

# Assessment of the requirements management process using a two-stage questionnaire

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## Abstract

*This research advocates the idea that although requirements management process is not carried out in many organizations there is some people within the organization that perform some requirements management practices. However, these practices are usually not documented and as consequence are not spread across the organization. This paper proposes an assessment methodology based on a two-stage questionnaire to identify which practices of the requirements management process are performed but not documented, which practices require to be prioritized and which are not implemented due to bad management or unawareness. In order to validate the assessment methodology, the questionnaire was applied to an industrial case study.*

## 1. Introduction

It is generally accepted that requirements are the foundation upon which the software process is built, however, the incapacity to manage requirements changes is one of the principal factors that contribute to delays on the software development process, which in turn, may cause customer dissatisfactions [1]. A good requirement should be traceable to business objectives and should be related to system lifecycle components. It should be consistent with the scope and constraint of the product, incorporate stakeholder expectations, should be measurable against acceptance criteria, and should be maintainable over the software project's lifecycle [2].

In order to help the software process, Requirements Management (RM) emerges as a systematic approach to identify, document, organize, and track all system's requirements. RM major aim is to establish an

agreement between the customer and the software team on the meaning of the requirements [3, 4]. A quality RM process is fundamental for successful software process.

An approach to get better RM process is using any "Best Practices Reference Model" as guide to improve the process. Some research centers have collected practices from organizations which have reached outstanding results in their software process. These practices are called best practices and are organized into processes.

A reference model is a set of activities, practices and processes that guides the organization's software process improvement efforts. The most known and extended best practices reference model in the software community is the Capability Maturity Model (CMM) [5, 6].

With the success of the CMM, other disciplines start developing capability maturity models in areas such as systems engineering, software acquisition, workforce management, and integrated product and process development. The use of multiple models, however, was problematic mainly because many organizations have to divide their improvement efforts across different models.

The Capability Maturity Model Integration (CMMI) [3, 4] was developed to solve the problem of using multiple CMM models, integrating practices from four different source models: for software (SW-CMM), for systems engineering (SE-CMM), for integrated product development (IPD-CMM), and for acquisition (EIA-731).

Though some organizations may use the CMMI as guide to improve their processes, the Software Engineering Institute (SEI) defined in the IDEAL model [7] that one of the first steps of a Software Process Improvement (SPI) effort is to appraise the

current state of the process. And therefore the SEI was developed SCAMPI as assessment method to appraise the current state of the organizations software process using the CMMI as a reference model [8].

Despite the fact that SCAMPI describes a series of steps to apprise the software process, at present time many of materials of the method are incomplete or still under development. Furthermore, SCAMPI is an expensive methodology because consume a lot of assessment recourses like: team size, training and cost. In some organizations the SCAMPI assessment cost could be too high from 40,000 to 100,000 USD per event [9]. The scope of a typical SCAMPI assessment might be too large particularly in a smaller organization.

The objective of this paper is to provide an accurate picture of the organization's Requirements Management (RM) process by the use of an assessment methodology based on a two-stage questionnaire. The questionnaire is based on the two practices of the requirements management process area of the CMMI [3, 4].

The authors argue that the use of this assessment methodology can be helpful to obtain useful information related to the current state of the RM process and identify which practices are performed but not documented, which practices require prioritizing and which are not implemented due to bad management or unawareness. Also, the data derived from the questionnaire could help to identify those people that perform some RM practices and incorporate their efforts to the Action Plan. Finally, the questionnaire could be used to help the data collection in a SCAMPI assessment.

This paper is divided into five main sections. In order to understand the objectives of the mechanism proposed in this research section 2 presents the critique of some questionnaires to appraisal the software process. Section 3 establishes the rationale for the questionnaire and its structure. Section 4 present the data analysis of an industrial case study. Section 5 presents the conclusions of this paper and points at future research activities.

## **2. Data collection instruments: a critique of the questionnaires used to appraisal the software process**

There are a wide number of data collection instruments that can be used to appraisal: questionnaires, surveys, interviews, and reviewing documentation, all having their advantages and disadvantages. However, questionnaire is one of

techniques that are most commonly used, because it can be applied to many people, is cost effective, non-invasive, provides quantitative data, and is possible to analyze the results with promptness [10].

Questionnaires can be classified into open and close questions. An open-question questionnaire provides more information than a closed one. But the complexity for the analysis of the data provided by open questions is higher than those in closed-questions [11]. It has been argued that the use of questionnaire consumes less time, effort and financial resources than other methods of data collection like interviews or document reviews [12].

### **2.1. Available appraisal questionnaires**

In order to propose an alternative assessment methodology based on a two-stage questionnaire, we analyzed the structure of the appraisal questionnaires available in the literature.

The first reviewed questionnaire was the SEI' Maturity Questionnaire [13]. The major disadvantage of this questionnaire is that it was developed using the SW-CMM [6] as a reference model, so it provides a little information about the RM process because it focuses on the maturity of the process and does not centre of attention to find the weakness of the RM practices. Another disadvantage is that this questionnaire is limited on the number of responses that can be selected (only two options "Yes" or "No") and it limits the information to two extreme ends (Yes, if the practice is performed and No if the practice is not performed). Therefore, it does not leave room for intermediate points. For example, the questionnaire does not provide options to capture the cases where the practices are performed but rarely documented or when they are not documented at all.

The use of a questionnaire with limited answer options may provide limited or misleading information. A project sponsored by the SEI support this argument: "We are not providing the results of the generic goals and practices and specific process areas sections of the web-based questionnaire in this preliminary report. In both of these sections, there were no radio buttons and therefore the responses provided were in the form of specific comments. Many of these specific comments contain little information. For example, responses such as none or no were common" [14]. In the same project the SEI used, in one-question, five possible responses: *Almost always*, *More often than not*, *Sometimes*, *Rarely if ever* and *Don't know*. But does not explain why this response structure was not used in for all questions.

The third reviewed questionnaire was the report of the Process Improvement Program for the Northrop Grumman Information Technology company [15]. They propose an appraisal questionnaire with seven possible responses (Does not apply, Don't know, No, About 25% of the time, About 50% of the time, About 75% of the time, and Yes). This questionnaire proposes more response granularity, however, it do not apply for the RM process, because it was developed using the SA-CMM [16] as a reference model and only focuses on the software acquisition process.

Finally, we reviewed the questionnaire structure developed by the Institute for Software Process Improvement (ISPI). An example of a ISPI questionnaire based on the "Key Practices of the Capability Maturity Model, version 1.1" is exemplified at detail by Cuevas, et al. [17]. This questionnaire uses five types of responses (Never, Rarely, Sometimes, More often, and Always). Despite ISPI' questionnaire may be more useful than the others reviewed, it only obtain partial information about the current state of the RM process because use the SW-CMM [6] as a reference model and it focuses on the maturity of the process.

In summary, the information provided by the questionnaires reviewed here is limited on its contents. The authors argue that this may be due to the fact that these questionnaires were designed with very limited number of responses. Hence the information that can be extracted is limited as well. Furthermore, the aforementioned questionnaires did not address in detail the requirements management process, and there is no evidence of a questionnaire that covers both practices addresses by the CMMI.

### 3. An alternative assessment methodology based on a two-stage questionnaire

The assessment methodology based on a two-stage questionnaire proposed in this paper uses closed questions with seven possible answers in order to be better informed of the state of the process:

- Five perform-level-answers to know the extent of each practice is performed: *Almost Always*, *More often than not*, *Sometimes*, *Rarely if ever*, and *Never*.
- Two validity-answers to corroborate the suitability of the question: *Don't Know* and *Not Apply*.
- Additional information spaces (Comments) to extract supplementary background information.

Each possible response of the questionnaire has a unique interpretation and indicates the perform level of the practice or subpractice (Table 1).

	Almost always	More often than not	Sometimes	Rarely if ever	Never
Perform Level	Always	Almost always More often	Sometimes	Rarely if ever	Never
Documented	Yes	Sometimes	Sometimes	No	No
Percentage Value	100%	75%	50%	25%	0

Table 1. Answer option of the two-stage questionnaire

*Almost Always.* The practice is performed and documented almost always.

*More often than not.* The practice is performed but sometimes is documented, or, the practice is performed more often and documented sometimes.

*Sometimes.* The practice is inconsistently performed and usually is not documented.

*Rarely if ever.* The practice is performed rarely if ever and is not documented.

*Never.* The practice is not performed.

#### 3.1. Questionnaire structure: the two-stage division

The questionnaire proposed here was based on the two types of practices of the Requirements Management process area (REQM) established by the CMMI and it is divided into two stages. The first-stage is related to the specific practices and the second-stage is related to the generic practices.

3.1.1. The first stage is applied to the employees that execute the processes like: analyst, developers, designers, programmers, etc. This stage is divided in five Specific Practices (SP). It is required to perform all SP in order to get a well established RM process (Table 2)

SP1	Obtain an understanding of the requirements with the users and clients
SP2	Obtain commitment to requirements of all the participants of the project
SP3	Manage requirements changes during the project lifecycle
SP4	Manage requirements traceability follow the life of a requirement in both a forwards and backwards direction
SP5	Find the inconsistencies to could exist between the project plans and the software requirements and taking corrective actions

Table 2. RM specific practices

**3.1.2. The second stage** is applied to the employees that manage the process like: senior management, system manager, software manager, or team leaders. This stage is divided in ten Generic Practices (GP), and aims to find if the requirements management are institutionalized or not.

The institutionalization is a critical aspect of process improvement and implies that the process is ingrained in the way the work is performed. GP provide institutionalization to ensure that the processes associated with the process area will be effective, repeatable, and lasting [3, 4]. It is required to perform all the GP activities in order to get an institutionalized RM process (Table 3)

GP1	Adhering to organisational policies
GP2	Tracking a documented project plan
GP3	Allocating adequate resources
GP4	Assigning responsibility and authority
GP5	Training the affected people
GP6	Placing under version control or configuration management
GP7	Reviewed by the people those affected
GP8	Measuring the process
GP9	Compliant the process with specified standards
GP10	Reviewing status with higher-level management

Table 3. RM generic practices

**3.1.3. The assessment methodology** establishes that for each question is required to calculate the arithmetic mean of all valid answers. Consequently, those practices which average is smaller to 75% are considered not implemented in the organization and it will be considered an aspect to improve.

On the other hand, those practices which average is greater or equal to 75% could be consider like a strong points of the process, but only if the standard deviation is smaller or equal to one ( $SD \leq 1$ ). If the standard deviation is greater, suggest that that there may be strong discrepancies between the answers. Therefore, it is necessary to analyse the answer-question in more detail with the use of interview techniques.

It is expected that the cross analysis of the responses of both questionnaires can allow the Information System (IS) practitioners to know those RM practices that have been covered by the software team and that have been spread throughout the organization as an institutionalized process. Similarly, this cross analysis can help also to identify other issues related to the combination of the parameters of both stages of this questionnaire. If you require a copy of the complete two-stage questionnaire then please do not hesitate to contact us

## 4. Case study: data analysis

To investigate the advantages and limitations of the assessment methodology based on a two-stage questionnaire, an appraisal of the RM process in a subsidiary of a multinational chemical company located in Mexico, City was conducted.

The questionnaire was applied in two stages: the first (Specific Practices) was applied to those employees that are analyst, developers, designers, and programmers. The second (Generic Practices) was applied to the system manager and team leader.

### 4.1. RM specific practices assessment

The analysis of the values obtained from the answers given from application of the first-stage questionnaire to this case of study found that none of the five Specific Practices achieves the minimal performance level (75%) to be considered as strong points of the process.

However, there are three practices SP1, SP2, and SP3 between 50% and 75% percentage of performance level, this suggests that the improvement effort could be focus only to document the process.

On the other hand, the values obtained for two practices, SP4 and SP5, were under 50%. This suggests that these practices should be prioritized in the organizational action plan (Fig 1).

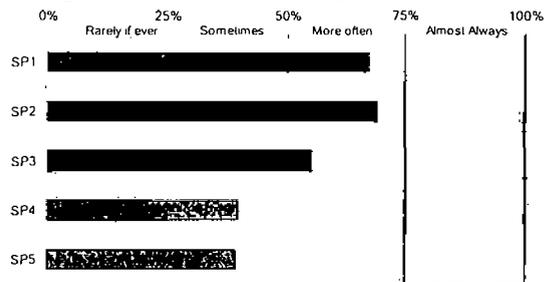


Fig. 1. RM specific practices perform level

Each Specific Practice (SP) of the Requirements Management (RM) process has divided in activities called subpractices: SP1 has six activities, SP2 has five activities, SP3 has five activities, SP4 has four activities, and SP5 has three activities.

**4.1.1. Perform level analysis of SP1.** In this case of study one activity of SP1: "A1-Designate the appropriate requirements providers" has a performance level greater than 75% and could be considered as process strength. This means that this activity is performed and documented (Fig. 2).

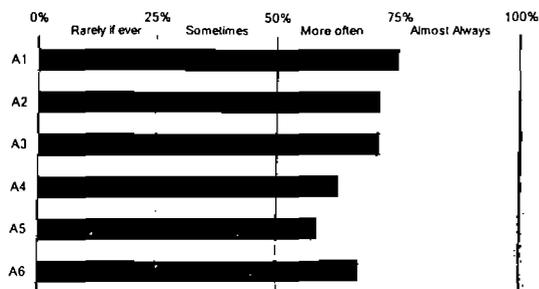


Fig. 2. SP2 obtain an understanding of the requirements with the user and clients

On the other hand, five activities (A2, A3, A4, A5, and A6) have a performance level between 50% and 75%; this suggests that the improvement effort could be focus only to document the process.

**4.1.2. Perform level analysis of SP2.** Two activities: "A1-obtain agreements and commitments with the project participants on the meaning of the requirements" and "A2-Review the agreements and commitments with the project participants" have a performance level greater than 75% and could be considered as some of the RM process strengths (Fig. 3).

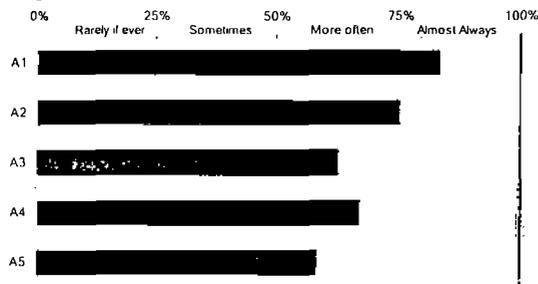


Fig. 3. SP2 obtain commitment to requirements of all participants of the project

On the other hand, three activities (A3, A4, and A5) have a performance level between 50% and 75%; and advise that the improvement effort could be focus only to document the process.

**4.1.3. Perform level analysis of SP3.** In the analysis of SP3 none of the activities are greater that 75%, consequently, one activity: "A4-Evaluate the impact of the requirements changes with the relevant stakeholders" is inconsistently performed and usually is not documented. This suggests that this activity should be considered as one of the priorities for the organizational improvement effort (Fig. 4).

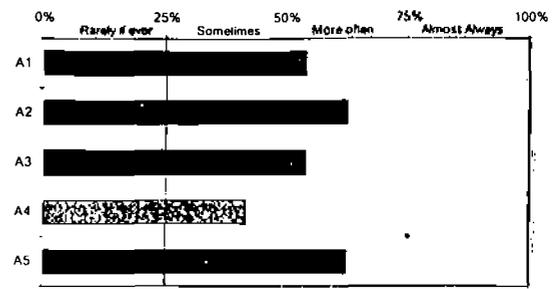


Fig. 4. SP3 manage requirements changes

**4.1.4. Perform level analysis of SP4.** In the analysis of SP4 none activities are greater that 75%, consequently, one activity: "A4-maintain the requirements traceability matrix" is barely performed, is not documented, and only some isolated people has the intention to perform it. This suggests that this activity needs to be explored in more detail with the use of interviews (Fig. 5).

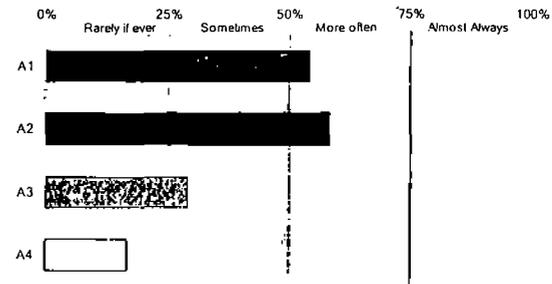


Fig. 5. SP4 manage requirements traceability

**4.1.5. Perform level analysis of SP5.** Finally in SP5 none of the activities are greater that 75% and all activities are inconsistently performed and usually are not documented. This suggests that these activities should be considered as one of the priorities for the organizational improvement effort (Fig. 6).

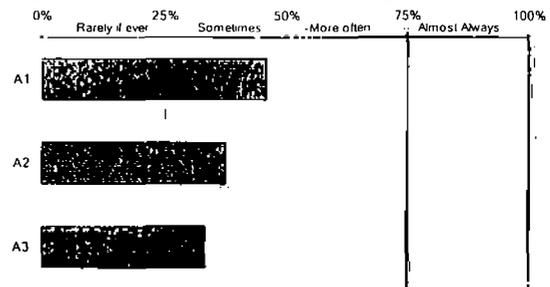


Fig. 6. SP5 find the inconsistencies to could exist between the project plans and requirements

All activities in this study with performing level was grater than 75% did not show a standard deviation

smaller than 1. Hence it can be assumed that there are not major differences amongst the values given by these answers.

#### 4.2. RM generic practices assessment

The analysis of the values obtained from the answers given from application of the second-stage questionnaire to this case of study was found that none of the ten Generic Practice (GP) achieves the minimal performance level (75%) to be considered an institutionalized process. This observation was expected since none SP was graded equal to 75% of perform level.

The highest value obtained from the second-stage questionnaire was "GP3-Provide the adequate resources to perform the RM process". This means that this GP is performed but only some times is documented for this case the action plan only be focus to document the practice (Fig. 7).

By contrast the lowest value obtained from the second-stage questionnaire was "GP5-Provide adequate training to the people to perform or support the RM process, GP6-Place the requirements under configuration management, and GP7-Request the involvement of stakeholders during the execution of the RM process". This suggests that these GP should be prioritized in the organizational action plan (Fig. 7)

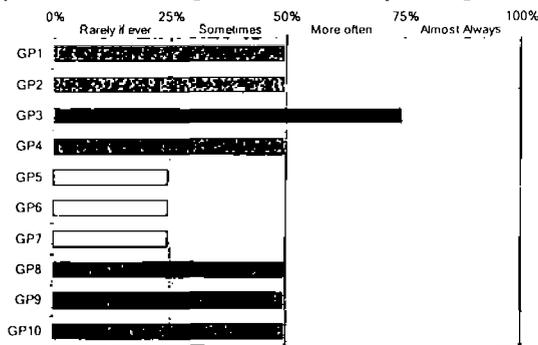


Fig. 7. Generic practices perform level

#### 5. Conclusions and further research.

This research proposes an alternative assessment methodology based on a two-stage questionnaire as instrument to evaluate the current status of requirements management process. The questionnaire is divided into two stages: the first to identify specific practices and the second to identify generic practices. In this way this questionnaire matches the needs of the CMMI since these differences are identified. Furthermore, this division also helps to differentiate

the roles of the employees. For instance, the first-stage refers to the series of steps that have to be followed to perform the requirements management process and it applies to those employees that execute the requirements management process. The second-stage refers to the maturity and institutionalization of the requirements management process and it applies to the employees that manage the process. This differentiation based on the idea that the questions that are applied to the process executors are not relevant to the process managers and vice versa. Therefore, by dividing the questionnaire into two stages the problem of addressing the wrong people is minimized.

At the same time the number of people to be interviewed in a second evaluation round was reduced because the questionnaire helps to identify those activities, and the corresponding employees, where more specific information is needed.

A case of study was used to confirm the feasibility of this instrument. It was found that the alternative assessment methodology based on a two-stage questionnaire, proposed in this paper, could provide valuable information related to those areas that require prioritize. In this case of study two specific practices and three generic practices showed some mayor problems. These suggest that they need to be a priority for the action plan.

Another advantage of this alternative assessment methodology based on a two-stage questionnaire is that it may help to reduce the cost, time and effort of the assessment. A typical project requires an average of 28 days for the appraisal process and to derive some results [17] In the case study, the use of the assessment methodology helped to reduce the appraisal to only ten days to present the results and the action plan.

The assessment does not provide any improvement on its own, but it provides valuable information of the current state of the process and lays the foundation for making better choices about the changes to the information technology practitioners should make [18].

As a result of the assessment a draft of the action plan was developed in order to continue with the improvement project. The action plan describes all activities, deliverables, schedule and prioritization of processes to be improved.

The following phase if this research is to confirm the results of this case of study. This can be done by comparing the time used by others assessment methodologies and the time used with the application of the two-questionnaire. These experiments are currently undertaken to identify which instrument consumes less time.

Finally, this research is aware that the identification of the practices that need to be implemented is only the first step of a continuous process and that in order to aim for a successful Software Process Improvement program there is the need to describe how to implement the identified practices. Further research to propose a methodology to implement most of the CMMI practices can also be undertaken.

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