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For successful demining operations to occur, detailed data collection, planning and assessments must be made in order to meet the expectations of the many stakeholders involved in the demining process. This article discusses the hierarchic approach of priority assessment for demining, using a multicriteria analysis and geographic information system (GIS) support.

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Introduction

The Republic of Croatia is one of the 10 most mine-contaminated countries in the world. There are almost 750,000 mines on 1,630 sq km of mine-suspected areas. About 170 sq km are actual minefields, while the rest of the area is contaminated with individual explosive ordnance. Mine-affected areas have not been used for years, pose a huge economic problem and obstruct infrastructure development, reconstruction and return of displaced persons to their normal lives. They also pose a significant safety problem. In particular, any activities carried out in mine-contaminated areas significantly threaten human lives and material assets. It is estimated that removing all the mines in the Republic of Croatia would cost approximately $1.473 billion (U.S.) and would require 10 years of intensive work.

Recent experiences indicate that the demining process is a "complex, slow and expensive job." Nevertheless, efforts have been aimed at increasing the efficacy of demining activities, while still avoiding human casualties. Even small demining cost-reductions present big savings, in an absolute sense, and on numerous occasions, overvalue investment and eventual methodological improvements. A good example includes an initiative for implementing" a new methodological approach based on GIS and multicriteria analysis for planning and operation of human demining. Lack of finances influences the definition of priorities for mine removal-assessing which territories offer the greatest potential benefit if the mines are removed. Clearly, such territories should be de-contaminated first.

The international community noticed that humanitarian mine action in Croatia presents problems and has been offering help. In 1996, it established the United Nations Mine Action Center (UNMAC) with the mission of implementing humanitarian demining in Croatia and collecting data on detected and suspected minefields. By the end of 1998, the mandate of UNMAC in Croatia ended, but almost immediately the Croatian Mine Action Center (CROMAC) was established. CROMAC developed intense and efficient counter-mine action. By the end of the 1990s, Croatia became the primary donor for humanitarian mine action operations. It contributes almost 80 percent of total funds for annual "Demining Plans" with its own finances from the state budget and World Bank loans. In order to satisfy ever-growing stakeholders' interests and due to the lack of finances for demining operations, CROMAC's management was forced to divide demining projects. At that time, the lack of priority coordination and the failure to meet the needs of stakeholders was noticed, namely frequent conflict situations that were sufficient motive to start research for new methodological approaches.

Background

As stated in a 2002 report, the existing system for developing the national mine action plan and for identifying priority tasks in Croatia has evolved over time.[1] In the immediate post-war period, mine clearance was seen as an integral part of the reconstruction effort and priorities for survey and clearance were determined by plans for reconstruction, the return of refugees and displaced persons and special projects to upgrade the national infrastructure (such as clearing the Sava River). Mine clearance was "demand-led" in its initial phases and, in general, the priorities were clear. However, the problem of identifying priorities became more difficult once the most pressing issues were addressed. The report states that""to some outside observers, including donors, it was unclear how priorities were being established within each county, whether politicians in the different counties were setting priorities based on similar criteria, and the degree to which socio-economic factors were considered when setting priorities." Conflicts among human demining objectives occur often, and they usually involve outside objectives conflicting with objectives generated within the system. The conflicts are then transferred to the criteria. This inconsistency of the criteria led to the implementation of multicriteria analysis because "classical" methods, including intuitive decision-making, cannot determine the optimal solution for the humanitarian demining problems. Therefore, in 2001, CROMAC, in collaboration with the Faculty of Civil Engineering at the University of Split, developed a hierarchic approach for the demining problem in Croatia. Within the pilot project for Sisacko-Moslavacka County, a multicriteria analysis method was applied in order to provide an objective approach to humanitarian mine action in Croatia, which is characterized by the fact that 14 of its 21 counties are endangered by minefields (See Figure 1).

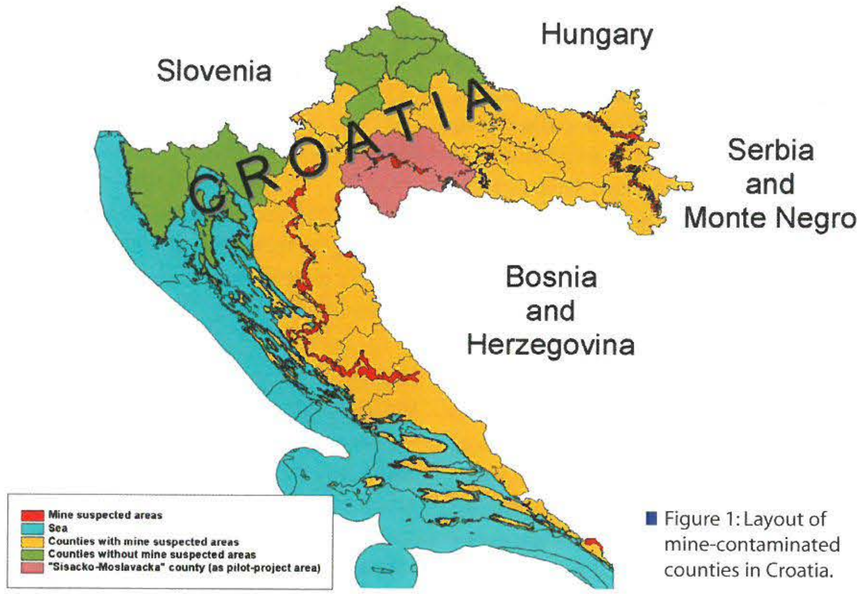

Figure 1: Layout of mine-contaminated counties in Croatia.

Hierarchic Approach in Priority Assessment for Humanitarian Demining

In developing a hierarchic approach in humanitarian demining, participants must consider different approaches at different decision levels. Due to the characteristics of humanitarian demining in Croatia, the multi-level approach was developed. For different problem levels, a special algorithm for evaluation criteria and actions (solutions) was developed. This means that for the each decision level, a separate "action set" is created (projects for demining of socio-political units, such as counties, municipalities, villages, minefields, homogenous areas, etc.). Such sets are evaluated by applying multicriteria analysis."This actually means that:

At the strategic level, problems should be treated at the state level; therefore, counties are a logical set of actions evaluated by multicriteria analysis. Alternatively, at the state level, homogenous zones can be defined as a set of actions that will be ranked according to the demining priorities related to the basic state orientations (tourism, energetic zones, water supply zones, transportation, valuable ecological areas, fire- endangered areas, areas that are under special state auspices, etc.).

At the tactical level, problems should be treated at the county (or canton) level, so the municipalities are defined according to a logical set of actions evaluated by multicriteria analysis. Alternatively, at the county level, homogenous zones can be defined according to a set of actions that will be ranked according to the demining priorities related to the basic counties' orientations. Generally, at this level, homogenous zones can be defined according to the criteria that concerns:

- *Terrain characteristics* (slope, petrology, accessibility), and supposed minefield characteristics (density, risk degree, information reliability, mine types)
- *Socio-economic parameters* such as demographic data (aging structure, nationality, family structure), economic parameters (basic economy mainstay of population, employment, average income, potential of the area, expected positive effect after demining, etc.)
- *Political parameters* such as direct intervention from state level or donors (for example, return of refugees, areas under special state auspices, boundary areas, etc.)
- *Legislative parameters* (for instance, property structure, general purpose of the area, etc.)
- At the operational level, the problem should be treated at the demining project level (minefields, demining company selection, selection of technological support, etc.).

For the different problem levels a particular "criteria set" for multicriteria evaluation has to be evaluated. However, for each decision level, expert teams from the Mine Action Center (MAC) have to make the criteria set more detailed, tailoring it to the characteristic demands for that particular level, as well as to the expectations of the "partners" in the decision process. For example:

- The strategic decision level is characterized by using macroeconomic and other global parameters and by coordinating with strategic partners such as governments, competent ministries and international organizations.
- The tactical level is characterized by an approach that favors those parameters that are the most important for a particular county's development, as well as parameters that are important for political stability and population satisfaction (understandable and global criteria that apprehend personal interests of each inhabitant, especially in areas where there are possibilities for national conflicts, or conflict caused by ratio of domicile and new inhabitants, etc.). At the tactical level, partners that have to be included in the discussion about criteria are socio-political organizations of counties, refugee associations, as well as important infrastructure systems and public corporations (waterworks, electro-works, telecommunications, big agricultural system, etc.). At this level, various donors can participate as partners in discussions as well.
- The operational decision level is characterized by the micro-approach related to the technological characteristics, as well as economic parameters in the case of valorization of each project or demining company. At the operational level, the partners are municipal organizations, bigger corporations, demining companies' delegations, etc.

For each decision level, the relevant data within the GIS is generated or expert teams are being formed for evaluation of those parameters that cannot be evaluated from GIS (for example, estimation of the number of refugees that will come back if an area is demined, or estimation of costs or benefits from demining operation). Figure 2 shows the schematic layout of the hierarchic approach, so the situation of money distribution at the strategic level for demining 14 mine-endangered counties can be simulated using results from multicriteria analysis. At the tactical level, the county distributes finances to the endangered municipalities—again based on multicriteria analysis. At the operative level, the municipality distributes approved funds to particular projects for settlements or infrastructure based on its own criteria, and results of the multicriteria analysis.

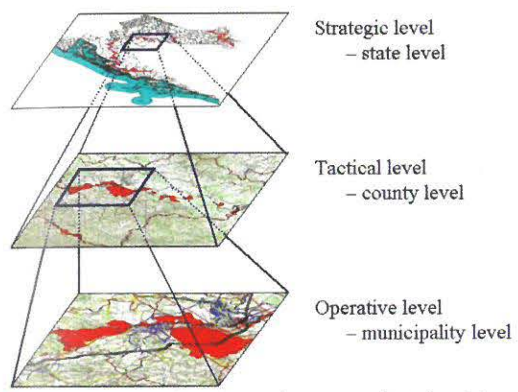

Figure2: Layout of the hierarchic approach in demining operations in Croatia.

Within the pilot project for Sisacko-Moslavacka County, the multicriteria analysis was applied at the tactical level. Namely, ranking mine-endangered municipalities was performed in order to check the above mentioned approach in practice, and to judge its convenience for other decision levels. In the following section, the same basic extractions from the pilot project, "Application of Multicriteria Analysis to the Humanitarian Mine Action Problem" are given.

Pilot Project for Sisacko-Moslavacka County

Regarding available data and the reality of the humanitarian demining problem, it was decided that the pilot project take place in Sisacko-Moslavacka County, and municipalities of the county would be treated as homogenous zones that would be ranged according to the agreed criteria.

According to the available parameters on the area of Sisacko-Moslavacka County, 640 minefields were registered. By terrain surveying, as well as by identification of suspicious areas, a digitized database was created containing all mine-contaminated and suspicious areas with 72 polygons on 11 municipalities in total. Regarding the fact that all aforementioned polygons were not homogenous, and it was impossible to make them homogenous by applying some simple procedure, it was decided that being part of the certain municipality should be a criteria for polygon joining. For example, when forming a set of actions (projects) to be ranked and analyzed, multicriteria analysis should be applied in order to determine the optimal options for risk reduction. Such an approach is reasonable because municipalities are the smallest territorial and political units that are involved in the evaluation of optimal policies for risk reduction.

According to the project demands and in order to ensure all relevant data and enable straightforward generation of more general data, GIS, containing various thematic layers, was created. ArcView and some other Environmental Systems Research Institute (ESRI) tools that enable more complex spatial data analysis were used. When analyzing the problem, the following problem characteristics were evaluated:

- High demining price
- Conflict of interests
- Hierarchic nature of the problem (several solution levels)

Within the project, the following objectives were defined:

- Establishment of more objective criteria for the evaluation of demining priority (i.e., optimal policies for risk reduction)
- Gathering of all relevant data
- Modelling of the decision process that is acceptable to the majority of the groups, which generally have conflict interests
- Involvement of more groups in the decision process

As the solving methodology, the following compromised steps are worked out:

- System approach in problem characteristics definition
- Providing of relevant data for numerical process by GIS
- Support system
- Modelling of the decision process
- Multicriteria analysis for making objective of the subjective demands (approaches)

According to the fact that during the evaluation of the optimal policies for risk reduction, several groups are involved in the decision process, the activities in the process of problem solving were defined:

- Defining of the characteristics, namely, of the set of the activities and set of the criteria (problem scope definition)
- Bringing together the sets of action and criteria with "partners" in the decision process (usually, some of the criteria are added due to the partner's insistence during the group decision-making)
- Definition of the criteria weight and preference types for each criterion
- Negotiating criteria weights in the iterative process
- Definition of the alternative scenarios of the criteria weight assessment, assessing more weight to the certain criterion group
- Model (numerical) problem solving and presenting of numerical and graphical results of ranked actions (of mine-contaminated areas) by the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE method)
- Sensitivity analysis, namely, stability checking of the set of the criteria weight scenarios
- Usage of GAIA (Geometrical Analysis for Interactive Aid) method for the visualization of the problem characteristics via geometrical representation
- Presentation of the multicriteria analysis results to the participants in the decision-making process, as well as numerical solving of the additional scenarios (criteria weight variations as the results of negotiation)
- Elaboration of multicriteria analysis results including verbal and

graphical interpretation of the obtained ranks

Figure 3 shows a schematic procedure, which contains GIS analysis as a first step and evaluation of relevant criteria presented as thematic layers. For the criteria that can be spatially presented, using GIS analysis, concrete numerical values as input for multicriteria analysis are being evaluated.

For the criteria that cannot be generated by GIS analysis, an expert team evaluation and mathematical estimation were performed. For example, by using data from "mine records" from both parties involved in the war conflict, it is estimated that on the territory of this county, 30,506 mines are placed—24,887 of which can be identified on the already known minefields in eight municipalities. For 5,623 mines, location is unknown, so the most plausible solution is that they are placed on the territory of 11 mine-endangered municipalities or less likely, on the territories of other municipalities in the county that currently are not contaminated with mines. Figure 4 shows the territory that presents possible contact of population and UXO. The obtained area presents an "objective estimated risk" for the domestic population calculated by multiplying the number of inhabitants of settlement that is within, or on, the border of mine-suspected areas with an average population density on the study area.

The value of infrastructure parameters, which is situated on suspected minefields, is calculated indirectly as well (i.e., around digitized installation infrastructure, a 100 meter double-sided buffer is determined, and after that by implementation of "geoprocessing function" an intersection area of minefields and infrastructure installation is determined). In a similar manner, for the mine-contaminated areas of each of the 11 analyzed municipalities, the values of estimated parameter values for other criteria are evaluated (roads, agriculture areas, forests, parks of nature, etc.—see Figure 5).

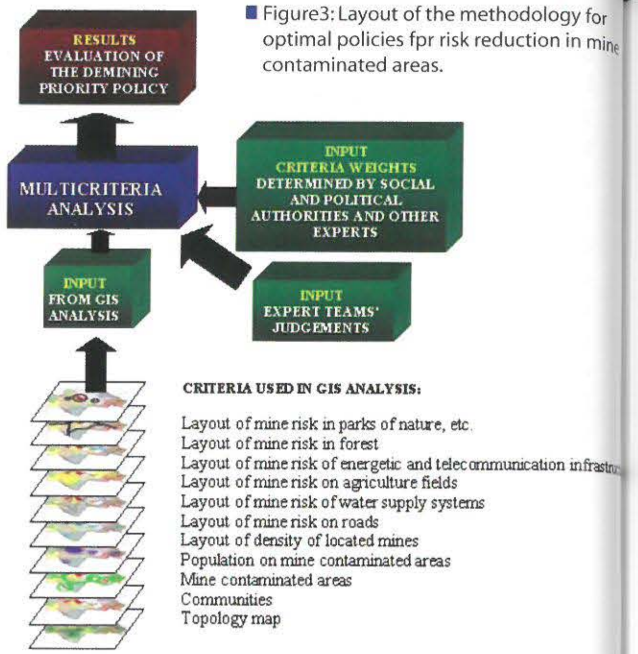

Figure3: Layout of the methodology for optimal policies fpr risk reduction in mine contaminated areas.

During multicriteria analysis for each of the criteria, the weights were assigned by the stakeholder involved in the decision process. Namely, it is important to involve representatives of social and political associations from the municipalities' territory, which are included in the priority ranking, in order to obtain results that would be accepted by them as optimal ones.

For the numerical part of multicriteria analysis, two methods, PROMETHEE and GAIA "Decision Lab 2000," are used. It is the commercial name of software distributed by "Visual Decision" from Canada. Contemporary architecture of this software, based on the Decision Support System (DSS) enables comfortable work and widespread support for the decision-making processes.

A large part of the information, most of which is possible to visualize (graphs, various colored diagrams) gives the decision-maker a complete insight into the problem characteristics and possible results of various problem-solving scenarios. Table 1 presents results of the numerical"analysis for Sisacko-Moslavacka County by the PROMETHEE method. For example, look at the evaluated ranks that present priority assessment for the 11 contaminated municipalities (presented results are not the final optimal solution).

Achieved synthetic parameter "Phi" presents valorization of priorities based on defined criteria and weighting coefficients. Table 1 shows that municipality Slunj is ranked first and represents demining priority because the total Phi value of 0.5364 dominates the second-ranked municipality, Petrinja, with Phi value of 0.3077. Follow the ranks to the last one, other municipalities to the last one, municipality Gvozd with negative priority value Phi -0.2397.

Synthetic parameter Phi is very convenient for the expression of differences or definition of priority "power," so it can be used for the determination of demining funds relations of each municipality. For example, if someone wants to distribute the total amount of money" to the top four ranked municipalities, the proportion of the distribution can be based on Phi indicator value (Figure 6).

Figure 7 shows the layout of the relations between criteria obtained by GAIA software, namely by application of principal component analysis for Phi values for each criterion. Insight into the criteria relations is important for understanding the problem and recognition of the correlation between different criteria parameters. As Figure 7 shows, it is easy to notice criteria with a high degree of correlation and criteria in conflicting positions.

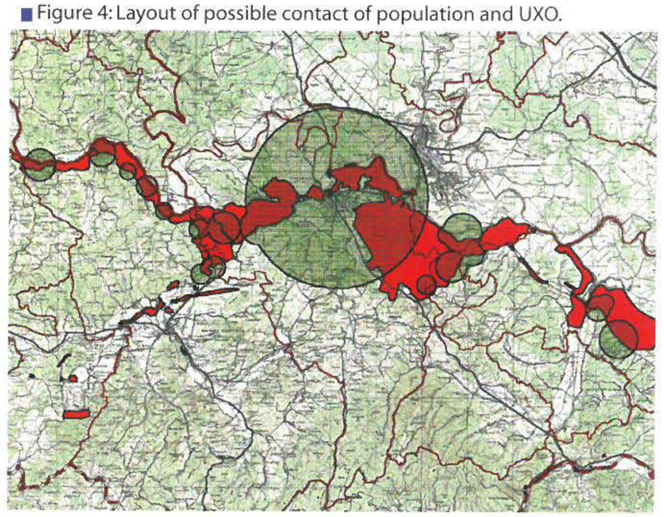
Figure 4: Layout of possible contact of population and UXO.

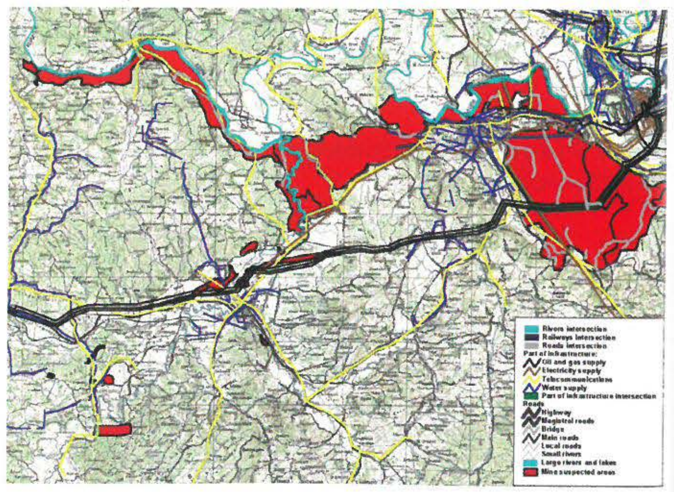
Figure 5: Layout of intersection area of mine fields and infrastructure installati

MUNICIPALITIES	Phi Plus	Phi Minus	Phi Net	Ranking
DVOR	0,1830	0,1537	0,0293	4
GLINA	0,1078	0,1470	-0,0391	5
DUBICA	0,0657	0,1797	-0,1140	7
PETRINJA	0,3888	0,0810	0,3077	2
SISAK	0,1043	0,1558	-0,0514	6
SUNJA	0,5803	0,0439	0,5364	1
TOPUSKO	0,0572	0,2088	-0,1516	9
KOSTAJNICA	0,0193	0,2206	-0,2014	10
JASENOVAC	0,1903	0,1356	0,0547	3
NOVSKA	0,0589	0,1896	-0,1308	8
GVOZD	0,0003	0,2401	-0,2397	11

Table 1: Municipalities ranked.

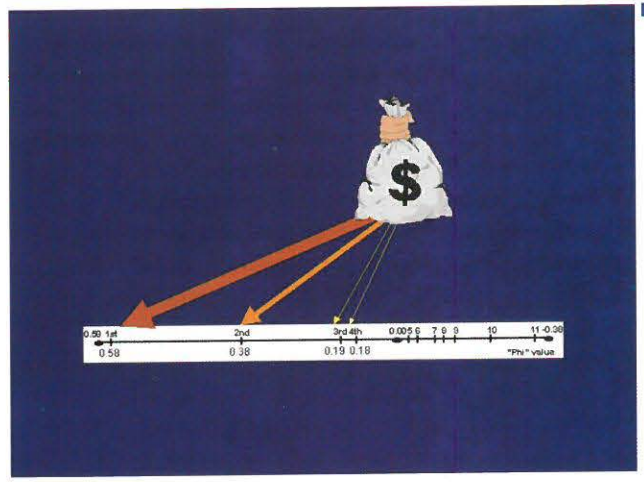
Figure 6: Illustrative layout of fund distribution based on obtained rank and calculated priority "Phi".

Conclusions

The developed hierarchic approach of priority assessment for demining, using multicriteria analysis and GIS support, illustrated the possibility of objective valorization in humanitarian demining that is acceptable for most stakeholders in the decision process. The relatively small costs of data collection, editing and analysis with simple control and transparency through all hierarchic levels, as well as involvement of all stakeholders (directly or indirectly) in the decision process, give such an approach an advantage compared to the other methods being used.■

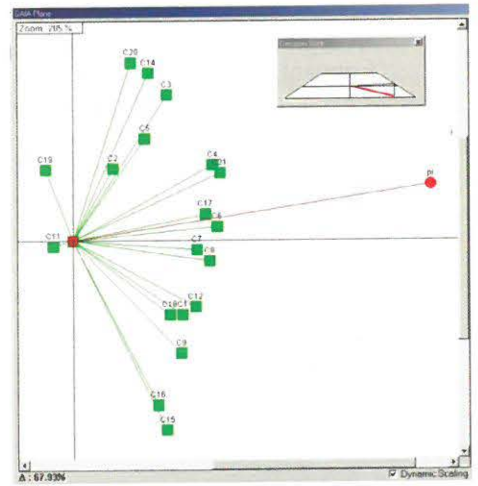
Figure 7: Geometrical presentation of the relations between criteria is shown by GAIA method .

References

1. Filippino E.M., Paterson T., "Report on the GICHD Mission to Validate the Pilot County Mine Action Plan for Croatia," GICHD, Geneva, Switzerland, 2002.

2. Benini A.A., Moulton L.H., Conley C.E., Landmines and Local Community Adaptation, *Journal of Contigencies and Crisis Management*, Vol 1 No 2, 2002.

3. Brans, J.P. and Mareschal, B. (1994) "PROMCALC & GAIA: A New Decision Support System for Multicriteria Decision Aid,"*Decision Support Systems*, 12, pp.297-310.

4. Mladineo, N., Lozic, I., Knezic, S., Mlinaric, D., Radica, T., "An Evaluation of Multicriterional Analysis for DSS in Public Policy Decision,"*European Journal of Operational Research*, North-Holland, No. 61, pp. 219-229., 1992.

5. Mladineo N., Knezic S., Pavasovic S., Simunovic I., Development of 'Land rent model' using multicriteria analysis and geographical information systems, *CIT - Journal of Computing and Information Technology*, 1993., 4, pp. 243-251.

6. Buzolic J., Mladineo N., Knezic S., Decision support system for disaster communications in Dalmatia, *International Journal of Emergency Management*, Vol 1. No. 2, 2002., pp.191-201.

7. Gorseta D., N Mladineo & S Knezic: Choosing the optimal policies for risk reduction in mine contaminated areas, Third International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation / Edited by C.A. Brebbia, Wessex Institute of Technology Press, Southampton, Boston, 2002. pp 498-506.

8. www.visualdecision.com/PROMETHEE.

**All graphics courtesy of the authors.*

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