Software Process Self-Assessment Methodology

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Abstract – **Controlling and improving the process used to develop and maintain a software product has been widely proposed as a primary answer to the poor quality and non-conforming software products. The ultimate goal of those efforts is to create a continuous SPI (Software Process Improvement) space. Once the organization is committed to begin the SPI effort, the first step is an assessment of the current process and the current capability of the organization to develop and maintain quality software. In this paper, the author presents a methodology for continuous software process self-assessment, developed, tested and successfully applied in several companies in Macedonia. The methodology, using the SW-CMM (Software Capability Maturity Model) as a referent model, is unique in:**

Development of a suitably structured Database of Documents covering nearly every practice used by the actual software process. The documents are grouped according to aspects of development, quality assurance, configuration management and project management. The database provides software input to the referent model.

Formalization of the complex structure of the referent model SW-CMM, enabling statistical evaluation of the practices used versus baselines of the model, starting from the bottom up to the Levels of Maturity. For that purpose a software tool has been created and applied.

There are very few methodologies and techniques, which include processes, modeling and documentation in a single package (Curtis et al. 1992). The main finding of this study is that an efficient, easy to use, sustainable and objective self-assessment and consequently self-improvement process should involve significant, well-designed initial efforts. This paper presents the methodology itself and reports our experiences in developing and conducting a self-assessment process that follows such a systematic approach.

Keywords– **Process Assessment, CMM, Software Process Documentation, Self-Assessment Software Tool.**

1. Introduction

The company where the methodology has been developed and tested, is a chemicals industry in Skopje. It is a large industry complex, with 3000 employees, comprised of nine plants with different technologies and common services. The IT department, employing 40 people and providing services for the company and for other vendors is considered as one of the most vital common services. In the process of transformation of the ownership, this company with relatively old technologies, with centrally organized management structure, experienced large number of changes and transformations that happened recently in the whole region. Frequent changes of the legislative, tax policy, customs regime, transformation of the capital, switching from the traditional markets are only a part of the problems faced by the company. In such unstable conditions it is very difficult to define standard working processes, to apply a quality system, even to set the strategic goals of the business. The organization is oriented to solving the problems on a daily basis, rather than to build up a longer- term strategy.

The IT department is with a long tradition of professional work in the country. It develops and maintains the application software for the company and provides services for other clients within the sector. Despite the experience and evident capacities, the IT department has been facing severe problems in the SW development and maintenance for many years. Before starting the process of SPI, it worked with a very few formal working procedures, inconsistent plans, estimations, measurements and other practices that define a mature SW process. Beside the fact that the management and the working teams put a lot of effort and knowledge into the process, there were many inconsistencies in the SW products. Not solving the problems or even not being aware of them sometimes led to serious defects in installation and maintenance.

Probably the most critical factor was the large quantity of "rework" (app. 40%) as a result of errors and defects. Because of the weaknesses of the SW process, the defects were not discovered in the early stages of the life cycle of the product. That significantly decreased the productivity. Periodical changes in technology or SW methodology didn't target the problem itself: to deliver a SW product that satisfies certain criteria of functionality and quality within the budget and schedule. In the last years, the company has located the problem into the SW process deficiency. An independent assessment,

although very rough from this perspective, demonstrated that the SW process was often chaotic, badly planned and managed. Development of a defined, documented, standard SW process and application of subset from its practices for each project which will enable repeatable successes and predictable results became a central strategy for the way out.

2. Focus on the Software Process Self-Assessment

The overall concept for continuous SPI follows the generic SPI model defined by ISPI (ESSI, 1994), with objectives similar of those in the IDEAL model from the SEI (Software Engineering Institute, Carnrgie Mellon University, USA), (McFeely, 1996). It is four-staged model (see Figure 1.):

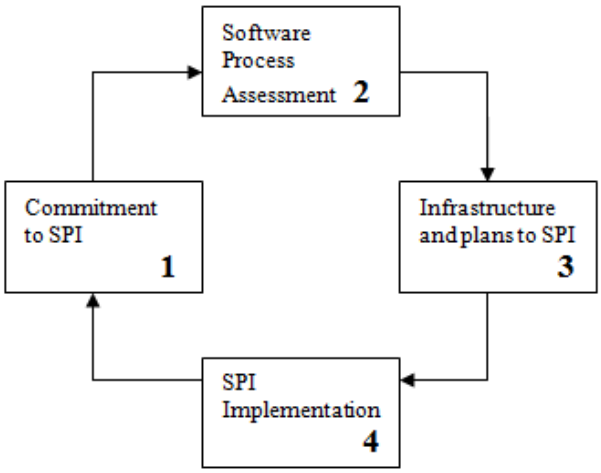

Figure 1. Generic Software Process Improvement model

Once the company demonstrates a strong commitment towards SPI efforts, the assessment becomes the central issue. The author, during her research into the software process assessment, developed a model for SPI with a focal point on an efficient, document-based methodology for self-assessment.

The basis of the methodology strongly relays on the capability of the organization to carry out a competent self-assessment of its own software process. Some concerns have been expressed that the cognitive perceptions of the participants might be influenced by individual and not only by the organizational factors (Stevenson, 1989). However, we believe that most software process assessments (and improvements) efforts limit their focus and concern to the technical and engineering aspects of the process and do not consider the relationship between these factors and the organizational and market variables (Cattaneo et al., 2001). There are many reports where independent assessment is under criticism. Considering this and having a certain previous own experience, the following factors have been recognized in favor of adoption of self-assessment approach:

- Self-assessment process should be on-line available.
- Related to the company's business goals
- Give maximum value for the money.
- Relays on the company's documentation.
- Participants are familiar with the deficiencies of the SWP.
- SPI program could be executed incrementally in small steps, rather than revolutionary.
- Software process could be refined, almost on-line.

Once this doctrine has been adopted, the main goal of this research was, through implementation of a properly selected, complex and formalized referent model for SW process, to develop a relatively simple and efficient methodology for SW Process Capability and Maturity Self-Assessment. The statistic analysis of the results with consideration of the specific context and environment should identify the most critical factors, strengths and weaknesses of the SW process. The determined problems will provide a basis for incremental process improvement.

3. Methodology for Document Based Self-Assessment

The framework for this research has certainly been searched among the existing standards, models and concepts for SW process management. Based on the many arguments provided in a comparative analysis, which has been carried out, SW-CMM (Capability Maturity Model for Software), (Paulk MC et al. 1993), developed by SEI has been chosen as a referent model. It is a conceptual framework in which the scientific elements of an efficient SW process are defined and covers large network of organizational, management and engineering practices. Which is more important for this concept, the model focuses on continuous improvement of the SW process and sets priorities in solving the numerous problems in the process, quantifies them and provides a formal basis for realistic evaluation.
In this research and implementation project, the SW-CMM structure has been used:

- To design the concept of the document database for the SW process.

- As a referent model in the evaluation of the findings of the assessment.
- To define the feedback into the software process refinement.
- As a roadmap for the process improvement.

The Initial Hypothesis of this research were:

- The complex, informal and descriptive architecture of the referent model SW-CMM could be formalized starting from the smallest practices of the SW process to the highest Levels of Maturity. For that purpose a SW product called SWP-Evaluator has been developed. Grouping and cross-referencing the various practices from the model structure will provide a solid ground for SW process analysis and evaluation.
- The objectivity of the results will be increased and the whole process of assessment will be more efficient, if a Database of Documents (or Experience Database) for the SW process is organized, the documents referencing to the various points of the structure of the referent model.
- After all, standards rely on written documents and documented procedures. What is even more important, the database's structure profiles the "Standard SW process for the Organization". To achieve this, a business process model for the organization from the SW process standpoint, should be also developed. The initial database design effort is considerable, but crucial for the successful implementation of the methodology.
- Implementation of the methodology will shape the profile of the Key Process Areas for the SW process. It will be a map of strengths and weaknesses of the process and will provide a ground for planning and initiation of process improvements.

The schema bellow represents the logical model of the methodology (Figure 2).

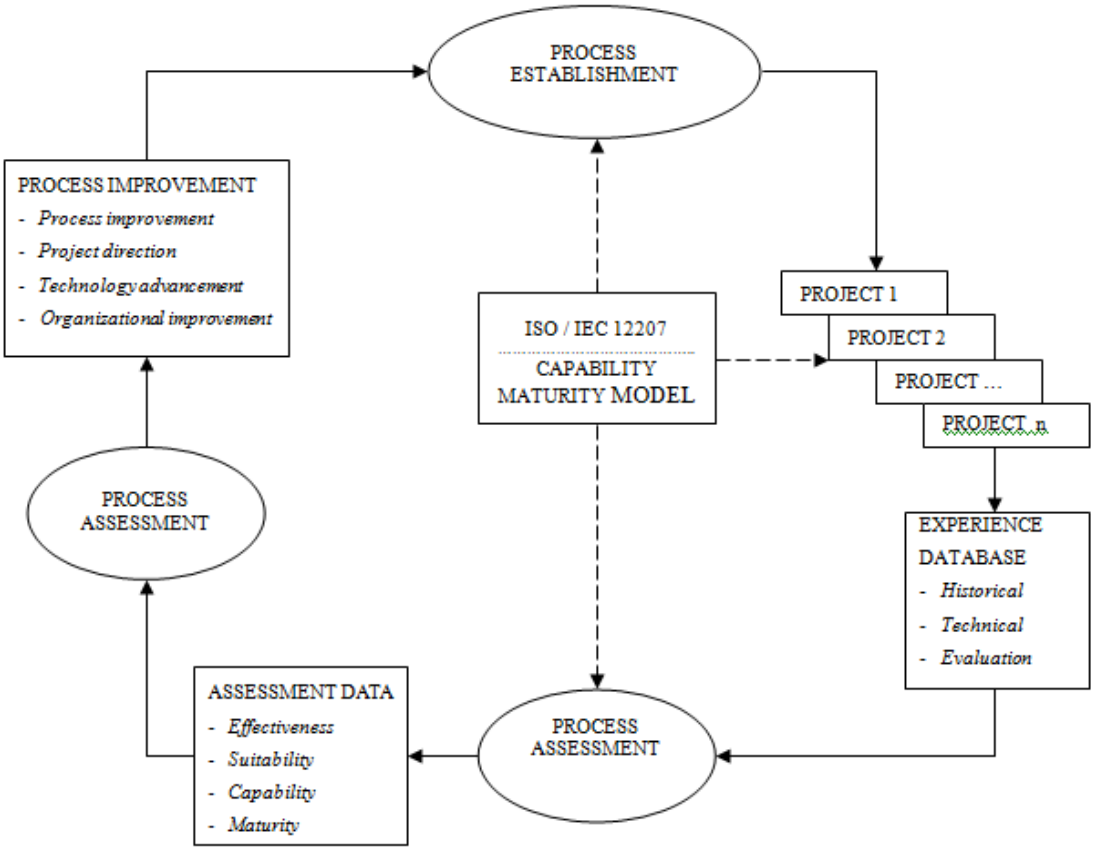

Figure 2. Methodology concept, logical model.

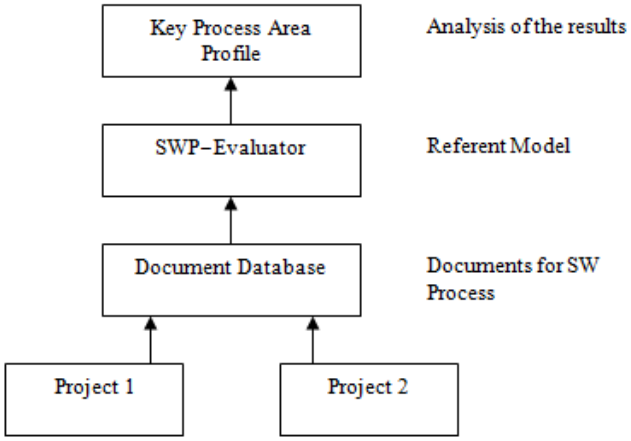

Figure 3. Methodology implementation steps

The system of evaluation starts from the bottom to the top of the structure and is presented on the Figure bellow. The dependencies of the Goals of the Key

Process Areas and the Common Features practices are predefined and provided in the process of evaluation.

In the SWP-Evaluator database, 18 Key Processes, 52 Goals and 350 Practices grouped into Common Features, have been processed. Also, in order to make a refinement of the Organization's software process, a possibility for additional structure elements has been provided. This leads to more accurate results and higher flexibility in the analysis.

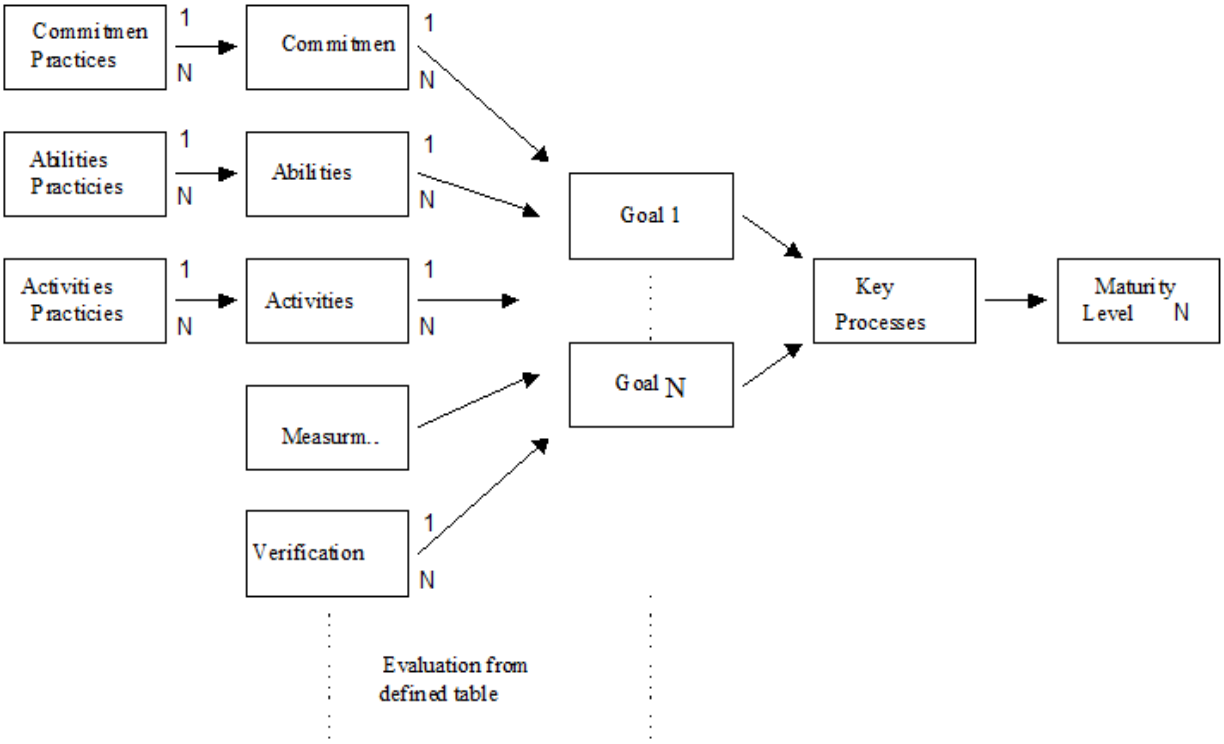

Figure 4. SWP-Evaluator logic

4. Software Tools for Methodology Implementation

SWP-Evaluator

The SW product consistently follows the structure of SW-CMM. The key tables or lists are those which refer to Projects, Levels, Key Process Areas and Common Features like: Commitments, Abilities, Activities, Measurements and Verification.

Document database

The reason for the design of such a base is to create and maintain documents that are generated by and from the SW process, and make them available for evaluation to the Referent Model. Each document references to one or more practices in the Referent Model. Moreover, the design reflects the business processes of the organization. The continuous refinement of the practices used by the process shapes the profile of the standard one.

The Figure bellow represents the logical structure of the Document Database (Figure 5).

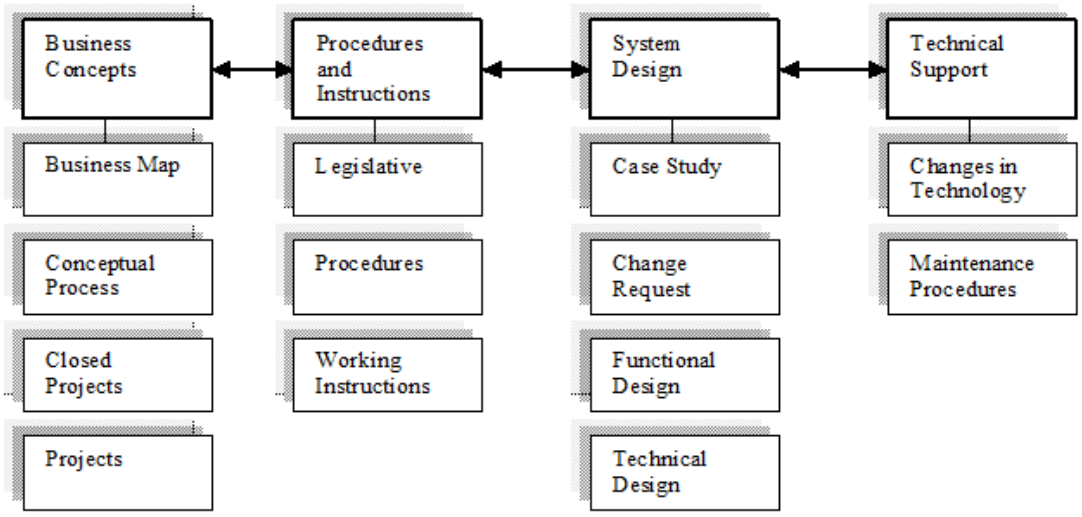

Figure 5. Structure of the Document Database

The Software Process and consequently the document logical model structure follow the guidelines of ISO/IEC12207 standard for software lifecycle, (ISO/IEC 12207, 1995), (ISO/IEC, 1998). Documents in the database fall into four categories, with several different types of documents.

- The first category "Business concepts" describes the working processes, the relations between them, the context, as well as the SW projects matched to the processes.
- In the second category "Procedures and instructions" the documents describe the working and organizational policies and procedures.
- The third category "System design" is the most important for the SW process analysis. The documents represent the engineering practices.
- The fourth category “Technical support" consists of maintenance documents for the installed software as well as of working procedures for the technical support department.

The documents are related to the phases of the life cycle of the SW products: requirements, planning, design, code, different tests, verification and validation, configuration modules, installation, maintenance, as well as the management practices and working procedures in all stages.

This specific design fits to a specific SW process placed in the broader working context of the business process of one company. A company that is to apply such a methodology could tailor the documents database to match its own software engineering process and business needs and priorities.

5. Methodology verification

The analysis has been carried out through comparison and statistical evaluation of the practices used by two (or more) different and complex software projects. The documents for the projects placed in different tables of the database, refer to different structural elements of the CMM model. The level of satisfaction for each structure has been measured and determined.

The detailed structure of the SWP-Evaluator, with possibilities for grouping and cross-referencing the practices, enabled the SW process to be analyzed by:

- *Level of Maturity*, which is exactly, defined stage with its attributes, areas, characteristics and especially best business practices in the development and maintenance of the SW. The Level of Maturity is not a subjective category, but rather an objective one.
- *Key Process Areas (KPA)* identify a cluster of related activities that, when performed collectively, achieve a set of goals considered important for enhancing the process capability. The path of achieving the goals may differ across projects based on differences in application domains and environments.
- *Common Features.* The practices that describe the Key Process Areas are divided in common features. They are attributes that indicate whether the implementation and institutionalization of a key process area is effective, repeatable and lasting.
  Commitment to Perform - typically involves establishing of organizational policies and leadership.

Ability to Perform - involves resources, organizational structures and training.
Activities Performed - typically involves establishing plans and procedures, performing the work, tracking it and taking corrective actions.
Measurement and Analysis - includes examples of measurements to determine the status of the SW process.
Verifying Implementation - typically encompasses reviews and audits by management and software quality assurance.

- Groupings of the practices, defining different *process categories* like management, organizational and engineering practices etc.
- Analysis of *individual Key Practices*.

The purpose of this paper is not to present the whole spectrum of results obtained but rather to demonstrate the possibilities of an efficient methodology for self assessment of a SW process. Therefore we present just an example of the Key Process Area analysis.

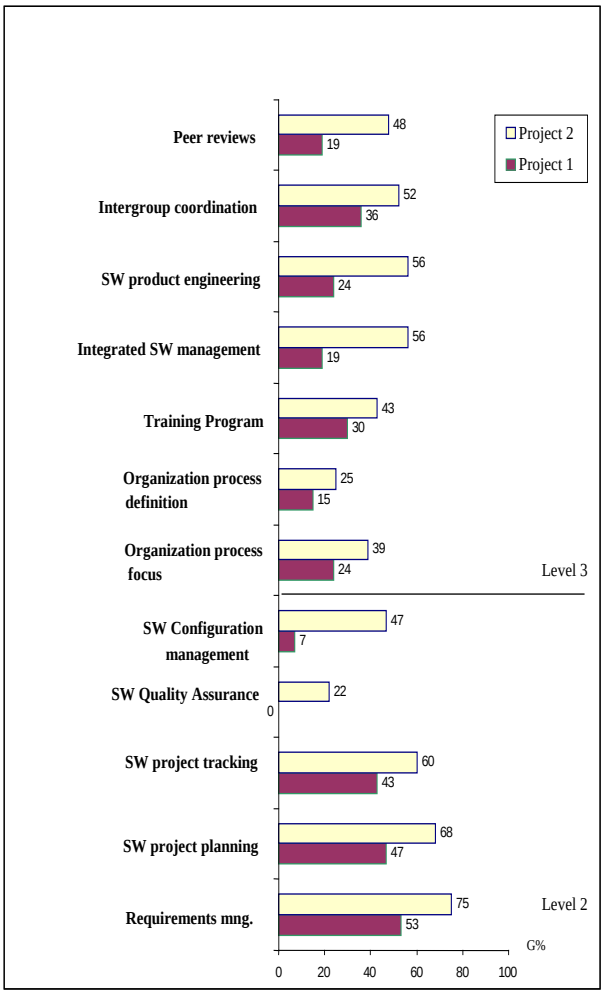

Figure 6. Goals achieved (in %) for Level 2 and Level 3, for Project 1 and Project 2

From the analysis of the Levels of Maturity in this particular case has been concluded that the present status of maturity of the SW process this company is in a transition from the Initial Level, to the Repeatable Level, or it converegates to the Level 2 referently to the SW-CMM model. Besides the fact that the goals of Level 2 for the recent projects are achieved, still the existence of certain number of older projects and lower performances of some key processes ("SW quality assurance" and "SW configuration management") lead to the conclusion that the SW process is not stabilized on Level 2. It means that some policies and procedures for SW project management are established. Implementing a fundamental discipline in project management increases the capability of the SW process. The projects implement processes that are, to a certain extent, defined, documented, measured and controlled. But, it doesn't represent the standard organizational process whose subset of practices could be implemented by the new projects.

Further on, the SW process has been analyzed by process categories, key process areas, common features, even by individual practices.

The applied methodology for SW process assessment based on the referent model SW-CMM and the derived profile of key process areas were basis for identification of key weaknesses of the organizational SW process. Those prioritized critical points are goals in the SPI.

The main goal in the strategy for the improvement of the company's SW process was to apply practices that would stabilize the process on a "Repeatable level" or Level 2 of the model.

From the general directions for process improvement (Humphrey W. 1989) and from the analysis of the results, four areas for the SW process improvement have been assessed and defined:

- Management system
- Process of planning
- SW quality assurance
- SW configuration management

6. Conclusion

In this paper, a methodology for relatively fast and efficient self-assessment and evaluation of a SW process was presented. The Referent Model used was the Capability Maturity Model for SW, developed by SEI group at the Carnegie Mellon University.

The methodology was developed and tested on the SW process in a large industry company in Skopje and implemented in several others.

The methodology is unique in:

Formalization of the whole structure of the complex model SW-CMM which enables statistical evaluation of the goals achievement on different layers of the model, starting from the bottom practices to the Levels of Maturity. This provides flexible and detailed analysis of the SW process.

The objectivity of the input data and the objectivity of the results interpretation, which is often a problem, were increased by organizing a Document Database as an input in the various structures of the referent model. This considerably speeds up the appraisal method. What is more important, the database as designed shapes the Standard SW process for the Organization.

The flexibility and modularity of the logical model of the methodology enables very deep analysis of the process aspects.

For each of these aspects, areas strategies and action plans for improvements were developed. New organizational structures, working procedures, documents, measurement methods, and estimation methods in some sub-processes were defined. In the implementation phase of the plan for improvement, these areas should be treated as a network of related activities.

It is very important to point out that the SW process is a complex process and involves many different activities. The areas of improvement determined with the methodology don't necessarily cover all the important aspects of the process, but certainly are of highest priority for this specific SW process. In the broader business context, the initiative for SW process improvement should be coupled with the strategic goals of the organization. Without this the improvements are not sustainable. The application of certain practices is highly dependent on the specific domain and working environment and no problem has unique solution. CMM is a necessary, but not sufficient technology (Sakamoto et al. 1996). The model doesn't solve the specific problems related to a specific project or situation, but revealing the weaknesses and critical points in the SW process, increases the ability for continuous improvement, step by step. Therefore, the presented methodology where over 350 practices of the SW process have been evaluated is a powerful tool for SW process assessment and improvement.

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