Critical Issues in SPI Programs: A Holistic View

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***Abstract* - With the competitive market in the domain of Information Technology (IT), companies are forced to expand their field to offer not only the service of software development, as well as direct customer services (e.g., help desk) or specialist technology services (e.g., testing and quality certification of systems). In this context, to apply software process improvement (SPI) requires addressing different needs and, therefore, the use of different models and standards. In this paper, we propose to use a holistic view to look at the whole company in planning a SPI program. This is done by defining that which we call critical issues, as elicited from stakeholders on the strategic, tactical and operational levels of the company. Critical issues are those which the stakeholders consider very important to have in the company in terms of software process but that they perceive the company does not have or is deficient in. Critical issues support SPI planning as well as a return on investment (ROI) evaluation, in a complete strategy for SPI institutionalization. Preliminary results obtained show that the critical issues are useful to steer the planning effort in the SPI program so to deal with that which is critical for the company.**

Keywords - Software Process; Improvement; multimodel; benefits; ROI.

I. INTRODUCTION

It is a fact well known that software process improvement (SPI) programs should be in line with the business goals of the organization [1][2]. This is particularly difficult when a company has a wide field of expertise, in services ranging from software development to direct customer service. Moreover, to define SPI programs, companies have several standards (e.g., ISO 9000 [3], ISO 29110 [4]) at hand along with quality models (e.g., CMMI [5[-[7], and MPS.Br [8][9]). The solutions proposed for SPI programs rarely include different standards and models in the same program nor consider the legacy of models already implemented in the organization.

This situation contributes to uncoordinated efforts and consequently concurrent improvement actions on different hierarchical levels or different areas of the company that choose a suitable model for their own needs, without taking into account other company initiatives [10]. To address this problem, we argue that it is essential to have a holistic view for the planning and evaluation of the benefits from SPI programs.

As defined in the Cambridge dictionary, holistic view means, 'dealing with or treating the whole of something or someone and not just a part'. We proposed, therefore, to take into account the expectation of benefits of the stakeholders from different levels of the IT Company (strategic, tactical, and operational) to plan the SPI program. To that end, we argue that we should identify critical issues to plan the SPI program in a way that it could later be used to evaluate the ROI with the institutionalization of the SPI program.

Critical issues are prioritized based on the company's business goals. They guide the goals of the SPI program and support the selection of one or more models/standards that best fit company needs. That means we consider the use of a multimodel approach in the definition of a SPI program.

This paper describes the work done to support the identification of such critical issues and also how to use them in the planning of a SPI program, using a real industry case.

The next section briefly introduces the idea of a multimodel approach for SPI. Then, Section 3 shows our approach to plan a multimodel program for SPI, using critical issues. Section 4 shows how to apply and use this approach in practice. Section 5 points at the advantages, limitations, and ongoing work avenues of this research

II. MULTIMODEL APPROACH FOR SPI

With the wide diversity of SPI standards, one of the biggest difficulties faced by organizations is the identification of the best-suited model to support them in achieving their business goal. In Brazil, a study on the evolution of software quality [11] showed a large adoption of the MPS-SW [8] and CMMI-DEV [5] models. Their use has brought benefits, such as higher customer satisfaction, increased productivity, and cost reduction. These and other benefits are often found in the literature as return on investment from these models (see, for example, [12-13]).

However, companies that have business features that go beyond the scope of improvement of these models require the implementation of other models. We can mention: (i) companies that develop software products and have a help desk or desk-service to meet the demands of their customers and (ii) companies that outsource the development of some lifecycle activities of their products.

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In the first case, CMMI-SVC [7] and MPS-SV [9] can be used; in the second one, CMMI-ACQ [6]. Multinational companies also need to implement specific models, as required for contracts in different countries (e.g., the Brazilian model is being required in several contracts with Brazilian Government).

One can also find several other models/standards required and used in a smaller scale, such as ISO 9000 [3], MoProSoft [14], ISO 29110 [4], MPT.Br [15] (a Brazilian model for software testing).

A joint implementation of these models simultaneously allows treating different points of improvement in the organization in a more appropriate way. However, it is necessary to determine when the joint implementation is needed, which models are relevant, on which levels of maturity/capability they should be deployed, and how the improvement program should be structured towards a feasible implementation in the company, without generating unnecessary costs, wasted resources, rework and looking for the best ROI.

With this scenario in mind, the concept of multimodel environment emerged [16] as a result of the effort of companies to integrate models and international standards to achieve process improvement. Its use, however, requires an understanding and an interpretation of how different models co-relate, which makes an implementation of multimodel improvement a complex task. Thus, the use of a strategy to harmonize and match these models is a critical success factor [17].

The harmonization implies defining solutions to support the company [10]: (1) determine and understand which models will help it accomplish its corporate goal; (2) understand both the differentiating and the overlapping features of these models; (3) create an organizational process focused on the company's mission and incorporating the features and contents of all models of choice.

In this context, Mirna et. al. [16] propose a method that focuses on the business goal and selects the standards and models that best fit the company, indicating what should be done to achieve such goals. PRIME (Process Improvement in Multimodel Environments) [18] proposes the alignment between business and improvement goals. Models are selected and categorized according to their type of contribution to company goals, and the points of intersection between models are determined. Both studies measure the results, evaluating the achievement of the organizational goals. Other examples of multimodel approaches can be found in [19].

Several benefits justify an investment in multimodel approaches, such as [18]: focus on the business rather than focusing on the model; cultural change in relation to the establishment of the processes in the company; measurement system; robustness and effectiveness of the organizational approach in the long run. However, a multimodel approach also presents some challenges [20][21]: getting the commitment from senior management; determining the organization's strategy, integrating and coordinating training; integrating measures so that they do not target the adopted models; knowing the differences and similarities regarding the various models adopted in the design of improvements.

We argue that, to support a multimodel approach, one needs a holistic view of the company in a way that the potential benefits achieved by the SPI program are visible to all the stakeholders involved.

III. A HOLISTIC VIEW FOR SPI VIA THE IDENTIFICATION OF CRITICAL ISSUES

Our proposal for process improvement is based on the idea that a company that decides to carry out a SPI program wishes to have some benefits that justify such investment. Thus, the characterization and understanding of the needs of the company should be made judiciously and should guide both the definition of the improvement goal and the selection of models to be implemented, to enhance the possibility of getting a better return on the investment. By applying a holistic view we assume to look at the company as a whole and, therefore, to look for benefits for all the stakeholders involved in the SPI program.

To support this idea we propose to identify critical issues in the company. Critical issues are what all stakeholders or their representatives, on the different organizational levels (strategic, tactical, and operational) consider very important to have in the company in terms of process but sense the company does not have or has in a deficient manner. By identifying these critical issues, the company can better define a SPI Program plan and later evaluate the benefits attained, to start a new cycle of improvement, institutionalizing a continuous process for improvement.

As shown in Figure 1, the core of a holistic view is the identification of critical issues that can address different stakeholder needs. Based on these critical issues the continuous streamlining of the SPI is done as follows: (1) *Characterizing the company*: understanding the characteristics of the company as related to its field of expertise (software development, software maintenance, software testing, service desk, product marketing, acquisitions, etc.), the improvement program initiatives already undertaken, and its types of customers (government, national, and international).

At this point the **Critical Issues** (CI) are identified with the different stakeholders from the strategic, tactical and operational levels; (2) *Defining a SPI Program Plan* – defining the SPI plan, including improvement goals, models/standards to be followed, resources, risk analysis and mitigation, and an execution schedule; (3) *Executing the SPI Program Plan*: Carrying out the plan, and measuring results based on the critical issues identified; and (4) *Evaluating the* Benefits *of a SPI Program* (4) – evaluating the reach of the benefits with the stakeholders, considering the critical issues they identified. These benefits represent the ROI for the SPI program and if not attained, they can be re-considered in the next improvement cycle.

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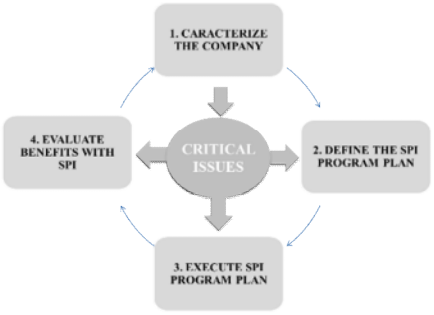

Figure 1. Continuous SPI with Holistic View

To support the identification of critical issues we defined questionnaires based on a detailed research on the benefits of SPI as shown in next subsection.

A. Supporting the Identification of Critical Issues for SPI

To define the questionnaires for the identification of critical issues we used a proposal that establishes the implementation of theoretical procedures (theoretical studies supporting the definition of the issues and their semantic validation) and experimental procedures (application of the questionnaire).

The theoretical procedures were supported by two main sources: (1) a systematic mapping of literature [22], where the benefits of Process Improvement Programs were mapped (in brief, from 112 papers found in literature, 28 were considered pertinent, and of those 34 different benefits for SPI were identified); and (2) the purpose of the processes for quality models in the context of Software (MPS-SW and CMMI-DEV models), Services (MPS-SV and CMMI-SVC models) and Testing (MPT.Br model). These models were picked due to their potential adoption by Brazilian companies.

As shown in Figure 2 the statements (i.e., issues) of the questionnaire were set in different categories: process issues and issues about benefits in SPI. Process issues were organized into common issues and specific issues, for each of the process types (software, services, or testing). Altogether there were 74 issues. This organization avoids the repetition of issues, making the overlapping of the process and help explicit in the definition of the SPI.

The definition of the questionnaire is based on [23] that adapted SERVQUAL questionnaires [24]. This way, all the issues are organized into two questionnaires: (i) one to collect the Importance of the issue for the respondent, and (ii) the second one to collect one's Perception of each issue in the company.

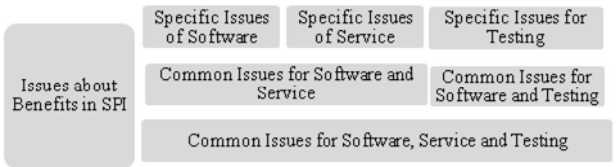

Figure 2. Categories of Issues in the Questionnaire

This way, each company stakeholder answers for each issue to the extent one considers it important for the organization according to one's point-of-view (strategic, tactical, or operational) and what one's perception is of the issue in the company. The issues are answered in a four-point Likert scale.

Critical issues are the ones identified as very important for the company but with a low level of perception by the stakeholders. Figure 3 and 4 show respectively an example of the issues presented in both questionnaires (to collect the degree of Importance and degree of Perception).

Each one of the statements in the questionnaire (i.e., the issues) is associated to some quality model or quality processes from a model, in a way that can further support the identification of which model/process should be addressed in the company. For instance, in Figures 3 and 4, the first statement from each questionnaire is related to Project Planning/Work Planning; the second statement is related to the Supplier Agreement Management from these models; the third to Configuration Management and the fourth to Process and Product Quality Assurance.

Two experts in Software Engineering, specifically on software process improvement, reviewed all the statements defined to ensure compliance with the following criteria: clearness (intelligible even for less experienced respondents) and simplicity (expressing a single idea). Once the questionnaires were reviewed, two semantic validations with the participation of industry professionals were done.

What degree of importance has for you: *	1	2	3	4
That the estimates be made using established techniques (e.g., function points, points per use case).				
That the acquisition of products or services be strictly planned and monitored.				
That project and process documents be stored in an organized and controlled manner.				
That it be checked whether employees follow processes and use the templates of the documents.				
That the acceptance of a new project or service be analyzed by objective criteria				
That the viability to continue the projects and services be periodically evaluated against strategic objectives of the organization				
That the portfolio of projects and services of the company be planned in line with their strategic goals				
That achieving the company's goals be assessed through measures				
That business decisions be taken from objective data, collected as result of measures.				

*(1) No importance (2) Low importance (3) Moderate (4) High Importance

Figure 3. Some statements of the questionnaire of Importance

To what degree you realize that in your company:*	1	2	3	4
The estimates are made using established techniques (e.g., function points, points per use case).				
The acquisition of products or services is strictly planned and monitored.				
The project and process documents are stored in an organized and controlled manner.				
It is checked whether employees follow processes and use the templates of the documents.				
The acceptance of a new project or service are analyzed by objective criteria				
The viability to continue the projects and services is periodically evaluated against strategic objectives of the organization				
The portfolio of projects and services of the company is planned in line with their strategic goals				
The achievement the company's goals is assessed through measures				
The business decisions are taken from objective data, collected as result of measures.				
The acquisition of products or services is strictly planned and monitored.				

*(1) No perception (2) Low (3) Moderate (4) High perception

Figure 4. Some statements of the questionnaire of Perception

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TABLE I – CRITERIA FOR QUESTIONNAIRE ADAPTATION

Nature of work in companies	Common issues			Specific issues		
	SW, SV, T	SW, SV	SW, T	SW	SV	T
Soft. Develop. or maintenance	X	X	X	X	-	-
Service-desk	X	X	-	-	X	-
Software testing	X	-	X	-	-	X

SW=Software; SV=Service; T=testing

The application of the full questionnaire depends on the nature of the work done by the companies as shown in Table I. Issues not pertinent are eliminated from the questionnaire before it is applied.

B. Supporting the SPI Program Plan

Critical issues are used to support the planning of the SPI Program. In order to reduce the degree of subjectivity in this planning a need was seen to adopt a method that would aid the company to grasp what processes deal with the more critical issues and, when needed, prioritise and set the order of the processes to be implemented in the different improvement cycles.

QFD (Quality Function Deployment) aims at relating product requirements to those of the clients, seeking to identify how the product requirements are used to build a product that meets client requirements [25]. The strategy put forward in this work does not aim at the building of a product but rather the planning of a SPI Program that addresses the critical issues identified by the company.

Thus, the QFD was adjusted to relate the critical issues (client requirements) with the software processes (product requirements) so to prioritise the software processes that will be used in the definition of a plan for the improvement program. The main output product is the relative importance (RI) index of the processes which will guide the prioritisation of the processes in the planning of cycles for the improvement of the software process.

IV. OUR APPROACH IN PRACTICE: AN INDUSTRY CASE

In this section we show how the questionnaires described in the section above were applied and used to define the SPI program plan in a very small Brazilian company.

A. Characterizing the Company and Identifying Critical Issues

The company has customers in Brazil and overseas. It does not hire services and/or software development from other companies and it does not have the Brazilian Government as a client. It works with software development and maintenance by demand, develops and sells final software products (components, COTS). It also has a help-desk service for its customers. Currently, one of its projects is to work as a software testing factory. As regards its history of process improvements, the company was rated as first level in the 2009 Brazilian model (MPS-SW), although the processes are only partially followed nowadays.

TABLE II – CRITICAL ISSUES IDENTIFIED AS PER CATEGORY

Common Issues			Specific Issues		
SW, SV, T*	SW, SV	SW, T	SW	SV	T
2	10	2	0	7	8
7%	34%	7%	0%	24%	28%
Accumulated (Common + Specific)			48%	66%	41%

SW=Software, SV=Service, T=testing

The questionnaires were answered by all company employees (stakeholders). As a result, 29 critical issues in the processes and 13 critical issues in the benefits of SPI issues were identified. Table II shows the number of critical issues as per category (see Figure 2). The majority of critical issues are related to services (66%), followed by software (48%), and Testing (41%). We also found that 48% are common issues in service, software and testing quality models.

We should like to point that, in defining improvement actions that address critical issues, the processes to be implemented should consider the overlap between models and also the characteristics that differentiate them. The critical issues are discussed below from the perspective of the respondents' profiles: (a) Technical team - operational level; (b) Project manager - tactical level; and (c) Senior manager - strategic level.

1. Critical Issues in Processes

For the technical team the critical issues are more concentrated in the realm of testing: control of test environment incidents; standardization of test results in projects; quantitative assessment of quality objectives; identification and elimination of root causes of defects; and implementation of peer review. As regards services, the critical issues are about the control of the implementation of changes and the ability to monitor performance requirements. There are expectations about improvements in risk management and knowledge sharing amongst the employees. It is interesting to note that there are no common critical issues between the technical team and the project manager.

From the perspective of the project manager, the critical issues are related to: the use of estimation techniques (C01); management of the projects and services portfolio: planning of the services portfolio based on strategic planning (C15); feasibility assessment for project continuation against the strategic goals of the company (C06). It is expected that the achievement of the business goals of the company are evaluated by measurements (C07). The critical issues specific to the services area refer to the definition of mechanisms for the development of new services; compliance with Service Level Agreements; control of budget and accounting services; information security and communication of information on services.

As regards testing, the critical issues for the project manager are: managing the completion of testing activities; automated source code assessment; re-use of work products previously developed in other projects and control of the use of new tools to support the testing process. Finally, the critical issues for senior managers concern supplier management agreements; use of

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estimation techniques (C01); management of the projects and services' portfolio (C05, C06, C15); knowledge sharing amongst employees; implementation of peer reviews; automated assessment of the source code; use of criteria for making important decisions; use of measures to evaluate the achievement of company goals (C07); and control of budget and accounting services.

As expected, no common critical issue was found in the three profiles. The expected benefits vary according to the responsibilities and activities performed by the respondents. This reinforces the importance of involving different stakeholders on different hierarchical levels in the definition of the critical issues.

2. Critical Issues in SPI Benefits

Critical issues in SPI benefits are expectations of benefits that are results of the entire SPI program, but some of them may be associated with specific processes (e.g., B01, B04, B08, B22, and B24).

For the technical team, the critical issues concern the monitoring of projects (B24), reduction of re-work, and the quality of the work life. Compliance projects schedules (B22) are the only common critical issue of the technical team with the project managers. The critical issues raised by the project manager refer to expectations of improvements related to the accuracy of estimates (B04); prompt answer to market demands; and a greater market share. Critical issues for senior management relate to company growth in terms of number of projects and clients in Brazil and overseas; ensuring that the cost of projects and services are kept as planned (if there is no change in requirements) (B08); better understanding of the tasks and responsibilities by the project teams (B01); and greater market share.

B. Defining a SPI Program Plan

The analysis of the critical issues identified in the company indicates the need of a multimodel approach with improvement actions for software, services and testing. As the company aims at increasing the number of projects and customers abroad, the use of quality models with international recognition is advisable; in this case the CMMI-DEV and CMMI-SVC. However, the MPT.Br and MPS-SW/MPS-SV models should be used for some specific issues related to testing and knowledge management, as there are no CMMI processes that address these issues.

To define the SPI Program Plan we should analyze all critical issues, bearing in mind that they should be addressed in several improvement cycles. Deciding which questions to address in the first place is no trivial task and should be done with caution. A bad start places the entire improvement program at risk. Thus, it is recommended that the critical issues identified be evaluated by senior management (strategic level), based on different criteria. The first one is the alignment with the business goals of the company. Once this aspect is ensured, it should also take into consideration company size, its legacy as regards SPI, target budget for SPI and the natural dependence between processes (i.e., processes presented on a high maturity level depend on the implementation of other processes, and therefore are hardly possible at first).

As shown in Table II, the company identified many critical issues to tackle and most of them relate to services (66%). However, the main company business is software development and maintenance and as a result of that senior management chose to first face the critical issues in the domain of software (48%). In spite of that, many of such issues are common to the services and testing areas.

The QFD approach was applied, considering, as client requirements, the critical issues mapped in the Software context. Having established the correlations between the critical issues and the processes, in the end the Relative Importance (RI) Index was found for the processes. Table III shows the four highest RI processes and the CI associated to such processes.

The processes with highest RI index are prioritised for implementation. Based on this, 4 processes were chosen to be implemented in the first SPI cycle: PP, PMC, M&A and PFM, as they had already been implemented in the company (PP and PMC) and are the basis for others. We chose also REQM (requirements management) because it has many correlation with other processes. The process M&A is so important for the analyses of benefits of the SPI program. For the second SPI cycle were selected the engineering process Verification and Validation, because of the high interest in the improvement to the quality of the product and the business goal of answer the market demand software testing projects.

The idea is to implement these processes in a capability level 2 (of CMMI) in the first cycle and to improve continuously in each new cycle of improvement. Considering the process to be implemented in the first and second cycles (six months each one), they cover software, service and testing quality models. Therefore, the definition of the process specific for the company should ensure the incorporation of all the required features for each model. Each cycle will be

At the end of each improvement cycle the perception questionnaire will be reapplied to measure if the level of perception of the critical issues are improving, which may influence in the prioritization of critical issues for the next improvement cycles. Moreover, to execute the SPI Program Plan a set of measures is proposed for each process to allow the evaluation of improvement actions and a return of the investment.

TABLE III – TOP FOUR RI INDEX FOR THE PROCESSES

Process	RI	CI
PP - Project Planning	13,67%	C01, B01, B04, B22, B24
PMC - Project Monitoring and Control	10,73%	
M&A - Measurement and Analysis	7,17%	C07
PFM - Portfolio Management	7,12%	C05, C06, C15

(*) B – Benefit in SPI, C-common to between quality models

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V. CONCLUSION

This paper presents an approach to support the implementation of SPI program based on a multimodel environment and on the eliciting of CI considering the whole company. CI are prioritised according to business goals of the company and guide the objectives, scope and planning of the SPI Program. We point as an advantage of this approach the participation of stakeholders from the different levels and profiles in the identification of critical issues; and, the idea of promoting the visibility of benefits achieved by the improvement actions considering the scope of the initial expectations of the stakeholders.

The holistic view occurs in two different dimensions: the horizontal and the vertical. The horizontal dimension goes through many lines of business. The vertical dimension goes through only one line of business considering the views of various hierarchical levels. The ability to cover these two dimensions depends on the structure of the company and their own desire to address them.

It is necessary to do a better systematisation of the final meeting, to support the alignment of the business goals with the prioritisation of critical issues and the definition of the number of SPI cycles. The general recommendations we made were essential for the decision making process, although the experience and certainty of top management were key factors for the definition of the SPI plan.

We are currently working on this weakness, investigating the pick chart technique as proposed by Lean [26] and QFD, to construct a House of Quality for the critical issues and the processes. Other ongoing works include the definition of a catalogue of measures for all CI and their related process to allow an evaluation of the ROI through the analysis of the benefits reaped; to support the company, presented in this paper in the execution of its SPI Program plan; and, to apply this approach to other companies.

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