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# Simulation Modeling of Innovative Project Management Processes

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***Abstract*—Simulation modeling as a managing method is used for a variety of tasks and processes. One of the most demanded tasks that can be solved by means of simulation modeling is the management of an innovative project at various stages of its life cycle. Innovative project characteristics – the simulation objects – are the main limitations of the project: its content, cost and time of the project, the quality of works and results. Simulation models allow taking into account the possible risks of innovative project implementing, and build various project management strategies depending on the current situation, including strategies for interacting with stakeholders. Despite special attention paid to the innovative project risk analysis, the measures taken are often not effective enough in real situation due to the complexity of the used procedures, the lack of a formalized description of the risks and the inability to respond quickly. In this regard, the authors' propose is to organize information support for decision makers based on knowledge engineering methods and simulation methods of project management processes.**

***Keywords—ontology, innovative project, simulation, decision making support, project management process, knowledge area***

## I. INTRODUCTION

Increase in the level of scientific and technological progress and related progress in public relations, social and cultural sphere, is caused by appearance of new ideas and possibility of its wide discussion and implementation in everyday life. With the advent of the "information age", a speed of information exchange, and, consequently, speed of scientific and technological progress in all areas of human activity has increased immeasurably, emergence of new technologies, products and services has become a commonplace. Almost every production enterprise has significantly increased the activity that can be rightfully related to innovative [1].

In accordance with the draft of Federal law "On scientific, scientifically technical and innovative activities in Russian Federation" the main goals of innovative activity state stimulation in Russian Federation are "ensuring a long-term sustainable development of the state, forming a knowledge economy in Russian Federation, development and effective use of innovative potential, as well as material and financial resources directed to the creation of high-tech technologies, goods (works, services), and production of high-tech, competitive product" [2].

Active innovative activity is also necessary for successful implementing of the import substitution programs, ensuring the independence of domestic companies from foreign suppliers of materials, components and equipment in case of political and economic differences aggravation. In these conditions, the state purposefully takes measures that contribute to the development of priority areas of science and technology. These areas include information and telecommunications systems, energy efficiency and energy saving, advanced types of weapons, military and special equipment [3]. Further development of the priority science and technology areas should be supported by critical technologies that have wide potential range of competitive innovative applications in different sectors of the economy. In turn, development of the critical technologies can be only carried out within the innovative projects implementation, since innovative projects are carried out in close cooperation of science, economy and production.

## II. SYSTEM APPROACH TO INNOVATIVE PROJECT MANAGEMENT

Innovative projects are distinguished by a combination of unique results and unique technologies for its obtaining, with a high level of uncertainty in the requirements to the final product and to the processes of achieving the goal. Modern approaches to the project activity organization involve forming the integrated management system for complex dynamically changing objects, which are projects (Fig. 1). At the same time, a project management system is understood not only as a tool that allows you to automate the most common individual functions of the project manager, such as scheduling, recording the facts of tasks compliance and preparing reports. These systems should include integrated components that are responsible for the full cycle of the knowledge management to accumulate and apply corporate knowledge and experience in project activities and decision making support in constantly emerging problem situations.

 

Innovative projects in large industrial enterprises, affecting the interests of large number of participants (including state agencies) and requiring coordination of many cooperantes, demands from the project management team timely control of the project parametrs for all knowledge areas. It should be noted that the project management team is a complex hierarchical organizational structure that includes representatives of active project participants [4], and organization of the effective interaction between them can be a rather complex non-trivial task.

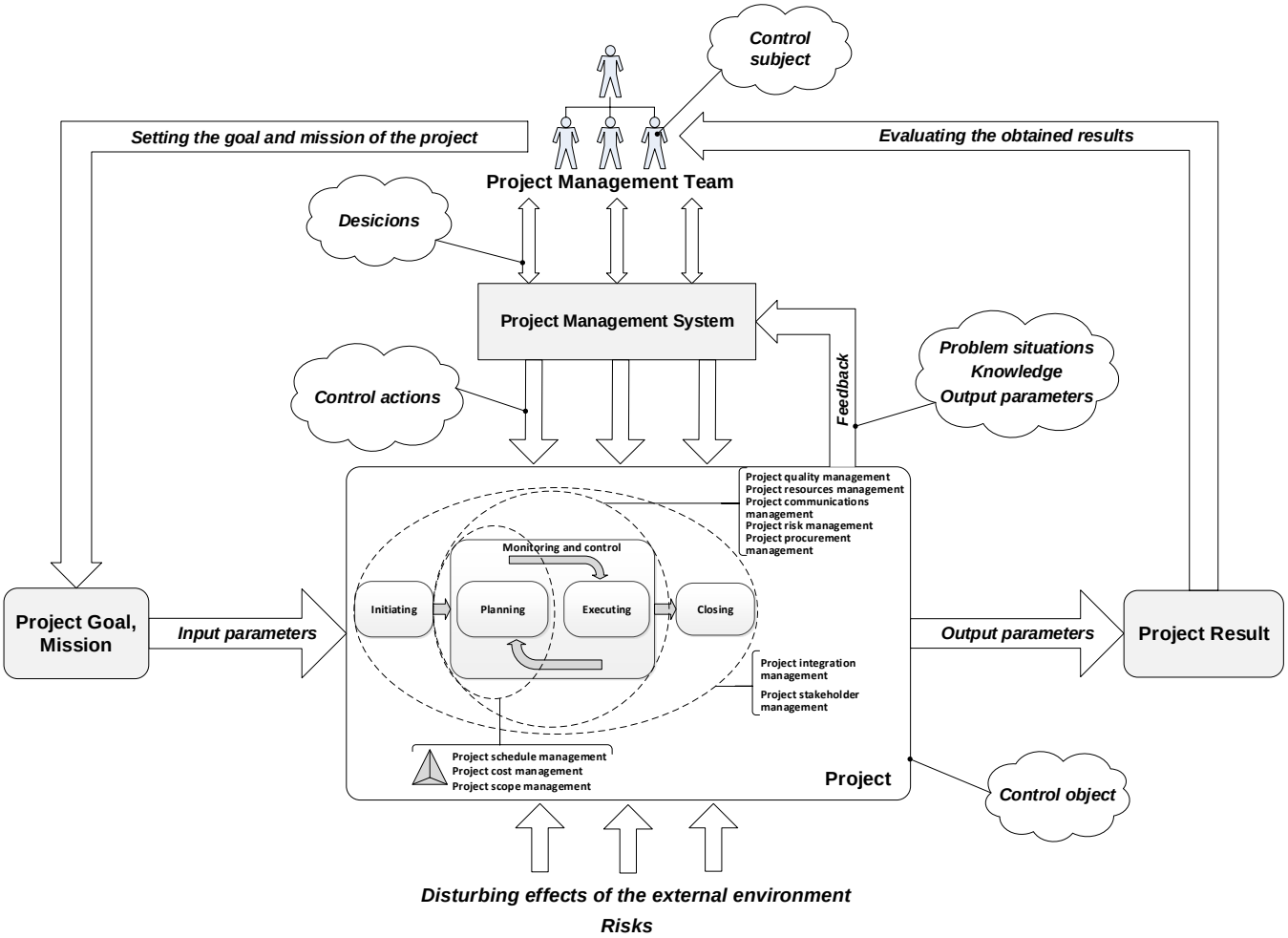


Fig. 1. Simplified scheme of the project management system

System approach involves continuous monitoring of project progress, identifying deviations in actual progress from planned and taking corrective actions up to agreed with the stakeholders correcting of the key project parameters – time, cost, final product characteristics and even goals [5]. The importance of timely control is also emphasized in the international project management standard PMBoK 6th Edition – monitoring and controling processes are included in all areas of knowledge [6]. We shouldn't forget that in complex systems, when one of its components is affected, changes can occur in other seemingly unrelated elements. In this is really the complexity of choosing the optimal solution from a variety of possible variants, when along with improving a some quantitative and qualitative project indicators, it is necessary to exclude or at least minimize the deterioration of the others. For example, when reducing the time required to complete the work and / or saving the project budget, it is important to avoid deterioration in the quality of the project product. In innovative projects it is not always possible to predict possible consequences of made decisions due to a high degree of uncertainty, so using the different types of models can significantly facilitate the choosing problem. We should not forget that the risks in innovative projects, both in quantitative and qualitative terms, are always higher in comparison with the risks of other projects.

A process of describing a complex dynamic system conceptual model is itself time-consuming and complex [7]. Methods of subject area abstracting and formalization help to reduce the complexity of the innovative project modeling process. One way to implement this is to present the conceptual model as a hierarchical tree structure, based on which a system-dynamic model is assembled from a finite set of typical templates [8].

As a conceptual model, an ontological description of an innovative project performed in a specific subject area can be used. Ontological modeling provides communication and knowledge exchange between project participants and applied computing systems, implementation of logical inference and reasoning using the ontological knowledge base, and facilitates the design context acquisition from diverse and heterogeneous sources. Currently, ontologies and knowledge bases are used in the socio-economic systems and project management [9-12]. Next, basing on the ontology that has

consistency and completeness, dynamic models, allowing to estimate possible project states (as a set of quantitative and qualitative parameters) in the case of various management strategies implementing, are built.

The logic used in the research includes development of an integrated ontology that combines a set of ontologies, formed to describe various knowledge areas of specialists in the field of innovative project management, which provides an unambiguous understanding of concepts in considered subject area, as well as based on them decision making rules and cases. An integrated decision making support ontology is formed basing the ontologies in the following knowledge fields: theoretical and practical knowledge in the field of project activity in conditions of uncertainty and risk; knowledge of decision making in problem situations, arising when innovative projects implementation; knowledge in selection and application of analytical and intelligent methods and models for decision making support in innovative projects management. Consolidation of the developed ontologies provides a possibility to integrate the knowledge about the individual business processes functioning, expressed in rules and cases, and to obtaine new knowledge.

## III. Problems of Knowledge Extracting and Formalizing within the Innovative Projects Management

Despite the fact that in recent years the project activity methods are gaining more and more popularity, the issues of knowledge extracting and formalizing, obtained during the project management in order to use them for justifying the decisions made while the control actions forming, as well as in subsequent projects, are still insufficiently worked out [13]. In our opinion, there are several reasons for this:

1) impermanence of the project team and temporary nature of the project manager activity, who doesn't have guarantees of appointment to this role in the future and, accordingly, does not want to spend time periodically (and this is very important) describing the current state of affairs. As a result, summing up only happens when the project or its phase is closed, and in most cases it is very formal;

2) high dynamics of the project itself, which is strictly limited by the time, which leads to the lack of an opportunity to calmly analyze the current progress of the project. Problems that occur from time to time, violating the planned work schedule, further aggravate the situation. Most often, problems need to be overcomed in all possible ways in a very short time, and project manager, as a rule, is not up to fixing the actions and describing the made decisions in a formalized form;

3) unknowing the statements of international and national project management standards, and lack of practice in maintaining such documentation. Despite the growth in the number of projects being implemented on various scales in all areas of economic and social activity, the number of certified project managers of various profiles across the country is very small – as on January 10, 2020, the PMI Register (Project Management Institute) lists 1,735 people having a PMP certificate (Project Management Professional) in Russia [14];

4) lack of tools, templates and techniques that allow to fix easily and quickly the current project state and get forecasts for its further development. Of course, there are many automated systems that accompany the project execution (*MS Project*, *Project Expert*, *Primavera*, *Asta PowerProject*, etc.). But, firstly, they all provide disparate information about various project parameters (or a small set of them); secondly, a project manager (or DM) must be a confident user of many information systems; and thirdly, usage of these systems is appropriate and justified not at all stages of the project life cycle, (for example, there is no calendar plan in *MS Project* at the early project stages, while problem situations, occurring at the initiating stage can lead to the project collapse before the planning stage);

5) we can not ignore the psychological aspects – if problem situation at first glance seems unserious, easily eliminated, there is a great temptation not to fix it, and try to take action and make as nothing happened. Project manager usually has reserves that he can spend on solving minor problems without involving higher-level managers. The same can be done by the ordinary members of the project team, hiding from the manager minor, in their opinion, problems, especially if they themselves were the cause of it occurrence. This is the danger of accumulating the small problems, a combination of which can cause the project failure as a whole.

## IV. Analysis of Project Risks through Simulation

In innovative projects there is a high risk of changing not only the main project constraints (time and cost), but also the content of the project itself, as well as the final and intermediate goals. However, innovative projects, like others, need to be managed, taking into account the possibility of drastic changes until the end of the project. We can reduce the risk of project failure by using simulation models of project management processes. The need for project management processes simulation arises both while a project planning to determine the required reserve amount of various resources, and at its implementation stage in the case of significant project threats, for example, due to the increase in probability of previously described risks occurrence or changes in the project participants composition. Fig. 2 shows a fragment of the ontology that displays the relationships between the class of project management problems and the classes of methods and simulation models used in the project risk management process.

Risk management processes include risks identification, its qualitative and quantitative analysis, development and implementation of risk response measures during the project realization. General recommendations and risks management processes schemes are presented in [6, 15], as well as in many other sources. International and national standards are the basis for corporate project management standards that are developed for conducting innovative projects at enterprises. Regulating the risk management activity in innovative projects makes it possible to use formalized methods for extracting and using knowledge.

At the same time, the following disadvantages of the existing risk analysis process for the innovative projects at the production enterprises are identified:

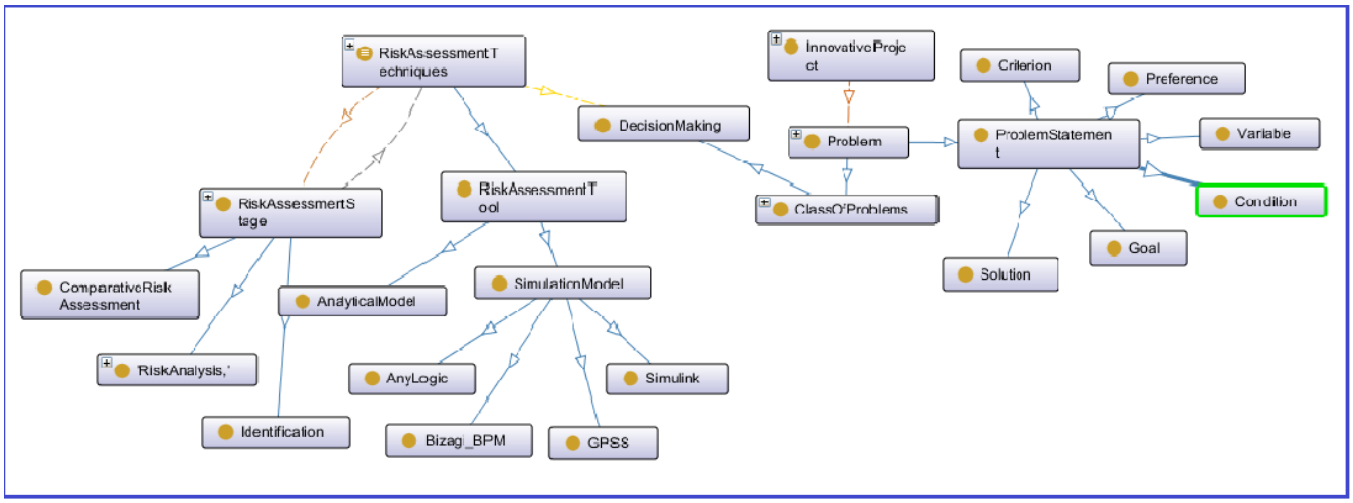


Fig. 2. Application of simulation modeling in the context of innovative project management and risk analysis

- There is a large number of regulatory documents (enterprise standards, regulations, methods) that describe in detail the principles of risk management, their identification and evaluation, but when problems arise, they are not associated with the identified risks, which does not give feedback and makes it impossible to learn lessons from the current problem situation.
- There is some differences in the terminology, classification, and description of the risks in various documents that accompany the one or more projects management. This is primarily due to the fact that these documents are created by different people for different projects, and often the experience gained during the risk analysis for the one project is not used in another.
- The project archive, even if it exists, contains the most general information, which is mostly useless when a proplem situation occurs, or it contains information in the form of schedules and monthly reports, which is very difficult to interpret for estimating the specific situation in the current project.

Issues of modeling the various project planning scenarios were considered in [16], business processes simulation, which are embedded in the project activities of various organizations – in [17, 18]. It is important to note that risk management models and methods should be integrated into the innovation project management model.

Risks are relevant to the all project knowledge areas, which means that a project manager must be well informed and competent in all activity areas. In real life, this situation is highly improbable, which makes it necessary to delegate the authority to manage individual project knowledge areas to the members of the project team. But without a formalized approach, this situation threatens, on the one hand, diffusing the responsibility for made decisions, and on the other hand – expanding the administrative project management apparatus, which complicates the interaction between the team members. A solution could be the use of intelligent decision making support instruments. The authors propose the following method for project risks describing, taking into account the use of the developed innovative project management ontology [4]:

1. Risks identification (identification of sources, possible causes, and probability of its occurrence).
2. Assigning the person, responsible for each risk.
3. Detecting the stakeholder's tolerance to the risks.
4. Establishing the dependence of risks on each other.
5. Determining the degree of its influence on individual project characteristics.
6. Fixing the identified risks in the project management ontology.

During the project risk management processes analysis, it was found that the following situations are possible when determining the degree of risks influence on the project characteristics (Fig. 3):

1) one risk affects only one characteristic of the project, for example, the time (despite the "iron triangle", changing the time may not always affect changing other parameters, especially if the time loss is small or the work that is delayed is not on a critical path);
2) one risk affects several characteristics of the project, for example, time and cost, either directly or through a chain of events (for example, the time of the work implementation increases and the project cost increases, for instance, due to increasing the length of the rent);
3) several unrelated risks affect a single project characteristic;
4) the risks that affect each other have a cumulative effect on several characteristics of the project.

Thus, the algorithm of project risk managing activity can be shortly described as following:

1) identification (risks identification);
2) risks classification into external and internal (with the external risks are most often associated problem situations, which are quarterly submitted to the project committee (the competence of the project manager is not enough to overcome such problems), with internal risks are often associated interior problem situations, solved by the project manager on its own (sometimes with the help of a supervisor);

3) defining the project stages and activities, which may be affected by the identified risks (in addition to determining the characteristics of the project itself – cost, time, quality and content). This information is visible from the project passport, where the risk impact is distributed by periods – if there is a calendar plan, you can easily determine which works with which resources (including labor and equipment) fall under the possible risk impact;

4) defining the persons, responsible for the works mentioned above, and including them to the list of stakeholders who need to be notified about the possible problems;

5) clarifying the level of the risks, taking into account identification of its additional impact on the project works;

6) coordinating the risks mitigation action plans with all stakeholders, not just with the project supervisor;

7) in the case of problem situation occures, it is necessary to find out which identified risk it is associated with, and on the base of this information, reevaluate (if it is possible) the probability and strength of the risk impact.

During the project management process, it is necessary to keep a log of problem situations, recording made decisions and linking the problem situations with the identified risks. At the same time, if the problem situation is not related to any of the risks included in the list, it is necessary to highlight this situation.

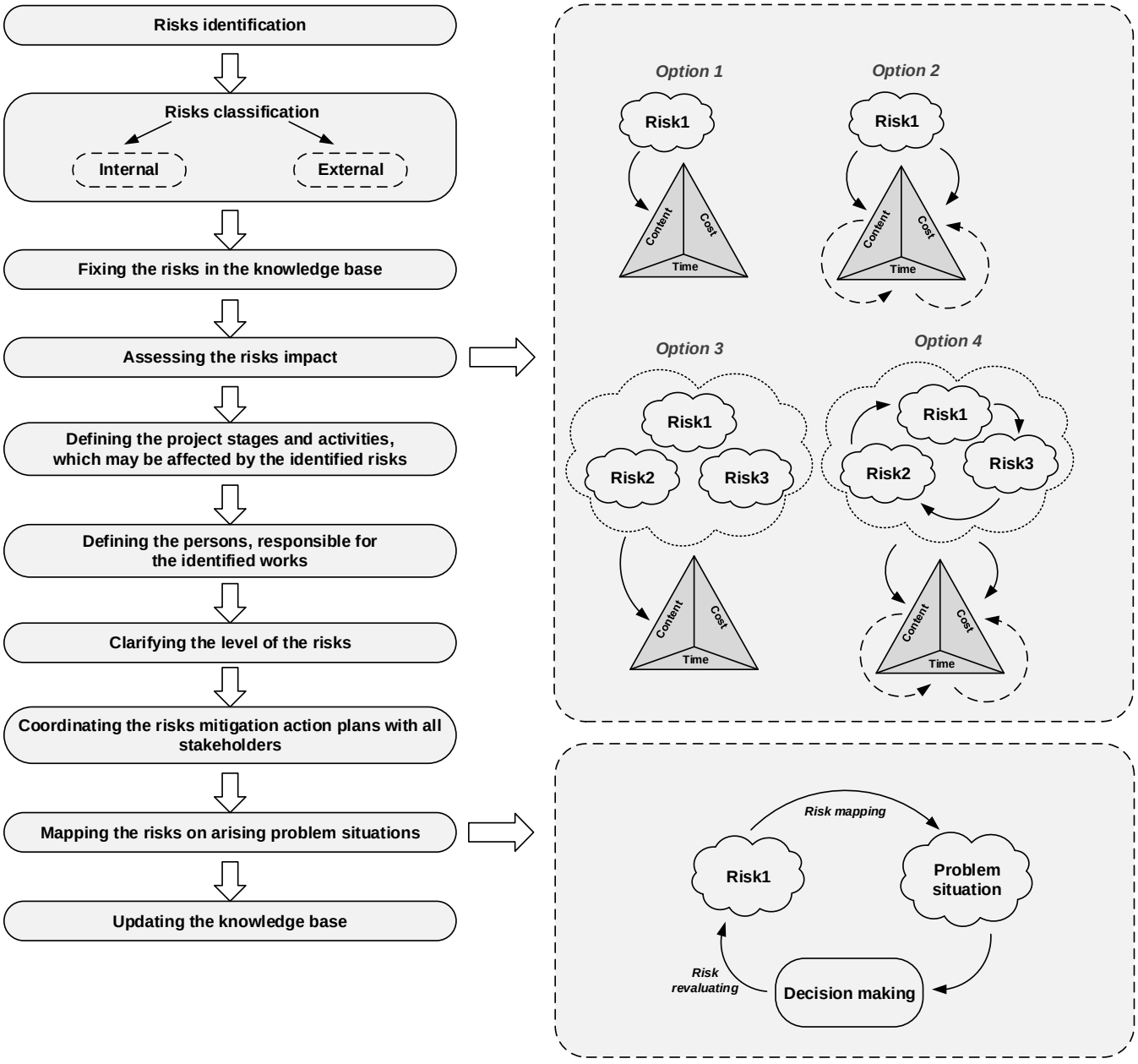


Fig. 3. Project risk management methodology

According to this, an ontological knowledge base should include rules that describe the relationships between identified risks and emerging problem situations, taking into account the project work and project team members, like:

***Rule:*** *Risk(?x), Risk_connected_to_Problem_situation(?x, ?y), Innovative_project_process_has_Problem_situation(?z, ?y), Innovative_project_process_has_Innovative_project_Stakeholder(?z, ?a), -> Problem_situation(?y), Innovative_project_process(?z), Innovative_project_Stakeholder(?a)*

## V. CONCLUSION

To improve the quality of decision making in problem situations, arising while the innovative project management process, the authors offer the following recommendations:

- assess the impact of the risk and its consequences not only on the overall project characteristics, but also on the individual project stages and works within this stages.
- notify the project stakeholders about the measures, taken to reflect or respond the risks in order to prevent (or warn) about the possible consequences after these measures are carried out.

Increasing the degree of scientific validity and accuracy of the forecast estimates will reduce the risks in making and implementing management decisions.

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