SEPAM - CMM Implementation for Developing Telecommunications Systems

Marjeta Frey-Pučko
Iskratel, Ltd.
Ljubljanska 24a, 4000 Kranj, Slovenia
pucko@iskratel.si

Roman Novak, Gorazd Kandus
Institut Jožef Stefan
Jamova 39, 1000 Ljubljana, Slovenia
{roman.novak, gorazd.kandus}@ijs.si

Abstract

[1]*CMM (Capability Maturity Model) is becoming a standard for organisations asking for a roadmap to evaluate and improve maturity of their processes in developing software/systems. Implementation of the CMM is also an important current activity in research & development at Iskratel, Ltd. The paper presents our experience with the use of the SE-CMM (Systems Engineering CMM), particularly with the use of SAM (SE-CMM Appraisal Method) as a self-assessment method. We adapted the method to our particular needs to collect more adequate information specifically about the maturity of the processes in telecommunications systems development. The adapted method SEPAM (Systems Engineering Progress Assessment Method) was developed in a joint project with the academic partner, Jozef Stefan Institute.*

1. Introduction

The increasing competition on the telecommunications market strongly influences the priority goals of telecommunications companies. Besides continuous introduction of new technologies, development of reliable and usable products within budget and schedule commitments becomes the crucial factor for success. The latter can be assured by sufficient maturity of the development process and by product quality. The CMM provides the common basis for process management and quality improvement concepts in software/systems development and maintenance.

Iskratel is a company with a 50-year tradition in developing telecommunications ystem. Alongside other telecom equipment, the company produces digital switches SI2000 and EWSD. While the SI2000 is completely the result of own development, the EWSD is being developed in cooperation with Siemens.

Since product quality and customer satisfaction are important goals of Iskratel, a quality system has been implemented and ISO 9001 certified in 1994. In order to reach other company goals the development processes must be continuously improved. Within the management initiative for a systematic and measured approach to process improvement the CMM has been recognised as a very helpful framework, and implementation of SE-CMM in the research & development department has been started. The SE-CMM has been selected for implementation in the system SI2000 development because of the tight integration of hardware and software development processes. The project of CMM implementation is being performed in cooperation with Jozef Stefan Institute and supported by the Ministry of Science and Technology of the Republic of Slovenia. Besides providing the facilitator for assessment, the main contribution of the Institute's participation in this project is in the joint development of the assessment method.

In this paper we present our experience of using SAM in assessing process maturity in telecommunications systems development and introduce a new version of the method named SEPAM (Systems Engineering Progress Assessment Method). The original method was adapted for two reasons. Firstly, in the assessment our main objective was to identify possibilities for improving very complex development processes. The process complexity results from the complexity of products, i.e. digital switches, including telecommunications hardware and software. Secondly, we need a small-scale assessment method which can be used frequently and with increased precision of answers.

The article is organised as follows. The next section briefly introduces the SE-CMM; we then overview the aspects of the CMM-based appraisal that are relevant for our work. The improved assessment method is described next. The main improvement steps are illustrated by practical examples. We close by summarising and presenting directions of future work.

2. SE-CMM - model and appraisal method

The CMM provides a roadmap for moving from an ad hoc or chaotic process culture to a culture of process discipline and continuous improvement [11]. The latter is based

[1]Euromicro 2001, pp. 272-278, 2001.

on both small, evolutionary steps and on revolutionary innovations. By means of CMM, these evolutionary steps are organised into five maturity levels which define an ordinal scale for measuring the maturity of the organisation's systems engineering process. The maturity levels also help the organisation to define priorities for the necessary improvement actions. CMM is organised into the following maturity levels:

Level 1 - Initial The systems engineering process is characterised as ad hoc, and occasionally even chaotic. Few processes are defined and success depends on individual effort and heroics.

Level 2 - Repeatable Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.

Level 3 - Defined The systems engineering process for both management and engineering activities is documented, standardised, and integrated into a standard process for the organisation. All projects use an approved, tailored version of the organisation's standard software process for developing and maintaining systems.

Level 4 - Managed Detailed measures of the software process and product quality are collected. Both the systems engineering process and products are quantitatively understood and controlled.

Level 5 - Optimising Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

SE-CMM architecture is well defined and composed of two basic portions. The domain portion is related to characteristics specific to the systems engineering process. It is a collection of essential elements, called base practices that are grouped into 18 process areas. The process areas belong to three categories; in addition to the process areas in the engineering category there are two further categories with organisational and project process areas supporting their execution. The capability portion contains the model components related to overall process management and institutionalisation capability. The five capability levels on the top of the capability portion are composed of one or more common features that are further detailed by several generic practices. The complete description of the architecture can be found in the technical report from the SEI [1]. The architecture is shown in Fig. 1 in relation to our method.

In addition to the model, SEI defined a method for using the SE-CMM to benchmark, or otherwise appraise, the process capability of an organisation's systems engineering process. The SAM (SE-CMM Appraisal Method) [6] provides guidelines for initiating, preparing and conducting an appraisal and is composed of the basic phases. The purpose of the Preparation phase is to define appraisal goals and scope, to obtain resources and collect necessary data. The On-Site phase is the most complex phase, which contains several steps of training participants, conducting interviews and processing results. The Post-Appraisal Phase is used for recording and reporting lessons learned and for managing appraisal artefacts.

Many misconceptions about the CMM exist. The major misconception is related to certification. CMM-based appraisals do not result in some sort of certification. The organisation cannot be certified for achieving a specific maturity level since the CMM-based process appraisal is not an audit. Appraisals are typically performed either in order to identify possibilities for self-improvement or to select suppliers. The SAM [6] strongly recommends tailoring the appraisal to meet the objectives of the organisation. The purpose of an appraisal is typically one of the following:

1. Identification of specific areas for improvement based upon known general areas of deficiency.
2. Confirmation of known data on the systems engineering process.
3. Obtaining commitment for change in the organisation.
4. Confirmation of process improvement progress (typically second or subsequent appraisal).

Other misconceptions are associated with the structure of the CMM and its application [9].

Our experience with performing an initial assessment following the SAM guidelines and considering the first two purposes listed above was positive. The project partner Jozef Stefan Institute provided a facilitator and a very helpful information support on Iskratel's Intranet, including the complete questionnaires. The results for some process areas fit surprisingly well to the results of ISO audits and of some other assessments and studies, especially in the project management category. However, we detected that some minor improvements could provide better customisation of the method to our needs, especially in aspects like the abstract level of the generic practices questionnaire, consideration of differences in respondent's knowledge depth of processes, and precision of answers.

3. Adapting the appraisal method

Several reasons led us to adapt SAM to fit the needs of our organisation. We are not reinventing the method. Our main objective of applying SE-CMM to the organisation's R&D process is to identify appropriate improvement opportunities rather than exact maturity level rating. A push for higher maturity level usually results from business goals, which include shorter product cycle time, less errors at all system engineering steps, less overtime work, and fewer schedule overruns. The exact level is only a measure, providing little information about the weaknesses of the system

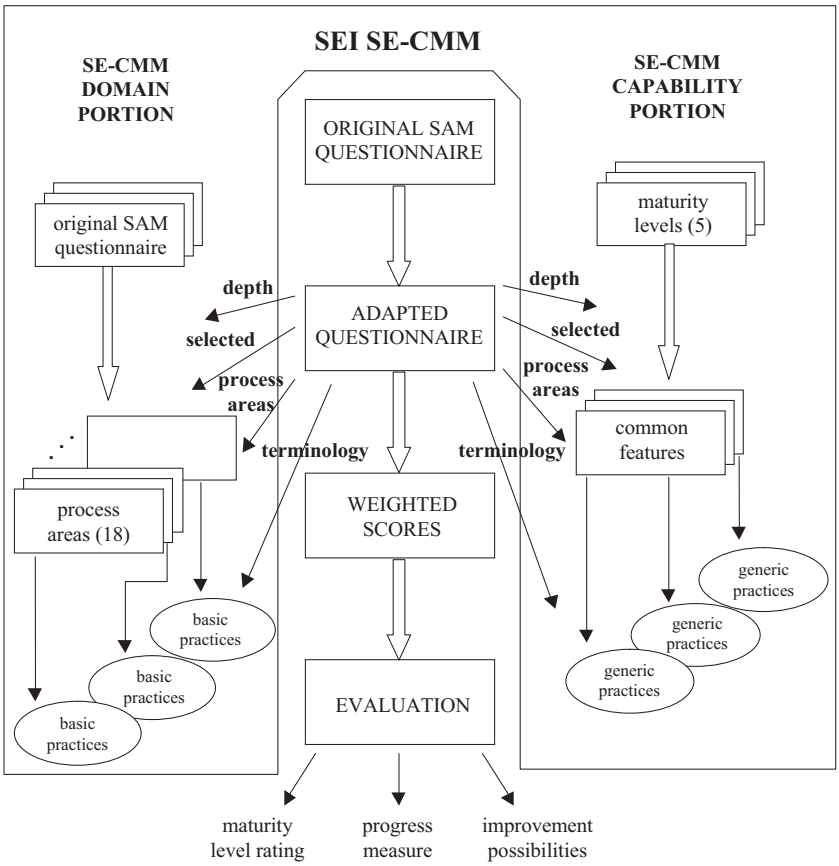

Figure 1. SE-CMM architecture and related method improvements.

engineering's processes; therefore it cannot be the main objective.

In order to identify improvement opportunities more quickly and to analyse the corrective actions taken as a result of previous assessments, we have introduced several modifications to the SE-CMM appraisal method. Large-scale appraisals are expensive and time consuming. Many companies find it difficult to perform them frequently. Modified SAM allows assessments to be performed more frequently. The method is particularly appropriate for small-scale low-budget assessments. Small-scale assessments should be carried out between large-scale assessments. The modified SAM can address all process areas, which is typical for an initial appraisal, or it may target specific process areas.

The SW-CMM appraisal method has been modified by many organisations in order to achieve similar objectives. Kodak uses a modular software process mini-assessment method [10], while Ericsson's version of the SW-CMM short assessment is called CMM Light Assessment [4]. Small-scale assessment techniques like the progress assessment technique by Motorola [2], Interim profile technique by SEI and Pacific Bell [5], and the Norad System Support Facility [8] are known.

Firstly, we have simplified the original appraisal process. Multiple activities have been joined together into a process of seven major activities. In order to increase the correctness of the answers, the questions relating to generic practices have been translated into the context of basic practices for each of 18 process areas. Multiple choice answers increase the precision of data gathering which in turn allow fewer respondents. Respondent specific weight is assigned to each process area, which is related to the respondent's understanding, responsibilities and insight into the process area activities.

3.1. Appraisal process

The original SAM distinguishes three basic phases in the appraisal process. A sequence of activities defines each phase [6]. Several activities of the second phase are provided to refine findings and SE-CMM profile. We have reduced the number of these activities by skipping the refinements. The activities that form our appraisal process are given in Fig. 2. They are close to the activities defined in the CMM-Based Appraisal for Internal Process Improvement (CBA IPI) assessment method [3]. The CBA-IPI method was developed by SEI to help an organisation gain insight into its software development capability by identifying strengths and weaknesses of its current processes related to the Capability Maturity Model for Software. Similarities can be found also between Kodak's mini appraisal process activities and activities in Fig. 2.

A minimal set of activities has been chosen for the appraisal process. The activities still allow an assessment to obtain valuable findings regarding systems engineering practices and to identify opportunities for their improvement. The quality of the appraisal's outcome depends mainly on the proper selection of respondents, on the precision of data gathering during interviews, and on rating judgements made during data analysis. The critical factor of the success is the precision of the answers to the SE-CMM questionnaire. Based on previous assessments we have found the "Yes/No" type of answers to be appropriate only when a large number of respondents is involved. In order to increase the precision of the answers and stimulate respondents to think over the subject, the questionnaire has been changed to allow multiple choice answers.

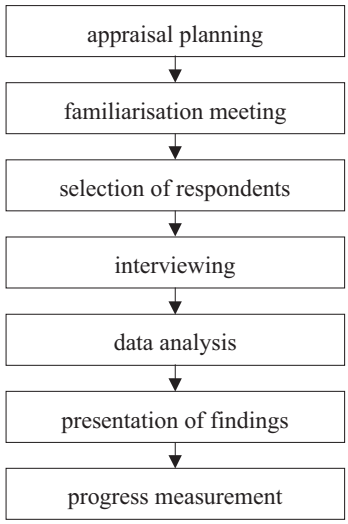

Figure 2. Appraisal process.

The original SAM requires the involvement of facilitators. They are the members of the appraisal team responsible for familiarising the team with SAM, for facilitating the appraisal process and for providing SE-CMM expertise. The Jozef Stefan Institute has provided the facilitator, as SAM suggests the facilitator to be drawn from outside the sponsoring organisation.

We emphasise some organisational issues related to the repeated assessment process resulting in process maturity progress. The subsequent assessments proceed in the following steps:

1. First, an assessment plan is prepared containing the selected process areas, activities and deadlines. The respondents are selected.

2. The assessment is announced in the quality review meeting following by the presentation of the assessment goals and the assessment plan. The set of the selected respondents is presented by their roles in the development process.

3. A familiarisation meeting is organised for the respondents not involved (if any) in previous assessments. Otherwise, the step may be omitted.

4. The assessment is performed following the plan.

5. During and after the assessment the collected data is analysed. The results are the progress measurement results and other findings about the development process based on the information from the interviews, for example improvement suggestions given by the respondents.

6. The results are presented and discussed in the next quality review meeting together with the progress measurement results.

7. Finally an improvement action plan is prepared including deadlines, responsibilities and a provisional deadline for the next assessment.

3.2. Questionnaire and rating adaptations

In addition to discussion with the respondent, the principal data-gathering technique during interviews uses the responses to a process maturity questionnaire. The original SAM questionnaire consists of a sub-questionnaire for each process area of the Systems Engineering Capability Maturity Model. Each process area begins with a summary description and a list of its base practices. The base practices are followed by three series of questions. Each series addresses a different perspective of systems engineering, performing the work, managing the process and infrastructure support. The questions that follow the base practices ask for the presence of generic practices and are actually the same for each process area.

The respondent should become familiar with how specific terms are used in the questionnaire. A glossary is provided for that purpose. We have noticed that the same form of questions for each process area may confuse the respondent. It happened several times that they gave answers related to a wrong process area. In order to avoid this kind of misunderstanding we have decided to translate the questions related to generic practices into the domain context. Different organisations have different internal meanings for common and uncommon terms; the terminology actually used in our organisation is used in the adapted questionnaire.

Using multiple choice answers increases the resolution of data gathering. The Yes/No type of choice used in the SEI's maturity questionnaire does not allow how frequently each practice is performed to be determined, without interviewing a large number of practitioners. In addition to "Don't Know" and "Not Applicable" choices, which have already been introduced in the SEI's questionnaire, we have defined six choices. These choices are "Always", "Often", "Mainly", "Sometimes", "Rarely" and "Never". In [10] five choices were proposed. We have decided to add an additional choice in order to prevent choosing the middle answer. It has been shown that respondents tend to choose the neutral middle choice.

CMM rates a process's capability as one of the five maturity levels, although process capability is a continuum. Multiple choice answers can be used to get finer resolution of process capability. Each of six choices is weighted using weights 1, 0.8, 0.6, 0.4, 0.2 and 0. "Don't Know" and "Not Applicable" answers are treated in accordance with the SAM guidelines. The weighted scores of all respondents for each practice in a given process area are averaged together to compute how frequently a given practice is performed. The second set of weights has been defined. These weights are respondent specific and are related to the respondent's knowledge about a specific process area. The objective of these weights is to emphasise the answers of the respondents who are more familiar with the area covered by the process area. Individuals who will provide answers that represent the existing situation should fill out the questionnaire. Those are the systems engineering leads, the experienced practitioners and the organisational experts.

A section on work products supplements the process maturity questionnaire. Work products are all the documents, files, data, etc., generated in the course of performing any process. For example, work products of identifying a review activity might be action item lists. On the other hand, work product of performing system integration might be the integrated system itself. Rather than describing individual work products for each process area, the SE-CMM lists typical work products of a particular base practice, to elaborate further the intended scope of that base practice. These lists are not to be considered as mandatory work products; they are illustrative only [1]. On our questionnaire, the list of typical work products is accompanied with the list of real work products that can be found in the real-life process. The real work products have been identified during previous assessments or they have been extracted from the company's standardised process description. These work products serve as a starting point for a new assessment. New work products may be added by the respondents and non-existent may be removed from the list.

In a small-scale low-budget assessment, the interviews cannot be performed always thoroughly. Therefore, the questionnaire allows additional explanations of some answers to be given by the respondents when the explanations cannot be discussed with the appraisal team during an interview. For instance, the generic practice "Document the process" under the common feature "Planning performance" on the capability level 2 - "Planned and tracked" is present when the approach to performing the process area is documented in standards and/or procedures. The questionnaire asks for the titles of the documents where these standards

and/or procedures are actually documented.

The activities of the appraisal process require support of the information technology in order to do an effective assessment as fast as possible. The organisation's Intranet is fully exploited for that purpose. The employees have access to the documentation about the capability maturity models and to the results of the assessments. They could trace the progress between the assessments. The data gathering during interviews is supported by the web-based technologies. Adequate support is provided for the data analysis and presentation of findings.

We collected the main reasons together with the concrete circumstances, which led us to improvement of the method in Tab. 1. In addition, the importance of the listed improvements for assessment success is given.

4. Future directions

The decision for the SE-CMM based improvement efforts has been chosen due to tight integration of hardware and software development processes in Iskratel. Further use of SEPAM (Systems Engineering Progress Assessment Method) is planned in development of the system SI2000 for assessing progress in reaching the short-term goal - the maturity level 3 for all process areas. SW-CMM would enable improvements in only one of the two major segments of telecommunication equipment production, although valuable findings could be expected. In the future, a migration towards CMMI-SE/SW (Capability Maturity Model-Integrated-Systems/Software Engineering) [7], which integrates both models, is planned. SEI began development of CMMI-SE/SW in early 1998. The current version of the model's specification is 1.02. Further changes are expected in the future.

We believe that the applicability of SEPAM is not limited only to Iskratel environment. Therefore, it would be of our interest to compare the experience of its use also in some other environments for telecommunication systems development with our experience. The comparison would provide us a valuable input for further improvements of the method.

References

[1] R. Bate, D. Kuhn, C. Wells, J. Armitage, G. Clark, K. Cusick, S. Garcia, M. Hanna, R. Jones, P. Malpass, I. Minnich, H. Pierson, T. Powell, and A. Reichner. A systems engineering capability maturity model, version 1.1. *Maturity Model SECMM-95-01, CMU/SEI-95-MM-003*, November 1995.

[2] M. Daskalantonakis. Achieving higher SEI levels. *IEEE Software*, pages 17–24, July 1994.

[3] D. K. Dunaway and S. Masters. CMM-based appraisal for internal process improvement (CBA-IPI): Method description. *Technical Report CMU/SEI-96-TR-007, ESC-TR-96-007*, April 1996.

[4] Ericsson. CMM light assessment. *LME/Q-96:117*, 1996.

[5] R. W. et al. Interim profile: Development and trial of a method to rapidly measure software engineering maturity status. *Technical Report CMU/SEI-94-TR-4, SEI, Pittsburgh, Penn.*, 1994.

[6] D. A. Kuhn, C. Wells, J. Armitage, K. Cusick, S. Garcia, M. Hanna, P. Malpass, and H. Pierson. A description of the systems engineering capability maturity model appraisal, method version 1.1. *Handbook CMU/SEI-96-HB-004*, March 1996.

[7] SEI. CMMI for systems engineering/software engineering, version 1.02. *Continuous (CMU/SEI-2000-TR-019) and Staged (CMU/SEI-2000-TR-018) Representation*, November 2000.

[8] M. Wakulczyk. NSSF spot check: A metric toward CMM level 2. *CrossTalk*, pages 23–24, July 1995.

[9] K. E. Wiegers. Misconceptions of the capability maturity model. *Software Development magazine*, page 57, November 1996.

[10] K. E. Wiegers and D. C. Struzenberger. A modular software process mini-assessment method. *IEEE Software*, 17(1):62–71, January/February 2000.

[11] S. Zahran. *Software Process Improvement*. Addison-Wesley, 1998.

Table 1. Reasons for improvements and their importance.

Reason	Concrete circumstances	Improvement	Importance
Appraisal process			
Small-scale assessment	Not all activities needed in subsequent assessments for particular process areas	Joining activities inside of all three phases	Medium
Focusing into process strengths/weaknesses	The process quality assessed in detail during the assessment	Skipping the findings refinement	Low
Questionnaire and rating			
General abstract terminology	Confusion with the questions related to presence of generic practices - differing practices in engineering process areas	Adapted terminology to development of telecommunications systems	High
Complexity/ architecture of concrete processes	Confusion with the level of sub-process, especially for process areas ”Derive and allocate requirements” and ”Evolve system architecture”	Specific questionnaires for all related sub-processes	High
Known aspects of process and respondent role	Different aspects known by project managers, practitioners, organisational management	Respondent specific weights of answers due to the role	Medium
Availability/number of choices for answers	Yes/no lacks for information on frequency, especially practitioners tend to give quantitative answers	Six choices	Medium
	Tendency of respondents to the middle neutral choice	No middle answer	High
Confirmation of correct understanding	Interviews cannot be performed always thoroughly	Additional explanations of some answers	Medium
General typical work products	Respondents have different views of work products	Lists of typical and identified work products	Medium