

O. Skakalina, A. Kapiton

National University "Yuri Kondratyuk Poltava Polytechnic", Poltava, Ukraine

IDENTIFICATION AND MANAGEMENT OF RISKS IN THE PROJECT MANAGEMENT OF THE DEVELOPMENT OF SOFTWARE PRODUCTS

Abstract. Software development is one of the most difficult areas of intellectual activity for forecasting and planning. By their nature, digital products are intangible, and software development projects often involve many stakeholders. Software development processes typically include several stages, including design, documentation, programming, and testing, all of which require a high level of professional, technological, and managerial knowledge. Due to the complex nature of digital projects, from the very beginning of the implementation of any software project, it is necessary to take into account and manage a wide range of risks, which are one of the most important factors affecting the success of a digital project. The work analyzes and classifies project risks, conducts a qualitative and quantitative identification of the main risks for the selected subject area, the Crawford card method was used to work with project risks, the risks were ranked, a responsibility matrix for the project was created, the workload of the project resources was analyzed, and the project was optimized.

Keywords: risks, project management, optimization, identification, Risky Project.

Introduction

Software development risks are factors that can affect the success of a digital project. They can arise both internally (when they are the result of situations within the company) and externally (when they are influenced from outside). There is also the issue of personal risks associated with the efforts and professional qualities of individual team members. There are many reasons why identifying software development risks has become so important. A software development risk management plan helps the team evaluate the entire project, plan for success, maximize results, meet deadlines, communicate effectively with stakeholders, and finally allocate funds to eliminate significant risks.

Risk is always a potential problem. In software development, a risk is any event that can jeopardize the success of a digital project. Relying on guesswork and crisis management is an ineffective approach. To properly manage and mitigate risk, you should always have a risk management plan in place. Proper implementation of such a plan can help you prevent the impact of risks if and when they arise, while at the same time improving the quality of your digital product. Even if every project comes with numerous software development risks, most of them can be prevented before they cause any damage.

Analysis of recent research and publications. Risk is the possibility of occurrence of any adverse situations and negative consequences in the future. The concept of "risk" is closely related to the concepts of "probability" and "uncertainty".

Risk management is a field of modern management related to the specific activities of managers in conditions of uncertainty, complex selection of options for management actions. Risk management can be defined as a system of making and implementing management decisions aimed at reducing the impact of the consequences of the implementation of risks on the organization's activities [1]. Planning and implementation of projects takes place in conditions of uncertainty caused by changes in internal and external

environments. Uncertainty is understood as the lack of complete and reliable information about the conditions of project implementation. Uncertainty associated with the possibility of adverse conditions, situations and consequences occurring during project implementation is called risk [2]. In a market economy, risk is an integral attribute of business. Uncertainty makes it impossible to avoid risk. But this does not mean that you should look for such solutions in which the result is known in advance, they are usually ineffective. It is necessary to learn to predict risk, assess its size, plan measures to prevent it. Risk is a complex economic and management category, in the definition of which there are a number of contradictions [3].

Risk management is the process of responding to events and changes in risks during project implementation.

At the same time, risk monitoring is important. Risk monitoring includes risk control throughout the entire project life cycle. Quality risk monitoring provides information management that helps make effective decisions before risk events occur.

The most widespread characteristic of risk is the threat or danger of failure in one or another activity, the danger of adverse consequences, changes in the external environment that can cause loss of resources, damages, as well as the danger against which it is necessary to insure. Therefore, project risk is a combination of constraints and uncertainty. It is possible to minimize the risk in the project by either eliminating constraints (which is quite problematic), or finding and reducing uncertainty [4].

Risks arise at different stages of the life cycle of an innovative project (Table 1). From the point of view of project management in the software development life cycle, risk management is the process of identifying risks, evaluating them and limiting or mitigating those that may hinder the achievement of the overall goal, while at the same time, maximizing opportunities and results. In the case of the risk management process in software development, it is about managing the risks that prevent the successful release of a well-tested and secure digital product.

Table 1 – Types of risks arising at different stages of the project life cycle

Phase	Types of risks
<i>Pre-investment</i>	Mistakes in the development of the project concept Incorrect determination of project location Attitude towards the local government project Making a decision about the feasibility of investing
<i>Investment</i>	Solvency of the customer Unforeseen expenses for construction work Exceeding construction terms, equipment costs Untimely supply of equipment Non-fulfillment of contractual obligations by contractors Untimely training of personnel
<i>Operational</i>	Emergence of an alternative product (service) Insolvency of consumers The scope and segment of the market in which the project product is implemented are incorrectly defined Change in prices for raw materials, transportation; salary Changes in the cost of capital and the level of inflation Threat to environmental safety Change in the population's attitude towards the implementation of the project

Practical implementation of the risk management process in the direction of software engineering, specific responsibility of the executors - the role of risk manager is performed by project managers or product owners. They are responsible for identifying risks in software project management, monitoring the project and making sure everything is going according to the project parameters.

In other words, they identify business risk factors, assess their probability and impact on the project, make a plan and carry out risk management. This is risk identification, risk analysis and risk mitigation in an optimal presentation.

Statement of the research problem. The following risk management algorithm is applied in the work, which consists of 5 stages in accordance with the features of the subject area - software engineering.

• *Stage I - identification of risks*

The first thing we do is identify potential problems and threats that could potentially affect the project. We then calculate their chances of showing up - a risk score. To do this, we can use various risk management tools and techniques, as well as general risk knowledge from previous projects and experience from other teams. How likely are these software risks to occur?

• *II stage - risk analysis*

At this stage, we assess the impact of a specific risk on the product. How serious is it? Thanks to this, we can prepare the right course of action and make business decisions related to reducing risks.

• *Stage III - setting priorities*

When we know what we're dealing with, what might cause a problem, and the breadth and depth of a particular business operation, we can rank risks based on their urgency and the damage they can cause.

• *Stage IV - responding appropriately*

We have identified threats to the software development process, analyzed them and prioritized

them. Now is the time to act. This step depends on whether we can prevent the risk or reduce it as much as possible. Depending on the type of threat, we take appropriate action.

• *Stage V – monitoring*

When the project plan is executed, we observe the changes – did the selected strategy work? If not, we make the necessary changes and try again. There is no end to risk management – therefore, it is necessary to constantly monitor project risks.

Risk management must begin with a thorough analysis of the client's business and the client's end-user needs. In addition, market and competitor business analysis helps to identify and mitigate certain risks associated with launching the program at an early stage, resulting in reduced risks. Depending on the results of the research and whether the product is innovative, it is suggested to perform a concept test of the project goal to check if the idea is feasible and to avoid the risk of low demand for the digital product.

Later, as the process continues, internal and external tests must be conducted. With these tests, we can eliminate the risk that the application will not be intuitive or will not have the necessary functions. In addition, the developer receives regular feedback about the project and information about threats and challenges that arose during the implementation of the project.

Basic material and results

The choice of the method of risk reduction is carried out as a result of comparing the necessary means to reduce risks with the benefits of preventing loss.

This ratio is determined using the risk factor.

$$Kp = Y / C,$$

where Kp is the risk factor; Y – the maximum possible amount of damage; C is the amount of own resources, taking into account precisely known inflows of funds [5].

The optimal risk factor is 0.3.

The effectiveness of measures to reduce risks is determined using the following algorithm:

1) the most significant risk for the project is considered;

2) the overspending of funds is determined taking into account the probability of the occurrence of adverse events;

3) a list of possible measures aimed at reducing the probability and danger of a risk event is determined;

4) additional costs for the implementation of the proposed measures are determined;

5) the necessary costs for the implementation of the proposed measures are compared with the possible overspending of funds due to the occurrence of a risky event;

6) a decision is made to implement or refuse anti-risk measures;

7) the process of comparing the probability and consequences of risk events with the costs of measures to reduce them is repeated for the next most important risk.

The subject area "*E-commerce Management*" was defined for the management of the developed digital project.

Modern technologies transfer direct marketing to new electronic spheres of activity. The term "electronic commerce" (e-commerce) unites a wide range of business activities carried out through electronic data exchange; using the Internet, telefax and e-mail for transactions, which speed up and facilitate ATM and start card calculations. All this brings business activity from "market as place" to "market as space". Although the growth rate of Internet purchases of goods (computers, software, books, CDs, video materials, video games) is constantly increasing, the volume of business transactions is increasing even faster [6].

A method using Crawford cards was chosen for qualitative and quantitative risk analysis of the selected subject area.

The method was developed by Dr. C.C. Crawford to quickly collect the opinions of a large number of people in a short period of time, and anonymously if the participants so desired. The surveyed group is asked a question. Participants must formulate their ideas and write each one down on a separate sheet - this is a mandatory rule. At the same time, there should be no exchange of opinions in order to exclude the influencing factor. Thus, the organizer will have at his disposal a fairly large number of cards with answers, from which a list is made and sent to the participants for making changes and additions [7].

The method of Crawford cards involves the following procedure:

- Each participant writes down each idea on a separate card.

- All submitted ideas are then copied on a large stand and briefly discussed. The purpose of the discussion is to find out the essence of each idea and exclude repeated ideas from consideration.

- The next step is individual work, when participants rank the proposed ideas. From the general list of ideas, each member of the group chooses no more than five ideas and writes them down on his card for ranking. When ranking ideas, participants assign numerical coefficients to these ideas, starting with 5 for the most important idea and ending with 1 for the least important.

- The organizer collects all cards with rankings and rewrites the coefficients assigned to the ideas on the poster. For each idea, the weights are summed. The overall score is also recorded on the stand. If the idea gained the most weight, then it is considered the most priority idea of the group and is adopted as a decision.

Therefore, we will form a list of risks for the project to develop a digital project for creating a computer game and its implementation by means of e-commerce:

1. Undemanding and unattractive game concept.
2. Technical implementation.
3. Violation of copyright.
4. Risk of information security.
5. Lack of qualified personnel.

6. Lack of vision of the final goal of the development.

After forming the list of risks, we will clarify them in the Table 2.

Table 2 – Determining the risks of the "Computer game development" project

Reason	Conditions	Consequent	Damages
Undemanding and unattractive game concept.	Poor analysis of focus groups and lack of contact with the audience.	Few copies of the game were sold.	Low or no profit from game sales.
Technical implementation.	Insufficient supply of technical resources.	Emergence of bugs and low optimization of the product.	User dissatisfaction and loss of trust.
Copyright infringement.	Excessive borrowing of ideas from analogues.	Legal proceedings with the analog developer.	Loss of time and money for legal proceedings and payment of compensation and loss of reputation in case of loss.
Risk of information security.	Insufficient security of the product against hacking.	Leakage of product and user information.	Disclosure of corporate secrets, possible financial losses and loss of reputation.
Lack of qualified personnel.	Work with software and technical support for which the necessary specialists are not available.	Low development productivity.	An increase in terms and complexity of development.
Lack of vision of the final goal of the development.	The development team does not agree on what the game should be.	Exceeding the game's release schedule.	Loss of audience interest due to postponement of release and loss of investor confidence.

Qualitative risk analysis includes ranking of identified risks. When analyzing the probability and impact, it is assumed that no risk prevention measures are taken. Qualitative risk analysis includes [8]:

- ✓ Determination of the probability of realization of risks.

- ✓ Determination of the severity of the consequences of the realization of risks.

- ✓ Determination of the risk rank according to the "probability - consequences" matrix.

- ✓ Determining the proximity of the risk.

- ✓ Assessment of the quality of the information used.

For a qualitative assessment of the probability of risk realization and determination of the severity of the consequences of its realization, as a rule, scales generally accepted in the organization are used, examples of which are given in Table 3, 4. To determine the risk rank, a matrix of probabilities and consequences is used (Fig. 1). The risk rank is determined by the product of the weight of the probability and the significance of the consequences.

Table 3 – Risk impact assessment scale

Weight	Value	Criterion
3	Catastrophic	Losses over \$100K
2	Critical	Losses from \$10K to \$100K
1	Moderately	Losses less than \$10K

Table 4 – Scale for assessing the probability of risk realization

Weight	Value	Criterion
3	Very likely	The chances of occurrence are quite high
2	Perhaps	The chances are equal
1	Not likely	The occurrence of the event is very doubtful

For the identified risks, we will choose risk response strategies:

1. Shortage of qualified personnel (grade 9) - *risk reduction*. Strengthen the quality of recruitment of employees, provide them with proper training and provide appropriate working conditions for retention.
2. The lack of demand and unattractiveness of the

game concept (grade 6) - *risk reduction*. Maximize the audience, for example, due to the simplicity of the game and taking into account the wishes of the players, and maximize the probability of a viral reaction (many indicators, including such as exchanging items, using friends as resources for personal play).

3. Technical implementation (grade 6) – *risk transfer*. To conclude a contract with the game publisher for the proper provision of technical and software equipment and the transfer of all responsibility for the provision of service and maintenance.

4. Lack of vision of the final goal of development (grade 6) - *risk avoidance*. Adding to the project plan meetings and meetings to discuss the stages of project development and agree on goals.

5. Information security risk (grade 2) – *risk reduction*. Take measures to ensure the protection of information and provide the maximum possible protection against hacking by hackers.

6. Infringement of copyright (grade 2) - *acceptance of risk*. It is difficult to follow all competitors, and if someone has claims, it will be difficult to prove the fact of plagiarism in court.



Fig. 1. Risk ranking and matrix of probabilities and consequences

The criteria for assessing the quality of the information used in the analysis are as follows:

- Degree of risk understanding.
- Availability and completeness of risk information.
- Reliability, integrity and reliability of data sources.

The result of qualitative risk analysis is their detailed description in risk cards:

- The first card "*Shortage of qualified personnel*"
- The second card "*Undemanding and unattractive game concept*"
- The third card "*Technical implementation*"
- The fourth card "*Lack of vision of the final development goal*"
- The fifth card "*Information security risk*"
- The sixth card "*Copyright infringement*"

A matrix of responsibility for the project was created (Table 5).

At the risk management stage of the project, three versions of the digital project were calculated for the determination of risks using the Monte Carlo method: optimistic (initial project completion period), expected (performance period multiplied by a factor of 1.3) and

pessimistic (performance period multiplied by a factor of 1.5). After calculating the terms, we will get risk forecasts using the "RiskyProject 7" program (Fig. 2).

Table 5 – Project responsibility matrix

Working	executant		
	#1	#2	#3
Determining the purpose of the project	✓	✓	✓
Planning project stages	✓		
Creating tasks for project stages	✓		
Establishing deadlines and dates for tasks	✓		
Establishing a sequence of tasks	✓		
Identification of required types of resources			✓
Creating a resource pool		✓	✓
Assigning the cost of resources			✓
Assignment of resources to the task			✓
Analysis of the causes of resource overload		✓	✓
Leveling of overloaded resources		✓	
Duration optimization	✓	✓	
Cost optimization	✓	✓	
Виявлення ризиків	✓	✓	
Аналіз та оцінка ризиків	✓	✓	✓

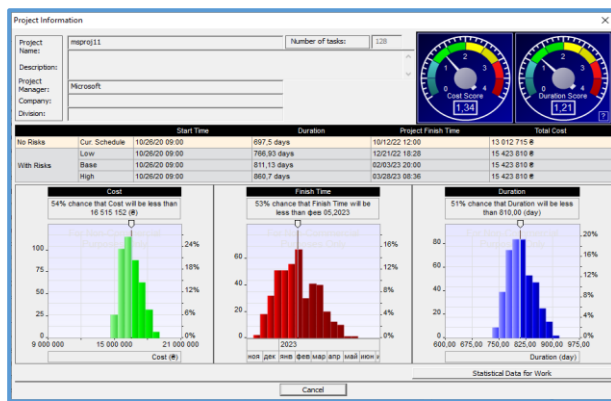


Fig. 2. Risk forecasts for the project

According to the results of risk modeling, it can be seen that with optimistic forecasts, the probability that the duration of the project will be 766.93 days, with the expected result, the duration of the project will be 811.13 days, and with pessimistic forecasts, the duration will be 860.7 days, which will be 1.21 more than the planned duration.

The projected cost of the project in all three versions of the forecast will amount to UAH 15,423,810, which will be 1.34 times more than the planned cost.

It is also predicted that with a 54% probability the cost of the project will be less than UAH 16,515,152.

There is a 53% probability that the end of the project will come earlier than 02/05/2023. There is a 51% chance that the project duration will be less than 810 days.

Conclusions

Risk management is an important component of digital project planning. Risk management in software engineering involves the identification and assessment of the probability of risks in the order of their impact on the project. Software development is a high-level activity that uses a wide range of technological advances. Every software development project contains elements of uncertainty due to these and other factors. The level of risk associated with each project activity determines the success of a software development project.

It is not enough to simply be aware of the danger. To be successful, project management must identify, assess, prioritize, and manage all major risks.

Most software engineering and software development projects strive to be unique, whether they are creating new features or improving the efficiency of existing digital projects.

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Ідентифікація і керування ризиками при проектному управлінні розробкою програмних продуктів

О. В. Скакаліна, А. М. Капітон

Анотація. Розробка програмного забезпечення є однією з найскладніших сфер інтелектуальної діяльності для прогнозування та планування. За своєю природою цифрові продукти є нематеріальними, а проекти розробки програмного забезпечення часто включають багато зацікавлених сторін. Процеси розробки програмного забезпечення зазвичай включають кілька етапів, включаючи проектування, документацію, програмування та тестування, усі з яких вимагають високого рівня професійних, технологічних та управлінських знань. Через складну природу цифрових проектів, з самого початку впровадження будь-якого програмного проекту необхідно враховувати та управляти широким спектром ризиків, які є одними з найважливіших факторів, що впливають на успіх цифрового демонструвати. У роботі аналізується та класифікується ризики проекту, проводиться якісна та кількісна ідентифікація основних ризиків для обраної предметної області, для роботи з ризиками проекту використано метод карт Кроуфорда, ранжовано ризики, створено матрицю відповідальності за проект, проаналізовано завантаженість ресурсів проекту та оптимізовано проект.

Ключові слова: ризики, управління проектами, оптимізація, ідентифікація, Risky Project.