Operations with Advanced Intelligence Decision Support System
for Mine Suspected Area Assessment in Croatia and Bosnia and Herzegovina

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M. Bajić, Operations with Advanced Intelligence Decision Support System for Suspected Area Assessment in Croatia and Bosnia and Herzegovina, Workshop “Merging Mine Action Technology and Methodology”, GICHD, Geneva; 6-8.09.2010
COUNTRIES/AREAS OF ITF ACTIVITIES

OTHER REGIONS/AREAS

Afghanistan
Azerbaijan
Armenia
Columbia
Cyprus
Gaza Strip
Georgia
Iraq
Jordan
Kazakhstan
Kyrgyzstan
Lebanon
Tajikistan
Turkmenistan
ITF Short Record of Achievements (1998 – 2010)

319.382.995 USD of donations raised by ITF
105.732.625 square metres of land in SE Europe and the South Caucasus cleared through ITF
69.370 mines and UXO found and destroyed in the region of SE Europe
40.000 and more children and adults included in MRE projects on yearly basis through ITF
2.450 completed projects
1.014 mine survivors rehabilitated through ITF
800 individuals trained in the field of Mine Action (MVA, humanitarian demining, management)
130 plus public and private donors
28 donor countries
18 beneficiary countries/areas
4 countries – Macedonia, Montenegro, Serbia and Albania – achieved Mine Free status
1 regional MA body – SEEMACC
ITF involvement into R&D activities (1998 – 2010)

- Geografical Information System In SEE Europe (2000-2003, core activities were analysis of MAC requirements for hardware and software for GIS and images processing, development of suitable equipment and guidelines for the region, organization of tendering procedures and centralized purchases for equipment for GIS and images processing, provision of staff support to MAC and organization of IT, GIS and image processing training courses applicable to MA)
- Partial involvement in European Commission project ARC (Airborne Minefield Area Reduction, 2001 - 2003)
- Partial involvement in European Commission project SMART (Space and Airborne Minefield Area Reduction Tool, 2001 - 2003)
- Support of development of demining machine MV 3 (implemented by DOK-ING, Croatia, 2001 – 2002)
Croatia and Bosnia and Herzegovina – Mine situation 2009/2010 (Suspected area in km2)

<table>
<thead>
<tr>
<th>Country</th>
<th>I. Category</th>
<th>II. Category</th>
<th>III. Category</th>
<th>Total all:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BiH</td>
<td>234,70</td>
<td>422,85</td>
<td>897,78</td>
<td>1,555,33</td>
</tr>
<tr>
<td>MSP with sufficient data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSP without sufficient data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Croatia</td>
<td>266,31</td>
<td>621,49</td>
<td>887,70</td>
<td>887,70</td>
</tr>
</tbody>
</table>

- Both countries has approached to Ottawa convention for prolongation of their national demining programs till 2019 (scope of problem and problem with financing of MA activities)
- Bosnia and Herzegovina is now facing with a lack of donor interests in financing of Mine Action
- Croatia is in a better position due to a fact that Croatia is finansing national Mine Action programme 75 % from a National budget
- For both countries as main problem remains III category of suspected area
- Involvement of representatives from other countries with mine problem – transfer of know – how (Azerbaijan)
AI DSS technology supports approach to Ottava Convention

A: optimal mine action program, B/C >> 1, B: cost equal to benefit for existing technology, C_{DSS}: cost for AI DSS, D: full clearance (Article 5 Ottava Convention),[4].

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Results of the first operational remote sensing project achieved 2008-2009 in Croatia

- First operational service for the reduction of a mine suspected area and risk assessment, by airborne remote sensing, spatial imagery and Advanced Intelligence Decision Support System (AI DSS) was applied at 158.16 km² at communities Gospić, Bilje and Drniš in Croatia.

- Results in the community Gospić (MSA 56.84 km²):
  - excluded from mine suspected area 28 km²
  - included into mine suspected area 6 km²

- Ratio of CROMAC’s conventional technology cost to the cost of AI DSS technology 141.83 : 1
Application of AI DSS service in community Gospić

Legend
- Red cross-hatched - for demining,
- red hatched – for search,
- yellow hatched – used at owner responsibility
- blue hatched – excluded from MSA.

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Advanced Intelligence Decision Support System
for Mine Suspected Area reduction and assessment

Application of AI DSS results in MAC

Danger Map
Confidence map

Reconstruction of MSA, indicators

Proposals for MSA reduction

Fusion, multi-objective multi-criteria processing

Airborne & satellite multisensor imagery
Indicators of mine presence & absence

Contextual data, information
Terrain analysis

Formalised experts’ knowledge. Quality assessment of data, information

Mine Information System

Geographic Information System

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Airborne multisensor imagery acquisition system of the AI DSS

- Sensors’ pod (below the fuselage of the helicopter Mi-9, installation 2 h).
- Subsystem for navigation, for imagery acquisition, pre-processing.
- Subsystem for the processing and interpretation (on the ground).
- Flight endurance 4:15 h.
- Cruising speed 110 km/h
- Width of the images strip 0.33 H, H – height above terrain.
- Area imaged per hour 36 km$^2$.
- [12].
Airborne multisensor acquisition system of FG UNIZ & CTDT

Color IR: 4 channels
Long wave IR: 1 channel
Hyperspectral: 95 channels
Color photo: 3 channels
Pillars of the AI DSS

**MINE ACTION CENTRE**
Mine action experts: scene analysis (MIS, GIS), general & special requirements on information and data acquisition

**DSS OUTPUT**
Fusion, danger map, confidence map, proposal for reduction, map of conflicts MIS-AI DSS

**MINE SCENE INTERPRETERS**
Scene understanding, satellite imagery & DEM terrain analysis, airborne mission planning, quality assessment of available data & information

**MINE SCENE INTERPRETERS**
Imagery processing, use of expert knowledge, contextual information, indicators of mine presence, absence

**MULTISENSOR AIRBORNE SYSTEM**
Multisensor imagery acquisition

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Metodologies used in MAC and used in AI DSS

- MIS (Mine field records, incidents, accidents, survey, QA,..) & GIS (HOK, TK25, DOF5, DOF2).
- Scanned military maps.
- War history data, data about explosive and landmine obstacles, 3D visualisation of the terrain.

**AI DSS**, [8], [9], [10], [4], [5]
- MIS, GIS, scanned military maps, war history data, data about explosive and landmine obstacles, satellite multispectral images, satellite digital elevation model (DEM).
- Analytic estimation of the mine suspected area (MSA). Control and statistical evaluation and quality assessment of all data sources.
- Detection of the indicators of mine presence (IMP) and mine absence (IMA) in the satellite images, airborne multisensor images, DOF (if available).
- Collecting and processing of the contextual data and information.
- Formalisation of experts’ knowledge (membership function, relative importance of IMP).
- Spatial analysis of the terrain.
- Classification, fusion, multi-objective, multi-criteria processing.
- Derivation of the maps: danger map, proposal for reduction, confidence map, map of conflicts between MIS and AI DSS data.
Where to apply AI DSS based on airborne and space borne assets

- Advanced Intelligence Decision Support System (AI DSS), based on space borne and airborne assets is aimed and is suitable for areas where access is not possible on the ground, or where ground based technology is too costly. Terrain without snow, forests, crop fields without leaves.

- In Croatia were selected three regions having different characteristics. In Bosnia and Herzegovina 11 regions were considered and 3 were selected for applications of the AI DSS service.

- Mine Action Centre shall provide available MIS and GIS data, scanned military maps, war history documents (if exist).

- Experts for deployment of the explosive and land mine obstructions, military experts which know war history on the considered terrain, experts for mine action, shall derive general and special requirements regarding the difference between available and needed information and data, that should be provided by application of a AI DSS.
The strong indicators of mine presence – main contribution to success
Trenches are visible on the aerial image
Map of potentially hazardous areas outside MSA

Legend:
blue – potentially hazardous area outside MSA, red – danger map inside MSA.
Contextual data compensate lack of data in Mine Information System

Example of information uncertainty: analysed 228 mine field records, 51 exist, 43 minefield polygons can be shown on a map, average positioning accuracy 40%; 81% mine obstruction locations unknown,[5].
Trenches visible on the satellite image
not on aerial digital ortho photo DOF 2 (M 1:2000)
Slopes of the relief, large waters are (new) indicators of mine absence

The mountain Velebit

The marsh Kopački rit

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Slopes of the relief, large waters features applied

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The indicators of mine presence and mine absence shown on MSA

Note: Velebit not shown

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Conclusions

1. The Advanced Intelligence Decision Support System (AI DSS) is the first fully operational solution for the assessment of the mine suspected area (MSA), based on the airborne and space borne remote sensing combined with advanced intelligence methodology, which passed stringent operational validation.

2. Application of the AI DSS enabled Croatian Mine Action Centre (CROMAC) to exclude 26 km$^2$ of 56.84 km$^2$ MSA and include 6 km$^2$ to MSA in one (Gospić) of three communities where AI DSS was applied. Application of the AI DSS results for other two communities is under way.

3. Ratio of CROMAC’s conventional technology cost to the cost of AI DSS technology 141.83 : 1.

4. The European Commission supported R&D projects regarding the application of the airborne and space borne remote sensing methods and technology for needs of mine action, which never became operational. We express scepticism regarding the ESA initiative.

5. The financial support of US Department of State by assistance of International Trust Fund, Slovenia, the financial support of Croatian Ministry of Science, education and sports and the operational support and strong feedback of CROMAC enable transformation from R&D concepts and methodologies into presented operational AI DSS.

6. We invite to the cooperation and further advancement and the development of the operations with AI DSS.

7. In October-November 2010, we will have internal Workshop (work – not presentations) in Mostar, Bosnia and Herzegovina. Information available.
Acknowledgments

- The Advanced Intelligence Decision Support System (AI DSS) was developed and realised in 2007-2008 as the operational system, by support of the Ministry for science, education and sports, of the Republic of Croatia through technology project TP-06/007-01.

- The International Trust Fund for Demining and Mine Victims Assistance (ITF), Slovenia, supported operationalization and advancement of the AI DSS in Croatia (2008-2009) and in Bosnia and Herzegovina (project is under way). ITF also supported operational verification and validation of the R&D projects SMART and ARC funded by European Commission (2001-2005).


- Croatian mine action centre (CROMAC) provided continuous operational support, data, information and expertise in mine action which were crucial for our orientation to solving the real problems instead to allocate efforts to the technical or scientific curiosities.

- The AI DSS is result of the continuous efforts of many scientists, researchers, mine action experts, Croatian Air Forces pilots, research institutions and academia, fruitful cooperation between Croatian and European scientists. It was our privilege and the pleasure to work with all of them.
References