Strategic Alignment of Software Process Improvement Programs Using QFD

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ABSTRACT

Software process improvement programs increase the competitiveness of software development organizations. But a critical success factor in this context is the proper alignment between the strategy of such programs and the organization's business strategy. In this paper, we discuss how Quality Function Deployment can be used as a technique to align strategic goals and software process within an organization, presenting results of its application in a small company in Brazil.

Categories and Subject Descriptors

D.2.9 [**Software Engineering**]: Management – *Software process models (e.g., CMM, ISO, PSP), productivity, cost estimation, time estimation, life cycle.*

General Terms

Management, Documentation, Standardization.

Keywords

Software process improvement, strategic planning, strategic alignment, CMMI.

1. INTRODUCTION

Software process improvement (SPI) programs increase the competitiveness of software development organizations [6]. But a critical success factor in this context is the proper alignment between the strategy of such programs and the organization's business strategy [2, 3, 7, 9, 17, 21].

However, the existing software quality models, such as the CMMI-SW, don't provide proper guidance on how organizations should define their processes based on their strategies [5, 15]. As the result, processes are implemented, but there is no guarantee that they will satisfy the strategic goals [10].

According to McCoy, process improvement may result in processes that, when institutionalized, aimed at the complete satisfaction of goals defined based on the organization's strategic planning (SP) [11]. The same author states that competitive advantages may be obtained when there is synergy between SP and process improvement.

QFD (Quality Function Deployment) is an effective technique that can be used to align SP and software process improvement. Several studies have proposed [8, 18, 22] the use of QFD together with SPI programs, but they fail on presenting empirical results from the use of this method.

For this reason, the purpose of this paper is to present QFD as an alternative to the strategic alignment of a SPI program. We briefly explain the concepts involved in strategic planning, SPI, and QFD, and present results of the use of QFD in a small company in Brazil. A preliminary evaluation indicates that the use of QFD can help organizations to see better and faster results in their SPI programs, with a reduced investment in the early phases.

This paper has the following structure: Section 2 presents the theoretical background. Section 3 discusses the use of QFD to support the strategic alignment of SPI programs. Section 4 presents the results obtained from the use of QFD in a small company in Brazil. Section 5 presents the lessons learned, and Section 6 concludes the paper.

2. THEORETICAL BACKGROUND

2.1 Strategic Planning (SP)

Strategic planning is a managerial tool that produces important decisions and actions to guide an organization in the long-term (usually three or five years). According to Mintzberg, SP can be summarized by the analysis of strengths and weaknesses, threats and opportunities (SWOT) of an organization, the definition of goals, investment and operational plans [12].

The organizational goals, derived from the SP, indicate "what" has to be done in order to achieve the results planned [14]. The goals are usually related to quantifiable milestones.

2.2 Software Process Improvement (SPI)

According to Pitterman [16] and Yamamura [20], a software development process improvement has been raising the quality of the information systems produced, reducing costs and effort spent

in the projects, while increasing the productivity of the activities performed. In this sense, the improvement of process quality is one of the main purposes of the software manufacturers, which can result in improvements in the final product as well.

Generally, companies structure process improvement programs based on pre-established software process reference models, such as the CMMI-SW. Such models establish, through maturity levels, software engineering best practices so that the companies can develop their processes.

Although the main software process reference models are structured by means of maturity levels, the investment required for the implementation of each one of these levels is still the main difficulty, mainly for small companies [6, 13]. Therefore, an option to make such initiatives feasible in such companies is prioritizing the implementation of the most important process improvements for the organization.

2.3 Strategic Alignment of SPI Programs

Process improvement may result in processes that, when institutionalized, intend to meet the goals defined in the organization's strategic planning [15]. Furthermore, the alignment between the strategy of a process improvement program and the organizations' business strategies has been mentioned as a critical factor of success of software process improvement programs [2, 3, 7, 9, 17, 21]. Such alignment shall guarantee that the processes institutionalized by an organization are guided towards the strategic goals, instead of only approaching the software engineering best practices established in the software process reference models.

Nevertheless, the strategic goals are not easily related to the process improvements to be implemented by an organization in the main software process reference models [5, 10, 15]. Companies develop their processes using these guidelines, but with no guaranty that these processes will be focused on the companies' business strategic goals. In this context, Quality Function Deployment (QFD) was found to be an effective technique to align and prioritize the process improvements based on the organizations' strategic goals.

2.4 Quality Function Deployment (QFD)

QFD was found to be an effective technique to align and prioritize the process improvements based on the organizations' strategic goals. It has been used in several domains, such as food, electronics, and information technology [10]. Thus, such technique was used as basis for the application of a strategic alignment process for improvement programs.

The QFD technique proposes the planning of goal-oriented actions in order to maximize the quality of a product. Approaching an organization's software development processes as a product, such technique is applied so that the process improvements are oriented towards the organization's goals as defined in the strategic planning.

This paper is not intended to describe the QFD technique; however, such technique can be seen in details from [1]. The main difference between this technique and traditional quality systems for example is the attempt to maximize the product quality through satisfying the client's goals [1].

This technique uses several matrices to collect, analyze and manage goals towards a final product. However, 95% of the studies applying QFD so far use only the first matrix, called House of Quality (HoQ) [4]. Basically, such matrix relates "what" – goals on a high abstraction level – to "how" – actions on low level [22]. Therefore, a crossover between rows versus columns is established and the impact analysis of each one of the relationships is determined in accordance with Table 1.

Table 1. Relationship levels

Impact	Value	Symbol
High	9	■
Medium	3	⬡
Low	1	▲
None	0	N/A

An example of HoQ is presented in figure 1.

Figure 1. House of Quality matrix.

The final product of an SPI program is the evolution of software development processes based on Software Engineering (SE) best practices. Then, the success of a SPI program is related to how the new and defined processes satisfy the organizational goals.

In this paper, we have applied three House of Quality matrices to collect, analyze and manage organizational goals within a SPI program, adapting the original QFD proposal. These matrices are used to link organizational goals with SE best practices. Such best practices are usually found in quality models such as CMMI-SW. As the result, an organization can identify what are the most important process improvement actions to be taken in the beginning, based on their strategic goals.

3. APPLYING THE PROPOSAL

This proposal was applied in a small software development company in Brazil. Such company develops corporate portals and web solutions related to information and knowledge management, focusing especially on increasing the productivity of its customers. The company has been active in the market for 10 years now, employing nearly seventy professionals allocated in two Brazilian capitals (Sao Paulo and Porto Alegre).

In order to fill in the first matrix, called HoQ Strategic Goals x Tactical Goals, four strategic goals with the improvement of

processes were defined from the strategic planning: increase profit, increase customer satisfaction, improve product quality, and prospect and produce larger projects. The current situation of these goals was checked via metrics (Table 2).

Table 2. Current situation

Stategic Goals	Situation
Increase profit	Profit margin: 9,25%
Increase customer satisfaction	customer assessing vendor: range from 1 to 5 (where 1 is very bad and 5 is excellent): 3.6
Improve product quality	Number of defects (after delivery): 21 per project
Prospect and develop larger projects	Average project sale price: U$ 45000

For each one of the strategic goals, the strategic planning was analyzed again, and related tactical goals were defined. In Figure 2, the matrix developed is presented.
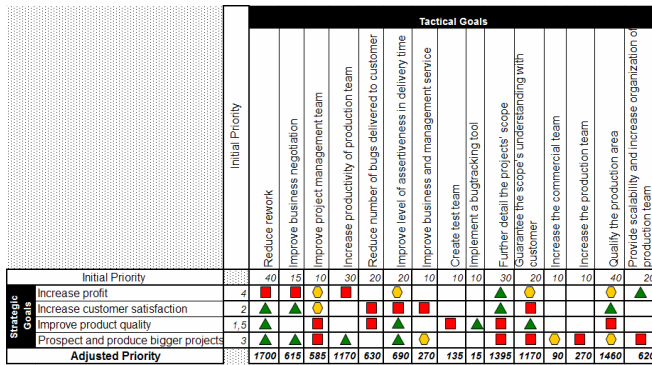

Figure 2. Strategic Goals Vs. Tactical Goals Matrix.

In the next step, current problems with the organization's software development process and its respective causes were identified. A value was also established to represent the priority of each cause of process problems. And the second matrix, called HoQ Tactical Goals x Cause of Problems was defined.

The last matrix, HoQ Tactical Goals x Processes, was used to link tactical goals to the CMMI-SW level 2 process areas. In the end, the priority of each process area was defined, based on the priority of each tactical goal.

3.1 Results

On applying the proposal, three process areas came up as the most important within the organization: Requirements Management (REQM), Project Planning (PP), and Project Monitoring and Control (PMC). It is important to say that this does not mean that the organization will invest only in those three areas, but will focus on them first, since apparently most of the problems and goals are related to such areas. The result of this QFD application was the planning of the SPI program focusig the three process areas as an initial step. According to

Table 3, the expectation with the SPI program was established using quantitative measures, related to the strategic goals.

Table 3. Organization's expectation with the SPI program

Stategic Goals	Expectation
Increase profit	Profit margin: 20%
Increase customer satisfaction	customer assessing vendor: range from 1 to 5 (where 1 is very bad and 5 is excellent): >4
Improve product quality	Number of defects (after delivery): zero per project
Prospect and develop larger projects	Average project sale price: > U$ 120000

In order to evaluate in what extent the SPI program was helpful on reaching the goals, four pilot projects were developed and observed. Those projects were developed using the new processes defined based on the three process areas, REQM, PP, and PMC. The results are presented in Table 4.

Table 4. Results achieved with the SPI program

Strategic Goals	P1	P2	P3	P4	Av
Increase profit (%)	23,04	17,29	20,05	29,90	22,5
Increase customer Satisfacton	5	5	3.5	5	4,6
Improve product quality	5	3	NC*	NC*	4
Prospect and develop larger projects (U$)	23800	21000	22400	119600	46700

*NC – not collected yet, projects not finished.

4. DISCUSSION

Analyzing the four projects, a number of benefits were obtained from the implementation of the three process areas, based on the application of QFD. This is described next.

4.1 Increase Profit

The organization's expectation for the strategic goal of increasing profit is that the process improvement secures a profit margin of 20% in the projects. Analyzing the profit margins of the four projects presented, it is found that only one of them stayed below that expectation. Project 2, with profit margin below 20%, was the only one with a smaller sale price. Thus, it is clear that the setting of a profit margin basically depends on a commercial process.

However, the implementation of the three process areas assured that the margins established during such commercial process could be secured until the end of the project (or at collection time, for projects in progress), including the margin of 17% of project 2, although it is below the expectations.

4.2 Prospect Larger Projects

The process definition using as basis a software process reference model resulted in smaller projects having a higher cost. In addition, it was found that as the project value is smaller, proportionally, the profit margin of these projects is also smaller. Therefore, the process improvement did not facilitate the accomplishment of the strategic goal related to obtaining larger projects, but actually obstructed the execution of smaller projects. The management view is that process improvement establishes the company's need in working with larger projects. That becomes clear when one of the organization's strategic goals is prospecting and producing projects greater than $45 thousand.

The average sale price of the four projects was $47 thousand, but projects 1, 2 and 3 are characterized by the organization as small projects, with the exception of project 4, which brought the average value up. Generally, the organization's perspective is that the process improvement guarantees that the profit margins of the medium and large projects are established and kept above 20%.

4.3 Increase Customer Satisfaction

The implementation of the three process areas guaranteed that the deadlines of the pilot projects could be better established and maintained. Thus, in project 4, the customer attributed value 5 (highest grade) for his satisfaction with the project and stated: "Things are going really well. The deadline is being complied and that was an important requirement for this project."

Nevertheless, the definition of process improvements generated the need of more documentation and approvals from the customer. For that reason, project 3 received the value 3.5 concerning customer satisfaction. The customer reported the following reason for such grade: "I think the control sending is excessive. For example, in certain weeks I receive 3 or 4 control documents, and this excess ends up being a little confusing".

Projects 3 and 4, as previously mentioned, are currently in progress. Thus, the customer satisfaction was pretty much related to meeting delivery deadlines, and the three process areas had direct impact on customer satisfaction.

Regarding the fact that project 3 received a low grade because of excessive control, such situation was identified as normal. In an improvement program, the first processes defined tend to require excessive bureaucracy; however, as the process is developed, this problem is dealt with.

4.4 Improve Product Quality

The customer satisfaction in concluded projects, such as projects 1 and 2, approaches other matters, besides deadline compliment. At this point, the customer assesses the product quality delivered. Now, there is a direct relation between the increase of customer satisfaction and the improvement of product quality.

In that sense, it is found that both pilot projects had grade 5 in customer satisfaction, precisely for having a small number of defects and low rework rate. In spite of that, a direct relation between the improvement of product quality and the process improvements performed was not explicitly found. Generally, the

changes in Requirements Management and Project Management have little effect on the work of developers and testers, for example.

The organization's expectation with the process improvement is increasing its customer-satisfaction current average of 3.6 to a minimum of 4. With the process improvement which was carried out, it is found that such expectation can be secured in customer satisfaction polls throughout the project, when the main point analyzed is compliance with delivery deadline. Regarding the customer-satisfaction poll at the end of the project, not much will be established for the process improvement made.

5. LESSONS LEARNED

Generally, SPI programs have been conducted disregarding the importance of a strategic alignment process at an early stage. Based on the use of QFD, the following lessons learned were identified.

#1 - Strategic goals with the improvement program: Despite the importance of having defined and analyzed strategic goals with the software process improvement program [10], it became clear that, in general, process improvements are planned and carried out without taking such goals into account. In case the proposed process was not applied to the studied organization, little effort would be made in that sense. Moreover, the possibility of defining processes oriented towards the strategic goals of the organizations is unknown by those involved in an improvement program. Generally, it was found that the programs have been structured to meet the requirements of a software process reference model, and not the organization's strategic goals.

#2 – Existing problems in the software development process: It is essential that a process improvement program approaches the existing problems in the software development process and proposes solutions [8]. The organizations' everyday problem solving produces commitment and interest from those who perform the defined processes. Nevertheless, it was found that different roles identify different problems, and the existence of a consolidation of such problems on organizational level is not common. Most of the times, a problem is solved, not because proactive action was taken, but because there was a requirement from a software process reference model comprising it.

#3 – Involvement of associates: At the beginning of an improvement program, the first versions of the processes defined are very difficult to be implemented. Generally, such initial processes tend to be excessively bureaucratic, change the way how the work was previously done, and require more capacities from the associates. From the case study, it was found that the associates who overcome such difficulties and execute the defined processes are justly those who are involved in the decisions and activities of the improvement program. According to [14], the involvement of an organization's associates in a process improvement program is one of the main critical factors of success of these initiatives. In practice, the strategic alignment process can involve different hierarchical levels and secure the commitment from those who were involved.

#4 – Monitoring of SPI programs: Defining strategic goals for a process improvement program from the organizations' strategic planning facilitates the assessment of such initiatives. Generally, a strategic planning analyzes the organization's current situation by means of metrics. Therefore, when a strategic goal is established for a process improvement program, it can be related to clear goals, generating expectations. Such goals involve the senior management and allow assessing whether an improvement program is being successful.

#5 – Required investment: One of the main difficulties to carry out improvement programs is the required investment [6, 13, 19]. Therefore, the expectation is that such programs generate results as quickly as possible. In addition, the most important element identification of a software process reference model for an organization allows the first efforts to be spent on these elements. Considering that these elements were prioritized from a consolidation of the organization's needs, the probability of effective results right from the beginning of improvement programs is increased.

6. CONCLUSIONS

The purpose of this paper was to present QFD as an alternative to align a SPI program and the organization's strategic goals. It is known that one of the main difficulties of SPI programs is the investment necessary [6, 13, 19]. And the definition of priorities related to process areas can help in this direction.

In addition, the strategic alignment of SPI programs allows the identification of what investments should be planned up front when engaging in such programs, maximizing the results of these programs in a shorter period of time.

The results attained from this research point towards the importance of having approaches allowing the identification of the organizations' strategic goals and, from those, the priorities in a software process reference model. In such case, SPI programs can be directed towards the company's strategy and seek for better results.

7. ACKNOWLEDGMENTS

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