

planned methodology prevail over the risks inherent to Agile methodology, they should apply Agile methodology.

Stage 4. If some components of the project meet the stage 2, and others meet the stage 3, the most adequate methodologies will be applied to the outlined components.

Stage 5. They map out the project's implementation.

Stage 6. They monitor the project's progress, evaluate the risks and potentials, re-adjust the balance, if necessary.

J. Sheffield, J. Lemétayer [4], by virtue of the reference analysis, point out the factors that have impact upon the choice of methodology to manage the software development project, which is focused on a rigid planned approach (Prince 2, PMBoK) or on the adaptive Agile approach. As well a survey of 127 specialists in the area of project management out of 22 countries has been made in the paper. The total number of respondents has included 26% of specialists on application of Prince 2, 28% - on use of PMBoK and 30% - on Agile. The least project as pointed out by the respondents has been evaluated of USD 2500 and has had the labour intensity of 2 man-months, the largest project's cost has been of USD 840 mln and has had the labour intensity of 1260 man-years. The survey of specialists has been aimed at specifying the factors in the project and its environment testifying to a necessity of application of Agile approach in successful projects intended to creating software products. Following from the survey, the list of prioritized factors has been formed. Low values of such factors denote the planned approach to manage the project, high values highlight Agile approach. The factor analysis has been conducted for four groups of variables characterizing the project's environment, the project, Agility at development of software products and the project's success. Hence 8 most important factors have been outlined.

S. Lazaros, D.C. Prodromos [5] dealt with a survey on performance of 112 projects in the area of software production by 63 companies from Greece. Findings of the survey have been analysed by means structural equations. The analysis has been aimed at examining the effect of the staff quality, quality of processes on the risks of software products projects. The paper reviews 6 risk factors in such projects, in particular: the user, requirements, complexity of the project, planning and control, project team and company's environment. The project's general quality has been measured by means of two factors: quality of processes and staff quality. The analysis has shown that there is a negative statistically significant relation between the quality of the project and the risks. There is a similarly negative relation

between the staff quality and five of six risk parameters (except the project's complexity one). As well, a significant negative relation is traced between the quality of processes and the project's team risk factor.

O. McHugh, H. Mairéad in [6] studied the issue of transition organization engaged in creation of software systems to the internationally recognized project management methodology. As exemplified by five Irish companies, the reasons of transition from the corporate methodologies to manage the projects to the internationally accepted ones, and also the reasons of implementing such methodologies in case the company has got no project management methodology at all are reviewed. In one company (with the least number of employees) they have been selecting the methodology based on advice of their colleagues and they have chosen PMBoK. In the second case, selection has also been made according to the advice of colleagues, however with that they have considered the option of tailoring the methodology to meet the company's needs. They have preferred PRINCE 2. The third company has selected the methodology subject to CMMI recommendations in order to pass through certification on that system thereafter. Besides, when selecting the methodology they have relied on the opinion of their US parent structure, which appreciates an option of getting the PMI certificate. It is no wonder that finally they have accepted the PMBoK methodology for application. The fourth company involving about 2500 employees has formed a freestanding team for selecting the methodology. When making the decision, they have taken into account the opportunity of adapting the methodology to meet the company's needs. Eventually they have taken the road to adjust PMBoK. Finally, in the fifth case, the major focus (while selecting a methodology) has been given to availability of plenty of bodies that certify specialists, hold trainings and provide support at implementation of a specific methodology. In addition, allowance has been made to the particular methodology as used in the parent company and to the possibility of adopting the methodology. As a result, the choice was made in favour of the PRINCE 2.

J. Xu, H. Zheng, Z. Zeng, S. Wu, M. Shen [7] dealt with the discrete task of searching for a compromise between time, cost of the project, crashing cost and impact on environment. Time of operations is set as a vague value with a triangle membership function. The adaptive hybrid genetic algorithm is offered for solution of the task.

3. SELECTION OF THE PROJECT MANAGEMENT METHODOLOGY BASING ON EXISTING RECOMMENDATIONS

The method of selecting the project management methodology is suggested. The method is designed for the situations when the project manager and project team do not have a full knowledge of alternative project management methodologies and standards. As a rule, the project manager is familiar enough with one or two methodologies. The knowledge of all the others is rather superficial. In case the team does not have enough time and/or resources for studying alternative methodologies during managing a specific project, it is reasonable to use the existing recommendations about their application under specific practical circumstances. The suggested method serves exactly for accomplishing this purpose.

The given method is a questionnaire for a project manager. The initial variant of the questionnaire was presented in the paper [8]. In the paper [9] the questionnaire was further developed. It consists of two parts. In the first part the short resume of the project is given (table 1). The second part is a set of fixed-choice questions (tables 2-6). They cover a scope of forming of a project team, the level of its expertise, the choice of the means of communication and the ways of reporting, as well as the level of project manager's responsibility, the list of any possible risks and consequences in case of unsatisfactory project outcome.

The answers to the questions correspond to the scores on the scale from 1 to 4 depending on the level of detail of the project management processes, including the required frequency and thoroughness of the inspection of the project implementation processes. The lower is the score for the questionnaire or the theme blocks, the more control elements the corresponding methodology should include. The total score corresponds to the recommended methodologies, which are the most suitable for managing the project.

Table 1. Brief Project Description

Questions	Answers
Project name	
Project scope	Main strategic project aim. Brief description of innovation/project
Project type	R&D, creation of new product (technology, service), creation of new manufacture
Project product	Brief description of the product, service, technology, innovation created in the project

Table 2. Project Team

Questions	Possible answer	Score	Recommended methodology
Customer's (investor's) experience of working with this project team	Has never worked with this team	1	PMBok
	Worked with some members of the team	2	PMBok
	Worked with the project team leader	3	SCRUM, PMBoK
	One or more common projects with the whole project team	4	SCRUM

Table 3. Evaluation of the Project Team's Expertise by the Project Manager

Questions	Possible answer	Score	Recommended methodology
1	2	3	4
Work experience in the given field	No work experience.	1	PMBok
	Experience of working in the field for less than 2 years	2	SCRUM*, PMBoK
	Experience of working in the field from 2 to 5 years	3	SCRUM
	Experience of working in the field for more than 5 years	4	SCRUM
Understanding of requirements, adapting ability, initiative	Almost do not understand the requirements; require frequent explanations and constant control	1	PMBok
	Understand the requirements, can follow them, but require regular control	2	PMBok
	Understand the requirements, can follow them, do not require regular control	3	SCRUM
	Have good understanding of the requirements; can follow them without regular control; can suggest better alternatives	4	SCRUM
Experience of cooperation	Have never worked together	1	PMBok
	Worked together on the creation of a product, but in the different field	2	SCRUM*, PMBoK
	Worked together on the creation of a product, but in the different field	2	SCRUM*, PMBoK
	Worked together on the creation of one product in a field of interest.	3	SCRUM
	Worked together on the creation of several projects in the field of interest	4	SCRUM

1	2	3	4
Knowledge of applied tools and methods	Tools and methods, applied in the given project, have never been used before and are unknown to the team	1	PMBok
	Tools and methods, applied in the project, are known to the team but have never been used before	2	SCRUM*, PMBoK
	Tools and methods, used in the project, are known to the team, but are rarely used	3	SCRUM
	Tools and methods are known to the team and have been widely used before	4	SCRUM
	Learning ability	It is hard for the team to learn new knowledge and technologies, and to adjust to changes	1
	For some members of the team it is hard to learn new information and technologies, but the team can adjust to changes	2	PMBok
	Easily absorb new knowledge, can adjust to changes	3	SCRUM
	The team can easily absorb information, always tries to learn something new; can well adjust to the changes	4	SCRUM
Team's ability to clearly formulate and openly express ideas	Can't clearly formulate ideas and rarely express them	1	PMBok
	Can clearly formulate their ideas but rarely express them	2	PMBok
	Can clearly formulate their ideas and openly express them	3	SCRUM
	Can clearly formulate, openly express and justify their ideas	4	SCRUM
Ability to admit mistakes	Don't admit making mistakes and can't learn from them	1	PMBok
	Rarely admit their mistakes but try to never make them again	2	PMBok
	Openly admit making mistakes and try to never make them again	3	SCRUM
	Openly admit making mistakes and always learn from them	4	SCRUM

Table 4. Reporting

Questions	Possible answer	Score	Recommended methodology
Means of communication	Written reports. Formal record-keeping	1	PMBok
	Voice communication (telephone connection, Internet-conference)	2	SCRUM*
	On-line communication (ICQ, E-mail)	3	SCRUM
	Direct communication (meetings, video conferences)	4	SCRUM
Frequency of reporting to the Customer	Reports on every operation	1	PMBok
	Reports on completing the blocks of work	2	SCRUM, PMBoK
	Reports on the readiness of a component of project's product	3	SCRUM
Understanding the scope of works	Reports about project finish	4	SCRUM
	There is a full list of works; further alternation is impossible	1	PMBok
	There is a detailed list of works, further alternation is possible	2	PMBok
	There is an approximate list of project works	3	SCRUM
	The team understands the project goal and several ways for its achievement	4	SCRUM

Table 5. Project Manager's Responsibility and Main Requirements to the Project

Questions	Possible answer	Score	Recommended methodology
1	2	3	4
Consequences in case of unsatisfactory project outcome	Loss of life	1	PMBok
	Loss of irreplaceable sum of money	2	SCRUM*, PMBoK
	Loss of insignificant sum of money	3	SCRUM
	Loss of comfort in work	4	SCRUM
Project cost	More than 1 mln. \$	1	PMBok
	From 300 thousand – 1 mln. \$	2	SCRUM*, PMBoK
	From 100 –300 thousand \$	3	SCRUM PMBoK*
	Less than 100 thousand \$	4	SCRUM
Requirements to the project quality	Highest international requirements	1	PMBok
	International requirements	2	SCRUM*, PMBoK
	National requirements	3	SCRUM*
	Local requirements	4	SCRUM
Requirements to the realization period of the project	The period is unlimited	1	PMBok
	Not very urgent	2	SCRUM*, PMBoK

1	2	3	4
	Urgent	3	SCRUM
	Very urgent	4	SCRUM
Requirements to the precise compliance with a deadline	The deadline should be strictly met	1	PMBok
	Insignificant deviation from the deadline is allowed	2	PMBok
	Considerable deviation from the deadline is allowed	3	SCRUM
	Compliance with the deadline is not strictly required	4	SCRUM

Table 6. Risks Probability

Questions	Possible answer	Score	Recommended methodology
1	2	3	4
Probability of occurrence of technical, manufacturing or qualitative risks	Risk will most probably occur (95%)	1	PMBok
	Risk is highly likely to occur (75%)	2	PMBok
	Probability of risk occurrence is equal (50%)	3	SCRUM*
	Risk is not likely to occur (10%)	4	SCRUM
Probability of occurrence of external risks (disruption of work by contractors, unfavorable political, economic situation in the country, market changes, etc.)	Risk will most probably occur (95%)	1	PMBok
	Risk is highly likely to occur (75%)	2	PMBok
	Probability of risk occurrence is equal (50%)	3	SCRUM
	Risk is not likely to occur (10%)	4	SCRUM
Probability of occurrence of organizational risks (disruption of funding, delivery of resources, inaccurate prioritizing, etc.)	Risk will most probably occur (95%)	1	PMBok
	Risk is highly likely to occur (75%)	2	PMBok
	Probability of risk occurrence is equal (50%)	3	SCRUM
	Risk is not likely to occur (10%)	4	SCRUM
Probability of occurrence of managerial risks (inefficient planning, controlling, communication problems, etc.)	Risk will most probably occur (95%)	1	PMBok
	Risk is highly likely to occur (75%)	2	PMBok
	Probability of risk occurrence is equal (50%)	3	SCRUM
	Risk is not likely to occur (10%)	4	SCRUM

The cases, when application of the methodology is not stipulated by the situation but is still possible, are marked with the sign “*”.

In the tables 1-6 the recommendations about application of two alternative methodologies – PMBoK and SCRUM – are given.

At this stage two existing methodologies, which are completely different in their approach to project management, have been analyzed. The choice of methodologies was stipulated by the intent to provide the most graphic example of application of two alternative approaches to managing a single project. On the one hand, it is the PMBoK Standard, which contains over 47 project management processes; and on the other hand – it is SCRUM, a framework methodology, which has been widely used for managing IT projects in Ukraine. The version of the questionnaire set out in this paper, is used to select a project management methodology namely in the field of IT.

Based on the obtained recommendations, the project manager can choose the most reasonable methodology regarding the given project. The selection process can be rather difficult, especially when the scores for separate blocks of the questionnaire suggest different methodologies. In such case project manager should make a choice based on the majority of recommendations and his own preferences. If the methodology is being selected by the company management for several perspective projects, among these project the most standard ones should be considered. Then the questionnaire, which is the first method, should be completed for all standard perspective projects and make a choice based on recommendations.

4. SELECTION OF PROJECT MANAGEMENT METHODOLOGY FROM PERSPECTIVE OF MAN-HOURS, MANAGEMENT COST AND RELATED RISKS

The second method is designed for the situations when the project team has sufficient knowledge of the alternative project management methodologies, and when it also has time and resources for evaluating the expenses and man hours regarding usage of each methodology as well the risks it may provoke. [9]

The given method suggests the solution for the three-criteria optimization problem of selecting a methodology with regard to the constraints. The optimization criteria are: the work content of managing a project with the methodology under study; the cost of management, the risks related to managing the project with the methodology under study.

The algorithm of work content and cost evaluation of a methodology consists of several

stages.

1 Analysis of project management methodology – how the project is handled, which processes need to be completed, to what extent the project team members are involved into managing the project.

2 Creation of a list of project manager's activities in terms of the given methodology. At this stage all processes, which may require involvement of the project manager both at the preparation stage, and during execution, have to be taken into account.

3 Calculation of project manager's man-hours, required for managing the project.

4 Identification of the processes, which may require involvement of other project team members and to what extent it may happen. For example, reporting or development activities almost always require participation of not only the project manager, but the whole project team.

5 Calculation of each team member's man-hours, required for managing the project.

6 Define general man-hours of project management.

7 Calculation of project management cost with the help of the following formula:

$$C_M = M \cdot P + \sum_{i=1}^m H_i \cdot W_i + \sum_{j=1}^n C_j \cdot K_j \quad (1)$$

where:

M – project manager's hourly wage rate;

P – project manager's man-hours;

H_i – hourly wage rate of an i -th project manager's assistant. An assistant can be represented by a business-consultant or any other professional, involved to managing the project;

W_i – man-hours of an i -th assistant;

C_j – hourly wage rate of a j -th team member;

K_j – man-hours of a j -th team member.

m – quantity of project manager assistants;

n – quantity of project team members.

8 To estimate the risks connected with the project management through use of the methodology under assessment.

Further, one should prioritize the methodologies in question subject to three criteria and choose the best one.

Restrictions on the cost of management process and on labour input thereof can be taken into account in

the course of optimization.

5. OPTIMIZATION OF THE PROJECT SCOPE

When solving the task of selecting the project scope, the choice of methodology to be used for management of such project is a vital fact. The applicable methodology of project management tells on time of its implementation, cost, quality of products, stages and the entire project as a whole, on the risks associated with it. Solving the objective of optimizing the project scope for alternative methodologies, one can choose it more substantially than it does with a methodology in isolation from optimization of the project scope. In this paper the choice of a methodology is proposed to do by solving the optimization problem for the project scope by criteria profit, time, cost, quality, risk.

In cases when it is acceptable in terms of studies complexity, such optimization can be performed for all the methodologies and optimization by the criteria: the work content of managing a project, the cost, the risks of the project as described above, can be avoided.

In order to reduce the labour intensity of the research, it is expedient to make a pre-selection of a small number of methodologies, for example two alternatives, by means of the previous method. As soon as the list of methodologies is narrowed, one can optimize the project scope provided that each of the left methodologies is applied.

For solving the objective of optimizing the project scope according to the criteria: profit, time, cost, quality, risks it is possible to use the method of implicit enumeration in combination with the generalized criterion [10-11] or the method of successive concessions as described in the paper [12].

The project scope optimization under the successive concessions method is advantageous if compared with the application of the generalized criterion [11]. It is not necessary to set weighting factors for each of the criteria, it is always difficult. It suffices only to prioritize the criteria from the point of view of the task to be solved and to specify the admissible concessions.

6. OPTIMIZING THE SELECTION OF PROJECT MANAGEMENT METHODOLOGY AND PROJECT SCOPE, TAKING INTO ACCOUNT CHANGES IN THE MATURITY OF THE COMPANY

The selected methodology of project management tells on the company's maturity degree. Thus, while

estimating the company's maturity by means of CMMI model [13], they make it clear if the company applies the standard project management processes, as well as the standard processes in production activities, whether the archives for the performed projects and actions of the company are kept, which methods of feedback are used, whether there is a continuous improvement of processes. The project scope as well as the applicable methodology to manage it, with the chosen depth and integrity of application, affects the change of the company's maturity degree.

For the projects that are managed through use of the selected alternative methodologies and the scope of which is optimized according to the criteria: profit, time, cost, quality, risks, the estimation is made towards the company's maturity change to be gained in response. At this time there is a chance to make a final selection of methodology out of alternatives based on comparison of values of six criteria: profit, time, cost, quality, risks and maturity of the company.

The choice shall be made by the company's representatives in terms of the strategic goals of its development.

7. CONCLUSIONS

The paper introduces methods to select the project management methodology that are designated for application under the conditions of different degrees of awareness of the decision-maker. The first method presupposes that the project manager fills in the questionnaire. Depending on his replies, this or that methodology is recommended for use. The second method is dedicated to assessment of labour intensity of the project management by means of the methodologies in question, cost of management and risks. Further, one resolves the triple-criteria task of optimization for selecting the best methodology.

The most precise choice of methodology is based on optimizing the project scope provided that a specific methodology is applied. For this purpose, subject to application of one of the simple methods, by means of which the list of suggested methodologies is narrowed to a small number, it is supposed to optimize the project scope subject to five criteria: profit, cost, time, quality, risks. Thereafter, one makes an estimation of change of the company's maturity while implementing the project on the chosen methodologies by means of CMMI model or any other maturity model in line with the relevant specificity of the company's activity. Selection of the best alternative to implement the project when using this or that methodology so far subject to six criteria: profit, cost, time, quality, risks

and maturity, takes place at the next stage.

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