Implementing Process Improvement in Nine Software Organizations: A Case Study

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ABSTRACT

This paper describes the experience of implementing a CMMI-based software process improvement (SPI) project in a group of nine software organizations. We explain the approach we followed to design and implement the project, enumerate the main problems we encountered during its implementation, and mention the principal lessons learned and the critical success factors we think should be considered for this type of projects. Finally, the project's results are summarized and future work is outlined. The issues discussed in this paper may interest software organizations, company consortiums, governments, and international financial institutions interested in conducting SPI projects involving software organizations.

Keywords: software process improvement, process maturity assessment, CMMI.

1. INTRODUCCTION

Quality is one of the most important competitive factors of a global industry such as software development. To demonstrate quality software organizations must assess their processes using international standards or models, such as the Software Engineering Institute's Capability Maturity Model Integration (CMMI) (Chrissis M.B. et al., 2004).

In July 2005, we initiated a software process improvement (SPI) project in 9 small and medium size software companies with the objective of improving their competitiveness. We used the CMMI as our quality model and initially focused on the 7 process areas at maturity level 2 in the first 9-month phase of the project.

In general small software organizations the necessary knowledge, expertise, and resources required to implement software quality programs by themselves. Their cash flow and available human resources do not allow them to make the necessary investments in training, consulting services, and human resources needed to implement a long-term software quality improvement program good enough to achieve CMMI maturity level 3 or above (Paulk M., 1999, Jenkins M., 2004a, Jenkins M., 2004b). In our case, a collaborative project with shared costs among the 9 participating companies was the only viable mechanism to implement the project.

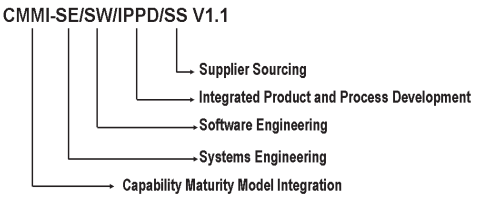
Eight of the nine participating companies in our project are small (less than 60 employees), with an average size of 40 employees. The ninth company is a medium size organization of 220 employees. All of them develop management information systems (mainly ERP´s) of different kind, costume-made web systems, and banking systems. Three of the nine organizations had an ISO 9000:2000 quality certification before starting this project (ISO, 2000), which gave them a leg up, and only three them currently export software to other countries.

2. BACKGROUND

2.1 The CMMI

The Capability Maturity Model Integration (CMMI) (Chrissis M.B. et al., 2004) is a software quality management model proposed by the Software Engineering Institute (SEI) as a guideline for software process improvement and capability determination. The CMMI is the result of merging 3 previous models: the software CMM, the System Engineering Capability Model (SECM), and the Integrated Product Development Capability Maturity Model (IPD-CMM).

The CMMI version 1.1 was published in 2003 and incorporates the following 4 disciplines altogether. Systems engineering and software engineering are the two core disciplines. Integrated product and process development and supplier sourcing are two additional sets of practices that can be incorporated by organizations that whish or must implement them.



Process areas (PA's) are the major building blocks in establishing the process capability of an organization. Each PA defines a set of specific goals that can be achieved by performing a collection of related practices. There are 25 process areas (PA's) in the CMMI-SE/SW/IPPD/SS that encompass more than 500 practices altogether.

The CMMI has two representations:

- The staged representation groups the PA's in 5 maturity levels. Each process area has been defined to reside at one the 5 maturity levels in the staged representation. To reach a given maturity level, the organization has to satisfy the goals associated with all the PA's at that level and below.
- In the continuous representation, the PA's are organized in 4 categories: project management, process management, engineering, and support. In a formal SCAMPI [6] appraisal, a capability level from 0 to 5 is assigned to each PA, thus defining the capability profile of the organization.

Figure 1 shows the CMMI staged and continuous representations. They both have the same 25 process areas, but organized differently. In our project we used the staged representation.

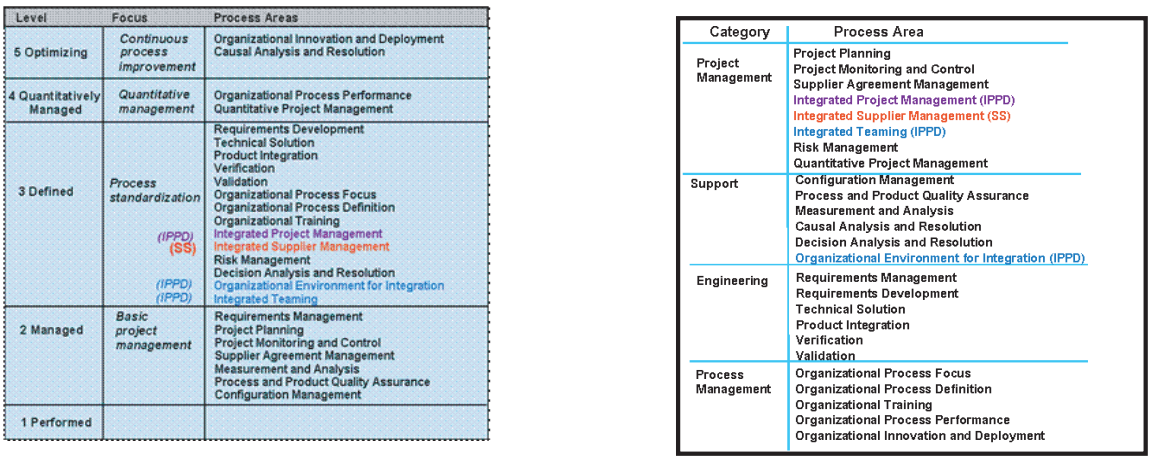
3. IMPLEMENTATION OF OUR PROJECT

3.1 The Project Tasks

The first phase of our improvement project was focused on the 7 process areas at CMMI level 2. During the 9-month period between July 2005 and April 2006 we performed the following tasks:

1. Basic CMMI training (3 days) for key personnel in the 9 companies.
2. CMMI level 2 implementation training (3 days) for key personnel in the 9 companies.
3. Conduct an initial assessment in each one of the 9 organizations
   - Perform the first SCAMPI type C assessment (SEI, 2001) of CMMI level 2 in each organization (1 day per company).

Figure 1. The CMMI staged representation (left) and continuous representation (right).



Level	Focus	Process Areas
5 Optimizing	*Continuous process improvement*	Organizational Innovation and Deployment Causal Analysis and Resolution
4 Quantitatively Managed	*Quantitative management*	Organizational Process Performance Quantitative Project Management
3 Defined	*Process standardization*	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition Organizational Training (IPPD) Integrated Project Management (SS) Integrated Supplier Management Risk Management Decision Analysis and Resolution (IPPD) Organizational Environment for Integration (IPPD) Integrated Teaming
2 Managed	*Basic project management*	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Measurement and Analysis Process and Product Quality Assurance Configuration Management
1 Performed		

Category	Process Area
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management (IPPD) Integrated Supplier Management (SS) Integrated Teaming (IPPD) Risk Management Quantitative Project Management
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution Organizational Environment for Integration (IPPD)
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Process Management	Organizational Process Focus Organizational Process Definition Organizational Training Organizational Process Performance Organizational Innovation and Deployment

- Define a process improvement plan for each organization based on the assessment's results.

4. Each organization implemented its improvement plan for the next 5 months performing the following tasks:
   - Define the process architecture.
   - Document the organizational policies.
   - Define the software product templates for the main software work products.
   - Plan the definition and implementation of the organization's procedures.
   - Define the software metrics to be used in the software process.
   - Define the organizational procedures.
   - Implement the procedures and software metrics program.
5. Perform the second SCAMPI type C assessment of CMMI level 2 in each organization (1 day per company).
6. Close the gaps found in the second assessment (3 months).
7. Perform the third SCAMPI type C assessment of CMMI level 2 in each organization (1 day per company).
8. Report final results to Management in each organization.
9. Close this phase of the improvement project.

3.2 The Assessments

As part of our project we performed a total of 3 SCAMPI type C assessments in each one of the 9 organizations. They were aimed at verifying "coverage" of the organization's defined process with the goals and practices contained in the 7 process areas at CMMI level 2. The objective is to determine the existing gaps between the current process and the CMMI model just for internal process improvement. This assessment is a quick look at the state of the organization's process and does not verify implementation of that process in specific projects, a task that would require a SCAMPI type A or B assessment (SEI, 2001).

For documenting the assessments results, we defined a simple 3-level ranking system to determine the level of coverage of the organization's process for each one of the 7 process areas at CMMI level2. Each CMMI specific practice is compared against the practices in the organization's process and assigned a ranking value as follows:

1. Red: the practice is not covered at all. This has a value of 0.
2. Yellow: the practice is partially covered. This has value of 1.
3. Green: the practice is fully covered in the process definition. This has a value of 2.

This simple evaluation system allows us to quantify the level of coverage of a given process with respect to the CMMI level 2.

The percentage of coverage for each PA is calculated as a weighted average as follows:

$$\%\ \text{coverage PA} = \frac{(\#\text{red} * 0) + (\#\text{yellow} * 1) + (\#\text{green} * 2)}{\text{Total Number of PA practices} * 2} \times 100\%$$

The same formula is used to compute the coverage of the entire CMMI level 2, as follows:

$$\%\ \text{coverage PA} = \frac{(\#\text{red} * 0) + (\#\text{yellow} * 1) + (\#\text{green} * 2)}{\text{Total Number of CMMI level 2 practices} * 2} \times 100\%$$

Table 1 below shows a portion of the findings of an assessment at one of the organizations.

The first column specifies the CMMI-expected practices and sub-practices; the second column is to checkmark once the practice is verified. The third column lists all the documentation reviewed for the analysis, and the last column contains a justification of the evaluation and any additional observations, including opportunities for improvement. In this example, there are a total of 7 practices with 2 in red (0 points each), 1 in yellow (1 point each), and 4 in green (2 points each). Therefore, the coverage of this portion of PP is calculated as follows.

$$\%\ \text{coverage PP} = \frac{(2 * 0) + (1 * 1) + (4 * 2)}{7 * 2} \times 100\% = 64\%$$

4. THE PROJECT´S RESULTS

The improvement achieved by some of the organizations in documenting and implementing their processes was remarkable. Figure 2 shows the progress obtained by company X in each one of the 7 PA´s of the CMMI level 2 through out the 3 assessments.

Figure 3 shows the CMMI level 2 overall coverage of company X, one of the organizations that achieved the most progress. They started this project with a coverage of 17%, increased to 59% in the second assessment, and finished with 82% of CMMI level 2 covered.

Figure 4 shows the coverage of CMMI level 2 obtained by each organization at the end of this project. The straight line shows de average coverage for the 9 organizations at 67%. Five organizations were above average, one was at 54%, and the remaining three were lagging behind in the 30´s. The relatively slow progress achieved by these 3 organizations is due mainly to the lack of commitment from the organizations Management, lack of available resources to invest in the improvement project, and their inexperience in defining and implementing quality management systems.

Table 1. An example of the assessment of a group of project planning practices

Goals and Practices	Verifications		Notes
SG2 - A project plan is established and maintained as the basis for managing the project.	**Verified Yes No**	**Document Reference**	
SP2.1-1 Establish and maintain the project's budget and schedule.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan Sales Management Procedure	The Schedule is created in Project 2003 based on a RUP template. The project's budget is manager using a standard Excel spreadsheet apart from the main plan. There is no documented procedure to create the project's budget.
1 Identify major milestones.	☐ ☐		
2 Identify schedule assumptions.	☐ ☐		
3 Identify constraints.	☐ ☐		
4 Identify task dependencies.	☐ ☐		
5 Define the budget and schedule.	☐ ☐		
6 Establish corrective action criteria.	☐ ☐		
SP2.2-1 Identify and analyze project risks.	X ☐	KJ-20 Risk list	There are three RUP templates to specify the project's risks.
1 Identify risks.	☐ ☐		
2 Document the risks.	☐ ☐		
3 Review and obtain agreement with relevant stakeholders on the completeness and correctness of the documented risks.	☐ ☐		
4 Revise the risks as appropriate.	☐ ☐		
SP2.3-1 Plan for the management of project data.	X ☐	None	The information of the projects is stored in carpets on the server. There are confidentiality letters signed with customers. The development plan defines the list of deliverables. There are no documented policies or procedures to manage the project´s information.
1 Establish requirements and procedures to ensure privacy and security of the data.	☐ ☐		
2 Establish a mechanism to archive data and to access archived data.	☐ ☐		
3 Determine the project data to be identified, collected, and distributed.	☐ ☐		
SP2.4-1 Plan for necessary resources to perform the project.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan Outsourcing of technical resources Sales Management Procedure	The project's plan and Schedule include the required human resources. The other resources are specified in the bid to the customer.
1 Determine process requirements.	☐ ☐		
2 Determine staffing requirements.	☐ ☐		
3 Determine facilities, equipment, and component requirements.	☐ ☐		
SP2.5-1 Plan for knowledge and skills needed to perform the project.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan LD-03 Description of roles and positions	The project's schedule includes all training activities. The project's plan defines the roles and responsibilities of the development team. Although there is an organizational training plan, the template for the project's development plan does not contain a section to plan the development of the skills needed to perform the project. The H.R. Department manages a skill matrix for all the team members. There is a documented description of the roles and positions in the organization.
1 Identify the knowledge and skills needed to perform the project.	☐ ☐		
2 Assess the knowledge and skills available.	☐ ☐		
3 Select mechanisms for providing needed knowledge and skills.	☐ ☐		
4 Incorporate selected mechanisms in the project plan.	☐ ☐		
SP2.6-1 Plan the involvement with identified stakeholders.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan	The development plan includes the identification of all project stakeholders
SP2.7-1 Establish and maintain the overall project plan content.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan LR-07 Repository location definition	A plan, schedule and proposal are documented. Each document is signed and approved. LR-07 Repository location definition defines the structure and location of the project's repository.

Figure 5 shows the average percentage of coverage of the 9 companies for each PA at CMMI level 2. Clearly the most difficult PA's to cover and the ones with the least progress are Measurement and Analysis (MA) and Process and Product Quality Assurance (PPQA), whose final average coverage was 51% y 47% respectively. Supplier Management agreement (SAM) was only evaluated in the third assessment for only 3 of the 9 organizations because the other 6 companies do not sub-contract projects.

5. CONCLUSIONS

The different organizations initiated this project at different levels of process maturity, commitment to the project, and process improvement experience. For example, three of them already had an ISO 9000:2000 certification when the project started, thus they already had experience documenting and deploying processes, so they were able to hit the road running. On the other hand, other companies had virtually no experience in process management, so for them it was extremely difficult to roll out the project.

The following are the main problems we faced during this project:

1. Lack of commitment from upper management.
2. Absence of a project manager and appropriate human resources for the SPI project.
3. Inexperience in designing and implementing software processes.
4. Some organizations went through a restructuring process that hampered the SPI project.

Figure 2. Progress made by company X in each of PA´s through out the project

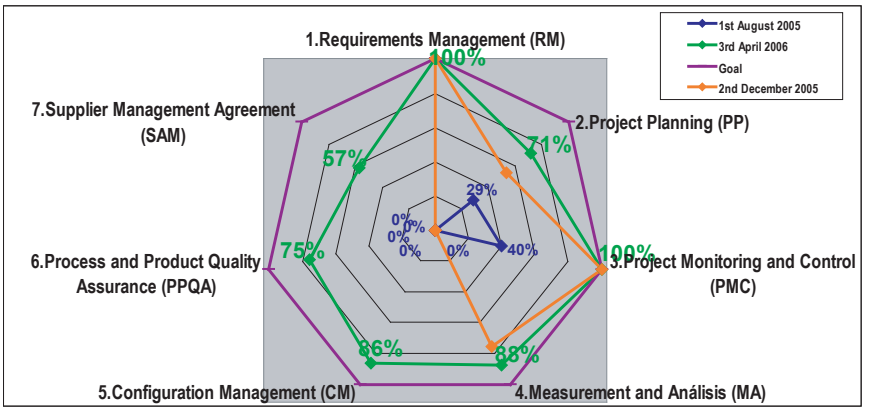
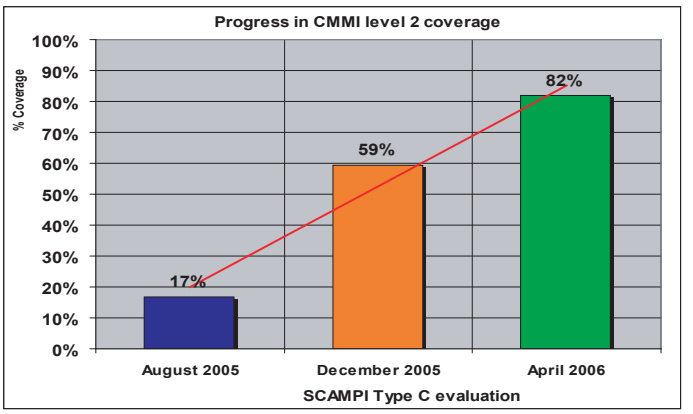


Figure 3. Overall progress made by company X through out the project



5. Change of organizational priorities due to market fluctuations or change of company's business model.

The organizations that achieved the greatest progress were those in which management was fully committed to the project, they designated a person directly responsible for it, and had previous experience with process management. Our experience shows that these are three of the most important success factors in SPI projects.

The three organizations with ISO 9000:2000 certifications had initial CMMI level 2 coverages of 23%, 66%, and 52% respectively. This demonstrates that in software organizations ISO 9000 quality systems generally do not cover most of CMMI level two's practices. On the other hand, organizations using commercial available processes such as Rational Unified Process (RUP) (Kroll P., Kruchten P., 2003) or Microsoft Solutions Framework (MSF), find it much easier and quicker to develop their CMMI-compliant processes. This is because RUP and MSF were specifically designed to cover CMMI levels 2 and 3.

This group of software organizations is now working in a second phase of this improvement project which will focus con CMMI level 3, but this time we are going to select only those that are really committed with the project and work with only 4 or 5 of them to assure a more uniform progress.

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Figure 4. Coverage of CMMI level 2 obtained for each organization at the last assessment

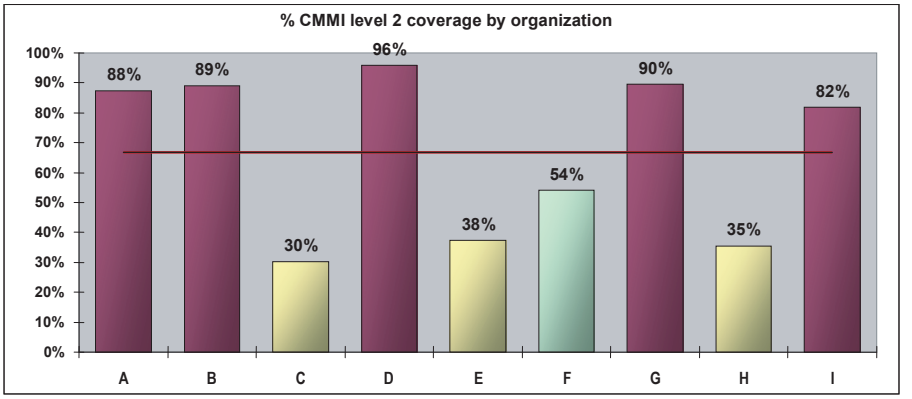
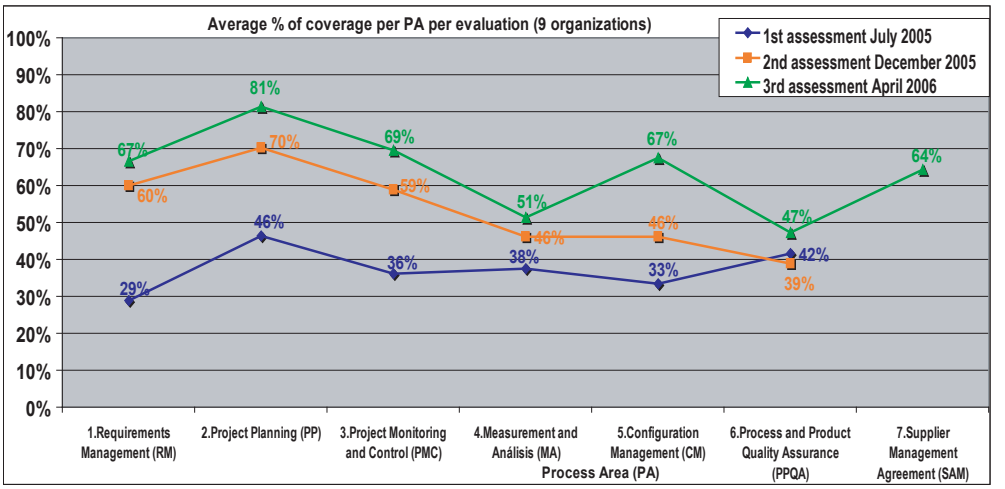


Figure 5. Average coverage of the 9 organizations for each PA at CMMI level 2



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