AN APPROACH TO SUPPORT THE STRATEGIC ALIGNMENT OF SOFTWARE PROCESS IMPROVEMENT PROGRAMS

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Abstract: The alignment between the strategy of a software process improvement program and the organizations' business strategies has been mentioned as a critical factor of success. However, the main software process reference models do not explicitly guide the companies towards defining processes which meet their strategic goals. Based on this context, the purpose of this paper is to present a process for the strategic alignment of software process improvement programs. Preliminary results indicate benefits beyond the demands of a software process reference model itself, which include the planning and execution of a software process improvement program taking into account the organization's strategic goals in a more systematic way.

1 INTRODUCTION

The modern software development organizations are inserted in a dynamic and competitive market. In this context, the Software Engineering area approaches the improvement of a software development process, by means of planning and execution of improvement programs, as the agent responsible for increasing the competitiveness of these companies (Dybå, 2005).

Considering the substantial investment required by such programs, the organizations tend to seek explicit reasons to put these initiatives into practice. One way to identify these reasons is defining the strategy of an improvement program based on the organization's business strategic goals.

However, in the main software process reference models existing in the industry today, such as SW-CMM and CMMI, such goals are not easily related to the software development processes to be implemented by an organization (Debou, 1999; Liu, 2005; Peterson, 1995). As a consequence, organizations carry out improvement programs without identifying what the maturity of their processes can deliver concerning their business strategic goals (Liu, 2005).

Therefore, this paper presents a research carried out intending to propose a strategic alignment process for software process improvement (SPI) programs based on organizations' strategic planning. The proposed process was applied to a company through a case study. From such study, an evaluation and a review of the process were performed.

In the sequence of the paper, section 2 presents the theoretical review. In section 3, the research methodology is described. Section 4 describes the proposed process and section 5 describes its application to a company. Section 6 presents the evaluation of the proposed process, and Section 7 a discussion based on the results found. Section 8 concludes the paper.

2 THEORETICAL REVIEW

An organization's success depends more and more on information systems as a competitive advantage. Nevertheless, the purchase of such information systems is complex, in view that the software projects frequently fail either in schedule, cost or quality.

According to (Pitterman, 2000; Yamamura, 1999), a software development process improvement has been rising the quality of the information systems produced, reducing the costs and the effort spent in the projects, while increasing the productivity of the activities performed. In this sense, the improvement of processes 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

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models, such as SW-CMM (Paulk, 1993) and CMMI (Chrissis, 2003). They are used as process definition guidelines through levels that assist the companies in the evolution of their processes.

These software process reference models establish software engineering best practices for the companies to use as basis in the definition of their processes. Nonetheless, such models do not explicitly guide the companies towards defining processes which meet their strategic goals (Liu, 2005). As a consequence, companies develop their processes using these guidelines, but with no guaranty that these processes will be focused on the companies' business strategic goals.

However, 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 (Biro, 1999; Brodman, 1995; Grady, 1997; Humphrey, 1989; Pulford, 1996; Zahran, 1998). 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.

According to (McCoy, 1998), the process improvement may result in processes that, when institutionalized, intend to meet the goals defined in a strategic planning (SP). This same author states that competitive advantages can be attained when the synergy between SP and process improvement becomes properly compatible.

When the SP is started, it is focused on the goals established for the organization and on the current diagnosis. As a result, feasible purposes and strategies are defined to meet such goals. Regarding process improvement, the basic inputs are purposes, strategic actions and resources. The result is a set of optimized processes which, when institutionalized, facilitate the performance of necessary activities to meet the organization's goals.

In that sense, in order to define processes that meet the strategic goals of the organizations, an improvement program shall be aligned with the business strategy. Considering the existing relationship between improvement programs and strategic planning, this paper presents a research which specifically approaches the strategic alignment of software process improvement programs.

3 RESEARCH METHODOLOGY

This is a research applied to the area of information systems. Since the theme is an emerging area, the use of an exploratory and qualitative research was defined. Regarding the research method, a case study was conducted, adopted as proposed by (Yin, 2003). The research was organized in three stages: theoretical review, development and evaluation.

The first stage started with the study of existing literature. The review comprised software quality literature, software process improvement, strategic planning and strategic alignment. During the development stage, a strategic alignment process of software process improvement programs (called AE-MPS) was defined and a supporting tool was developed. The evaluation stage was intended to check the suitability of the AE-MPS process by carrying out a case study.

With the purpose to systemize the task of collecting and analyzing data originated in the case study and, consequently, increase reliability, a protocol for the development and formalization of the study was defined and used. For the data collection, a triangulation process was used: structured interview, with open and closed questions, direct observation and documentation (Yin, 2003).

The structured interviews were applied through two research instruments. The first was a questionnaire exploring the analysis of the company situation in a moment prior to the application of the AE-MPS process. The second was a questionnaire to evaluate the suitability of the proposed process regarding its purpose, efficiency of the supporting tool and the company situation after the use of AE-MPS.

With the structured interviews, a content analysis through category identification was performed. The document review allowed the corroboration and appreciation of the evidences arising from the interviews, providing further details regarding the answers from the interviewees. The observations delivered additional information about the application of the AE-MPS process.

Based on the qualitative analysis of the data, an evaluation of the AE-MPS process was performed. Furthermore, a review of the proposed process was carried out. In the following section, the structure of the AE-MPS process is presented.

4 AE-MPS PROCESS

The proposed process is intended to align the strategy of a software process improvement program based on the organizations' strategic planning. As a result of the application of such process, the most important elements of a software process reference model for the organization can be identified.

The Quality Function Deployment (QFD) technique proposes the planning of goal-oriented actions in order to maximize the quality of a product (Akao, 1990). Approaching an organization's software development processes as a product, such technique is applied so that the process definitions are oriented towards the organization's goals as defined in the strategic planning.

Such process proposes the involvement of professionals from an organization's strategic, tactical and operating perspectives. Therefore, in order to establish the most important elements of a software process reference model, the current problems with the software development process and its respective causes, as well as the strategic planning, are taken into account.

The QDF technique uses a number of matrices, which collect, analyze and manage goals as an end product. However, 95% of the QFD applications apply only the first matrix, called House of Quality (Cox, 1992). Basically, such matrix relates "what" – goals on a high abstraction level to "how" – actions on low level (Zaijun, 2005). Then, 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.

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

While filling in the House of Quality matrices, a value representing the priority of each one of the defined elements shall be established. The higher the value attributed to an element, the higher will its priority be over the others. Furthermore, the use of different-value scales is allowed to prioritize each group of elements (a group of elements may be defined in the rows or in the columns of the matrix).

At the end, these values are adjusted considering the impact between the elements defined in the matrix. Thus, each low-level action ("how") is prioritized taking in account its relation with high-level goals ("what"). In the AE-MPS process, three matrices are proposed based on the House of Quality matrix.

4.1 Strategic Goals Vs. Tactical Goals Matrix

In order to use this matrix (Figure 1), the strategic and tactical goals with the process improvement program shall be defined. Furthermore, the relationship impact between such goals should be analyzed. For such activities, the strategic planning should be used as an input artifact.

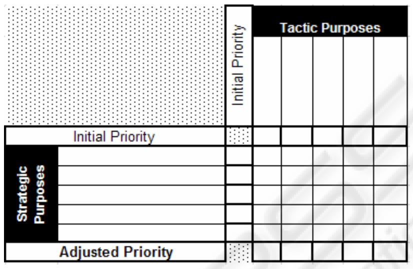

Figure 1: Strategic Goals Vs. Tactical Goals Matrix.

An initial priority value for each strategic and tactical goal is established. Thus, the adjusted priority of the tactical goal is defined with the application of the following expression:

$$TA_j = TI_j * \sum_{i=1}^{k} EI_i * R(E_i, T_j) \qquad (1)$$

where,

TAj is the adjusted priority of the tactical goal j;
TIj is the initial priority of the tactical goal j;
EIi is the priority of the strategic goal i;
R (Ei, Tj) is the value representing the relationship between the strategic goal i and the tactical goal j;
k is the quantity of strategic goals.

4.2 Tactical Goals Vs. Causes of Problems Matrix

For the use of this matrix (Figure 2), the organization's software development process needs to be analyzed and all the existing problems and their respective causes need to be identified. Therefore, it is necessary to fill in the matrix and analyze the relationship impact between the tactical goals and the causes of problems.

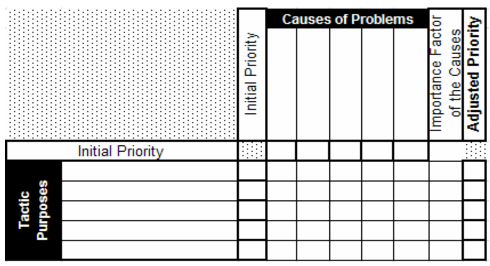

Figure 2: Tactical Goals Vs. Causes of Problems Matrix.

The initial priority of each process cause of problems should be established. Concerning the initial priority of the tactical goals, it is originated in the result from Strategic Goals Vs. Tactical Goals matrix. Thus, a new adjustment in the priority of the tactical goals can be performed:

$$TA2_j = TA_j * \sum_{i=1}^{k} CI_i * R(C_i, T_j) * F \qquad (2)$$

where,
TA2j is the adjusted priority 2 of the tactical goal j;
TAj is the adjusted priority of the tactical goal j;
CIi is the priority of the process cause of problems i;
R (Ci, Tj) is the value representing the relationship between the process cause of problem i and the tactical goal j;
F is the importance factor of the process cause of problems;
k is the quantity of process cause of problems.

4.3 Tactical Goals Vs. Processes Matrix

The relationship impact analysis between the tactical goals and the elements of a software process reference model is established in this matrix (Figure 3). The elements of a model that should be filled out in the matrix are the software engineering best practices related specifically to a level of maturity. In the matrix, they are called Processes.

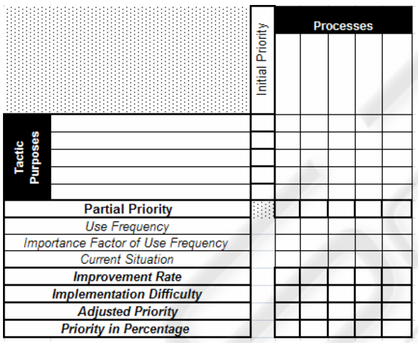

Figure 3: Tactical Goals Vs. Processes Matrix.

After that, the priority of each element of the software process reference model can be determined from their relationships with the tactical goals. The following expression is considered:

$$PI_j = \sum_{i=1}^{k} TA2_i * R(T_i, P_j) \qquad (3)$$

where,
PIj is the initial priority of the process j;
TA2i is the adjusted priority 2 of the tactical goal i;
R (Ti, Pj) is the value representing the relationship between the tactical goal i and the process j;
k is the quantity of tactical goals.

Next, the current situation and the use frequency of each element of the software process reference model in the company are analyzed. An importance factor for the use frequency should be also established. Such factor can vary between 0.1 and 1.0, where: 0.1 – the smallest value, and 1.0 – the highest value, and establishes the importance of the use frequency in changing the priority of an element of the software process reference model. With such data, an improvement rate is established for these elements:

$$T_j = SA_j * (F_j * FI_j) \qquad (4)$$

where,
Tj is the improvement rate of process j;
SAj is the current situation of process j;
Fj is the use frequency of process j;
FIj is the importance factor of the use frequency.

At the end, the priority of the elements of the software process reference model is adjusted considering the improvement rate and the implementation difficulty. The expression used for such adjustment is the following:

$$PA_j = (PI_i * T_j) * DI_j \qquad (5)$$

where,
PAj is the adjusted priority of process j;
PIj is the initial priority of the process j;
Tj is the improvement rate of process j;
DIj is the implementation difficulty of process j.
The application of these matrices allows the establishment of the importance percentages of the software process reference model elements for the organization. Next, the proposed process is illustrated with the data obtained from the case study.

5 AE-MPS IN PRACTICE

To evaluate the proposed process, a case study was carried out in a small Brazilian software development company. 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).

The company is improving its processes using the software process reference model MR-MPS (Montoni, 2007; Weber, 2005). This model was developed in the context of a nationwide initiative for Brazil aiming to make small companies more competitive in local and global markets. The initiative has been executed since December 2003 and the main goal is to disseminate software process improvements aligned to Brazilian software industry realities.

The seven MR-MPS maturity levels are: A (Optimizing), B (Quantitatively Managed), C (Defined), D (Largely Defined), E (Partially Defined), F (Managed) and G (Partially Managed). The level G is the most immature level, and level A is the most mature one. The MR-MPS maturity levels are based on the CMMI staged representation maturity levels.

The MR-MPS levels F, C, B and A correspond respectively to CMMI levels 2, 3, 4 and 5. The MR-MPS level G is an intermediary level between CMMI levels 1 and 2, and the MR-MPS levels E and D are two intermediary levels between CMMI levels 2 and 3. The company wants to implement the level F, approaching the following processes: Project Management, Requirements Management, Acquisition, Configuration Management, Quality Assurance and Measurement.

5.1 Strategic Goals Vs. Tactical Goals Matrix

In order to fill in this matrix, 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.

For each one of the strategic goals, the strategic planning was analyzed again, and related tactical goals were defined. From that, the Strategic Goals Vs. Tactical Goals Matrix can be filled in and the relationships can be analyzed. In Figure 4, the matrix developed in the case study is presented.

A value to represent the priority of each strategic and tactical goal was established. Considering the relationship between strategic and tactical goals the priority of the tactical goals was adjusted as per expression 1.

5.2 Tactical Goals Vs. Causes of Problems Matrix

The current problems with the software development process of the organization and its respective causes were identified. With such information, this matrix was filled in and the relationship between the tactical goals and the causes of problems were analyzed. In Figure 5, a concise view of the matrix developed in the case study is presented.

Subsequently, a value to represent the priority of each cause of process problems was established. Furthermore, the value 1 was established for the importance factor of the causes of process problems for the new adjustment of the tactical goals, in a range from 0.1 – the smallest importance, to 1 – the highest importance. From expression 2, the tactical goals had their priority adjusted again.

5.3 Tactical Goals Vs. Processes Matrix

In order to establish the partial priority of the elements referent to level F of the MR-MPS model, this matrix was filled in and the relationship level between the tactical goals and these elements was analyzed. Therefore, expression 3 was applied, and the process partial priority of the MR-MPS model was established. In Figure 6, this matrix is presented.

In the sequence, the current situation of each element of the MR-MPS model was analyzed (Table 2). The following levels to characterize this current situation were used: T – Totally Satisfied; L – Largely Satisfied; P – Partially Satisfied; and N – Not Satisfied (ISO/IEC 15504-2, 2003).

Table 2: Current Situation of MR-MPS Processes.

MR-MPS Processes	Current Situation	Value
Project Management	P	0.66
Requirements Management	P	0.66
Acquisition	P	0.66
Configuration Management	N	1
Quality Assurance	N	1
Measurement	P	0.66

		Initial Priority	Reduce rework	Improve business negotiation	Improve project management team	Increase productivity of production team	Reduce number of bugs delivered to customer	Improve level of assertiveness in delivery time	Improve business and management service	Create test team	Implement a bugtracking tool	Further detail the projects' scope	Guarantee the scope's understanding with customer	Increase the commercial team	Increase the production team	Qualify the production area	Provide scalability and increase organization of production team
			Tactical Goals														
Initial Priority			40	15	10	30	20	20	10	10	10	30	20	10	10	40	20
Strategic Goals	Increase profit	4	■	■	⬢	■		⬢				▲	⬢			⬢	▲
	Increase customer satisfaction	2	▲	▲	⬢		■	■	■			▲	■			▲	
	Improve product quality	1,5	▲		■		■	▲		■	▲	■	▲			■	
	Prospect and produce bigger projects	3	▲	▲	■	▲		▲	⬢			■	■	⬢	■	⬢	■
Adjusted Priority			1700	615	585	1170	630	690	270	135	15	1395	1170	90	270	1460	620

Figure 4: Strategic Goals Vs. Tactical Goals Matrix developed in the case study.

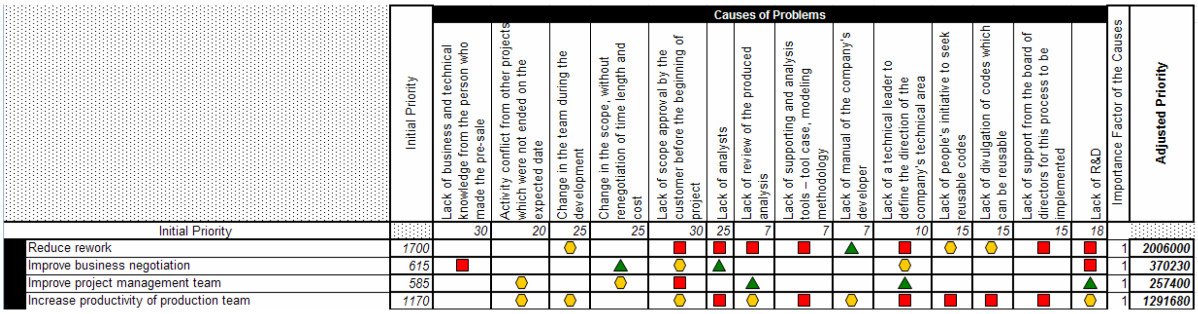

Figure 5: Tactical Goals Vs. Causes of Problems Matrix developed in the case study.

Then, the use frequency of each MR-MPS element was determined in a range with four values: no use; little use; reasonable use; and much use. It was also established the value of 0.5 as an importance factor of this use frequency, ranging from 0.1 to 1.0, where: 0.1 – smallest importance; and 1.0 – highest importance. With that, the improvement rate of the MR-MPS processes was established from expression 4.

Table 3: Frequency of the MR-MPS Processes.

MR-MPS Processes	Use Frequency	Value
Project Management	Much use	1
Requirements Management	Much use	1
Acquisition	Little use	0.33
Configuration Management	Much use	1
Quality Assurance	Reasonable use	0.66
Measurement	Reasonable use	0.66

Then, the implementation difficulty of each MR-MPS element in the organization was established. A range with four values was used: no difficulty; little difficulty; reasonable difficulty; and much difficulty.

Table 4: Implementation Difficulty of MR-MPS Processes.

MR-MPS Processes	Implementation Difficulty	Value
Project Management	Little difficulty	0.75
Requirements Management	Reasonable difficulty	0.5
Acquisition	Much difficulty	0.25
Configuration Management	Reasonable difficulty	0.5
Quality Assurance	Much difficulty	0.25
Measurement	Reasonable difficulty	0.5

After that, the priority of the MR-MPS elements was adjusted from expression 5. At the end, each MR-MPS element had its final priority established. Therefore, the importance percentage of each MR-MPS element for the organization could be identified.

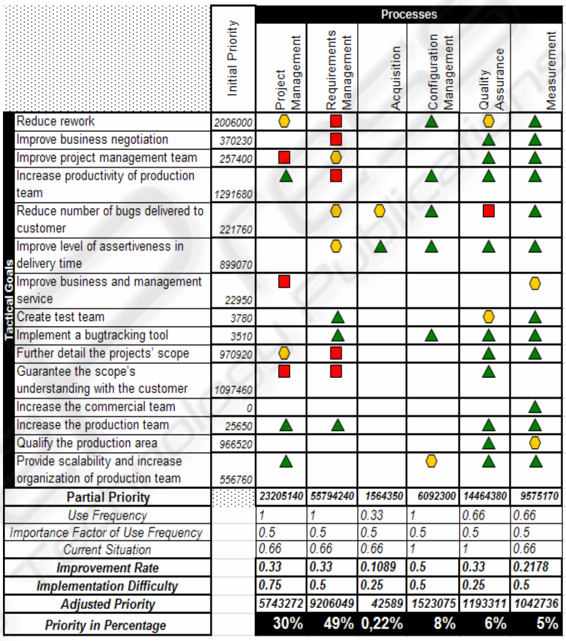

Figure 6: Tactical Goals Vs. Processes Matrix developed in the case study.

Based on these importance percentages, the organization defined process improvements from Requirements Management and Project Management. After these processes are defined, a professional team was trained and four pilot projects were started. An evaluation of the AE-MPS process, based on the results from the case study, is described next.

6 PROCESS EVALUATION

Based on the qualitative analysis of the data, we evaluate the suitability of the AE-MPS process in aligning the strategy of a software process improvement program and the organization's strategic planning. The evaluation for each one of the proposed matrices is reported, as well as the involvement of different hierarchical levels.

6.1 Strategic Goals Vs. Tactical Goals Matrix

According to most of the people involved with the use of the AE-MPS within the organization, the use of the proposed process successfully allowed the software process improvement program strategy to be aligned with the organization's business strategy.

Considering the importance of goals defined for an software process improvement program (Liu, 2005), the use of this matrix guaranteed them to be established, prioritized and related to the current problems and elements of the MR-MPS model. Moreover, the AE-MPS process proposed the analysis of the current situation of the strategic goals by means of metrics, clarifying the quantitative expectations of the company with the improvement program.

6.2 Tactical Goals Vs. Causes of Problems Matrix

Unanimously, the ones involved in the use of the AE-MPS affirmed that this process assisted a lot in the analysis of the current problems with the organization's software development process and their respective causes. Since it was the first time that this type of analysis was carried out in the organization, those involved outlined the importance of a consolidation of the current problems and their causes on organizational level.

As a weak point, it was found that a few problems with the software development process were mentioned in individual interviews; however they were not consolidated during the matrix filling-in activity. On the other hand, the team work allowed the identification of two new problems which were not mentioned in any individual interview.

Furthermore, the ones involved mentioned that they were not aware of the existing convergence between the organization's causes of problems and the tactical goals. With the use of this matrix, such relationship can be quantified and the current process problems in the strategic alignment of the improvement program can be considered.

6.3 Tactical Goals Vs. Processes Matrix

According to those involved in the application of the proposed process, the main advantage of this matrix was allowing the identification of the MR-MPS model elements, which shall be prioritized by the organization. As per the attained answers, the MR-MPS model elements prioritized by means of the AE-MPS process application are indeed the most important for the organization. Considering that this prioritization is based on the organization's goals with the process improvement program and on the current problems with the software development process, it was guaranteed that the prioritized MR-MPS elements represent the organization's needs as a whole and not in personal views.

Those involved outlined that the application of the proposed process made it easier for the organization's strategic goals with the improvement program to be met. In addition, the senior management's satisfaction with this initiative was guaranteed.

6.4 Involvement of Different Hierarchical Levels

According to those involved, the AE-MPS process delivers a higher involvement of the organization's strategic, tactical and operating levels with the improvement program. However, they mentioned that the main difficulties in the application of this process are the number of people required and the reduced availability of those involved in the performed activities.

Concerning the number of people required, it was found that such difficulty, at the same time, establishes an advantage for the proposed process, which is involving every organizational level. The AE-MPS process is intended to guarantee the associates' participation in the process improvement program, intending to involve the highest number of people possible (Niazi, 2003).

7 DISCUSSION

The main contribution of this research was proposing a process that assists in the definition of the strategy of an improvement program based on the organizations' strategic goals. The intention of the AE-MPS process is that the process improvements in an improvement program meet, in a more systematic way, the organization's strategic goals and not only the demands of a software process reference model.

In addition, the most important element identification of a software process reference model for an organization allows the first efforts in an improvement program to be spent on these elements identified by the AE-MPS. 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.

Regarding the definition of strategic goals for a software process improvement program, it was found that they facilitate the monitoring of such initiatives. Such goals involve the senior management and allow assessing whether an improvement program is being successful.

The AE-MPS process also considers the current problems with the software development process of the organization and their respective causes. According to (Hierholzer, 1998), it is essential that a process improvement program approaches the existing problems in the software development process and proposes solutions. It was found that the resolution of such problems produces commitment and interest from those who perform the processes.

8 FINAL CONSIDERATIONS

In this paper, a process for the strategic alignment of software process improvement programs based on the strategic planning was proposed. That contributes for the systematization of how to maximize the results of these programs based on the organization's goals and the current problems with the software development process, either by using models such as CMMI or SPICE, or their derivatives, such as in this study.

Since only a case study was carried out, the generalization of the attained results is restricted. However, this is a typical situation in qualitative researches of exploratory nature. As a future work, this process shall be applied to other companies, extending the possibility of result generalization.

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. Therefore, the improvement programs can be directed towards the company's strategy and seeking better results.

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