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A Software Process Evaluation Method for Small Organizations combining ISO/IEC 14598 and CMMI

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ABSTRACT
Small software organizations – independently financed and organized companies with fewer than 50 employees – are fundamental to many national economies' growth [1]. Many small software organizations have acknowledged the need to improve their software product. Evaluating the software product alone seems insufficient since it is known that its quality is largely dependant on the process that is used to create it. Thus, small organizations are asking for evaluation of their software processes and products.

The ISO/IEC14598-5 standard [2] is already used as a methodology basis for evaluating software products. This paper explores how it can be combined with the CMMI [3] to produce a methodology that can be tailored for process evaluation in order to improve their software processes. It also describes the resulting method and field trials.

KEYWORDS
Software Process, Process Evaluation, Small Organizations

1. INTRODUCTION

Many small software organizations have recognized the need to improve their software product. Evaluating the software product alone seems insufficient since it is known that its quality is largely dependant on the process that is used to create it. Thus, small organizations are asking for evaluation of their software processes and products. The ISO/IEC 14598-5 (ISO/IEC 1459805, 1998) standard is already used as a methodology basis for evaluating software products, combined with quality measures that are described in ISO/IEC 9126 (ISO/IEC 9126-1, 2000). Can the same method be used to evaluate software processes against the CMMI (CMMI Team, 2001), leading to its qualitative measurement? This paper describes the design activities to define a software process evaluation based on ISO/IEC 14598-5 and the CMMI. It also describes the method and the results.

1.1. ISO/IEC 14598-5

The ISO/IEC 14598 series is concerned with the process of evaluation, seen from different viewpoints. The standard is separated in six parts and provides guidance for 3 different perspectives: developer, acquirer and evaluator. As we are interested in an independent evaluation of a software process, part 5 of 14598 was used. The ISO/IEC 14598-5 is a standard that describes the evaluation process and the activities needed to perform an independent software evaluation in terms of quality characteristic as defined in ISO/IEC 9126 [2].

Figure 1 summarizes the ISO/IEC 14598-5.

1.2. Problems with ISO/IEC 14598

Insufficient goal formulation - The standard does not give much support on how to define evaluation goals. Another omission is that the standard does not provide support on how to involve stakeholders in goal formulation. Further, the standard does not address how to cope with changing goals [6].

Implicit relationships between activities - The standard does not specify clear relations between the activities. The lack of these relationships cause the activities to be conducted in isolation without taking the output of previous activities into account, while uncertainty exists about whether activity outputs will be applied by successor activities.

No attention to the trade-off between goals and resources - standard addresses the concept of resources with the concept of evaluation modules. However, the standard does not handle trade-off as such, because it is often impossible to trace the evaluation goals to the evaluation modules [6].

Insufficient attention to feedback – The standard does not explicitly address monitoring and feedback in its definition of the evaluation process. Nor have we seen such feedback in other evaluation literature so far. This causes evaluations whose results are only evaluated at the end of the process.

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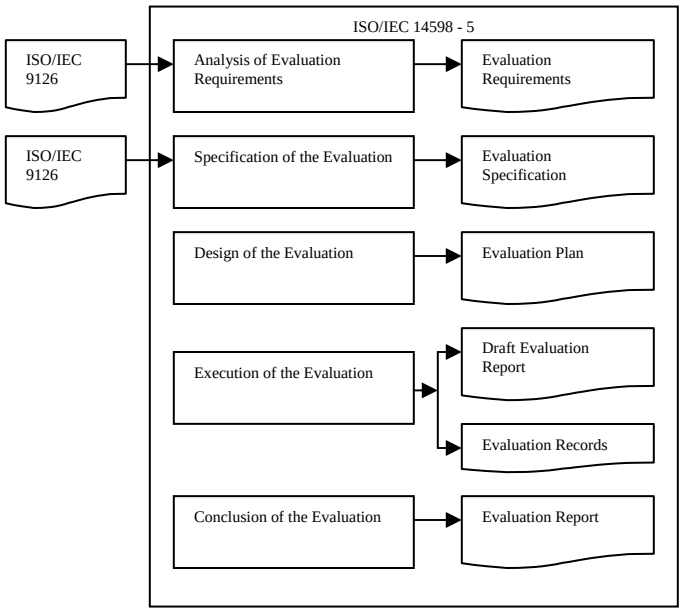

Figure 1. The ISO/IEC 14598-5 Evaluation Process [2]

1.3 The capability maturity model integration (CMMI)

The Capability Maturity Model Integration (CMMISM) is known in the industry as a best practices model. It combines practices of Systems Engineering (SE), Software Engineering (SW), Integrated Process and Product Development (IPPD), and Supplier Sourcing (SS) disciplines. The CMMI is mostly used to "provide guidance for an organization to improve its processes and ability to manage development, acquisition, and maintenance of products and services". The CMMI was conceived to allow organizations to rely on a single model to evaluate their maturity and process capability, establish priorities for improvements, and help them improve their practices [3].

1.4 Motivation for combining ISO/IEC 14598-5 and the CMMI

Several small organizations have expressed the need to improve their products quality. Many of those organizations are equally concerned with quality attributes of their software products and the quality of their software engineering process. Combining 14598-5 and 9126 is a natural choice to evaluate internal quality, external quality, and quality in use of a software product but there is no quality measures to apply to the software engineering process in 9126.

Maturity models such as the CMMI are used as a basis for process capability evaluation in the software engineering industry. At first, the question was raised as to whether it was appropriate to combine 14598-5 and CMMI to eventually come up with an evaluation method that will look at both the process and the product. A first glance at 14598-5 provided indications that combining CMMI and 14598-5 was appropriate. A well designed CMMI based evaluation method driven by 14598-5 recommended activities and deliverables should provide expected results at a reasonable cost for small organizations: areas of software process improvement with a positive return on investments within a week, with a level of effort between 70 and 90 hours (team of 2 evaluators).

2. THE DESIGN APPROACH OF THE EVALUATION METHOD

2.1 Expected usage context of the evaluation method

The designed method aims to evaluate project processes of small organizations, typically with team size of 2 to 10 developers. Those small organizations have limited budget and usually cannot afford a formal CMMI appraisal. It is expected that 2 evaluators execute the method within a week. The evaluation can certainly be applied to bigger organization. However, it is expected that the required level of effort would be higher.

2.2 Scope of the evaluation method

Considering available resources to design the evaluation method, a decision was made to limit the scope to software processes, leaving the evaluation of the product for a next iteration of the design. Given that, appropriate Process Areas (PA) of the CMMI were selected, typically all level 2 PA and those level 3 PA that are usually performed in small businesses that may not have organizational defined software processes.

2.3 Influences from known assessment methods

The authors had previous experiences or knowledge with known process assessment/appraisal methods called "mini-assessments". Other documents where looked at and provided influence on the design of the method, such as ISO/IEC 15504 (ISO/IEC 15504-2, 2003) and Assessment Requirements for CMMI (ARC) (CMMI Product Team, 2001).

2.4 The design process

The design activities that were followed to develop this process evaluation method are shown on Figure 2 along with necessary support activities. The different inputs to the design process are the CMMI models and the ISO/IEC 14598-5 standard. Other standards, such as ISO/IEC 15504 and ISO/IEC 9126, and the designer's experiences with software assessment methodologies also influenced the design process. The core activities of the design process were to define the method activities and the artifacts that go along with it. Peer reviews were applied on all the artifacts that were generated. Supporting activities to this design process were defined. Theses activities were to plan the design process activities, track the design and manage the design process outputs (the artifacts created).

A Configuration Management (CM) tool was used from the beginning to establish baselines and maintain integrity of the method and its artifacts. At the end of the project, process evaluation method deliverables were provided from the CM repository.

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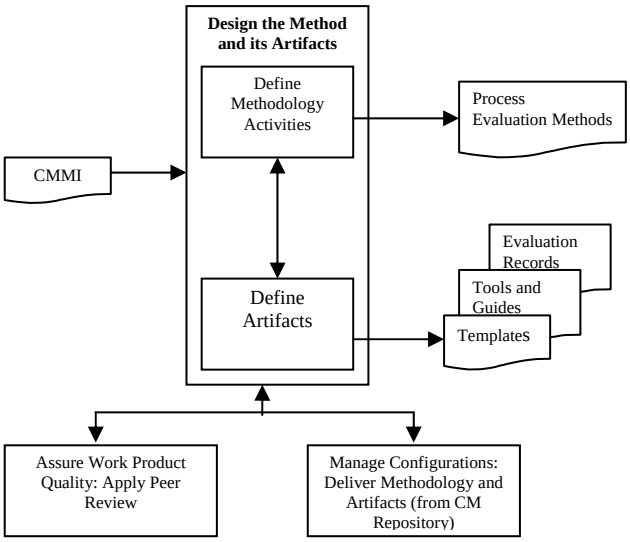

Figure 2 The design process of the method

2.5 The challenge of integrating ISO/IEC 14598-5 and the CMMI

The challenge was to replace references made to ISO/IEC 9126 by the CMMI as the main input to the method. ISO/IEC 14598-5 provides the list of output to produce and a brief overview of the evaluation report.

The CMMI provided the content of most method artifacts. In order to design a usable process evaluation method, "synthesis" knowledge level (Bloom, 1956) of the CMMI is necessary. Experience with at least one process assessment method is also required.

2.6 Usage of a process template

A simple process template was used to document the evaluation method. The process is described in a 2-layers approach. The first level is a diagram showing a high level graphical view of the complete process showing major steps with their inputs and outputs. The second level is a more detailed textual description of the process. This way of representing the process provides a quick overview of the process that allows faster understanding of the overall process. The textual description provides the required detail of activities for performing the evaluation.

3. THE CMMI-BASED PROCESS EVALUATION METHOD

This section describes the overall method that was designed, its major steps and artifacts (outputs).

3.1 Steps of the method

The overall evaluation method is shown in Figure 3. The diagram provides a high level view of process with required inputs (to the left) and produced output (to the right). Inputs and outputs in **bold** are those created as part of the process evaluation method.

3.2 Activities

Each step is further described in the method. For each step, there is:

- A short description;
- Step objectives;
- Inputs;
- Pre-conditions to the realization of the step;
- Normal flow of activities;
- Alternate flows, if appropriate;
- The list of verification activities that are conducted;
- Outputs;
- Post-conditions to the realization of the step; and
- The measures that need to be taken.

3.3 Artifacts

Table 1 lists the artifacts produced through the method (outputs), their objectives, and the step in which they are created or modified.

Table 1 Artifacts (outputs) of process evaluation method

Artifact	Objective	Realization Activities
Statement of Work	Define evaluation objectives and scope.	Analysis of Evaluation requirements
Client contract	Contains confidentiality agreement.	Specification of evaluation
Evaluation Plan	Planning of reviews and interviews to be conducted.	Design of Evaluation
List of selected questions	Interview questions on CMMI selected process areas.	Design of Evaluation
Interviews and document review observations	Evaluator's personal observations noted.	Interviewing project participants and review project documentation, conclusion of the evaluation.
Findings	Description of findings.	Previous activities, reviewing and reporting
Evaluator checklist	For validation of activities.	-do-
Evaluation Report Action Plan	Action plans to be carried-out to improve the software process on major findings.	Conclusion of evaluation, Planning of improvement actions

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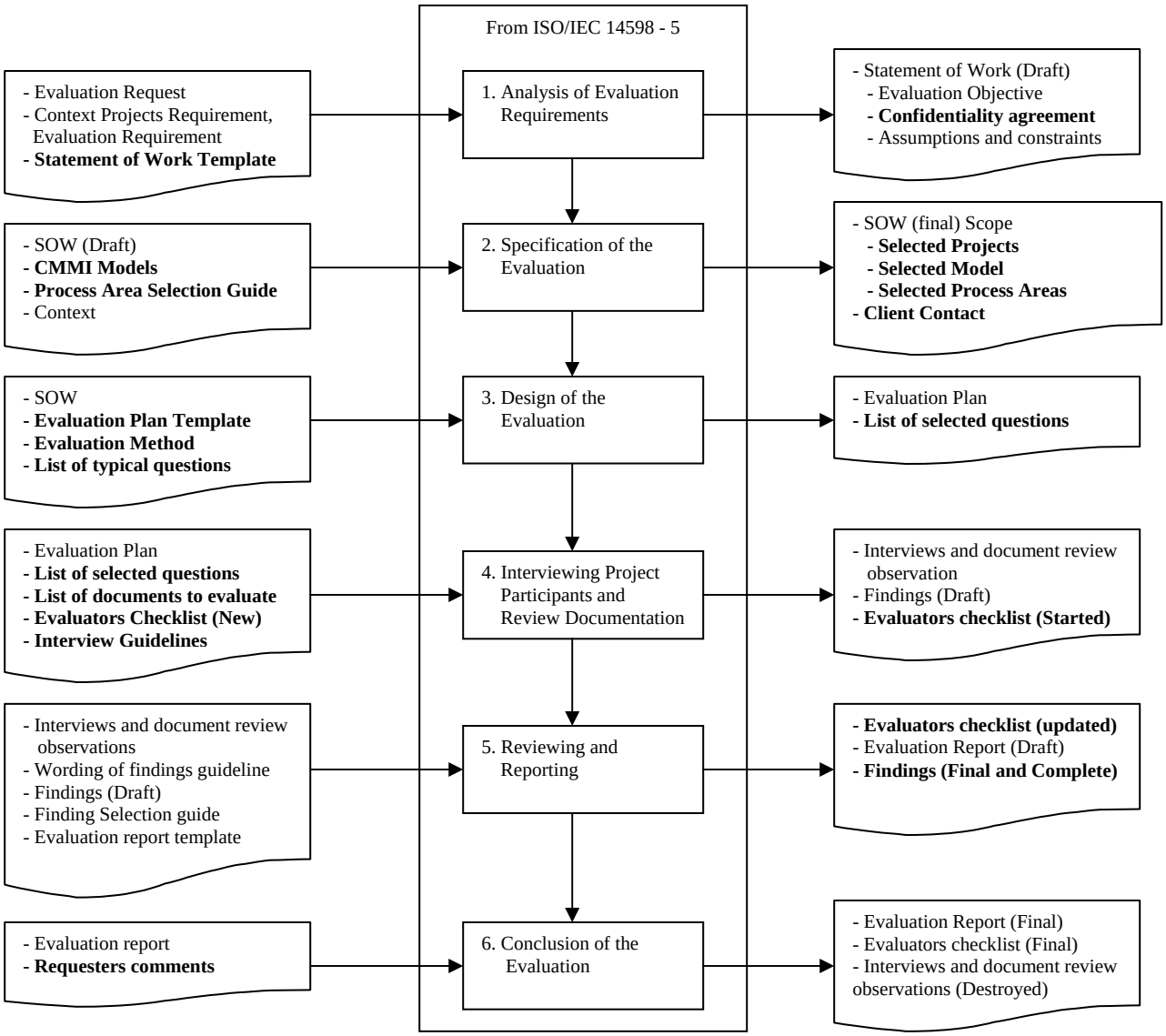

Figure 3 Process Evaluation Method

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3.4 Templates
The following templates were made in order to reduce the required effort from the evaluators to generate some of the evaluation artifacts:

- Statement of Work template;
- Evaluation Plan template;
- Evaluator's checklist;
- Evaluation Report template; and
- Action Plan template.

3.5 Compliance with ISO/IEC 14598-5
This section describes the similarities and differences between the Process Evaluation Method and the compliance for each Evaluation Process Requirement of the ISO/IEC 14598-5.

3.5.1. General requirements
The general requirements apply to the Process Evaluation Model. Wherever applicable, fulfillment of these requirements has been embedded in the Process Evaluation Method. A design decision was taken to include the evaluation requirements and stakeholders' responsibilities in a Statement of Work (SOW) for which a reusable template was developed.

3.5.2. Analysis of evaluation requirements
This step has same name in the Process Evaluation Method. The analysis step is slightly different when used in the context of doing a CMMI evaluation for improvement. To match the context of use, evaluation requirements represent the requester's needs and objectives. Using objectives provide enough of the organizational context to allow for selection of process areas.

3.5.3. Specifying of the evaluation
This step has the same name in the Process Evaluation Method. There is no need to conduct an analysis of the product specification at the component level as proposed in ISO/IEC 14598-5 since the process is examined rather than a product.

Instead of selecting product components as proposed, projects are selected along with their documentation that needs to be reviewed. Instead of specifying measurement, the list of process areas to evaluate is defined in order to meet evaluation objectives.

3.5.4. Design of the evaluation
This step has the same name in the Process Evaluation Method. The evaluation of process areas is conducted using interviews of project participants and document reviews. This kind of evaluation requires a simple tooling that consist of evaluation questions and findings tables. The questions allow for identification of the observation that will be grouped and consigned in findings tables.

The activity planning involves scheduling interviews with participants. More emphasis on people have to be made in this planning than the than the ISO/IEC 14598-5.

3.5.5. Execution of the evaluation
This step is split in two steps in the Process Evaluation Method, which are Interviewing Project Participants and Reviewing Project Documentation, and Reviewing and Reporting. The rationale for breaking these in two is that the interviews and reviews must be completed prior to the reporting. Another rationale to separate the two is the fact that the review and interviews may be conducted in parallel by the evaluators. Then, the evaluators agree on major findings to be reported and act upon.

3.5.6. Conclusion of the evaluation
This step has the same name in the Process Evaluation Method. This step completely conforms to the ISO/IEC 14598-5.

4. RESULTS
The method has been used to evaluate software engineering processes of one company. Feedback from evaluators was provided and used to improve the method and its artifacts. The first field trial was done at an early method development stage in a small size software organization (30 developers) (organization names and date of evaluations are confidential) that wanted to improve its software development processes (reduce cost and schedule overruns) and learn how to evaluate software processes. An evaluation team of 6 people (one external and 5 internal) interviewed half of the development staff through 3 software development projects. The evaluation duration was 2 weeks, due to the scope size, the organization size, and the knowledge transfer on a CMMI based evaluation method to the internal team. The customer stated being satisfied at the end of the evaluation.

It is estimated that approximately 20% of the time was spent teaching one of the internal resource about the CMMI and ISO/IEC 14598. All templates were used with minor tailoring to suit organization's needs. The customer indicated being satisfied with the results. Results are encouraging, leading the authors to believe that 2 evaluators can apply the process evaluation method in a small software organization with a maximum duration of 45 hours, including some action plans.

5. OPEN AND RESOLVED ISSUES

5.1 Relation with ISO/IEC 9126
ISO/IEC 14598-5 is closely related to ISO/IEC 9126 since an evaluation method of a software product requires defined measures. So how 14598-5 could be used to evaluate software processes without measures? This issue was resolve by replacing all references made to 9126 by the CMMI content wherever it was deemed appropriate. As an example, process areas are used during planning of the evaluation and CMMI practices are used to design the list of typical questions.

5.2 Repeatability of the method
In order to develop a method that is reproducible and repeatable, it was decided to build up a list of typical questions. This list is to be used, at step 5 of the valuation method, during the project participant's interviews to help the interviewer to cover all practices from process areas that are part of the evaluation scope.

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5.3 No measures for software processes compliance to the CMMI

ISO/IEC 9126 does not provide measures for software process compliance to a known model such as the CMMI. The process evaluation method does not either. The CMMI structure does allow for a "level" measure that can be applied either on the whole model in the staged representation or on every process area in the continuous model providing a "profile" of levels. The method does not provide such measure as a SCAMPI may give through voting and reaching consensus among evaluators. Nonetheless, the method was developed for customers who want to improve their software process performance without caring about a level. The method has been designed to uncover major findings to act upon. From the customer point of view, growth in capability should be measured by fewer cost and schedule overruns and higher customer satisfaction with their products. Measures may be added such as process evaluation method compliance during execution and evaluators satisfaction of the method usage. But is it possible to evaluate a software process and come up with a set of measures that would be repeatable and reproducible? This is still an open issue.

6. CONCLUSION

The objective of the author's was to develop a CMMI-based evaluation method driven by ISO/IEC14598-5 recommended activities and deliverables in order to produce a software process evaluation method at a reasonable cost for small organizations. The method proposed is aligned with the ISO/IEC 14598-5 evaluation process. One additional step was added to ensure that the findings resulting from the evaluation were addressed in action plans where priorities were established and responsibilities were assigned to the relevant stakeholders. A few field trials that were done using this method have demonstrated that the research objective can be met.

Using this method, it is possible to perform a software process evaluation in a small organization (team size of 2 to 10 people), within one week including a first draft of action plans to address some of the major findings.

7. FUTURE SCOPE

The software evaluation method proposed can be further extended to mid-size software organizations. It may not be possible to complete the software evaluation process within a week in that case due to the increase in team size. In order to fulfill the need of a mid-size organization, the only change to the method would be to the evaluation plan where the activities and the schedule are defined.

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