scientific and academic institutions and the private sector.

The international donor community has been over the past 60 years has invested millions of trillions of dollars through development cooperation to alleviate poverty and hunger in many countries around the world. Successes have been recorded, but in many countries, due to wars and strife, backward steps have occurred. We have another 14 years to finally achieve this goal, which we can achieve if we address the core issue in these countries and implement Integrated Demining through our development Cooperation. With such an approach, Government would be able finally be able to address issues that have been put on the backburner due to landmines and explosive remnants of war.

The Transition of National Mine Action Capacities after Article 5 Compliance with the Anti-Personnel Mine Ban Convention[1]

Hans Risser[2], Christian H. Ruge[3]

ABSTRACT: State Parties to the Anti-Personnel Mine Ban Convention (APMBC) with Article 5 obligations face several challenges in complying with that Article and reaching a status of being free of all known mine fields as required by the treaty. But the challenges do not end with completion of Article 5 obligations. In this article, the authors consider what can be done with the national mine action capacity after all known mined areas are cleared and what sort of capacity will be needed in the future to respond to the inevitable residual ERW contamination. The case of Mozambique provides an example of how State Parties can prepare for the challenges of completion and plan ahead for the transition of their national mine action capacity.

Introduction

In June 2014, State Parties to the Anti-Personnel Mine Ban Convention (APMBC) met in Maputo, Mozambique for the 3rd Review Conference on the status of the Convention, fifteen years after the convention's entry into force. As the review conference approached, state parties faced a growing call from civil society and some state parties to 'commit to complete' as rapidly as possible all obligations in the treaty. The majority of state parties have already completed their obligations to destroy stockpiles of anti-personnel mines. But surveying and clearing all known mined areas in a state's territory in accordance with obligations under Article 5 of the treaty, is no easy task. Countries with heavy contamination will need decades to clear all their known minefields. But, considerable progress has been made and some states with moderate to heavy contamination are moving towards an end state. In 2015, Mozambique completed demining of the last known minefield in the country; an achievement that took approximately 20 years and not fifty to a hundred years like many believed would be required when it first started demining back in 1994.

1 Elements of this paper were originally introduced as a discussion paper to the 3rd Review Conference of the APMBC held in Maputo in 2014. The discussion paper asked the question, 'how can States Parties with Article 5 obligations prepare for the transition from a dedicated mine-clearance operation to a sustainable long-term capacity to address general explosive and UXO contamination?'

2 Hans Risser worked as the UNDP Chief Technical Advisor on Mine Action to the National Demining Institute in Maputo, Mozambique from 2011 to 2015. Since 2004, he served as a UNDP project manager and technical advisor for a variety of projects in Small Arms Control, Mine Action and Armed Violence Reduction. Hans holds a MA in International Policy Studies from the Monterey Institute for International Studies and a BS in Foreign Service from Georgetown University in Washington, D.C.

3 Christian H. Ruge is Senior Adviser at Norwegian Peacebuilding Resource Centre NOREF, and has worked with issues related to armed conflict, arms and security for more than 15 years. From 1997 he spent five years as landmine policy adviser with Norwegian Peoples Aid. From 2001 Ruge directed the New Security Programme at the Fafo Institute for applied international studies. From 2007 he was consultant to the Norwegian MFA on Mine Action, in particular on Norwegian support for Mine Action in Mozambique. He continued to directing the Arms programme at the International Law and Policy Institute. Ruge has a BA in social sciences and an LLM in Public International Law.

As more States with Article 5 obligations get closer to completion, governments and mine action stakeholders should consider certain issues that arise as a consequence. Completion of Article 5 obligations is a major achievement for mine-affected States, but in most instances it does not mark the final conclusion of explosive ordnance disposal in their country.

As President of the Third Review Conference, Mozambique facilitated a discussion during the Review Conference and at a subsequent regional meeting on how to prepare for the transition from Article 5 mine clearance to longer-term operations to address residual ERW. The objective was to identify policy recommendations that may be considered by States Parties to the convention.

The discussion focused on the following questions:

- How to secure optimal productivity up until the completion date?
- How can national authorities assist deminers to find other employment following completion of all demining tasks?
- How should national authorities prepare their mine action coordination structures and their demining staff for the post-completion situation?
- How to ensure that key personnel stay with the operations as long as is necessary to conduct closing and quality control operations and secure proper documentation of the efforts for future use?
- After Article 5 completion, how will national authorities identify and manage the hazard and risk posed by residual ERW?
- After Article 5 completion, what will happen to the national mine action database and will clearance records be utilized and updated to manage information on any residual ERW accidents and clearance activities?

In a longer perspective, many States will need to retain a long term capacity to address explosive ordnance in a rational way, and therefore need to consider how to best adjust their present mine clearance capacities and competence to such a situation. This article will review some of the challenges State Parties to the APMBC face in completing their obligation to clear all known mined areas, what can be done with the national mine action capacity after completion and what sort of capacity will be needed in the future to respond to the inevitable residual ERW contamination. The case of Mozambique provides an example of how State Parties and their international partners can prepare for the challenges of completion and plan ahead for the transition of their national mine action capacity.

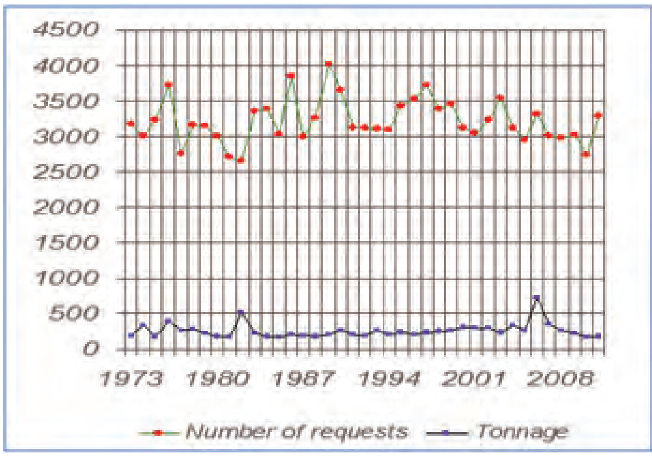
ERW contamination is not always a humanitarian crisis

Most states that have experienced sustained armed conflict over the last century will have some sort of explosive ordnance problem that needs to be addressed in a rational, transparent and systematic manner. Experience from Europe and other parts of the world that still contain areas contaminated with Explosive Remnants of War dating back to both World War I and II, indicates that this is a long-term problem, requiring a sustainable long-term national response.

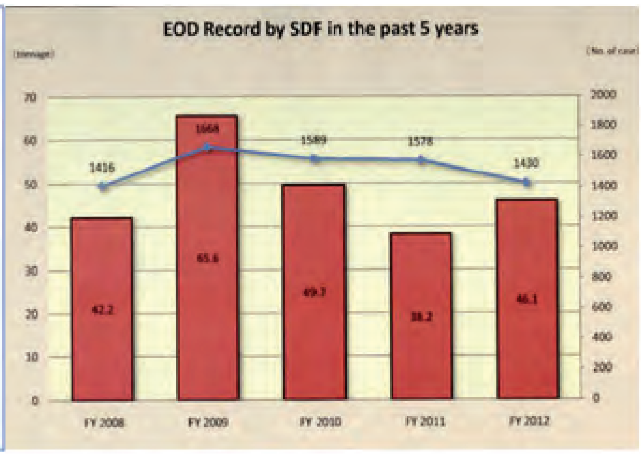
Immediately following the end of conflict, ERW contamination often poses a serious humanitarian problem hindering recovery efforts. In such cases, systematic, pro-active survey and clearance operations are required that are often led or assisted by international partners.

In most instances, the ERW contamination that remains following systematic clearance operations poses a limited humanitarian problem. Even after the best and most thorough clearance operations, a small residual risk will remain that a missed mine, UXO or previously unknown area may be identified after the end of clearance operations. However minor the residual risk may be, ERW contamina-

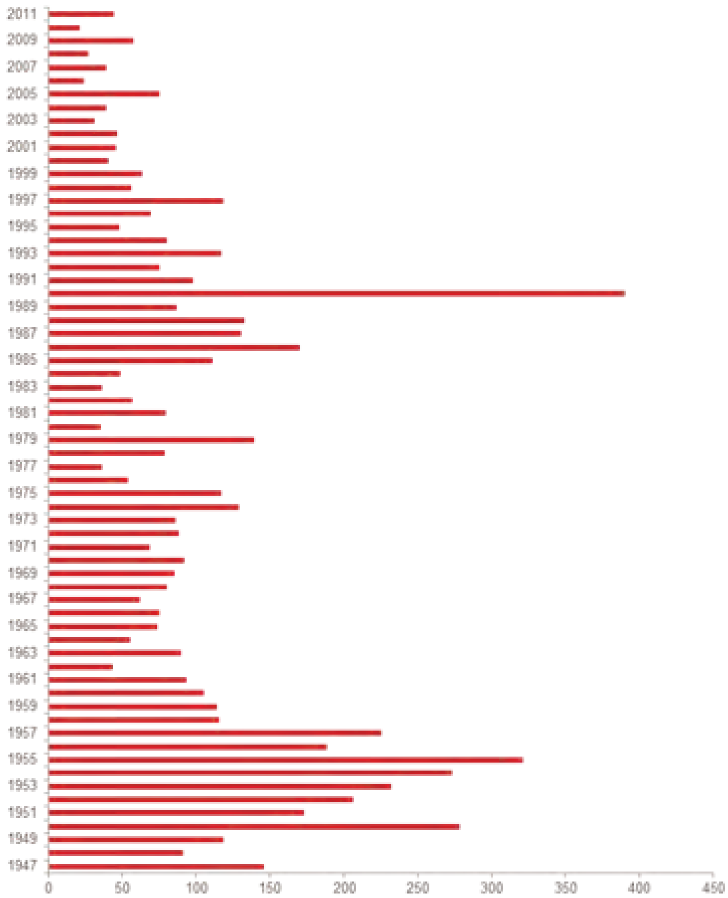
Belgium: Annual ERW Response



Japan: Annual ERW Response



Berlin: Annual disposal of unexploded ordnance disposed in metric tonnes 1947 – 2011



*Note: the above charts were provided by the GICHD's Management of Residual ERW Project.

tion does constitute a certain security and safety risk to the population, and it may hamper, and significantly increase the cost of infrastructure development. Explosive ordnance may also be a source for explosive materials for groups and individuals involved in criminal activities. It is thus a situation that needs to be addressed by the state, as part of its responsibility to uphold law, provide security for its citizens and maintain an enabling environment for development. A sustainable, national capacity is required to identify the risk from any residual ERW and manage the hazard posed to the population.

In order to prepare for this, many current mine affected states need to consider how to transition from a having a dedicated mine action centre to establishing a sustainable explosive ordnance disposal capacity.

Addressing the residual ERW problems

Addressing long-term ERW contamination requires a different approach and capacity than addressing mined areas. Mine clearance under Article 5 is essentially a proactive process involving relatively large numbers of survey and demining teams often supported by international technical advisors and international financial assistance. Whereas addressing the long term ERW problem in most states would entail a reactive process involving a smaller, more sustainable national capacity, where threats are identified by civilians and then responded to. It requires different timelines than the 5 – 10 years cycles provided by the Mine Ban Convention. With little or no realistic baseline against which progress may be assessed, it is also typically not possible to define a definite end-point.

Most States would need a robust reactive system for reporting, recording and responding to explosive ordnance, designed to function in a sustainable manner over decades. This may be the responsibility of one institution, but not necessarily. For instance, the competence required to set up and maintain a reporting and recording system that is trusted by the general public and all relevant stakeholders so that it actually is used is different from the competence needed to identify and render safe an unexploded bomb or grenade. Governments need to identify what role, if any, current mine action coordination structures should have in both the transition and the post- completion scenarios. Preparing for this transition to a post-completion scenario will ensure State Parties have a sustainable capacity to report and address the discovery of any previously unknown mined areas that may eventually be discovered after reporting compliance with Article 5.

Preparing for completion and transition

National authorities approaching completion of Article 5 obligations would benefit from taking a strategic view on how to prepare for both completion and transition within the same framework. In this process, one could look at the Article 5 deadline not as an end-point, but as an important milestone and transition-point in a long-term exercise that aims at maintaining a rational and effective response to the problem of explosive ordnance.

However, getting to completion is a major achievement in itself. One of the challenges of completion is maintaining the motivation and technical capacity required to ensure the demining is completed within the timeline set by the country's article 5 obligations. Previous experience in Mozambique and elsewhere has shown that productivity rates among deminers tend to decrease as they approach the end of demining operations. Knowing that the deminers are working toward their own unemployment poses a paradox where they may be tempted to extend demining tasks for as long as possible for their own economic self-preservation. The situation can be even further complicated when mine-affected communities benefit economically from the presence of demining teams (e.g. employment of local people or the provision of services to demining teams) creating an incentive for them to falsely report areas as mine suspected. Designing incentives and rewards to keep deminers and QA inspectors motivated, honest and productive until the end is an important issue to ensure demining does not fall behind schedule. Restructuring and retraining programmes and other incentives that assist deminers' transition to new employment following the completion of demining tasks could also be a means to keep deminers motivated until the end.

In the case of Mozambique, morale and motivation was kept high among the deminers through the organization of completion ceremonies for each province as it was completed, with special recognition given to the deminers involved. The government also encouraged the demining operators to incorporate re-training and education programmes as well as severance packages for the deminers into the operator's annual budget. Critically, the Government of Mozambique also discussed the situation with donors and encouraged development partners to support the retraining and education of deminers.

Mine affected States would benefit from assessing how their current mine action structures and resources, such as their technical staff, may be best used to support long term efforts. Considering the resources invested by both national and international actors to build national mine action coordination structures, it is worth understanding how these capacities can be retrained or re-focused for future use by the national authorities. The creation of a viable transition plan for mine action structures before all demining tasks are completed, can help to retain skilled employees and national capacities. In order to prepare for the departure of large scale international demining capacities and the transition of national capacities to a post-completion scenario, national mine action authorities should review and map the capacities and role of the mine action centre vis-a-vis national legislation on the national disaster management authorities and the control of the civilian explosives industry (i.e. the production, transport, sale, storage and licensing of commercial operators). Records of clearance operations will need to be maintained for future construction projects and to clarify any liability issues in case of future accidents. For many mine-affected countries, demining organizations in the field respond to regular reports from civilians for EOD spot tasks to remove explosive items as part of their normal mine action duties. Following Article 5 completion, the police authorities should be trained to assume this role and civilian population informed on how to report suspicious items. The role of information management of UXO and EOD information will still be required.

As an example, a transition plan for post-completion national capacity may include some of the following issues:

(i) Training of the police, military or civilian protection forces for small EOD spot tasks and accident investigation as an emergency response for public safety;

(ii) An authority to maintain a national database with information available to the public for liability issues or use in future construction projects that may require digging to depths below the depth of clearance established by the national mine action standard in previously contaminated areas;

(iii) Quality Assurance or Quality Control capacity for EOD or mine action related activities as well possibly to control the implementation of national legislation on the production, transport, and use of explosives in the civilian commercial sector;

(iv) A licensing and contracting authority for either commercial entities or NGOS to do future EOD spot tasks as required for residual ERW or clearance operations in a larger area if previously unknown mined areas are discovered; and

(v) provide advisory services to private investors and planning units or project management units in the ministries on how to arrange for any risk reduction and verification services (from local or regional firms or NGOs) that might be required for future private or public development projects.

In Mozambique's case, all the above issues were considered. With the assistance of the GICHD and UNDP, a transitional strategy was drafted for the management of residual ERW. This plan called for the transition of the Mine Action Centre into a training facility and depository of best practice, which will be used to train and equip police officers in each province in basic EOD. The national database and all mine clearance records will be handed over to the state authority that manages land where it

Trainers from the Mozambican National Demining Institute and US AFRICOM conducting EOD training in Inhambane Province, September 2015. [Photo Credit: National Deming Institute of Mozambique]

will be maintained and used by anyone seeking to build or develop an area. Starting in 2014, the National Demining Institute partnered with the US military's AFRICOM to train and equip a team of Mozambican trainers, who would later train provincial police officers in ERW identification, risk analysis and basic level 1 explosive ordnance disposal. AFRICOM and the National Demining Institute developed a core curriculum and began training police officers, with an aim to have a small team of police trained and equipped in each province to manage residual ERW after the demining operators completed the survey and clearance of all known mined areas. With the support of AFRICOM and UNDP, the trainers from the National Demining Institute successfully trained and equipped more than 124 police officers across all of the country's 10 provinces by the end of 2015.

Donors to mine clearance efforts may also benefit from considering how to structure their support in a way that facilitate efficient and effective resource use while retaining the national capacities established with their support. In the case of Mozambique, the National Demining Institute and international demining operators began discussions with donors early on transition plans and retraining for deminers. This early focus on the transition process secured the support of some donors and the critical funding for these long-term transitional efforts. Structuring international support for this transition period may address claims by previously mine-affected State Parties that financial assistance to address UXO and ERW issues stopped immediately after declaration of Article 5 compliance. While Article 5 compliance may signal the end of active demining operations, international support and assistance can and should be used for the establishment of a sustainable national capacity that shifts its focus to other ERW priorities such as a response to residual UXO, explosive storage stockpile management or the clearance of other areas contaminated by ERW other than landmines.

The clearance of all known mined areas in a previously landmine contaminated country is a monumental achievement with many benefits. But it is by no means the end of ERW work in a country. It should also not mean an end to support to landmine victims. Important work will continue long-after the last minefield is cleared. Governments, international partners and demining operators should careful consider what it will take to clear the last mine, but also what comes afterwards. In most cases, a great national capacity was built to achieve this goal and that capacity should not be entirely lost. Rather it should be refitted and repurposed appropriately for the continuing needs of the country.

The Center for International Stabilization and Recovery (CISR) Upcoming Senior Managers' Courses (SMC) in 2016:

2016 Regional SMC for Europe

Dates: October – with specific dates to be confirmed soon.

Location: To be held in Croatia, in partnership with the Croatian Mine Action Centre (CROMAC).

Countries for the 2016 Regional SMC are: Albania, Armenia, Azerbaijan, Bosnia & Herzegovina, Bulgaria, Croatia, Georgia, Kosovo, Macedonia, Moldova, Montenegro, Serbia, and Ukraine

To Apply: For more information on the Regional SMC and how to apply, contact the SMC Administrator at smc.jmu@gmail.com or visit our website at http://www.jmu.edu/cisr/programs/training.shtml

Applications will be available starting May 1, 2016. Course dates will be confirmed at that time.

What is the SMC?

CISR, working in collaboration with faculty from JMU's College of Business (COB), specializes in management training for leaders in humanitarian mine action around the world. The SMC in Explosive Remnants of War (ERW) and Mine Action seeks to integrate the latest thinking in the field of business management with the practical experience of ERW/mine action operators. The goal is to hone the skills of senior managers of national programs so that countries can more effectively and efficiently clear their lands of landmines and other ERW that adversely affect their citizens' well-being and impinge upon economic development. To date, CISR has trained 226 senior managers representing 40 countries through the SMC program.

"*The course covered all necessary aspects of management that a manager need[s] to know to be effective.*" – 2015 Regional SMC Participant

"*The course was very valuable in all aspects, the professors were very well prepared and clear to understand. I learned a lot*." – 2013 Global SMC Participant

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2016 Global Senior Managers' Course in ERW and Mine Action at James Madison University

Dates: 23 May – 10 June **No longer accepting applications**

Countries for the 2016 Global Senior Managers' Course are: Afghanistan, Angola, Colombia, Democratic Republic of the Congo, Iraq, Laos, Lebanon, Libya, Marshall Islands, Palau, Senegal, Solomon Islands, Somalia, South Sudan, Sri Lanka, Tajikistan, Turkey, Vietnam, Yemen and Zimbabwe.

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JAMES MADISON UNIVERSITY. CISR Center for International Stabilization and Recovery

COLLEGE OF BUSINESS JAMES MADISON UNIVERSITY

hcr HRVATSKI CENTAR ZA RAZMINIRANJE

The Role of NGO "Croatia Helps" in Mine Action in Croatia

Mine Risk Education and Victim Assistance

Đurđa Adlešič[1]

HRVATSKA POMAŽE

UDRUGA ZA PODRŠKU I POTICANJE ZAJEDNIŠTVA HRVATSKA POMAŽE

I. Introduction

City of Zagreb has, among others, initiated the establishment of the Association for the support and encouragement of community "Croatia helps". The founders are the cities of Zagreb, Dubrovnik and Osijek. Constituent Assembly of the Association was held on 14 October 2014 so the City General Administration Office of the City of Zagreb on 22 October 2014 issued a decision on registration entry into the Republic of Croatia Associations register.

The Association for the support and encouragement of community "Croatia helps" was established in order to promote common interests and enhancing cooperation between the towns in the Republic of Croatia, particularly cooperation regarding the improvement of the economic and social development among their communities.

This Association in accordance with its objectives, operates in the field of protection and promotion of equality and peace, the fight against violence and discrimination, the promotion and development of volunteering, humanitarian activities, sustainable development, local community development, international development cooperation and the development of democratic political culture.

In order to achieve these objectives, the Association will also perform organizational and mine action assistance activities in the Republic of Croatia, along with other previously mentioned activities.

II. Education

a) For the purposes of the Croatian Hunting Association

The Association for the support and encouragement of community "Croatia helps", as the leader of the Project, in cooperation with the Croatian Mine Action Centre and explosion-protection Department of the Croatian Ministry of the Interior, organizes and provides Mine danger education for the Croatian Hunting Association and their members.

[1] president of the Association

This project aims to, though training and providing information, increase the level of knowledge about the mine dangers, subsequently preventing the incidents of hunters and other interest groups along the mine suspected areas, as well as to advise the target group about Mine Action and mine dangers on Croatian territory.

Noted education about the mine dangers is especially organized in the Counties and areas contaminated by mines and explosive remnants of war.

On 10 June 2015, an education about the mine dangers has been held in Zadar municipality, inside the premises of the Hunting Association of the Zadar County. Pursuant to the curriculum the following topics were covered: Mine dangers Programme, Main features of mines and unexploded ordnance, Mine action in Croatia (Basic features of mine suspected areas, risky and proper behavior in hazardous areas, How to use CROMAC MIS portal and Mine victims in Croatia – civilian casualties with reference to the hunters suffering) and in addition, latest data on the topic of Mine victims in the Republic of Croatia.

Mine risk education for members of the Croatian Hunting Association of the Zadar County

The next day, on June 11, 2015, identical training was organized among hunters of Šibensko-kninska County, in Skradin municipality. During this occasion, topics similar to ones as in Zadar municipality were covered, taking into account the specific characteristics of the National Park "Krka" area and the surrounding land.

On Saturday, 13 February 2016, at the premises of the pheasant farm of the Hunting lodge in Darda municipality, the education about the mine dangers, unexploded ordnance and their elements was held for hunters of Osječko-baranjska County and Croatian Hunting Association members. Education was carried out according to the plan and program, as in previously provided trainings.

Educational specificity for members of the Croatian Hunting Association, as the target group, is the presentation of mine suspected areas along their hunting grounds, with an emphasis on the class and type of mines that are located in their immediate vicinity during the hunt. Also, hunters were familiarized with the specifics of mine explosion (zone of burst and lethalness effect) in the vicinity of

Mine risk education for members of the Croatian Hunting Association the Šibensko-kninska County

Mine risk education for members of the Croatian Hunting Association of Osječko-baranjska County hunting area, control and supervision of hunting dogs that can enter the mine suspected area and cause an explosion of tripwire mines, displacement of mines by poachers and the position of mine warning signs inside hunting operational area. In addition to lectures and presentations, hunters were also introduced with many educational mine-explosive devices which can be found in the minefields around the Croatia.

b) For the children from Gunja village

At the initiative of the Association for the support and encouragement of community "Croatia helps", in cooperation with the Office of the Mayor of the City of Zagreb and the Red Cross of the City of Zagreb, summer vacation for 50 children (from Gunja, Rajevo selo and Podgajci) out of the areas affected by floods in 2014, was organized from 20-27th of June 2015, in Novi Vinodolski Resort, owned by the Red Cross of the City of Zagreb.

During mentioned summer holidays, children were visited by Zagreb Mayor Milan Bandić, where he was greeted by their singing and dancing. Mayor wished a good time and cheered them with lovely news and the promise that this year, Zagreb would provide free textbooks to primary school pupils and secondary school students in Gunja, Rajevo selo and Posavski Podgajci villages. Apart from the Zagreb Mayor, the children were visited by his deputy Vesna Kusin, president of the "Croatia helps" Đurđa Adlešič, Mayor of Gunja municipality Hrvoje Lučić, Mayor of Novi Vinodolski municipality Oleg Butković, director of the Red Cross Zagreb Peter Penava and secretary of the Croatian Football Association Zorislav Srebrić as well, who has also brought gifts – Croatian national football team balls.

As part of the noted holidays, during the Friday, June 26 2015, in cooperation with the Ministry of the Interior of the Republic of Croatia, a lecture on protection from ERW has been organized. On this occasion, school age children were presented with the dangers of finding an explosive remnant of war or firearms, including direct contact with unfamiliar objects, all with a purpose to prevent possible incidents. Children very closely followed the lecture during which have, among other things, shown interest about the use of pyrotechnic products.




c) For the children from Srebrenica municipality

City of Zagreb and the Croatian Red Cross, the Red Cross of the City of Zagreb, organized a holiday for children from Srebrenica municipality, from Bosnia and Herzegovina, from 13 to 20 July 2015, in the Red Cross of the City of Zagreb resort in Novi Vinodolski.

As part of the holiday, during Thursday, 16 June 2015, at the request of the Red Cross of the City of Zagreb, the Association in cooperation with the Ministry of the Interior of the Republic of Croatia and the Croatian Mine Action Centre organized a lecture on ERW protection.

School age children were familiarized with the dangers of finding an explosive remnant of war or firearms, including direct contact with unfamiliar objects, all with a purpose to prevent possible incidents.

d) For the Ukrainian children

At the initiative of the Association, in cooperation with the City of Zagreb, GDCK of the City of Zagreb and the Embassy of Ukraine, a group of 50 children, mostly refugees from the territory of Donetsk and Lugansk Ukrainian County, summered in the Red Cross of Zagreb resort, in Novi Vinodolski, from 27 August to 7 September 2015.

Children were visited by Zagreb Mayor Milan Bandić as a host, Ambassador of Ukraine, HE. Oleksandr Lavchenko, president of the “Croatia helps” Association, Đurđa Adlešić and the director of the Red Cross, Peter Penava.

During the holiday in Novi Vinodolski, Association “Croatia helps” organized an educational lecture about the Mine dangers, since the children came from war affected areas.

Moreover, along with numerous educational activities, amusement and games, the Association, during the mentioned visit, organized a visit to the island of Cres, where children could see birds of prey shelter on the Prvić island and take a sightseeing boat trip around Novi Vinodolski archipelago. Finally, on their return trip to Ukraine, little Ukrainian guests were greeted and hosted once again, at the “Bundek” lake, by the Zagreb Mayor Milan Bandić.

e) For the Instructors

The Association “Croatia helps”, in cooperation with the Croatian Mine Action Centre (CROMAC) and the Ministry of the Interior of the Republic of Croatia, organized a training of Instructors for the purposes of the “OSA” – Special Police Units Association.

III. Demining

Within its Statutory obligations, mentioned at the beginning of this paper, the Association is also engaged in activities to raise funds for demining of certain parts of the Republic of Croatia.

At the donor lunch, held during the “ATP Umag” tennis tournament, under the high patronage of the Croatian President Kolinda Grabar-Kitarović, funds for demining the parts of Ličko-senjska County, were raised.

Association “Kroatienhilfe Hochtaunus” e.V. from Bad Homburg, Federal Republic of Germany, through the “Croatia helps” Association, also contributed funds for demining of Ličko-senjska County.

As can be seen, the aforementioned three donations were intended exclusively for Ličko-senjska County areas, which is affected with the largest mine suspected area in the Republic of Croatia.

So, raising funds for Mine action in the Republic of Croatia will continue to be in the future work of the Association.

IV. Summary

Since its establishment, the Association for support and encouragement of community “Croatia helps”, whose founders are the cities of Zagreb, Dubrovnik and Osijek, from October 2014, as part of its activities, particularly focused itself on mine action assistance in the Republic of Croatia. This activity was related to the two basic tasks: funds rising for demining of certain parts of the Republic of Croatia and education of the population about the landmines danger.

Educational activities of the Association are aimed at the specific target groups (children and hunters) and the Instructors, who will in the context of their acquired knowledge, conduct training toward other interest groups.

HRVATSKA
POMAŽE

Cluster munitions threat elimination through communication with the local community

Smiljan Galić[1], Igor Rebac[2], Josip Čerina[3]

ABSTRACT: This paper presents a model of communication with the local community in addressing the cluster munitions dangers. The research has been conducted in the case of cluster munitions endangerment and connected procedures for the citizens in the town of Šibenik. The analysis showed that the determination of threat arises from the local community reports. Consecutively, responsible authorities react with a goal to eliminate the ERW danger and provide preventive marking of the area along with informing the general public through media and representatives of local authorities directly. The following assessment of the extent of area contaminated by cluster munitions is the authorized responsibility of the CROMAC. When the hazardous area is precisely defined, local authorities are informed in writing about the designation of this area as the mine suspected area, while the general public is provided with the same information through CROMAC web pages. The procedure of cluster munitions endangerment elimination starts by demining activities and finishes on the Certificate issuance coupled with special regard on maintaining the communication with the local community. Furthermore, it has been shown that the public informing media have an important role in the elimination of cluster munitions dangers procedure along with CROMAC continuously being main source of the information. Dissemination of information is necessary during all stages of the cluster munitions danger removal and mentioned communication contributes to civil security.

KEYWORDS: communication, the danger of cluster munitions, the media, local community

1. Introduction

Multiple rocket launcher M-87 "Orkan"[4] usage is primarily the main source and origin of the cluster munitions contaminated area problem in the Republic of Croatia. Defining the area contaminated by the cluster munitions is being carried through different models with regard to ammunition type (Creighton, M., Karlsen, A. and M. Qasim, 2013; Evans, 2015). After the position of the single asset (KB-1) has been detected, trough mathematical model based on the individual rocket, an area of 118,800 m^2 is designated as the one which needs technical review in order to completely eliminate the risk (Šimunović, 2015). During the Homeland war (1991.-1995.) enemy army has frequently used rocket launchers "Orkan" to attack the area for which they suspected of being used by the Croatian

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4 The system consists of a vehicle with 12 launching tubes, fire management system, 262 mm rocket and the side vehicle that carries two combat missile sets. Rockets with cluster warhead, which contains 288 cluster bombs, activate at a height from 800 to 1000 m. Surface contamination is about 2 hectare and a lethal radius of action for each bomblet is 10 m. These cluster bombs (KB-1) are also called bellflowers in the jargon.

Army for accommodation or gathering before combat actions or indiscriminately bombed the settlements in retaliation, such as the case of city of Zagreb shelling, after the military operation "Bljesak" was conducted. The Republic of Croatia, as a signatory to the Convention on Cluster munitions, has obligated itself not to use, produce or store cluster munitions, and to have the cluster munitions contaminated areas cleared for the safe usage.[5] One of the most important benefits of the Convention is its preventive role. States oblige themselves not to produce cluster munitions, to destroy their stockpiles and to clean contaminated areas.[6]

The area contaminated by cluster munitions is a specific area as compared to systematically mined area. The main feature of mentioned area is the lack of identical dispersion of ammunition during the cassette rocket opening, which is due to the position from which the rocket attacks are carried out, the location of the target, weather conditions and driving pressure at the opening of the cassette. However, the biggest problem is the lack of records on the number of rockets with cluster munitions used and their targeted area. In most cases, the position of finding an individual asset (KB-1) was due to report of the local population and further action in defining the contaminated area. This paper will show the chronology of defining the cluster munitions contaminated area on the example of the city of Šibenik, with special emphasis on the importance on maintaining communication with the local community.

2. Cluster munitions contaminated area definition on the example of the town of Šibenik

In the perimeter of the city of Šibenik, there were several areas where cluster munitions were found. These were, besides the city center, that includes an old town and Šibenik general hospital, which was under attack, areas closest to the settlements such as the ones in the northern city district Šubićevac and the eastern areas around city cemetery Kvanj. Croatian Mine Action Centre is responsible for communicating with local citizens and local government, and provides a permanent access to information. Communication in the affected communities should aim to promote safe behavior in the mine suspected areas and systematically warn about the risk that outcomes from the irresponsible behavior when explosive remnant of war is found. (Čerina and Zgrabljić, 2009; Čerina 2012). This type of communication is most appropriate using local media through which the affected population quickly and easily gets informed about the extent of contamination of certain areas and the past activities of mine action, as well as to acquire education about safe behavior in the vicinity of mine suspected areas.

2.1. Kvanj area[7]

On 27 July 2002, the area of Kvanj hill, around Vrsina vicinity was affected by a heavy wildfire. During the remediation of the fire site, thirty locations, where explosive materials known as KB-1 or so called *bellflowers* were found, have been marked. Wider area was rapidly and preventively marked to avoid

[5] The Republic of Croatia signed the Convention on December 3rd 2008, entering into force on August 1st 2010.

[6] Results monitoring the international Convention on Cluster Munitions signatories are conducted through Review Conferences on Cluster Munitions. The first conference was held in Dubrovnik, from 7-11. September 2015. It was highlighted that the implementation of this Convention was only the beginning of efforts to be carried out as cluster weapons are a major problem for the civilian population long after the end of armed conflicts (https://mine.gov.hr/prva-pregledna-konferencija-konvencije-o-kazetnom-streljivu-dubrovnik-7-11-rujna-2015/1350, 23.02.2016.).

[7] CROMAC archive: preventive action, determination of status and danger prevention.

casualties and a designated employee of CROMAC has been placed to collect additional data. The first information about the explosions inside the fire affected area came from members of the Fire Department. Further analysis of the field collected data by the police and residents of nearby settlements provided the information necessary for the definition of the area. During the field inspection, CROMAC employees contacted people from the local community who are in possession of olive groves in these hazardous areas. At the stage of collecting additional data, one of the contacted people has showed to CROMAC employee a position where he saw KB-1 bomblet. Special attention was paid to the discovery of possible missile launching locations to determine the direction of the "Orkan" cluster missiles flight paths, which hold a decisive influence on the dispersal of cluster munitions. After confirming the information on reasonable suspicion of contamination in the area, precise definition of the area that will later be the subject of the project, has been started. Based on a comprehensive analysis of the collected data, areas contaminated by cluster munitions have been defined. In the subject area of 361,567 m², 66 pieces of cluster ammunition KB-1 were removed. They were mainly found in the areas that have been a neglected olive groves and vineyards. Afterwards, the Certificate of demining has been issued and committed to the city of Šibenik, while the public was informed through the local media on completion of demining activities and safe usage of officially examined surface. However, after four years, the owner of a neighboring, derelict, olive grove reported a finding of one cluster ammunition KB-1 bomblet. Subsequently, explosion protection service employees of the Police Department made an on-ground intervention, eliminated the identified ammo, and informed CROMAC about the case. This situation required urgent preventive marking and informing the local population about the need for additional demining activities. The collected data has opened doubts about the existence of additional quantities of cluster ammunition in mentioned area. A new hazardous area, which is partly leaning on a previously demined area, contaminated by cluster munitions, has been defined. Additional demining project of 87.780 m² in size, has been created, which resulted with the removal of 19 pieces of KB-1, so Kvanj area was finally cleared of cluster munitions.

2.2. Šubićevac district[8]

This area is defined as a densely populated northeastern part of the city of Šibenik, and has been, on several occasions, attacked with the "Orkan" rocket launchers. Foremost information about the existence of the cluster munitions danger in the Šubićevac district area, CROMAC has received from the reports of cluster munitions activation during the construction works for a residential complex. According to the operator of the construction machine, in September 2007, while loading soil in the truck, an explosion occurred. The activities were immediately stopped and the worksite leader was informed, who afterwards called the Explosion protection forces. The established system of mutual information exchange between Police and CROMAC required the initiation of the process of defining the ERW contaminated area. On the basis of this information, preventive marking was carried out and for the safe performance of the building works, demining project in an area of 4,000 m² has been created, along with simultaneous procedure of collecting additional data. Inside above-mentioned area, six pieces of cluster munitions have been found, which also suggested potential risk in the surrounding surfaces. As it was populated neighborhood, because of possibility of incidents connected with contractors or citizens, it was necessary to act swiftly. Preventive marking has been conducted at a wider area and left in visible positions, access roads and trails, until the degree of the cluster munitions danger has been established. 46,000 m² of new hazardous area has been defined and the public was accordingly informed throughout the local media. During demining activities, large amounts of ERW have been found: 16 pieces of KB-1, 5 pieces of air bombs from II. world war, two RB M35 gre-

8 CROMAC archive: preventive action, determination of status and danger prevention.

nades, several 7.9 mm ammunition pieces and one artillery shell. The last information connected with this area was reported on December 10, 2015, about KB-1 finding. According to information from the Department for Explosion protection of the Šibenik-Knin Police Department, reported location of mentioned finding was in the area located about 200 meters from the previous project, the Jamnjak territory. After the destruction of this cluster bomblet by the police deminers, the location of the finding was delivered to CROMAC. CROMAC employees immediately and preventively marked the wider area around the location of finding and the procedure for additional data collecting about cluster munitions bombing has been initiated. After the finalization of data collecting procedure, the hazardous area of around 60,000 m^2 was defined and precisely marked with signs of danger from unexploded ordnance, while the public was informed through the media.[9]

3. The role of communication with the local community

The active involvement of local community in Explosive Remnants of War (ERW) data collecting, conducted by CROMAC, increases in importance with time that has passed from the end of the Homeland war. Already in the first steps in defining the area contaminated by cluster munitions, CROMAC staff must rely on the local community, as opposed to the case of defining systematically mined areas where this is not a critical requirement. In systematic mining the first step is to analyze the data from military sources such as databases of the mined area logs, war cartography, communication with military units active in those areas, however the same can not be conducted for surfaces contaminated by cluster munitions since the first information typically comes from eyewitnesses of the local community and witnesses of war events of the area in question. The information path about individual KB-1 finding goes from eye-witness to the police or CROMAC, rarely from an eyewitness through a unique National Protection and Rescue 112 number according to the police or CROMAC. Hence, the first step in defining the area contaminated by cluster munitions is a direct communication with the person who found the ERW or has knowledge about the removal activities during the war time. Explosion protection service employees destroy the discovered remnant on site and provide the information about the position (coordinates) of the finding to CROMAC. Also, when citizens sometimes stumble upon ERW they provide this information to National protection and rescue directorate in which case such information is forwarded to the police and CROMAC. After determining the position of the finding, a preliminary analysis of the CROMAC database is carried out with the purpose of defining a safety belt that should be marked with ERW danger signs according to preventive marking process, after which warning signs are being placed. Furthermore, procedure involves informing of local government and media in order to prevent panic in the community but also, at the same time, urge the local population to cooperate in the process of collecting data relevant for the precise determination of the cluster munitions hazardous area. Information is collected about the time of the rocket attacks, possible location from where the rocket attacks were carried out, Civil Defense activities and Police and Military units that operated during the war.

Particularly important are the information about the eyewitnesses and participants of cluster ammunition removal shortly after the attack ended. Finally, local population that was present during the rocketing attack or now works or lives around mentioned area has a special role in the process of collecting this important data.

[9] Due to unexploded "bells" olive harvest and asparagus on Jamnjak becomes a dangerous sport, http://m.sibenik.in/sibenik/zbog-neeksplodiranih-zvoncica-berba-maslina-i-sparoga-na-jamnjaku-postaje-opasan-sport/53124.html; Unexploded "jingle" in Šibenik, a town with a mine free certificate, http://www.hrt.hr/315364/vijesti/neeksplodirani-zvoncici-na-podrucju-sibenika-grada-s-potvrdom-da-je-ociscen-od-mina

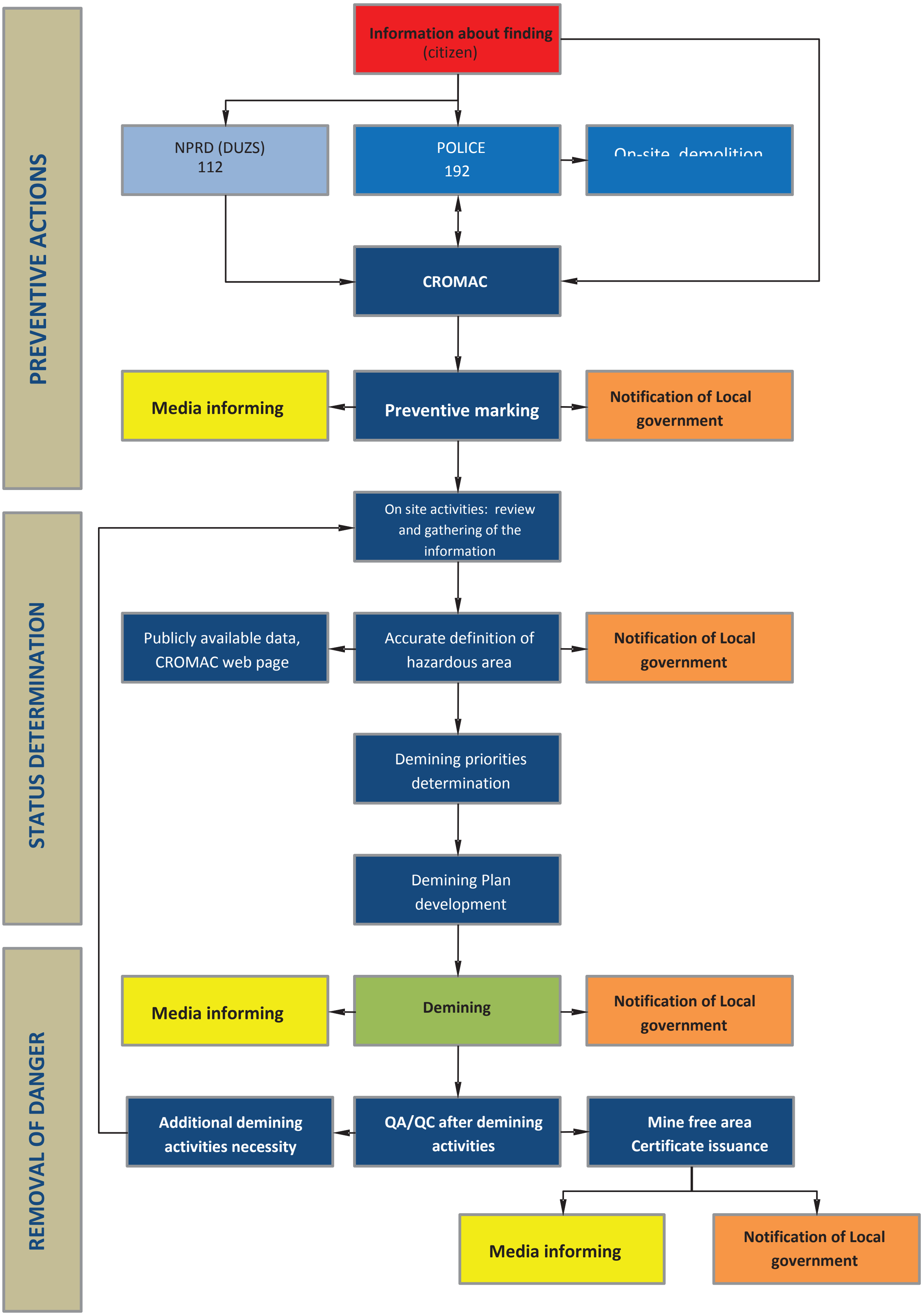

FIGURE 1: Model of communication with the local community in eliminating the threat of cluster munitions

After precise determination of the cluster munitions contaminated area, related information is also publicly available at the CROMAC website. Available data is published with intention of warning citizens about the extent of hazardous area for which they are as individuals interested. At the same time, the local government is notified in writing about inclusion of the areas inside their administrative units in the mine suspected area. During the next step of the ERW danger removal system, a part or whole area is being defined as a priority for demining activities. Related demining project includes instructions that need to be obliged, and this segment requires communication with the local community as well. This is especially the case when it comes to private land ownership where demining machines are used because their actions change the contents of the area (damage trees, grinding vegetation and stones, damaging the boundary between the plot and similar). Therefore, the project incorporates special attention instructions during demining activities so no additional, needless damage to the local population is incurred. After project design and the public tender competition completes, third communication phase, that includes information about the start of ERW demining activities inside the administrative area of the local government, starts. At this stage, information is provided to the media about the start of the process and ongoing demining activities. Local media is especially important in this form of communication, because they are trying to gain the attention of members of the local community, which in this particular case are also an interested party in the demining process. Also, besides media, official protocol is as well used to inform the local administration on the introduction to demining operations and the start of demining activities. Communication during demining activities is the responsibility of CROMAC employees that also supervise the operations. So prerequisite for successful execution of the determined tasks is maintenance of the communication quality, which is important for good cooperation during the additional data gathering procedure. After demining activities finalization, a final quality analysis of the ERW removal project is conducted with the purpose of determining the need for additional activities or to conclude that the danger of cluster munitions has been removed through defined project. Location of finding of an each KB-1 bomblet directly affects the necessity for additional demining operations. If these findings are concentrated on the edge of the cleared area, mentioned event will require the expansion of the project area to the adjacent surface in order to completely eliminate the risk. Practice shows that for surfaces which are not defined by mathematical model related to single cluster munitions rocket, additional demining activities and the expansion of the project area often occur. In regard to this situation, it should be emphasized that the preventive marking after the first alert and finding includes this possibility and it usually covers mentioned area as potentially suspicious. If there is no need for additional activities, danger sings are removed from the surrounding area. After successful completion of demining activities a Certificate of mine free area is issued implying the exclusion of the project surface from mine suspected area. Noted Certificate is also mandatory to be delivered to the local government. Moreover, it is recommendable to provide the media with the information about the completion of the demining activities, all in a sense that the local communities are promptly informed about the danger removal and possibility of a safe usage of the cleared area.

4. Conclusion

The use of cluster munitions during the Homeland war was aimed at targeting potential military unit's residence areas or settlement areas motivated by retaliation after the Croatian forces performed liberating actions. Mentioned case was recorded in the city of Šibenik which has repeatedly been targeted by enemy cluster munitions missiles. It has been shown that, after a rocket attack, cluster munitions were removed from surfaces within the residential areas, but on the outskirts and further away from the city area practically weren't, so the information's about finding a particular cluster munitions on the ground were invaluable in the further process of defining hazardous areas. Moreover, ERW finding in the vicinity of an inhabited area typically attracts media attention and triggers a series of reactions in the local web portals and print media. Special attention is paid to preventive marking and informing the public about the dangers through local media. When deminers appear at particular area and demining activities start, the locals react and interaction becomes more common, which contributes to a better determination of the area which needs to be inspected. The procedures that were used for data collection and informing of the local community have been developed in accordance with the requirements for more accurate validation of input data, which is the basis for creating the assessment of the contaminated hazardous area. For this purpose, primary communication with employees of the Explosion protection service at the County level was established, which enables CROMAC to be notified about each information or a tip in sense of further action commencement, consequently aimed on complete removal of the ERW threat in the subject area.

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Komuniciranje s lokalnom zajednicom u otklanjanju opasnosti od kasetnog streljiva

Smiljan Galić, Igor Rebac, Josip Čerina

SAŽETAK: U ovom je radu predstavljen model komuniciranja s lokalnom zajednicom u procesu rješavanja opasnosti od kasetnog streljiva. Istraženo je postupanje u slučaju opasnosti od kasetnog streljiva za građane grada Šibenika. Analiza je pokazala da utvrđivanje opasnosti počinje dojavom iz lokalne zajednice. Nadležne službe izlaze na teren radi uništavanja EOR-a i preventivnog obilježavanja te se o tome obavještava javnost preko medija, a predstavnike lokalne vlasti neposredno informira. Slijedi utvrđivanje opsega onečišćenosti prostora kasetnim streljivom za kojeg je ovlašten i odgovoran HCR. Kada se precizno definiraju onečišćene površine, obavještavaju se predstavnici lokalne vlasti pismenim putem o uključenim površinama u minsko

sumnjiv prostor, a javnosti su takvi podaci dostupni na web portalu HCR-a. Otklanjanje opasnosti od kasetnog streljiva počinje postupkom razminiranja i završava izdavanjem potvrde pri čemu se posebna pažnja daje održavanju veze sa lokalnom zajednicom. Pokazalo se da su mediji važan čimbenik za informiranje građana u procesu otklanjanja opasnosti od kasetnog streljiva, a HCR i nadalje treba biti glavni izvor informacija. Širenje informacija je potrebno u svim etapama uklanjanja opasnosti od kasetnog streljiva, a takva komunikacija doprinosi građanskoj sigurnosti.

KLJUČNE RIJEČI: komuniciranje, opasnost od kasetnog streljiva, mediji, lokalna zajednica.

Unified mine victims database – an important precondition for the socio-economic reintegration of mine victims and their families

Hrvoje Debač[1]

Victim assistance and mine clearance are two sides of the same coin. There can be no comprehensive solution of mine problem in any country without genuine continuous engagement on both fronts. Assistance to victims, covering emergency, continuing healthcare, physical rehabilitation, psychological support, economic inclusion, as well as adequate legal and policy regulation of their status is the most substantial part of this equation. On the other hand, the land cleared of mines and safe for human use is the key precondition for a sustainable and integrated development of mine-affected communities. Only such comprehensive approach to mine problem can produce long term and sustainable results.

In these considerations it should be kept in mind that according to the Mine Ban Convention, "mine victim is defined not only as a person who is injured or killed by a mine, but also his or her nuclear family". At the same time, the Convention on Cluster Munitions broadened and strengthened the obligations towards victims; to include not only direct cluster munition/UXO victims, but also all those living on the territory polluted by cluster munitions – that is, cluster munitions/UXO affected communities. Many States Parties and signatories to the Ottawa Convention and Convention on Cluster Munitions have taken steps to meet their obligations in that regard, including through the creation of adequate legal framework for victim assistance and implementation of the relevant points contained in the Maputo and Vientiane Action Plans.

However, although such a framework undoubtedly represents an extremely important precondition in resolving mine problem, our experience shows that even more important is a full and unequivocal implementation of undertaken obligations. In that context, it is obvious that much more needs to be done to provide appropriate response to the needs of survivors and victims, as well as to their full socio-economic reintegration.

To ensure the most efficient use of limited resources available to mine clearance and mine victims, high-priority goals and effective actions for their implementation have to be identified. This prioritization is only possible through thorough collection and adequate assessment of all relevant information. In that context, there is obviously a need for identification of victims' needs based on a systematic data-collection which is executed through an effective coordination between national institutions and development of a longterm strategic plan. Precisely following this approach, CROMAC in co-operation with the Office for Mine Action of the Croatian Government, established the "Unified database project", whose final aim is economic and social reintegration of victims and their families, in particular their (re)-employment, based on relevant education and training necessary for their full socio-economic reintegration.

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Currently, the available data are partial,[2] not reliable (not updated) and collected using different methodologies and tools. The lack of a unified database and precise knowledge of the needs of victims does not allow for full accomplishment of the victim assistance strategy nor the integration of victim assistance into broader national frameworks.

The newly established Unified database project is developed on desk research of documentation collected since 1996 to present days. The future activities will be based on the field research in order to supplement existing information and to obtain more concrete information of the current situations and needs of mine victims. The field research will cover all municipalities and counties, no matter if they are mine free or not, in order also to include mine victims living in areas that were demined in the meanwhile.

It is important to note that data collection and establishment of the comprehensive database is a serious, time and staff consuming, undertaking. In that regard, it is crucial that the field assessments are completed by institutions/entities with considerable previous experiences and executed by trained researchers. These institution/entities and researches will have to respect general data collection methodology and basic analytical rules, which includes the creation of the list with names of all landmine victims in the Republic of Croatia, as well as analysis of all available sources. This process includes special emphasis on the filed verification and supplement of all available sources with information obtained from victims and their families. In order to gather aforementioned information in a systematic and standardized way, these institutions/entities will be asked to further develop and improve a template questionnaire which should consist of a number of identification questions (first and last name, parents' name, place and date of birth, personal identification number, etc.), questions which specify facts about the incident (place and time of incident, type of action taken, etc.) and the open- ended questions which will allow for a precise definition of current needs. The questionnaire will be filled in by educated researchers and not by respondents themselves, with the purpose of getting systematic and standardized information.

Considering the sensitivity of the research topic and the danger of secondary traumatization (experienced by persons who have not been directly exposed to a traumatic experience, but have indirectly been traumatized through conversations with and exposure to persons with primary traumatization) for researchers, due to permanent work with those who have suffered severe traumas, it will be requested that the field work is performed in teams consisting of two researchers, in order to ensure adequate mutual support. Regarding the organization of the team, each researcher should be responsible for several (local) volunteers, with whom the researcher arranges field visits depending on their availability. In addition, further possible support and inputs on methodology will be provided by Geneva's ICBL/CMC experts.

Let me also in this context mention here the fact that the Republic of Croatia has a fully functioning National Co-ordination Committee for Mine and UXO's victims, as well as the fully developed National Mine Action Plan for assistance to mine victims, which are completely integrated into the institutional forms of care for persons with disability based on the existing national legislation. The Co-ordination Committee consists of the representatives of all relevant ministries, including Ministry of Foreign and European Affairs, Ministry of Health, Ministry of Veterans and Ministry of Interior. At the same time, the membership in the Committee includes many other relevant institutions possessing the necessary expertise, such as the Croatian Mine Action Centre, Croatian Public Health Institute, National Protection and Rescue Directorate, Croatian Health Insurance Institute, Croatian Pension Insurance Institute, Croatian Employment Institute, City Office for Health and Veterans of the City of Zagreb, Office for Human Rights of the Government of the Republic of Croatia, Mine Aid

[2] According to the Croatian Mine Action Centre (CROMAC) some 1.981 people are estimated as direct victims who have survived (another 512 were killed) and some 20.000 were identified as closest family members.

Association, Association of Mine Victims of Karlovac County and Union of Associations of Civil Victims of Homeland War of Croatia.

The Republic of Croatia supports the views expressed in the Oslo Progress Report of 2012, with the particular emphasis on the enhancement of cooperation between State and civil society actors on the ground through the establishment and strengthening of linkages across related international and domestic legal instruments. In that context, Croatia as a State Party to the CCM and also a State Party to the CRPD – the main instrument in the area of promotion and protection of human rights of persons with disabilities – is undertaking appropriate steps to synchronize and mutually reinforce legal obligations arising from these two core international agreements. Establishment of the Unified data base is a living testimony of these efforts and a step toward a full integration of victim assistance into the broader national policies, plans and legal frameworks aimed at protection and improvement of life of the Croatia's most vulnerable citizens.

Validation of the Mine Risk Education Computer Game *Great Rally on the Back of Electronic Turtles*

Sanja Vakula[1], *Marta Kovačić*[2], *Nikola Pavković*[3],
Marek Kacprzak[4], **Igor Ostrowski**[5], *Andrzej Masłowski*[6]

1. Introduction

"Great Rally on the Back of Electronic Turtles" is an educational computer game, played by a group of children with their individual Internet-connectable mobile devices under supervision of a teacher-instructor. The game is of board-type, and its content is a rally through a terrain with mine risks. The board represents a map with a net of paths connecting the start point with the finish line of the rally. Pawns, named "electronic turtles", are depicted as three-wheeled vehicles, equipped with a camera and tiny intelligence – derived from cybernetic turtles that were designed for initial cybernetic experiments with artificial intelligence. Detailed characteristic of the game have been presented in [1]. In general, far reaching educational aim is forming safe behavior of children in the face of danger of explosive remnants of war (ERW). Direct effect measured in validation testing of the game was the increase of mine risk knowledge of children, as a result of playing the game. Validation testing was conducted in two steps: a pretest in Poland, and a final test in Croatia.

2. Validation method

Validation tests, both in Poland and in Croatia, were conducted according to the plan presented in Fig. 1.

Briefings, conducted by instructors before playing the game, have a form of presentations: the first one on dangers of ERW, the second one on the game rules and on the test itself. After the first briefing, a poll measuring the children's initial mine risk (MR) knowledge with a proper questionnaire (ANNEX) is carried out. Then children play the game three times in a row, but with somewhat different content. After that, the poll measuring the children's mine risk (MR) knowledge is repeated without informing children whether their answers in the previous poll were correct, in order to measure the increase of the children's knowledge. The results of the measuring are calculated in the following way. The questionnaire includes 10 questions with 35 possible answers. 21 right answers read "yes"

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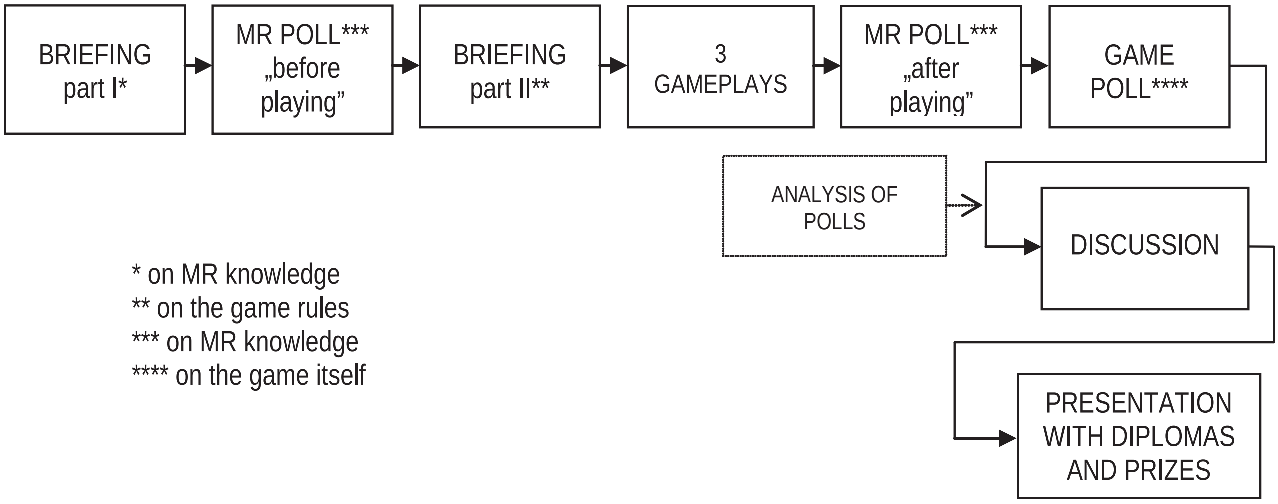

FIG. 1. Testing plan

and 14 right answers read "no". "Yes" is marked by a player with a cross, "no" is marked with an empty place. Each right answer gives the player one point. Immediately after the second poll on MR knowledge, the poll on assessment of the game itself, with proper questionnaire, is conducted.

Diplomas, signed by the instructor and by the TIRAMISU project representative, are for: the fastest contestant in all three gameplays-races, for the first, second and third places, for observers, for guides (scout-type proficiencies) and for participation.

Participation in the tests is voluntary, and participating children have to have the consent of their parents/guardians in form of an "Informed Parental Consent Form".

3. Validation results

3.1. Pretest in Poland

A pretest has been conducted in an elementary school in Warszawa-Wesoła on June 9, 2015 with 8 pupils 10 years old, both boys and girls.

The outcome of the game was the following:

- 7 players finished the first game; the first player in 6 min 23 s, the last one in 9 min 42 s.;
- 3 players finished the second game; the first player in 8 min 21 s, the last one in 9 min 53 s.;
- 6 players finished the third game; the first player in 3 min 43 s, the last one in 5 min 7s .

Results of the polls are presented in Table 1.

TABLE 1. Results of polls on mine risk knowledge conducted in Warszawa-Wesoła

Player No.	Correct answers in the poll before the game		Correct answers in the poll after the game		Improvement %
	number	%	number	%	
1	20	95.24	20	95.24	0
2	18	85.71	20	95.24	9.53
3	19	90.48	20	95.24	4.76
4	19	90.48	16	76.19	-14.29
5	19	90.48	20	95.24	4.76
6	17	80.95	20	95.24	14.29
7	18	85.71	20	95.24	9.53
8	19	90.48	20	95.24	4.76
Average score	**18.62**	**88.69**	**19.50**	**92.86**	**4.17**

In the poll on the game itself 87.5% of the pupils said it was easy to understand the rules, 75% said that it was easy to play, 37.5% said that it was very interesting and 50.0% said that it was interesting.

3.2. Final test in Croatia

Final tests have been conducted in two elementary schools: on October 22, 2015 in Moscenica, with 8 pupils 13-14 years old, and on October 23, 2015 in Lekenik with 10 pupils 10-12 years old, both boys and girls in each school.

3.2.1. Moscenica

The outcome of the game was the following:

- nobody finished the first game;
- 3 players finished the second game; the first player in 4 min 41 s, the last one in 6 min 26 s.;
- 1 player finished the third game in 5 min 27 s.

The average number of points gained by the players in the first poll was 25.62, and in the second poll 27.87, which means that the overall knowledge of the pupils improved for 2.25 points – i.e. for 6.43 %. The knowledge improvement of individual players is presented in Fig. 2.

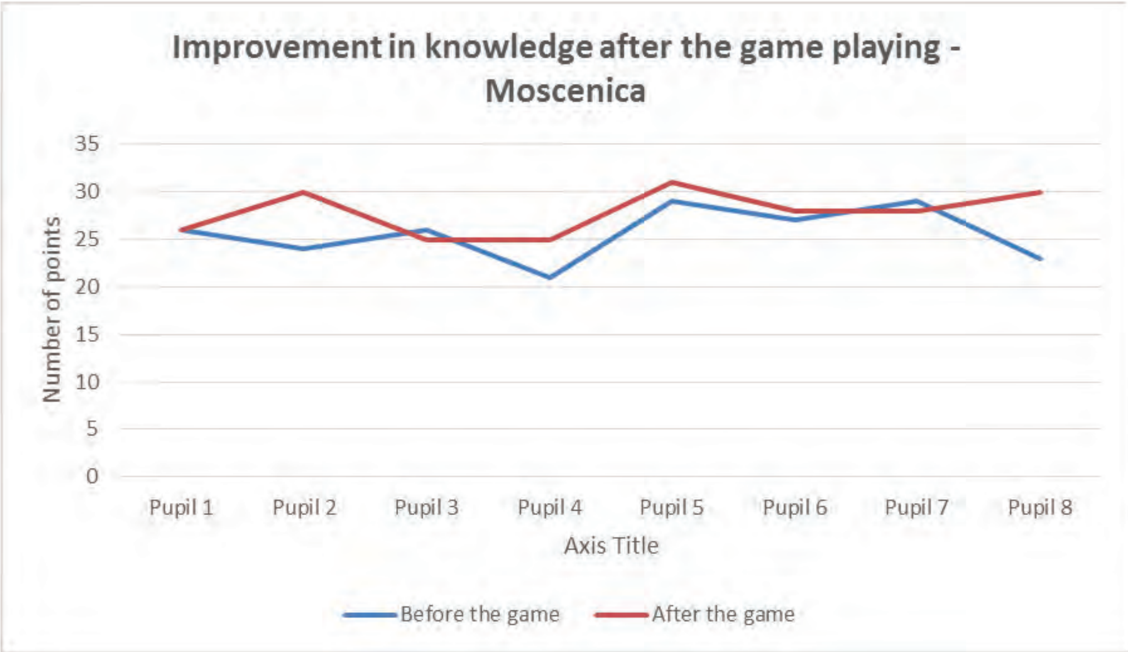

FIG. 2. MRE knowledge improvement in the test in Moscenica

In the poll on the game itself 100% of the pupils said it was easy to understand the rules, 75% said that it was easy to play, 37.5% said that it was very interesting and 63.5% said that it was interesting.

3.2.2. Lekenik

The developers decided to split the pupils in two groups from the beginning, to avoid technical problems, which means that there were six game-playing sessions altogether. The outcome of the games was the following:

Group 1:

– nobody finished the first game;
– 2 players finished the second game; the first player in 8 min 52 s, the last one in 7 min 55 s.
– 1 player finished the third game in 16 min 53 s.

Group 2:

– 1 player finished the first game in 8 min 34 s. The players got 3 Observer and 2 Guide proficiencies;
– 1 player finished the second game in 10 min 44 s.
– 3 players finished the third game; the first player in 8 min 45 s, the last one in 13 min 37 s.

The results of the polls on mine risk knowledge taken before and after the games for both groups together were the following.

The average number of points gained by the players in the first poll was 25.10, and in the second poll 27.00, which means that the overall knowledge of the pupils improved for 1.90 points – i.e. for 5.43 %. The knowledge improvement of individual players is presented on the Fig. 3.

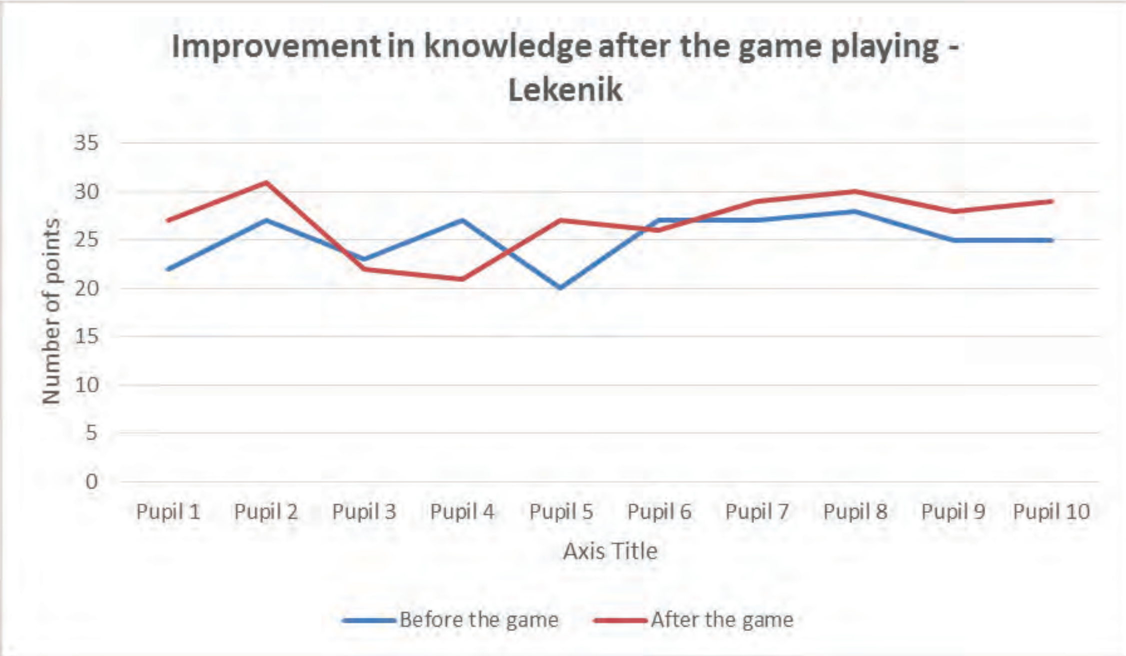

FIG. 3. MRE knowledge improvement in the test in Lekenik

In the poll on the game itself 70% of the pupils said it was easy to understand the rules, 70% said that it was easy to play, 60% said that it was very interesting and 40% said that it was interesting.

3. Summary and conclusion

According to the children psychologist's opinion, at the outset the pretest "has showed, both in quality examination and behaviors analysis, an essential efficiency of prophylaxis of dangerous behaviors on the terrains where mines are located". The detailed results obtained in the polls, both of the pretest and final tests, confirm this opinion. In all tests an increase of children's MRE knowledge as a result of playing the game was observed. The players were able to understand and apply the game rules and were interested in playing the game, so it was proved that the general concept of the game is appropriate for the children from 10 to 14 years old.

The time initially planned for playing the game was comparable with one class hour (ca. 45 min) which ensures keeping attention and receptivity by children. However in the tests it turned out that with significantly shorter time of playing, the game is easy to play, interesting, and brings good didactic results. So, it is necessary in the future to consider applying a formula of a "triple-game" filling up one class hour as a regular solution.

ANNEX

A POLL
WHAT DO YOU KNOW ABOUT DANGERS ON TERRITORIES WHERE MINES ARE LOCATED

Copy No. …..

There are 10 questions in the poll. Read carefully each of them and think about your answer. Place a cross by the answer which you consider correct. Be careful – there are questions with more than one correct answer. If you leave an answer without a cross, it will mean: "I do not know".

Let us start!

What is safe:

	A path through a hill top
	Walking down the centre of the path
	Following a river
	Walking at the side of the path
	A path near a partly ruined but inhabited house

Is it true that:

	One way to avoid injury in a dangerous area is to run as fast as possible
	The edge of the path is very dangerous and you must neither enter nor touch anything there
	Burning vegetation in a mined terrain is a good way to clear mines
	Every strange, unusual object is dangerous

If I see a dangerous object near the path...:

	I will search for something to mark it with, I will mark it, and I will inform an adult of the location
	I will inform an adult of the location

Is it dangerous:

	To throw stones from afar at a suspicious object
	To pick fruit off the trees near an empty house

Which area is unsafe:

	Vacant house
	Frequented path
	In the vicinity of a house with a smoking chimney
	Near a large tree
	Vegetable garden

On which questions you will answer "yes":

	Should the sight or smell of a dead animal be reported as a sign of mines danger?
	Are craters, the holes made by an explosion, really dangerous?
	Are there traditional signs indicating safe areas?

What on the path can signal a danger:

	Many footprints in one space
	Animal feces
	Two wooden crosses put on the path
	String or wire crossing the path

Do you accept the following advices in a mine suspected area:

	Follow the people, keep to populated sites
	Walk in twos
	Walk one behind the other

Are overgrown areas or places where people do not usually go equally dangerous as abandoned military installations:

	Yes
	No

Which of those are dangerous in a mine suspected area:

	Water wells
	Dams
	River banks
	Canals
	Streams

Thank you for answering the pool!

Questionnaire received by:	
Name	
First Name	
Date	
Signature	

ACKNOWLEDGMENTS

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Measurement of the forces generated in the ground by the free fall of DEMICHAIN

René Joeckle[1], Christian Baras[1], Bernard Gautier[1], Robert Goepfert[1], Jean-Pierre Hancy[1], Michel Samirant[1]

ABSTRACT: The free fall of an array of heavy chains (360 kg/m²) generates pressure in-depth of the ground. This pressure has been measured and compared to the threshold values which trigger blast antipersonnel landmines. Rather moderate heights of fall of the chains array (less than 2 m) generate pressures triggering most landmines, provided that their pressure plate area is larger than a few cm².

Introduction

First designed by Jacques DEMICHELIS, DEMICHAIN is a new concept of demining. It consists in dropping by free fall an array of heavy chains on the ground to be demined. The stresses delivered in the ground will set off the active landmines buried in the ground.

Recent measurements by buried load cells of the pressure in the impacted ground show the parameters giving pressure that will set off most of the landmines[2].

Overview of the characteristics of AP landmines

Of concern are the buried (usually blast) antipersonnel landmines (B-APLM), which are set off when a force exerted through the soil on the pressure plate is larger than the triggering force. We have examined a selection of B-APLM and collected their triggering force and the surface of their pressure plate as given by a common landmines handbook[3]. This allows deducing their triggering pressure in Fig. 1.

Most of the landmines are set off by a pressure smaller than 2 Bar. Three landmines need a higher pressure. However, these ones have small pressure plates and require to be installed at the surface of the ground and their triggering rod is usually located over the ground surface.

Description of the DEMICHAIN concept

Heavy chains are arranged in a horizontal array in order to form an area exhibiting a uniformly distributed mass. This array of heavy chains is hanged horizontally over the ground where active landmines are suspected to be buried. When the array is released, it falls on the ground and when it hits the ground, it delivers a field of vertical stresses.

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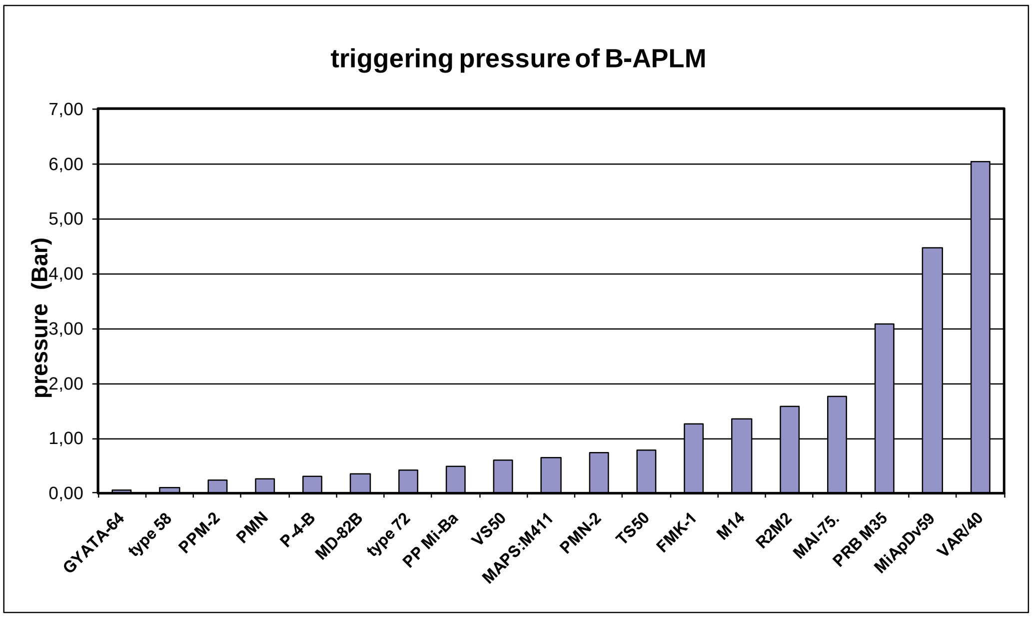

FIG. 1: Triggering pressure of a series of blast antipersonnel landmines

The basis of the theoretical description can be found in Scott and Pierce[4], it gives a description of a soil hit by the free fall of a uniformly distributed mass.

As far as the height of the free fall is moderate, it can be assumed that the behavior of the ground is elastic and that, after a very short time, the surface of the ground moves at the velocity of the falling mass and the ground is compressed. The vertical stress generated at the impacted surface is proportional to the velocity of the falling mass and to the elastic constant of the ground. Under the impacted surface, the stress is also uniformly distributed and is spread in- depth in the ground at the velocity of sound. This vertical stress field produces a force on the pressure plate of an active mine, which can be set off provided that this force is larger than the triggering force of the mine.

Approximate expressions have been established assuming several crude simplifications. They show two important statements:

- The maximum pressure is obtained at the surface. It is directly proportional to the height of the free fall. It is independent of the specific mass (mass per unit area) of the chains array.
- The duration of the pressure wave is directly proportional to the specific mass.

FIG. 2: 1 m² high mass density chains array

Experimental study of the stresses generated in the ground by the fall of a chains array

Four load cells FC22 by Measurement Technologies using the strain gage technology were adapted in housings presenting a pressure plate of 3.1 cm in diameter. These load cells can be buried into the ground. The four generated signals (0 to 5 V for a nominal load of 100 Lb) are recorded simultaneously by a digital oscilloscope Voltcraft DSO-8064.

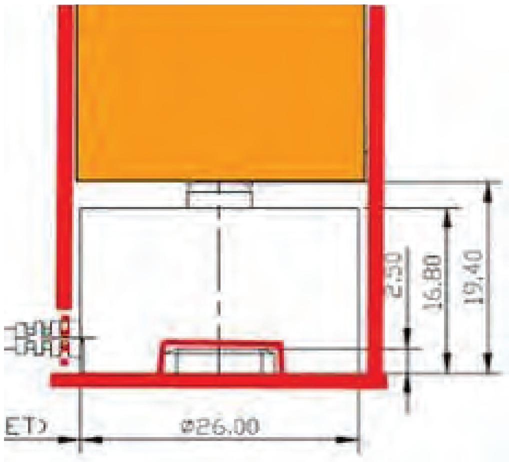

FIG. 3: Sketch of a pressure load cell

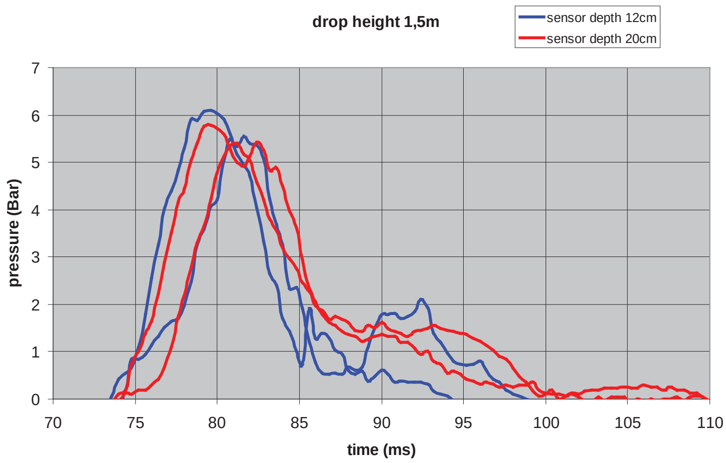

FIG. 4: Pressures of four load cells test with a drop height of 1.5 m

A large number of tests have been performed using different DEMICHAIN systems and detectors depths. Most of the tests have been performed in a sand containing gravel, several tests in vegetal ground.

A reinforced web of chains offering a mass density of 360 kg/cm² has then been built. The fall height has been limited to 1.5 m, which yields forces included within the range limit of the load cells. Typical records are displayed on fig 4.

Following graph summarizes the maximum pressure values for different tests as a function of the fall height.

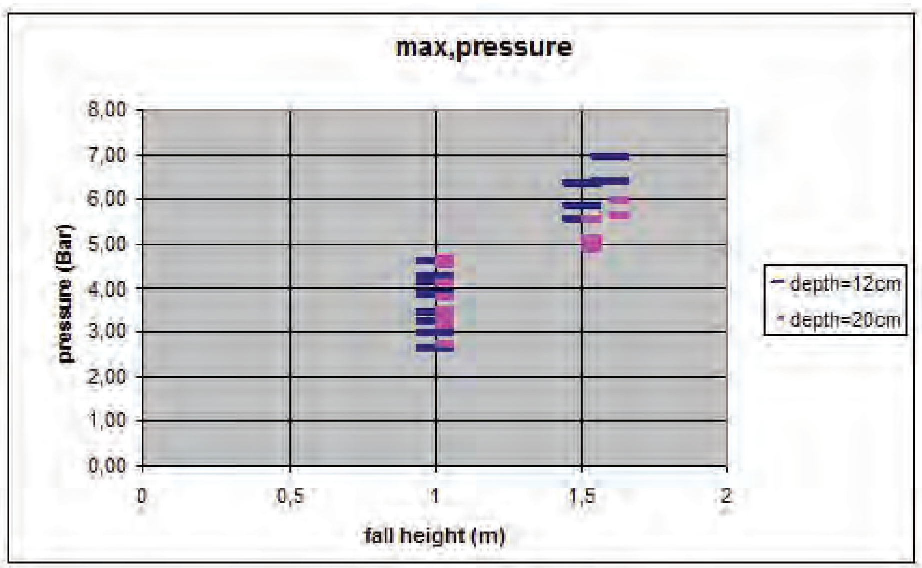

FIG. 5: Maxima pressures for a large series of tests as a function of drop height for the two detector depths

The pressure seems to be directly proportional to the drop height. It can be noticed that there is no noticeable variation of the maximum pressure as a function of depth. The variation of the pressure as a function of the time looks smoother for the larger depth of burying of the pressure plate. The duration of the pressure impulse at the half height is about 6 to 7 ms. It would be interesting to compare this value with the delays built in several APLM to avoid the triggering by nearby explosions.

For a fall height of 1 m, the measured pressures are higher than 2.6 Bar, whereas for a fall height of 1.5 m, they are higher than 4.7 Bar.

These values have to be compared to the triggering pressures of most of the APM (fig.1): with the exception of particular APM with a very small pressure plate, a modest fall height of 1 m will trigger buried APM, even if buried at depth of 20 cm.

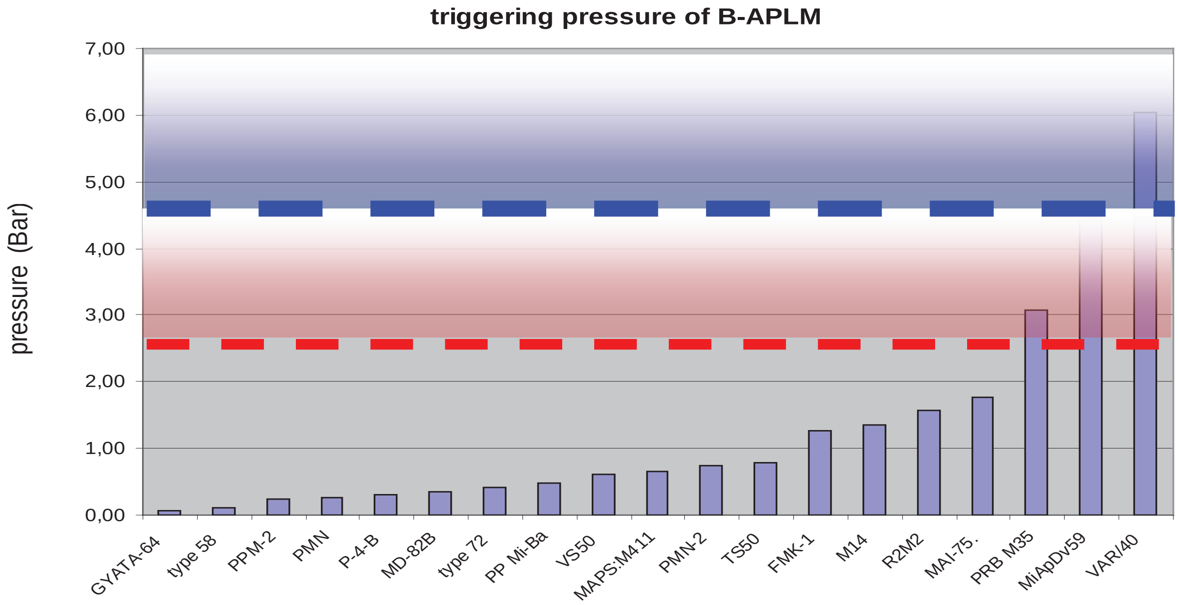

FIG. 6: Triggering pressures of B-APLM compared to the measured pressure levels

Advantages of DEMICHAIN

- The forces developed are vertical, similar to the forces developed by the mines targets
- The soil's structure is not changed by the demining process (this is interesting for ways, roads and paths).
- The developed forces decrease slowly in the depth, large depths of soil can be demined
- The tool is not sensitive to abrasion as flails are by sand
- Ordinary and cheap chains are used to build the tool, which can be built in rustic workshops and easily adapted to specific needs and lands. The DEMICHAIN tool can be mounted on an ordinary machine (crane, hydraulic arm) commonly used in demining
- When a free fall winch is used, DEMICHAIN can be remote-operated

The DEMICHAIN concept does not need to invest in a specialized device, because ordinary machines can make the job. Therefore, DEMICHAIN is convenient for small organizations or for reduced amplitude jobs.

Conclusion

It has been shown that a free fall of a chains array with a mass density of several hundred kg/m² develops in the ground a pressure of several Bars, which is able to trigger most of the buried (antipersonnel) landmines, even if they are buried deep.

This demining tool can be used for different purposes, as for instance:

- In order to reduce the mined zone area before using the manual clearance
- For demining deep-buried mines, for instance in sand or in river banks
- For control purposes of areas cleared with other techniques.

ACKNOWLEDGEMENTS

Many thanks to Gilbert and François SCHURRER, who gave us a warm welcome in their farm in RANSPACH-LE-BAS and who made at our disposal a tractor equipped with a hydraulic arm to lift the chains as well as an appropriate place with a sandy ground for carrying out the tests.

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   The core mission of the ISL (French-German Research Institute of Saint-Louis) is: "Research, scientific studies and basic predevelopment in the field of defense and security". ISL has reinforced its activities on issues of civil security and countermeasures against terrorism (see www.isl.eu)

   In the years 2000, ISL was involved in research concerning new techniques of demining.

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VIMADE – Virtual map for deminers designed for training purposes.

Igor Ostrowski[2], Andrzej Masłowski[1],
Lt. Col. (ret.) Marian J. Łopatka[2], Cpt. Tomasz Ślęzak[2]

ABSTRACT: VIMADE is a computer application developed for the Microsoft Windows operating system. It contains knowledge tests *from the area of task site preparation, area of safety and demining procedures and practice test of demining task organising abilities. 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 on virtual map. Exercises on virtual map are prepared using included software for instructors. This paper describes details of using VIMADE.*

1 Introduction

VIMADE is acronym of words Virtual Map for Deminers, logo of the application is shown on figure 1.

FIGURE 1: Logo of the application

Main purpose of this software is to train humanitarian deminers team commanders in planning demining tasks. Application let choose map from all over the world, and prepare excercises on that. Application contains also tests from the area of task site preparation and deminers procedures according to official regulations.

2 Application overview

2.1.1 Knowledge test from the area of task site preparation and area of safety and demining procedures.

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 demi-

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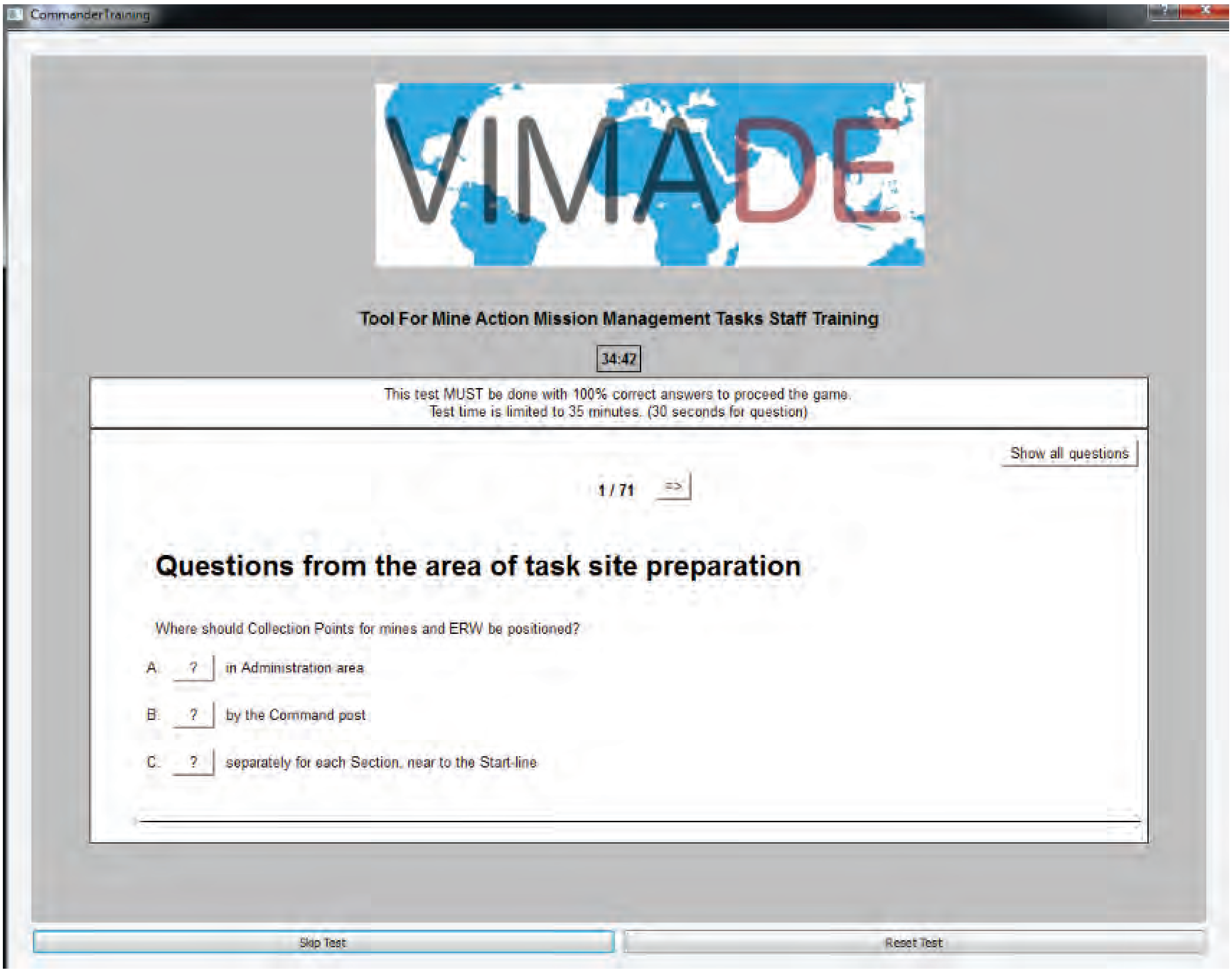

FIGURE 2: Application window with example question

ning 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. This purpose should be gained by proper presentation. The question and at least three answers (a, b, c) should be shown but correct answer is in random place. Acceptance of the highlighted answer is requisite in order to go the next question. The questions are mixed thematically. Trainees have possibility to repeat test unlimited times. Window of the application during test on the figure 2 is shown.

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 30s. Correct answers for all questions have to be given to pass the exam.

2.1.2 Practice test of organizing abilities

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 of necessary distances between facilities. Window of the application during map exercise solving on the figure 3 is shown.

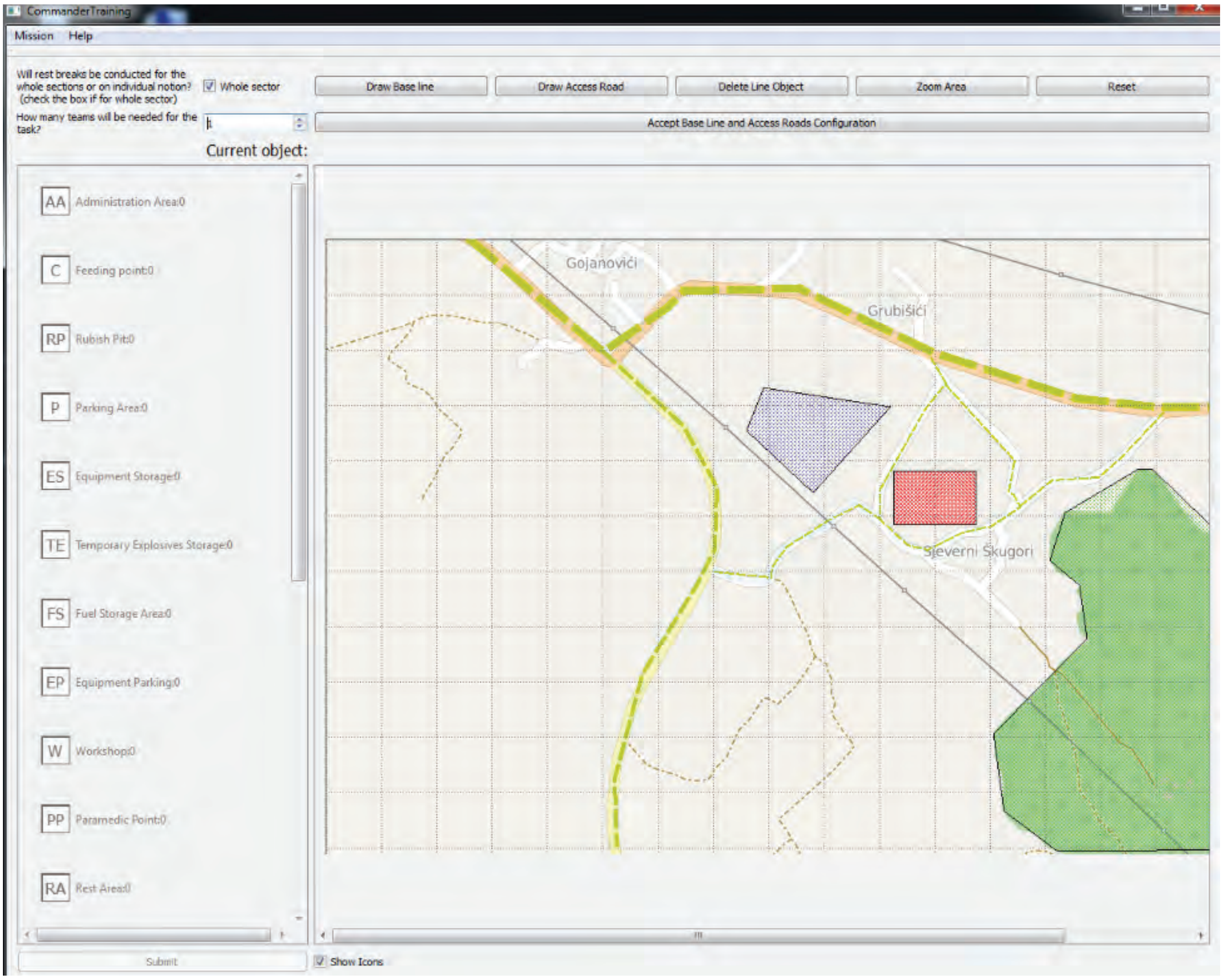

FIGURE 3: Exercise on the map

3 Technologies used

3.1.1 C++

This application was prepared using C++ language with Qt framework and OpenLayers library. It can be compiled for various operating systems and different type of devices.

3.1.2 HTML

For preparing tests much easier for future users we choose HTML as programming language of the test preparing. Tests can be prepared like simple website and exchanged with the previous one. User can use any html editor for creating tests.

3.1.3 OpenStreetMap

View of the world map we prepare using OpenStreetMap. OpenStreetMap is an initiative to create and provide free geographic data, such as street maps, to anyone. The OpenStreetMap Foundation is an international not-for-profit organisation supporting, but not controlling, the OpenStreetMap Project. It is dedicated to encouraging the growth, development and distribution of free geospatial data and to providing geospatial data for anyone to use and share.[1]

4 Using VIMADE

4.1.1 Preparing excercise

Preparation of the exercise is made in section "Builder". Work starts with choosing area on world map. World map is taken from OpenStreetMaps. During choice making map is provided with grid of 100 m. Area of exercise should not be lower then 500 meters each size. User draw necessary information about map using buttons on left side (figure 4). This information are SHA or CHA, roads and its sizes, another objects that can be important like obstacles and its type: forest, building, water etc. Displacement of the objects is made with pick and place method, rotation using roll on the mouse. I exercise trainer have to define what type of mines are in SHA/CHA(figure 5). After successfully preparing exercise it can be write to file and given to trainees – via e-mail or any another way.

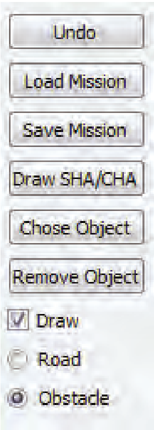

FIGURE 4: Buttons in section "Builder"

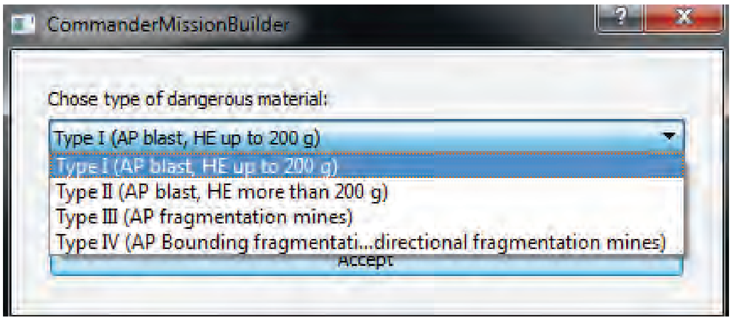

FIGURE 5: Types of dangerous materials

4.1.2 Solving exercise

The purpose of the transition to the rest of the application – exercises on the map it is necessary to pass a test.

Inside of the application there have been defined types of infrastructure elements necessary for the proper conduct of demining the area, as well as guidelines for their deployment in the field. These elements can be divided into linear and surface. Their location is closely linked to the area of the danger zone and its availability. Descriptions of these elements, together with the necessary information on their deployment are given below.

Danger zone (Suspected Hazardous Area SHA or Confirmed Hazardous Area CHA) is determined every 15 m by red bars or white-and-red stones and warning signs every 30 m – in a game marked with a red circuit appearing in this map after accepting the job.[3]

Linear elements are:

Start demining line (Start-line) – limit the safe zone with a minimum width of 2 m determined on the basis of benchmarks determined from the danger zone of 1 m red stakes, and from the safe at least 3 m stakes whites. It is the start of the line EOD (from the manual mode is carried out it into the field of stripes with a width of 1.2 m / efficiency of 1 m / s to 5 m). Start-line it is recommended to use the existing line structures (roads, copper, etc.). Initially, it coincides with the border safe area during mine clearance means the lines yellow (Base-line) gradually sliding into a proven danger zone – in a game marked with a red line.[2]

Access routes and evacuation (Access-lanes) – it is advisable to use straight sections and the use of existing dirt roads and downhill road, which should provide the ability to quickly reach the Base-line to assist or evacuation. Must have a minimum width of 2 m (when using it only pedestrians), or about 2 meters wider than moving its vehicles and machinery. It is measured every 3 m white stakes – the game marked with dashed black line.[2]

Surface elements are:

Administration area AA the location of the Task Supervisor Supervisor, Platoon Commander and Platoon. It may be in the form of a container or tent equipped with a working table, a table with a map and means of communication. Administrative area should be at a safe distance from the danger zone, so that it was not required to wear personal protective equipment and localized located on the road of access and evacuation. In order to allow direct visual inspection of the operations, the distance from the farthest places of the tasks should not exceed 1000 m, the area of 10x10 m. In addition, its location should prevent uncontrolled access to the danger zone.[2]

CP (Control-points) represent the location of the commanders team / section. They should be located a safe distance from the base-line and can be combined with zones of rest.

Zones of rest RA (Rest area) are organized at a safe distance

base-line individually for each team / section. They can also be located directly at the base-line when the rest is held simultaneously for the entire composition of the team / section; area of 10x10 m. In the resting area you can remove personal protective equipment.[2]

P (Paramedic Post) should be at a safe distance from the base-line, with the proviso that walking time to reach the farthest minesweeper should not exceed 5 minutes. Therefore, you should allocate appropriate numbers of medical points.[2]

Nutrition Point C (Canteen) should be near the administrative zone, size 20x10 m;

Toilets L (Latrine) should be near the administrative zone, and when a large extent also de-mining area near points of rest. If the composition of the plutonium are a woman then you should also provide toilets for women.[2]

RP (Rubbish pits) should be located near the administrative zone.[2]

ES (Equipment storage area) should be close to the administrative zone, so that the inspection took place the use of equipment, and a short distance from the parking lot to reduce the need to carry equipment with means of transport; dimensions 10x10 m (tent or container).[2]

Parking for vehicles of plutonium and people visiting P (parking area) should be arranged so as to contain the plutonium and all vehicles had at least two additional vacancies. Should be at a safe distance from the danger zone at the road access and evacuation, possibly near the administrative zone; area of 20x50 m.[2]

EP (Equipment Parking) whenever possible should be located near the administrative zone, on the road access and evacuation; dimensions of 20x20 m.[2]

W (Workshop) should be located near the administrative zone and parking machines rozminowujących the road access and evacuation; dimensions of 20x20 m.[2]

RI (Robot Inspection areas) should be in a safe area, close to the line input (base-line); individual for each robot. The RI control is performed in terms of safety, ie. Whether the elements driving or chassis had attached no dangerous elements.[2]

PM (parking and maintenance for robots) should be near the administrative zone, on the road access and evacuation; dimensions of 20x20 m.[2]

FS (Fuel storage area) should be at least 20 m away from other objects, and 30 meters from the composition of the explosives, but as close as possible rozminowujących parking machines; dimensions of 20x20 m.[2]

TE (Temporary Explosives storage area) consists of 4 containers, containers or crates. Stored explosives HE – High explosives are located in the trench. Blasting Caps (detonators), detonating cord and other materials initiating stored in a separate container also placed in the trench, located at least 1 m from explosives. Safety equipment necessary to blow up the way electric and destruction of chemical agents should be in a separate container at a minimum distance of 1 m from the trench. The composition of the explosives should be surrounded by at least 20 m safety zone, be close to the administrative zone (supervision) and access and evacuation routes; area of 15x15 m.[2]

TC (Metal-Detector Test and Calibration) should be between zones of rest, and the base-line; 1 m^2; [2]

M (Mine and ERW Collection Points) should be located in the vicinity of tasks, near the start line or lines start demining (base-line); [2]

MP (Scrap-metal collection pits) should be between the rest area and the danger zone. It organizes one per team / section.[2]

DA (Demolition area) should be min. 250 m from the seats occupied, roads, etc. May be near the starting line or lines start demining; dimensions of 20x20 m.[2]

HLS (Helicopter Landing Site) should be located away (min. 50 meters) away from trees, buildings and encampments. It should be on the road access and evacuation, it is necessary signage visible from afar; dimensions min. 50x50.[2]

Information on individual components included in the software, and can be changed by instructor.

The type of mission (the type of hazard, limits, and other data) and the guidelines for placing trained individual elements will be informed before the start of the mission. This information is in the same form are also available during the game in the "Help". The values of each size and distance can be modified by the instructor at the stage of the exercise by using "Builder" which is an integral part of a computer application to develop the habits and needs of developing knowledge staff proves humanitarian demining HD action.

4.2 ACKNOWLEDGEMENTS

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CROATIAN STANDARDS INSTITUTE (HZN) and Technical Committee HZN/TC 523, Humanitarian Demining

Dražen Šimunović[1] Davorko Čehulić[2]

The Croatian Standards Institute (hereinafter: HZN) is established by the Government of the Republic of Croatia in October 2004 based on the Standardization Act as the national standards body of the Republic of Croatia. Former National Institute for Standards and Metrology (DZNM), established in 1992, has been divided into three independent institutions covering the field of standardization, accreditation and metrology. HZN started its activities as an independent public institution in 2005. Prior to Croatia's entrance into the European Union, former associated membership in the international (ISO[3] and IEC[4]) and European institutions for standards (CEN[5], CENELEC[6], ETSI[7]) had to be turned into the full membership by, of course, meeting the necessary requirements. HZN met the conditions set by CEN and CENELEC in 2008 by adopting all published European normative documents and integrating them into its own system in that way becoming a full member of CEN and CENELEC in 2010. The Republic of Croatia became the European Union member state in 2013.

Technical Committee HZN/TC 523, Humanitarian Demining is one of the HZN's technical committees acting in the field of METAL MATERIALS. In accordance with the HZN's goals, the committee task is to monitor the international and European documents (CWA[8]) relating to the field of humanitarian demining and production of original Croatian standards in the field of humanitarian demining (mine action) given the fact that no standards of that kind had been published in ISO or CEN up to then. The reason for that was non-existence of mine-contaminated areas on the European territory.

Technical Committee HZN/TC 523, Humanitarian Demining was established on July 17, 2002, thanks to the enthusiasm of CROMAC assistant director, Nikola Gambiroža, Ph.D., appointed first president of the Committee. The Committee work is participated by the current president of the TC, Mr. Dražen Šimunović, secretary within the HZN, Mr. Davorko Čehulić and other Committee members, reputable experts from the field of humanitarian demining (mine action) as well as representatives of all other interested parties (ministries, faculties, army etc.).

The work of the Technical Committee HZN/TC 523, Humanitarian Demining is based on general principles of standardization: consensus, involvement of all interested parties, transparency, implementation of highest development level of techniques and science.

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3 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

4 INTERNATIONAL ELECTROTECHNICAL COMMISSION

5 EUROPEAN TELECOMMUNICATION STANDARDS INSTITUTE

6 EUROPEAN COMMITTEE FOR STANDARDIZATION

7 EUROPEAN COMMITTEE FOR ELECTROTECHNICAL STANDARDIZATION

8 CEN WORKSHOP AGREEMENT

The scope of activity of the Technical Committee HZN/TC 523, Humanitarian Demining covers the following: terminology and preparation of technical documentation; manual demining; mechanical demining; features of deminer PPE, detection means and demining machines; combined demining using MDDs, equipment, tool kits and instruments; methods of establishment of suspected hazardous area (SHA), quality assurance and quality control degrees.

HZN/TC 523, Humanitarian Demining subcommittees are as follows:

1. TC 523/SC 1 – Detection of mines and unexploded ordnance (UXO), quality assurance (QA) and control (QC)
2. TC 523/SC 2 – Technical requirements and conformity assessment of machines, dog-handler teams, equipment and devices
3. TC 523/SC 3 – Terminology, competence and qualification
4. TC 523/SC 4 – Explosive Ordnance Disposal (EOD)

At the meeting held in the premises of the Croatian Standards Institute at the end of 2015, it was agreed that the subcommittees shall become inactive and all members' activities shall be taking place within the central technical committee.

All original Croatian standards published so far from the field of humanitarian demining have been passed by procedure consisting of six stages: encouragement, preparatory phase, committee draft, public hearing, approval and publication.

Technical Committee HZN/TC 523, Humanitarian Demining has so far published the following original Croatian standards:

HRN 1142:2009, Humanitarian demining – Demining machine requirements and conformity assessment

HRN 1129:2011, Humanitarian demining – Terminology glossary

HRN 1132:2015, Humanitarian demining – Competence, qualifications, responsibility and authority

HRN 1133:2015, Humanitarian demining – Marking of suspected hazardous area (SHA) and worksite

HRN 1134:2015, Humanitarian demining – Survey and reduction of suspected hazardous area (SHA)

HRN 1143:2015, Humanitarian demining – Medical support and evacuation

Note: The Standards HRN 1142:2009 and HRN 1129:2011 have been translated into English language and can be used by experts from abroad as well.

The following original Croatian standards from the field of humanitarian demining are currently in the phase of drafting proposals:

nHRN 1135, Production of project documentation

nHRN 1136, Worksite organization and conduct of demining operations

nHRN 1137, Explosive Ordnance Disposal (EOD)

nHRN 1138, Quality Assurance (QA) and Quality Control (QC)

nHRN 1139, Requirements for PPE, tool kits and instruments and conformity assessment

nHRN 1140, Safety, protection measures and communication system

nHRN 1141, Records, data protection and reporting

HZN Hrvatski zavod za norme Croatian Standards Institute

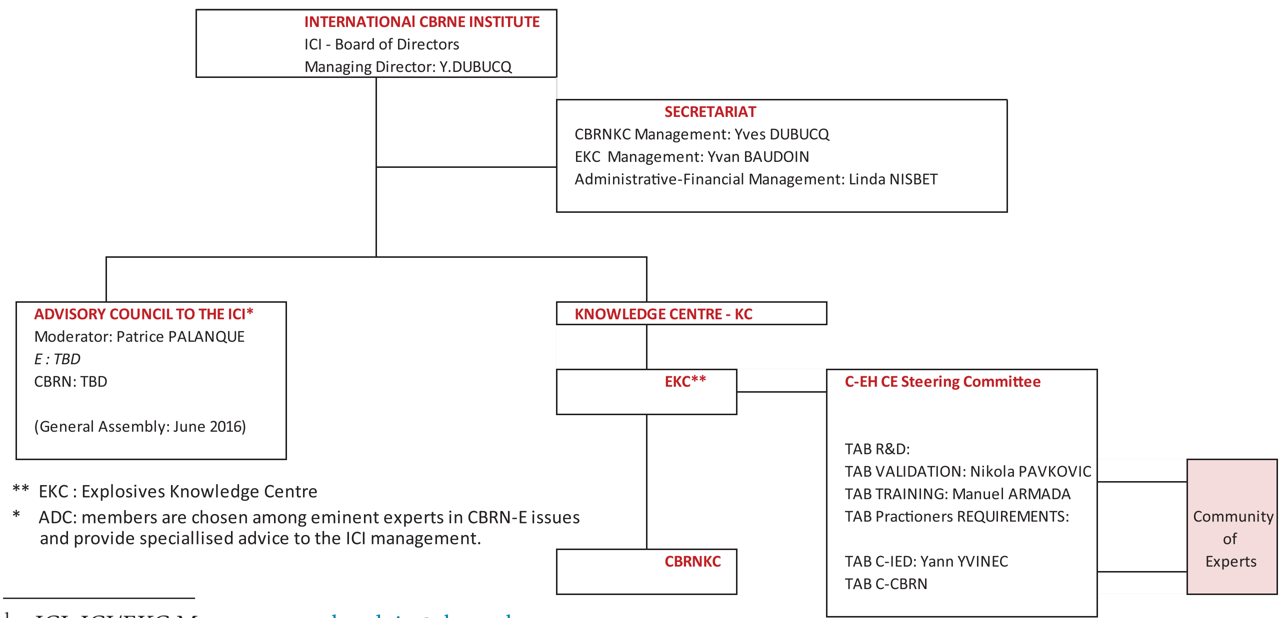
Counter Explosive Hazards – Community of Experts (EKC)

Yvan Baudoin[1]

Integrated into the International CBRNE Institution (ICI – www.ici-belgium.be), **a COUNTER EXPLOSIVE HAZARDS Community of Experts (EKC/C-EH CE) intend** to ensure sustained impact on the demining community and value to the general public, support the European Union (EU) Security facing explosive hazards threats (and possibly CBRNE threats) and welcome Experts in Explosive Hazards-related issues.

The proposed Community of Experts shall focus on the exploitation of the toolboxes and initiatives developed in EC projects so far and on expanding their application to other explosive hazards threatening civil society. The **EKC** will follow the European Agenda on Security and the new EC security research programme in HORIZON 2020. To avoid duplication and ensure the ongoing exchange with practitioners and experts, cooperation with existing Centres is established, e.g. with the NATO Explosive Ordnance Disposal Centre of Excellence, the Counter Improvised Explosive Devices Centre of Excellence (C-IED COE), the International Centre of Demining (CID), located in Madrid, the Geneva International Centre for Humanitarian Demining(GICHD[2]), the European Corporate of Security Associations (ECSA[3]).

The Community, administratively managed by his Explosive Knowledge Centre (**EKC**) will be coordinated by a Decentralised Steering Committee, responsible for external relations and visibility, while the members of the community are acting in five Technical Advisory Boards, or TAB, and will pursue the objectives described in Annex A.



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[2] www.gichd.org

[3] www.ecsa-eu.org

ANNEXE A

Objectives of TAB 1: Technology Watch and Shared R&D

- Continuously improve technologies[4] through an exchange of R&D results among the scientific community and through adequate interdisciplinary technology transfer
- Share expertise and particularly research through dedicated workshops in close cooperation with the above mentioned Centres and other stakeholders
- Monitor the developed tools and prepare their validation and their wider implementation.

Objectives of TAB 2: Validation and European Standards

- Promote EU-wide standards of relevant counter explosive hazards (C-EH) technologies, tests and evaluations of C-EH equipment
- Maintain a dedicated area of permanent lab-space for baseline testing of performance and suggest appropriate test areas for field testing, e.g. the CID or/and the C-IED COE in Spain, the HCR-CTRO Test Facilities in Croatia, the ICI facilities in Belgium, the Joint Research Centre in ISPRA, Italy, among others
- Suggest and validate new / improved testing procedures, in cooperation with ICI, GICHD, NATO, the European Defence Agency, the European Committee for Standardization (CEN) and others
- Pursue (or propose/extend) new CEN Workshop Agreements initiated by the FP7 Projects or initiated under the current HORIZON projects.

Objectives of TAB 3: Training and Risk Education

- Develop Survey (prediction, prevention, detection) e-Tutor
- Offer advanced multinational e-C-EH courses and C-EH training
- Risk Education tools for C-EH Practitioners

Objectives of TAB 4: Meeting the C-EH Practitioners Requirements

- Support comprehensive and integrated use of Information Management Systems (IMS) as requested by end users
- Realisation of synergies between all Centres focusing on Counter Explosive Hazards in view of the Systems and Security challenges of the European Union
- Participatory Analysis of C-EH Requirements

Objectives of TAB 5: C-IED Threats

- Prepare the validation and wider implementation of tools, in particular in the current context of terrorist threats in Europe[5]
- Promote EU-wide standards of relevant security technologies, tests and evaluations of security equipment
- Develop EOD/IED e-Tutor and have them validated
- Support the training of practitioners in the domain of Improvised Explosives and CBRNE
- Complement IMS with a Dissuasion Management Action Plan for C-IED threats
- Realisation of synergies between all Centres focusing on the Counter Risky Hazards Actions in view of the Systems and Security challenges of the European Union (Surveillance of Borders, CBRN-E threats)
- Close cooperation with practitioners in the field of Counter Terrorist activities and the European Corporate Security Associations (ECSA)

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4 In particular: Detection Tools, Robotics (UGV, RPAS), Protection tools, Neutralisatio/Disposal/Forensic

5 European Program HORIZON focusing on the Security – In April 2015 the European Commission adopted the European Agenda on Security (EAS) for the coming five years. On the basis of the EAS, the Council adopted in June 2015 the renewed European Union Internal Security Strategy 2015-2020 confirming tackling and preventing terrorism, radicalisation to terrorism and recruitment as well as financing related to terrorism, preventing and fighting serious and organised crime and preventing and fighting cybercrime as the main priorities for European Union's actions

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A platform approach for Information Management in Mine Action by using Open Source frameworks and co-creation with End Users

Franco Curatella[1]; Linus Gisslén, Anders Törne[2]

ABSTRACT: The definition of a standard for information management for Mine Action, which is widely adopted and used, is problematic, due to the diversity of actors operating in this domain, and to the diversity of environments and cultures.

In recent years new web technologies and open source business models have created alternatives to custom code development. Several off-the-shelf modules (either open source or proprietary) are now available that can be integrated to match end users' needs with reduced costs of development and maintenance.

In D-BOX project we followed this approach. Two open source frameworks have been selected (Mediawiki ®, the engine of Wikipedia ® and uDig, an open source GIS reader) to create: D-BOX for Planning, to manage processes and information, and D-BOX for Operations, to assemble data from sensors and humans and to update hazard information. These tools exchange information via a web service infrastructure called D-BOX Sharing.

By using existing open source modules, time and money have been saved and project members could work more intensively with End Users. For example, we co-created a procedure with End Users for Non-Technical Survey which has been implemented in D-BOX for Planning. The D-BOX architecture is also the outcome of workshops with End Users.

D-BOX platform (planning, operations and sharing) can help deminers to assemble and assess data to create information to define hazard areas, make and receive reports and issue instructions. D-BOX platform could provide the means to establish an effective value chain linking all the stakeholders in Mine Action.

A proposal is made to create an open source community in Mine Action.

KEY-WORDS: Humanitarian Demining, Information Fusion, Information Management, open source, co-creation.

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1 Introduction

The humanitarian demining working context has several constraints for technology development. Information Management, in particular, is problematic because the information has to be shared among different stakeholders remotely located, and information owners in most of the cases are not willing to share information due to political, strategical or even cultural reasons. Furthermore, demining is a safety critical domain and the end users can only make use of tools and information which are fully reliable and fully safe. New opportunities to improve information management come from new technologies (Content Management Systems, Web and Mobile, both off-the shelves and open sources). These technologies will be only useful for deminers, if they are designed to tackle the contingencies of their working context. In D-BOX, the solution has been co-created with End Users.

1.1 Project D-BOX

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, systems, procedures and sensing technologies. D-BOX Information Management proposes a platform approach which is also described in [1].

2 D-BOX Information Management

The D-BOX architecture is composed of three main components which will be shortly presented in the following.

2.1 D-BOX for Operations

D-BOX for Operations, is deployed on the user PC or tablet, provides GIS features and it is used to gather data from the source (humans or detection tool) no matter where the source is located, and no matter the internet connection.

2.2 D-BOX for Planning

D-BOX for Planning is a real knowledge management system and planning tool which enables collaborative decision making between stakeholders in the same organization as such it enables advantageous anticipatory and responsive planning. The product of the planning and decision process is the definition of hazard areas that are minimized with respect to the balance between risk, societal impact and available information and to the national land release criteria of the organization. For a more in-depth description of the underlying architecture and reasoning please see [2].

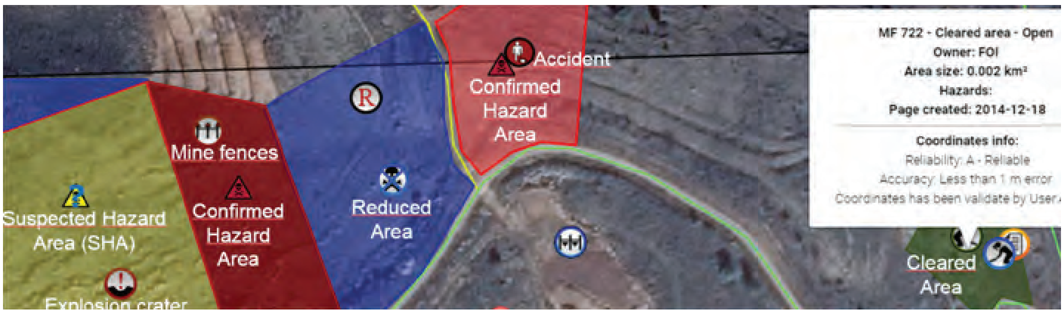

FIGURE 1: Screenshot from the map view of D-box for Planning. Each icon represents information stored in the database.

2.3 D-BOX Sharing

D-BOX Sharing is the information sharing infrastructure which enables instances of D-BOX for Planning and D-BOX for Operations hosted by different organizations to exchange data. D-BOX proposes the creation of network(s) between stakeholders 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 secured way. Coordination is required on a bilateral base only.

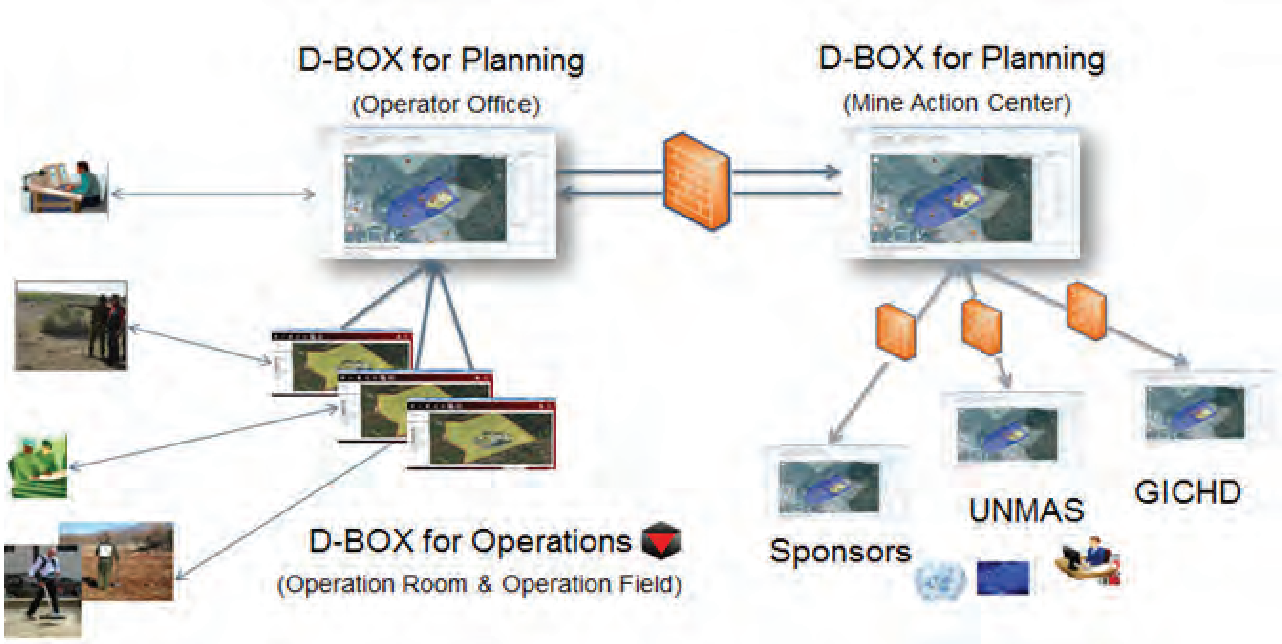

FIGURE 2: The objective of D-BOX is to create a value chain that includes all the stakeholders of Mine Actions irrespective of where they are located and the organization they belong to.

3 Co-creation with end users

End Users have taken part on the specification and design phase of D-BOX. Below two main outcomes of cooperation with end users are described.

3.1 D-BOX Architecture

During the specification and design, the team has organized task forces with a panel of end users to evaluate the different options. The tasks forces were composed of end users, system architects, and software developers altogether. An advantage of this approach is that engineers have learned about demining, while deminers have learned about possibilities offered by technology.

3.2 The Non-technical Survey (NTS) Procedure

In the D-box for Planning tool there is support and a workflow for the NTS procedure. It was designed with the close collaboration with end-users in the field of Mine Action. The procedure is integrated in the software and guides the user when executing the NTS. By using a reasoned and tested systematic process it highlights gaps in knowledge and information as well as increasing the efficiency in the information gathering. The main steps of the NTS procedure is identifies as:

1. Overview,
2. Task preparation,
3. Standard Operational Procedures (SOPs),
4. Visits to general area,
5. Team preparation,
6. On-site visit,
7. Cancellation of land,
8. Post NTS.

The procedure is described in detail in the D-Box CEN Workshop document [3]. A similar procedure for the Technical Survey (TS), Clearance operation and General Mine Action Assessment (GMAA) is also implemented in the software. Note that the procedures in the software are not fixed but delivered as a default template and alternation dependent of the need of the organization is easily implemented and encouraged if needed.

4 Use of Open Source Technologies

4.1 D-BOX for Planning

The D-box for Planning was implemented on top of the Semantic MediaWiki software which is an open source technology. GUI map functionalities, information storage (hazard areas, demining tools, hazards, infrastructures, etc.), user groups, traceability of information changes, discussion boards, semantics and ontology, web services, distributed database, etc. have been included in the final product.

4.2 Example: D-BOX for Operations

D-BOX for Operations has been developed on top of an open source framework called uDIG. The goal of uDIG is to provide a complete Java solution for desktop GIS data access, editing, and viewing.

4.3 Pros of Open Source Software

- The underlying software is constantly updated and managed by an active community.
- No license or software cost.
- New functionality can be added by the community as well by the user organization.

4.4 Cons of Open Source Software

- No underlying organization is responsible for the software.
- For new functionality to be supported by the community it needs to be accepted by the community maintaining the software.
- No training is provided with the software.
- Some Open Source licenses are viral and make new software to become itself open source.

5 Next Steps

5.1 Move to Operations

The first round of implementation has been finished with the end of the D-box project. The concept has been demonstrated to, and evaluated by, end-users in lab environment. The next step is to perform tests on the concept in the field with the help of active end-users in the field of Mine Action.

5.2 Creating an Open Source Community for Humanitarian Demining

– The use of Open Source technologies requires that the user is implied in the community to maintain and to extend the technology.
– MediaWiki, the technology behind D-BOX for Planning can be downloaded freely from internet and customized to implement the end user processes. New process and procedures can be created in National and International workshops.
– MediaWiki can be enveloped in a web-service infrastructure and new tools can be developed to complete the functionalities of MediaWiki.

National Mine Action Centers should reflect on the possibility to create an open source community and develop their own tools. Local resources will be employed and financed by sponsors with the results to improve and create national capabilities.

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D-BOX www.d-boxproject.eu

ATEX legal and standard framework applied to UAS in Mine Action and other risky interventions

Mário Monteiro Marques[1], *Júlio Gouveia-Carvalho*[2/3], *Ricardo Pascoal*[4], *Cristina Matos*[5]

ABSTRACT: In this paper, we aim to review the ATEX (ATmosphères EXplosibles) legal and standard framework which may be used for the certification of electric equipment for use in potentially explosive atmospheres and its application to unmanned aerial systems (UAS). Recent advancements in UAS have led to their deployment in support to demining operations and other risky interventions, as the case of chemical, biological, nuclear and radiological (CBRN) operations, in particular when it results in a reduction of personnel exposure or in acquiring valuable data for operational planning. In this context, this review is directed for the use of ATEX certified UAS in demining operations and other similar risky interventions, with a particular focus on concepts of operations and the implications of the ATEX legal and standard framework in requirements specification within the perspective of UAS research and development. The knowledge of the ATEX directives and related harmonized standards, applied to UAS, offers a cutting edge approach for novel and further development in applied robotics and Mine Action.

KEYWORDS: Unmanned Aerial Systems, ATEX, CBRN, Mine Action, Robotics

Introduction

Management practices and operational procedures for humanitarian mine action are constantly evolving. Improvements are made, and changes are required, to enhance safety and productivity. Changes may come from the introduction of new technology, in response to a new mine or unexploded ordnance (UXO) threat, and from field experience and lessons learned in other mine action projects and programs. [1]

The need to reduce risk and to provide a safe working environment are fundamental principles of mine action management. Risk reduction involves a combination of safe working practices and operating procedures, effective supervision and control, appropriate education and training, equipment of inherently safe design, and the provision of effective personal protective equipment and clothing. [2]

In this context, owing to their capability of reducing the risk of personnel exposure to hazards or in acquiring valuable data for operational planning, the advancements in unmanned aerial systems (UAS) in recent years have led to their deployment in support to demining operations and other similar risky interventions, as the case of chemical, biological, nuclear and radiological (CBRN), or explosive ordnance disposal (EOD) operations.

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The use of UAS in mine action, considered in both technical and non-technical survey, or in support to CBRN or EOD operations, each one with different approaches, poses new challenges and can introduce new risk factors in the event of potential explosive atmospheres, as a result of the existence of critical infrastructures or explosive remnants of war (ERW) such as liquid propellant-fuelled systems, fuel air explosive (FAE) systems, enhanced blast munitions (EBM) or thermobaric weapons.

Recent conflict has seen significant deployment or use of liquid propellant-fuelled systems. The legacy of the use of these munitions remains, and they could become a clearance or disposal task for demining organizations in the future. They potentially pose a significant hazard to the local population and their safe clearance and disposal is a particularly complex technical task. Demining organizations might encounter hazardous fumes, vapor or residue from liquid propellant systems. [3]

In the context of CBRN operations, the UAS can be used for reconnaissance, hot zone awareness, site survey or spot detection tasks, including specific payload for that purposes. The explosive risk could be a possibility in several types of CBRN operations.

Unmanned aerial vehicle system architecture

Unmanned Aerial Vehicle (UAV) is a vehicle with no onboard pilots that operate by air. The systems could operate in a fully-autonomous mode, semi-autonomous by means of waypoints, tele operated or by remote control. These platforms could be controlled by electronic equipment on the vehicle, coordinated by the goals of the mission that it was assigned for, monitored by a ground control station. [4]

Autonomous navigation or remote-control navigation, instead of an onboard pilot, control the power source that provides the dynamic lift and thrust based on aerodynamics that an UAV must accomplish to fly.

The architecture of an UAV could be divided into four parts: the Guidance, Navigation and Control system (GNC); the Ground Station Command, Control and Communications (C3); the payload; the propulsion.

The GNC system includes sensors and processors in order to collect data for the overall control of the vehicle, like stability.

The C3 is a layered structure that ensures the adaptability, flexibility, security and cognitive controllability of the bandwidth, frequency and information/data flow so that an UAV can communicate (understand and be understood) by ground control stations or other unmanned systems. [5]

The payload is every equipment or sensor that does not take part of the original skeleton of the vehicle but can be attached to the platform in order to facilitate, help or enable the vehicle to successfully undertake his mission, such as Radar or Sonar equipment.

The propulsion is a particular matter, due to the available configurations, but the best situation of all is necessarily one which presents efficiency for the mission along with the lowest possible cost (cost is to be understood as equating several factors – cost function).

ATEX legal and standard framework

ATEX is a term commonly used to describe potentially explosive atmospheres and standards for protection systems and equipment that are intended for use in these atmospheres.

The ATEX Directive 94/9/EC became mandatory on July 1, 2003 and was replaced by the 2014/34/CE that will become mandatory on April 20, 2016. [6, 7]

The Directive 94/9/EC is a "product requirement specification directive" which establishes explosion, technical and process specific minimum requirements to help ensure the free movement for equipment, components and protective devices (briefly called products) for operation in potentially explosive atmospheres.

Due to Health & Safety concerns, standards have been developed for equipment intended for use in these environments. These Standards are harmonized. A harmonized standard is a European standard developed by a recognized European Standards Organization. Those standards were mandatory with the introduction of the Directive 94/9/EC.

> *Integrated explosion safety is conceived to prevent the formation of explosive atmospheres as well as sources of ignition and, should an explosion nevertheless occur, to halt it immediately and / or to limit its effects.*
>
> *In this connection, the manufacturer must take measures with respect to the potential ignition sources. In addition, equipment and component must be designed and constructed after due analysis of possible operating faults in order as far as possible to preclude dangerous situations taking the misuse which can reasonably be anticipated into account.* [8]

Among these standards there are standards for the electrical products (EN 60079 and EN 60079 – series) and for the non-electrical products (EN 13463 – series) for explosion protection, for example: flame arresters, explosion suppression systems, explosion pressure-relief systems, rotary valves, but they have quite similar approaches.

The Standards are harmonized and have been formally adapted to the directive 94/9/EC.

Consideration must be given to the design, manufacturing, testing of equipment, protective systems and devices and to the essential Health and Safety Requirements with regard to conformity assessment procedures.

UAV potential sources of ignition could be: electric sparks, arcs and flashes, electrostatic discharges, electromagnetic waves, ionizing radiation, hot surfaces, mechanically generated sparks.

Requirements specifications applied to UAS

There exist many physical implementations of what are termed UAS. Depending on the specific mission one will have to choose that which best fulfils the requirements. The emphasis of this paper is on UAS designed to operate in risky scenarios, particularly those in potentially explosive atmospheres and, furthermore, with the capability to hover in a controlled manner about a position in order to gather information about that environment.

There are several possibilities in what respects the classification of zones as function of the probability of occurrence and duration of a potentially explosive environment and, with these, the requirements on the product also vary. Vehicle design is above all, a function of the acceptable levels of risk and there is no single answer.

The worst case scenarios are presented by zones in which an explosive mixture is continuously present, these correspond to Zone 0 and Zone 20 of the EU and IEC classification for gases and dusts respectively. There exist two equipment groups, I and II. Since group I relates exclusively to equipment for use in mines, let us consider group II G (gas) and II D (dust). Under each group of equipment there exist three categories of equipment, 1, 2 and 3, according to the level of protection they offer. Given a Zone 0 and Group II constraint, only Category 1 equipment is deemed appropriate and implies very stringent requirements, in fact at levels of risk pertaining to potential sources of ignition under rare malfunction.

In order to hold position in a controlled manner, it is usual to consider vehicles whose main source of lift force and propulsion are rotary wings. These vehicles, as mentioned, will carry sources of energy, onboard sensors, processors, and actuators. For relatively small rotary wing craft in UAS Groups 1 and 2, i.e. vehicles with up to ~10 kg and ~30 kg, respectively, and payload type capabilities which vary accordingly, [9] the energy source are usually low voltage cells and the actuators are brushless motors.

There are many details to consider. The low voltage cells are most likely safe from the standpoint of ignition energy. However, the heat produced by the motors during operation will produce a temperature rise that has to be considered. High speed propellers may generate static electricity over the foils and excessive build-up which may require the use of discharge wick or similar device or a forced reduction of propeller speed. [10] The use of well designed carbon fiber propellers may alleviate this problem. Good electrical ground connection within the UAS frame should be established and there should be a discharge path to the air where, again, a discharge wick may suffice.

Onboard sensors using high voltage (e.g. radiation detectors) should either be turned off until otherwise is verified safe, or adequately encapsulated. Electrical connectors which are exposed to the environment should be of adequate quality and locking mechanisms should prevent inadvertent release. When in doubt, and to avoid incurring costly modifications at later stages of development, intrinsic safety and molding [11] applied to electrical components should be considered in many cases, but gas sensors for instance cannot be fully encapsulated and therefore adequate flame arrestors have to be considered (most sensor manufacturers provide with flammable gas sensors only). Having high quality Lower Explosion Limit sensors onboard is of utmost importance and redundancy at several levels is required to meet the most stringent requirements.

There are several protection classes (temperature and ignition). In most relevant cases a Type Examination is required, which means that the design is to be compared against the requirements of the standard specifications and, additionally and EC Notified Body will undertake either Product Quality Assurance or a Product Verification.

Conclusions

Recent advancements in UAS, have led to their operational deployment becoming increasingly ubiquitous in several types of risky interventions, mainly due to their capability of reducing the risk of personnel exposure to hazards or in acquiring valuable data for operational planning. This aspect can be of significant importance in the use of UAS in support to demining, CBRN or EOD operations, where the explosion risk may be present in several types of scenarios.

Considering the particular case of explosive atmospheres, there is a legal and standard ATEX framework that can be applied to UAS research, development and innovation activities.

The application of ATEX frameworks to the design of UAS can significantly increase the level of complexity in the design and verification. The acceptable level of risk dictates to what extent the equipment must prevent or protect from potential sources of ignition. The framework, however, lends itself to a semi-quantitative approach, at times amenable to interpretation, since a quantitative risk assessment requires much more information than is typically available.

The development of ATEX certified UAS can play an important role in the near future considering its use in several types of risky interventions, and may open a wide range of possibilities of applications, offering a cutting edge framework of opportunities in applied robotics.

ACKNOWLEDGMENT

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Generation and Fusion of Landmine Detection Intensity Maps, Using a Three Stage Algorithm

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ABSTRACT: Over 100 million landmines are buried in more than 80 countries around the world, and 26,000 people are killed or maimed by landmines every year. As such, facilitating the safe removal of landmines is a significant humanitarian issue. In order to improve landmine detection rates in sub-surface sensor data a feature detection, mapping, and data fusion algorithm has been proposed, developed, and implemented by the University of Leicester as part of the D-Box project. Testing of the developed algorithm and software has revealed the capability to detect landmines in test data, and to fuse two detection intensity maps using fuzzy logic.

Introduction

Over 100 million landmines are buried in more than 80 countries around the world, with 26,000 people killed or maimed by landmines every year (MacDonald et al. 2003). As such, safe removal of landmines is an urgent and significant humanitarian issue. Reliable detection of landmines is the first step in the removal process. In order to improve landmine detection rates in sub-surface sensor data a computationally efficient feature detection, mapping, and data fusion algorithm has been proposed, developed, and implemented in software. The algorithm and software are intended to be applied to the data arising from corresponding pairs of Metal Detector (MD) Ground Penetrating Radar (GPR) and/or other close-in detection tools used to scan landmine affected areas, allowing improved detection intensity maps of the areas to be developed in comparison to detection intensity maps derived from individual sensor scans.

Developed algorithm

The proposed and developed algorithm possesses three key stages: i) feature calculation, in which input data values are processed in some way to highlight the potential targets; ii) mapping, in which the feature data values are mapped into a two dimensional detection intensity map in plan; and iii) map fusion, in which maps generated using different input data and/or feature and map combinations are fused together using fuzzy logic.

A modular approach to the development of the three key algorithms stages has allowed multiple interchangeable methods to be developed for each of the steps. For the first stage, feature calculation, three feature calculation methodologies have been developed: i) a localised entropy calculation, ii) a statistically derived residual calculation, and iii) a Sobel based horizontal edge energy calculation. For

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the second stage, mapping, aggregation of the calculated feature values into detection intensity maps is achieved through either averaging of the feature values, summing the squares of the feature values, or counting of the number of qualifying feature values matching various qualifying criteria. For the third stage of the algorithm, map fusion, two detection intensity maps are combined utilising a Mamdani-Type fuzzy inference (fuzzy logic) system into a single detection intensity map. The developed software bookends the three stage algorithm with data loading/pre-processing and data outputting functionality, resulting in the usage flow shown in Figure 1.

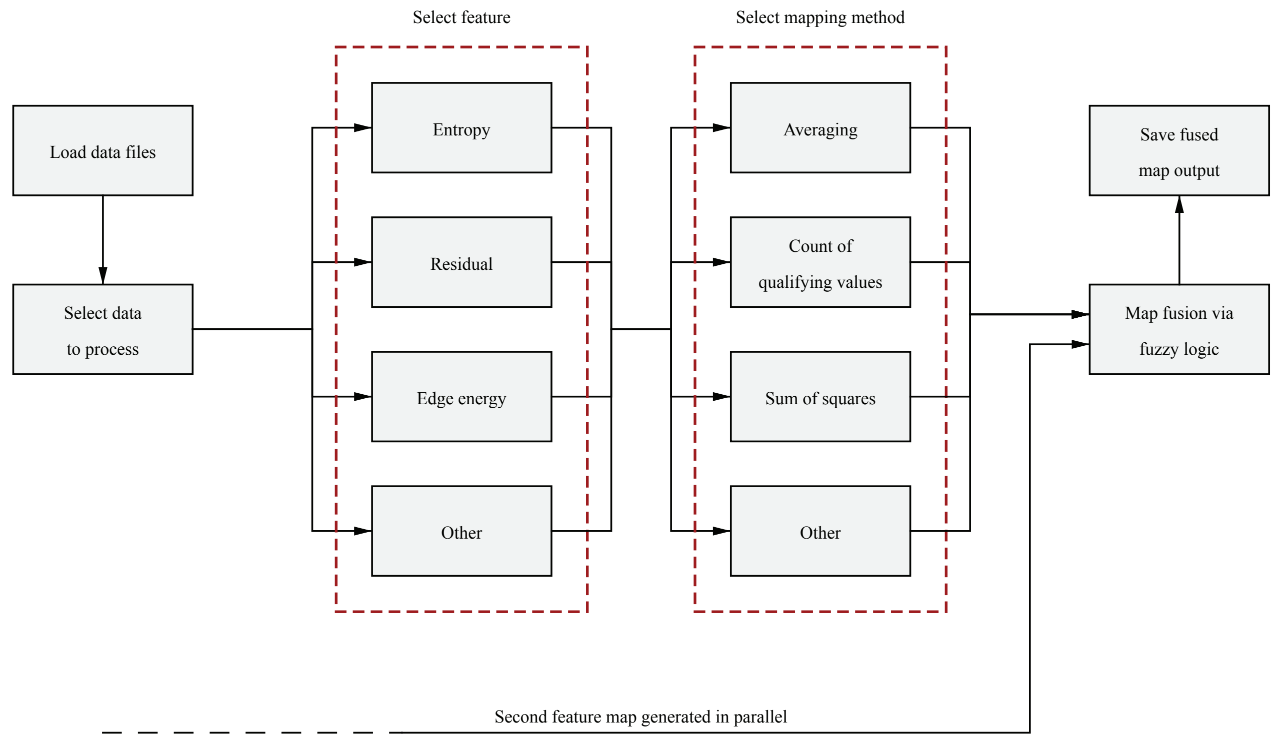

FIGURE 1: Three stage algorithm steps with interchangeable methods, bookended by data input/preprocessing and output functionality.

In the first algorithm stage, input data arising from the application of close-in detection sensors (e.g. GPR, MD etc.) is processed to highlight potential targets represented within that measured data. The methods implemented, entropy, residual, and edge energy, are described below.

The entropy feature, in the context of the information theory (Shannon entropy), quantifies the number of bits required to represent the range of values in a dataset. The entropy feature is calculated by dividing input data into a series of appropriately sized localisations (in plan and per layer), known as sub-units, and calculating the Shannon entropy for each of these sub-units using Equation 1.

$$H = -\sum_{i=1}^{N} p_i \cdot \log_2 p_i \tag{1}$$

The residual feature re-normalises the measurement floor of the input data to zero, and is calculated by subtracting from each layer of input data a representative value derived from the input data. The representative value for a plan layer of input data is the modal value of that layer's input data. The modal value for each layer of input data is estimated by quantizing the N datum points of the layer data into $\sqrt{N}$ bins that span the layer's data range, and taking the central value of the bin with the largest datum point count.

The edge energy feature quantifies the horizontal edges present in three dimensional data. The calculation steps acts sequentially on vertical slices of the data in two passes: cross-track and down-track. For this reason, three dimensional input data is a requirement. For each vertical slice of data the edge energy is calculated by 1) subtracting the mean of each row from its corresponding row to remove reflections of the surface, 2) convolution with a low pass (Gaussian) kernel to remove the high frequency content, and 3) convolution with a horizontal Sobel edge detection kernel (***Gx,*** see Equation 2).

$$\boldsymbol{G}_x = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{2}$$

In the second algorithm stage, feature values calculated using one of the feature calculation methodologies, described above, are converted into two dimensional plan view detection intensity maps. Each methodology aggregates the layers of feature values into one, producing a plan view summary. In the case where input data (and hence the derived feature values) are already two dimensional in plan the application of a mapping process is optional. The methods implemented, averaging, sum of squares, and count of qualifying values, are described below.

The averaging mapping method is a simple and robust process that involves summing each layer's feature values at each point in plan, and then dividing by the number of layers, resulting in a two dimensional detection intensity map where each point is the mean of the column of feature values it aggregates. The sum of squares method similarly operates on columns of feature values at each point in plan, but in contrast to the averaging method, squares each feature value before summing the column. This results in a two dimensional detection intensity map where each point is the sum of the squares of the column of feature values it aggregates.

The count of qualifying values method takes the number of feature values at each point in plan that meet some criteria as the detection intensity. A number of criteria that qualify a value to be counted can be used. The first, exceeding a defined threshold (e.g. the 85th percentile of the feature values), is the simplest. The second applies an additional constraint in which the qualifying values are only counted if the qualification is consecutive between layers. The length of the longest continuous qualifying values is then taken as the detection intensity. The third applies a further constraint in which the input data localisation (sub-unit) surrounding the feature value in question for two consecutive layers must be measurably similar. This measurement is achieved by treating the data in each localisation as a multi-dimensional vector and calculating the Euclidean distance (E_d see Equation 3) between them. If the Euclidean distance is small the localisations are designated similar.

$$E_d = \sqrt{\sum_{i=1}^{N} (q_i - p_i)^2} \tag{3}$$

The third stage of the algorithm, the fusion of two detection intensity maps, utilises a Mamdani-Type fuzzy inference (or fuzzy logic) system. The fusion process involves fuzzifying two crisp inputs, i.e. two corresponding intensities from a co-incident pair of detection intensity maps, combining the fuzzified inputs according to a prescribed logic, and then de-fuzzifying the result to generate a single detection intensity point on an output detection intensity map. This process is then repeated for each pair of detection intensities in the input detection intensity maps.

Five input membership functions for each input map value, and three output membership functions for the fused value are used, along with 25 "and" rules that cover each input pair possibility. The rules are not bound to a particular type of input data, and are intended to provide a generic fusion method for two arbitrary types of sensor data. This approach was chosen due to the data that was available for testing (see below), and the lack of an expert operator to consult regarding the fusion process. As such, the map fusion step currently provides a "proof of concept" functionality. Development of the fuzzy logic rules and membership functions is ongoing.

Testing results

Testing of the developed algorithm and software was performed using an open source GPR image of a test bed with buried targets and clutter (Counts et al. 2007). Additionally, a simulated MD image was derived from the ground truth associated with the GPR image, and was used as a second input into the algorithm. Detection intensity maps derived from various feature/mapping combinations applied to the GPR data, as well as select feature/mapping combinations applied to the simulated MD data, and an example fusion of two detection intensity maps, were compared to the ground truth detailed in Counts et al. (2007). The Receiver Operating Characteristic (ROC) curves, derived by varying the threshold of detection for each detection intensity map, resulting from such a comparison are shown in Figure 2.

Figure 2 shows the ROC curves for the entropy/averaging, residual/sum of squares, and edge energy/averaging feature/map combinations applied to the GPR data. Additionally show is the entropy/averaging feature/map combination applied to the simulated MD data, and the ROC curve for the fusion of the edge energy/averaging GPR and the raw MD data. While the entropy/averaging GPR ROC curve does not suggest performance better than a random guess, the residual/sum of squares GPR

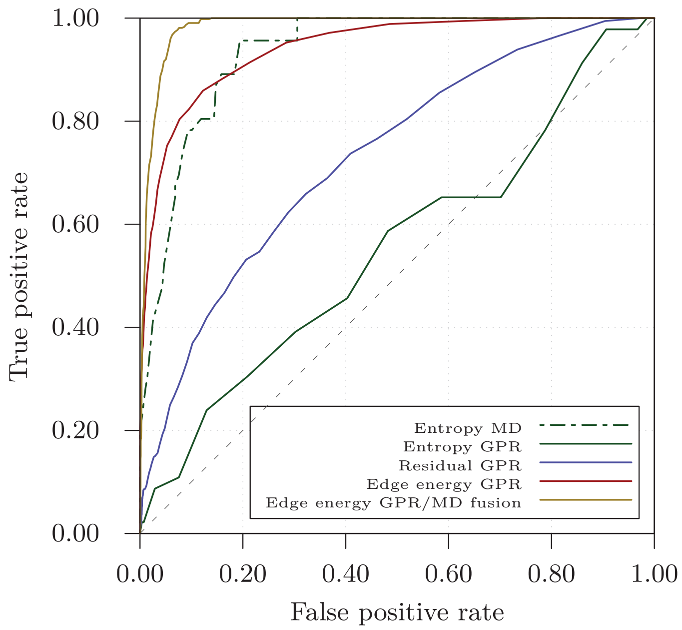

FIGURE 2: Plot of ROC curves for GPR input data using various feature calculations and layer averaging maps, along with a MD entropy feature and a GPR edge energy/MD fusion example.

ROC curve performs significantly better than a random guess, reaching a 50% detection rate with an approximately 20% false positive rate, and an 80% detection rate with an approximately 50% false positive rate. The edge energy/averaging GPR ROC curve performs better again, reaching a 50% detection rate with an approximately 1.5% false positive rate, an 80% detection rate with an approximately 8% false positive rate, and reaching an approximately 99% detection rate with an approximately 50% false positive rate. While the use of simulated data with the remaining two ROC curves invalidate assertions regarding the true and false positive rates they do suggest that the variety of feature calculation methods are useful to differing input data types, and that the fusion process is capable of improving on single sensor derived detection intensity maps.

Conclusions

A close-in detection data analysis algorithm and associated software has been developed as part of the D-Box project. The developed algorithm can be broken down into three key stages: i) feature calculation, ii) mapping, and iii) data fusion. Algorithm options include three methods for feature calculation (entropy, residual, and edge energy), three mapping methodologies (averaging, sum of squares, count of qualifying values), and a specification for the fuzzy logic data fusion rules. Testing of the developed algorithm has revealed that the residual and edge energy feature options are capable of detecting landmines when using an open source measured GPR dataset as input, as is the entropy feature option when applied to simulated MD data. The fusion of two detection intensity maps using fuzzy logic has also been demonstrated.

ACKNOWLEDGEMENTS

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Validation testing of the APT-796 (Area Preparation Tractor)

Authors[1]: Giovanni Polentes, ***Matteo Zoppi****, Michal Przybylko*

ABSTRACT: The APT is designed to assist manual deminers by cutting undergrowth and preparing the ground surface in advance of Technical Survey or area clearance. Built around proven agricultural technology, it is a small, low-cost demining asset that can be fitted with road wheels and driven on-board when not radio-controlled for use inside a Suspected Hazardous Area. An agricultural 3-point linkage and hydraulic power take off mean that a wide range of implements can be easily fitted. A robust vegetation mulcher and ground processing tool was fitted for the tests. APT's hydraulic gearbox allows it to creep along slowly or to be driven over roads at more than 30kph in order to move between working areas. Having been originally designed to work in mountain vineyards, its ability to climb slopes and manoeuvre around obstacles is unparalleled.

The machine was shown at the 2015 CTRO Symposium and subjected to blast and fragmentation testing shortly thereafter. Having performed well in the blast tests, it was successfully field tested by CTRO during May and August 2015. Testing took place on abandoned agricultural land and in an overgrown forest. It included testing the training of operators and evaluating our draft training materials. A CTRO accreditation certificate and validation report were issued on 27th July and 26th October 2015.

A final production machine is under construction. Because it will not be identical to the machine tested, we look forward to conducting further tests with CTRO before formally offering it for sale to the demining community.

The Area Preparation Tractor (APT) for humanitarian demining was developed under the EU supported TIRAMISU Research and Development project. Its design has been a collaboration between an Italian tractor manufacturer, Pierre Trattori, and the Engineering Department of the University of Genoa. Throughout the project the design team have been guided by end-users and staff of the Centar Za Testiranje, Ravoji Obuku (CTRO – Centre for Testing, Development and Training) in Croatia.

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This project began with the aim of producing a reliable, low-cost machine that could cut undergrowth and prepare the ground surface in front of manual deminers. This would make manual demining faster by removing the undergrowth and preparing the ground surface. It would also make the demining safer by initiating or chopping the fuzes off any fragmentation mines and breaking any tripwires that were present. Although the machine would not be designed to deliberately detonate mines, it would be the first asset used in suspected hazardous areas so had to be able to withstand blasts and fragmentation from antipersonnel mines that might detonate under its wheels or tools. The machine also had to be remotely controlled for work in hazardous areas and capable of being driven over roads to the minefield. Finally, it also had to be readily converted back to agricultural use when it was no longer needed for demining. These design requirements seem simple, but they proved to be challenging.

It was decided not to design from the ground up because this would be sure to encounter many problems that had already been solved. Instead, we decided to use a base machine that was already proven to be strong, rugged and dependable.

The base machine is a small, commercially successful tractor designed to work on the steep slopes of Italian vineyards. To allow it to manoeuvre easily between vines, its front-wheel steering is augmented by an articulated chassis. This makes it the first machine in demining that is powerful enough to climb and work on steep slopes and also manoeuvrable enough to work closely around obstacles and mature trees. Its hydraulic gearbox allows it to creep along very slowly, or drive on roads at speeds over 35 kph.

The challenges involved in converting the machine for use in demining began with the need to develop blast-resistant wheels that could replace the road wheels before entering a minefield. The wheels had to absorb enough of the blast energy to prevent shock-loads damaging the bearing and axles and without the wheel distorting or being damaged in a way that prevented the machine carrying on working.

There have been two main iterations in APT's development. The first machine was known as Locostra and was the successful platform for perfecting APT's radio-control system and blast resistant wheels. The second iteration was named the "Area Preparation Tractor" (APT). This was fitted with a more powerful engine and armoured in readiness for blast testing and field trials in Croatia.

Experienced wheel designers were consulted, prototypes produced and blast-tested and the design team eventually produced the successful wheels that are used on the APT today. To keep costs low, the design uses high quality off-the-shelf parts and metal fabrication techniques that are available in any workshop capable of repairing the chassis of road vehicles. The machine is supplied with both road wheels and blast resistant wheels which it tows to the worksite on a trailer. An integrated jacking system makes changing the wheels simple and fast.

A high specification industrial radio control system was fitted without removing any of the manual controls, so allowing the machine to be controlled from on board for road transit and remotely controlled when entering a hazardous area. The range of the radio-control varies according to obstructions in the environment but is at least 200 metres in any environment, and 500 metres in open country.

The tractor was armoured to protect against fragmentation from mines using grades of steel that are readily welded should repair ever be necessary. Most engine maintenance can be conducted through hatches and when necessary the armour shells from the two halves of the articulated body can be lifted away. The added weight of the armouring led the design team to fit a larger engine with an enhanced engine cooling system to allow it to be run at high speed for prolonged periods in hot climates. The air-filters are reversible, so allowing accumulated dust to be blown clear periodically. Built into the armouring is a protected camera system that can be used when maintaining operator line-of-sight is either not possible or too hazardous.

With a standard agricultural three point linkage, a PTO and a large hydraulic pump, APT can have a wide variety of commercially available tools attached at both front and rear and work in either direction with the same gearing and power. A heavy-duty hydraulically controlled vegetation mulcher and ground processing tool with blast deflectors has been fitted as the main area-preparation tool. This is not intended to dig for mines, rather it is meant to mulch undergrowth and loosen the ground surface in preparation for manual demining. When it detonates an anti-personnel mine, that indicates where the mines are and is useful as part of area reduction. Although the machine could keep on working and detonate more mines, it would normally be withdrawn to allow manual demining to take place without disturbing any mine pattern.

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

Having performed well in the blast tests, the same machine was field tested by CTRO over five days during August 2015. Testing took place on abandoned agricultural land and in an overgrown forest that was a suspected mined area. The work included testing the training of operators and this helped to inform the development of our operator training materials. An independent demining specialist[2] was present as a critical observer along with representatives from the manufacturer and the University of Genoa. The testing was successful and helped us to determine APT's strengths and limitations in a real working environment. A CTRO accreditation certificate and validation report were issued on 27th July and 26th October 2015.

During the field testing, several recommendations for design refinement for inclusion in the final production machine were identified. The friendly cooperation of CTRO staff is greatly appreciated because it has been instrumental in our being able to optimise APT's utility for field users and avoid making claims that it cannot live up to.

A final production machine is currently under construction. Because it will not be identical to the machine tested, we look forward to conducting further tests with CTRO before formally offering it to the demining community.

The independent observer at our in-house blast testing and the APT field trial in Croatia, Andy Smith of AVS Demining Consultants, said:

> *"APT is a tool that has long been needed. By comparison with all other demining machines, it has low purchase, maintenance and running costs. It is also easily transported and can climb steeper slopes than any of its competitors. The remote controls are genuinely robust and so simple*

2 Andy Smith (Andrew Smith) of AVS Demining Consultants. See www.nolandmines.com

that I could use them well within a few minutes. I think it has achieved the design aims. It will increase the speed of manual deminers by cutting undergrowth and preparing the ground surface in advance of Technical Survey or area clearance and help to find minelines without disrupting any pattern there may be. It should also make demining safer by reducing the fragmentation mine threat and by breaking the ground surface so that excavating mines is easier to do safely. It is such a versatile machine that there any many other tasks it could do to help the local community during off-duty hours. If I were still a field manager in demining, there is no doubt that I would want one now."

The APT team believe that this Research and Development project has been successful primarily because it has involved continuous close cooperation between the manufacturer and the University. This has ensured that the theoretical input has always been grounded by practical considerations. The encouragement and support of CTRO and other people with field experience helped us to target the work appropriately and has been invaluable throughout.

Other uses

The Area Preparation Tractor's standard agricultural three point linkage, PTO, hydraulic pump and hefty generator allow it to be fitted with a very wide range of commercially available agricultural and construction-site tools.

It's ability to move in a very controlled way, crossing rough ground, climbing slopes and weaving between obstacles make it an ideal carrier for a range of specialist equipment. It is a very small tractor but would make an unusually large IED robot if it were fitted with a hydraulic arm, disruptors and/or explosive charge-placement systems. If there is demand for this version, its armouring would be more heavily braced to enhance its sustainability in the event of an unintended detonation.

CONTACT

For more information about the manufacturer of the Area Preparation Tractor (APT), see http://www.pierretra.it/index.php?lang=en. To discuss APT, or perhaps discuss ideas for other applications, please contact Matteo Zoppi at the University of Genoa (zoppi@dimec.unige.it) or Giovanni Polentes at the Pierre Trattori factory (giovannipolentes@pierretra.com).

Latest developments on tools for Mine Risk Education within TIRAMISU project

E. E. Cepolina[1], I. Ostrowski, A. Masłowski, M. Kacprzak[2]

ABSTRACT: TIRAMISU[3] EU co-funded project has recently ended. Among many tools developed by project partners during the four year research and development work, two tools have been designed, implemented and tested specifically for Mine Risk Education. The two tools differ for nature and targeting audience, but are both designed to be flexible and adaptable to the local context. Latest developments on the "Rally on the back of electronic turtles", an educational computer game designed for children and on "Billy Goat Radio", a system for creating campaigns based on a short serial drama to be broadcast by radio, are here presented together with evaluation of latest in- field test results.

Introduction

TIRAMISU (**T**oolbox **I**mplementation for **R**emoval of **A**nti-personnel **M**ines, **S**ub-munitions, and **U**XO) project dealt with the research and development of many different innovative tools for humanitarian mine action; among them two tools are specifically targeting Mine Risk Education (MRE). They address a broad spectrum of different beneficiaries and contexts, as the Rally on the back of electronic turtles computer game, developed by the Institute of Mathematical Machines, is addressed to children living in those countries where technological context and computer literacy allows them to enjoy this technology, while the system for creating short educational serial dramas to be broadcast by radio and performed lively across mine affected communities Billy Goat Radio, developed by Snail Aid – Technology for Development, is especially addressed to adults and young adults living in any place, either isolated or not.

Although the work on the tools has started only in January 2013, at the moment both the computer game and the tool based on the radio serial drama have reached high maturity level and have been validated twice.

While Billy Goat Radio tool has been validated first in the Saharawi refugee camps in Algeria in 2013 and in Pailin region of Cambodia in 2014, the Great Rally on the Back of Electronic Turtles has been pre-tested in Poland 2015, and finally tested in Croatia in late 2015.

Although being different, both tools share the same approach: they are designed to be used by local stakeholders to build and shape their MRE campaigns according to their needs, embedding a comprehensive adaptability system that assure both the tools great flexibility.

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3 Toolbox Implementation for Removal of Anti-personnel Mines Sub munitions and UXOs, co-funded under the European Community's Seventh Framework Programme (FP7/2007 – 2013) under grant agreement n° 284747.

Great Rally on the back of electronic turtles

The game is played by children with their individual Internet-connectable mobile devices under supervision of a teacher-instructor. The game is of the board type, and rally on the backs of electronic turtles through a terrain with mine risks is its content.

The board of the game depicts a map with a net of paths connecting start point with finish line of the rally. During the game, the players see on screens of their portable devices only a fragment of the board, the neighborhood of their pawns-turtles – likewise as contestants in a real rally. And likewise as real contestant, the player can pull out the "map" of the rally and see it on the screen.

Pawn-turtles have to be feed on "grains of movement"; one grain lets the turtle to make one step on the path. Each step is triggered off by player by touching the path on the screen, but can be executed only if there are grains of movement in the turtle's resource. Replenishment is accomplished as a result of players' visits in Information Outlets, playing role of filling stations where payment is executed by correct answers to questions of the quizzes on safe behavior in the face of mine risk. [Kaczmarczyk et al, 2015]

The game "Great Rally on the back of electronic turtles" is prepared as server – client solution in which trainer and trainees connect to server via web browser. Game has been developed as internet service accessible all time from all over the world. Demo of the game can be accessed under address http://tnij.org/mregamedemo.

FIG. 1. Logo of the game

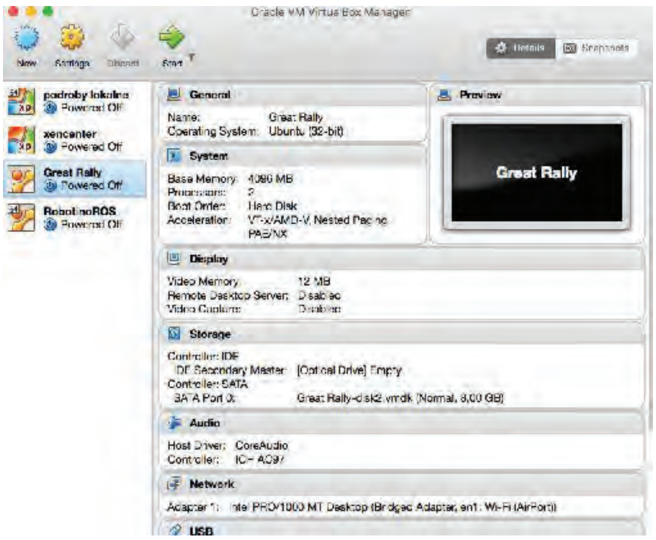

FIG. 2. Window of the VirtualBox application

FIG. 3. Teacher's screen for editing or choosing game variants

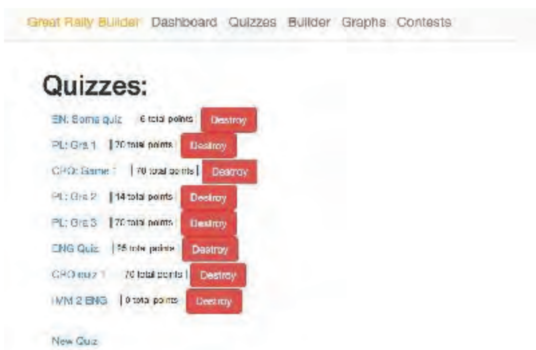

FIG. 4. Teacher's screen for editing the game quizzes

For playing game is necessary touchscreen or touchscreen simulator. Game server is a typical LAMP server on which IMM proprietary software is running, server is located in the IMM, Warsaw, Poland. During tests in Croatia we experienced some trouble with Internet connection, and the game wasn't accessible occasionally because of this. Practical solution to this problem was to initiate a local server with the same software. This work takes too much time with all software implementation and configuration. This work can be done only by information technology engineer. Because game is played by children with their individual Internet-connectable mobile devices under supervision of a teacher-instructor, the teacher should be able to set up server and operate it. Operating the server is as simple as it can be (fig 3, fig 4). Simplification of the setting up server have been developed by creating virtual machine, which include all necessary software and run it automatically. Virtual machine is prepared for open source software VirtualBox [Virtualbox]. Virtual box can be download free for most used operation system like Mac Os X, Windows, and Linux too [VMmanual]. The Virtual box is an easy to use software with very clear user interface (fig. 2) Minimum requirements for the host computer (where game server will be running) is: CPU: 2 cores, RAM: 4 GB, VirtualBox version 5.0.1 or later.

That means that a typical laptop computer can be used as a server during lesson with the game. Now the game server can be set up by every person even without good knowledge in computer technology.

Billy Goat Radio

Billy Goat Radio is a Mine Risk Education tool, developed by Snail Aid – Technology for Development, in the framework of TIRAMISU project. It consists of a modular and adaptable system aimed at enabling local end- users to create cost-effective Mine Risk Education or more generally Risk Education (RE) campaigns.

RE campaigns created with Billy Goat Radio tool consist of three elements:

a. Radio broadcast serial drama – the core of Billy Goat Radio tool

b. Itinerant live shows

c. Group discussions, embedding a first form of evaluation

The core element of Billy Goat Radio is the serial drama. The serial drama consists of six episodes lasting circa twenty minutes each. As usual, the serial drama structure foresees a story fragmented in chapters and the happenings don't find a conclusion inside the single episode, needing a certain level of concentration capability and memory to be followed. For this reason and for the topics present in the story, Billy Goat Radio tool is specifically addressing adults and young adults: this doesn't mean it is not recommended for children, but that it is meant to be educational and entertaining for an adult audience. Educational messages especially thought for children needs are still present in the story, but they are presented in form of messages parents or teacher should convoy to children, and not directly addressed to a very young audience.

The educational use of serial dramas is a result of the Entertainment-education theories. Descending from socio- psychology and human communication theories, Entertainment-education principles are aimed to modify wrong or risky behaviours of common people by spreading information through a mass medium.

Fundamental is the assumption that people from every country are widely exposed to entertainment through media: this intense fruition of messages assimilated through viewing, listening and reading proposed by media suggests that mass media, more than other tools, can effectively modify the way how people feel, think and behave. Thus, Billy Goat Radio is a tool designed to use radio as a mass medium able to simultaneously entertain and educate its audience.

Fundamental characteristic of Billy Goat Radio system is its adaptability. The adaptability system, one of the core modules of Billy Goat Radio system, allows to write a different educational short serial drama, tailored to the local context both in terms of daily life and risk messages, for every different context. It is designed to be used by local operators with understanding of clan system, religion, language, gender, age, geographic location and socio-economic status, to create stories with appeal to the local audience, without having them to be professional writers nor to engage in a long and expensive re-writing process. RE messages are chosen, among the ones suggested by the Adaptability System, by local operators, after an ad-hoc needs assessment of local threat, casualties data, categories of people most at risk, socio-economic status of at risk people, possible economic alternatives to risky activities, important resources whose access is blocked, data about organizations who can help mine victims, and so on. Thus, the adaptability system guarantees the cost-effectiveness of the system.

Billy Goat Radio is modular since it’s a kit composed by different modules. According to the situation only some of these modules might be needed. The modules Billy Goat Radio system consists of are:

– Adaptability system, the core module, consisting of an intuitive software for creating the script of the serial drama, adapted to the local context and an intuitive software for selecting RE messages adapt to the local context.
– Actors training guidelines, a guide to teach nonprofessional actors simple tricks to make their performance good for the radio broadcasting through exercises.
– Audio recording and post-processing guidelines, a list of cost-effective and robust tools to be used to record actors voices for later broadcasting with details on how to connect them with each other to set up a simple recording studio. The audio recording guide and audio post-processing guide follows, enabling local operators to post-process the audio recorded using a free but very powerful software, with key functions explained in details
– How to set up a small radio station guidelines, a guide to set up a small local radio station
– Group discussion guidelines, guidelines for carrying out group discussions after the live show and perform a first evaluation of the system in terms of fidelity assessment and understanding of messages.

Billy Goat Radio reached its maturity at an early stage and could be validated through two different pilot campaigns in two regions of the world, diverse for society, environment and educational needs; the Saharawi refugee camps in Algeria [Scapolla et Cepolina, 2014] and Pailin region of Cambodia [Scapolla et Al, 2015].

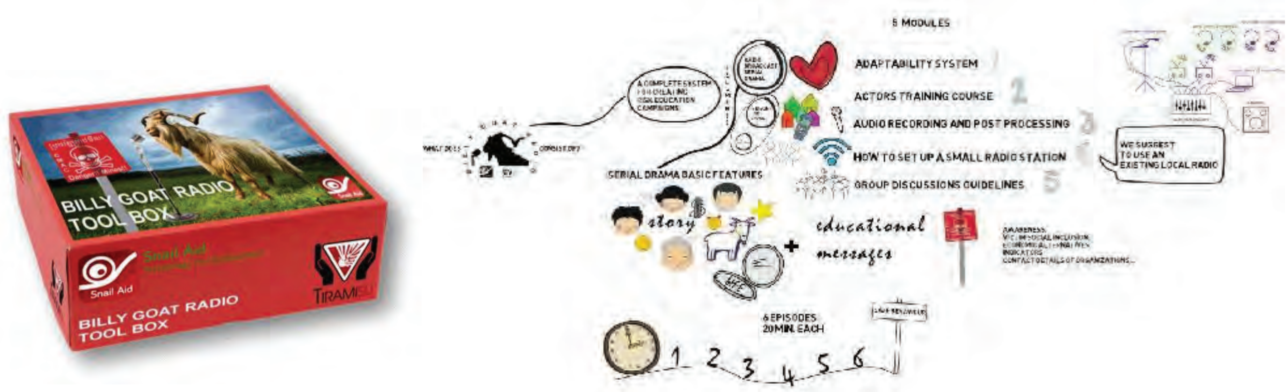

FIG. 5. Logo of Billy Goat Radio digital tool box and representation of what it cosists of.

Results and feedbacks obtained during the MRE campaigns of 2013 and 2014 have been used to tune Billy Goat Radio system toward its final, current version, in which the Adaptability System is more intuitive and flexible.

In this new version, the Adaptability system, once constituted of a system of cards, is replaced by a simple software in the form of an html file, running on any browser, without interent connection. The software is created with Twine (http://twinery.org/) an open-source software designed to create stories in which end-users can shape how the story evolves by making choices.

The Adaptability System leads local operators through a series of questions about the local context in terms of details of daily life (such as common names, jobs, habits of the characters,...); after going through all questions, end-users will automatically get the script of the story, adapted to and mirroring the local context, already organized and detailed, ready to be played by actors, needing only the insertion of the educational messages selected. The selection process of relevant educational messages is also provided by the Adaptability System.

MRE key messages have been reorganized 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 landmines / booby traps / UXO threats and new new digital cards have been added to guide end-users to formulate by themselves those MRE messages they can’t find among the proposed ones.

Once selected all the fitting messages, local operators have to embed them inside the serial drama script following the indications written in the script itself.

Having decided to use a simple software necessarily implies the need of using a computer, whose elementary knowledge is one of the basic requirements end-users must have to use Billy Goat Radio tool, together with adequate English language skills (the language of the system). 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.

Latest developments include the launch of a demo version of the Adaptability System on the internet accessible by anybody who is interested in getting an idea about how it works, upon request of a password from Snail Aid (only for statistic purposes). The demo can be accessed here:

http://www.snailaid.org/index.php/Give_Billy_A_Try.

The tool is now ready to be used and we are also investigating the possibility to make it available for free to interested stakeholders for a limited time period. Interested people are invited to contact the authors.

ACKNOWLEDGMENTS

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[virtualbox] www.wirtualbox.org

[vmmanual] Oracle VM VirtualBox® User Manual" Oracle Corporation Copyright © 2004-2016 Oracle Corporation

Embedding target discrimination capabilities into commercial handheld metal detectors for humanitarian demining

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Liam A Marsh, John L Davidson and Anthony J Peyton[2]

ABSTRACT: In this paper, we analyze the technical framework for embedding target discrimination capabilities into commercial handheld metal detectors (HMD) for use in humanitarian demining. We introduce the target discrimination concept based on the application of directional magnetic polarizabilities, determined from HMD response and positional data of its search head. We identify five key technical factors that need to be addressed for the purpose of target discrimination based on the proposed concept, namely (i) the analysis of MD search head in terms of its directional sensitivities; (ii) analysis of MD signal processing features, (iii) search head tracking system; (iv) novel human-machine interface (HMI); and (v) operating procedures needed for supporting these new HMD functionalities. We analyzed the existing technical approaches and proposed some new changes that could bring the whole concept a step closer to realization.

1. Introduction

Handheld metal detectors (HMDs) are nowadays considered as workhorses of the humanitarian demining (HD) industry [1]. These devices are sensitive to extremely small metallic targets 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 effectively between the metallic parts of a mine and innocuous metallic clutter.

The technology enabling discrimination of hazardous metallic targets such as landmines and unexploded ordnance (UXOs) from innocuous metallic clutter is becoming more mature and is gradually coming out of research laboratories towards full deployment in the field. Although performances of devices utilizing such technology have been successfully demonstrated in real-world conditions, namely for military-based UXO clearance [2] and security scanning [3], the HD community is still waiting for practical solutions that could address these challenges in everyday field operations.

In this paper, we analyze the technical framework for embedding target discrimination capabilities into commercial HMDs and discuss key features of such devices that need to be addressed for that purpose. Our work is motivated by an assumption that any novel target-discrimination device based

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on a metal detection principle should resemble to the existing HMD devices in terms of implementation robustness, operating procedures, price, ergonomics etc., if it is to be accepted within the HD community.

2. Target discrimination concept

A most common approach in HD that provides basic target discrimination capabilities relies on the application of dual sensors, e.g. MDs and ground penetrating radars (GPR) [4]-[6]. Such devices utilize complementary features of electromagnetic induction (EMI) and GPR technology enabling detection of both metallic content and plastic casings / charge of hazardous items. Dual-sensor detectors are commonly arranged with an integrated search coil / GPR antenna and separate detection (alarm) channels. In this way, target discrimination is accomplished by applying rather simple binary rules to the states of each alarm channel (e.g. *if* MD = "ACTIVE" *and* GPR = "ACTIVE" *then* target = "DETECTED").

In this paper, we refer to a fundamentally different target discrimination concept that relies on EMI sensing modality only, however the concept could be readily extended to dual mode detectors. The general idea is to use the EMI response of a HMD and positional data of its search head to extract information on target's geometry (i.e. its size, shape and orientation) and preferably its material properties. In other words, the target is first characterized in terms of its intrinsic EMI properties which can be later used as target discriminators / classifiers [7].

For a class of targets whose metal content size is rather small compared to the size of a search coil (e.g. low metal content landmines), the EMI response of the target can be represented by the so-called magnetic polarizability tensor [8]. This tensor may be observed as a symmetric 3x3 matrix containing six complex independent parameters, i.e. directional magnetic polarizabilities. These polarizabilities strongly correlate to target size, shape, orientation and material properties. They also depend on frequency (for frequency-domain (FD) or continuous wave (CW) sensors using sine-wave excitation), or the time instance at which sensor data are taken (for time-domain (TD) or pulse induction (PI) sensors employing pulse excitation).

3. Key enabling features of HMDs

In order to make commercial HMDs capable of reconstructing directional magnetic polarizabilities of a target from a typical detector sweep and apply it for target discrimination, there are several technical challenges that need to be resolved.

3.1. Directional sensitivities of search coil(s)

Search coils of commercial HMDs used in HD typically feature planar designs, normally based on single transmitter and one or more receiver coils, Fig. 1. Such designs are usually optimized with respect to detector size and its sensitivity to metallic targets in a single (e.g. vertical) z-direction only. Due to their compact form and high z-direction sensitivity, planar coils are very well suited for metal detection purposes. However, target characterization can become quite difficult with such sensors since the target needs to be subjected to all three orthogonal field components so that its directional magnetic polarizabilities can be estimated unambiguously. Fortunately, sweeping the search coil over a buried target usually helps in obtaining magnetic field distributions that result in better directional sensitivities of the sensor at target location.

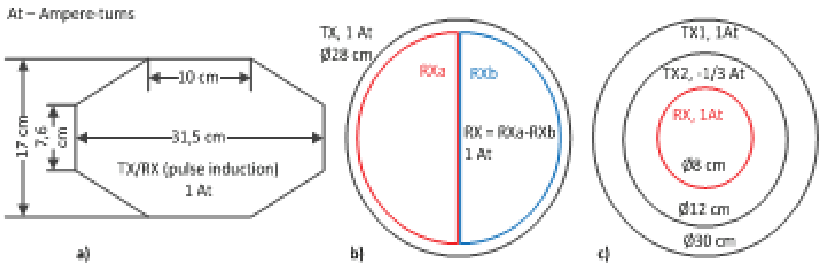

FIG. 1. Characteristic search coil designs: a) oval mono- coil, b) "double-D" gradiometer, c) magnetic cavity design.

Directional sensitivity maps are very convenient tools for estimating the sensor's ability to reconstruct directional magnetic polarizabilities of a buried target. Examples of such sensitivity maps calculated for directions that correspond to three principal magnetic polarizabilities of a normally oriented target (i.e. *xx*-, *yy*- and *zz*-directions) are shown in Fig. 2. The maps are calculated for three characteristic search coil designs, well known in the HD industry, Fig. 1. In general, larger areas of higher sensitivity imply better reconstruction of a magnetic polarizability component for a given direction. The sensitivity maps from Fig. 2 reveal that *z*-direction sensitivities dominate over *x*- and *y*-direction sensitivities, as expected for planar sensors. For a mono-coil and double-D gradiometer case, commensurable sensitivities in *x*- any *y*- directions can be obtained near the coil edges.

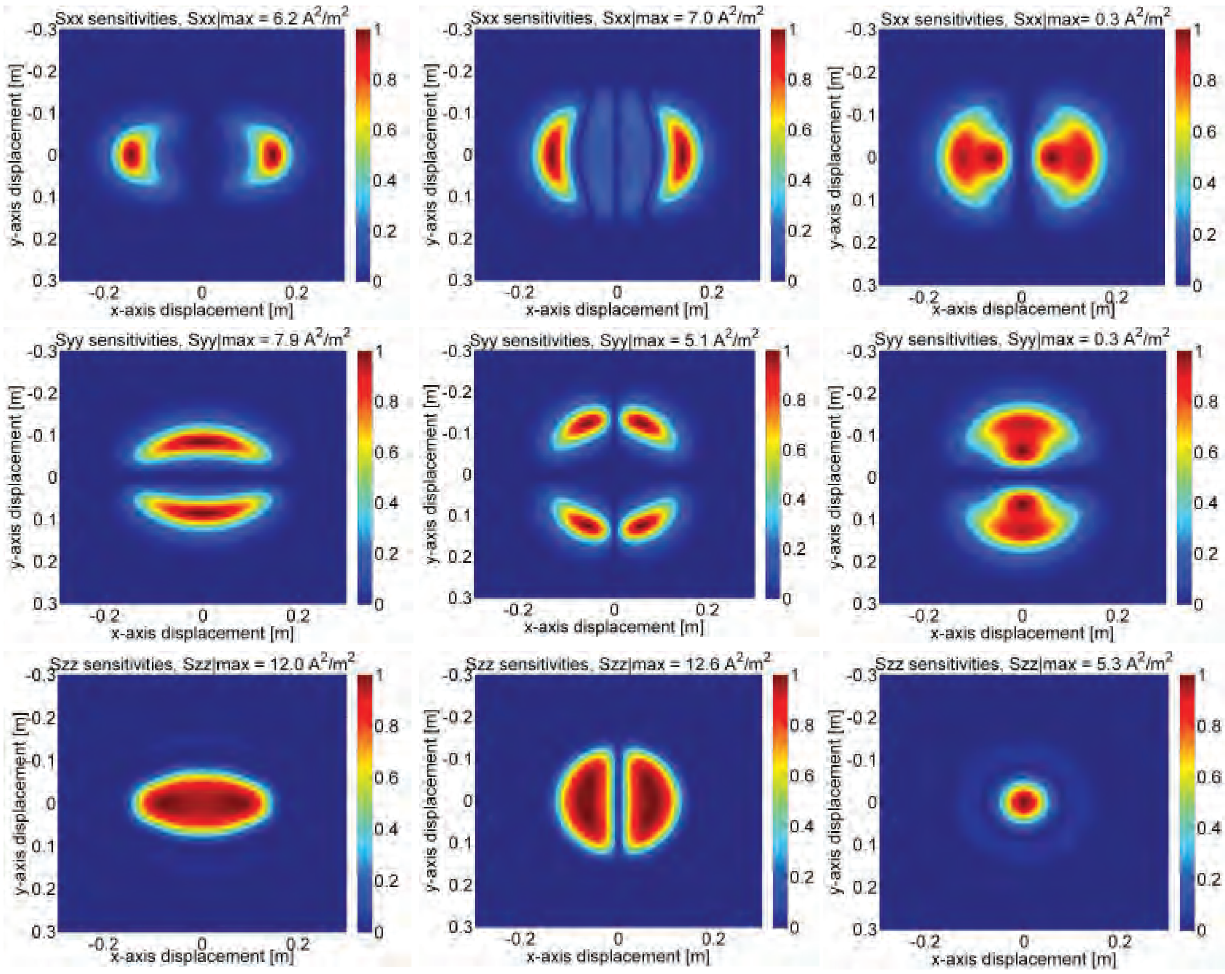

FIG. 2. Normalized sensitivity maps corresponding to *m*xx (1st row), *m*yy (2nd row) and *m*zz (3rd row) for octagonal mono-coil, double-D gradiometer and magnetic cavity design (col. 1-3, resp.), 5 cm depth.

FIG. 3. Current solutions for a search head tracking system. a) optical system using CCD camera mounted on a search head [6], b) inductive system utilizing a transmitter coil as a magnetic beacon [2], c) ultrasonic-optic system [9].

3.2. Signal processing features

The proposed concept of target discrimination using directional magnetic polarizabilities can be equally applied to CW and PI MDs. For a CW detector, it is important that its search coils (and corresponding electronics) support multi-frequency operation in a range 1 – 100 kHz. Obtaining target's polarizabilities at multiple frequencies (i.e. performing magnetic polarizability tensor spectroscopy) leads to more reliable target signatures. It also improves the accuracy of target localization.

For a case of PI detectors operating in time- domain, target polarizabilities need to be reconstructed at multiple time instances (i.e time gates), which is principally equivalent to spectroscopic operation of CW detectors. For that purpose, detector electronics must be able to sample the target EMI response accordingly.

3.3. Search head tracking system

Another requirement for the estimation of the directional polarizabilities of the target is that positional data (i.e. position and orientation) of a search head need to be provided. For robot-mounted MDs, this issue can be easily mitigated since the search head pose is strictly defined in a robot coordinate system by the kinematics of a manipulator. On the other hand, handheld detectors need to have a separate tracking system operating in (near) real-time.

Different solutions have been proposed for that purpose. A well-known dual-sensor ALIS detector uses a CCD camera mounted on a search head and two white discs placed near the scanning area, Fig. 1.a) [6]. An experimental handheld UXO detector MPV-II employs an inductive system where the transmitter coil is used as a magnetic beacon whose pose is determined from the two stationary receive coils, Fig. 1.b) [2]. Other proposed solutions include ultrasonic-optic triangulation, Fig. 1.c) [9], data fusion of inertial sensors and optical flow camera [10], systems with stereo cameras [11], special metal markers combined with inertial sensors [12], etc. In general, an optimal search head tracking system would have to provide a sub-centimetre accuracy, high update rate (in milliseconds range), minimum complexity, unobtrusiveness and convenience.

3.4. Human-machine interface

One of the most important features of a target discriminating HMD is its human-machine interface (HMI). While it is quite clear that any detection device used in HD should have a standard interface in compliance with CWA-14747 or other regulatory requirements (if needed) as a basic option, a key question that arises here is how to present the additional information on a target (e.g. its size, shape, orientation, location, level of similarity to a stored EMI footprint of a known target, etc.) to a deminer. In general, the level of abstraction and confidence of target information that is available would be a key factor determining the possible HMI solutions.

Current HMI solutions applied for HMDs vary in terms of their complexity. In the HD industry, novel MDs and dual-sensor detectors usually feature graphic displays that provide visual representations of alarm signals, Fig. 4.a [4]. A much more complex approach is adopted in ALIS detector, where reconstructed EMI images and C-scan GPR images of a target are superposed on an image of the scanned area captured from the camera and projected on a head-mounted display [6]. Similar innovative data visualization concepts are found in some HMDs for archaeological exploration, Fig. 4.b [13], treasure hunting, etc.

FIG. 4. Current HMI solutions for MD data. a) HMI of a Vallon VMR3G dual-sensor detector [4], b) next-generation metal detector for archaeological exploration utilizing eyewear for data visualization [13].

3.5. New operating procedures

The probability that a new detection device with target discrimination features will be adopted within the HD community depends to a large extent on its required operating procedures. In general, devices that require no or minimal modifications to the existing and well-established procedures for manual demining using MDs are highly preferred.

Having that in mind, we envisage a two-step operating procedure for the application of target- discriminating HMDs. In the first step, a device would operate in a standard, deminer-familiar MD mode using a standard audio HMI. After a detection signal is obtained, a deminer could switch the device into the "target discrimination" mode and use the additional target information provided through dedicated HMI for its decision on how to proceed. This second step might require slight modifications of the standard MD procedure in terms of scanning speed and/or pattern, as well as some specific operations related to the application of a search head tracking system.

Conclusions

The metal detection technology enabling discrimination of landmines and unexploded ordnance from innocuous metallic clutter is becoming more mature and is gradually coming out of research laboratories towards full deployment in the field. We have analyzed key technical factors that need to be addressed from a practical point of view so that such technology could be directly applied to commercial handheld metal detectors for use in humanitarian demining. The technological innovations in terms of position measurement would also be beneficial to the analysis of GPR data as B- and C-scans could be accurately constructed. This would itself allow more advanced inversion algorithms and fusion with the MD data, for instance co-location of the metal components identified from the tensor inversion with the GRP signature of the plastic casing / charge. Of course an advanced HMI would aid both MD and GPR. Inputs from the demining community, especially regarding human-machine interfaces of such devices, as well as their operating procedures, are crucial for bringing the whole concept closer to realization.

ACKNOWLEDGMENT

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Advances in the Development of a Polymer-Based Sensor System for Explosives Detection

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ABSTRACT: Luminescence-based sensing methods are ideal for detection of explosives given their potential advantages in size, sensitivity, and fast response times, and since buried landmines can continue to release vapours regardless of casing material and buried depth. Conjugated polymer films are well-suited for this application, since when these light-emitting materials are exposed to very dilute vapours of TNT-like compounds, the explosive molecules adhere to the film and turn off the light emission.

A portable, robust instrument for in-field vapour-sensing integrating luminescent conjugated polymer films has been designed, prototyped and successfully tested in a simulated landmine environment, with efforts to optimise the system for field trials. The system, developed within the TIRAMISU project, was designed to be a complementary device to be used in conjunction with other mine-detecting instrumentation, such as metal detectors or ground-penetrating radar, to enhance confidence in mine clearing.

The system was tested with simulated buried landmines that had been buried for more than a year. The explosive vapours TNT and DNT were buried in sand and soil in either metal or plastic cases at depths of 2 cm, 5 cm, and 10 cm. The system showed good sensitivity to the vapours by quenching to around 20% of the original intensity over 2 minutes.

REST filters have been used for ERW-detection in conjunction with the polymer vapour sensors; we have prototyped an integrated system of the portable optical sensor with a filter-loading stage and heating chamber for speedy, localised use of REST filter methods. Initial results are presented with a view to future deployment.

1 Introduction

Efforts in the development of novel technologies for landmine detection have been ongoing in recent years, with an emphasis on optical sensing via conjugated polymers in this laboratory. Conjugated polymers have been of interest as nitroaromatic-sensing materials since their high sensitivity to these vapours was first noted [1-5]. The basic principle of sensing is seen by the light emission from the polymer being quenched when explosive vapours are adsorbed to the surface (Figure 1).

Since this light level can be readily monitored by photodiodes, a portable system was designed for use in the field. The system was developed with the end-user in mind, so was intended to user-friendly,

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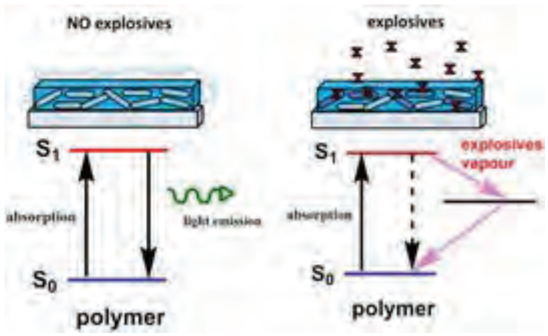

FIGURE 1: Quenching mechanism for conjugated polymers by explosive vapour

robust and lightweight. The prototype described in this paper was characterised and assessed for its suitability for the field, and for its adaptability to be upgraded or integrated with other techniques.

One method that would be very useful in mine clearance efforts, used in conjunction with the optical sensing system, is the use of REST filters. Air is drawn past the filters and the explosive molecules adhere to the surface; upon heating the filters release the molecules back into the environment. A drawback with this method, however, is the long wait time between sampling and analysis. If the filters can be immediately analysed on-site, then this could dramatically increase demining efficacy.

In this paper we report on the performance of a vapour-sampling optical sensing system, the performance of REST filters in conjunction with the polymer films, and efforts to integrate the two methods for field-use.

2 Experimental

2.1 Film fabrication

Films based on Merck Super Yellow and polyfluorene (PFO) were prepared by dissolving the polymer in toluene at a concentration of 6.5 mg/ml, prior to spin-coating at 2000 rpm on 1 cm^2 cover glasses from Agar Scientific. Film thicknesses, measured with a Veeco Dektak 150, were found to be 100 nm on average. Absorption and photoluminescence spectra were measured with a Cary 300 Bio UV-Vis spectrometer and Edinburgh Instruments FLS980 Fluorescence spectrometer respectively, and were 440 nm and 590 nm for Super Yellow and 384 nm and 420 nm for PFO. Photoluminescent Quantum Yield (PLQY) was measured with a Hamamatsu Photonics C9920-02 integrating sphere and found to be 40% for Super Yellow and 46% for PFO.

2.2 Instrumentation design

Briefly, the sensor system is comprised of an IP67 enclosure; an excitation LED (matched to the absorption peak of Super Yellow); a lock-in sample holder; sample chamber; pump to draw the vapour from the bottom face of the enclosure, past the sensor film, and exhausted at the rear face; collection optical components; and an Arduino microprocessor. The data is sent to a LabView programme for real-time monitoring, or a simple green/red light interface to alert the user to the presence of explosive vapours.

A heating element was introduced to the enclosure with a light filter holder, with control valves to allow equilibration between the heating chamber and the sensor chamber after heating. The unused space in the original prototype was utilised for the heating components, so the system size is unchanged, though with an increase in weight of around 0.5 kg.

FIGURE 2: Prototype of the explosive vapour sensor (lid off)

2.3 Landmine simulation and vapour measurement

The explosive samples are based on NESTT materials (www.xm-materials.com), which are silica particles coated with the explosive material (~8% explosive). The simulated buried landmines were prepared by putting approximately 1g of either TNT or 2,4-DNT samples into metal or plastic containers and buried in soil or sand at depths of 2 cm, 5 cm and 10 cm in a pot, and left for one year before measurements were made. The samples were securely held in a glove box to provide a controlled environment, with humidity and temperature inside the sealed box constant at 28% RTH and 23°C.

2.4 Filter sampling

Air sampling was conducted at the Benkovac test site in Zadar County, Croatia. A clean filter was loaded into a nozzle attached to a portable vacuum unit, and the air above a landmine lane sampled for 10 minutes. The filter was removed from the nozzle and placed into a glass vial, and subsequently placed in the heating chamber as shown in Figure 3. As the filter is heated, the explosive vapour molecules are desorbed from the surface and introduced to the sensor chamber via a fan and valve.

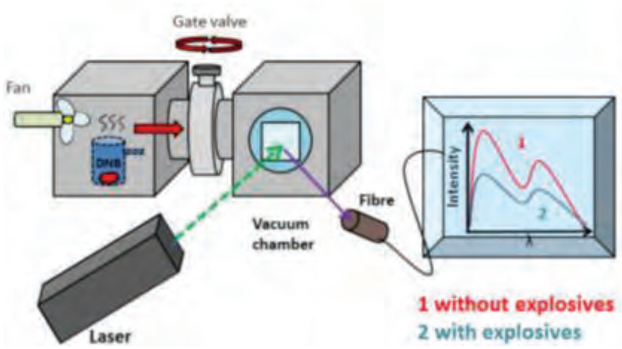

FIGURE 3: Schematic of heating element set-up for filter sampling

3 Results

Figure 4 shows the instrument response to air sampled above explosive materials, in this case, TNT in a metal casing at a depth of 5 cm in sand, and DNT in a plastic casing at a depth of 5cm in soil. These response curves are typical of the responses from TNT and DNT buried at various depths in either soil or sand and in metal or plastic casing. It can be seen that the light quenches to approximately 20%

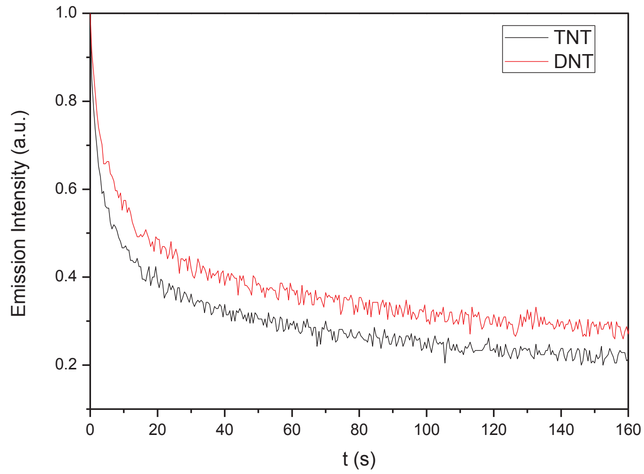

FIGURE 4: Response of prototype with Super Yellow film to buried TNT (black line) and DNT (red line)

over 2 minutes, with the majority of quenching occurring in the first 20 seconds. The saturated vapour pressure of TNT is 9.15 ppb, while that of DNT is 411 ppb[6]; the vapour pressure above the simulated buried landmines is expected to be significantly lower. This result indicates the sensor system has high sensitivity to explosive vapours released at ground level.

Figure 5 shows a representative response of a PFO-based sensor above a PMA3 landmine. It can be seen that there is a higher response to exposed filters than that of control filters. Further optimisation of the air sampling and detection system is ongoing to enhance the sensor response to contaminated REST filters.

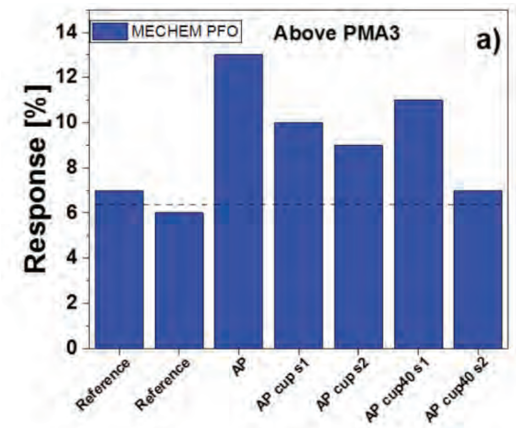

FIGURE 5: Response of the PFO sensor to samples collected above the PMA3 landmine using MECHEM filter

4 Conclusions

An optical sensing system has been developed which exploits the sensitivity characteristics of conjugated polymers to nitroaromatic vapours. The system has been designed and built to be portable, user-friendly and robust, and successfully detected explosive vapours from simulated landmines buried for over a year. Sampling in the field with REST filters was undertaken with initial promising results, and integrating the two methods for a single technical survey & close-in detection tool may provide a valuable system for humanitarian demining efforts.

ACKNOWLEDGEMENTS

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New technology for mine action – the hyperspectral Non-Technical Survey from UAV and helicopter

Milan Bajić[1], Tamara Ivelja[2]

ABSTRACT: The potentials of hyperspectral remote sensing are widely used in many domains, e.g. in the geology, agriculture, forestry, vegetables and fruit industry, protection of the environment, sea and land pollution monitoring, forensics. Our attention is aimed on the application of potentials of hyperspectral remote sensing for humanitarian demining, unexploded ordnance survey (UXO), on detection of improvised explosive devices (IED). The start was in European Commission FP6 project ARC (2001) for humanitarian mine action, continued with monitoring of sea pollution (Croatian Ministry of Science project 2008), finished in FP7 project TIRAMISU (2012-2015) with mine action and UXO detection. In these cases was used hyperspectral line scanner V9 (Specim) integrated in push-broom mode acquisition system. In 2015 we introduced full frame hyperspectral sensor, UHD-185 (Cubert). Both types of sensors (line scanner and full frame sensor) were integrated into aerial acquisition and navigation systems on board of multiengine UAV and a light helicopter and applied in very intensive data collecting campaigns over the mine fields. Also the radio controlled blimp and a large helicopter were tested and evaluated as platforms for line scanner. Main results of the research and development, testing and evaluation of this new technology for mine action are presented.

Introduction

Several kinds of aerial platforms have been used in research and development of hyperspectral technology for survey of the mine fields, Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5. The acquisition system is assembled from several components, the acquisition computer, WiFi communication unit, GPS receivers, which require supply of electric power and encumbers the aeral platform with significant payload. For helicopters payload parameter wasnt a problem, while for blimp and multiengine UAV this was the most critical issue, limiting flight performances and endurance. The used line scanner requires inertial measuring unit on board of aerial platform for measurement of its pitch, roll and yaw, complex and time consuming parametric geocoding, while for the fullframe HS camera procedure is much less demanding and time consuming.

Development of system for mine action survey

A research and development of the system and the technology for hyperspectral Non-Technical survey of suspected hazardous area (SHA) and confirmed hazardous area (CHA) is successfully accomplished in the project TIRAMISU. The hyperspectral data aerial acquisition, pre-processing, process-

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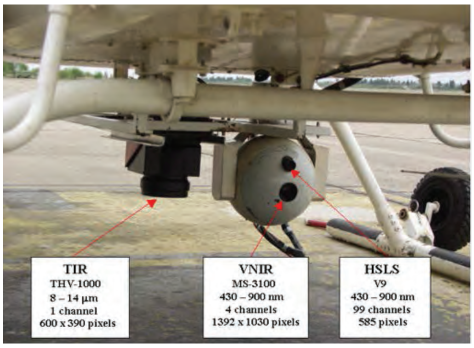

FIGURE 1. Hyperspectral line scanner HSLS V9 in gimbal bellow helicopter Bell206B (ARC, 2001-2003).

FIGURE 2. HSLS in pad bellow helicopter Mi-8 (2008 – 2012). USA funded projects in Croatia, Bosnia and Herzegovina, FP7 project TIRAMISU (2012).

FIGURE 3. HSLS installed on radio controlled blimp. FP7 project TIRAMISU (2012-2013).

FIGURE 4. HSLS installed on multi engine UAV, 2013-2014.

ing, calibration are very complex activities which strongly depend on sensor technology, on aerial platform characteristics and on the features of a surveyed scene. Two different hyperspectral sensors were used, a line scanner V9 (from 1999) and full frame matrix camera UHD-185. The full frame camera was available only one month in 2015, but its application enabled us to finalize successful development of the system and technology for aerial NTS survey. Two platforms are approved and selected for final solution, a light helicopter Bell-206B and multi-engine UAV, Fig. 5. The method for discrimination of the spectral indices response of grass inside of the mine field (IN) and in vincinity outside of mine field (OUT) was main research goal as well as the development of the technology for hyperspectral data acquisition.

a b c

FIGURE 5. Final versions in 2015 of aerial platforms with hyperspectral sensors. a) team for hyperspectral survey from helicopter Bell-206B. b) The line scanner V9 and full frame UHD-185 are located inside of yellow pod on helicopter, c) multi engine UAV with UHD-185.

Discrimination of grass inside and outside of the mine field

Research of methods for discrimination of grassy vegetation features between reference (clean) and test (mine contaminated) areas, based on hyperspectral data collected simultaneously, started in TIRAMISU in 2012. Research and development continued in 2013 and in 2014 on the ground vehicle-based system (methods and technology) and on the airborne system (methods and technology) using hyperspectral line scanner V9. Besides the spectral measurement inside of test site, the spectral response was measured in its vicinity outside of the test site and vegetation samples have been collected, Fig. 6, Fig. 7. The reflectance spectra of grass inside of the mine field, Fig. 6 has typical behaviour of healthy grass in its maximum developed phase. The grass outside of the mine field has reflectance spectra diagram that is different from grass inside of mine field, Fig. 7. The hyperspectral data collected by ground based acquisition and from helicopter using line scanner V9 have been analysed. Vegetation indices were analysed and (Simple Ratio, Red Edge Vogelman I, Red Edge Normalized Difference Vegetation Index), they discriminated areas with grass inside and outside of the mine field. Due to this indicative fact, we continued in 2015 intensive collecting of hyperspectral data by both sensors (V9 and UHD-185) and both platforms (helicopter Bell-206B and UAV) to provide statistical significant set which enables thorough analysis. The results shown at Fig. 8, Fig. 9, Fig. 10, Fig. 11 are derived from data collected in 2015 by UHD-185 on helicopter. Additional vegetation indices are applied (Carotenoid, Total Chlorophyll, CRI550) (Gitelson et al. 2002), using reflectance data at 510 nm, 550 nm, 700 nm, 750 nm and 802 nm and they showed better discrimination then indices previously used.

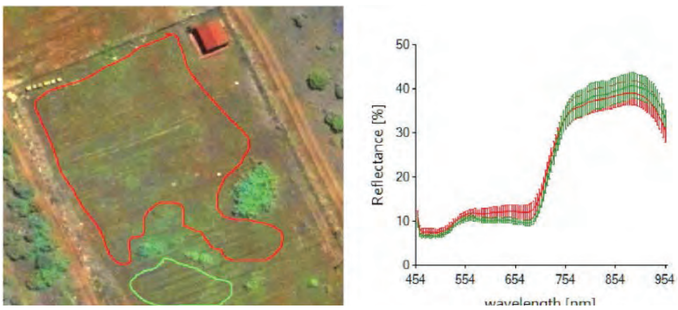

FIGURE 6. Full frame hyperspectral camera enables checking the reflectance spectra of interesting targets during the data collecting flight. Selected areas (red and green polygons) are in the mine field Benkovac, colours of polygons and colours of spectral diagrams are the same.

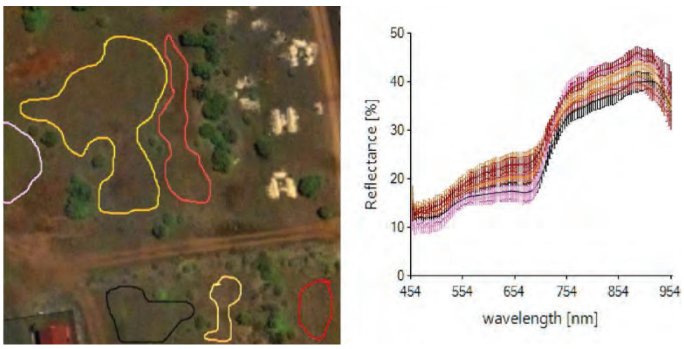

FIGURE 7. Full frame hyperspectral camera enables checking the reflectance spectra of interesting targets during the data collecting flight. Selected areas (yellow, black, pink, red polygons) are outside of the mine field Benkovac, colours of polygons and colours of spectral diagrams are the same.

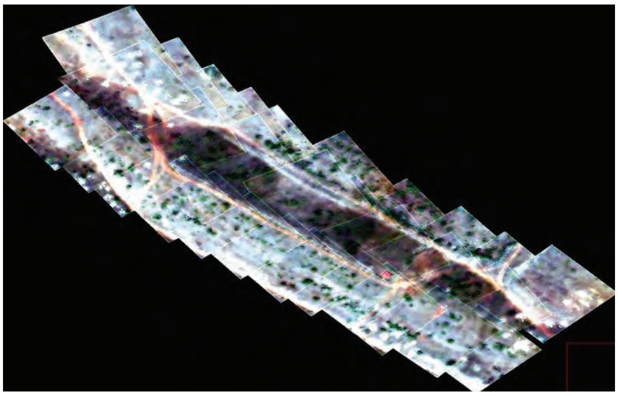

FIGURE 8. Hyperspectral mosaic of Benkovac mine field, visualised as colour RGB image by 10 nm wide spectral channels (centres at R=650 nm, G=550 nm, B=450 nm).

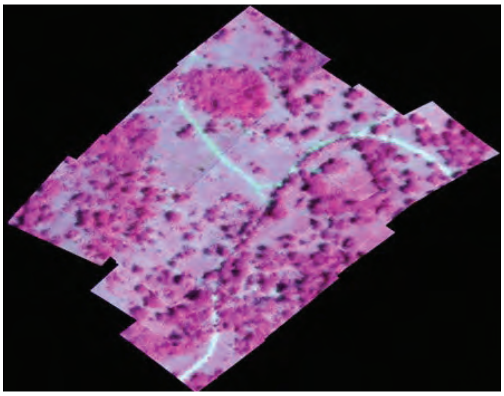

FIGURE 9. Hyperspectral mosaic of Murgići mine field, visualised as colour infrared image by 10 nm wide spectral channels (centres at R=750 nm, G=650 nm, B=550 nm).

The mine field Benkovac area is 10000 m^2, it contains 1000 landmines. Area outside of mine field – OUT (between red and green polygons) is larger, it has 36000 m^2, black – border line of imaged area. The analysis of only one spectral signature, Carotenoid shows interesting and valuable behaviour. The increase of threshold level of Carotenoid data shows that areas with Carotenoid decrease faster outside (OUT) of mine field then areas inside (IN) of the mine field, Fig. 12. Derived probability density function (PDF) of Carotenoid IN and OUT, Fig. 12, enables full quantitative analysis of the discrimination of grass inside from grass outside of the mine field in considered case. Contributions of other indices will increase the performances of grass discrimination which is achieved by Carotenoid analysis.

FIGURE 10. Area of mine field BenkovacIN (red polygon),

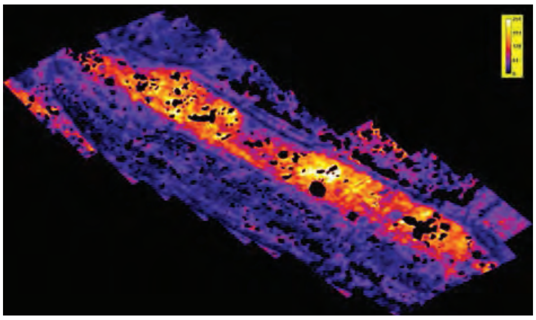

FIGURE 11. Carotenoid distribution map of Benkovac area from Fig. 10

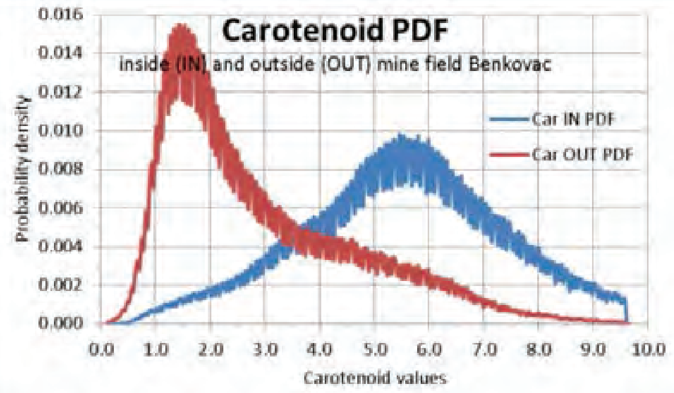

FIGURE 12. Probability density function PDF of Carotenoid inside of mine field Benkovac (Car IN PDF) and outside of it (Car OUT PDF) dependence on values of threshold level.

Conclusion

New technology for mine action is developed and implemented in the frame of FP7 project TIRAMISU, the hyperspectral Non-Technical Survey from UAV and from light helicopter. The survey from helicopter is suitable for large areas and for cases where highest quality of hyperspectral data is required. The survey from UAV is suitable for smaller areas and is especially suitable for targeted survey, it can be combined with technical survey also.

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Modelling of a command wire detector

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Some improvised explosive devices are activated by command-wires. These IEDs may therefore be triggered even if the target is protected against radio-controlled IEDs by a jammer. Detecting these wires is a way to detect threats that could be otherwise difficult to spot.

Current command-wire detectors are hand-held detectors. The goal here is to design and mount a command-wire detector on a unmanned ground vehicle in order to detect road-side improvised explosive devices. The unmanned ground vehicle could carry other detectors that could complement the command-wire detector.

Several command-wire detectors based on electromagnetic induction are commercially available but the factors that influence their performance have not been studied thoroughly yet.

A numerical simulation that would help such an evaluation and that could help identify ways to improve these detectors (optimisation antenna) should include the simulation of command-wires, the detector, the soil in which the command-wire is buried and improvised explosive devices and the interaction between the magnetic field and the buried command-wire. Factors influencing detection include the depth at which the command-wire is buried, the type of soil, the type and length of command-wires, the design of the receiving coil of the detector and, in case of an active detector, the design of the transmitting coil, the orientation of the detector with respect to the wire and possibly other factors.

This paper will show first results of numerical modelling.

TIRAMISU Advanced Intelligence Decision Support System

Andrija Krtalic[1]

ABSTRACT: Advanced Intelligence Decision Support System (AI DSS) is an operational Non-Technical Survey (NTS) system for collecting and processing (additional) data about suspected hazardous areas (SHA); data fusion and producing thematic (danger) maps about SHA. The existing Advanced Intelligence Decision Support System (AI DSS) was upgraded within FP7 project TIRAMISU (Toolbox Implementation for Removal of Anti-Personnel Mines, Submunitions and UXO) into TIRAMISU Advanced Intelligence Decision Support System (T–AI DSS) by implementing various new and improved sub-modules. T-AI DSS has benefited from the development of its components in TIRAMISU. The gaps identified by end-users and system operators have been filled in. The objectives include increasing its robustness, decreasing the workload of the operator, improving the semi-automatic mapping of features of interest for the detection of unexploded ordnance UXO, developing simpler imagery and data collecting units, implementing new sensors, optimizing application on different aerial platforms, verification in applications. T-AI DSS is an operational Non-Technical Survey (NTS) system which can integrate several NTS TIRAMISU tools and also use results obtained by several TIRAMISU tools which are not integrated into a system. The system consists of several sub-systems: for aerial multisensor image and data acquisition, for pre-processing and processing, for management of knowledge and contextual information, for implementing the outcomes of subjective photointerpretation, for fusion at pixel level, at features level and at decisions level. T-AI DSS is the only NTS tool within the frame of TIRAMISU that performs fusion. T-AI DSS is the operational TIRAMISU solution for NTS that is proposed to the mine action centres (MAC) worldwide because it is adaptable to specific terrain and situations. A simplified version (without remote sensing data acquisition) has also been developed that can be used in MACs for the support in the SHA assessment, reduction, re-categorisation and inclusion, indicating only mine presence and mine absence derived from MIS data. Services will be provided to realise NTS mission, to ensure transfer of know-how and capacity building.

KEY WORDS: operational, data collecting, data processing, decision support, thematic maps

1. Introduction

Advanced Intelligence Decision Support System (AI DSS) is an operational system that uses new collected data and mine inforrmation system (MIS) data for analysis and assessment of suspected hazardous areas (SHA). It is a tool to support decision about the status of SHA. The input includes data from mine information system (MIS), expert knowledge, airborne and satellite data, contextual data, etc. The outcomes are detected and proved positions of indicators of mine presence (IMP) in space, reconstruction of battlefield (in time and space), better (re)definition of SHA, proposals for exclusion

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from or inclusion in the SHA (thematic maps). AI DSS is the unique Mine Action technology that combines remote sensing with advanced intelligence methodology into successfully operational system. A first version of the system (titled AI DSS) was in use and yielding good results in Croatia; it has also been used with success in Bosnia and Herzegovina. The existing AI DSS was upgraded into TIRAMISU (Toolbox Implementation for Removal of Anti-Personnel Mines, Submunitions and UXO) AI DSS (T–AI DSS) by implementing various new and improved sub-modules within TIRAMISU FP7 project. T-AI DSS has benefited from the development of its components in TIRAMISU project to fill gaps that were identified by the end-users and system operators. The objectives include increasing its robustness; improving the semi-automatic mapping of features of interest and improving producing of thematic maps was done. T-AI DSS is a solution that is proposed to the MACs worldwide for specific terrain and actions. A simplified version (without data acquisition) was also be developed that can be used in MACs for the support of the SHA assessment, reduction, re-categorisation and inclusion, only with indicators of mine presence and mine absence derived from MIS data. Services is provid to ensure transfer of know-how and capacity building. T-AI-DSS is also focused on the problems generated by the possible explosion of Ammunition Depots. The main characteristic of the AI DSS is compatibility and operability with the processes and main functions in Mine Action Centres (MAC) (Bajic *et al.*, 2011). T-AI DSS is a tool to support the decision about the status of Suspected Hazardous Areas. T-AI DSS is a complex system that consists of three modules: module for analytical assessment of MIS data; module for data acquisition and module for pre-processing and processing of data. The modules can be used as a whole or individually. The integration of some TIRAMISU tools for NTS can be possible, but the results of application of several NTS tools without integration into T-AI DSS are also possible.

2. Module for analytical assessment of MIS data

The crucial document for the success of T-AI DSS application is Analytical preparation for the process of collecting additional data on a suspected hazardous area in humanitarian demining (Matic et. al. 2014) 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 collection and production of new, additional data, information and evidences about the former situation in an SHA (Bajic et al., 2011).

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

A simplified version of T-AI DSS was introduced (without the airborne multisensor acquisition and satellite images). It can be used in MACs for the support of the SHA assessment, reduction, re-categorisation and inclusion, only with the indicators presenting the mines and mine absence derived from the MIS data and MAC’s SOP’s (CROMAC 2009).

The guidelines for conducting an analytical assessment of data from the MIS (MAC) to define the general and special requirements for the collection of additional data needed for better definition of SHA are defined and described in detail (Matic et. al. 2014) and have been offered to the humanitarian demining community. FGUNIZ and CTDT offer the use of a simplified version of T-AI DSS using data that are part of the MIS of certain MACs.

3. Module for data acquisition

The T-AI DSS (within TIRAMISU) module for data acquisition for non-technical survey of the SHA consists of:

- matrix cameras: Nikon D90, DuncanTech MS4100, Photon 320,
- hyperspectral linear scanner (Imspector V9),
- system for power supply,
- navigation devices (iMAR, GPS devices),
- industrial computers, laptops (for navigation and iMAR management),
- monitor (12V).

The system for aerial data acquisition of T-AIDSS has been advanced, installed, tested and used on several platforms (Mi-8, Bell-206 and Gazela helicopters, UAV X8 MK and UAV 8 ZERO RPAS and blimp), with new sensors and acquisition units in a variety of new combinations. Note that the initial system AIDSS was used only on two helicopters (Mi-8 and Bell-206), with single sensor's pod, with one personal computer used for acquisition and one laptop for survey navigation.

This module should ensure the stability and reliability of (aerial) data acquisition for non-technical survey of SHA on each platform. Subsystems (system configurations are different for different platforms) for (aerial) data acquisition are examined on multiple platforms (helicopters Mi-8, Bell-206, and Gazela, RPAS UAV X8 MR and UAV 8 ZERO, and blimp) and should operate in a stable manner, without cancellation, on every platform. The criteria for this are given in the technical data for every platform and mission.

Technical stability and robustness of the system is confirmed by testing and evaluation (based on the behaviour of the system during the data collection over the test areas) of the systems on different platforms and missions in Croatia in the period from June 2012 to the end of TIRAMISU project, and in Mine Action operations in Bosnia and Herzegovina in 2014. The testing of the blimp as a platform for T-LHSIS was conducted and finished in 2014. Helicopter Mi-8 was also used, tested and finally excluded from further use in 2014.

4. Module for pre-processing and processing of data

The module for pre-processing and processing of airborne and satellite imagery consists of a series of sub-modules. These sub-modules are:

- pre-processing (parametric geocoding of hyperspectral and multispectral images, conducting atmospheric correction on hyperspectral images providing the coverage of the field with images, the determination of the quality of images),
- triage (viewing and separating the images for further processing),
- processing and interpretation of images (subjective and semi-automatic interpretation of digital images), data fusion (various thematic maps, multi-criteria analysis).

These sub-modules should ensure a smooth flow of data preparation and processing for interpretation and analysis.

The basic idea of interactive methods of semi-automatic interpretation of digital images of SHA is to provide assistance to the interpreter in the interpretation of digital images rather than to replace him. Experience from the projects undertaken led to the conclusion that the human eye of an interpreter (of a mine scene) can hardly be replaced by automatic methods of digital image processing. The established method (Racetin and Krtalic 2014) yielded good results in highlighting UXOs on the images collected with the camera Nikon D90.

The creation of thematic map with different methods of multiple-criteria decision analysis (MCDA) for data fusion is possible. Danger map is a thematic map produced in order to provide support to experts in the process of humanitarian demining, the experts from the Mine Action Centre (MAC), in making decisions about the reconstruction of battlefield and reduction of SHA, in confirming suspicions, or its extension.

5. Conclusion

The TIRAMISU Advanced Intelligence Decision Support System (T-AI DSS) is the customised, holistic system with the technology (modules) for: assessment of data from MIS of MAC's; multisensor aerial aquisition for non-technical survey of the SHA and triage, pre-processing, processing and interpretation of the airborne and satellite imagery. The main outcomes of T-AI DSS 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. T-AI DSS is a solution that is proposed to the MACs worldwide for specific terrain and actions.

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TIRAMISU Methodology for Semi-Automated Interpretation of Digital Multisensor Images

Ivan Racetin[1], *Andrija Krtalić*[2]

ABSTRACT: In the scope of the EU FP7 TIRAMISU project a novel methodology for semi-automatic interpretation of digital multisensor images for the purpose of detection and extraction of unexploded ordnances was developed. Image interpretation is usually being executed by a professional human interpreter, which is highly reliable but simultaneously labor intensive and time consuming procedure. Experience showed that a human interpreter can't be replaced by automatic methods of digital image processing, while some methods of digital image processing can reduce the workload of the interpreter. Methodology is based on combination of pixel and object based image analysis where lessons and rules learned on test dataset are then applied on other images of the same scene but different locations. Pixel based image analysis like transformations to various color spaces (IHS, CIELAB), Principal Component Analysis (PCA), Independent Component Analysis (ICA) and basic raster math were used. By executing these processing new datasets with different statistical properties are created. Now we have series of artificial layers which serve as input for statistical analysis and enables us better delineation of targeted objects. Object based image analysis offered additional geometrical parameters and reduced the human error in the process of manual vectorization of identified objects. Achieved results of methodology implementation on aerial images of exploded ammunition depot in Padjene (Croatia) are presented. Validation procedure was executed on randomly selected spatial subsets of 25 images and the outputs are shown in the form of confussion matrix.

KEY WORDS: color spaces, interpretation, methodology, statistical analysis, object based image analysis

1. Introduction

Severe forest fire caused the explosion of ammunition storage depot in Padjene, Croatia (44°4'28.05" N, 16°8'12.75" E) in September 2011 (Figure 2). This disaster triggered reaction of CROMAC – CTDT (Centre for Testing, Development and Training) and Faculty of Geodesy research teams which were involved in EU FP7 TIRAMISU project. Data acquisition module of Advanced Intelligence Decision Support System (AI DSS) – multisensor imagery acquisition system (Bajic, 2010) was engaged for the aerial survey of wider area of ammunition storage.

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2. Methodology

Image interpretation is usually being executed by a professional human interpreter, which is highly reliable but simultaneously labor intensive and time consuming procedure. Experience showed that a human interpreter can't be replaced by automatic methods of digital image processing, while some methods of digital image processing can reduce the workload of the interpreter. Novel methodology for semi-automatic interpretation of digital multisensor images for the purpose of detection and extraction of unexploded ordnances was developed (Racetin, Krtalic, 2014), Figure 1.

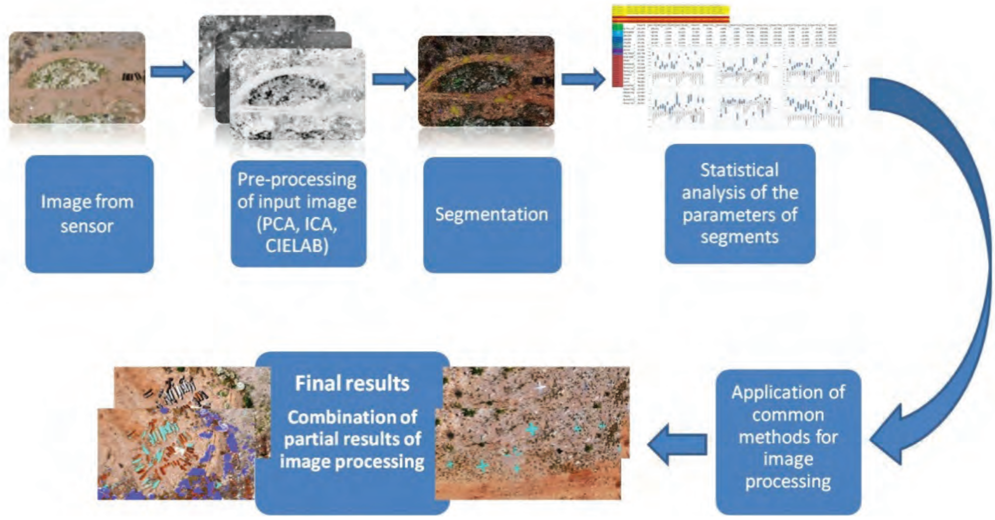


FIGURE 1: Methodology for Semi-Automatic Interpretation of Digital Multisensor Images (Racetin, Krtalic, 2014)

Methodology is based on combination of pixel and object based image analysis where lessons and rules learned on test dataset are then applied on other images of the same scene but different locations. Pixel based image analysis like transformations to various color spaces (IHS, CIELAB), Principal Component Analysis (PCA), Independent Component Analysis (ICA) and basic raster math were used. By executing these processing new datasets with different statistical properties are created. Now we have series of artificial layers which serve as input for statistical analysis and enables us better delineation of targeted objects. Object based image analysis offered additional geometrical parameters and reduced the human error in the process of manual vectorization of identified objects.

3. Validation

Methodology validation was performed on 25 aerial Nikon D90 matrix RGB images acquired over the exploded ammunition depot in Padjene (Figure 2).

Randomly selected spatial subset of 500 by 500 pixels for every image was defined (Figure 3a) as validation sample.

As no ground truth was feasible, images were visually interpreted and manually classified. Object were vectorized using the object-based image analysis (Figure 3b, Figure 4a, and Figure 4b) to reduce the human error in the manual vectorization.

For 25 analyzed images confussion matrix was calculated and summarized results are presented in Table 1 and Figure 5a, 5b and 5c.

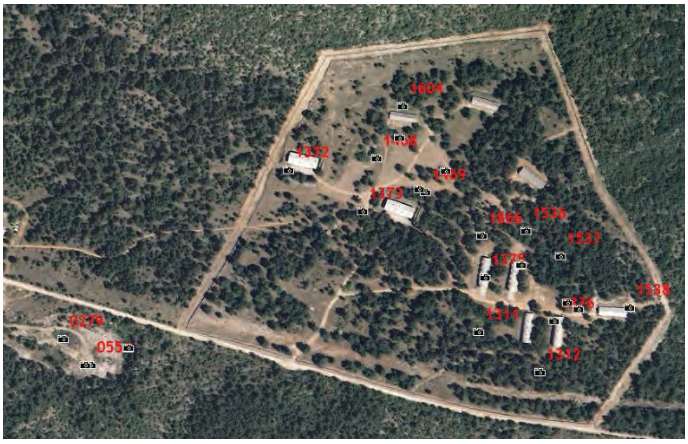
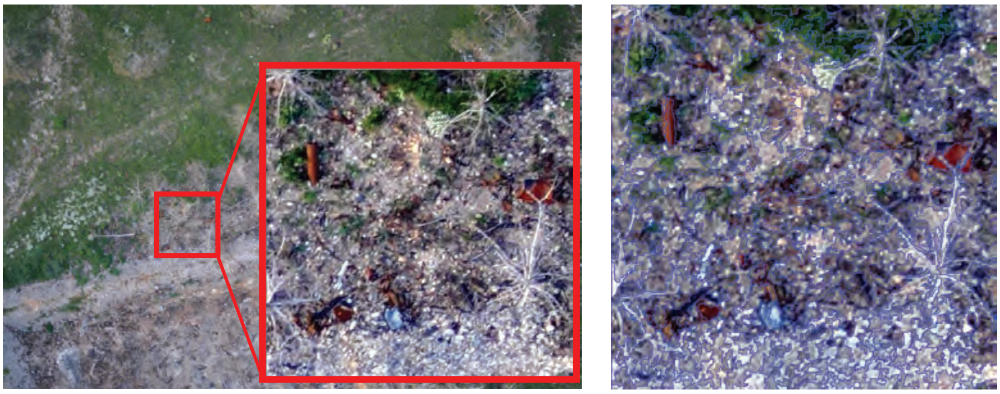
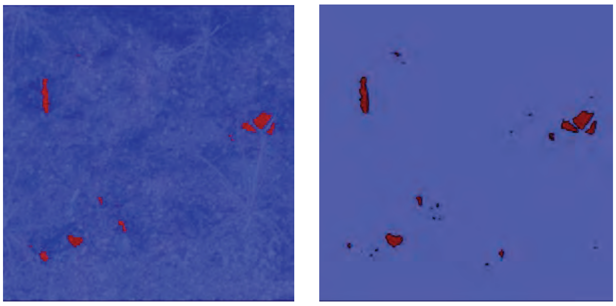


FIGURE 2: Locations of images used for validation displayed on top of the digital orthophoto – before explosion (State geodetic Administration WMS service)



a b

FIGURE 3 a – Aerial Nikon D90 image of exploded ammunition depot, red rectangle – spatial subset used for validation purposes, b – segmented image – spatial subset used for ground truth definition



a b

FIGURE 4 a – Ground truth data created by visual interpretation and manual classification, b – Result of implemented methodology on the spatial subset; red – corroded objects, blue – not corroded

TABLE 1: Summarized confussion matrix values for 25 analyzed images

	Commission Error for Corroded Objects [%]	Omission Error for Corroded Objects [%]	Overall Accuracy [%]	Kappa Coefficient
Average	18.54	5.57	99.52	0.85
Min	0.00	0.00	97.26	0.27
Max	84.20	43.02	100.00	1.00

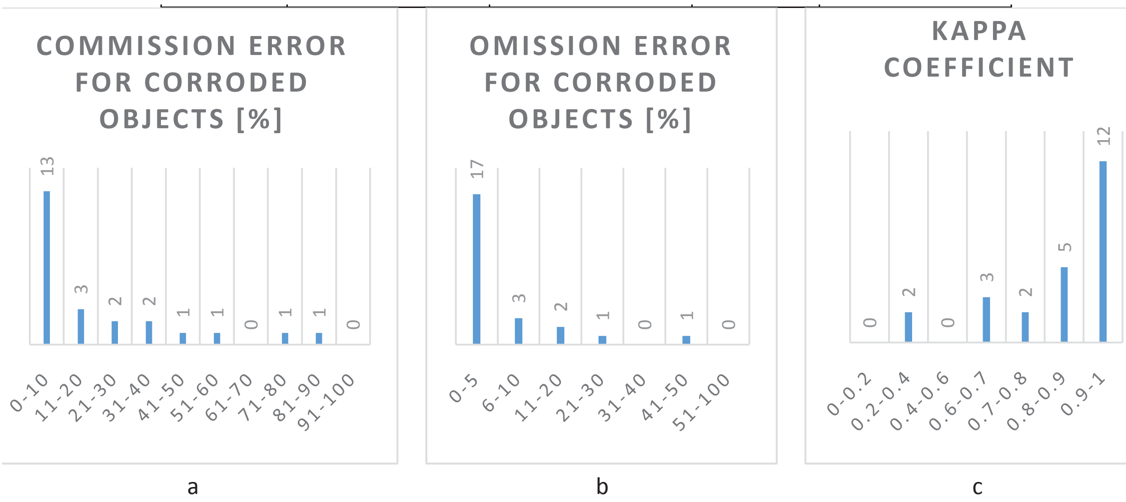


FIGURE 5: a – Histogram of commison error in percentage for corroded objects, b – histogram of omission error in percentage for corroded objects, c – histogram of kappa coefficient

4. Conclusion

For addressing situations of exploded ammunition depots ground teams of demining experts are engaged for clearance and recovery tasks, which is highly reliable methodology but on the other hand it is labor-intensive, time consuming and extremely dangerous.

Aerial survey of contaminated area is primarily used in planning of terrain activities and determination of impact area. Aerial image interpretation is usually being executed by a professional human interpreter and contributes to clearance and recovery tasks with additional valuable information's. Besides rigorous demands regarding data confidence due to the exceptionally hazardous nature of the demining operations, reaction time is also important factor. Manual image interpretation is time-consuming while automatic methods of image processing cannot provide sufficiently reliable data for this application. Methodology devised in this paper aims to assist interpreter to execute needed tasks more efficiently, rather than to replace him.

Presented methodology is sensor independent and can easily be applied on different objects of interest. Significant improvements still can be achieved on the part of statistical analysis which is used for definition of the most promising image processing for desired object detection and extraction. Future steps include evaluation and implementation of more statistical tools.

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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Detection of preconditioned honeybees on data in visible wavelengths range collected from RPAS

Slavica Ćosović Bajić[1], ***Tamara Ivelja***[2], *Milan Bajić*[3]

ABSTRACT: A remote sensing method for assessment of spatial-temporal distribution of bees, was derived from 2003 to 2006 while its first operational application started in 2013 in the framework of the TIRAMISU Project. The method derives spatial-temporal distribution of the preconditioned (trained) honeybees above an area that is contaminated by explosive or landmines. For this purpose, a long-wave infrared cameras and high-resolution digital cameras were used.

Direct detection of honeybees on an image is limited by the resolution of the electro-optical sensor, so for detection and assessment of spatial-temporal distribution of honeybees the principal components analysis (PCA) is crucial. The key feature of the method is an indirect detection of bees, by detecting their signatures in the principal component raster, obtained by processing the images of the time sequence.

Within this project we have tested a several platforms for data acquisition: radio controlled blimp (2013), remotely piloted aircraft system (2014, 2015) and a mast (2013, 2015).

The greatest challenge was to find an appropriate airborne platform and operational parameters for visible wavelength data acquisition since it is much harder to detect honeybees in this wavelength range, regarding lower contrast of honeybees to ground surface.

Finally, in 2015, successful results were achieved with an RPAS and color camera with these parameters: 4096x2160 pixels, 24 bits and 25 frames/s. The 25 frames per second enables fine temporal resolution and estimation of spatial-temporal density.

KEYWORDS: Detection, preconditioned honeybees, visible wavelength data acquisition, RPAS.

1. Introduction

The honeybees were recognized and approved as very sensitive biosensors of nuclear and chemical pollution, among others, and they were used in Croatia to assess the contamination after the accident in Chernobyl, [1].

The preconditioning and training of the honeybees for this purpose is well developed and their sensitivity for the detection of explosive was approved by several researches. One of the most important applications of honeybees as biosensors is detection of landmines (explosive vapors, that is) in the

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humanitarian mine action. Since one hive provides more than 10,000 foraging bees, it is possible to provide very high density of bees above the contaminated area.

Within the framework of the TIRAMISU Project research of honeybee colony conditioning methodologies for humanitarian mine action application was done, [2]. One of the tasks, a great one, was to find an appropriate sensor, airborne platform and operational parameters for acquiring the data that enables detection and extracting spatial-temporal density information of the free flying honeybees above the area of interest.

2. Problem definition

Despite well-developed honeybee conditioning methodologies, the integration of aerial platform and appropriate imaging sensor for operational usage was extremely hard. The reason for that lies in special characteristics and limitations of sensors and platforms, as well as physical characteristics of honeybees. Potential acquisition platform has to have good maneuverability performances and also be stable/still, since consecutive imagery has to cover as much of the exact same ground area as possible.

The basic characteristics of the honeybees that are important for detection methods and techniques are following:

- one hive has from 20,000 to 40,000 bees, nearly 50% of them are foraging,
- the radius of the foraging is from 1 to 3 km from the hive,
- the speed of the bees is 3.66 m/s in the orienteering flights, and 5.61 m/s in the foraging flights,
- the typical physical size of a honeybee is 0.375 cm^2.

These basic information can assist in definition of the requirements regarding the parameters of a potential applicable sensor. Probability of the survey (detection, recognition and identification) of honey bees can be defined by modified Johnson's criteria and could serve as guidance for the selection of the operational parameters of the electro-optical sensor and platform.

3. Development of the method for temporal – spatial distribution assessment of preconditioned honeybees

The method for the assessment of the spatial-temporal distribution of the honey bees above area of interest, which is in this considered case the area with landmines, was developed from 2003 to 2006, while its first operational application has started in 2013 within the framework of the TIRAMISU Project.

Since, direct detection of honeybees on an image is limited. Due to the limited resolution of the electro-optical sensor, this method is based on the principal components analysis (PCA) and filtering of the clutter, [3], [4].

The method consists of starting with a sequence of aerial images acquisition over area of interest, and uses features obtained by the processing of the second principal component (and possibly higher components) of the consecutive images in a time sequence with the reduction of a clutter in principal components raster. It enables detection of the movement of bees even if the spatial resolution and signal to clutter ratio are low and direct detection of honeybees is not possible. Output of the method is a map that defines the spatial temporal distribution of honeybees over the target area (Fig. 1). Sequence of images for this method can be collected from any platform, which enables imaging the area of interest with electro-optical sensors (in visible wavelengths, in long-wave infrared wavelengths).

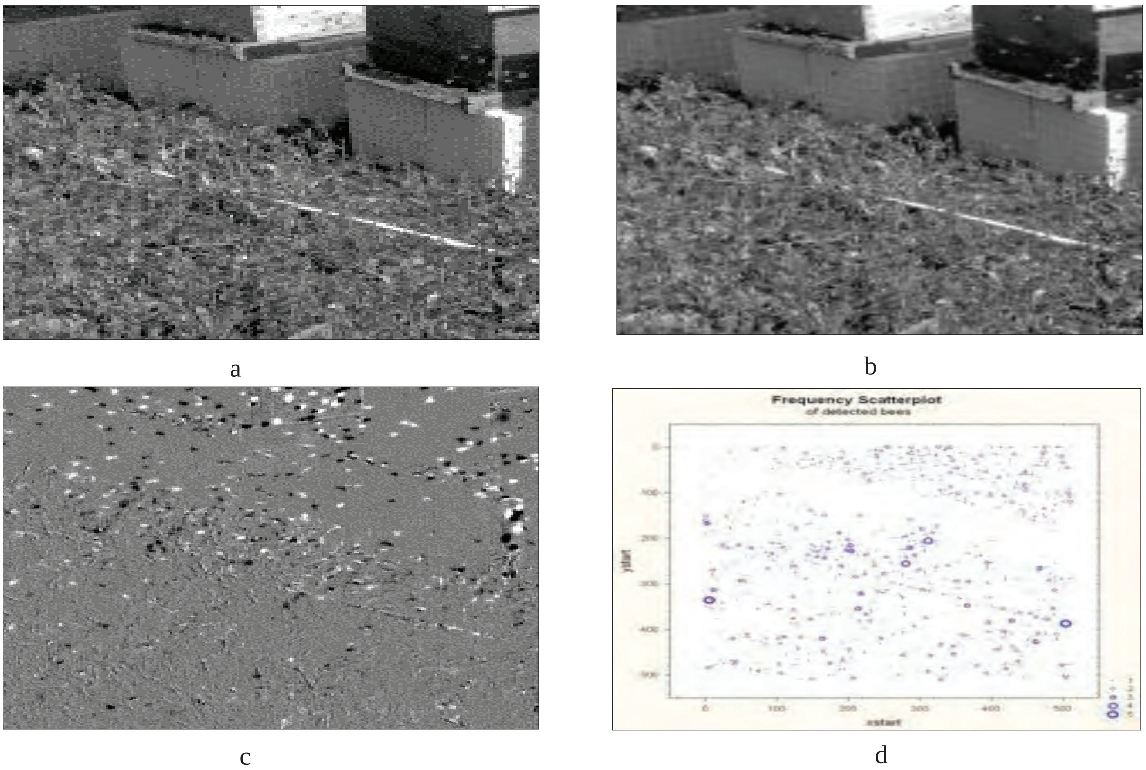

FIGURE 1: Method for assessment of spatial – temporal distribution of bees based on sequence of N images of the same area. Second principal component PC2 calculated from two successive images Ii and Ii+1, i = 1, N. a) Image Ii, b) image Ii+1, c) second principal component PC2, d) spatial – temporal distribution of bees.

4. Data acquisition of preconditioned honeybees development

Pros and cons of the honeybees detection on long-wave infrared and visible wavelength region data, regarding the limitations of the sensors, are well known. Long-wave infrared imagery enables better contras of the honeybees to ground surface but with coarse image resolution and limited field of view (FOV). Color cameras, on the other hand, provide imagery with larger FOV and fine resolution, but struggle with honeybees-ground contrast.

Testing of different acquisition methods and finding an appropriate one, together with definition of the most suitable sensor and platform for acquisition of free flying honeybees inside of landmine contaminated area, was conducted on the test mine site Cerovac and Benkovac in the course of TIRAMISU Project. Several airborne platforms were tested (radio controlled air blimp, RPAS) and RPAS was proven to be the most appropriate platform for such application, considering its stability and maneuverability.

5. Visible wavelength data collection from RPAS

First testing of RPAS with a high resolution color camera started in 2014 on the mine test field Cerovac. Acquired imagery was not satisfactory due to several reasons. The most limiting factor was low frame rate (app. 1frame/s) so estimation of temporal and spatial density could not be extracted. Finally in 2015, successful results were achieved. Tests and data acquisition were conducted in minefield Cerovac on 14th, 15th and 16th of July and large amount of data (168 GB) was collected. The height of the RPAS flight was between 3 and 4 m above the terrain. After the confirmation that honeybees are not interfered by RPAS, collecting of color images was done in several time intervals, 9-12 h, 10-13 h, 14-15 h, 15-16 h, 16-17 h, 17-19 h, taking into account parts of the day when bees are most active. Both references (clean) and test (mine contaminated) area were defined and surveyed in order to be able to make estimations of spatial-temporal density of bees over clear and mine contaminated area. Each image has 4096x2160 pixels, 24 bits, 25 frame/s, which enables fine temporal resolution (0.04 s). An example of recorded color image and result of the principal component analysis i.e. principal component raster is shown in Fig. 2. This principal component raster is the result of initial, one step processing of applied PCA. In order to achieve confirmation of the method limited processing procedure was applied on only 10 consecutive images that were collected under 0.5 s. No further processing was done but it remains clear that detection is possible with defined operational parameters, selected RGB sensor and platform.

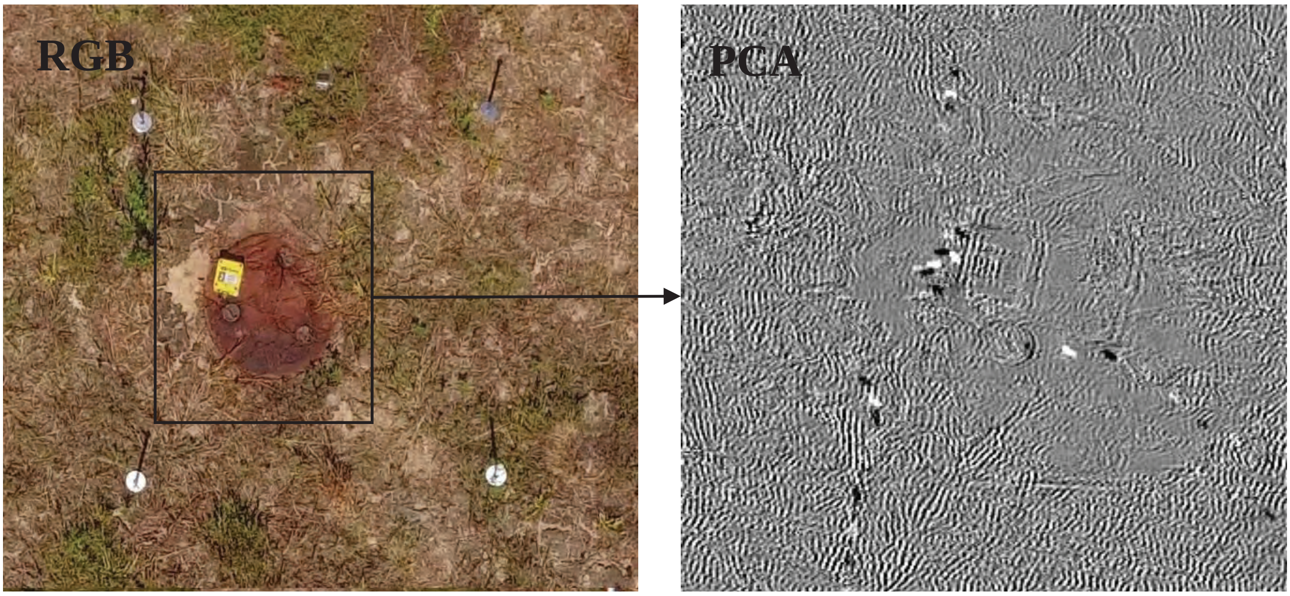

FIGURE 2: Left – A segment of color (RGB) image acquired from the RPAS above the landmine, Right – Principal component raster obtained by PCA of the sequence of 10 RGB images. Bees are shown by white and black spots.

6. Conclusion

The result shows that this kind of processing method, operational parameters, sensors and platforms enabled detection of honeybees movement, i.e. data quality was achieved and the spatial-temporal distribution could be extracted. What is very important are well-defined operational parameters. For this platform and sensor, in the scope of testing and acquisition period, one stands out; hovering altitude during survey has to be between 3 and 4 m. On this altitude bees are not disturbed by the RPAS and the optimal ground resolution is achieved. Also, in order to be able to extract spatial-temporal distribution frame rate of the color camera has to be larger (25 frames/s is good enough) since honeybees velocity can be greater than 5 m/s. This king of platforms and cameras are evolving very fast and becoming more accessible so potential is even greater. One of the most valuable results of the research of honeybees by remote sensing methods is significant set of collected imagery available data for further research and analysis.

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Proposal for a New Framework for the Acceptance Test and Comparative Evaluation of Demining Machines not designed to detonate hazards

Emanuela Elisa Cepolina[1]

ABSTRACT: The paper presents results from a long work aimed at filling an important gap in the standardized protocols for testing and evaluating demining machines. Born from needs highlighted in previous researches and formalized in the conclusions drawn from a three months in-field study, carried out by the author across six countries in 2013, the work on the new framework has been inserted in recent efforts directed toward the creation of a new Technical Note for Mine Action (TNMA) and a new CEN (European Committee for Standardization) Workshop Agreement (CWA). While the proposal for the TNMA received a "go-ahead" by the International Mine Action Standard (IMAS) Review Board, the discussion on the CWA keeps on going. The author feels it is worth publishing her research efforts leading to the proposal presented here, co-funded by the recently closed European Project TIRAMISU[2], with the hope to seek comments from a larger audience than the one to which the CWA is currently limited to and involve into the discussion more stakeholders.

Background

A Test & Evaluation (T&E) Protocol on demining machines already exists. It is called T&E Protocol 15044:2009 and was previously known as CWA15044:2009. The framework proposed here is not meant to substitute the current document but to complement it, by answering the need to expand its scope, included in the document itself. Paragraph 4 of the T&E Protocol 15044:2009 states: "*For the purposes of this document, demining machines are defined as those machines whose stated purpose is the detonation, destruction or removal of landmines. This does not necessarily imply a fully demined area following passage of the machine. Ground preparation machines are those, which are primarily intended to improve the efficiency of subsequent demining activities such as manual demining. This may include breaking of hard ground, vegetation cutting, fragment removal, or rubble removal. It may or may not involve the detonation, destruction or removal of landmines. It is recognised that this CWA concentrates on the testing of machines employed to clear mines, and there is a need to expand future work to address a number of issues, including: Appropriate testing for ground preparation devices, including test of…..*"

Therefore, the framework suggested here is specifically targeting demining machines not designed to detonate hazards, but rather to improve the efficiency of following up demining operations. Moreover, to keep it simple and practical, the scope of this framework is limited to land vehicles, and excludes equipment with sensors to detect landmines or other Explosive Remnants of Was (ERW). A

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2 Toolbox Implementation for Removal of Anti-Personnel Landmines, Sub munitions and UXOs (TIRAMISU), co-funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 28474.

set of documents that provide guidelines on how to test and evaluate metal detectors, already exists: CWA 14747 and CWA 14747-2.

Moreover, while T&E Protocol 15044:2009 focuses on the first two phases of the testing and evaluation process each demining machine should go through, the Performance test and Survivability test, this framework focuses on the third and last phase: the Acceptance test and evaluation of machines in field conditions, in mine affected countries, leading to the accreditation of them by National Mine Action Authorities (NMAAs).

IMAS 09.50 states that "*The NMAA should operationally accredit demining machines*" and that "*each machine should be T&E to determine its suitability for the task it is expected to carry out in the conditions in which it will work*". While the T&E Protocol 15044:2009 defines accreditation as "*The process, including the acceptance test, by which a mechanical equipment is allowed to be used in humanitarian demining in a specific mine affected country*", and IMAS 03.40 specifies that "*Acceptance trial should establish that the performance of the equipment in the hands of the user meets the characteristics specified in the SOR*[3] *in field conditions*"

Although the accreditation of a machine by the NMAA of the country where the machine is intended to work is foreseen by the IMAS, in many countries the accreditation process is limited to the appraisal of documentation previously produced on the machine, either by the manufacturer or by a specialized test centre in another country, and no actual testing in the field is foreseen [Cepolina E. E., 2012]; moreover, general guidelines on how to perform the acceptance trials of demining machines are currently not available.

Scope

The framework proposed here is meant to guide NMAAs through a test and evaluation process aimed at:

- assessing the performance of machines not designed to detonate hazards in terms of mobility, vegetation cutting, ground treating and obstacle removal in field conditions, typically found in their country
- identifying the residual risk, in terms of hazardous items, remaining from the employment of mechanical assets in a ground processing role and operational procedures for integrating the mechanical assets with other demining assets, i.e. their follow-up (such as manual deminers, mine detection animals..), for countering this residual threat.
- assessing the capacity of machines not designed to detonate hazards to withstand explosions from live mines typically found in the country
- comparing machines not designed to detonate hazards on the basis of their Cost-Efficiency Ratio (CER): the cost per unit area of using each machine plus its proper follow up (manual deminers, mine detection animals..) necessary to release land, compared to the cost per unit area of a full manual demining clearance process (baseline, typical of every country), calculated with the formula below:

  CER = (CE of full manual demining process [€/m^2]) / (CE of machine+follow-up [€/m^2]), where CE stands for Cost-Efficiency.

[3] Statement of Requirement, defined in the IMAS Glossary of mine action terms, definitions and abbreviations as "the document that provides a detailed statement of the characteristics and performance expected of the equipment, based on the preferred solution"

When different machines are tested and evaluated as suitable to work in a specific environment, they can be compared on the basis of the economic advantage they bring, on the basis of their CER value, regardless of their nature (vegetation cutters, sifters, …). **The CER value becomes an intrinsic property of every different machine in a certain scenario and represents a means by which to quantitatively compare different machines in the same environment**. Nevertheless, the CER value can also be used as an absolute indicator of the economic advantage a certain machine in a specific environment brings with respect to a full manual demining approach.

If CER >1, the mechanical equipment brings economic benefits

If CER ≤1, manual demining is more convenient.

Acceptance test and evaluation steps

The framework is thought and structured to maximize the possibility to compare results obtained with different machines, not only in the same country, but also across different countries, in similar environments. This is made possible by using as much as possible quantitative data and simple and cost-effective tools, in particular the cone index penetrometer, and procedures for defining accurately the environment itself, in terms of soil and vegetation, derived from agricultural common practices [Cepolina et Al., 2014]. The same tools and practices are used after the test has taken place to appreciate the modifications caused to the environment by the machine. The appraisal of the actual effect of a machine on the environment, beside its intended effect on the obstacles to be removed (among which vegetation) and the targets, is considered to be helpful at helping defining the best follow-up process to release land. For example, a machine ability to make soil very loose might be considered an advantage for manual deminers following up, since the time for excavating signals could be significantly reduced.

Table 1 lists data to be collected about the test site before the test takes place and the reasons for collecting them. The framework proposed is meant to be used during the acceptance test of all demining machines not designed to detonate hazards, also machines which haven't been previously tested in specialized test centres abroad because of money or logistic constraints, as it might be the case for the ones designed and produced locally, in mine affected countries. Therefore, the framework proposed is articulated in the subsequent test steps explained in Fig. 1 and more in details hereafter, in accordance to the scope presented before.

Pre-test data collection and assessment: before starting the actual testing of a machine, the NMAA should ask the manufacturer to provide a list of data about the machine, called Baseline Data, including essential data for machine classification (and test planning), technical data and cost data, including the purchasing costs, the custom, shipping, commissioning costs, the running costs in terms of number of operators needed, as well as maintenance costs related to engine, prime mover and implement, when possible supported by relevant documentation. Fig. 2 reports the data about the classification of the machine, as an example.

Before starting the actual testing of a machine, the NMAA should also collect Country Specific Data, in particular the following sets of data: key staff salaries (including deminer, operator of mechanical equipment, mechanic,..), fuel cost, other equipment cost, including metal detector purchasing cost, mine detection animal purchasing cost, mine detection animal running cost (food, veterinary,..). Country specific data are necessary to calculate machine cost-efficiency and cost-efficiency ratio.

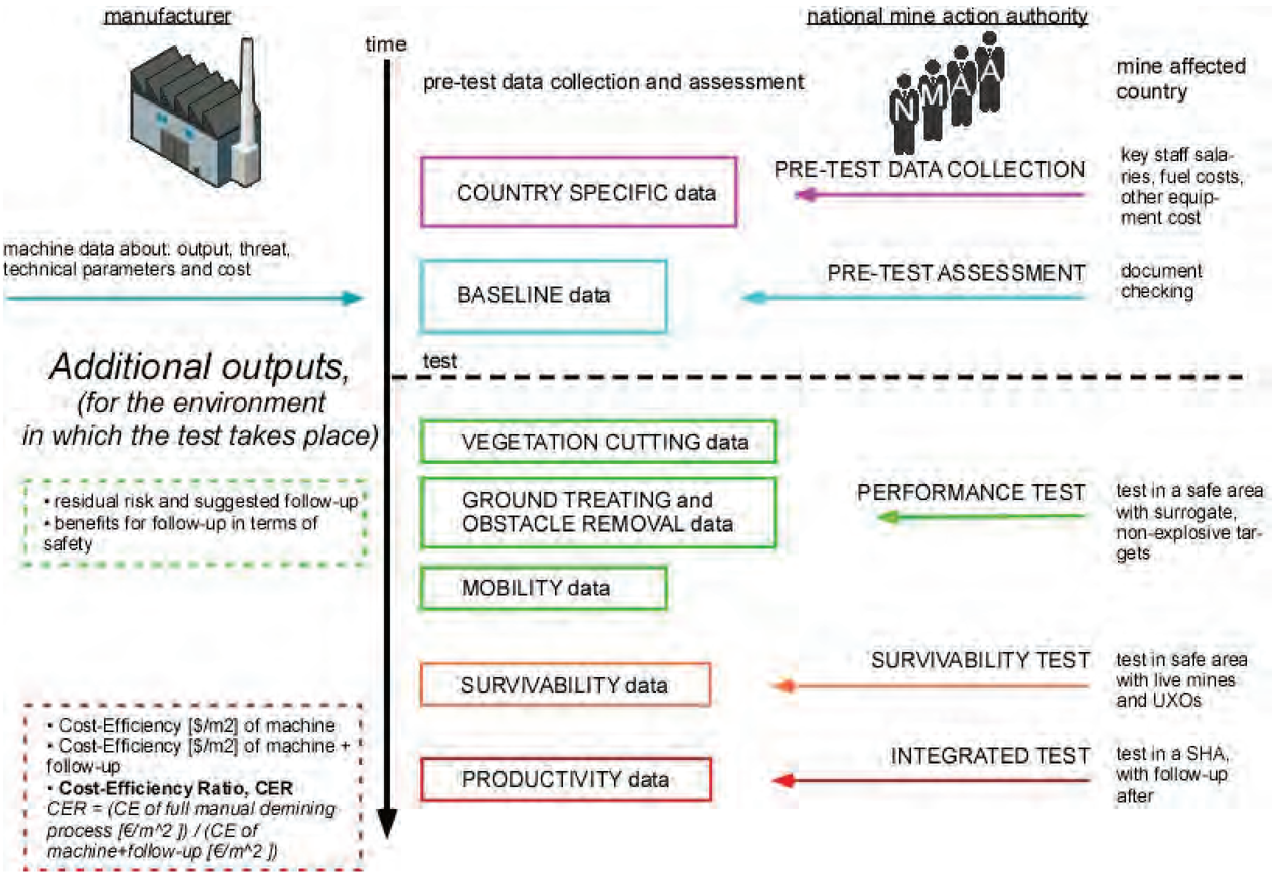

FIG. 1: Scheme of the proposed new test and evaluation protocol for demining machines not designed to detonate hazards.

A.1. CLASSIFICATION

			Claimed				
origin			**value**	**1° output**	**2° output**	**3° output**	**notes**
MANUFACTURER	OUTPUT in terms of	vegetation cutting [tripwire removal, vegetation cutting, vegetation removal]		na	na	na	
		ground treating [breaking hard ground, mine		na	na	na	
		obstacle removal [metal fragments removal, rubble removal, barber wire removal,..]		na	na	na	
		other		na	na	na	
	POST CLEARANCE USE						
	mode of USE	intrusive					
		non intrusive					
	type of LOCOMOTION	wheels					
		tracks					
	mode of OPERATION	direct operation from the cabin of the machine					
		operation by remote control					
		operation by remote control and video monitoring					
			Claimed		Pre-test assessment		
			value	notes	verified by test? [y/n]	by which test centre?	reference report/notes
	THREAT it can withstand and keep on working after in terms of	highest content of explosive in blast explosion [g]					
		highest content of explosive in fragmentation explosion [g]					

FIG. 2: Data used to classify the machine and plan the test, provided by the manufacturer (screenshot of data collection tool).

TABLE 1: Data to be collected about the test site before the test takes place and the reasons for collecting them

Data to be recorded before the machine processes the area		Reasons for collecting the data
Vegetation type	Qualitative description	Affecting machine vegetation cutting performance
	Mean diameter of plants (in a randomly chosen patch of 1m by 1m) [mm]	Affecting machine vegetation cutting performance
	Spatial density of plants (n. of plants in a randomly chosen patch of 1m by 1m)	Affecting machine vegetation cutting performance
	Mean height of plants (in a randomly chosen patch of 1m by 1m) [mm]	Affecting machine vegetation cutting performance
	Volume of vegetation (volume of 500g of bushes cut manually) [m3]	To be compared with the volume of vegetation left over by the machine, when not removed by the machine; an advantage of using a machine could be in the reduction of volume of the vegetation to carry away
Soil	Mean Cone Index value at three depths (0mm = flash with surface, 76mm, 152mm) (over 5 measurements in randomly chosen points) [psi]	Affecting soil trafficability and therefore machine performance
	Density (weight of a soil sample dug out from the soil /its volume)[kg/m3]	Affecting soil trafficability and therefore machine performance
	Moisture content (measured as ratio of the weight a soil sample dug out from the soil dried up, after 5 days, over the same sample of soil wet (just collected) multiplied by 100) [%]	Affecting soil trafficability and therefore machine performance
	Root presence (measured with the time taken by digging manually 0.25 m^2 of soil) [min]	To be compared with the root presence after the machine has processed the ground; an advantage of using a machine could be in the reduction of root presence
	False alarm rate before (n. of metal fragments in a randomly chosen patch of 0.25 m^2, found by metal detector at the national required clearance depth)	To be compared with the number of false alarm rate after the machine has processed the ground; an advantage of using a machine could be in the reduction of false alarm rate
	Other obstacle presence, over the soil (measured with the time taken by collecting manually 0,5m3 of it) [m3/min]	To be compared with the removal of other obstacles after the machine has processed the ground; an advantage of using a machine could be in the reduction of obstacles to be removed
Orography	Slope [°]	Affecting machine performance
Atmospheric conditions	Temperature [°C]	Affecting machine performance
	Relative humidity [%]	Affecting machine performance

***Field Performance test*:** a test to establish whether the demining machine is capable of performing the role which it is intended for in field conditions in mine affected countries. It should performed in a safe area, with the same characteristics of Suspected Hazardous Areas (SHAs) that can be typically found in the country, with surrogate non-explosive targets. If more than one typical environment is found in the country, the test should be repeated one time per each scenario. Two different test protocols are foreseen according to how the machine is classified in Baseline Data.

For vegetation cutting machines, the vegetation cutting test simply foresees cutting vegetation over an area of at least 500 m^2.

For ground processing machines, the ground treating and obstacle removal test consists in processing the ground, after having placed surrogate non explosive targets and fibreboards in the first lane the machine approaches. The smallest area on which performing the test should be at least of 500 m^2, including one lane 25m long and as wide as the machine, where 30 non explosive targets and 3 fibreboards are placed according to the scheme in Fig 3.

In both the protocols the area cleared, the time taken, including also the time for manoeuvring the machine, to process the entire surface and the fuel used are the key results to record. Additionally, as explained before, the effects of the machine on the vegetation and the soil should be recorded together with qualitative evaluation of benefits for the follow up in terms of safety and residual threat with indication of the best follow-up asset to counter it. In the ground treating and obstacle removal test the effect of the machine on the targets should also be recorded according to the table in Fig. 3.

mine (target) treating	0 depth		no movement	below	up >=1m	up>1m
		no damage				
		>=1 piece				
		signs				
	10cm depth		no movement	below	up >=1m	up>1m
		no damage				
		>=1 piece				
		signs				
	max depth		no movement	below	up >=1m	up>1m
		no damage				
		>=1 piece				
		signs				

FIG. 3: Fiberboard and targets placement during ground treating and obstacle removal test; data about target treating.

Surrogate non explosive targets should be made out of concrete in a square shaped mould with side equal to the minimum dimension of the smallest Anti-Personnel (AP) mine in the country and height of 5cm. They are painted with rubber painting (Urethane rubber) or any other glaze-like cover that allows appreciating scrapes inflicted by the mechanical equipment on the target. The colour of the painting should be chosen to make target easily recognizable and easy to find during their collection after tests have taken place. In order to increase the possibility to find them after tests, a metal nail should be hammered into each target, allowing targets to be searched with metal detectors.

All machines should also be subject to the mobility and trafficability test. This test should be conducted in field conditions, in the same area already processed by the machine, therefore without vegetation. The test consists in assessing machine mobility in terms of minimum turning radius, maximum driving speed, maximum hill climbing ability, and maximum traversing and descending slope. Trafficability data, such as wheel slip, if collected, together with geometry and mass property data, available from Baseline Data, could be used to feed a trafficability model and identify the better implement – prime mover combination in different operating environments.

***Field Survivability test*:** a test aimed at assessing the capacity of mechanical equipment to withstand explosions from live mines typically found in the country under realistic and repeatable conditions. This test should be conducted in field conditions, in the same area already processed by the machine, therefore without vegetation. Only machines classified in Baseline Data as Intrusive and Operated by Remote Control should be subject to this test. The effects of explosive forces on the operator, in the case of machines driven on board, should be assessed using T&E Protocol 15044:2009, in specialized test centres, or in local universities test sites, where the necessary measuring and evaluating equipment are available. The effects of explosive forces on the operator, are, in this case, verified during the Pre-test assessment by checking the documentation. The possibility to use simple go/no go measuring equipment, suitable to field tests, to verify if the pressure and acceleration caused by the explosion on the operator are below acceptable thresholds is under preliminary investigation by the author.

The explosive targets to test the mechanical equipment with should be chosen among live mines to be destroyed; they should be in conditions good enough to make them not dangerous to be handled, either because they come from stockpiles or because they are generally found in good conditions when they are collected from the ground. Moreover, the explosive content should to be equal or less than the highest content of explosive manufacturers have claimed the equipment can withstand and keep on working after and the type of detonation (fragment or blast) should be the same manufacturers have claimed the equipment can withstand and keep on working after.

On the top of each explosive target a small boost charge should be placed, in order to make sure that the explosive targets will be detonated by the machine passage.

If more than one type is chosen, the type likely to cause less severe damages to the machine should be used first, and the protocol used, repeated as many times as many types of explosive targets selected.

Tests should be designed keeping the worst case scenario in mind, therefore explosive targets should all be positioned flash with surface. As a minimum, three explosive targets should be positioned in a 25m long lane, each 10 m away from the other. The first target will be 2m away from the lane starting, the second 12m away and the third 22m away. The first target will be placed in the middle of the lane, the other two on the sides of the lane, in the middle of wheels or tracks footprint area.

Results should be recorded in terms of damages inflicted to parts of the mechanical equipment by the explosive detonations by identification of the part, qualitative description of damages, acknowledging splitting or separation of material, acknowledging permanent deformation of steel parts, and in terms of reparability by acknowledging of possibility to continue working after a detonation, or to withdraw from the hazardous area with equipment own power, or need of repairing. In this latter case, estimation of possibility to do the repairing in the field, or to do the repairing in a workshop, of time and cost to do it.

***Field Integrated test*:** a test to evaluate cost-efficiency of demining machines in SHAs, in field conditions in mine affected countries. The Field Integrated test is aimed also at evaluating the Cost-Efficiency Ratio (CER) of the machine.

Since every environment is different, it is essential to identify and document the environment where the test takes place as precisely as possible using both quantitative and qualitative parameters. Since the actual test site is a Suspected Hazardous Area, ground and vegetation measurements have to be done without entering the SHA itself in an area known not to contain hazards nearby the SHA selected from the test.

Apart from the data of Table 1, data on the expected explosive threat should also be collected, in terms of name of explosive devices, type [blast/fragmentation], quantity and type of explosive embedded, device expected pattern [belts/random], and where possible, classification of the SHA after Non Technical Survey (NTS).

The area chosen for the test should be suspected to be contaminated only with live mines and other ERWs the manufacturer claims the mechanical equipment can withstand and keep on working after and have proven not to severely damage the equipment during the Survivability test.

The test consists in using the mechanical equipment according to the Standard Operating Procedures (SOPs) defined after Field Performance test with the follow-up as specified in the SOPs. As a minimum the test should last five working days.

Results should be evaluated in terms of mechanical equipment performance, by measuring the area processed, the time to process it and the fuel consumed, in terms of downtimes, by describing the problem, measuring time to solve it, the cost of spare parts and labour to fix them, in terms of follow-up performance, by the number of assets at work (manual deminers or animals and animal handlers) and by the time taken by them to accomplish the work, and in terms of overall performance, by measuring the area processed and the time taken by the machine and the follow-up together.

After Integrated Field Performance test different mechanical equipment are compared in quantitative terms on the basis of the cost-efficiency at achieving a certain Output in a certain operating environment in terms of cost/m^2. The cost/m^2 of the mechanical equipment is calculated using the formula hereafter:

$$\$/m^2 = \frac{\$/h}{m^2/h}$$

$$\$/h = \left(\left(\sum initial\ costs[\$]\right)/lifetime[h]\right) + \left(\sum annual\ costs[\$]/workinghours/year[h]\right) + \sum running\ costs[\$/h]$$

$$\sum running\ costs[\$/h] = \sum personnel\ costs[\$/h] + \sum maintenance\ costs[\$/h] + \frac{l}{h} \cdot \frac{\$}{l}$$

Where, m^2/h, productivity, and l/h, fuel consumption, are measured during the test, \$/l, cost of fuel per litre, and personnel costs are taken from Country Specific data, and all other values are from Baseline data.

Moreover, after Integrated Field Performance test, to each piece of mechanical equipment plus its follow-up is associated the Cost Efficiency Ratio, an intrinsic property of every different machine in a certain scenario, allowing a quantitative comparison of different machines in the same environment, regardless of their nature or their Output. The CER is calculated by comparing two terms: the sum of the cost/m^2 of the equipment calculated as described above and the cost/m^2 of the follow-up, calculated multiplying the time taken by the asset chosen to follow-up (manual deminers, dog handlers plus dogs,..) to release land after the mechanical equipment has processed the area, according to SOPs, by their cost, as defined in Country Specific data or in other documents, and the cost/m^2 of a full manual demining process in a comparable scenario.

Data about the cost/m^2 of full manual demining clearance should be taken from available databases or measured in the field in at least two days of work.

Conclusions

The paper summarizes a work described more in details in a longer and more structured document that the author is very happy to share and discuss with interested stakeholders, with the hope to make it useful to end-users. The paper and the document it summarises should be considered a basis on which constructively discussing modifications and adjustments to satisfy end-user needs.

In parallel to the definition of the framework, work on a data collection tool that could guide NMAAs into the test steps and make the data collection process easier and intuitive has started. The data collection tool is thought to be connected to a database hosted in the cloud and accessible by all stakeholders.

It is believed that if properly collected in a database accessible by mine action practitioners around the world, data from the acceptance test of machines not designed to detonate hazards together with the value of parameters defining the operating environment they refer to, could really help improving cost-efficiency of mine action worldwide by helping end-users choosing the right and most cost-efficient tool for the right task.

ACKNOWLEDGMENTS

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Effect of Explosion Effect on Bottom of the Hull of Mine-Resistant Ambush Protected (MRAP) Vehicles

Janusz Sliwinski[1], *Cezary Sliwinski*[2], *Michal Ludas*[3]

ABSTRACT: The paper presents MRAP vehicle's tasks during operations and levels of protection against explosives, as specified from the perspective of their resistance to mine blast. Impact factors affecting the bottom of the hull of the vehicle during an explosion, such as a blast wave, a secondary blast wave reflected from the ground surface and fragments of the device's housing and a heat impulse (fireball) have been discussed, as well as the explosion-proof design of a MRAP vehicle's hull which disperses and absorbs blast wave energy. A comparative analysis of hull design solutions of an MRAP vehicle and an APC against explosions has been presented. The former is characterized by double bottom flat floor hull, whereas the later utilises a double bottom hull, with the lower being curved or V-shaped. Furthermore, blast wave effects on the vehicle's hull, including the formation of a cumulative blast wave and air compression, have been presented in theory and during tests with the use of 150 g block of TNT, where it has been found out that since V-shaped hulls cumulate part of the energy inside of the vehicle, it is not the most optimal design solution. What is called for, is such a design in which the shape of the cumulative blast wave generated would resemble flat characteristics as closely as possible. Lastly, the currently executed and future projects of the Military Institute of Engineer Technology, on designing of a several stage explosion energy dispersion system for an APC vehicle have been indicated.

1. Introduction

Due to their asymmetric character, modern armed conflicts require the use of different types of armoured vehicles, such as Armoured Personnel Carriers (APCs) or Mine-Resistant Ambush Protected vehicles (MRAPs). Depending on the construction, the later are used both for patrolling, convoy, medical evacuation and neutralization of explosive devices. The constant threat of an enemy attack with the use of explosive devices results in causes the need to ensure safe transport conditions. This can be accomplished through high mine and explosion resistance.

2. Characteristics of MRAP vehicle's

It is well known that MRAP vehicles are designed to increase the survivability of the crew, who is exposed to mine explosions and ambush attacks. The increased resistance to explosion is mainly due to the construction of the lower part of the vehicle hull, which is a double bottom hull. The lower part of

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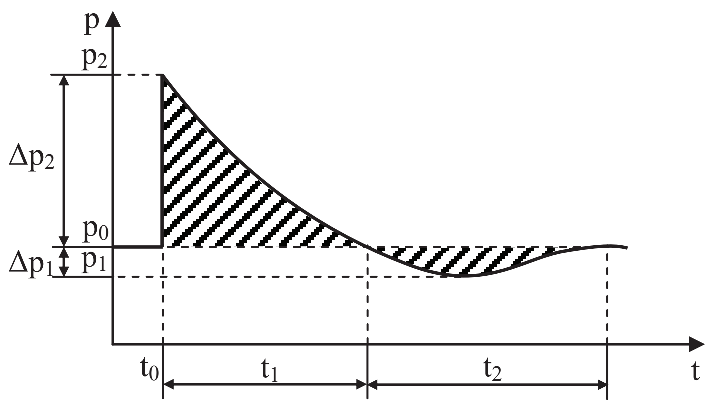
the bottom is V-shaped or has a curved shape, whereas the upper part is flat. The main disadvantage of MRAP vehicles, in particular in battlefield conditions, is their great height, increased weight and thereby high center of gravity. It causes the vehicle to be much more visible during operations and less stable in the transverse direction, which can lead the vehicle tipping over (from November 2007 till June 2008 there were 66 MRAP accidents, 40 of them were caused by a tip over) [1].

MRAP vehicles [2], [3] have been categorized according to their weight and mine resistance. Category I vehicles are 7 kg TNT blast-resistant, when the charge detonates under the bottom of the hull, and 14 kg TNT blast-resistant, when the charge detonates under the wheel of the vehicle. Category II MRAP vehicles are 15 kg and 21 kg TNT blast-resistant, respectively, while Category III vehicles are 21 kg TNT blast-resistant either when the charge detonates under the bottom of the hull or under the wheel of the vehicle.

3. Factors affecting the bottom of the hull of the vehicle during blast

Factors acting on the hull of a vehicle during an explosion of a mine or an Improvised Explosive Device (IED) include: a blast wave, a secondary blast wave reflected from the ground, fragments of the device's housing and a heat impulse (fireball). Because of the MRAP's hull design, the blast wave is the largest threat. This wave is defined as a thin layer of gas particles moving at a supersonic speed and it is characterized by high pressure, high density and high temperature [4]. Pressure impulse and overpressure at the blast wave front are two defining characteristics of blast wave. Figure 1 presents a typical blast wave pressure waveform. The energy of the pressure impulse is outlined as hatched area.



p_2 – peak pressure at the blast wave front; p_1 – minimum pressure at the blast wave front; p_0 – atmospheric pressure (undisturbed medium); t_1 – duration of blast wave positive phase; t_2 – duration of blast wave negative phase; Δp_2 – peak positive pressure at the blast wave front; Δp_1 – maximum negative pressure at the blast wave front

FIG. 1. Blast wave pressure waveform [5]

Maximum positive pressure at blast front is expressed by formula [5]:

$$\Delta p_2 = \varphi(k) \times E/R^3 \tag{1}$$

where:

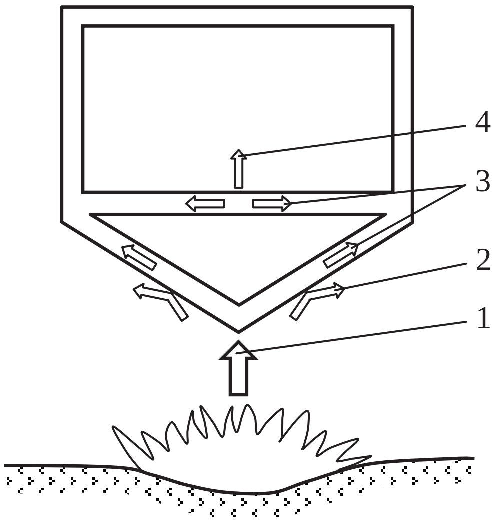
Δp_2 – peak overpressure value at the blast wave front (MPa);
R – distance from the explosion centre (m);
E – average explosion energy per unit weight MW (MJ/kg);
k – isentropic exponent of gas in the blast wave impact area;
$\varphi(k)$ = 0.1038 – for large explosion in the atmosphere.

Formula (1) shows that with the increase of distance from the explosion centre, the peak pressure Δp_2 at the blast wave front decreases with the 3rd power.

4. Explosion-proofing tasks of the vehicle hull

The MRAP hull is designed to minimize the impact factors following the explosion of mines and IED's to prevent the loss of crew health due to vibrations, hull deformations and pressure pulsations. This is accomplished by blast wave absorption and dispersion (Fig. 2). Dispersion of the blast wave energy is achieved by the use of specific hull geometry design and by increasing the distance from the vehicle's bottom to the ground surface in order to lower the blast wave impact energy. Absorption of the blast wave energy is achieved by the use of proper materials for the vehicle hull, such as armoured plates, protective panels (with the capability of undergoing deformation, e.g. sandwich structures, aluminum foam, honey comb) as well as interior linings.

To disperse the blast wave energy (pressure impulse) released by an explosion, mine resistant vehicles are fitted with hulls which have curved shapes, such as the V-shape (Fig. 3 and Fig. 4).



1 – blast wave energy; 2 – reflected blast wave energy; 3 – absorbed blast wave energy;
4 – blast wave energy transferred forward

FIG. 2. Blast wave absorption and dispersion by the MRAP's hull

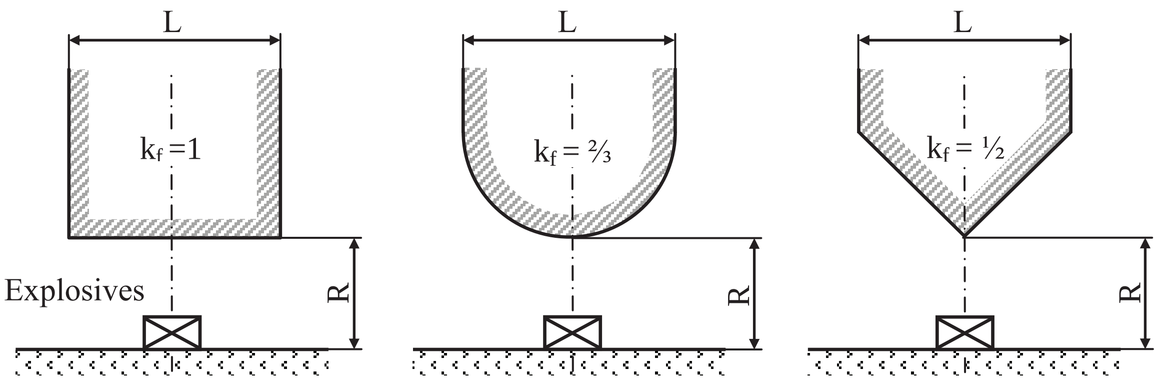


FIG. 3. Hull bottom shapes and their ability to disperse blast wave energy [4]

The formula estimating the value of energy acting on the vehicle's hull bottom is the following:

$$E = k_f \times E_w \quad (2)$$

where:

E – energy acting on the vehicle's hull bottom (J/kg);
E_w – explosion energy (J/kg);
k_f – coefficient of the shape of the bottom of vehicle hull.

Figure 3 shows that compared to a flat-shaped hull bottom, the V-shaped+ and the curved hull bottoms disperses the blast wave energy up to 2 times better. Detailed analysis and calculations on the impact of various shapes of components on the dispersion of the explosions energy can be found in literary sources [6].

Figure 4 illustrates the propagation of pressure waves resulting from mine or IED explosions. The pressure value at the wave front P_0 is resolved into two components: P_N – the normal and P_T – tangent to the hull underside plane. The normal component (perpendicular to the hull surface) effectively impacts the hull and causes its damage, which is much greater in case of a flat-bottomed hull than in case of a V-shaped hull.

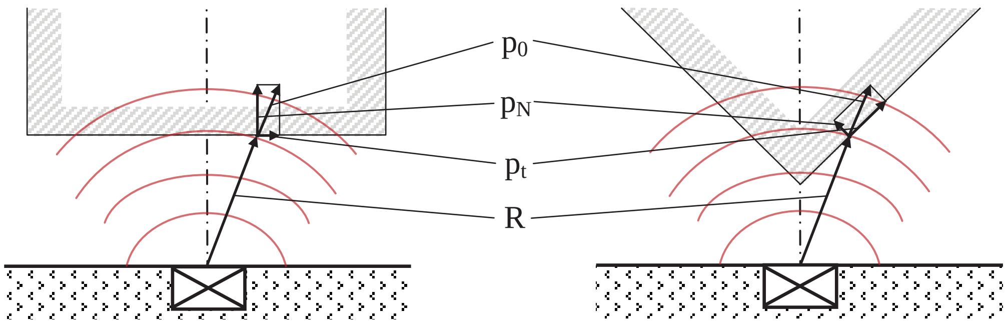


FIG. 4. The impact of pressure waves on a flat-bottomed hull and a V-shaped hull

The first MRAP vehicles had the space between the V-shaped underside and the flat floor hollow. Because of the frequent, several-day patrols, the hollow hull was used as water storage for the crew. It turned out that the presence of water as well as air did impare the vehicle's explosion-resistance. The reason for the transported water to have a negative effect was the fact that the blast wave's velocity in water is much higher than in atmosphere. In the latter blast wave propagation caused movement of the air trapped towards the centre of the hull within the hull's which is accompanied by its compression. This phenomenon is presented in chapter 6. Nowadays the bottom part of the hull is filled with blast wave energy-absorbing materials.

5. Comparative assessment of explosion resistance for hull design solutions in MRAPs and APCs

The Military Institute of Engineer Technology (WITI) in Wroclaw analyzed the attributes and parameters of different types of explosion-proof APCs and MRAPs. Comparative calculations of hull bottom design solutions for both types of vehicles have been performed. Figure 5 presents the vehicle's configuration as taken for analysis.

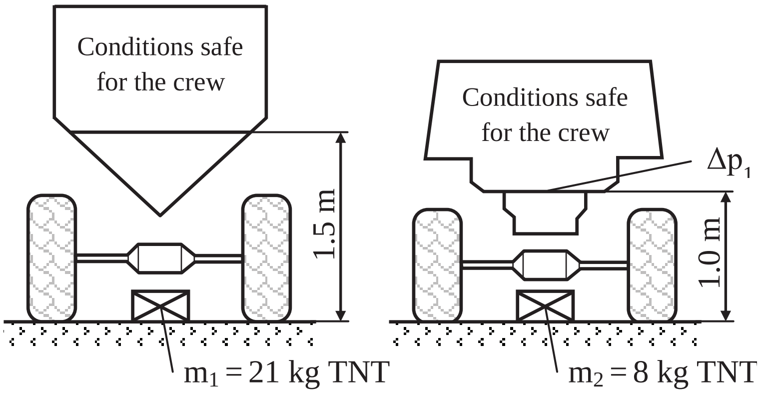


FIG. 5. Explosion under the bottom hull of a Category III MRAP vehicle (on the left) and an APC (on the right) [7]

For the above-mentioned calculations, the following assumptions have been made:

- parameters of explosion exposure in the crew compartment in both types of vehicles are safe;
- the space between the bottom hull and the flat floor is empty;
- for means of comparison, the flat, upper part of the hull bottom of both vehicles had been raised to the height of 1.5 m above the ground surface (Fig. 6);
- the direct factor causing crew injuries is the blast wave generated by the deformation and vibration of the upper flat part of the hull bottom.

Comparative calculations of hull bottom design solutions, in terms of being explosion-proof, of both, a Category III MRAP vehicle and an APC can be found in literary sources [7]. These calculations show that the double bottom hull design with two thin flat floors (APC, e.g. Rosomak and Piranha) is a better solution than a double bottom V-shaped hull design (Fig. 6).

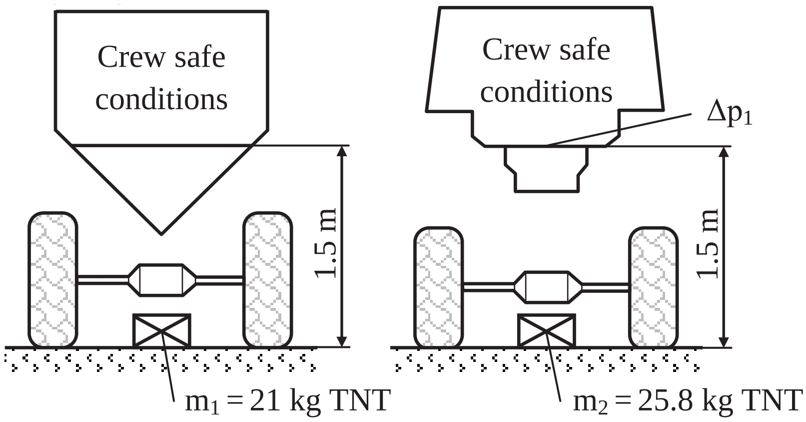


FIG. 6. Explosion under the bottom hull of a Category III MRAP vehicle (on the left) and an APC (on the right) for the case of the flat floor of both vehicles being at a height of 1.5 m [7]

6. Blast wave effect on crew members in an MRAP vehicle

The blast wave generated by explosion of a mine or an IED causes deformation and vibrations of armoured plates of the curved-shaped or the V-shaped bottom hull (Fig. 7A). Deformations and vibrations of those plates generate cumulative blast waves which propagate spherically within the bottom part of the vehicle's hull. If the hull is hollow, their motion causes the air to move towards the center of the vehicle while undergoing simultaneous compression. This is shown in detail in Figure 8. In the last stage of the explosion, the cumulative blast waves and compressed air act on the flat floor of the bottom hull. This phenomenon causes deformations and vibrations of the flat floor, which in turn generates a blast wave which propagates through the crew compartment (Fig. 7A). The resulting pulsations inside of the vehicle's hull effect the crew members and injure their inner organs. The principle of blast wave energy accumulation due to the curved shaped bottom hull is shown in Figure 7B.

Figure 7B shows that if blast waves move from position I to II, then the accumulation of their masses ($m=m_1+m_2+m_a$) and velocities ($V=V_1\times\cos\alpha_1+V_2\times\cos\alpha_2$) occurs, where m_a is the mass of the compressed air.

The change of Momentum m×V equals Impulse F×Δt is expressed by formula (3).

$$m\times V = F\times\Delta t \text{ (kg×m/s)} \quad (3)$$

where:

m – mass (kg);
V – velocity (m/s);
F – the force acting on the flat bottom hull (N);
Δt – duration of the force acting on the flat bottom hull (s).

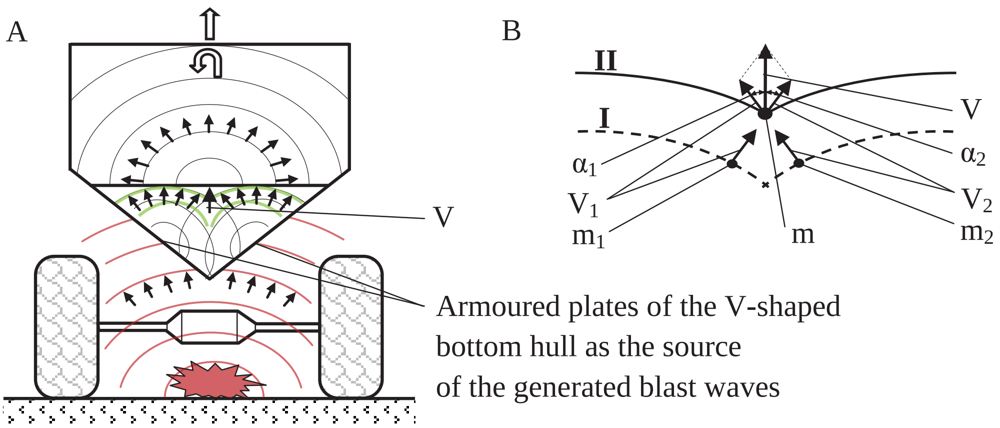


FIG. 7. Explosion impact on the V-shaped double bottom hull [7]
A – blast wave propagation; B – blast wave accumulation

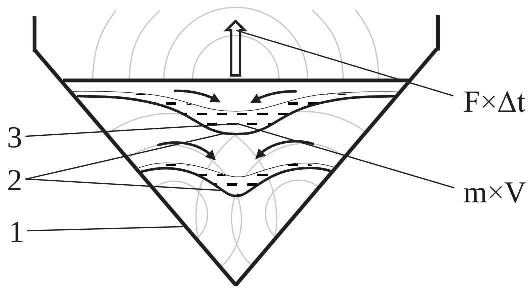


FIG. 8. Cumulative blast waves compressing air in the axis of the hull bottom
1 – bottom hull; 2 – cumulative blast waves; 3 – compressed air

Figure 9 illustrates cumulative blast waves generated by a curved-shaped bottom hull under the impact of a 150 g block of TNT.

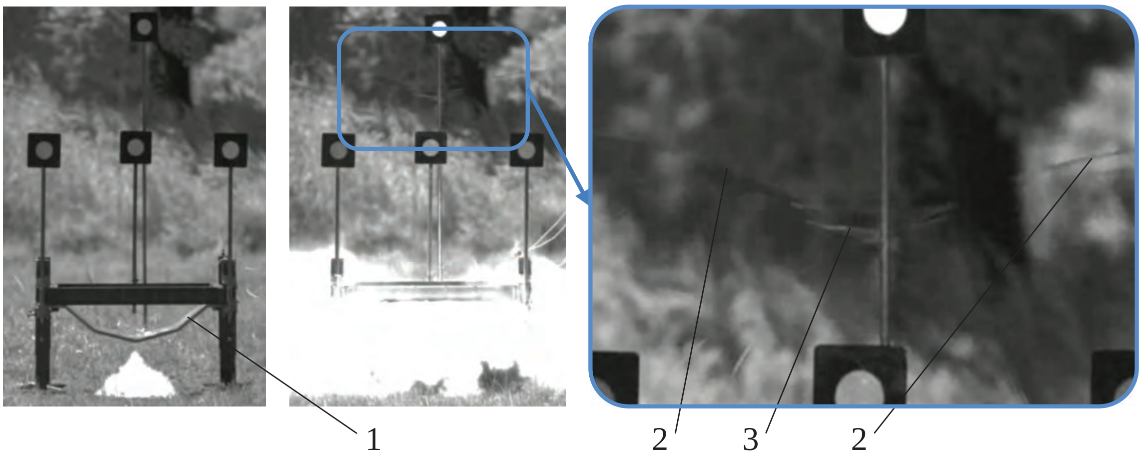


FIG. 9. Cumulative blast waves compressing air [3]
1 – bottom hull; 2 – cumulative blast waves; 3 – compressed air

The analysis shows that the blast wave impulse acting on a flat floor of an explosion-resistant is high mainly due to the accumulation of blast wave energy and air compression. The energy may be much greater than the blast wave impulse acting on a double bottom flat floor of an APC, such as the Rosomak or Piranha.

7. Mine-resistant vehicle hull development projects

An MRAP vehicle used in regions where the probability of mine explosion, of enemy IED attacks and of attacks with the use of other explosive devices is high, should have a proper bottom hull and a several stage explosion energy dispersion system. The system's task would be to effectively disperse blast wave energy and limit mine fragments effecting the vehicle hull so as to minimize the risk of the crew getting injured.

The Military Institute of Engineer Technology in Wrocław works on a test stand for studying physical phenomena occurring during blast wave and how they impact different types of vehicle hull design solutions.

As next comparative tests of energy dispersion and absorption of different types of explosion resistant panels (rigid, flexible, multilayered etc.) will be performed.

Analysis of how to change the design of the V-shaped bottom hull by inserting fillings which would properly shape the blast wave geometry and would also effectively absorb it is also carried out. The point is to change the secondary, cumulative blast wave character which is generated by the V-shaped hull so that it would assumes a flat shape having reached the upper flat part of the hull. This is shown in Figure 10.

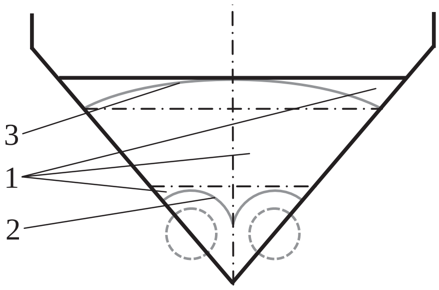


FIG. 10. The concept of filling of the vehicle's hull with blast wave energy absorbing materials in a way that changes the wave's character to a quasi flat-shaped one
1 – hull filling; 2 – cumulative blast wave; 3 – quasi flat blast wave

A solution to this problem would result in a much higher vehicle explosion-resistance. It would allow to both disperse the energy of a direct mine explosion (due to the V-shaped design) and minimize the effect of the cumulative blast wave acting on the vehicle's flat floor.

8. Conclusions

1. Mine resistant vehicles during combat operations should ensure safe transport conditions for crew members through high mine and explosion resistance.
2. Analysis of the many aspects of the blast wave impact on vehicles with a double bottom hull, with the lower one being curved or V-shaped, show that the V-shaped hulls cumulate part of the energy inside of the vehicle.
3. Analysis performed showed that a double bottom hull, with the lower being V-shaped or curved, is a less advantageous design when compared to a double bottom flat floor hull as used in APCs.
4. Considering the current state of knowledge about the double bottom hull design, with the lower one being V-shaped, as used in MRAP vehicles, it can be stated that this is not the best possible design solution.
5. A new bottom hull design for the MRAP vehicles should be developed. It should change the blast wave's characteristics to a quasi flat shaped one, when reaching the flat floor of the crew compartment.

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