Applying balanced scorecard in software process improvement: a case study of small software organization

Bakir Karahodža*, Elma Avdagić-Golub * and Alem Čolaković*
* University of Sarajevo, Faculty of Traffic and Communications, Sarajevo, Bosnia and Herzegovina
{bakir.karahodza, elma.avdagic, alem.colakovic}@fsk.unsa.ba

Abstract - **Software processes consist of a complex set of activities required to deliver software products within predicted quality, costs, and deadlines. To accomplish such goals, a software organization needs a quality and mature software process as a prerequisite for success. Adopting Software Capability Maturity Model Integration (CMMI) represents a well-known path in the pursuit of mature software processes. However, its implementation is a subject of a permanent effort that implies different approaches and methods, and often leads to unsuccessful or limited success, though. This is especially emphasized in small software companies given the dynamic environment influenced by different factors, including insufficient resources, changes in technology, and staff turnover. In this paper, a case study of a small software company implementing software process improvement is presented. In a tailored approach to process improvement, a specific method using the balanced scorecard as input into the IDEAL model has been designed, enabling a narrow link between business goals and specific improvement goals. The results show that the software process and selected performance indicators were improved, and suggest the potential of the proposed approach in small organizations.**

Keywords - software process improvement, CMMI, implementation, small organization, balanced scorecard, implementation method

I. INTRODUCTION

The relation between the quality of the software product and the quality of the software processes used to develop and maintain software is an ongoing challenge in software companies. One of the industry-accepted approaches for Software Process Improvement (SPI) projects is the capability maturity framework, which transforms an ad hoc process into a mature and documented process capable of producing software of predictable quality [1]. Such frameworks are the Capability Maturity Model (CMM) introduced by the Software Engineering Institute, as well as the later introduced Capability Maturity Model Integration (CMMI) [2] that contains a similar approach, yet slightly changed and tailored for wider types of software companies. The CMM-based frameworks are mostly aimed to be introduced in large software projects and companies [3]. There is a proven record of research describing various risks for success in their implementation in small and minimum companies (SMEs). They tend to have a larger possibility of failing in the improvement projects. There are a few common risks and described causes [4], [5]: high dependability of individuals and a small number of projects, a small number of employees, non-existence of the formal organization structure, small investment opportunities, insufficient resources, staff turnover, etc.

However, by using the CMMI framework and with its individual adjustment to a specific use case tailored to the organization's size and business goals, measurable effects could be reached, though [3]. There have been a few studies using balanced scorecard in SMEs, mostly providing the theoretical basis for the potential benefits of its implementation. They lack details on how to use in SPI projects or need a broader case study for validity. The objective of this research is to propose an extended approach in the initiating phase of the software process improvement project. It combines the best features of the IDEAL model and directly links the strategic business goals to internal business processes**.**

The proposed model also provides a priority-based approach to the selection of process areas using several additional factors, including the complexity of changes, commitment to improvement, and impact on customer satisfaction. Common constraints often presented in small software organizations are further taken into account by tailoring process areas and interpreting specific goals and objectives.

The rest of the paper is organized as follows: Section 2 presents the project background, including a review of previous similar research, along with the description of the software company which is the subject of process improvement, and its previous improvement efforts. In Section 3, the general method of improvement is described, including the role of the balanced scorecard analysis with other methods and defined inputs. The results of the case study are presented in Section 4, where all the necessary steps required by the IDEAL model have been performed. Finally, Section 5 presents the conclusions of the paper.

II. BACKGROUND

A. Software process improvement in small companies

The general guidelines for SPI within the CMM-based models are described by the Software Engineering Institute (SEI) in their IDEAL model [6]. It provides an

approach for continuous process improvement by describing in detail steps needed to initiate and successfully conclude the improvement program [3]: (I)nitiating: Laying the groundwork for the process improvement; (D)iagnosing: Determining the current and desired state of the maturity; (E)stablishing: Planning a specific way to achieve the desired state; (A)cting: Execution according to the previously established plan; (L)earning: Aquiring knowledge and learning from experience. However, as previously noted, the challenge for successful process improvement in SMEs contains additional issues that need to be resolved. In CMMI, there are a large number of process areas with generic and specific goals needed to achieve, having a large number of limitations and challenges [7]. To overcome the problems and limitations, opportunities presented by the specific environment of SMEs are described with emphasis on the relationship between business goals and CMMI efforts [8], [9].

Since its introduction, the Balanced Scorecard methodology has usually been used for strategic management and corporate planning. Later research questioned how it can be applied in small and medium companies given their characteristics [10]. In [11], the CMMI-based SPI is presented, where the general business goals are classified by a balanced scorecard, and later linked to the improvement criteria.

B. *Description of company*

The company described in the case study is positioned in the Bosnia and Herzegovina market with a goal to "develop and maintain business software for enterprise organizations". It is a private company with 25 employees, including managers, project managers, developers, and other employees working on their business goals.

The company previously reached the ISO/IEC 12207 [12] certificate in order to improve the company's positioning in the domestic market, but also to achieve the prerequisites for entering the international market. At the suggestion of an external consulting firm (further noted as SCC), the company's management initiated a procedure for process maturity assessment within the CMMI framework.

The formal improvement program carried out by SCC consisted of assessment activities and recommendations for the continuation of the improvement project.

TABLE I. SCC ASSESSMENT

Key Process Area / Level	**Assessment**
Repeatable (Level 2)	
Requirements management	.75
Project Planning	.5
Project Monitoring and Control	0
Supplier Agreement Management	0
Process and Product Quality Assurance	1
Configuration Management	.5

The SCC delivered its final report based on the CMM levels of maturity. Table I. presents the results of the SCC assessment, including the assessment of individual process areas, on a scale between 0 and 1. At Level 3, only three process areas with positive (0.5) assessments were recognized: Organizational Process Focus, Organizational Process Definition, and Product Integration.

III. METHOD

Based on the previously presented results, the company's management has decided to continue with the improvement activities based on measurable results that should be related to business goals.

As a direct improvement goal, it could now already be declared as satisfying Level 3, taking into account the previous maturity assessment. However, after analyzing the process areas where improvement is needed, the following issues were revealed:

- *A large number of process areas for improvement*: Having six process areas at Level 2 and seven process areas at Level 3, several dozen in total need to be implemented.
- *Lack of a standardized method for improvement*: Although the SEI offers the IDEAL model for process improvement, it's still too broad and doesn't clearly describe how to deal with each specific situation in an organization, especially in a small organization.
- *Insufficient budget for consulting services*: The management was not able to provide, nor expand the budget needed for external consulting services.

Considering these issues in the context of the research, it was necessary to create a new approach for the formal extension of the improvement program. During the analysis of the CMMI Integration model, it was found that it contains similar elements to the ISO/IEC 12207 standard. Additionally, the model provides a continuous presentation that enables the selection of process areas adapted to the direct needs of the company's business goals, without the need to satisfy all process areas before moving to a higher level of maturity.

The second question was related to the selection of process areas for improvement. The idea was to use the previous assessment given by the SCC, and additionally to align the selection and the overall improvement process with company business goals. As business goals are a subject of frequent changes in small organizations, it is necessary to first specify the business goals in more detail. The technique used for this purpose is the Balanced Scorecard table, which has been widely used and developed in practice within improvement programs.

A summary of the proposed method that combines several techniques along with the necessary inputs can be described in the following, as presented in Fig. 1:

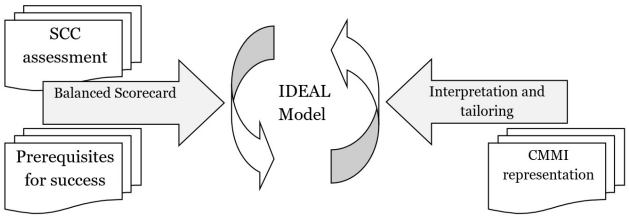

Figure 1. Proposed improvement method

1. The framework for improvement is the CMMI for Services
2. The basic model for the improvement process is the IDEAL model
3. The technique for selection, evaluation, and connection of process areas with business goals is the Balanced Scorecard table
4. Use the following input parameters:
   - Previous assessment results of SCC
   - Previously recognized prerequisites and risks of improvement in SMEs
5. Interpretation and tailoring of the CMMI model for selected business and process areas will be carried out according to SEI recommendations and practices from other cases.

There was also an additional input containing a set of prerequisites for success. This is especially emphasized in SPI projects in SMEs environment, given the previously described specific challenges.

IV. RESULTS

Following the adopted method, the IDEAL model is used to follow up the predefined phases and steps needed to accomplish the SPI project.

A. Initiating

The stimulus for change of the existing business practices is partially explained in previous chapters, and can be specified as the following:

- Changes in the company's business environment and market demand.
- Management's decision to continue with the software processes improvement project.

To establish the context in which changes should be made, the following questions were discussed and analyzed:

- What specific business goals, direct and indirect, should be realized or supported by these changes?
- What are the expected business benefits from the changes and SPI?

TABLE II. BALANCE SCORECARD TABLE

	Objectives	**Measures**	**Targets**
Financia	Increase sales revenue; Increase profitability	Income	Current Income *1.2
		Profit	Current Profit * 1.3
Customer	Acquire new customers; Retain customers; Offer standardized maintenance services	New customers	Current: 2 /year Target: 5 /year
		Customer churn	Current: 10% Target: 0%
		Maintenance services	Current: ~ 150 Target: ~ 30
Internal business process	Frequently add new features; Enable predictable maintenance costs & deadlines; Proactively control of development & maintenance	New major features	Current: 5/application/year Target: 10/application/year
		Average requests' resolution time	Current: 7 working/days Target: 3 working/days
		Coverage of tasks with automation utilities	Current: development tasks Target: support and maintenance tasks
Learning & Growth	Provide training for staff: software maintenances activities, standards & process	Training hours	Current: 0 h Target: 15 h

Given the discussion with the management, a sample of the resulting Balance Scorecard table was prepared and presented to the management. There were also other inputs taken in the preparation: analysis of quarterly and annual business and financial reports, and broad market analysis. The results are presented in Table II. Along with the strategic mapping, the key indicators for measurement and their target values were identified.

The resulting Table II shows that the critical success factors are mostly concentrated around software maintenance and customer support activities when insight is taken from the process perspective. This also leads to the conclusion about the slight, yet obvious shift in the goals taken from the management perspective: from the initial software development business, as stated by the management, towards the support and maintenance activities. The results could be explained by the current customer base: there are 20 customers with about 3,000 end-users, and 15 software applications provided and maintained. The average duration of the current maintenance contracts is 5.4 years.

The main effect of using the Balanced Scorecard is the conclusion that the software maintenance processes are the primary group of areas that should be carried out. The company's management has agreed to participate directly in those parts of the activity where their participation is necessary.

The necessary resources are allocated in terms of the following: one project manager, two senior developers, and external consultants including the authors of this paper. The formal initiation document containing previously defined goals, resource allocation and expected results of the improvement is created.

B. Diagnosing

The most critical part of the program was the Diagnosing phase, where the current and the desired - future state of the software processes should be clearly stated, as well as the development of recommendations. Having the recognized support and maintenance tasks as the pillars of internal processes, the following problems were identified:

- There is no formal department within the company responsible for support and maintenance tasks
- The activities are poorly documented
- The nature of the job is reactive, with customers dictating the entire work and deadlines, including sparse communication.

The recommendations have been completed using interpretation and tailoring of the CMMI model for selected process areas according to SEI recommendations. Recommendations from previous case studies which provide a relevant interpretation of process tailoring in SMEs were also used [9], [13], [14], and can be summarized in the following statements:

- Consider each contracted service level or business maintenance contract as an individual project
- Create maintenance projects within the Service Level Agreement (SLA)
- Enable quality assurance and control for each project.

C. Establishing

The establishing phase is required to develop a detailed work plan. The process areas presented in Table II required their prioritization due to limited resources and organizational goals defined within the Balanced Score table. The priority-based approach was developed using the following weight factors for each process area: impact on business goals, the complexity of changes, commitment to improvement, and impact on customers. The resulting priorities on a scale between 1 and 5 are presented in Table III. The process areas with an average weighting factor >= 3.5 were selected for priority in the improvement.

Before the action plan, the following actions needed for the improvement were specified:

(a) Map all internal maintenance tasks and assignments to selected process areas (bolded in Table III) and integrate them with the existing Workload system
(b) Classification of all maintenance requirements according to the ISO/IEC/IEEE 14764 standard

TABLE III. IMPROVEMENT PRIORITIES

	Process area	Weight factors				
		Impact on business goals	Complexity of change	Commitment for improvement	Impact on customers	Average
1.	**REQM - Requirements Management**	**5**	**3**	**3**	**4**	**3.75**
2.	**PP - Project Planning**	**4**	**4**	**3**	**4**	**3.75**
3.	PMC - Project Monitoring and Control	3	4	2	4	3.25
4.	**MA - Measurement and Analysis**	**4**	**2**	**3**	**5**	**4**
5.	PPQA - Process and Product Quality Assurance	3	3	2	4	3
6.	**CM - Configuration Management**	**5**	**3**	**4**	**3**	**3.75**
7.	**REQM - Requirements Management**	**5**	**4**	**4**	**4**	**4.25**
8.	SAM - Supplier Agreement Management	5	3	3	2	3.25
9.	**SD - Service Delivery**	**5**	**3**	**4**	**5**	**4.25**
10	**WMC - Work Monitoring and Control**	**5**	**3**	**3**	**4**	**3.75**
11	**WP - Work Planning**	**5**	**3**	**3**	**4**	**3.75**
12	OT - Organizational Training	3	3	2	2	2.5
13	RSKM - Risk Management	3	2	2	3	2.5

(c) Create standardized Service Level Agreements and offer them to all current customers and prospects
(d) Name a single point of contact for each customer
(e) Introduces software tools for the automation of support and maintenance tasks
(f) Perform internal training for all staff.

Based on the defined actions, a detailed plan with a schedule, activities, milestones, and responsibilities was developed.

D. Acting

According to the previously prepared action plan, the members of the process group and management were trained. The management prepared analytical reports on the implementation of existing maintenance requirements. Reports have shown that there are about 150 different maintenance and support requests from customers and end users. Requirements refer to all areas of software, system software, software, and information systems in a broader sense, hardware platforms, requests for consulting, etc. Through a detailed analysis, those 150 different requirements were reduced to about 40 standard requirements, and then the requirements were classified according to ISO/IEC/IEEE types of software maintenance.

Upon completion of the classification, mapping, and interpretation of the process according to process areas were accomplished. This activity was of crucial importance for the implementation of all other improvements within selected process areas. In Table V an extract of the interpretation of the process area Requirements management is presented.

Additionally, the entire workflow of the maintenance process was documented and presented to all stakeholders. Afterward, the standardized SLA was created and presented to customers.

TABLE V. INTERPRETATION OF PROCESS AREA REQM

Specific goal / Practice (SP)	**Interpretation**
SG 1 Manage requirements - Requirements are managed and inconsistencies with plans and work products are identified.	
SP 1.1 Understand requirements	The customer manager (single point of contact) should understand the requirements and should be committed. Present the documented requests from SP 1.2 to the customer's authorized person and ask for confirmation of understanding of the request.
SP 1.2 Obtain Commitment to Requirements	
SP 1.3 Manage Requirements Changes	The customer's authorized person is authorized to approve changes during the implementation of the request within the agreed SLA. Each person from the customer's side should have the appropriate access level to the help desk software.
SP 1.4 Maintain Bidirectional Traceability of Requirements	The SLA manager reviews requirements and checks whether they are in line with SLA and the software product, and also checks bidirectional traceability between source requirements and lower requirements.

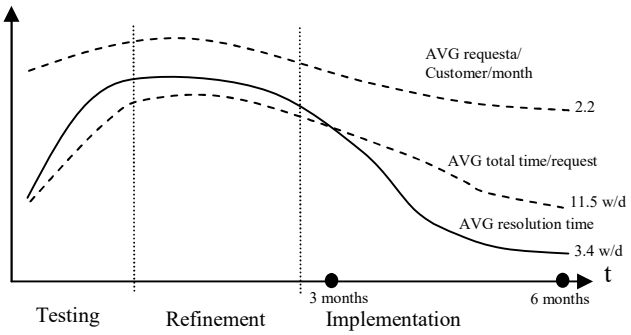

Figure 3. Monitored measures

After the completion of all the main activities from the activity plan, the solution with real examples from selected customers was tested. The testing results showed certain improvements, and a few weaknesses, though. For example, the customers demanded high urgency in resolving each documented request, explaining the requests were not classified correctly. On the maintenance side, the staff demanded an additional explanation about the term "required level of details" presented in a few interpretations of specific goals and also asked for clarification of the required amount of documentation needed to satisfy related practice. The additional training of stakeholders was completed to help with the requests prioritization and to clarify the amount of documentation.

For the further implementation of the solution, the gradual approach was selected. Along with each presented and signed SLA, the corresponding customer's training was carried out, and the single point of access with the company for each customer was named. The following implementation measures were monitored:

- Average resolution time per request (unit: working day)
- Average total time spent on the request's processing (unit: working day)
- Average number of requests per customer per month

In Fig. 3, the values per the timeline are presented. The resulting graph shows a steep growth during the testing phase for all values, following the stable values in the refinement phase, and later decline in the implementation phase. This is especially noticeable for the total time spent on each request, having the increased number of support activities introduced in the process. The staff needed additional time to acquire the necessary skills for documentation of each process, and using the implemented software tools.

E. Learning

By comparing the goals set at the beginning of the improvement cycle with the results, the following effects of the improved processes and practices can be concluded:

- Improved flexibility and readiness of the company to accept and resolve requests within a shorter resolution time with the same resources

- Improved understanding of tasks, assignments, and expected results of support staff
- Improved customer understanding and expectations regarding resources spent on each request.

Besides the positive effects, there were also several issues recognized that needed resolution during the implementation, such as the difference in levels of motivation of the staff working on the improvement. It was necessary to repeat several training sessions for customer management and the persons responsible for daily contact with customers.

Given the overall results of the improvements and the gained experience, there are a few recommendations and proposed feature actions:

- Introduce and implement software tools for configuration management (CM) and requirements management (RM)
- Automation of the workflow system and its integration with the help desk, CM and RM systems
- Prepare and launch the following improvement cycle: the goal should be to improve all process areas within Level 3 of the maturity currently not considered, e.g. PMC - Project Monitoring and Control, and PPQA - Process and Product Quality Assurance.

V. CONCLUSIONS

Small and medium software companies should provide a proportionally greater effort compared to large organizations in the SPI. There are a lot of limiting factors that prevent successful process improvement, and the pursuit of a successful approach for each case is constantly present. By using the CMMI for Services with the continuous presentation, the ground prerequisites for continuous improvement are provided in a way that can be easily applied in small software organizations with limited resources. The Balanced Score table enabled the possibility to directly link the company's business goals with the improvement efforts. Although there could be an additional discussion about whether it should be analyzed in the diagnosis phase (the description of the current state vs. desired future state), it assured its purpose. Eventually, it further enabled the selection of process areas for improvement that best match the business goals. This created a specific improvement path presented in this case study and provided the prerequisites for easier implementation of improvements according to the CMMI framework. It also ensured that efforts and resources spent on improvement would be measurable and profitable for organizations with sparse resources. As the improvement process is an ongoing and permanent project, there are a lot of further actions that need to be performed. The software company described in this case study continues with its effort and prepares its processes for the formal CMMI assessment. This is aligned with the widely accepted recommendations for continuous improvement as the primary way to meet business goals.

REFERENCES

[1] W. S. Humphrey, "Characterizing the software process: a maturity framework," *IEEE Softw.*, vol. 5, no. 2, pp. 73–79, 1988.

[2] Software Engineering Institute, "CMMI for Services, Version 1.3," Pittsburgh, Pennsylvania, 2010.

[3] B. Karahodza, E. Avdagić-Golub, and A. Čolaković, "Assessment of factors affecting the software process improvement in small organizations," *Sci. Eng. Technol.*, vol. 2, no. 1, pp. 7–15, 2022.

[4] M. Tuape and Yirsaw Ayalew, "Factors affecting development process in small software companies," in *SEiA '19: Proceedings of the 2nd Symposium on Software Engineering in Africa*, 2019, pp. 16–23.

[5] J. G. Romana Vajde Horvat, Ivan Rozman, "Managing the complexity of SPI in small companies," *Softw. Process Improv. Pract.*, vol. 5, no. 1, pp. 45–54, 2000.

[6] B. McFeeley, "IDEAL SM: A User's Guide for Software Process Improvement. CMU/SEI-96-HB-001," Carnegie Mellon University, Pittsburgh, 1996.

[7] N. Wongsai, V. Siddoo, and R. Wetprasit, "Factors of influence in software process improvement: An ISO/IEC 29110 for very-small entities," in *2015 7th International Conference on Information Technology and Electrical Engineering (ICITEE)*, 2015, no. July 2020, pp. 12–17.

[8] A. F. H. Conradi, "Improving Software Process Improvement," *IEEE Softw.*, vol. 19, no. 4, pp. 92–99, 2002.

[9] G. Coleman and R. O'Connor, "Investigating software process in practice: A grounded theory perspective," *J. Syst. Softw.*, vol. 81, no. 5, pp. 772–784, 2008.

[10] H. Andersen, L. Gavin, and I. Cobbold, "Balanced Scorecard implementation in SMEs: reflection in literature and practice," in *4th SME-SME International Conference*, 2001, pp. 1–10.

[11] J. Soini, K. Harri, and T. Mäkinen, "Toward a balanced software business measurement," in *3rd Software measurement European Forum*, 2006, pp. 33–46.

[12] ISO/IEC 12207:2008, "Systems and software engineering — Software life cycle processes," 2008.

[13] P. Allen, M. Ramachandran, and H. Abushama, "PRISMS: An approach to software process improvement for small to medium enterprises," *Proc. - Int. Conf. Qual. Softw.*, vol. 2003-January, pp. 211–214, 2003.

[14] N. Paternoster, C. Giardino, M. Unterkalmsteiner, T. Gorschek, and P. Abrahamsson, "Software Development in Startup Companies : A Systematic Mapping Study," *Inf. Softw. Technol.*, vol. 56, no. 10, pp. 1200–1218, 2014.