

USE OF NEW TECHNOLOGIES AS DECISION SUPPORT IN DEFINING MSA

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Plenary Session

Two civilian operational remote sensing technologies based on aerial and space assets were presented, that are in use for the needs of the humanitarian mine action. These are the first two technologies ever to be used.

Milan Bajić: *From the Concept to Operational Airborne Remote Sensing System and the Suspected Hazardous Area Assessment*

The first European civilian R&D airborne remote sensing project aimed at minefield detection was launched in 1998; it had the ill-posed objective to detect anti-personnel land mines. After several R & D projects aimed at suspected area reduction by airborne and space – borne remote sensing, the first operational project was implemented in 2009. In this Croatian project, based on the generic methodology of EC SMART, the following was realized: a) an airborne multisensor image acquisition system (AMSS) and b) the decision support system (DSS). In AMSS hyperspectral and multispectral imaging, processing and interpretation were implemented. In the DSS, the fusion of the indicators of mine presence and mine absence, contextual data and the formalised experts' knowledge and classification based on fuzzy set methodology were applied. The news was the introduction of the quantitative terrain analysis as a new source of indicators of mine absence, procedures for defining the needs for information completion; reconstruction of the warring parties separation zones, detection of the war remnants. The operational result of the project was reduction of 23 out of 158 km² at the cost that is 141 times lower than it would have cost CROMAC if it had applied conventional demining technologies. A similar operational project is under way in Bosnia and Herzegovina. The new (although expected) experience of this first operational remote sensing project is a very significant contribution of the

information extracted from satellite imagery; this shall become an ordinary practice in the future projects on the assessment of the suspected hazardous area.

Avi Buzaglo Yoresh: *Mine Detection by Air Photography*

The new technology for identification of minefields by analysis of hyper spectral aerial and satellite imagery was presented; no other subjects offer this kind of analysis yet. It allows identifying minefields by the spatial resolution of 30x30 meters from satellite images and 1x1 m from aerial hyperspectral images. The system is based on chemical reaction which takes place between the materials of the mine and the soil at its vicinity. The chemical reaction affects the spectral response of the soil and the vegetation. The unique spectral analysis discovers where the spectral response has been changed. Tests and evaluation made at Golan and in Angola approved that there lie the mines. This is the first civilian operational project outside Europe aimed at detection of mine fields.

Thomas Bouvet, M. Kruijff, D. Ericksson: *MineFree: Space Assets for Demining Assistance*

Several aspects of humanitarian mine action were considered with the aim to identify where the space assets could potentially assist, both in planning and in field operations.

An in-depth feasibility analysis that should be implemented by the European Space Agency (ESA) under the Integrated Applications Promotion (IAP) initiative will approve weather space-assisted services prove valuable and sustainable. Because the IAP is a user driven programme, relevant user communities should be involved. The ESA is expected to provide support and work around internal technicalities that may block this support.

Workshop No. 2

The tools and methodologies presented at the workshop No.2 continued the aims and goals of the papers presented at the plenary session, which is detection of minefields and reduction and assessment of a Mine Suspected Area (MSA).

Heinrich Meurer, M. Wehner, S. Schillberg, K. Hund-Rinke, Ch. Kuehn, N. Raven, T. Wirtz: *An Emerging Remote Sensing Technology and its Potential Impact on Mine Action*

This concept of the technology for stand off detection of landmines, uses as a working principle visibility enhancement by a biomarker, i.e. genetically engineered micro-organisms producing a fluorescent protein when in contact with the nitrogen compounds (TNT or DNT) released by explosive ordnance. The scene is investigated from an airborne platform with a laser scanner exciting and detecting fluorescent signals. The micro-organisms can be sprayed from another aerial platform at least 12 hours prior to the sensing phase. The technology could sense traces down to 10 ppm of TNT and DNT from an altitude of 300 meters. Currently the technology has been successfully demonstrated in controlled conditions, and still needs to be tested in operational field conditions.

Milan Bajić, Čedo Matić, Andrija Krtalić: *Decision Support to Experts for Better Defining and Reduction of Mine Suspected Areas*

The system presented is aimed at reinforcing the knowledge on the presence or absence of land mines in a Mine Suspected Area (MSA), for reduction or extension of MSA. It starts by the multisensor airborne (and from satellite images) surveying indicators of mine absence and indicators of mine presence. This information is then fused with other relevant information from other sources (e.g. military record, contextual data, satellite imagery, etc...) and processed with appropriate software and expert knowledge, into danger maps. The data fusion and processing towards readily usable information for decision makers is achieved by a Decision Support System (DSS). The DSS and multisensor airborne acquisition system were implemented for survey and definition of MSA in Croatia. The mine suspected area (MSA) in Croatia was defined by Croatian Mine Action Centre (CROMAC). Because of lack of information and in order to reduce risk for the local population, MSA was defined with safe margins. In the former years, CROMAC updated the

mine information system (MIS) with new information and permanently reduced or extended the MSA in accordance with the mentioned information. The multisensor airborne acquisition system and decision support system (DSS) provide help in collecting and processing of new information for purposes of reduction or better definition of MSA. Requirements for new information on objects that are present on the scene are defined in collaboration with experts from CROMAC. Collecting information with multisensor system is performed in order to find and position objects which were assumed by experts that can be defended/protected with mines (indicator of mine presence - IMP), or objects for which experts assumed that can be free of mines (indicator of mine absence - IMA). Indicators are objects on the scene which lead to the conclusion that some phenomena exist on viewed area: Indicators of mine absence (IMA): asphalt roads, agricultural land in use, slope of the terrain, water areas. Indicators of mine presence (IMP): agricultural land no longer in use, trenches, bunkers and other military objects, minefield records. The proposal for the reduction of the MSA or its extension is derived by DSS in form of several outputs: the danger map, the confidence map, map of conflicts and the map of mine field indicators.

Sheri Osborne, Edward Cross: *Aircraft Mounted Ground Penetrating Synthetic Aperture Radar*

The concept of the technology of Mineseeker Operations intends to perform landmine stand off detection, by the Ground Penetrating Synthetic Antenna Radar (GP SAR), aimed by longwave infra red sensor and high resolution camera mounted on a lightweight aerial rotary wing platform. Detection should be performed by a two phase process: first the aircraft flies in “wide area mode” covering 100 acres / hour, to pinpoint contaminated zones. In a second step, the operations switch into a “spot light mode”, where the aircraft flies 360 degrees around the target zones to generate a 3D image of landmines. The technical testing and evaluation of the basic operational parameters of this technology will be done in controlled conditions at the land mine test sites Benkovac and Cerovac in Croatia.

Čedo Matić, Andrija Krtalić: *Statistical Processing of Minefield Records*

The team of researchers (Scientific council of HCR-CTRO) and experts of CROMAC invited by ITF, supported by USA State Department donation, realised the project: *Deployment of the Decision Support System for Mine Suspected Area Reduction*. CROMAC, asked by HCR-CTRO, has defined the mined suspected areas (MSA) for deployment of the mentioned project and provided MIS and GIS data (HOK, TK25, DOF5, DOF2). Some of MIS data (minefield records of one MSA) were used in this work. Minefield records (MR) are the best source of information about presence, position, shape and contents of minefields. Experience has showed that those information are not perfect, so, there is a need for critical assessment of their value and applicability. The type of imperfection of information was defined: uncertainty, imprecision, incompleteness, ambiguity, conflict. CROMAC experts have put these 39 information in 5 categories: A – cartographical data, B – data for orientation and positioning of mine-field, C – type and number of mines in the mine-field, D – characteristics of mine-field, E – information about placing mines. The level of imperfection of information from MR was expressed by the ratio of the completeness of each MR and the expert's estimation of mine-field positioning accuracy.

Brano Krljaš: *The mine situation in Bosnia and Herzegovina*

The current mine situation in Bosnia and Herzegovina was presented. The information about the application of the Decision Support System and the Multisensor Airborne Imagery Acquisition System and the capacity building was given too.

RESUME

Four papers were presented, as well as one presentation outside the announced agenda. The workshop attendance ranged from 36 to 41 persons. The discussion was held on both plenary session and Workshop 2 topics. Fifteen questions and three times as much sub questions or additional questions were raised. Answers were given by the authors, although often completed with comments or explanations by other participants of the workshop. The exchange of experience continued after the workshop and resulted in several new initiatives

or advancements of previous ones (Geomines – HCR-CTRO; Faculty of Geodesy – ESA – Mineseeker; HCR-CTRO – Osijek-Baranja County, BH MAC – HCR-CTRO).

The aim of the workshop and the plenary session, which was to inform about the contents and the achieved level of the availability of new technologies to support decision in the reduction and assessment of a Mine Suspected Area, was reached in the following aspects:

1. First two civilian operational remote sensing technologies in the world, based on aerial and space assets that are fully operational, were presented. They are a) Decision Support System with Multisensor Aerial Imagery Acquisition for Mine Suspected Area Reduction (Croatia) and b) Assessment and the Minefield Detection by aerial and satellite hyperspectral remote sensing (Israel). Both technologies are based on the airborne and space borne remote sensing, although they are aimed at different purposes and conditions. DSS and Multisensor Airborne Acquisition System have a goal to reduce and to assess the Mine Suspected Area and are suitable in the states where Mine Action Centers exist and are fully functional. The Hyperspectral Detection of Mine Fields is aimed for the two extreme conditions: a) if there is not a Mine Action Centre in the country (many countries in the world), b) if all data about minefields exist and are available (e.g. in Israel).
2. The concept of detection of mine fields by the Airborne Ground Penetrating Synthetic Antenna Radar (GP SAR), aimed by longwave infra red sensor and high resolution camera was presented in its transition phase from the available equipment to technical testing and evaluation of the operational parameters. This concept shows readiness to pass all phases from the concept to the operational validation as a prerequisite for operations in humanitarian mine action.
3. The possibility to use genetically modified bacteria and the airborne LIDAR was presented, although with opinions against this risky approach.
4. The intentions of the European Space Agency, to support industry in geographically limited number of EU countries was presented, aimed to support humanitarian mine action.

Reactions of the audience were allocated mainly to the emerging and conceptual approaches, while the discussion about two operational remote sensing technologies was intensified after the workshop. Very interesting, although renewed idea to use genetically modified bacteria

launched several questions. Ethical objections were already known from a similar initiative in Croatia (early 2000), but new ones are economically based. Undeveloped countries can use the ground after the mine clearing for eco production of food (soil was not treated with chemical fertilizers) and this is the strongest objection against the use of genetically modified bacteria. The presentation of the concept of the airborne detection of minefields by GP SAR triggered the avalanche of questions followed by a strong skepticism. Co-authors showed that they are aware of the limitations and the difficulties with which they are faced. They informed about the roadway from the concept to the service. The first step will be testing and evaluation in accordance with ITEP methodologies. The serious approach and the readiness to face the problems was recognized by the audience.

The intentions and the action (Invitation To Tender) of the European Space Agency were greeted, although with a bit of skepticism. The Humanitarian mine action community has waited more than ten years (Symposium 1998. in JRC, Ispra) for deployment of spatial assets into operations, several R & D projects indeed introduced the use of spatial assets (Minefield detection Mosambique, SMART, ARC, PARADIS). In the two existing operational systems the use of spatial assets makes a very significant part. The action of ESA due to geographical limitation has a low chance to achieve any significant (if any) impact on humanitarian mine action, therefore we would like to propose the ESA to recheck their ITT.