

Assessment of Risks and Capabilities in an Innovative Project Quality Managing

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Abstract— Quality management in the creation of new products is always associated with different types of uncertainties. Formulating the tasks of development and production in the form of an innovative project allows structuring and identifying emerging uncertainties. Existing project management methods and requirements for quality management systems identify uncertainties as "positive and negative risks" and "risks and capabilities", respectively. In this sense, it is advisable to turn to the theory of entrepreneurship, where the concepts of "risk" and "uncertainty" are divided based on the possibility of using mathematical models or their inapplicability for non-computable uncertainty. A brief review of the methods and models for risk assessment is given. It is shown that risk assessments based on expert opinions, statistical and probabilistic methods, game theory methods, random and fuzzy sets are applicable to economic activities, but can't correctly represent innovative activities related to risks and opportunities. The problems of uncovering the uncertainties described in the works of Knight are given. Approaches to the disclosure of non-computable uncertainties based on the ontological approach and the use of methods of the theory of solving inventive problems for the stages of the innovation project are proposed. The ontological approach includes the description of problem areas and knowledge bases based on basic research and involves forecasting risks and opportunities through targeted search. Practical use of the theory of solving inventive problems includes the allocation of significant uncertainties at the stages of an innovative project, the formulation and solution of key problems.

Keywords— *quality management, innovative project, uncertain, risk, capability, ontology, digital production*

I. INTRODUCTION

Innovation activity is always connected with uncertainties, and its usual implementation in the form of an innovative project (IP) involves the need for a formalized disclosure of uncertainties. Usually this is achieved by applying a variety of models and methods built using the theory of probability and related disciplines. The category "quality" most fully reflects the purpose of managing the IP, which is represented in the form of products and services that meet the needs of the market in the context of resource constraints. Structured and formalized quality management of IP includes identification, assessment and management of factors caused by the existence of uncertainties. The most important factor that is usually taken into account in the practice of IP management is the risk in its possible varieties. Disclosure of this uncertainty and interpretation in terms of quality management IP are still

discussed both in theory and in practice. It is this factor that has been given considerable attention in the theory of control of an IP. The project risk is defined in [1] as an undefined event or condition that, if any, has a positive or negative impact on at least one of the project objectives. In the current version of Quality management systems - Fundamentals and vocabulary [2], the risk is defined as the influence of uncertainty, expressed in a positive or negative deviation from the expected result, and the term "possibility" is introduced as the ability of an object to meet requirements. In the practice of applying the current version of Quality management systems - Requirements [3] to the quality management of IP, the use of the concepts risks and opportunities is methodologically justified for obtaining the necessary estimates and results.

II. UNCERTAINTIES IN PROJECT MANAGEMENT

The basic concept of uncertainty comes from physics [4]. Applied concepts associated with uncertainty are necessary for management tasks, when the decision-making on the choice of a particular type of management is an uncovering of uncertainty. Existing methods of supporting management decisions are diverse and their choice depends on many factors. An important factor is the availability of necessary information. The available or predicted information is described in terms of probability theory. However, the fundamental difference between innovation activity is precisely that probability distributions of the necessary quality indicators may be absent. This means that at some stages of the IP, the application of probabilistic models will not be justified. This situation is described in the well-known work of FH Knight [5], where the main and fundamental difference between the concepts of risk and uncertainty is that in some cases "risk" means a certain amount that is accessible to measurement, whereas in other cases it is something quite different. Further reasoning by FH Knight and his numerous followers for the practice of IP management is reduced to the possibility of carrying out economic activity in conditions of uncovering uncertainty with the help of probabilistic and accompanying models at the stages where information can be taken as reliable. At other stages, the disclosure of such uncertainty (it is called non-computable) requires other approaches. In this sense, say, for example, the risk of losses and the uncertainty of the win.

III. MODELS AND METHODS OF ESTIMATION OF RISKS AND CAPABILITIES

The article does not consider the review and classification of such models and methods. In these examples, it is of interest to have the influence of experts or other sources of the "human factor", implement a risk assessment, taking into account a positive or negative deviation from the expected result, an assessment of capabilities. In traditional routine practice, risk assessments are usually used as the probability of damage. In the practice of managing the quality of IP and assessing its effectiveness, risks with a positive deviation from the expected result and capabilities are often difficult to separate, therefore it is suggested to be considered as one quality indicator.

One of the most common methods of risk assessment is FMEA [6]. This method does not contain complex mathematical models, is completely based on expert opinions, uses 10-level matrices of significance, probability and event detection, leading to damage.

The matrix method [7] includes the filling in of the effects / damage matrix by the expert and the risk matrix based on the available statistics, assumes a transition to the Wald, Savage, and Hurwitz criteria in accordance with the chosen strategy. There are a number of other examples - [8 - 11], where the assigned or assigned values of risk indicators are processed in accordance with the developed methods. The lack of basic information for decision-making is often replaced by experts' opinions when allocating resources, establishing priority values, significance factors, and weight. This approach is a forced measure and is not justified, at least for two reasons. The use of the principle of indifferenciation is not correct [12], unless the rationale for equiprobability based on the logical or physical properties of the situation is presented. In game models, in the absence of information, the principle of fair sharing is the initial distribution or accepted status quo. The arguments presented are simplified and require special consideration.

The solution of this problem with regard to the assessment of risks and opportunities in quality management of IP leads to the need to develop new approaches. It was proposed In [10] to use fuzzy sets according to the model for such estimates [13]. The use of fuzzy sets makes it possible to obtain a result in the formation and selection of variants in conditions of incomplete information. However, the corresponding techniques [13], [14], [15] contain a component of the "human factor" in the selection and assignment of parameters of membership functions, significance factors.

The methodological basis of fuzzy sets continues to be the subject of research [16], [17]. In the opinion of [16], the theory of fuzzy sets reduces to the theory of random sets using the concept of "projection of a random set".

Further development of research in this field is carried out within the framework of the ontological approach and soft calculations, including fuzzy computations.

Using the ontology of the domain in the form of a partially ordered set of concepts, relations between them and management mechanisms [18 - 20] makes it possible and creates the best conditions for uncovering uncertainties. The

development of digital production and the concept of "Industry 4.0" are focused on the creation of knowledge bases implemented in technological innovations. In the developed project HERMES [21], databases are introduced at the stages of the technological process to remove uncertainties in the form of possible inconsistencies. More complex uncertainties can be uncovered using sufficient knowledge and search tools in the problem area under consideration [22].

IV. DISCLOSURE OF UNCERTAINTIES AND QUALITY MANAGEMENT INNOVATION PROJECT

IP as an object of management is characterized by a structural representation of the sequence of stages and their formalized description. These properties allow us to apply classical models and methods of step-by-step analysis, evaluation and optimization based on selected quality criteria. These criteria can be interpreted in terms of risks and opportunities as a result of disclosure of uncertainties associated with these criteria.

Another developed trend in quality management is determined by the digitalization of processes. The end-to-end digital life-cycle model of the IP contains a goal, parameters and characteristics, including risks and opportunities. The creation and improvement of databases and knowledge is organically combined with the tools of choice in the sequential management of each stage of the IP. In this sense, the IP is part of the problem area, and the application of the ontological approach creates the conditions for uncovering uncertainty in the form of risks and opportunities and their subsequent evaluation. The predecessor of such an approach is the process of decision-making in the IP stages proposed in [23] for a given set of quality indicators at each stage, when the processes of identifying inconsistencies, identifying key problems, solving key problems, developing directions of solutions are carried out using the methods of rationalization and inventive problems (TRIZ).

Technical implementation of digital productions as IP provides for the search and selection of innovations in the development and production of products. For the development and production of electronics in separate stages, databases of components and materials, standardized types of marriage, etc. are used. The use of databases and large amounts of information provides new opportunities to reduce the number of inconsistencies at all stages of the product life cycle. The well-known practice of applying TRIZ confirms the effectiveness of this approach in quality management at the IP stages [24].

We consider IP as a sequence of steps $S_1, \dots, S_b, \dots, S_n$. At the input of each stage S_i is represented the set of quality indicators $\{q\}_{d_i}$, where d_i is the dimension of the set. The transition to each subsequent stage is represented as the transformation $\{q\}_{d_i}$ in $\{q\}_{d_{i+1}}$, where d_{i+1} is the dimension of the set of indicators at the output of the i -th stage and at the input of the $(i + 1)$ -th stage. In the general case, $\{q\}_{d_i} \cap \{q\}_{d_{i+1}} \neq \emptyset$. It is assumed that $\{q\}_{d_1}$ is defined by the project goal, and the restrictions on duration and resources are determined by the set of constraints $\{c_j\}$.

The transformation of quality indicators at the i -th stage is performed as one or several technological processes $\{t\}_{d_i}$,

where d_i is the dimension of the set. Here, the technological process is understood as any type of activity, many of which are necessary for the implementation of the project. The dimensionality of the set of technological processes is generally unlimited, but it is due to the type of phase chosen in structuring the IP in accordance with life-cycle standards.

As an example of the proposed approach, the end-to-end digital life cycle of the creation of electronic products is presented. Along with the selected or specified indicators and quality criteria, the values of the associated inconsistencies in the design, production and other stages of such a PI are selected. The values of such inconsistencies pose risks.

Evaluation and achievement of the required quality (reduction of the number of non-conformances) is proposed to be performed on the basis of simulation of the stages of the IP with the help of Markov chains with further choice of technological innovations ensuring the elimination of non-conformances in accordance with the requirements.

When performing the step, it is necessary to consider the probability P_{ii+1} of the transition from the previous state of S_i to the subsequent state of S_{i+1} in accordance with the requirements. In case of rejection, the probability of failover is represented as P_{if} . The transition probabilities for 7 stages are given by a matrix of the form (1)

$$\|P_{ij}\| = \begin{pmatrix} 0 & P_{12} & 0 & 0 & 0 & 0 & 0 & P_{1f} \\ 0 & 0 & P_{23} & 0 & 0 & 0 & 0 & P_{2f} \\ 0 & 0 & 0 & P_{34} & 0 & 0 & 0 & P_{3f} \\ 0 & 0 & 0 & 0 & P_{45} & 0 & 0 & P_{4f} \\ 0 & 0 & 0 & 0 & 0 & P_{56} & 0 & P_{5f} \\ 0 & 0 & 0 & 0 & 0 & 0 & P_{67} & P_{6f} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & P_{7f} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & P_{ff} \end{pmatrix} \quad (1)$$

The probability distribution of states at the beginning of the process $P1(0), P2(0), \dots, Pi(0), \dots, P7(0)$ is determined on the basis of the accumulated statistics, and their transition probabilities are determined by the selected technological innovations. The resulting final distribution is the basis for optimizing the IP.

The management of quality indicators at individual stages of the IP can be performed in accordance with the Bellman optimization principle. In this case, at each stage the control action is determined taking into account its influence on the final result. Let's define, for example, the optimal control for ensuring the maximum value of the criterion for minimizing the time of the limiting operation, which will shorten the time of its execution as much as possible. When choosing the control action at one particular stage, possible options for the state of the previous stage are taken into account. When determining the amount of funds spent on the introduction of innovations at this stage, it is necessary to take into account how much money is left at that moment and what result by the criterion of minimizing the duration of the production cycle was obtained at the previous stage. Thus, when choosing the control action, it is necessary to take into

account the variants of the PI status at the previous step and possible control actions on the remaining steps. The IP state variants in the previous step are taken into account when performing conditional optimization. Possible control actions on the remaining steps are taken into account in the conditional optimization performed from the final step to the initial step.

To construct a mathematical model it is necessary to introduce the following conventions:
 S_0 is the initial state of the IP;

S_{fin} is the final state of the IP;

Y is the control action that brings the PI to the final state.

Here, under the influence of management is understood the allocation of resources to the application of technological innovations at each stage of the IP:

$$Y = y_1, y_2, y_3, y_4, y_5, 0 \leq Y,$$

where y_i is the control action at the i -th stage. The basic equation will have the form

$$t_{\max} = \max_{1 \leq i \leq N} t_i^0 - \Delta t_i y_i \rightarrow \min, \sum_{i=1}^N y_i \leq Y.$$

At all i -th stages, under the influence of the control variable y_i , the IP passes from step S_{i-1} to step S_i . The objective function is defined as $f_i(S_{i-1}, y_i)$.

At each stage, such management is chosen, which leads to the optimal result, i.e. provides the maximum value of the criterion for minimizing the time of the limiting operation. In accordance with the reverse sweep algorithm, the optimal control for all states at each step, starting with the last one, is determined. The sequence of functions $\{f_k(y)\}$, $k=1, N$ is introduced. Each function has the meaning of the minimum execution time k of the remaining operations for admissible control actions $y_0 < y < Y$:

$$f_k y = \max_{1 \leq i \leq k} t_i^0 - \Delta t_i y_i \rightarrow \min.$$

To obtain a functional equation, it is necessary to consider k operations in which technological innovations can be applied. If the control action y_k is applied to the k th operation, then taking into account $f_k(y)$ the minimum execution time of k operations is

$$f_k S_k = \min_{0 \leq y_k \leq Y} \left[\max_{1 \leq i \leq k} t_i^0 - \Delta t_i y_k, f_{k+1} S_k \right].$$

At the last step, the optimal control is determined by the Bellman function, in accordance with which

$$f_5 S_5 = \min_{0 \leq y_5 \leq Y} t_5^0 - \Delta t_5 y_5, \Delta t_5 \geq 0, y_5 \in Y.$$

Further calculations are performed according to the recurrence relation connecting the Bellman function at each

stage with the same function computed in the previous step. After the Bellman function and the corresponding optimal controls are found for all stages, unconditional optimization is performed. Using the fact that at the first stage the state of the IP is known is its initial state S_0 , one can find the optimal result at all stages and the optimal control. Optimum control by the criterion of minimizing the time of the limiting operation will lead to a reduction in the duration of the entire IP.

V. CONCLUSIONS

IP features in the task of quality management, due to its formalized multi-stage representation, make it possible to distribute the disclosure of the uncertainty of the entire project to the solution of this problem at different stages. The use of developed problem-oriented knowledge bases at each stage makes it possible to reduce the dimension of the disclosed uncertainty to the corresponding set of quality indicators. This makes it possible to use the ontological approach without constructing complex knowledge bases. Such an approach allows to perform more effectively both the assessment of risks in the form of damages, and to find new capabilities determined by the essence of innovation activity. If there is a need to identify a common quality criterion for all steps (for example, the proportion of discrepancies or the duration of the process), then the quality assessment of the whole IP can be performed using, for example, Markov chains, and optimization based on Bellman's optimality principle.

References

- [1] The PMBOK Guide. A Guide to the Project Management Body of Knowledge - Fifth Edition. ISBN 978-1-62825-008-4 1. Project management. I. Project Management Institute. II. HD69.P75G8452013
- [2] ISO 9000-2015 Quality management systems - Fundamentals and vocabulary (IDT)
- [3] ISO 9001-2015 Quality management systems - Requirements (IDT)
- [4] In Afanasyev's Ontology of Scientific Uncertainty <http://www.proza.ru/2014/02/21/2161>
- [5] Knight FH Risk, uncertainty and profit: Trans. with English. - Moscow: The Case, 2003. - C.
- [6] GOST R 51814.2-2001 Quality systems in the automotive industry. Method for analyzing the types and consequences of potential defects
- [7] Tukkel I.L, Management of innovative projects: a textbook / I.L. Tukkel, A.B. Surina, N.B. Kul'tin / Ed. And L. Tukkelya. - St. Petersburg: BHV-Petersburg, 2011.-416 p. : ill.
- [8] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
- [9] D.Yu. Subbotnitsky, Risk and uncertainty: an endless path to an unattainable truth. News of the Russian State Pedagogical University. A.I. Herzen. Russian State Pedagogical University. A.I. Herzen (St. Petersburg) Number: 97, Year: 2009. p.121-125
- [10] Ostanin V.A., Rozhkov Yu.V, On the differences in the assessment of uncertainty and risk of economic activity and entrepreneurship. Economics and Entrepreneurship. 2013. No. 3. Part 3.
- [11] O.N. Vybornov, Ontological model of the process of risk assessment ISSN 2072-9502. Bulletin of ASTU. Ser. : Management, Computer Science and Informatics. 2015. No. 2 C 97-101
- [12] R. Carnap, Philosophical Foundations of Physics. M., Progress, 1971. P. 392.
- [13] Zadeh L.A, Fuzzy sets // Information and Control. 1965. Vol. 8, No. 3. Pp. 338-353
- [14] Chernov, V.G., Fundamentals of the theory of fuzzy sets. Solving the problems of multicriteria choice of alternatives: Textbook. allowance / VG Chernov; Vladimir. state. un-t. - Vladimir: Publishing house of Vladimir. state. University, 2005. - 100 s.
- [15] Golota Ya.Ya., Tisenko V.N., On a class of problems solved by the logic of antonyms. International Conference of Soft Computing and Measurements, v.2 / St-Petersburg, 1998. RR. 211-214.
- [16] Orlov A.I., Lutsenko E.V. System fuzzy interval mathematics. Monograph (scientific publication). - Krasnodar, Cub of the State Automobile Inspection. 2014. - 600 s.
- [17] D.V. Semenova, N.A. Lukyanova Recurrent construction of discrete probability distributions of random sets of events. Applied discrete mathematics. No. 4 (26), 2014. From 47 - 58.
- [18] Gruninger, M., Atefi, K., Fox, M., Ontologies to support process integration in enterprise engineering, Computational and Mathematical Organization Theory, 6, pp. 381-394, 2000.
- [19] D.V. Kudryavtsev Knowledge Management Systems and Ontology Application: Textbook. allowance / D.V. Kudryavtsev. - SPb. : Publishing house of Polytechnic. University, 2010. - 340 with.
- [20] Tuzovsky A.F., Chirikov S.V., Yampolsky V.Z. Knowledge management systems (methods and technologies) / Under total. Ed. VZ Yampolsky. - Tomsk: Publishing house of NTL, 2005. - 260 p.
- [21] <https://www.the-hermes-standard.info/>
- [22] Solnitsev R.I., Korshunov G.I., Ryzhov N.G., Do Xuan Cho, Paranichev A. V. The Nature-Technogenic Control System. Design Information Maintenance. 2017 XX International Conference on Soft Computing and Measurements (SCM). SPb. : IEEE, 2017. May 24-26. P. 662-665. DOI: 10.1109 / SCM.2017.7970681
- [23] Kassu AR-M, Korshunov GI. Improving the quality of management of innovative projects on the basis of modeling efficiency metrics // Innovation. Scientific and technical lists of SPbSPU. 2009.S. 90-94.
- [24] G.S. Alshuller. To find an idea: Introduction to the TRIZ theory of solving inventive problems - 2010, 3rd ed., - M.: Alpina Publishers p. 392.