# An Approach to Consideration of Risks and Threats in Decision-making Support

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## ABSTRACT
A wide spectrum of factors, both positive and negative, needs to be taken into account when strategies are formulated for managerial decision-making. A special place among factors, exerting negative impact upon a decision, belongs to threats and risks. Risks and threats need to be considered to facilitate the more adequate modeling of subject domains in the context of decision-making and strategy building. In the current paper an approach to consideration of threats and risks in the decision-making process is suggested. The suggested approach incorporates expert methods and statistical tools.

## 1. INTRODUCTION
A need for strategic planning often arises in management problems. Any strategy can be considered as a long-term constructive rational uncertainty-proof plan of consecutive actions, which is substantiated by ideology, followed by constant analysis and monitoring during implementation and targeted at successful achievement of a certain goal represented by desired result. Any strategy is capable of transition from abstraction to specific form expressed in specified plans for functional organizational units.

It should be noted that methods of economical analysis do not fully satisfy the requirements in the context of strategy-building. For example, projects of a national space programme, featuring commercial spaceship launchings and telecommunication are always more economically profitable than any scientific innovative projects. As for project estimation in the long-term perspective, economical analysis is incapable of yielding credible results. On the other hand, according to the experience of countries, maintaining the leadership in space industry, such as USA, in the long-term prospect innovative research projects do produce economical profit [1]. According to NASA, projects related to "Apollo" space mission fully recovered all the costs after approximately 30 years, mostly due to wide economic implementation of innovations first suggested during the space mission preparation. These innovations include a whole spectrum of products and services, which provided the decisive push for economic development (from domestic water filters to sport footwear, originally designed for astronauts).

Strategy-building is often characterized by the insufficiency of determined information on subject domain. Under such circumstances, experts are the only source of information necessary for adequate description of this subject domain [2], and expert decision-making support methods provide the tool to build the knowledge base on subject domain and conduct project estimation.

Formerly, strategy-building started with attempts to estimate alternative scenarios, formulated by experts in the chosen field. There were too many scenarios to consider, and it was unreasonable to delegate of resource distribution among projects, involved in this or that scenario, to experts. In this context a strategy can be understood as a predefined set of projects with a predefined funding sum allocated for their implementation during quite a long time interval (in the case of space industry project implementation can last 15 years or more). Consequently, hereinafter we shall define strategy building as resource distribution among projects within a certain time interval. It would be adequate to define this distribution in the beginning of each stage of strategic plan implementation, when resources for the next stage are allocated, as well as in the case of unexpected changes in the domain, not envisioned during initial subject domain modelling.

It would be reasonable to define the following requirements to strategy building methods: 1) Orientation of a strategy towards a certain objective – the main goal of a complex target-oriented programme (CTP); 2) Calculation (evaluation) of alternative actions in the long-term perspective – consideration of project implementation terms and delays of mutual impacts between sub-goals; 3) Consideration of funding volumes necessary for fulfilment of specific tasks; 4) Relevance of expert estimates to be used in combination with quantitative data (as the subject domain can be a weakly structured one); 5) Consideration of risks and threats endangering task fulfilment.

## 2. METHOD OF TARGET-ORIENTED DYNAMICAL TERNATIVE ESTIMATION: STRATEGY-BUILDING ASPECT
The method of target-oriented dynamic alternative estimation (MTDAE) [3], developed to estimate alternatives (projects, decision variants) on a time interval in decision-making support systems (DSS), satisfies the above-mentioned requirements. The method's idea, set forth in [3], is currently updated, the method itself is improved and implemented in the respective software product (DSS). Some aspects of MTDAE are similar to forecasting graph method proposed by V.M.Glushkov [2], and some are common with Saaty's Analytic Hierarchy Process [4].

In MTDAE the estimation is conducted based on the subject domain model, built by experts. The method provides an opportunity for using the most general weakly-structured subject domain models, which are sufficiently adequate and comprehensive to reflect the specific features of this or that subject domain. In this case the models are represented by knowledge bases (KB) – goal hierarchies, which are easy to depict in the form of connected oriented graphs. Nodes of such a graph represent the goals, formulated by experts, while arcs reflect connections between these goals. The graph usually features a root node (representing the main goal to be achieved), intermediate nodes, and projects (terminal nodes with no “descendants”, lying at the lowest level of the hierarchy). To build the most adequate models of a subject domain and provide the tool for consideration of dynamics in relative alternative estimate changes in time, the values of terminal delays, defined by experts are assigned to the graph’s arcs.

The advantage of MTDAE in comparison to other existing methods, for instance, multi-criteria ones [5], featuring respective optimization approaches [6], is that it allows to estimate heterogenic projects, for which it is problematic or impossible to form a unified set of estimation criteria. Besides that, the MTDAE does not require the expert to have thorough understanding of the whole problem, but allows the examination organizer to involve multiple expert groups in decision support. Each group must be fully competent only in some part of subject domain. Because of the above-mentioned features, the MTDAE can be considered one of the keystone methods in expert decision-making support. The essence of this method features a set of expert procedures, intended for subject domain KB building and determination of a set of quantitative parameters, such as sub-goal impacts, impact delays, project fulfillment times, etc. Once the KB (goal hierarchy) building is completed, the method allows to calculate the ratings of alternatives for the compiled KB structure.

Practical implementation of the MTDAE envisions the following stages: 1) Building of goal hierarchy (the process of the main goal decomposition, involving groups of experts (i.e. specialists of various profiles), project set formation, etc); 2) Estimation (determination) of partial coefficients of impact (PCI) between goals in the hierarchy; 3) Calculation of relative estimates (ratings) of decision variants (projects) according to their contribution into strategic goal achievement.

It is appropriate to list the characteristic features of MTDAE implementation for strategy building: 1) Strategy formation is the selection of a set of projects with resources distributed among them in a certain way (proportion); 2) Resources are distributed based on their contribution into strategic goal achievement within the defined time interval (planning period); 3) Risks and threats are modeled as projects with a negative impact. They are characterized by probability of emergence of this or that threat endangering the project, and by an expert estimate of potential damage, resulting from the negative impact. Risks and threats are taken into account when contribution of each project into achievement of strategic goal is calculated; 4)When the subject domain model is built, resource distribution depends on the chosen term of perspective plan implementation and general resource (funding) volume allocated; 5)Usage of the described arsenal during strategic planning can provide answers to the following questions: (a) Which programmes (projects) must be funded during long-term planning, and in what proportion, under defined funding volumes? (b) What the total funding volume should be in order for defined programmes to be considered as potential candidates for implementation? (c) Which corrections should be introduced into the strategy in the case when some projects are not fulfilled or just partially fulfilled?

With the above-mentioned MTDAE features taken into consideration, special attention should be given to incorporation of threats and risks in the subject domain model. If risks and threats are considered, respective preventive actions can be planned.

In [8] it is suggested to consider events, resulting in a threat or a risk, as CTP components, or as “external environment projects”. In a CTP each of these “projects” is represented by a goal, directly influenced by the respective risk or threat. In [8] the threat is a result of activity of certain groups of people, while a risk is a consequence of some random event. A threat is characterized by a realization degree $D \in [0;1]$ and a realization probability $p(t)$ at the moment $t$. It should be noted that, like any other goal in a CTP, a threat is characterized by an impact upon its immediate super-goal (ancestor in the graph) $w(t)$, and a set of other goal-related parameters and features.

In [8] a risk is characterized by a risk factor (a random process with relative efficiency of a risk-related project with risk factor taken into consideration should differ from project efficiency with the risk factor not taken into account) and a risk indicator (fictional goal whose only sub-goal is the risk factor). Random events, leading to a risk, comprise a full group of events, so respective risks are incompatible. For example, if the risk factor is represented by water fluctuations in a reservoir, flood and draught are incompatible events.

In terms of system analysis [9] a risk is characterized by two indicators: the risk degree (probability of an event, leading to negative consequences) and the risk level (the scale of potential damage, caused by the risk factor impact).

## 3. SHORTCOMINGS OF EXISTING APPROACHES TO CONSIDERATION OF RISKS AND THREATS DURING DECISION-MAKING

Articles [8] and [10] cover a procedure of CTP building where risks and threats are taken into account.

Project efficiency (with probability of risk\threat-related project taken into account [11]) is defined using Monte-Carlo method for a given confidence interval. To determine the impact of every risk for a given confidence interval, the necessary number $N$ of momentary random process (risk factor) values is randomly generated. This approach is acceptable if the number of risk factors is relatively small. But if the number of risks is large (let us define their quantity with $k$), the number of experiments necessary for calculation of risks’ impacts upon their super-goals amounts to $N_1 \times N_2 \times ... \times N_k$. As we can see, if risks are represented by multiple projects, the procedure becomes quite labor-intensive.

It should be noted, that the approach described in [8, 10], is set forth at the level of an idea but not at the level of software product implementation. For the abovementioned reasons, an attempt to realize the algorithm in the form of respective software, might lead to certain difficulties.

## 4. THE ESSENCE OF A NEW APPROACH TO CONSIDERATION OF THREATS AND RISKS

First of all, it is suggested to unify the concepts of a threat and a risk. At least in the CTP-building context, it can be assumed that a risk is a currently unrealized threat, not influenced by any goal (project) of a CTP (as a risk usually depends on externatl, objective factors (flood, meteor falling, etc.)).

To model a risk, it is first suggested to conduct measurements and accumulate statistics of random parameter values, reflecting the risk, and changing with time (for instance, seasonal fluctuations of water levels in a reservoir – an example borrowed from [8]).
Based on accumulated statistical data, the random parameter distribution law can be determined (parametrically or non-parametrically [13]).
At the next stage it is suggested to use Monte-Carlo method [12] to model the values of the random parameter (for example, water level changes during spring floods), distributed according to the just-defined law, for the given confidence probability and interval.
This will allow us to determine the risk degree $P$ (in terms of [8] we are talking about the fictional CTP goal – the risk factor). $P$ shall be determined as a relation of the number of values, reflecting the risk-related event occurrence, and the total number of values generated.
Then it is suggested to define the value of risk manifestation (the threat that models the risk) as $D=0$ and determine the risk degree $P$ under this value.
If measurements cannot be performed, or the obtained set is not statistically relevant for determination of risk degree $P$, the necessary values should be obtained from experts.
We suggest modeling of relative impact of the risk/threat $W$, lying within the range $[0;1]$, according to the formula:

$$W(t) = w(t)D(t) + w(t)(1 - D(t))\,p(t),$$

where $w$ is the partial impact coefficient of the project, representing the risk or threat, under full realization of risk or threat (determined by experts using pair comparison-based methods, such as triangle, square or eigenvector method [2, 9], as $w$ is a relative value); $D$ – the degree of threat manifestation at the current moment $t$ (also can be determined through expert estimation); $p(t)$ – threat realization probability.
Consequently, the suggested approach allows us to unify and considerably simplify the procedure of risk and threat modeling.

## 5. CONCLUSION

A new approach to consideration of threats and risks in the process of decision-making is suggested. The advantages of this approach over the existing tools include: 1) Extension of the method for risks' and threats' consideration to the case when it is problematic to model risks and threats using statistical apparatus; 2) Reduction of labour-intensiveness of risk and threat modeling procedures through expert methods' usage; 3) More adequate subject domain model, and, consequently, more credible recommendations submitted to the decision-maker; 4) The opportunity to formulate a clear algorithm, allowing to realize the approach as a software application.
The suggested approach allows to expand the opportunities of existing and new DSS in the area of strategic planning and managerial decision-making at various levels.

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