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Capability maturity models in engineering companies: case study analysis

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Abstract. In the conditions of the current economic downturn engineering companies in Russia and worldwide are searching for new approaches and frameworks to improve their strategic position, increase the efficiency of the internal business processes and enhance the quality of the final products. Capability maturity models are well-known tools used by many foreign engineering companies to assess the productivity of the processes, to elaborate the program of business process improvement and to prioritize the efforts to optimize the whole company performance. The impact of capability maturity model implementation on cost and time are documented and analyzed in the existing research. However, the potential of maturity models as tools of quality management is less known. The article attempts to analyze the impact of CMM implementation on the quality issues. The research is based on a case study methodology and investigates the real life situation in a Russian engineering company.

1 Introduction

Engineering companies in Russia and worldwide facing a number of challenges generated by the current economic downturn are eagerly searching for managerial frameworks and tools which promise them higher effectiveness of business processes, higher quality of products and solutions and better adaptability for change [1, 2]. More and more engineering companies in Russia and other countries are turning to various capability maturity models (CMMs) that help them improve their processes and practices.

Capability maturity models help engineering organizations to assess and position the company's internal processes and resources, to define the current level of maturity and to elaborate the evolution path to improve the processes and resources [3]. There are dozens of different maturity models [4]. However, a typical maturity model consists of a sequence of maturity levels for all or the most important processes of an engineering company [5]. The lowest level stands for the initial state with the poorest performance of the business processes. The top maturity level is characterized by the best practices and the highest performance. With the help of the capability maturity models the management of the engineering companies can define the areas of processes that need to be improved, prioritize all the improvement efforts, develop the strategy of the business process optimization across the whole company, assess the results of the efforts [6].

Since the 1900s when the first maturity models were introduced in the practice of engineering companies they became extremely popular due to the ability to bring about real improvements. There is the documented evidence that CMMs can lead to significant cost and time reduction, improvements in budget performance and timeliness of engineering projects [7–9]. However, the improvements in the quality of engineering solutions and products is widely declared in the theory of CMMs, but is investigated rather sketchily. This article attempts to analyze the impact of CMM implementation in a Russian company on the quality issues.

2 Capability maturity models and their application in engineering companies

The first capability maturity model was developed by Software Engineering Institute in Carnegie-Mellon University in 1991 [10]. In the development of the first version of the capability maturity model many specialists in the engineering of computer, electronic, electrical and mechanical systems participated. The main contribution was made by the specialists from Department of Defence and Systems Engineering Committee of the National Defence Industrial Association of the United States.

Initially, the CMM was developed for new software development projects and programs. However, the model became quickly very popular among not only software companies, but also engineering companies engaged in the various system engineering and development projects and programs initiated for the military and civil purposes. The initial CMM helped companies to streamline and optimize the internal processes of system design, development and technical maintenance.

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After the successful implementation of the CMM in many companies the model went through the stages of the further developments and improvement. On the basis of the first CMM the second version was elaborated. It was called Systems Engineering Capability Model [11]. At the same time, the more specialized version of the model was created for the software systems – Software Engineering Capability Model. The idea was to offer two types of models – one for the broad spectrum of companies and projects dealing with engineering of the systems of the various purposes and natures and another one specifically for software system engineering. However, the specialized capability maturity models did not prove to be very popular and after some time SEI developed integrated model – Integrated Product and Process Engineering Capability Maturity Model (IPD-CMM) which allowed streamlining the activities connected not only with the new product development and also with the process development, deployment and optimization [5].

The successes of the different versions of CMM inspired specialists in other industries and professional spheres to create similar capability maturity models. For example, there was an attempt to develop the specialized model for human resources management process – People Capability Maturity Model [12]. The concept of organizational maturity became very popular and productive in the field of project management. The dozens of different capability maturity models were developed in various organizations by different specialists. One of the first project management maturity models was the model developed by Ibbs and Kwak [13]. As the original capability maturity model it consisted of five levels of maturity of processes, different characteristics of processes and key distinguishing capabilities on each maturity level. Another well known project management maturity model was elaborated by Kerzner [14]. Even more detailed model was based on PRINCE2 standard of project management and was called P3M3 (Portfolio, Programme and Project Management Maturity Model) [15]. The distinguishing feature of this model was that it included not only the processes of project management, but also the processes of portfolio and program management. The same approach was used by Project Management Institute in their own project management maturity model – OPM3 (Organizational Project Management Maturity Model) [16]. As P3M3, it was based on the family of international standards of portfolio, program and project management [17–19]. Up to now, OPM3 is the most sophisticated and widely known project management maturity model.

Engineering companies initially showed high interest in project management maturity models. However, after a while the popularity of project management and other specialized maturity models decreased significantly [20]. The reasons for this were:

- Project management maturity models and other specialized models somehow duplicated the approach embodied in the traditional capability maturity models created by SEI,
- They covered only a part of the whole system of processes in engineering companies, whereas CMM was more holistic in nature,
- They were less elaborated and less detailed than CMM.

Today some researchers are highlighting that the classic CMM (in its latest version – CMMI [5]) can be considered as much more popular and useful than any other modification of this model, including project management maturity models [21].

There is some body of research on the results of CMM implementation [7; 8]. Many researchers agree upon the fact that CMM implementation can lead to higher performance in terms of cost and time reduction. However, the effect of CMM on quality is not so clear. The article attempts to fill the gap in the current research and describes the findings of the empirical case study research in the area of CMM implementation results for quality management.

3 Research methodology

The research presented in this article is based on the case study methodology. The reasons for this research design decision are:

- The implementation of the managerial frameworks and optimization models in each organization affects different parts of the organization. In one company CMM can be applied to one process area and in another company to quite different group of processes.
- As result, CMM implementation brings different results which are difficult to generalize and compare within the empirical study based on the surveys.

There are two main perspectives of the case study methodology. One perspective emphasizes the crucial role of the case or the object of study. According to Stake (1998) the most important is not the methods of research, but the object of study itself: "As a form of research, case study is defined by interest in individual cases, not by the methods of inquiry used" [22]. Other perspective, presented by such researchers as Yin (1994), places more emphasis on the tools and techniques of investigation [23]. The authors of this article not denying the importance of research tools and techniques agree more with Stake and consider as one of the most important decisions pertaining to case study research methodology is the selection of the appropriate case.

4 Description of the company

The object of study in the case study methodology should be a complex contemporary functioning unit investigated in its natural context [24]. In order to investigate the results of the CMM implementation and the possibilities of the combined application of CMM and other management optimization approaches we needed to find an engineering companies that already implement CMM and other tools which was ready to share the results of this implementation.

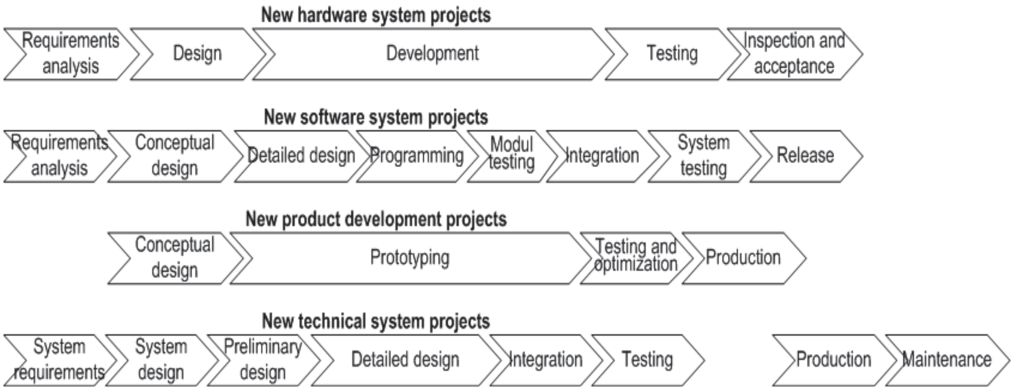

Figure 1. Life cycles of the project in four different business streams of the company

As the case in this article we selected a Russian company engaged in the engineering of radio stations and radio systems for military use. The company is one of the leaders in its industry on the territory of Russia and countries of the former Soviet Union. The business of the company can be considered as four main project streams. The life cycles of the projects from each stream are shown in Figure 1.

In early 2013 the company started the implementation of CMMI. This endeavor was initiated as a part of the strategic program of the internal business processes optimization. The program included the following strategic directions:

- Adaptation of CMMI with the strategic targets of the company,
- Identification of the best practices in process management and dissemination of them across the company,
- Organization of a corporate project office responsible for the coordination of all company projects,
- Identification of the interfaces between internal business process and business processes of contractors and vendors, optimization of these interfaces.

5 Findings of research

The assessment of the current state of business process was undertaken with the help of external consultants and representatives of partners. It was defined that the majority of business process had the third level of maturity. As a result, management of the company decided to upgrade the processes to the fourth level of maturity. At the beginning of 2014 the assessment showed that this aim was achieved and almost all business processes reached the fourth level of maturity. After that it was decided to continue the optimization efforts according to the recommendations from CMMI, and in 2015 the bulk of the processes obtained the fifth level of maturity.

The following analysis is based on the comparison of the situations at the beginning of 2013 and at the beginning of 2015. In other words we analyzed the performance indicators at the third level of maturity and at the fifth level of maturity.

In the area of project management performance it was detected that as the result of CMMI implementation the schedule performance index improved from 0,78 to 0,93. The timeliness of project completion improved by 4,9%. The cost performance index in all company projects increased from 0,88 to 0,96. The indirect costs were cut on average by 7,3%. The product development costs decreased by 28%.

In the area of quality management the improvement were even more notable. The time wasted on defects detection and correction decreased by 6,35 times. The reduction of time wasted on defects detection and correction through different stages of the project life cycles is depicted on Figure 2.

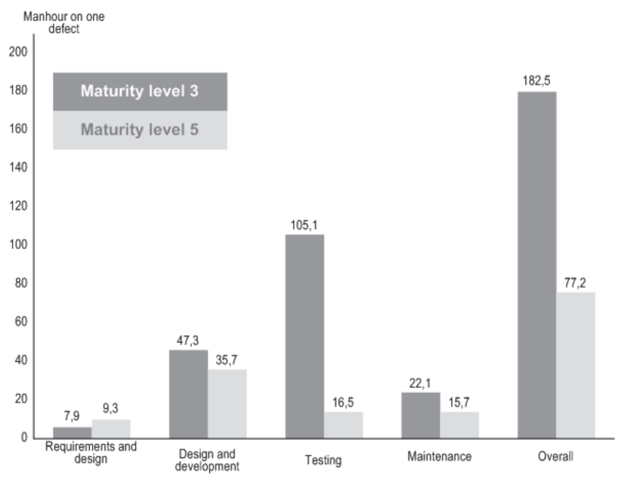

Figure 2. Reduction of time wasted on defects detection and correction on different project stages

From Fig. 2 it is clear that the overall number of defects decreased significantly. But the most outstanding improvements were achieved at the stage of testing.

The costs of defects detection and correction were cut on 22%. The number of critical defects dropped on 62,5%. The index of defect containment (the measure of how many defects were detected and corrected at the place where they were made) improved on 240%.

6 Conclusion

In accordance with the previous research [7–9, 21] the findings suggest that CMM implementation can bring about serious improvements in processes of engineering

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companies in terms of cost and time reductions. The transition of the process of the company from the third level of maturity to the fifth was accompanied by the prominent improvement of time and budget performance indexes. At the same time, the research shows that CMM implementation significantly improved the engineering project performance in terms of the quality management. The cost of and time on defects detection and correction reduced notably. The number of defects dropped dramatically as well. Therefore, capability maturity models can be considered not only as a tool of process optimization, but also as an instrument of quality improvement.

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