# Decision Making in Organizations with Local Area Network: Decision Support System «Veche»[1]

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## Summary

DSS «Veche» is developed to support the collective activity in problem solution of several key persons of an organization. «Veche» is oriented to an environment with the only DM, who has ultimate responsibility for the decision's consequences. It uses psychologically correct approaches only to elicit information from both a DM and a participant in a problem solving process. The results obtained help a DM to look at the problem critically and to hunt down his/her preferences, as well as to find out non-standard outcomes for situations that seems to be a deadlock.

## 1. Introduction

Successful activity of any organization in both the public and private sectors depends on the ability of its management to arrange operations of their staff in a such way, that joint skill is greater than a mere sum of individual skills.

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Reasonable combination of expertise and experience of individuals generates a new powerful intellect, that widens capabilities of the whole organization.

Various Group Decision Support Systems (GDSSs) and Negotiation Support Systems (NSSs) emerged in last decade to manage the problems that require knowledge contribution of multiple decision makers. Comprehensive review and analysis of such system one finds in [Matsatsinis NF, 2001]. The main objective of GDSSs and NSSs is to achieve consensus between the participating individuals, or, at least reduce the amount of conflict among them.

DSS «Veche» has quite a different orientation. It is developed to support the collective activity in problem solution of several key persons of an organization. But we do not consider each participant as a DM. «Veche» is oriented to an environment with the only DM, who has ultimate responsibility for the decision's consequences. While the participants are engaged intensively in the search for the best alternative solutions according their own preferences, their best solutions and evaluation criteria are necessary to give a DM the information about opinions of the most experienced people of his/her organization and/or an idea only what to do with the problem. It is possible in some cases to obtain the solution that acceptable to all or to majority of participants, but it is not main objective.

So, the first objective of DSS «Veche» is to support joint and productive work of a DM and his/her staff.

The second objective is to collect practical skills of participants expressed in the form of those alternatives and criteria they use in the process of a problem's solving. Nowadays is evident that availability of collective knowledge well contributes in an organization success. But there are essential difficulties in the development of organizational knowledge bases. We believe that the competitive participation in the important problem solving is one of the best ways to development of such knowledge bases.

The third objective of DSS «Veche» is staff evaluation. DM could form his/her judgment on how active was an individual in the process of a problem solving and how valuable were new ideas proposed by him/her.

## 2. Main Ideas of the System «Veche»

Key assumption that underlies DSS «Veche» is the following: staff members use their knowledge and their accumulated potential more effectively when they solve the same problem individually, while taking into account the proposals of others. When an individual perceives that he/she has to solve a problem in the competitive environment (with a number of participants), he/she makes every effort to propose the most valuable solution and to reason it. Furthermore, since the participants know about a transparency to DM of their individual works with the problem, they have to be impartial in respect of proposals of each other. Undisturbed conditions of individual work with computer help a participant of any collective problem solving to consider his/her proposals and the proposals of other participants more deeply and to explain them in details.

### 3. Scenario of DSS «Veche» Operation

Typical operation scenario (Fig. 1) of DSS «Veche» consists of the following stages:

- A DM describes the problem situation in brief, names the problem and specifies the deadline to submit the individual solutions.
- A DM determines participants to solve the problem.
- A DM has an option to create the initial lists of alternative solutions and evaluation criteria, respectively. He/she may mark all or any items of such lists as mandatory ones to participants.
- A DM confirms the assignment and transfers the information above to the participants.
- A participant proposes possible problem solutions, specifies and/or adds the criteria, exchanges information with his/her peers, and evaluates all possible solutions upon all criteria.
- A participant makes the decision on accomplishment of his/her operations in the system independently (taking into account the deadline for a result submission) and transfers his/her results to a DM. (Note, a DM has an option to ascertain the author of any alternative solution. It's necessary to satisfy the objective 3 above.)
- Final report for a DM is created automatically and includes the following: the set of the best solutions of each participant; the lists of the each participant alternative solutions ranked according to their preferableness along with their estimates upon criteria; the reasoning for the best solution choice (if any), and the estimate of such solution stability.
- A DM analyzes the results of each participant individual work and makes a decision, at his absolute discretion.

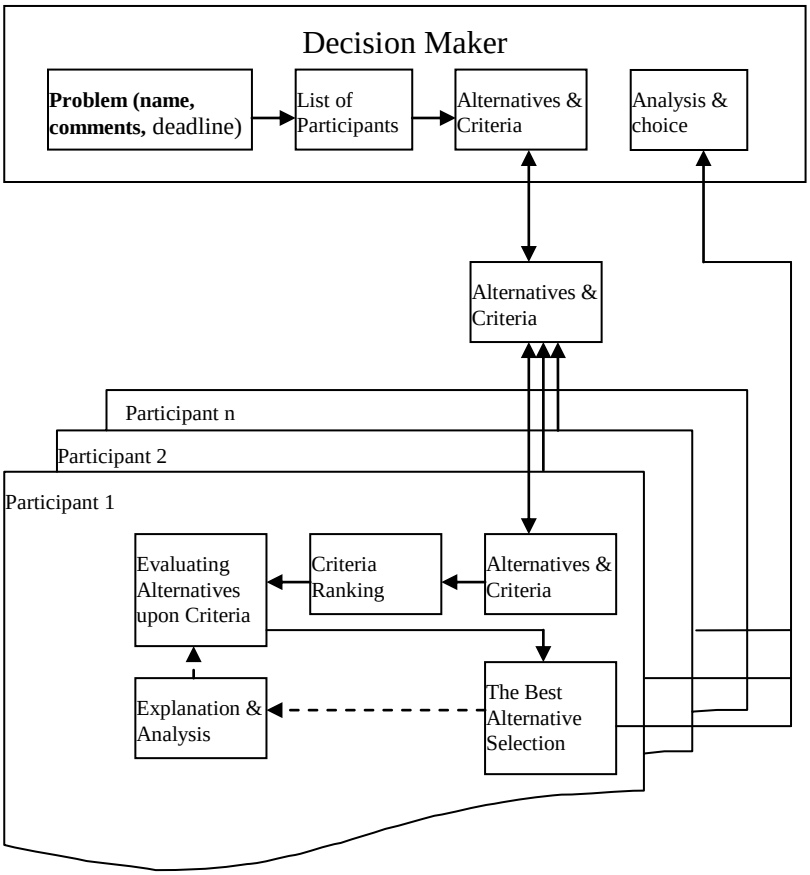


Fig. 1. Operation Scenario.

## 4. DM's and Participant Workplaces

### *4.1 DM's Workplace (*before routing approved assignment*)*

DM key objectives are the following:

- To ascertain different points of view on the problem under consideration;
- To obtain new alternative solutions from participants;
- To examine the criteria proposed by participants to evaluate preferableness of alternative solutions;
- To study the best alternative solutions of each participant, and to make a final decision.

DM workplace consists of the following displays: «Problem», «Participants», «Alternatives», «Criteria», «Estimations», «Table» and «Results».

On the display «Problem» a DM may select a scenario of work, indicating the deadline for the submission of results by participants. In addition, a DM may permit or prohibit the participants to enter their own alternative solutions and/or criteria.

Once a DM has filled in the relevant fields of this display, he/she may proceed to the display «Participants» and create the list of participants.

Further, a DM may, at his discretion, create the lists of alternative solutions and criteria to their evaluation through the displays «Alternatives» and «Criteria», respectively, and transfer such lists to participants.

Let us consider the following example.

The problem is: The maturity of a loan becomes due. The company has only a part of money amount to be repaid. There is a commercial proposal to use such money with a great potential profit, that allows to receive sufficient funds to repayment in 2-3 months.

A DM suggests to consider the following alternative solutions of this problem:

- Negotiations with creditors
- Selling assets

Then a DM moves to the next display and specifies the list of criteria, necessary, from his point of view, to evaluate a preferableness of alternative solutions.

Let a DM specifies the only criterion:

- Expenditures

When a DM completes all functions, he/she deems sufficient to proceed to collective discussion, he/she confirms the assignment and forwards all information created by him to the participants, each of which may start the work at his/her own workplace.

### *4.2 Participant's workplace*

The system provides for ample opportunities, all participants may use to create alternative solutions of the problem under consideration, to compare their preferableness, and to select the best solution(s).

The participants may be assigned several problems to discussion in the same time period. Display «Problem Selection» allows to select the problem a participant intends to solve currently.

Participant's workplace includes such displays as «Alternatives», «Criteria», «Ranking», «Estimates», «Table», «Questions», «Results», and «Explanations».

A participant uses display «Alternatives» (Fig. 2) to create the list of alternative solutions he/she deems reasonable ("Personal alternatives"). Such list should include alternatives indicated by DM as mandatory ones (if any), and/or alternatives proposed by him/her and/or alternatives he/she chose from the «Participants» alternatives" list. It should be noted, that all alternative solutions in the «Participants» alternatives" list are shown as anonymous ones. The list of alternative solutions may be modified any time until a participant confirms it, except for adding new alternatives. Confirmed list of alternative solutions are forwarded to all other participants for possible consideration.

Let us return to the example above and assume that one participant proposes to consider the following solutions: «Reborrowing» and «Negotiations and reborrowing», and another participant proposes «To become bankrupt». The

third participant decides to consider all of alternatives proposed both by DM and by other participants.

A participant uses the display «Criteria» to specify the criteria for evaluation of alternative solutions. Operations at this display are analogous to those at the display «Alternatives».

Let us assume in the example above, a participant has reviewed the list of all proposed criteria and decided to use the following criteria: «Expenditures», «Feasibility», «Profit», «Possible consequences», «Morale aspects», «Expert's satisfaction».

Further, a participant moves to the display «Ranking» to order the criteria according to their importance, from his/her point of view. Such order has qualitative nature, i.e. the lesser the rank of a criterion the greater its importance is. Note, it is not necessary to do a strong ranking: a participant is allowed to indicate any criteria as equally important.

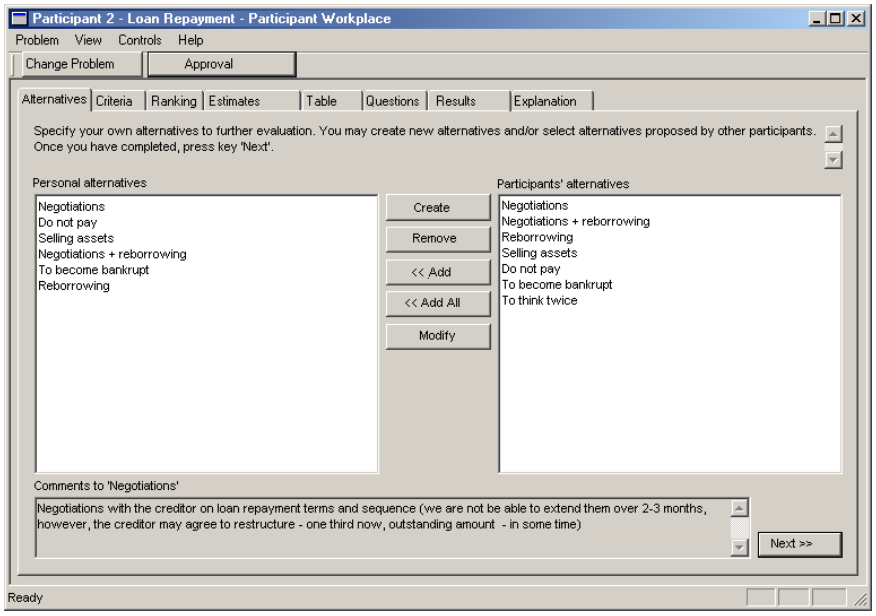


Fig. 2. Display «Alternatives» of Participant Workplace

Next display is «Estimates» (Fig. 3); a participant uses it to evaluate alternative solutions upon criteria with respect to his/her opinion on strengths and weaknesses of each alternative.

Each alternative is evaluated upon the criteria as follows. There is the "switch" in the right bottom part of the display with three options: "High", "Medium", and "Low". A participant selects one of these options as a qualitative estimate upon a current criterion to the alternative under consideration. There is the color quantitative ruler under the switch, where a vivid green color means the best estimate, while a cherry red color means the worst one. A participant may amplify his/her qualitative estimate, moving the slider to the left or to the right

along the quantitative ruler. A participant uses such opportunity to distinguish, firstly, the relations between the estimates of alternatives upon each criterion.

Each of 9 slider positions on the quantitative ruler is assigned an integer number (a score) in the range from 1 (the worst estimate) to 9 (the best estimate). Thus, a participant specifies to each alternative both qualitative and quantitative estimates upon each criterion.

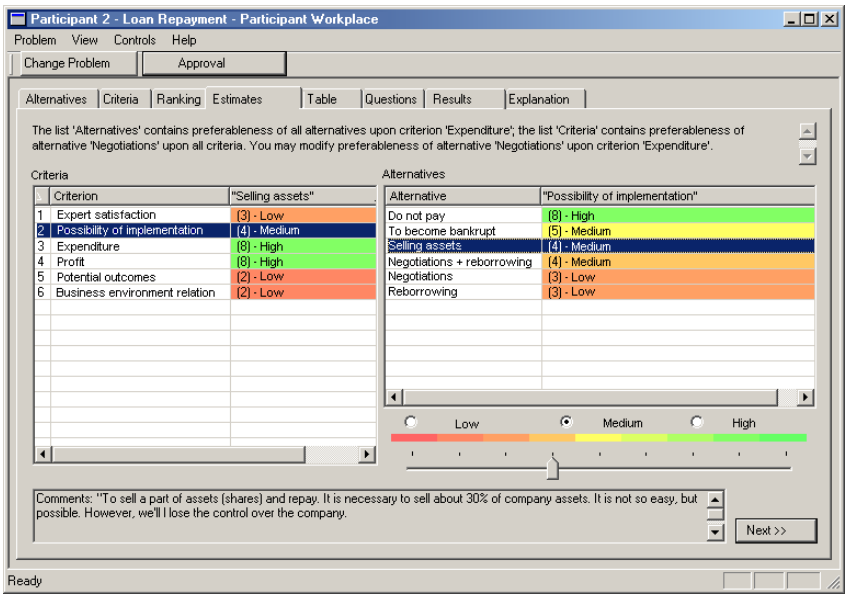


Fig. 3. Display «Estimates» of Participant Workplace.

It should be noted, that such approach to a participant preference elicitation is correct, from the psychological point of view, and, as such, well contributes to reliability of information obtained. [Larichev OI, 1995].

If a participant does not want to evaluate any alternative solution upon any criterion, he/she is allowed to skip over the alternative when such criterion is highlighted (it corresponds to response «No estimate»).

Sometimes a participant is invited to answer some additional questions in the following form: “What is better to you: <the estimate *s* upon the criteria X and the estimate *t* upon the criteria Y> or <the estimate *u* upon the criteria X and the estimate *v* upon the criteria Y>, if the estimates upon other criteria are equal, respectively?” As a rule, it is not a difficult question, however, a participant may select the answer «I don’t know». Such questions are optional, however, a participant answers would be useful to compare alternatives in difficult cases (see Rule 3 below).

**Algorithm for choosing the best alternative solutions for a participant**

So, we obtain from a participant the information of the following types:

criteria ranking according to their importance;

qualitative (absolute) estimates upon criteria for each alternative solution;

quantitative estimates (scores) upon criteria for each alternative solution.

In addition, sometimes a participant is invited to answer some questions in the following form: "What is better to you: <the estimate *s* upon the criteria X and the estimate *t* upon the criteria Y> or <the estimate *u* upon the criteria X and the estimate *v* upon the criteria Y>, if the estimates upon other criteria are equal, respectively?" As a rule, it is not a difficult question, however, a participant may select the answer «I don't know». Such questions are optional, however, a participant answers would be useful to compare alternatives in difficult cases (see Rule 3 below).

Let us note again, the first two types of information are more reliable than the third one. That is why qualitative information is taken into account to compare alternatives in the first instance.

DSS «Veche» implements the following algorithm for selecting the best alternative solution.

1. Search for non-dominated subset of alternative solutions ($D_1$) on the base of the Rule 1.

Rule 1. For each pair of alternative solutions A and B, if A has not less preferable estimates upon all criteria and at least one preferable estimate than B, then A is preferable to B.

2. If $|D_1|>1$, reducing $D_1$ to non-dominated subset of alternative solutions $D_2$ on the base of Rule 2.

Rule 2. For each pair of alternative solutions A and B from $D_1$, if for each criterion upon which the alternative B is preferable to alternative A there is «it's own» more important criterion upon which the alternative A is preferable to alternative B, then A is preferable to B.

3. If $|D_2|>1$, reducing $D_2$ to non-dominated subset of alternative solutions $D_3$ on the base of Rule 3.

Rule 3. For each pair of alternative solutions A and B from $D_2$, if it is possible to decompose the set of criteria on subsets consisting of two and/or three criteria so, that for each subset either total relative superiority of alternative A upon more important criteria of the subset is greater than total relative superiority of alternative B upon the rest less important criteria of the same subset, or, in the case of two-criteria subset, a participant prefers estimates of alternative A to estimates of alternative B upon the criteria of this subset, then A is preferable to B. ("Total relative superiority" means the sum of arithmetic differences between the estimates upon the given criteria.)

4. If $|D_3|>1$, reducing $D_3$ to non-dominated subset of alternative solutions $D_4$ on the base of Rule 4.

Rule 4. Three sets of criteria' weights are determined according to their relative importance as follows

$\forall j \in \{1,\ldots,3\}$

$$\sum_{i=1}^{k} w_i^j = 1$$

$$\forall i, 2 \le i \le k-1,\ w_{i+1}^j - w_i^j = w_i^j - w_{i-1}^j$$

$$\frac{w_k^j}{w_1^j} = r^j$$

$$\text{i.e. } w_i^j = \frac{2}{k(r^j+1)}\left(1 + \frac{(i-1)(r^j-1)}{k-1}\right),$$

where

j - the set of weights number

k - number of criteria

$w_i^j$ – weight of the $i^{th}$ criterion in $j^{th}$ set of weights

$r^j$ – ratio between the $k^{th}$ weight and the $1^{st}$ weight in $j^{th}$ set of weights,

$r^1 = 1.5,\ r^2 = 2,\ r^3 = k$

Then the aggregate values of alternatives A and B are calculated for each set of weights

$\forall j \in \{1,\ldots,3\}$

$$e_A^j = \sum_{i=1}^{k} w_i^j A_i$$

$$e_B^j = \sum_{i=1}^{k} w_i^j B_i$$

Let us denote

$$N_M = \sum_{j=1,\ldots,3 \mid e_A^j > e_B^j} 1 \quad \text{– number of sets, under which aggregate estimate of A more than aggregate estimate of B (i.e., } e_A^j > e_B^j)$$

$$N_E = \sum_{j=1,\ldots,3 \mid e_A^j = e_B^j} 1 \quad \text{– number of sets, under which aggregate estimate of A equal to aggregate estimate of B (i.e., } e_A^j = e_B^j)$$

$$N_L = \sum_{j=1,\ldots,3 \mid e_A^j < e_B^j} 1 \quad \text{– number of sets, under which aggregate estimate of A less than aggregate estimate of B (i.e., } e_A^j < e_B^j)$$

If $N_M = 2$ or $(N_M = 1$ and $N_E = 2)$ then A is preferable to B.
If $N_M = N_L$ then A is equivalent to B.

Obviously, this heuristic algorithm results in either the only best alternative solution, or the set of the equivalent ones.

If DSS has to apply the Rule 4 for any pair of alternative solutions, it checks the result of comparison in respect to its stability. «Stability» means, that using of three various sets of weights results in the same preferable alternative solution within the pair. So, if for the best alternative solution there exists any

alternative solution that is less preferable to former one and this relation is unstable, then DSS indicates that the latter alternative as noteworthy one.

A participant uses the display «Results» to analyze the results of alternative solution evaluation, including relevant DSS comments.

In the example above DSS displays the result of a participant as follows: The best alternative: «Negotiations». Besides, it should be bring a notice to the following alternative: «Selling assets». It is the next best alternative, that may become the best one, if estimates or criteria' ranking are changed a little.

At a participant request, DSS «Veche» displays detailed explanation for any preference relation obtained (Fig. 4). Such option provides for feedback and transparency of DSS operations.

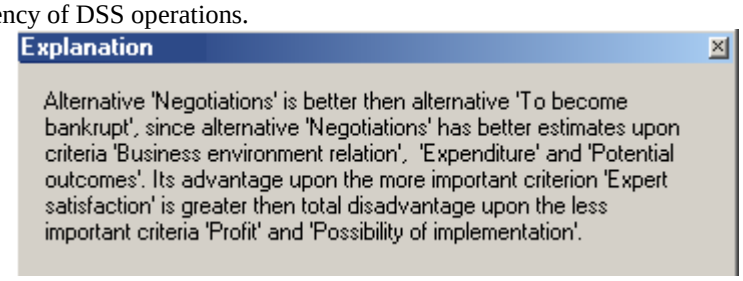


Fig. 4. Participant Workplace, Explanation of Choice

Once a participant has completed all functions needed to contribute in the collective search for the problem solution, he/she may transfer the results to DM.

### *4.3 A DM workplace (opinion analyzes)*

As mentioned above, a DM has an option to use the display «Alternative» of the DM workplace to define alternative solutions by himself.

On the other hand, this display allows a DM to acquaint with the results of discussion in the form of alternatives proposed by the participants and to analyze the preferableness of such alternatives.

Similarly, the display «Criteria» allows to a DM not only to specify his/her own criteria, but to acquaint with the evaluation criteria proposed by the participants.

The display «Estimates» is used by a DM to review each participant individual tables with alternatives' estimations upon the criteria.

The display «Results» allows to a DM to analyze the results of the problem discussion. He may review the lists of alternatives, ordered according to a individual preferences.

DSS determines, if there is the alternative solution that is the best one for all participants, or, at least to their majority.

Should there is no such alternative and a strong disagreement in respect of the best alternative(s) takes place among the participants, a weighted sum of each alternative scores is computed to each participant. The values obtained are normalized on the [0,1] interval taking into account the maximal and minimal values for each participant. Such normalized values are averaged over all participants who have evaluated the given alternative. It implies, that the alternative with the least averaged sum of scores may be that best one.

A DM has possibility to acquaint with the arguments of the participants, to agree or to refuse their proposals or to adjust the problem and to transfer it to the participants for further consideration.

A DM may analyze the conclusion, based both on the individual and the consolidated estimates of the best alternative. DSS analyzes a stability of the results obtained and displays it to a DM.

> In the example above, the result is: "No alternative is the most preferable to the majority of participants. However, alternative «Selling assets» may be deemed as the best one on the base of the sum of estimates upon criteria."

As it noted above, a DM alone makes a final decision and accepts all responsibility for consequences. Thus, the most important task of a DM is an intensive analysis of the results obtained and a decision making on the base of such analysis and his/her own preferences.

### 5. DSS «Veche» Architecture

DSS «Veche» is implemented on the base of Local Area Network and has «client-server» architecture (Fig.5).

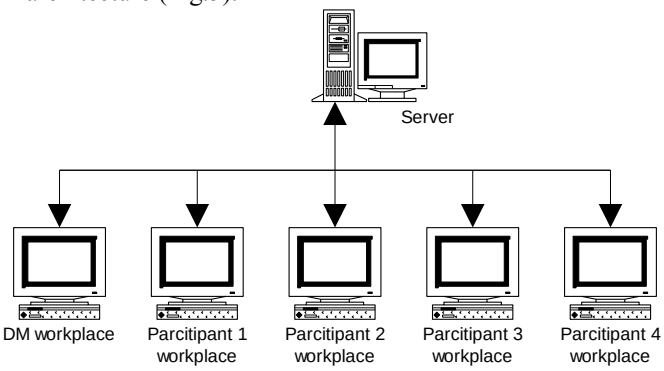


Fig.5. DSS «Veche» Architecture

The system consists of a number of executable modules:

1. Server;
2. Participant Workplace; and
3. DM Workplace,

each of which has a special function.

Each client (DM, Participant) exchanges information with the server only, not directly with each other.

The server is a system data depository, and it coordinates interactions between other modules.

The Server may be started up either on a dedicated computer or on any client computer.

The principle arrangement of the server operations is as follows. The server accepts new and modified data from any client and stores such data, and then it sends the messages to all clients that need them for operation.

Client modules - DM and Participant workplace - have the same program architecture. Their functions are to create data under a user control, transfer such

data to the server, to store them and to respond to the messages on data modifications.

DSS is implemented on C++ with Microsoft Visual C & MFC library; it operates under the Windows 95/98/NT/2000. The protocol of interactions in LAN bases on TCP/IP.

## 6. Conclusions

DSS «Veche» implements communication between users on the base of language common to a particular organization. It uses psychologically correct approaches only to elicit information from both a DM and a participant in a problem solving process. In the case of qualitative variables the system analyzes a stability of results. The DSS explains any its prompts and results. And, occasionally, it helps a DM to find new and sometimes unexpected solutions for important problems.

The DSS may be used in one-user mode also. A user operates both as a DM, and as a participant. As a DM, he/she creates the sets of alternatives and criteria, and as a participant he/she evaluates such alternatives upon the criteria according to his/her own preferences.

The results obtained help a user to look at the problem critically and to hunt down his/her preferences, as well as to find out non-standard outcomes for situations that seems to be a deadlock.

**References**

Larichev OI, Olson DL, Moshkovich HM, Mechitov AJ (1995) Numerical vs. Cardinal Measurements in Multiattribute Decision Making: How Exact is Enough? Organizational Behavior and Human Decision Processes, Vol. 64, No. 1, pp.9-21.

Matsatsinis NF, Samaras AP (2001) MCDA and preference dissagregation in group decision support system. European Journal of Operations Research, 130, pp. 414-429.

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