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A Balanced Scorecard Forming Method for Efficiency Assessment of the Software Projects Management

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***Abstract*—The evaluating project activities effectiveness is acute due to the implementation unpredictability, tasks specificity to be solved, the technologies used and the final results. A software project is a complex dynamic control object. The project hierarchical structure can be viewed not only from the standpoint of sequential detailing implementation stages, but also from the standpoint of a set of knowledge areas, including processes, practices, inputs, outputs, tools and methods. The methodology application will help build a project management system which taking into account various factors affecting the success of project implementation.**

Keywords—balanced scorecard, strategy, project management, performance targets, performance indicators

I. Introduction

There are no enterprises regardless of the business scale of the business which can be absolutely confident in the stability of its positions in the market even in the near future. Long time ago there were days when organizational and production processes were carried out unchanged. All employees took care of their jobs and made different decisions that described in the best practices. The external environment of the enterprise almost has not changed at all. The companies worked with the same counterparties used the same interaction technologies and worked with constant superior management structures. Under these conditions it was possible to make plans for 10-15 years ahead.

Everything was changed after the political and economic reorganization of the Russian society and the information age beginning. The rupture of economic and political ties, the breakdown of the usual interaction patterns and drop in the exchange rate of national currency made impossible to have almost all type of economic activities. At that time companies were not ready to quickly adapt to changes. The strategic planning covered no more than 2-3 years. In that situation, it were significant to use relevant and reliable information about the state of all elements of the economic object and events occurring in the external environment. The rapid development of information and communication technologies had played critical role in enabling far-sighted enterprise managers to use tools. Such kind of tools allow them to make informed decisions on enterprise management and include both automated business process management systems and corporate information systems. Using these tools cannot give a serious economic effect in case of a well-thought-out strategy absence for the enterprise development. Such a backbone factor may be using of the BSC (Balanced Scorecard) methodology proposed by R. Kaplan and D. Norton [1] for developing the strategic goals of an enterprise. This methodology allows you to track various areas of activity including the implementation of the main and auxiliary production and organizational processes, relationships with customers and partners, staff development and modernization of the production base and monitor the most significant performance indicators in the short and long term. The BSC methodology has been acknowledged by formation of strategic development plans and enterprise management, which has a hierarchical organizational structure. The authors propose to use the BSC methodology for managing software projects in the production environment of project-oriented organizations.

II. Management features of project-oriented organizations

With reference of varied environment of business conditions, the enterprise management is increasingly thinking about more flexible matrix or design-target model. Such a transition is due to the fact that companies are able to provide customers with a quality product or service in accordance with their requirements in a shorter period to receive a competitive advantage. Customer satisfaction leads be motivated for having a huge variety of scenarios for organizational processes that indicates shift to project management. Therefore, companies operating through the implementation of variety projects can be considered as project-oriented. Such organizations often have a highly specialized focus for example financial, legal, strategic, organizational, and others. In this case, the customer and the executor of the project can be the same organization.

Project-oriented organizations perform tasks for the information gathering and subsequent analysis of the enterprise activities, help with the maintenance of innovative projects, make a forecast of development potentials and implement the introduction of new scientific and technical features. Taking into account the variety of project-oriented organizations activities, we will focus on those organizations. A software project is a specific type of activity consisting in the development and introduction of specialized software designed to increase the efficiency of an economic facility. Thus, we will consider an IT company like a project-oriented organization, are which developing and implementing software.

Effective management of a project-oriented organization is possible only in the case when attention is focusing on

strategic planning issues. Acceleration of changes, opening up new possibilities for customer, increased competition, recent trends in technology as well as a number of other reasons led to a sharp increase in influence of strategic management. Not only the management, but also each employee must be focus on successfully solving their tasks. The efficiency of activity depends on information technologies development rate.

III. KNOWLEDGE AREAS AND PROJECT MANAGEMENT PERFORMANCE TARGETS

In recent years, flexible project management methodologies [2] have become widespread. Their application is especially effective when implementing projects in small teams consisting of highly qualified and energetic specialists. These specialists are focused on the rapid implementation of changes. Agile methodologies have been based on approaches to develop reliable software products with small but tightly controlled requirements with the declared functionality. The excellent results of using Agile have influenced to spread this experience to other areas of activity. A shining example is that fact where simultaneously with the latest version of Project Management Body of Knowledge (PMBoK) Guide 6th Edition the PMI project management institute published the Agile Practice Guide developed in collaboration with the Agile Alliance [3].

The project management methodology has 10 areas of knowledge for successful project management. Each area of knowledge has its own list of processes which help company with a certain degree of probability to achieve pointed goals. Areas of knowledge, their main processes and a list of objectives are provided in the PMBoK Guide 6th Edition [4].

The Scrum methodology as well as PMBoK has areas of knowledge and the corresponding processes called activities [5]. A comparative analysis of these two methodologies shows their great similarity.

At the same time, Scrum or the other methodology has no direct indication of the listed goals and the main processes, the target indicators, which make it possible to determine more accurately the achievement of goals. Moreover, the choice of target indicators is always project manager's risk and his choice directly depends on his experience and qualifications in each of the areas of knowledge. It is needed more certainty in this question when choosing one or another way to achieve the project goals. In order to reduce uncertainty the authors propose to consider each area of knowledge as a separate project management subsystem with its own set of targets, control actions and management methods [6]. It is important to understand that priority areas of knowledge depend on project type. In case of the shortage of resources, the necessary number of them will be directed to the highest priority subsystem.

In [7] an attempt was made to determine the main target indicators for each of the knowledge areas. This uncertainty is associated with the lack of a project type indication. The project type and the subject area are significantly affected the organizational structure of the project and the principles of its management.

The classification of projects according to various criteria and the types of organizational structures are described in many sources [4, 8–10]. The scope of the study is limited to the consideration of software projects, so in this article the authors propose a set of indicators specific to this type of project. Target and permissible values of the indicators are achieved during the implementation of specific processes, see table 1.

TABLE I. FRAGMENT OF THE LIST OF SOFTWARE PROJECT MANAGEMENT PERFORMANCEINDICATORS

Knowledge Areas	Performance indicators	Calculation formula	Expected value of performance indicators
Project Integration Management	Burnout time (BT)	(Total time for all tasks completed during the sprint) + (Total time for all difficulties) – (The total time estimates for the tasks of the sprint)	$\lim_{sprint\ time \to 0}(\text{BT (sprint time)}) = 0$
	Accuracy evaluation (AE)	The sum of the initial estimates of all tasks / ((The amount of completed time for all tasks) + (The amount of time remaining for all tasks))	$\lim_{sprint\ time \to 0}(\text{AE (sprint time)}) = 1$
Project Scope Management	Requirement Stability Index (RSI)	(Total number of original business requirements + Number of requirements changed till date + Number of requirements added + Number of requirements deleted) / (total number of original requirements)	$\lim_{sprint\ time \to 0}(\text{RSI (sprint time)}) = 1$
	Rework attributable to requirements (RAR)	Number of improvements due to changed or number of new requirements / Number of requirements	$\lim_{sprint\ time \to 0}(\text{RAR (sprint time)}) = 0$
Project Cost Management	Influence of difficulty	The amount of time spent on all difficulties during the sprint x Team member average hourly pay	Influence of difficulty → min
	Average cost of repairing a defect	Cost of work on the repairing defects / Number of defects	Average defect cost → min
Project Time Management	Velocity	The sum of all sprint story points / Number of sprints	$\lim_{sprint\ count \to \infty}(\text{velocity(sprint count)}) = 1$

Knowledge Areas	Performance indicators	Calculation formula	Expected value of performance indicators
	Estimated time of delivery	Total number of remaining story points in product backlog / Velocity	Estimated time of delivery → min
Project Human Resource Management	Timeliness	Expert review	Timeliness → max
Project Quality Management	Defect density (DD)	The number of defects in a separate module / Number of defects	$\lim_{sprint\ time \to 0}(\text{DD (sprint time)}) = 0$
	Technical debt ratio (TDR)	The technical debt ratio = technical debt / estimated development cost. And by default (this can be changed in the settings of SonarQube), the estimated development cost is computed as "LOC x 30 minutes".	$\lim_{sprint\ time \to 0}(\text{TDR (sprint time)}) = 0$
Project Communication Management	Teamwork	Time for communication + time for daily meeting	Teamwork → max
	Flow Efficiency	Work time / (Work time + Wait time)	Flow Efficiency → max Wait time → min
Stakeholder Management	Stakeholder engagement	Cycle time from ideation to Feature approval	Cycle time from ideation to Feature approval → max
	Number of missing requirements – Number of requirements that were omitted from the analysis in the sprint		Number of missing requirements → min
Project Risk Management	Throughput – количество задач, которое может выполнять команда в единицу времени (день, неделя, месяц).		Throughput → max

The table 1 shows that Agile practices focus on planning, executing, and monitoring project work. Therefore, Scrum does not define practices related to initiating or completing a project. [5].

IV. Development of Balanced Scorecard of Software Projects for Individual Areas of Knowledge

The areas of knowledge and targets presented in table 1 can be the basis for developing a balanced scorecard, presented in the form of a strategic map. No matter how the recommendations were detailed according to international standards. The practice is much more complicated than theory. The practice often offers to solve problems for which there are no answers in textbooks. In addition, international standards cannot take into account the special aspects of their application at the national level, which implies the need to develop additional methodologies for Russian project-oriented organizations.

The proposed methodology for creating a balanced scorecard is based on using a process approach to managing the organization's activities, the basic principles of the BSC methodology [1], recommendations of the international standard PMBoK Guide 6th Edition [4], and also takes into account the experience of implementing projects for software for Russian manufacturing enterprises [11].

The method involves the implementation of a sequence steps. A prerequisite for its use is the presence of framework standards for managing software projects and documents reflecting the development strategy of the enterprise.

- Step 1. Highlight areas of knowledge that are primarily needed to manage a software project. If necessary, rank them from the position of the project manager.
- Step 2. Determine which Agile activities (processes) are part of each of the knowledge areas.
- Step 3. Align the processes performed and the goals achieved.
- Step 4. Based on the theory of process management, as well as PMBoK, determine the inputs and outputs (results) of processes.
- Step 5. Determine the targets and the range of their acceptable values for each process.
- Step 6. Select the prospects in accordance with the BSC-methodology and distribute the processes with indicators on the prospects.
- Step 7. Determine the responsible for the implementation of processes and monitoring the achievement of target values of indicators (associated with areas of knowledge).
- Step 8. Build a strategic map for managing a software project, taking into account the influence of the areas of knowledge and their constituent processes on each other.

The strategic map is designed for decision-making managers which allows you to see the relationship of goals and performance indicators for a long term. At the same time, the values of individual indicators and the achievement of local goals depend on the activities of specific performers. The structural units are the centers of responsibility for the tasks implementation. In [12] a strategic map of a typical consulting enterprise is given. Each structural unit of a project-oriented organization may be responsible for its own field of knowledge, so a different strategic map can be developed for each of them.

The goal of “Improving project management efficiency” in the “Business Processes” section of the main strategic map relates to all structural divisions ensuring the release of software products. For each of them this objective is formulated in accordance with the functional role of each structural unit.

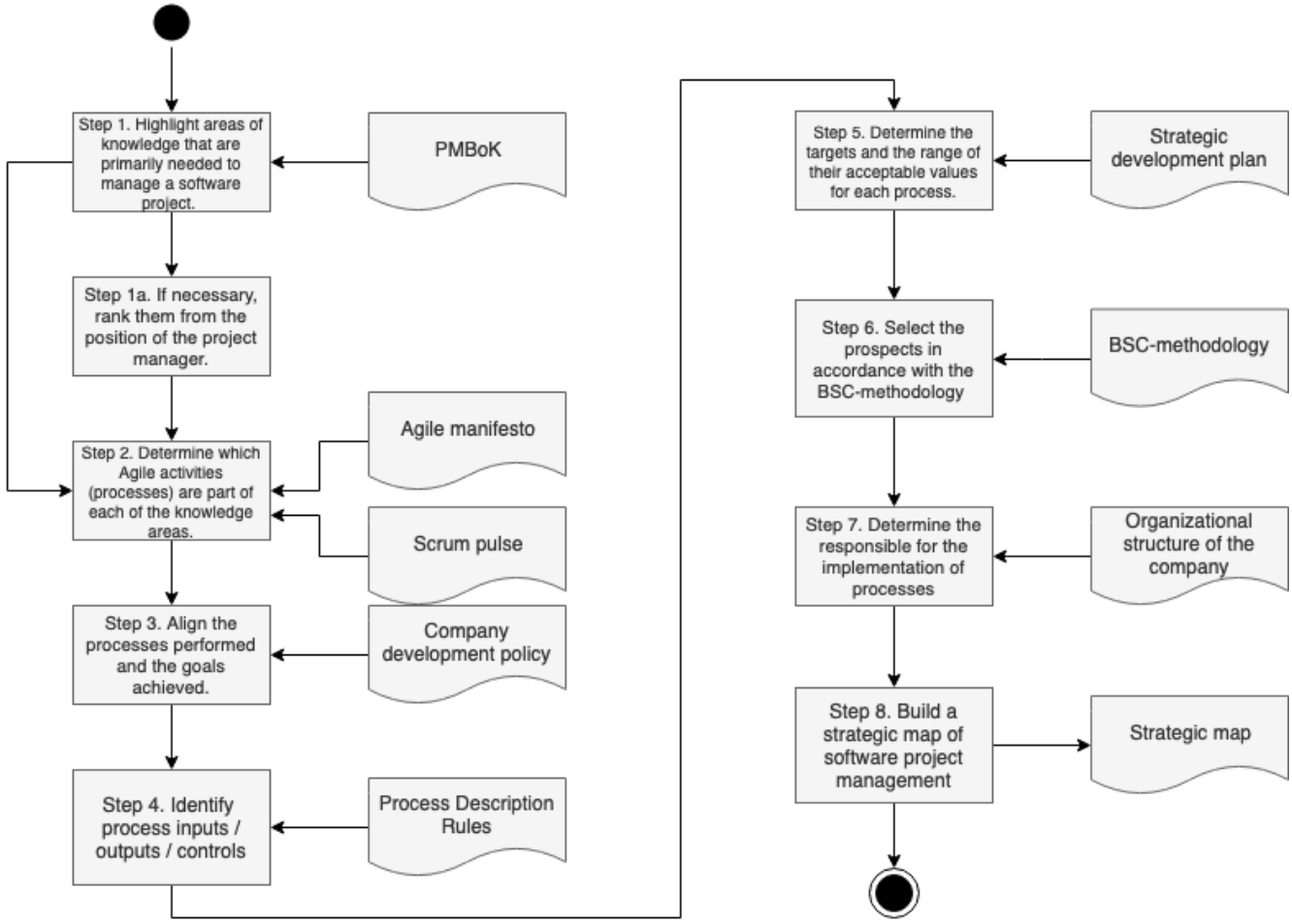

Fig. 1. A balanced scorecard forming method for efficiency assessment of the software projects management

The main goal for employees of the quality assurance department will be “Improving the quality of the software”. The achievement is measured in the number of errors found and corrected, as well as the time needed to solve problems and interact with other participants in the process (Fig. 2). This activity corresponds to the area of knowledge "Project Quality Management".

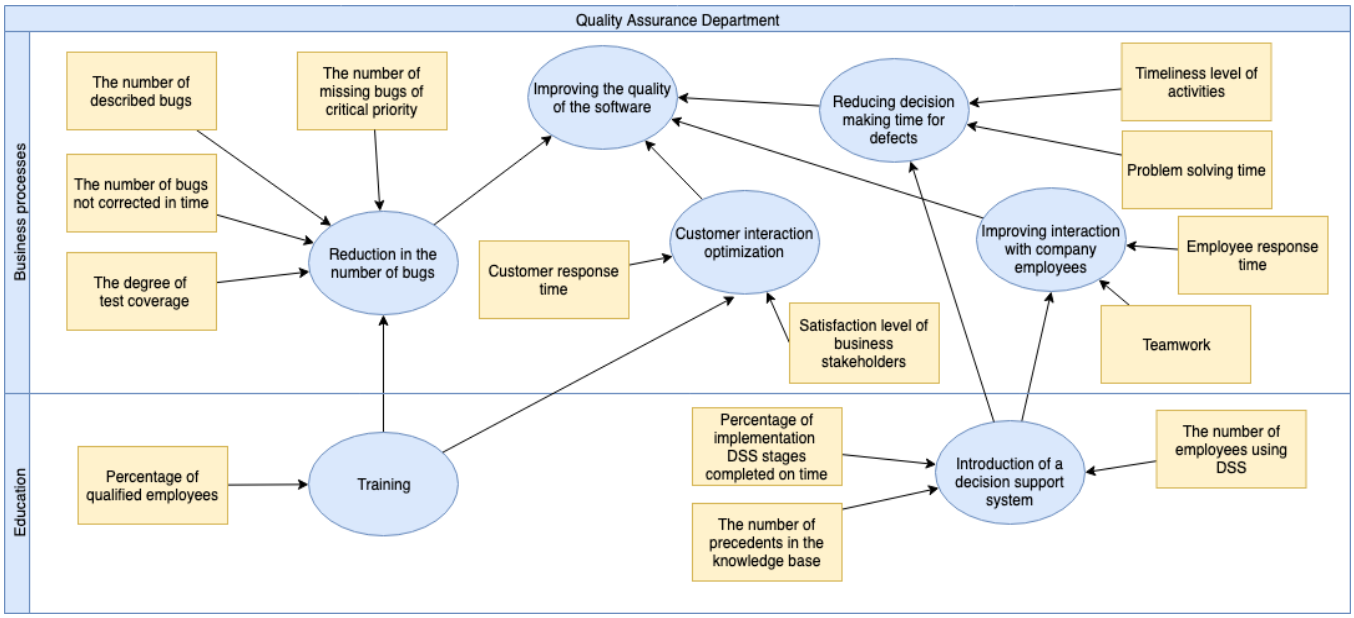

Fig. 2. Strategic map of the quality assurance department

The construction of a strategic map involves the appointment of persons responsible for achieving the target values of the indicators, as well as for entering the correct values and monitoring the execution of processes. This allows us to create a matrix of responsibility, which will help determine the degree of loading of executors when performing technological processes.

V. Conclusions

Developing a strategy for a project-oriented organization based on a comprehensive study and analysis of its performance indicators from the point of view of various areas of knowledge is an important condition for the effective implementation of software projects, as well as a guarantee of successful development of the organization in the long term.

The use of modern management methods, consideration of international standards recommendations and the best practices in the field of project management, as well as information technology allow us to analyze the current state of processes. The effectiveness of managing software projects is determined by the quality of decision making under uncertainties. Reducing the impact of the uncertainties can be achieved by using a formalized approach to manage a software project based on the recommendations of PMBoK in conjunction with the development of a balanced scorecard for a project-oriented organization.

Project-oriented organizations use the BSC:

- to develop a clear formulation of the strategy, as well as the goals of the activity and bring the strategy to the notice of all the employees of the company;
- to align the goals and objectives of the structural units with the company's strategy;
- to align strategic objectives with long-term goals and annual budgets;
- to review progress and strategic results periodically and systematically;
- to create feedback to obtain information and timely change strategies if necessary.

The novelty of the method of forming the balanced scorecard is its application to software projects, and not to the organization as a whole. This method allows taking into account the influence of interrelated knowledge areas and their constituent processes on achieving the ultimate goal of specific projects. At the same time, each area of knowledge is assigned for a specific set of indicators with a range of permissible values, which allows us to quickly identify problem areas of the implementation of a software project and track the impact of control actions on the achievement of target values of indicators.

Recently, ontologies and other intellectual technologies are central components of large-scale production information systems management [13, 14]. The strategic map created during the application of the proposed method can be used in the different types of intelligent decision support system for managing software projects carried out in industrial enterprises at the stage of the ontological subject area analysis to study their interpretation based on quantitative assessments.

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References

[1] Kaplan R., Norton D. Balances Scoredcard. (in Russian) – M.: Olimp-business, 2003. – 342 P.

[2] Agile manifesto //Site agilemanifesto.org. (https://agilemanifesto.org/). Viewed on 28 February 2019.

[3] Pavlov A. N. Effective standard bases project management PMI PMBoK 6th Edition / A. N. Pavlov. (in Russian) - M.: Laboratory of knowledge, 2019. - 270 P.

[4] A Guide to the Project Management Body of Knowledge (PMBoK Guide) - Sixth Edition. PMI, 14 Campus Boulevard, Newtown Square, Pensylvanya, 19073-3299, USA.

[5] Kevin Thompson. The Agile PMO //Site projectmanagement.com. (http://www.projectmanagement.com/pdf/TheAgilePMO.pdf).Viewed on 28 February 2019.

[6] Chernyakhovskaya L. R., Nikulina N. O., Barmina O. V. Evaluating the effectiveness of decision support in a software development project // Information Technology for Intellectual Decision Support: труды 6 Proceedings of the 6th International Workshop: ITIDS'2018, T.2, 28-31 May, Ufa-Stavropol, Russia, 2018. – P. 16-22

[7] Chernyakhovskaya L. R., Nikulina N. O., Malahova A.I. Application of the BSC methodology for project management in IT companies (in Russian) // Economic management: methods, models, technologies: Proceedings of XVIII International Workshop 18-20th October 2018 г. – Ufa, 2018. – P. 385-390.

[8] Mazur I. I., Shapiro V. D., Olderogge N. G. Project management: tutoria. (in Russian) – M.: Omega–L, 2005. – 664 P.

[9] Tovb A. S., Tsipes G. L. Project Management: Standards, Methods, Experience. (in Russian) – M.: «Olympus - Business», 2003. – 240 P.

[10] Archibald R., Management of High-Tech Programs and Projects / Russell D. Archibald; per. from English Mamontova E. V. (in Russian) – M.: DMK Press; IT co, 2006. – 472 P.

[11] Nikulina N. O., Ivanova I. F., Barmina O. V. Project management in business process management: tutorial / USATU (in Russian) - Ufa: RIK USATU, 2017. - 260 P.

[12] Barmina O. V, Nikulina N. O. Intelligent system for interactive business processes management in project-oriented organizations. (in Russian) Ontology of designing. 2017; 7(1): P 48-65. DOI: 10.182**8**7/2223-9537-2017-7-1-48-65.

[13] Yusupova N., Smetanina O., Agadullina A., Rassadnikova E. The Development of Ontologies to Support the Decisions in Production Systems Management. (in Russian) In: Proc. 2017 Second Russia and Pacific Conference on Computer Technology and Applications (RPC). IEEE Xplore Digital Library, P: 188–193, 2017.

[14] Kovács, G., Yussupova, N., Rizvanov, D. Resource management simulation using multi-agent approach and semantic constraints (in Russian) // Pollack Periodica Vol. 12, Issue 1, 2017, P. 45-58.