

FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

# Electronic Assessment for Software Development Certifications

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Mestrado Integrado em Engenharia Informática e Computação

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# Abstract

Due to the change of the paradigm of current markets, resulting from the phenomenon of globalization, organizations are forced to streamline their business, in order to be able to maintain their competitiveness and ensure a favorable market position. To achieve such agility, their processes need to be less time consuming and more effortless, so they can focus on what really matters: value creation.

Certifications are a formal recognition of an organization that will provide guidance and tools for those who want to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved. However useful for the organization, the evaluation for certification takes too much effort and time. For example, the SCAMPI method takes a significant effort, being in some cases a very painful and expensive process. SCAMPI is the Standard CMMI Appraisal Method for Process Improvement, the evaluation method of CMMI model. CMMI is a model for organizations to improve their processes and is required by many U.S. Government contracts, especially in software development. Tool support is fundamental for facilitating the adoption of CMMI practices. SCRAIM is an example of a project life cycle management tool specifically designed to facilitate CMMI implementations.

The main goal of this dissertation is to develop methodologies, techniques and tools, integrated in the SCRAIM interface, that will make evaluations and certain parts of certifications easier and less painful for the SCRAIM users.

Although there are a number of life cycle and project management tools, few combine this with process management techniques. SCRAIM combines the two and will provide the users new features that will semiautomate the assessment for certification of an organization. The full automated process is not yet feasible, so human intervention is still mandatory.

After an initial assessment of the the level of support of SCRAIM regarding CMMI practices, it was decided to focus the electronic assessment on maturity level 2, for which assessment rules were defined, and a prototype was implemented and validated on a real world project.

Experimental results show that the rules provided accurate results (with a maximum error of 1 point) for 79% of the practices evaluated.

We can see many advantages of this innovation, and we believe that the application of this innovation will help reduce the costs and time of an evaluation using the SCAMPI method.



# Resumo

Com o efeito da globalização, assistimos a uma mudança no paradigma dos mercados atuais, mudança essa que forçou as organizações a melhorar os seus processos de modo a manter a sua competitividade e deste modo garantir uma posição favorável no mercado. Para que tal aconteça, é necessário que comecem a simplificar e a perder menos tempo nos processos, pois só assim é possível à organização focar-se no que realmente interessa: a criação de valor.

As certificações são um reconhecimento formal de uma organização que fornecem orientação e ferramentas, no sentido de garantir que os produtos e serviços vão de encontro às necessidades e requisitos dos clientes e a sua qualidade é constantemente melhorada. Apesar de serem úteis para a organização, as certificações exigem um esforço muito elevado e consomem muito tempo. Por exemplo, o método SCAMPI exige um esforço elevado, sendo por vezes muito doloroso e custoso monetariamente para a organização. O método SCAMPI é o método standard de avaliação para a melhoria de processos, associado ao modelo CMMI que é um modelo para as organizações melhorarem os seus processos e é exigido por muitos contratos do governo dos EUA, especialmente no âmbito do desenvolvimento de software. SCRAIM é a ferramenta que vai fornecer meios para simplificar esse tipo de avaliações, com o objetivo de economizar tempo e consequentemente dinheiro.

O objetivo principal do presente trabalho de dissertação é desenvolver de metodologias, técnicas e ferramentas, integradas no SCRAIM, que irão tornar as avaliações e certas partes das certificações mais fáceis e menos extenuantes para os utilizadores do SCRAIM. Embora haja um número elevado de ferramentas que permitem gerir os projetos e o ciclo de vida deles, poucas combinam isso com técnicas de gestão de processos. O SCRAIM combina os dois e irá fornecer funcionalidades que irão permitir semi-automatizar a avaliação para a certificação de uma organização. O processo totalmente automatizado ainda não é viável, pois a intervenção humana ainda é obrigatória.

Após uma avaliação inicial do nível de suporte do SCRAIM em relação às práticas do CMMI, foi decidido focar a avaliação automática no nível 2 de maturidade, para o qual foram definidas regras de avaliação e implementado um protótipo, que foi testado e validado com um projecto do mundo real.

Resultados experimentais mostram que as regras forneceram resultados precisos (com um erro máximo de 1 ponto) para 79% das práticas avaliadas.

Podemos ver muitas vantagens da criação e desenvolvimento desta inovação e acreditamos que a sua aplicação ajudará a reduzir os custos e o tempo de uma avaliação utilizando o método SCAMPI.





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Last but not least, I would like to thank my family and close friends, they were always supporting me and encouraging me with their best wishes.

Nelson Daniel Ribeiro Mendes



*“All Models are wrong, but  
some are useful.”*

George E. P. Box



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# Abbreviations

ARC	Appraisal Requirements for CMMI
CAR	Causal Analysis and Resolution
CM	Configuration Management
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
DAR	Decision Analysis and Resolution
IPM	Integrated Project Management
OE	Objective Evidence
OPD	Organizational Process Definition
OPF	Organizational Process Focus
OPM	Organizational Performance Management
OPP	Organizational Process Performance
OT	Organizational Training
OU	Organizational Unit
PI	Product Integration
PII	Practices Implementation Indicators
PM	Process Management
PMC	Project Monitoring and Control
PP	Project Planning
PPQA	Process and Product Quality Assurance
PSP	Personal Software Process
QPM	Quantitative Project Management
RD	Requirements Development
REQM	Requirements Management
RSKM	Risk Management
SaaS	Software-as-a-service
SAM	Supplier Agreement Management
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SEI	Software Engineering Institute
SPICE	Software Process Improvement and Capability Determination
SQI	Software Quality Institute
TS	Technical Solution
VAL	Validation
VER	Verification
WBS	Work breakdown structure



# Chapter 1

## Introduction

This chapter presents the context and motivation of this thesis, describing the main goals, its objectives and the expected results.

### 1.1 Context and motivation

Nowadays current markets are changing, we can see more often the globalization phenomenon and with that organizations are compelled to streamline their business in order to achieve a favorable market position and be able to maintain or increase their competitiveness.

In our everyday lives software takes an important role, it is everywhere and is needed more often. When is in development it is important to make it more efficient and with more quality. For software development organizations failures and errors are not allowed and each one of them implies increased costs and resources being wasted. To avoid this scenario and to achieve maximum efficiency and agility, their processes and their methodologies need to be less time consuming and more effortless so good practices need to be followed in order to allow them focus on what really matters: value creation. This will provide them advantages and make them more trustworthy.

Organizations need to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved and certifications are a formal recognition of those ideals. Sadly those recognitions take too much time and effort and in some cases they are very painful and expensive.

Capability Maturity Model Integration(CMMI)[CMM] is a framework of best practices and does not describe the processes themselves, it describes the characteristics of good processes in order to improve organizations and is required by many U.S. Government contracts, especially in software development.

SCAMPI is the Standard CMMI Appraisal Method for Process Improvement and it provides benchmark quality ratings related to CMMI models.

SCRAIM is a life cycle and project management tool developed by Stronstep combined with process management techniques. It is going to provide the background and the base to work and simplify those kind of evaluations in order to save time and money. That way companies will deliver their products and services better, faster, and cheaper.

### 1.2 Goals and expected results

The main goal of this dissertation is to develop a group of methodologies, techniques and tools integrated in the SCRAIM, that will make evaluations and certain parts of certifications easier and less painful for the SCRAIM users. Although there are a number of life cycle and project management tools, few combine this with process management techniques. SCRAIM combines the two and will provide the users new features that will semi-automate the assessment for certification of an organization.

More specifically, the goals of this dissertation work are as follows:

- i Analyze to what extent the SCRAIM tool supports the implementation (including the collection of evidences) of the specific practices of CMMI-DEV for maturity levels 2 and 3 (ML2-3), and recommend relevant improvements to SCRAIM;
- ii Define rules to automatically assess the degree of fulfillment of CMMI-DEV ML2 practices by SCRAIM users, by analysing organizational project data and any other relevant evidences recorded in SCRAIM;
- iii Define questionnaires to assist the users in doing a manual assessment, for the practices of CMMI-DEV ML2 that cannot be assessed automatically, ;
- iv Implement in SCRAIM rules and questionnaires defined in steps (ii) and (iii), for some process areas, including appropriate user interfaces to conduct assessments and visualize assessment results;
- v Validate the electronic assessment approach in real world projects.

The full-automated process is not yet feasible, so human intervention is still mandatory. With the use of SCRAIM, good practices will be followed and in the end the generated information will facilitate the decision making process. We can see many advantages of this innovation, and we believe that the application of this innovation will help reduce the costs and time of an evaluation using the SCAMPI method.

### 1.3 Document structure

This document is divided into six main chapters. The first and present chapter serves as an introduction where it is presented the context and motivation for this thesis as well as the goals and expected results to be delivered.

## Introduction

In chapter 2 it is made a problem analysis, giving insight about CMMI, SCAMPI and the tool to be used SCRAIM.

Chapter 3 presents the state of the art and related work regarding electronic assessment. It is described in detail the most used and most important tools that are currently being used in the appraisals.

In chapter 4 it is clarified the scope of the project and in chapter 5 it is made a description of the found solution.

Chapter 6 presents an example of usage and experimentation of the developed solution.

The final chapter sums up the document, presents the final conclusion and future work.

## Introduction



## Chapter 2

# Problem analysis

The evaluation for certification is a complex process, and requires many approaches, some acquired knowledge and some experience. To understand the problem and objectives of this dissertation, it is necessary to understand what CMMI is, in particular the SCAMPI [SCA13] method as well as what SCRAIM is.

### 2.1 CMMI

#### 2.1.1 What is CMMI

To understand better what CMMI is [CMM10], we need to understand what a capability maturity model is.

Capability Maturity Models [FMG02] contain essential elements of effective processes, based on concepts developed by Crosby, Deming, Juran, and Humphrey.

The SEI (The Carnegie Mellon Software Engineering Institute that is a federally funded research and development center headquartered on the campus of Carnegie Mellon University in Pittsburgh, Pennsylvania, United States) adopted the process management premise, "the quality of a system or product is highly influenced by the quality of the process used to develop it and keep it" and defined CMMs that incorporated this premise.

CMMI stands for Capability Maturity Model Integration and is an evolution of CMM like shown in Figure 2.1.

CMMI is a framework of best practices administered and sold by the Carnegie Mellon University. This framework in some business activities is required and mandatory like many DOD (United States Department of Defense) and U.S. Government contracts, especially in software development.

The CMMI model does not describe the processes themselves; it describes the characteristics of good processes, thus providing guidelines for companies developing or honing their own sets of processes.

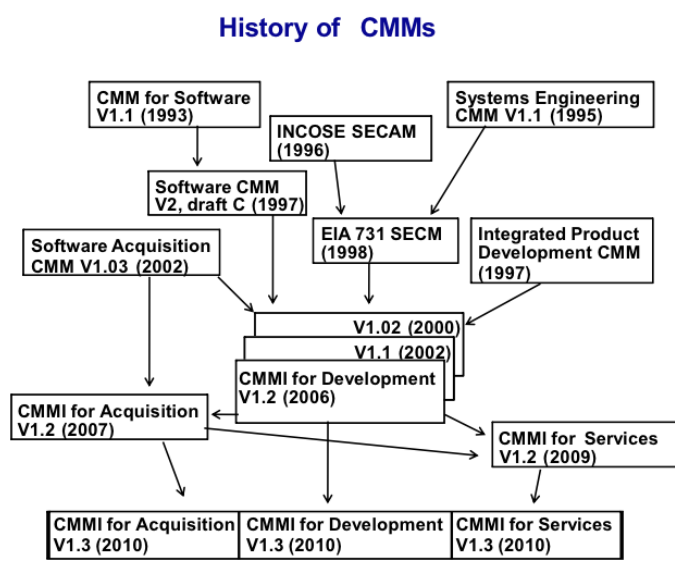


Figure 2.1: History of CMMs

Carnegie Mellon University says that CMMI can be used to guide an organization, a division and process improvement across projects. The CMMI processes and methodologies can be classified according to maturity levels.

Currently CMMI is on Version 1.3 and is registered in the United States Patent and Trademark Office by Carnegie Mellon University.

### 2.1.2 CMMI models and process areas

Best practices of CMMI are published in documents called models; each model addressing a different area of interest. The current version of CMMI, version 1.3, has three different areas of interest: development [CKS06], acquisition and services.

These models are produced taking for base the CMMI framework that contains all the goals and practices used to produce the models that are part of CMMI constellations. The CMMI models contain 16 core process areas, covering basic concepts fundamental to process improvement in any area of interest.

For each process area it can be defined a set of goals and practices. The Figure 2.2 is a diagram where it is shown the connection between process areas, goals and practices.

There are two types of goals and practices:

- Generic goals and practices: Part of every process area.
- Specific goals and practices: Specific to a given process area.

A process area is satisfied only when the company processes cover all specific and generic practices and goals for the process area idealized.

## Problem analysis

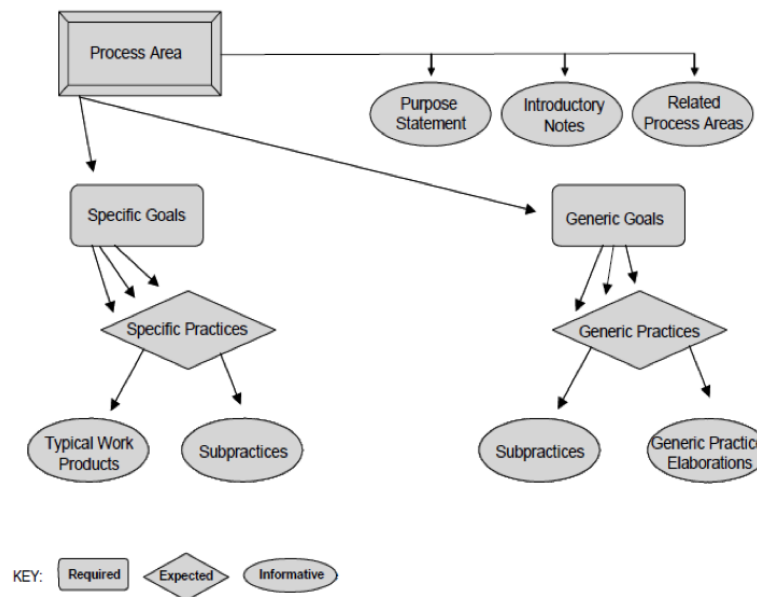


Figure 2.2: Specific and generic goals and practices

The material in core process areas is almost the same for all constellations of CMMI, the rest of the material needs to be adjusted to a specific area of interest, so the material won't be exactly the same.

### 2.1.3 CMMI model framework

CMMI framework is a basic structure that organizes and groups the CMMI components, elements of the current models, rules, methods for model generations, appraisal methods and training material. It contains process areas that will vary for each one of the CMMI areas that will be used. Process areas are the areas that cover the organization processes.

For the latest version of CMMI for Development (Version 1.3) there are 22 Process Areas, which represent the product aspects and the coverage for the organizational processes.

### 2.1.4 CMMI representations

CMMI is available in two representations: continuous and staged.

The continuous representation is represented by capability levels. It allows each organization to select the order of improvement that best meets their business objectives or those to which the organization assigns a high degree of risks. It enables comparisons across and among organizations on a process-area by process-area basis.

The staged representation is designed to provide a standard sequence of improvements, by maturity levels, each serving as foundation for the next. This representation results in a single rating (Maturity Level) that summarizes appraisal results and can serve as a basis for comparing the maturity of different projects and organizations.

## Problem analysis

Each representation has advantages and disadvantages. The staged representation is focused by organizational maturity, continuous representation, whilst the continuous representation is focused on process area capability.

Organizational maturity and process area capability are similar concepts. The difference between them is that organizational maturity pertains to a set of process areas across an organization, while process area capability deals with a set of processes relating to a single process area or specific practice.

In the pictorial diagram below in Figure 2.3 both representations are shown where ML represents Maturity Level and PA represents Process Area.

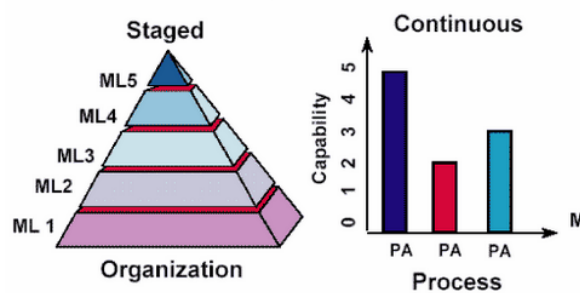


Figure 2.3: CMMI representations

### 2.1.5 Maturity levels in CMMI for development

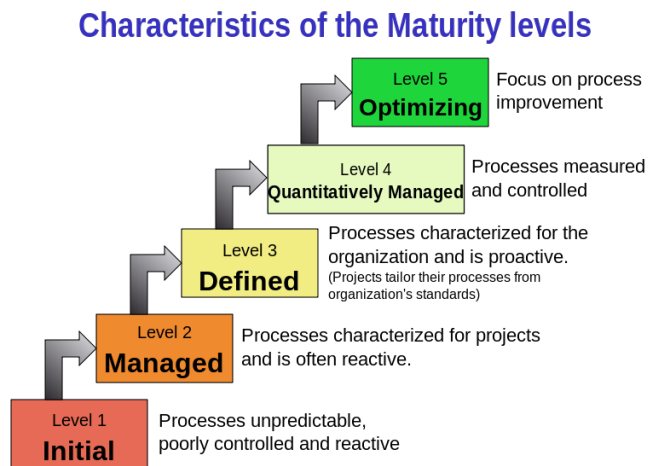


Figure 2.4: CMMI maturity levels

Processes under the CMMI methodology are rated and grouped in maturity levels. As shown in Figure 2.3 there are five maturity levels defined as: Initial, Managed, Defined, Quantitatively

Managed, Optimizing. These maturity levels that are rated are presented and awarded for levels 2 through 5.

### 2.1.6 Capability levels in CMMI for development

In CMMI models with a continuous representation, there are six capability levels designated by the numbers 0 to 5.

A capability level is a plateau that describes the organization’s capability relative to a process area and consists in a group of related specific and generic practices associated with a process area.

Capability levels are also cumulative, so a higher capability levels contains the attributes of the lower levels.

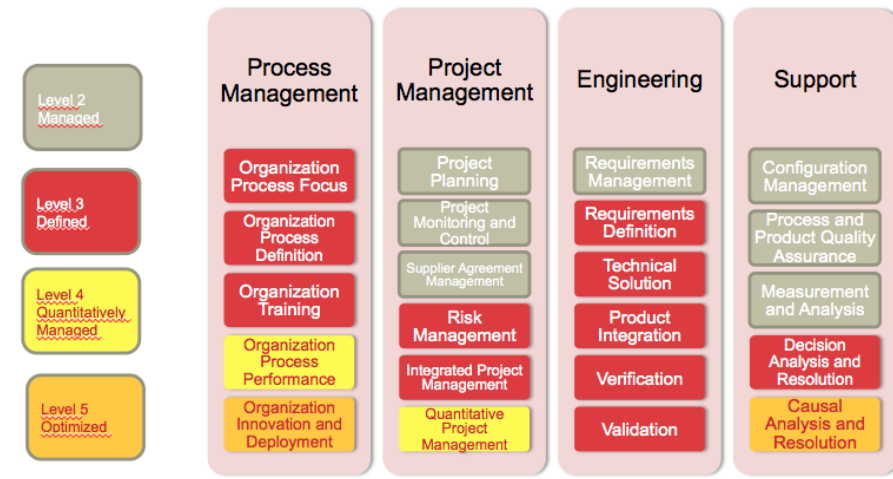


Figure 2.5: CMMI-DEV process areas organized by categories and maturity levels

## 2.2 SCAMPI

Organizations cannot be certified in CMMI, so they are appraised.

In an appraisal the organization gets awarded a maturity level from one to five or a capability level achievement profile. As said before, many organizations are required to get some kind of recognition and others find value measuring their progress and determining how well the processes adopted by the organization are compared to CMMI best practices, to meet contractual and customers requirements and to know which areas they can improve and appraisals are the right way to do it.

Appraisals using a CMMI model must comply with the requirements set out in the Appraisal Requirements for CMMI (ARC) document[Tea01]. There are three classes of appraisals, A, B and C. All of them compare the processes used in the organization to CMMI processes and best practices, that way are identified improvements to make. From all of the three classes of appraisals the most formal is class A and it is the only one that can output a level rating.

## Problem analysis

When an appraisal is done teams use a CMMI model and an ARC document. The results from the teams are used to plan improvements for the organization.

Statistics are made and updated every six months in a maturity profile since the release of CMMI show us that the median times to move from Level 1 to Level 2 is 5 months, and from that to Level 3 more 21 months.

### 2.2.1 What is SCAMPI

SCAMPI is the abbreviation for Standard CMMI Appraisal Method for Process Improvement and is an appraisal method that meets all the ARC requirements. In SCAMPI appraisals there are three types of classes: Class A, B and C appraisal methods. The most rigorous method and officially recognized as that is the Class A method and it's the only method that can result in a benchmark quality rating.

Results of a SCAMPI appraisal can be published on the CMMI web site of SEI, if the organizations approves this. This appraisal supports ISO/IEC 15504, Software Process Improvement and Capability Determination (SPICE) [Dor93], a set of technical standards documents for the computer software development process and related business management functions.

The ARC Class A appraisal is normally conducted by SCAMPI A appraisal. The SCAMPI A Method Definition Document is where are defined rules to ensure the consistency of the appraisal ratings, so the same maturity rated in two companies means they are equal in methodologies and business processes.

### 2.2.2 SCAMPI principles

As said before the class A appraisal is the only full comprehensive appraisal method that involves an ARC class A method and uses CMMI models as reference models.

This appraisal will allow organizations to gain insight about their capability by identifying the strengths and weaknesses of its current processes, prioritize improvement plans, focus on those improvements, correcting weakness that will generate risks, derive capability rating as a maturity level rating and identify risks related to capability and maturity determinations.

This appraisal follows these principals:

- Start with a process reference model.
- Use a defined appraisal method.
- Involve senior management as an appraisal sponsor.
- Observe strict confidentiality and non-attribution.
- Approach the appraisal collaboratively. (When SCAMPI is used for Supplier Selection or Process Monitoring modes, it may not be possible to use a collaborative appraisal approach.)
- Focus on the sponsors business objectives.

### 2.2.3 The SCAMPI process

The Method Definition Document [SCA13] is a document that describes the SCAMPI appraisal method; this document sets the key elements of appraisal planning and the rules of conduct. It is also included in this document the level of process tailoring permitted, qualifications of the team members, evidence requirements, how to scope the appraisal and more.

There are essentially three phases in the process:

- Phase I - Plan and Prepare for Appraisal (presented in the Figure 2.6)
- Phase II – Conduct Appraisal (presented in the Figure 2.7)
- Phase III – Report Results

The following charts shows us these phases, where the last one includes the results reporting phase.

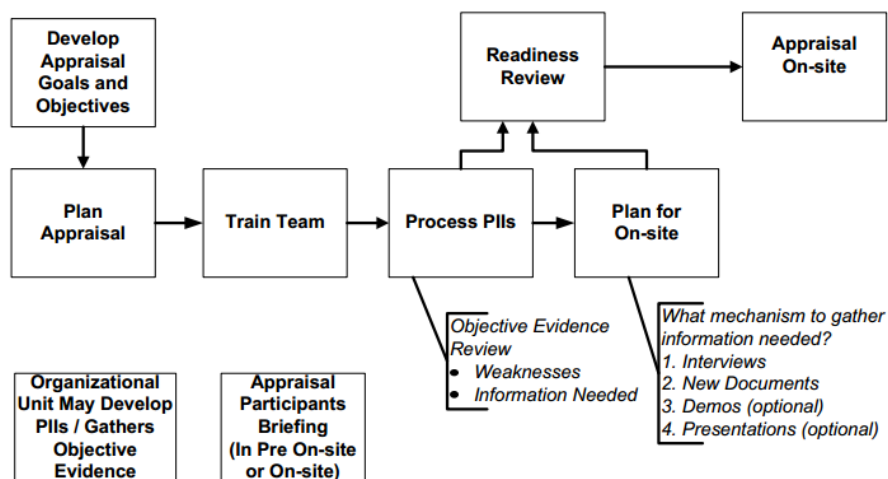


Figure 2.6: Plan and Prepare for Appraisal Activities

### 2.2.4 Special terms

There are some terms to consider with special meaning: Organizational Unit (OU), Organizational Scope, Subgroup, Basic Unit, Support Function, Objective Evidence, Instantiation, Database of Objective Evidence and Practice Characterization.

Organizational Unit is the subject of an appraisal. Can be deployed one or more processes that have a consistent process context, operates in a coherent set of business objectives and is typically part of a larger organization. In a small organization, this unit can be the whole organization.

Basic Unit stands for a set of interrelated and managed resources that delivers products or services to a customer and usually works like planned. The plan is documented and specifies the

## Problem analysis

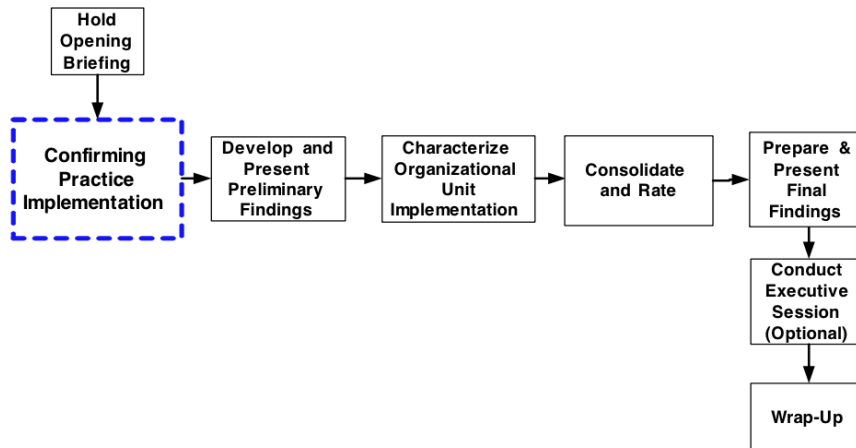


Figure 2.7: Conduct Appraisal Activities

services or products delivered or implemented, the funds, the future work and the work that is currently being done.

A collection of basic unit and support functions that represent practices used within and organizational unit is the Organizational scope.

A Subgroup is a cluster of basic units that are shared between similar process implementations and a common sampling factor alternatives.

Support Function is an organizational group that for a certain and well defined set of activities needed by other parts of the organization provides products and/or services.

Objective Evidence (OE) are indicators of the implementation or institutionalization of model practices. Verifying practice implementation is the review of Objective Evidence to determine whether a practice is implemented within a basic unit, support function, and/or organization. Can be of two types: artifacts or affirmations. The artifacts are a tangible form of evidence indicative of work being done, which is both the main output of a practical model or a consequence of the implementation of a model of practice. Affirmation is an oral or written statement confirming or supporting the implementation (or lack of implementation) in a practical model provided by the practice performers, provided through an interactive forum in which the evaluation team has control over the interaction. In certain cases for some practices, documents are accepted as artifacts even if they are not the primary desired result of practical practice.

Instantiation is the implementation of a model practice used in its context in the organizational unit boundaries.

### 2.2.5 Practice characterization

Practices Implementation Indicators (PII) are a proof of a correct implementation of a certain CMMI Practice. When a Practice is performed it will leave a mark or evidence of that operation, for example that evidence can be a document produced while the practice is performed.



## Problem analysis

Appraisers look for an objective evidence in order to make an assessment. There are three types of indicators presented in the Table 2.1.

Table 2.1: Indicators Types

Indicator Type	Description	Examples
Direct artifacts	The tangible outputs resulting directly from implementation of a specific or generic practice. An integral part of verifying practice implementation. May be explicitly stated or implied by the practice statement or associated informative material.	Typical work products listed in reference model practices Target products of an Establish and Maintain specific practice Documents, deliverable products, training materials, etc.
Indirect artifacts	Artifacts that are a consequence of performing a specific or generic practice or that substantiate its implementation, but which are not the purpose for which the practice is performed. This indicator type is especially useful when there may be doubts about whether the intent of the practice has been met (e.g., an artifact exists but there is no indication of where it came from, who worked to develop it, or how it is used).	Typical work products listed in reference model practices Meeting minutes, review results, status reports, presentations, etc. Performance measures
Affirmations	Oral or written statements confirming or supporting implementation (or lack of implementation) of a specific or generic practice. These statements are usually provided by the implementers of the practice and/or internal or external customers, but may also include other stakeholders (e.g., managers and suppliers).	Instruments Interviews Presentations, demonstrations, etc.

## Problem analysis

After the collection and examination of evidences, it is made a characterization of the extent to which Model practices are implemented. The model practices are characterized as described in the Table 2.2.

Table 2.2: Practice characterization table

Fully Implemented (FI)	Sufficient artifacts and/or affirmations are present and judged to be adequate to demonstrate practice implementation, and no weaknesses are noted.
Largely Implemented (LI)	Sufficient artifacts and/or affirmations are present and judged to be adequate to demonstrate practice implementation, and one or more weaknesses are noted.
Partially Implemented (PI)	Some data are present to suggest some aspects of the practice are implemented, and one or more weaknesses are noted. OR Data supplied to the team (artifacts and/or affirmations) conflict –some data indicate the practice is implemented and some data indicate the practice is not implemented, and one or more weaknesses are noted.
Not Implemented (NI)	Some or all data required are absent or judged to be inadequate. Data supplied does not support the conclusion that the practice is implemented, and one or more weaknesses are noted.
Not Yet (NY)	The basic unit or support function has not yet reached the stage in the sequence of work, or point in time to have implemented the practice.

### 2.2.6 Appraisal participants

In an appraisal there are several participants with roles and responsibilities crucial to its success.

The Appraisal sponsor is responsible to sponsor the appraisal and owns the appraisal results and signs the Appraisal Disclosure Statement.

Middle managers are originally from the line or staff management positions and are interviewees and data providers; if they are participant, they review preliminary findings.

Basic Unit leaders have leadership responsibilities for a project or service. They are as well interviewees and data providers and if they are participants, they review preliminary findings too.

Support Function as the past roles are interviewees and data providers; they are practitioners and review preliminary findings.

### 2.2.7 Appraisal team

The appraisal team is composed by two main key roles: Team Leader and Team Members. Team Leader is the person who has the overall responsibility for the appraisal, is a SEI - Certified SCAMPI [SCA13] leader appraisal and has experience and training; he also signs the final findings. Team members are those who satisfy requirements of experience and training to be part of the team and they assume one or more specific roles.

One of the key roles of the appraisal team is the team leader who has overall responsibility for the appraisal. He is also responsible for: assigning team roles for each member, ensuring that the planning activities are complete, that the SCAMPI process is being followed; scheduling, monitoring and checking performance; facilitating team resolution in case of conflicts and impasses; and reporting results to SEI.

For each team member the team leader will assign a role that will ensure the proper function of the team and will facilitate the appraisal. Those roles are the following:

- Appraisal coordinator - Responsible for handling on-site logistics. This position is also composed by more than one member for a multi-site appraisal.
- Librarian - Documents are managed by this member and in the end of the appraisal they are returned.
- Timekeeper - For each mini-team can be one Timekeeper and his main purpose is track team time and schedule constraints during interviews and other activities.
- Note takers - For all PAs is responsible for taking notes during data gathering sessions.
- Appraisal team - All the work is reviewed by members.
- Mini-teams - Teams typically consist of two or three members and verify the implementation of reference model practices, reviewing objective evidence provided and identify weaknesses in the implementation. The practices at instantiation levels are characterized by its implementation extent. They have the power to request additional information if needed.

### 2.2.8 SCAMPI results

The appraisal is completed after the collection and evaluation of objective evidence to support the implementation of practices.

Goal satisfaction depends on satisfaction of practices associated with it.

A goal is rated as satisfied if and only if all associated practices are characterized as largely implemented or fully implemented, and all the weaknesses associated with the defined goal don't have a significant impact on goal achievement. With the help of a program we can obtain a matrix as shown in Figure 2.8.

When a given goal is determined to be either satisfied or not, then a Capability Level (for the continuous representation) can be derived.

## Problem analysis

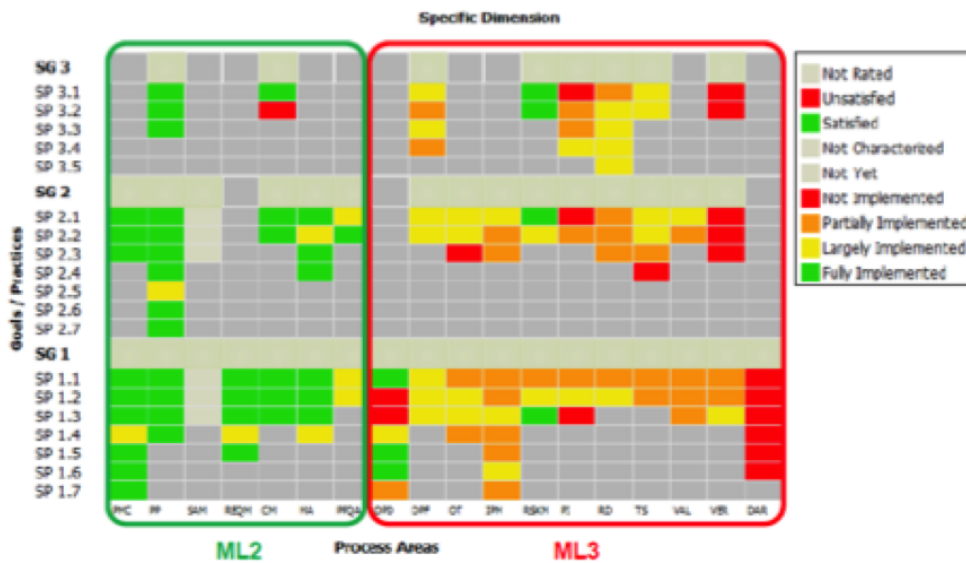


Figure 2.8: SCAMPI results

## 2.3 SCRAIM

SCRAIM [SCR] is a project management tool developed at Strongstep based on advanced methodologies with intelligent decision support mechanisms. It also has some ready-made processes that facilitate a better management.

### 2.3.1 Software-as-a-Service

SCRAIM is a Software-as-a-Service (SaaS) product. SaaS emerges as an innovative approach to deliver software applications based on cloud-computing technology. [CC07]

This type of software sometimes referred as simply hosted applications allows organizations and clients to access functionalities and all data stored on that platform everywhere, and it costs less than a typical licensed application. SaaS has many advantages compared to typical software. Since it is hosted remotely and accessed through Web browser, it bypasses server provisioning and software installation as requirement, making software cheaper. Another advantage is that organizations don't need to perform and handle installation problems, updates and performing maintenance.

“SaaS is one of the biggest technology trends to affect business applications in recent years.” [Hou09]

### 2.3.2 Methodologies and processes definition

One of the reasons that can lead to a project failure is the lack of use of a defined software development process. It is also known that one of the success factors is the adoption of appropriate

## Problem analysis

development processes in organizations projects.

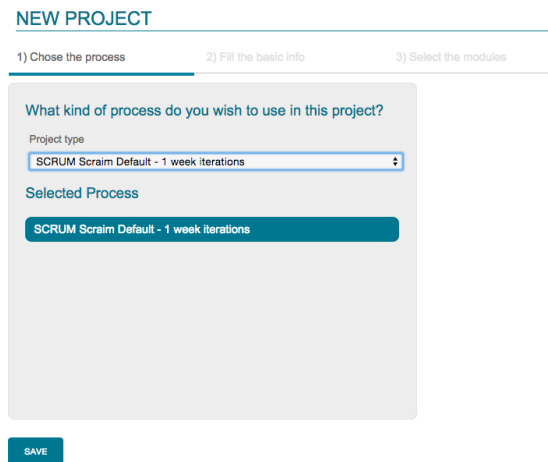


Figure 2.9: SCRAIM process choose wizard

SCRAIM supports the most advanced technologies like CMMI [CMM10], TSP [Hum00] and SixSigma [Six] to help organizations increase projects quality. SCRAIM has a set of ready made processes like SCRUM [PQ11], chosen in the Figure 2.9 and it's possible to adapt to the specific needs of a project and save to use it later.

### 2.3.3 Project planning and tracking

The Planning page represented in Figure 2.10 presents to the user a chronological view of the project's iterations (Centralized on the current iteration).

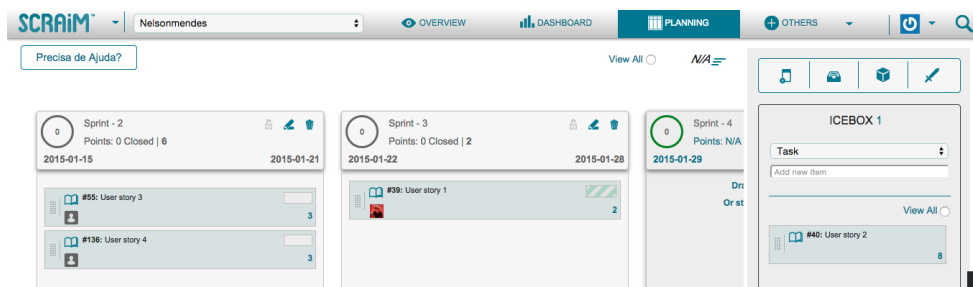


Figure 2.10: SCRAIM Planning Page

In this page users are able to create, update and estimate tasks and assign those tasks to iterations and team members.

### 2.3.4 Risk and issue management

Risk Management is also supported by SCRAIM. This part of the software is designed to give the possibility to identify what can go wrong (risks), how to prevent that from happening

## Problem analysis

(mitigation actions) and what to do if something happens (contingency actions).

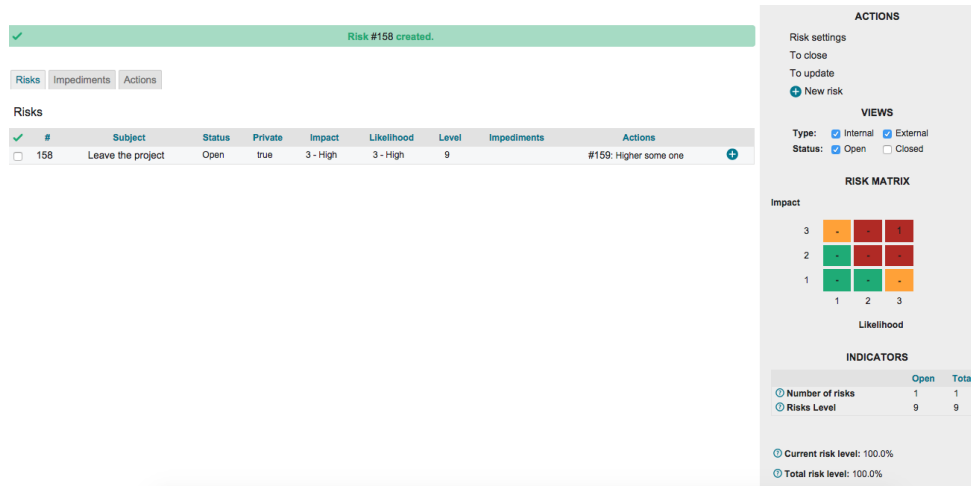


Figure 2.11: SCRAIM Risk View

### 2.3.5 Test management

Test management features provided in SCRAIM are used to store information on how testing is to be done, plan testing activities and report the status of quality assurance activities.

Figure 2.12 is presents the project tests configuration, presenting all the actions that can be made by the user, and that are related to traceability and execution of test cases.

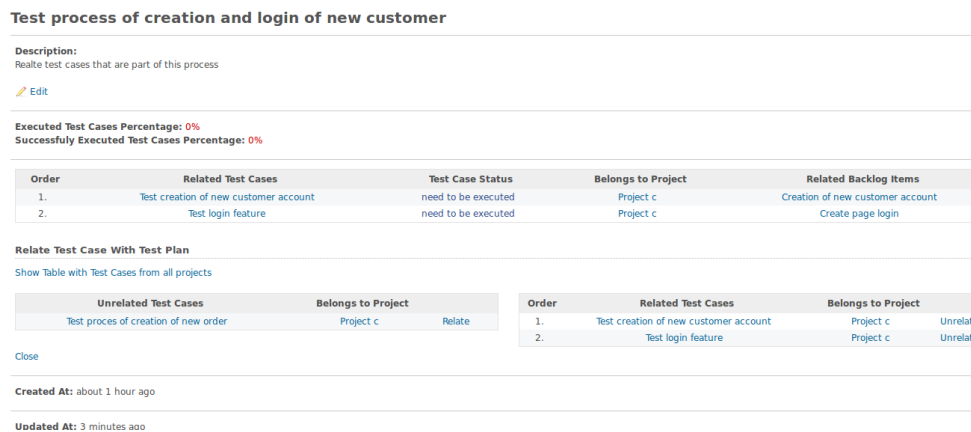


Figure 2.12: SCRAIM Test configuration view

### 2.3.6 Other functionalities

The project information is easily trackable. SCRAIM allows to manage files and documentation associated to each one of the project and to attach external repositories in order to track the changes of source code.

## Problem analysis

In SCRAIM it's possible to schedule deliverables for each release of the project; with this it is possible to know in real time what's being delivered, what's being scheduled and who's in charge of each deliverable.

Wiki, forums, news and notification system are other features that facilitate team collaboration.

Problem analysis



## Chapter 3

# State of the art analysis

In this chapter it is presented the related work. Here is introduced some electronic assessment tools that are currently being used in the market and others made for teaching purposes.

### 3.1 CMMI assessment checklist

CMMI assessment checklist [cap] appears as an online solution to make a lightweight assessment tool and is a free online assessment tool that make it possible to get and track an organization capability across eight key business functions based in a group of 31 questions.

#### Assessment items

In this tool, each assessment item has a statement about a particular capability or several capabilities and a scale that allows to indicate the level of agreement with the statement, based on the organization performance. An example is shown in Figure 3.1.

Question 1 / 31

RESPONSES 0 | SKIPPED 0

My organization estimates work and creates plans to ensure the work is accomplished on time and within budget.

STRONGLY AGREE      SOMEWHAT AGREE      SOMEWHAT DISAGREE      STRONGLY DISAGREE

Figure 3.1: Assessment item question

The scale included in the assessment item also includes a descriptive information about the organization performance at both ends of the scale, visible on the example given in Figure 3.2.

These descriptions are given to the user with the intention of helping the most accurate positioning of the organization on the scale.

## State of the art analysis

The image shows a Likert scale interface for an assessment item. At the top, there are four points on a horizontal line labeled 'STRONGLY AGREE', 'SOMEWHAT AGREE', 'SOMEWHAT DISAGREE', and 'STRONGLY DISAGREE'. Below the line, there are two text boxes. The first box, under 'STRONGLY AGREE', contains the text: 'We produce realistic estimates based on the work to be accomplished, using well-defined techniques. Our plans are detailed enough to enable effective tracking and understand when corrective actions are needed. A shared understanding of the scope and details of the work are agreed to with the people who will perform the work and the customer.' The second box, under 'STRONGLY DISAGREE', contains the text: 'Our estimates are unrealistic and our plans are either too detailed to be followed or not detailed enough for adequate control. Work efforts are often late, or deliveries are over budget or contain less than the agreed to features or functions.' Below the text boxes are three buttons: 'NOT APPLICABLE' (with a subtext 'Don't show again'), 'SKIP QUESTION' (with a subtext 'I'll respond later'), and 'SUBMIT ANSWER' (with a subtext 'or save and continue later').

Figure 3.2: Assessment item scale

The organization term in the assessment tool is defined by the user for purposes of self-assessment. The evaluated scope is also defined by the user and can be the company, organizational unit, division, directorate, department or work group.

It's possible to skip a question in the list of items and come back later to answer and there is an option named Not Applicable to exclude the question from the results. This answer should only be chosen if:

- The actual question is related to an area outside of the organization scope.
- It's valid for the organization but the performance of the activity is not known.
- The user that is performing the assessment has insufficient expertise in the subject to understand the intent of the question.

The answers are editable before the submission of the assessment in a screen for a final review. It is possible to save the current state and progress at any time and resume it later. It is only possible to submit and get an assessment if all questions are answered.

After answering all questions provided as requirement the survey is submitted and will be shown a high level snapshot of the organization current capability states and will be included in each item some suggestions for developing the next steps as seen in Figure 3.3.

The goal of this research work is to fully automate the assessment for as many practices as possible. As explained in Section 4.4, we take advantage of some of the questions in this tool to help in the assessment of the remaining practices.



Figure 3.3: Example of a result an assessment

## 3.2 PSP checker

The Personal Software Process (PSP) [Hum05] is a process framework with the objective of guiding developers to define their own processes, track and plan their work and manage the quality of the produced products.

PSP checker [PF10] is a tool developed at FEUP that has the main objective of helping teachers to evaluate the assignments submitted by PSP students and help them to achieve better results and understand PSP.

The PSP checker was only made and planned for teachers as a support for evaluation and feedback. It is also suitable for students too depending on the type of teaching. That way they can improve their work. A short period of time is required to use this tool and is currently available only as a desktop application.

This desktop application has as main functionalities:

- Automatic verification of checklists

Each checklist item has different types of verification and as output; if an item in the checklist is completely satisfied, it is shown the line in green, otherwise the line is highlighted in red or given a special message on the screen.

- Custom processes

The user, when starting the program, can choose which items of the PSP process to associate with this evaluation.

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- Remote data importation
- Illustrative charts

Charts that facilitate the perception of what is wrong and what is well done to understand which points can be improved.

- Automation of support messages (use of knowledge acquired by specialists)

Messages provided by specialist to understand the errors in a more complex level.

- Information Import/Export (Figure 3.4)
- Modularity and scalability

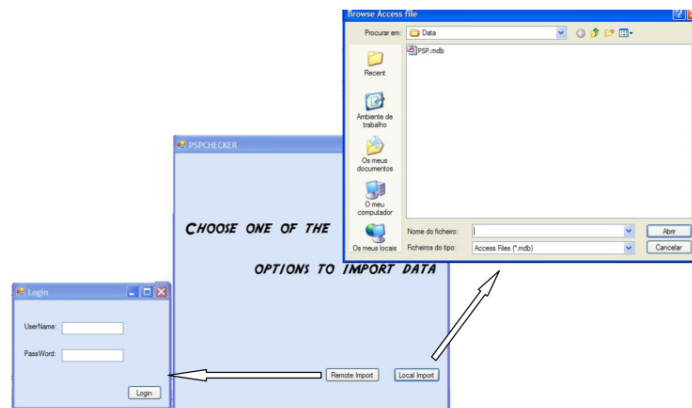


Figure 3.4: Example of a data import for PSPChecker

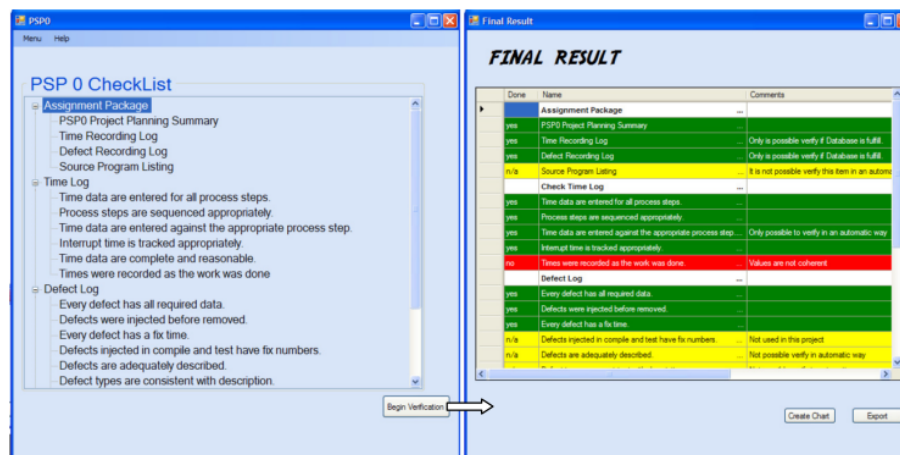


Figure 3.5: Final results of PSPChecker

In Figure 3.5 it is represented two of the last screens of PSPChecker. It is shown on the left hand side the checklist imported or chosen and on the right side the final screen, where we can

generate charts and export the data. Items successfully checked are colored in green. Items not satisfied are colored in red. Items that could not be evaluated automatically are colored in yellow.

This method of evaluation is used to make a similar approach to CMMI instead of PSP.

### 3.3 Appraisal assistant

The Software Quality Institute of the Griffith University [Sof] developed the Appraisal Assistant tool. The Appraisal Assistant [App] is a software application that supports the appraisal or assessment of process capability or organization maturity.

This tool follows consistent approaches with the requirements of ISO/IEC 15504 [ISO] and it's distinguished from other tools by taking an evidence-driven approach to the recording of evidences generated in an assessment.

SQI personnels have performed SCAMPI A and B appraisals and SPICE assessments with the help of Appraisal Assistant and have been it using since the first beta release. The Beta release was used to examine relationships between ISO 15504-2 and SCAMPI appraisals

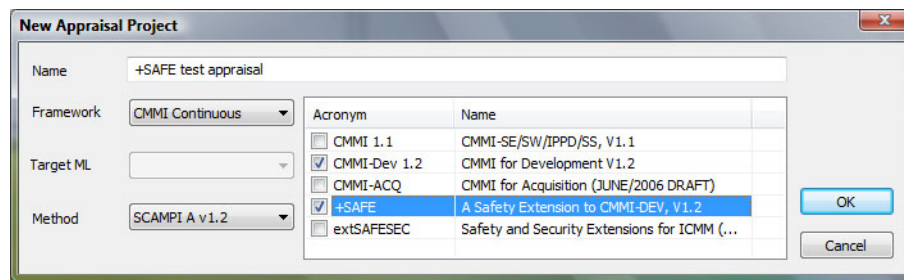


Figure 3.6: Appraisal Assistant New Project Screen

The Appraisal Assistant provides several functionalities and benefits:

- Support for multiple process models such as: ISO/IEC 15504-5, ISO/IEC 15504-6 (FDIS) [Rou03], Automotive SPICE, CMMI®-DEV v.1.2, +SAFE, and CMMI® SE/SW/IPPD/SS V 1.1 [Tea02];
- User defined appraisal models;
- Multiple methods for performing an appraisal / assessment;
- User defined assessment methods;
- Conversion of results between frameworks;
- Split and consolidate evidence capture activities;
- Generate automatically reports such as Appraisal Disclosure Statement, PIID, Assessment Record, Appraisal / Assessment Findings, Strength / Weakness summaries, Rating Profiles, and workload summaries;

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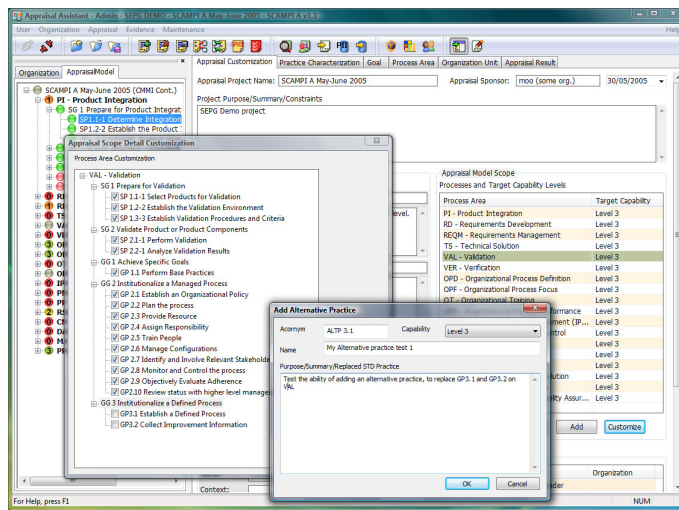


Figure 3.7: Appraisal Scope Customization

- Model coverage and automatic reporting by collected evidence.

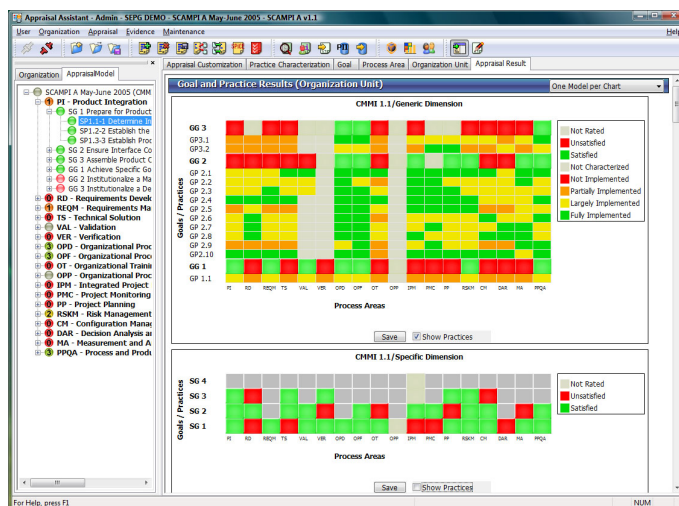


Figure 3.8: Appraisal Assistant Results

In Figure 3.8 it is shown an example of an appraisal result and the output of the tool after labelling all the process areas.

We take advantage of the way results are presented on this tool, regarding CMMI practices organized by their areas, goals and practices.

### 3.4 ITMark appraisal tool

ITmark [ITMa] is a certification scheme designed specifically for SMEs that combines various improvement models streamlined into only one scheme.

This certification is developed by leading appraisal providers across technical and business related disciplines, gathered in an International Consortium of Centers of Excellence dedicated to support Software Intensive Organizations throughout the world.

This certification assesses and certifies the processes in small organization in three different areas:

- Business Management
- Software, Systems and Services Engineering
- Security Management

It provides a group of analysis tools that help a company enhance its business, information security management and software development processes. A company can have additional recognition for their level of capability through ITMark certification.

ITMark will provide organizations:

- Process improvement of product development and services
- Improvement of other critical processes of the organization: business and security
- Low cost and quick implementation of the improvements
- Philosophy of quality
- Internationally recognized

The ITMark Appraisal tool [ITMb] fully supports this process.

When an assessment is created in the interface we can access the three areas and see all the specific questions that we need to answer in order to get the results in Figure 3.9, we can see in the top the three areas and an example of a question with the possible answers that are "yes", "no" or "not applicable".

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BUSINESS	SECURITY	SOFTWARE
<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center; margin: 0;"><b>SOFTWARE</b></p> <ul style="list-style-type: none"> <li>• 1. Requirements Management</li> <li>• 2. Project Planning</li> <li>• 3. Monitoring &amp; Control</li> <li>• 5. Process and Product Quality Assurance</li> <li>• 4. Measurement &amp; Analysis</li> <li>• 6. Configuration Management</li> <li>• 7. Supplier Agreement Management</li> <li>• Appraisal Status</li> <li>• Results Charts</li> <li>• Recommendations</li> <li>• Report</li> <li>• Client Report</li> </ul> </div>		
<b>REQM</b>		
<b>REQM SG01</b>	<b>Manage Requirements</b> Requirements are managed and inconsistencies with project plans and work products are identified.	
<b>REQM SP0101</b>	<b>Understand Requirements</b> Develop an understanding with the requirements providers on the meaning of the requirements.	
Are criteria for distinguishing appropriate requirements providers established?		
<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="radio"/> N/A		
Are objective criteria for the evaluation and acceptance of requirements established? Examples of evaluation and acceptance criteria include the following: clearly and properly stated, complete, consistent with one another, uniquely identified, consistent with architectural approach and quality attribute priorities, appropriate to implement, verifiable (i.e., testable), traceable, achievable, tied to business value, identified as a priority for the customer.		
<input type="radio"/> Yes <input checked="" type="radio"/> No <input type="radio"/> N/A		

Figure 3.9: ITMark Appraisal tool question example

After answering all the questions this tool will provide us graphs and some charts with the assessment results. We can see an example of those graphs in Figure 3.10

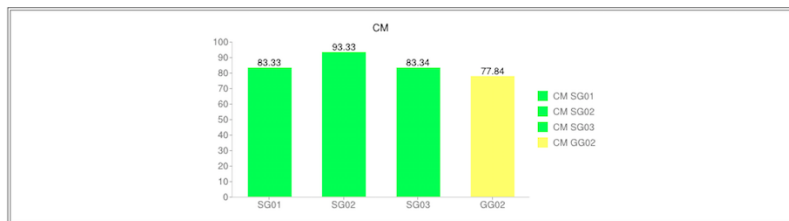


Figure 3.10: ITMark Appraisal tool result example

The overall assessment results will be available on a bar graph like the one presented in Figure 3.11, where we can see the maturity level associated.

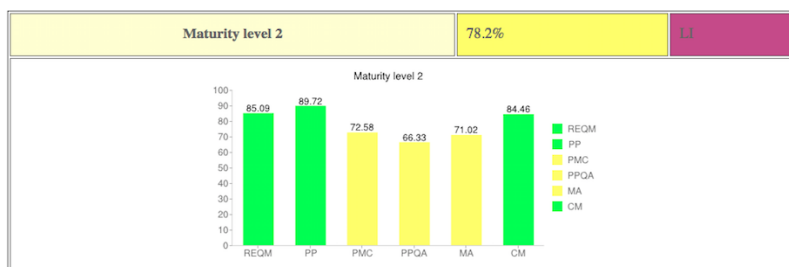


Figure 3.11: ITMark Appraisal tool result overall example

As will be explained in Section 4.4, we take advantage of the questions in this tool to help in the assessment of the practices not evaluated automatically.



## Chapter 4

# Conception

In this chapter is presented the process, rules and questionnaires that were conceived to enable semi-automatic SCAMPI evaluations. It is also presented an assessment of the level of support provided by SCRAIM regarding CMMI practices.

### 4.1 Assessment Process

The Electronic assessment process is represented in Figure 4.1. The process starts with a selection of the projects and process areas to evaluate. Then for each evaluation, we have two ongoing tasks; the survey based electronic assessment and the rule based assessment.

The survey based electronic assessment is a manual process (conducted with tool support) where the user needs to answer the questions that are provided. The rule based electronic assessment is fully automatic using the rules described later in this section.

Both assessments receive project data to generate the results that can be seen afterwards. This workflow also presents the manual adjustment, a part that can be useful if in some case a certain part is not evaluated correctly or the assessment result is by consented opinion of the team accepted or rejected. And lastly it shows the final results.

The details of rule based and survey based assessment are provided in section 4.3 and 4.4.

In order to get a full overview of SCRAIM, an assessment of the tool was performed. That assessment provides the current state of the tool and possible gaps to overcome.

## Conception

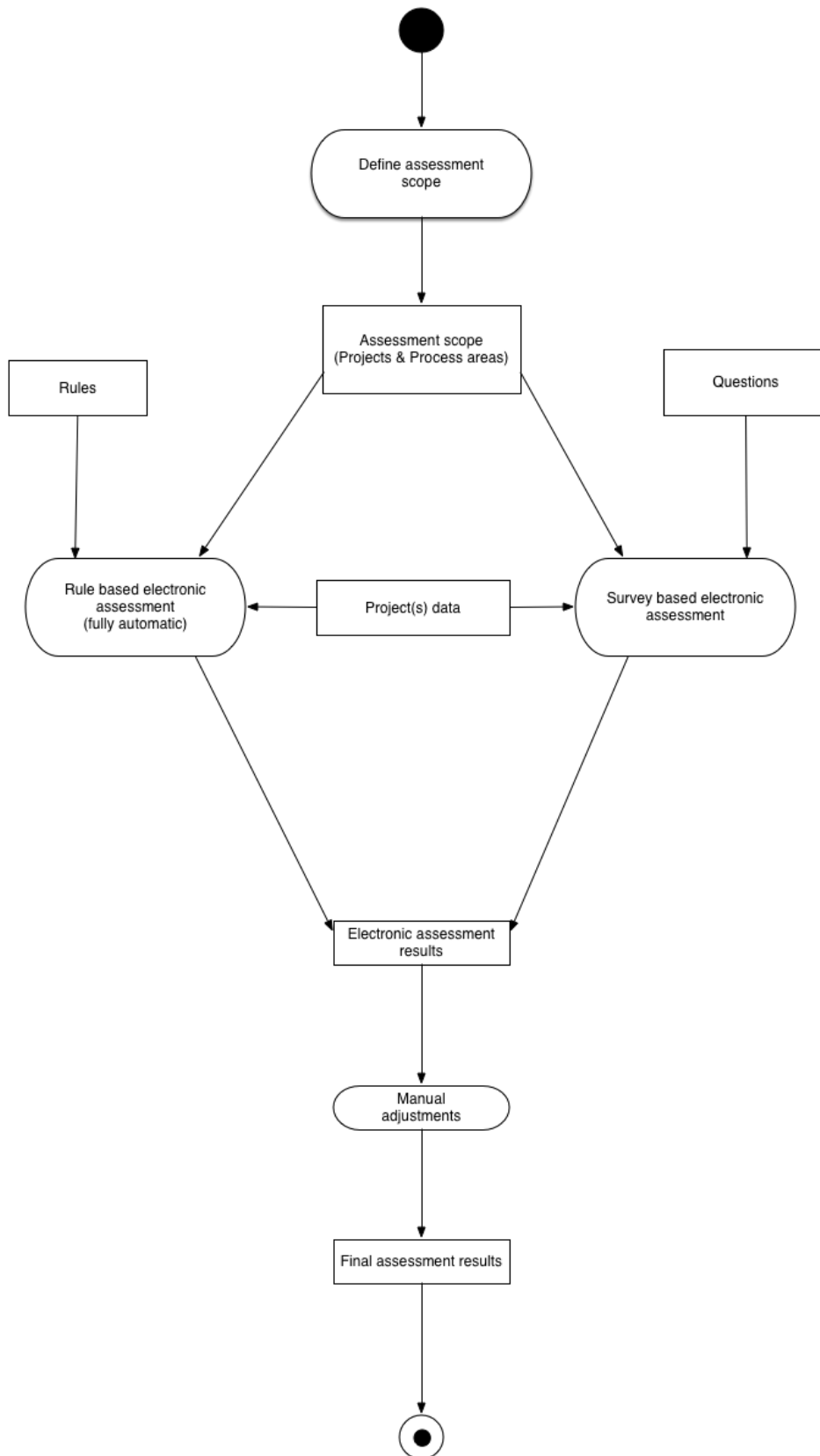


Figure 4.1: UML activity diagram depicting the Assessment Process Workflow

## 4.2 Pre-assessment of Scraim support

In a primary phase as mentioned before, an assessment of the tool was performed. The actual purpose of this assessment was to check if it was possible and currently viable to match Scraim and its functionalities with the third maturity level of CMMI for Development.

Maturity levels comprise a set of process areas, each with a set of goals and practices. So, if Scraim could be mapped to a more extensive number of practices and goals, a higher level of maturity could be covered.

The assessment was done with Appraisal Assistant, a tool currently used to assist and help appraisals in the field (see Section 3). This tool allows us to visualize the results in a matrix, providing a full overview of the current state and the coverage of Scraim in relation to the maturity level 3 of CMMI for Development.

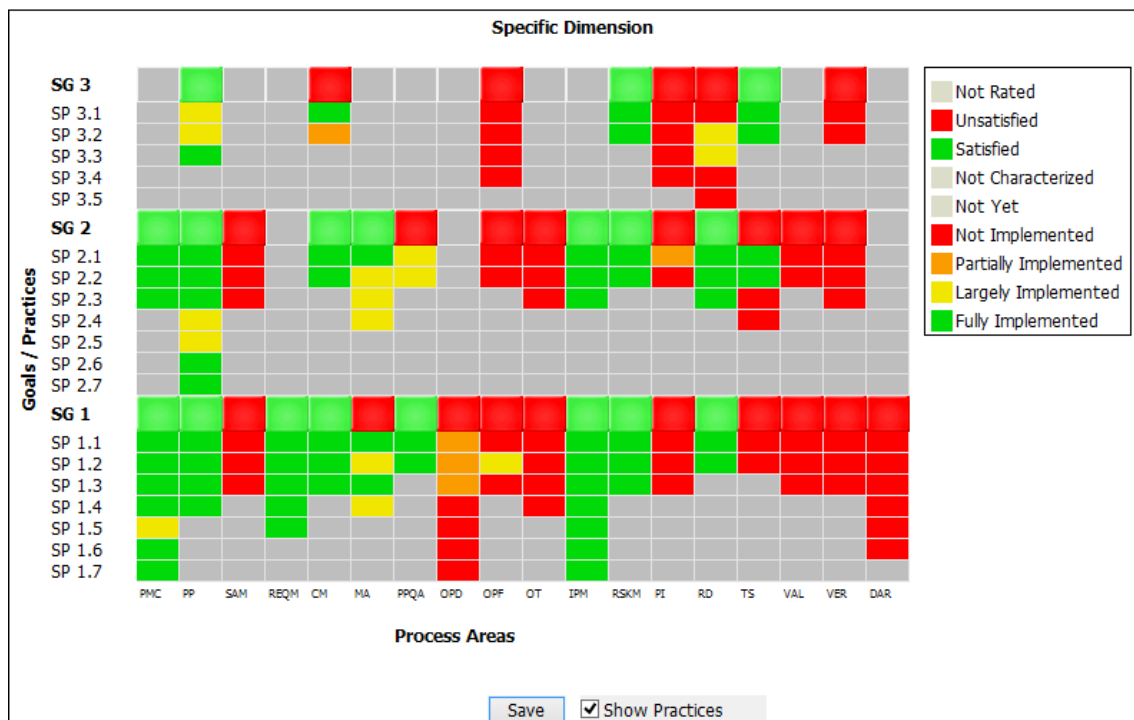


Figure 4.2: Scraim Assessment to CMMI for Development Level 3

In Figure 4.2 we can see that, despite the fact that Scraim covers many practices, the maturity level three is still too far from being achieved successfully.

For example some areas like Verification (VER) and Decision Analysis and Resolution (DAR), are not currently supported by SCRAIM, so it will be impossible to automatically assess the fulfillment of their respective goals and practices by SCRAIM users.

In Figure 4.3 we can see that the map for the second level of maturity is more accurate, more trustful and can be more covered automatically.

## Conception

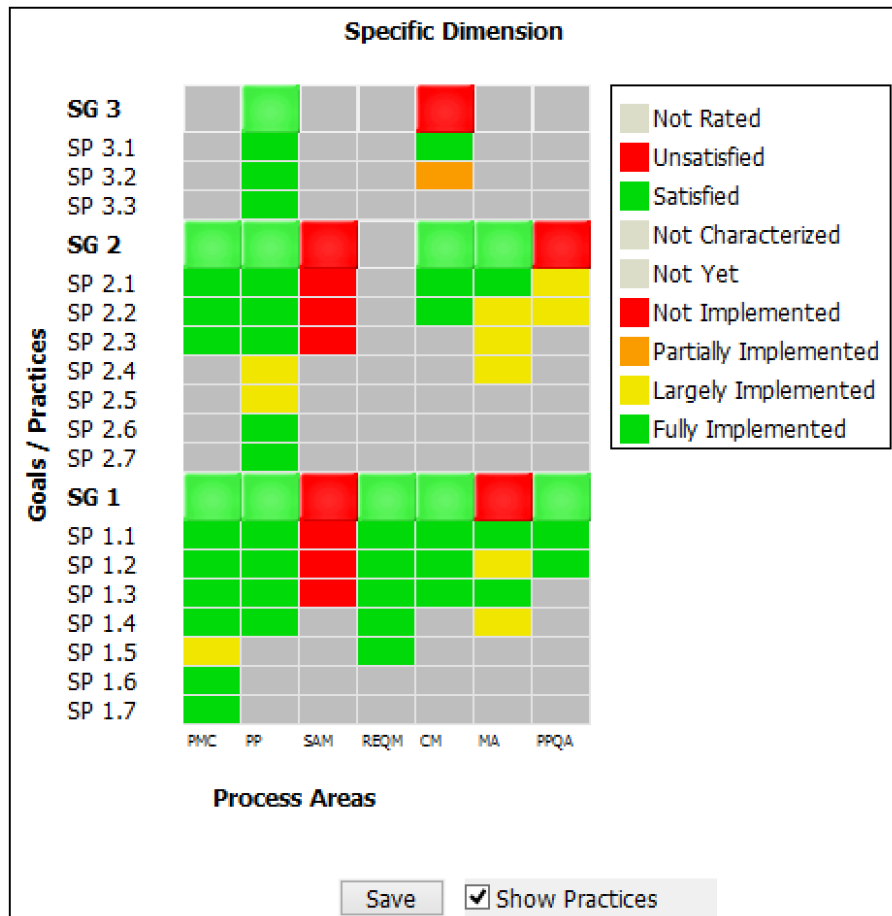


Figure 4.3: Scram Assessment to CMMI for Development Level 2

The initial decision of making this set of tools to SCRAIM focusing in the level is supported by these two assessments to the tool.

### 4.3 Electronic assessment rules

In order to get rules it was needed to perform a mapping between CMMI concepts and SCRAIM data items.

Taking as reference the previous assessments of the tool, this map was possible with the creation of a new scale to show the results of the assessment and be possible the map corresponding the information.

One appraisal consists in classifying each practice in one of four states: Fully Implemented, Largely Implemented, Partially implemented and Not implemented.

In the first attempt, was tried to match those levels with 5 levels, corresponding to different evaluation levels in Scram. In the Figure 4.4 is possible to see the map between CMMI for Development and Scram. In this example it is analyzed the criteria from the practice 1.1 from

## Conception

Levels	PP.SP 1.1 Estimate the Scope of the Project
1	No wbs , epics, backlog items
2	Existence of a few backlog items less than 5
3	At least one epic with backlog items
4	Several epics with several backlog items each
5	WBS defined, epics with backlog items(user story, task, ...) associated

Figure 4.4: Project Planning SP1.1 Map to 5 levels

the Project Planning area, which says, "Establish a top-level work breakdown structure (WBS) to estimate the scope of the project." and can be mapped into Scraim into this 5 levels. The first Level would be where there is none WBS item or backlog item, and the max level where all WBS are fully defined and epics with backlog items associated.

Levels	PP.SP 1.1 Estimate the Scope of the Project
1	No wbs , epics, backlog items
2	Existence of a few backlog items less than 5
3	Several epics with several backlog items each
4	WBS defined, epics with backlog items(user story, task, ...) associated

Figure 4.5: Project Planning SP1.1 Map to 4 levels

After some mapping this scale was confusing and far from real so the best way was to map and try to match the four levels of SCAMPI with four levels of Scraim assessment.

This new scale is more accurate and closer to a real assessment as shown in Table 4.1. In Figure 4.5 is observable that the mid levels are more easily distinguished and more differentiable from the others.

Table 4.1: Scale comparison

SCRAIM	SCAMPI
1	Not Implemented
2	Partially Implemented
3	Largely Implemented
4	Fully Implemented

In the tables presented below are explained the Rules established for the automatic assessment. The rules were validated with consultants from Strongstep.

When in the tables are shown 2 levels (Yes or No), represents the Maximum and the Minimum of the scale considered, Yes corresponds to the level 4 and No the level 1.

The practices that currently cannot be evaluated automatically, are assigned the result of 1 (Not Implemented) during the automatic assessment. They should be subsequently reevaluated with the survey.

## Conception

### 4.3.1 Project Planning

Levels	PP.SP 1.1 Estimate the Scope of the Project
1	No WBS , epics, backlog items
2	Existence of a few backlog items less than 5
3	Several epics with several backlog items each
4	WBS defined, epics with backlog items(user story, task, ...) associated

Levels	PP.SP 1.2 Establish Estimates of Work Product and Task Attributes
1	No estimates
2	Estimates in size or complexity (story points) (less than 1/2)
3	Most items estimated (between 1/2 and 2/3)
4	All items estimated in size or complexity

Levels	PP.SP 1.3 Define Project Lifecycle Phases
1	No iterations defined
2	One iteration defined
3	Several iterations with just one phase
4	All iterations related with process phases

Levels	PP.SP 1.4 Estimate Effort and Cost
1	No estimates found
2	A few tasks have effort estimated
3	Most task effort estimated
4	All tasks have effort estimated (directly or derived from points and velocity) and project costs are estimated

Levels	PP.SP 2.1 Establish the Budget and Schedule
1	No budget or releases
2	Budget
3	Budget + Releases
4	Budget + Releases plan + next iteration plan

Levels	PP.SP 2.2 Identify Project Risks
1	No risks identified
2	One risk identified
3	Several risks identified
4	Risks identified and quantified

## Conception

Levels	PP.SP 2.3 Plan Data Management
Yes	Existence of a page on scraim wiki module to manage data as forms of documentation
No	

Levels	PP.SP 2.4 Plan the Project's Resources
Yes	Existence of a page on scraim wiki module to explain the project resources and needs as labor, equipment, materials, methods
No	

Levels	PP.SP 2.5 Plan Needed Knowledge and Skills
Yes	Existence of a page on scraim wiki module to explain the needed knowledge and skills.
No	

Levels	PP.SP 2.6 Plan Stakeholder Involvement
1	No stakeholder involvement
2	Existence of an account of the type customer
3	No existence of account but periodic meetings with customer
4	Existence of an group with the customer attached to meetings

Levels	PP.SP 2.7 Establish the Project Plan
Yes	Existence of a page on scraim with the project plan or a document with a template name.
No	

Levels	PP.SP 3.1 Review Plans That Affect the Project
Yes	The project plan document was updated more than once
No	

Levels	PP.SP 3.2 Reconcile Work and Resource Levels
Yes	Calendar updated and organized
No	

Levels	PP.SP 3.3 Obtain Plan Commitment
Yes	Existence of the project plan documentation and the kick-off meeting
No	

### 4.3.2 Project Monitoring and Control

Levels	PMC.SP 1.1 Monitor Project Planning Parameters
4	With the use of scraim is satisfied: typical indicators of project progress and performance and include attributes of work products and tasks, costs, effort, and schedule.

Levels	PMC.SP 1.2 Monitor Commitments
1	No meetings created on Scraim
2	Existence of one meeting created
3	At most 3 meetings
4	More than 5 meetings created

Levels	PMC.SP 1.3 Monitor Project Risks
1	No risk identified
2	One risk identified
3	Several risks identified
4	Risks identified and quantified

Levels	PMC.SP 1.4 Monitor Data Management
Yes	Existence of a page on scraim wiki module to manage data as forms of documentation
No	

Levels	PMC.SP 1.5 Monitor Stakeholder Involvement
1	No stakeholder involvement
2	Existence of an account of the type customer
3	No existence of account but periodic meetings with customer
4	Existence of an group with the customer attached to meetings



## Conception

Levels	PMC.SP 1.6 Conduct Progress Reviews
4	With the use of scraim is satisfied: burndown-chart

Levels	PMC.SP 1.7 Conduct Milestone Reviews
1	No budget or releases
2	Budget
3	Budget + Releases
4	Budget + Releases plan + next iteration plan

Levels	PMC.SP 2.1 Analyze Issues
1	No defects or bugs reported
2	At least one bug or one defect reported
3	One bug and one defect reported
4	More than 5 bugs and defects reported

Levels	PMC.SP 2.2 Take Corrective Action
Yes	Status of bug or defect changed and progressing
No	

Levels	PMC.SP 2.3 Manage Corrective Actions
Yes	Status of bug or defect changed and progressing
No	

### 4.3.3 Requirements Management

Levels	REQM.SP 1.1 Understand Requirements
4	Use of the given templates

Levels	REQM.SP 1.2 Obtain Commitment to Requirements
Yes	Existence of a kick-off meeting and project plan updated
No	

Levels	REQM.SP 1.3 Manage Requirements Changes
Yes	Track changes on Scraim interface
No	Lookup history of issues Track impact

Levels	REQM.SP 1.4 Maintain Bidirectional Traceability of Requirements
Yes	Related issues, use of test cases module
No	

Levels	REQM.SP 1.5 Ensure Alignment Between Project Work and Requirements
Yes	Status of bug or defect changed and progressing and impediments
No	

#### 4.3.4 Supplier Agreement Management

Levels	SAM.SP 1.1 Determine Acquisition Type
1	Necessary take survey to determine the acquisition type. Examples of acquisitions types are: purchasing modified COTS (Commercial off-the-shelf) products of significant value to the project, obtaining products through a supplier agreement, products from an in-house supplier, products from the customer and obtaining products from a preferred supplier.

Levels	SAM.SP 1.2 Select Suppliers
1	Necessary take survey to determine if the suppliers were selected using a formal evaluation process that evaluates identified alternatives against established criteria.

Levels	SAM.SP 1.3 Establish Supplier Agreements
Yes	Document Submitted on SCRAIM
No	

Levels	SAM.SP 2.1 Execute the Supplier Agreement
1	Necessary take survey to check supplier progress reports and performance measures, review materials, reports and items tracked to closure and product and documentation deliveries

Levels	SAM.SP 2.2 Accept the Acquired Product
1	Take survey to Ensure that the supplier agreement is satisfied before accepting the acquired product.

Levels	SAM.SP 2.3 Ensure Transition of Products
1	Only evaluated through question where is seen if is ensured the transition of products acquired from the supplier.

### 4.3.5 Measurement and Analysis

Levels	MA.SP 1.1 Establish Measurement Objectives
4	Using SCRAIM the project performance monitoring objectives are

Levels	MA.SP 1.2 Specify Measures
1	Needed survey to: estimate and measure of effort and cost (e.g., number of person hours), quality measures (e.g., number of defects by severity), information security measures (e.g., number of system vulnerabilities identified) and customer satisfaction survey scores

Levels	MA.SP 1.3 Specify Data Collection and Storage Procedures
Yes	Documents stored on SCRAIM or links on wiki page for MA
No	

Levels	MA.SP 1.4 Specify Analysis Procedures
Yes	Document submitted on SCRAIM to specify how measurement data are analyzed and communicated
No	

Levels	MA.SP 2.1 Obtain Measurement Data
4	Using SCRAIM the data to measure if obtained automatically, but necessary question on survey to check if is properly obtained.

Levels	MA.SP 2.2 Analyze Measurement Data
4	Using SCRAIM the data analysis is computerized but is still necessary a question on survey to check if the data from the document submitted is not empty and provides all the information needed to satisfy

Levels	MA.SP 2.3 Store Data and Results
4	Data is stored and analyzed on SCRAIM repositories and databases

Levels	MA.SP 2.4 Communicate Results
4	Possible with the dashboard view of SCRAIM

### 4.3.6 Process and Product Quality Assurance

Levels	PPQA.SP 1.1 Objectively Evaluate Processes
1	Use of process without phases defined
2	Use of process with phases defined
3	Process with all phases defined and with WBS items
4	Use of a given process

Levels	PPQA.SP 1.2 Objectively Evaluate Work Products
Yes	Evaluate work products taking for base evaluation reports, noncompliance reports and corrective actions, accessible with a document submitted or with a survey question
No	

Levels	PPQA.SP 2.1 Communicate and Resolve Noncompliance Issues
1	No bugs or defects reported
2	Bugs and/or defects reported
3	Bugs and/or defects reported with corrective actions
4	Bugs and/or defects reported with corrective actions and a wiki page for quality trends or document submitted

Levels	PPQA.SP 2.2 Establish Records
Yes	Existence of documents or a wiki page with evaluation logs and quality assurance reports
No	

### 4.3.7 Configuration Management

Levels	CM.SP 1.1 Identify Configuration Items
1	None release
2	At least one release
3	Releases with documentation and product
4	Process with WBS items pre-established and releases associated

Levels	CM.SP 1.2 Establish a Configuration Management System
1	No usage of control system
2	Usage of a control version system with link on wiki page
3	Usage of Scraim version control
4	Use of Scraim version control and a document submitted with procedures, and tools for recording and accessing change requests

Levels	CM.SP 1.3 Create or Release Baselines
4	With Scraim process with WBS items its possible to create baseline and associate them with releases

Levels	CM.SP 2.1 Track Change Requests
1	Project plan updated and necessary question to complete the evaluation

Levels	CM.SP 2.2 Control Configuration Items
1	Necessary to evaluate with question on the survey

Levels	CM.SP 3.1 Establish Configuration Management Records
Yes	See if version control is being used
No	

Levels	CM.SP 3.2 Perform Configuration Audits
Yes	WBS defined in the process for the audit and respective task and closed
No	

## 4.4 Electronic assessment questions

Regarding the mapping, it was discovered that some practices can not be automatically evaluated so another way of providing some results needs to be found.

The founded way is to make a survey based on pre-established questions. Those questions were derived from the "CMMI assessment checklist" (see Section 3.1) and the "ITMARK Appraisal tool" (see Section 3.4). One question example is presented in Figure 4.6.

The survey has on average 4 questions per practice of CMMI level 2 (covering all practices). The survey is not included in this documents because of its extension (40 pages).

**SAM SP0101 Determine Acquisition Type**  
 Determine the type of acquisition for each product or product component to be acquired.  
 Is the type of acquisition for each product or product component to be acquired determined?  
 Yes No N/A  
 Are the acquisition types documented?  
 Yes No N/A

Figure 4.6: Question example to cover Supplier Agreement Management Special Practice 1.1

## 4.5 Recommendations for extending the Scraim support

Some of the gaps found in Section 4.3 can be solved with the integration of some plugins, frameworks and rules of usage, as follows:

- Plugin for wiki templates [wik]

This plugin allows to choose a wiki template when a new page is added. It is possible to see a preview of the template before it is applied. This plugin will allow to resolve and insert some information directly in Scraim, without the use of other programs to generate those documents.

- Plugin for Document Management System Features [DMS]

Allows to manage documents submitted on Scraim, document approval workflow to be configurable, and maintain a version control of this documents.

- Naming conventions

For example the Project plan must be submitted with a certain name to the Scraim files, to be automatically evaluated or it will not be considered.

Conception



# Chapter 5

## Implementation

This chapter describes the details of implementation, in particular the architecture of the tool and the database and module structure.

### 5.1 Architecture of the solution

The solution is a module implemented on top of SCRAIM using the same technologies and infrastructures. SCRAIM is developed in the Ruby on Rails [H<sup>+</sup>09] programming language and a MySQL [MyS] database. The solution uses also a new framework for charts c3js [c3j].

The architecture was designed with flexibility and extensibility in mind, so that additional practices and reference models can be easily supported in the future.

The architecture of the solution is presented in two parts: the database structure and the overall application structure (module structure).

### 5.2 Database structure

The prototype was implemented inside of Scraim in order to store all the information that is generated an extension of its database was done.

For that purpose several tables in the database were created. Each one one to be flexible enough to store the information of the automatic assessments.

The tables created can be viewed in Figure 5.1, their purpose is as follows:

- **Model**

This table contains the reference models against which assessments can be made, identified by their name; in this case the only model stored is CMMI Level 2.

- **Area**

In this table are stored the Areas; each Model must have one or more Areas.

## Implementation

- **Goal**

Goals are part of the Area and each Area has one or more Goals.

- **Practice**

Each practice is characterized by its name, a summary that gives a simplified description of the practice, its description which is more complete and with some examples in some cases and its weight. Each practice has different weights in the result of the assessment.

- **Practice Evaluation**

Represent each Practice evaluation; each practice is evaluated with different criteria and is saved in the database for the presentation of the results.

- **Global Assessment**

The Result of the assessment is represented by this table where it is saved the global result, which is the aggregation of all practice evaluations for the assessment.

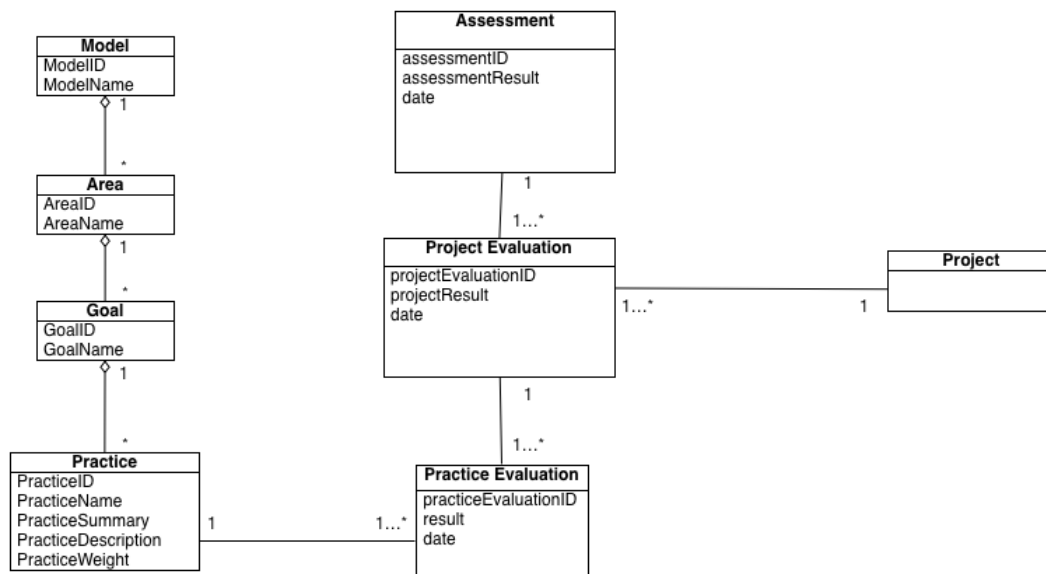


Figure 5.1: Data Model of the tables added to the SCRAIM database (UML class diagram)

On the left side of the Figure 5.1, the tables represented are those who are going to be populated with the information from the CMMI for Development and on the right side it is where the generated information is going to be stored.

### 5.3 Module structure

In Figure 5.2 we can see the overall structure of the module created.

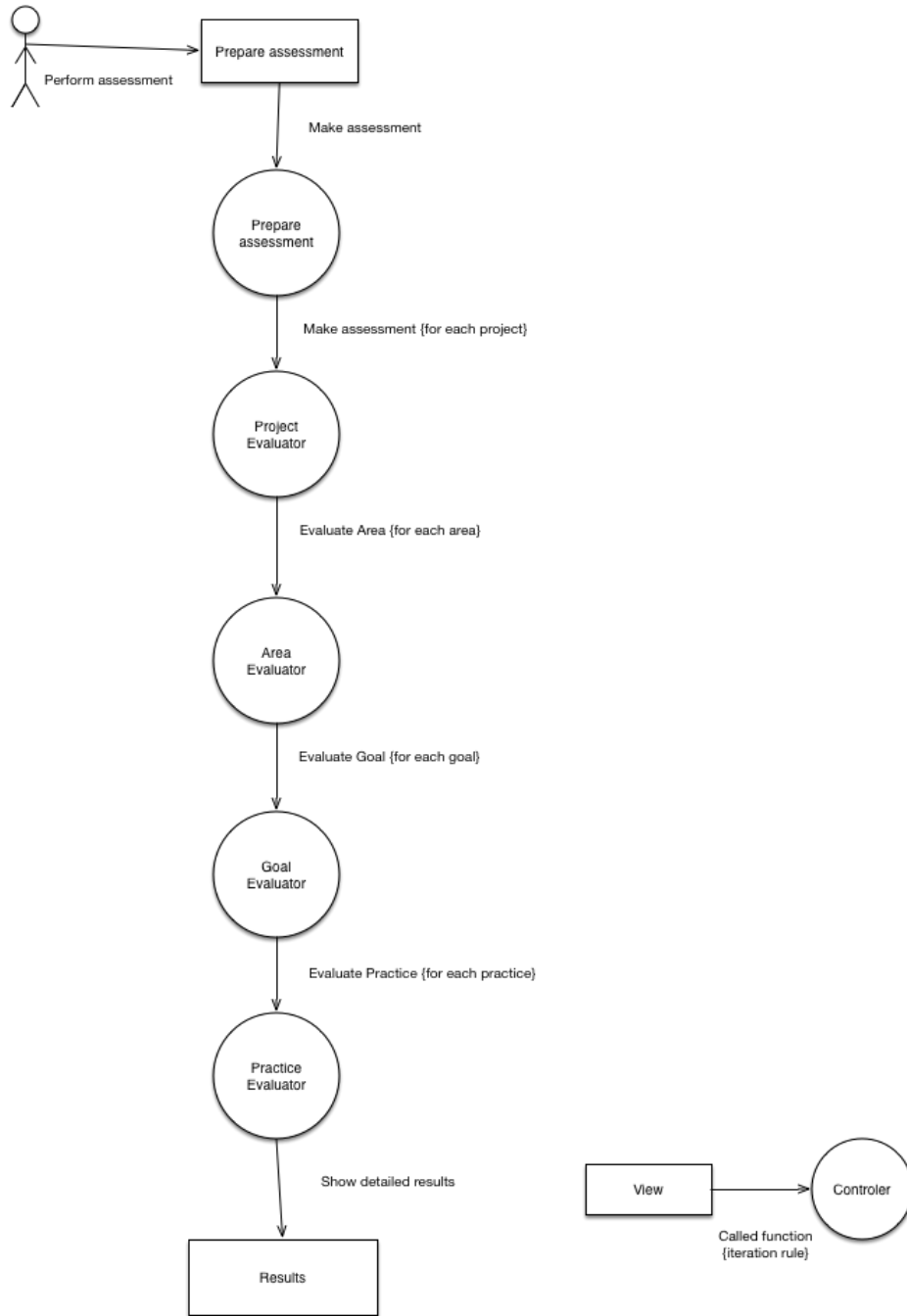


Figure 5.2: Eletronic assessment process

## Implementation

### **Prepare assessment**

Represents the view that is showed to the user to input the assessment options. It also represents the function called that validates the options selected.

### **Make assessment**

It's the constructor and main function of the module. It calls the functions that perform the evaluation of the projects and saves the evaluations results.

### **Project Evaluator**

For each project it is called this controller that calls each area evaluator.

### **Area Evaluator**

This part of the module is a controller that depending of the process area, calls all the goals evaluators and receives their results.

### **Goal Evaluator**

This evaluator is called by area evaluator; each area has one or more goals, so this is called several times for each area evaluation.

### **Practice Evaluator**

For each practice the evaluation is different, so the function that is going to generate the result of that evaluation is different, has a different logic, but has an analogous structure. All the Practices Evaluation follow the same structure.

Despite the conception and the mapping of all areas from maturity level 2 of CMMI for development, this prototype only contemplates the implementation of two areas: Project Planning and Project Monitoring and Control.

## **5.4 Scalability and flexibility**

The model represented is fully capable of handling expansions of the database and the practices evaluators, the only thing needed is to follow some steps:

- **Database Insertion:** It is needed to include in the file that starts the database the information of the new models (areas, goals and practices), that are going to be inserted into the tables.

## Implementation

- **Implement all Practices evaluators:** Must be implemented the rules evaluators; those evaluators are represented by the abstract evaluator.
- **Add to the Main Function:** The function that is going to evaluate the practices must be added to the Main Function to be called in the assessment.

After these steps the new models added are evaluated and presented in the assessment.

## Implementation

## Chapter 6

# Usage and experimentation

In this chapter it is presented an usage example of the created prototype. It is also presented a comparison between a manual evaluation and an evaluation generated by this tool.

### 6.1 Usage example

To demonstrate the prototype it is presented in this section an usage example.

As said before all the prototype was implemented inside Scraim, so its usage is restricted to users that have a Scraim account with this module enabled.

#### Home Screen

So if a user that is registered in Scraim logs in, on the side bar of Scraim (its menu) it is possible to see the assessment icon. By clicking on that icon, the user is directed to the assessments module homepage, presented in Figure 6.1.

This screen is shown when we don't have assessments performed. If there are some assessments done in this screen is presented a list of the assessments, as shown in Figure 6.2. In the Image, the three assessments are shown by chronological order, with the most recent assessments on the bottom.

#### Assessment Options

In Figure 6.2, on the right top corner, there is a button entitled "New assessment". When that button is pressed the application leads the user to a screen where is prepared the assessment. This preparation screen can be seen in Figure 6.3; in this page the user may specify a custom name for the assessment. If the name is not specified an automatic name will be generated with the date and time of the assessment. Additionally, the user has to choose the project or projects that are going to be evaluated.

## Usage and experimentation

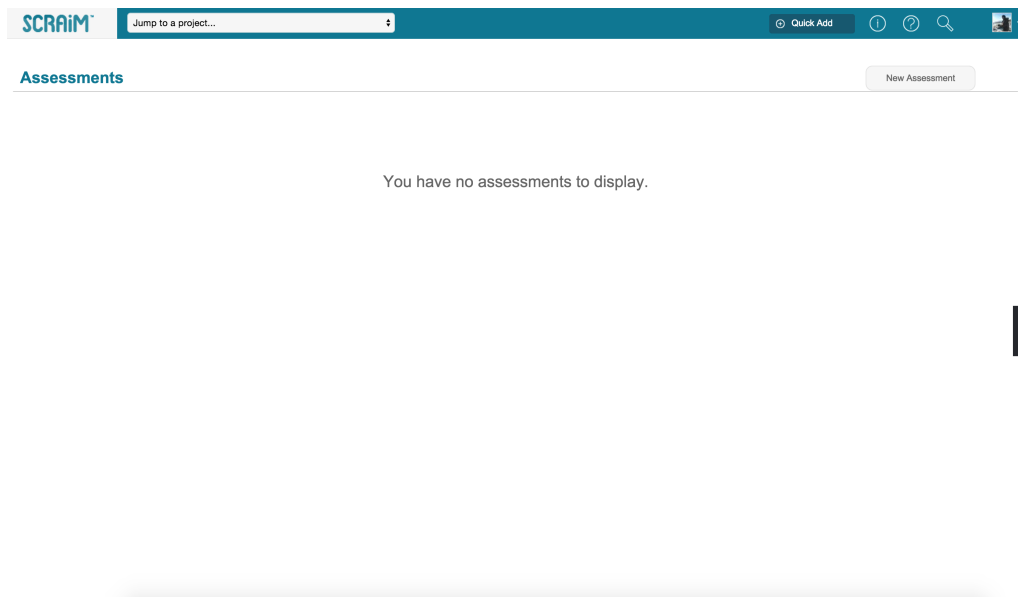


Figure 6.1: Homepage without any assessments done

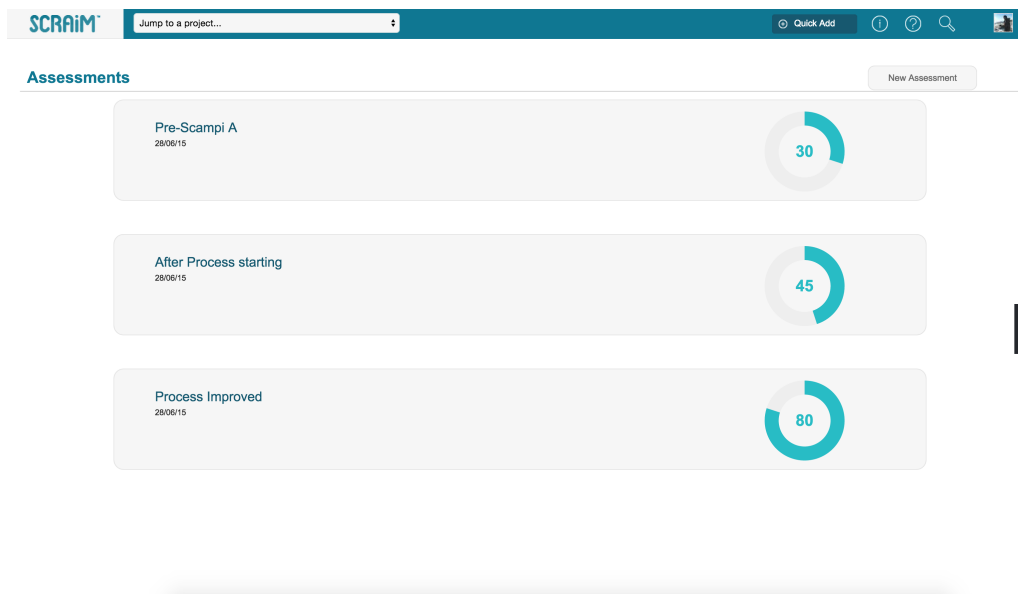


Figure 6.2: Homepage with three assessments done

Only the text field can be empty; it is mandatory to choose at least one project. After completing this process, the button "Make Assessment" can be clicked, leading to the screen presented in Figure 6.4.



## Usage and experimentation

The screenshot shows the SCRAiM Administration interface. At the top, there is a navigation bar with the SCRAiM logo, an 'ADMINISTRATION' tab, a search bar labeled 'Jump to a project...', and several utility icons including 'Quick Add', a home icon, a refresh icon, a search icon, and a user profile icon. Below the navigation bar, the page title is 'Assessment Options'. Under this title, there is a section for 'Assessment Name:' with a text input field containing 'Assessment Name'. Below that is a section for 'Projects to evaluate:' with two checkboxes: 'Project Development Mobile' and 'Project Web App'. A prominent blue button labeled 'Make Assessment' is centered below the checkboxes. On the right side of the page, there is a vertical 'Feedback' button.

Figure 6.3: Assessment Preparation

The screenshot shows the SCRAiM Administration interface after an automatic assessment. The navigation bar is identical to the previous screenshot. The main content area displays the text 'Automatic Assessment Done Go to Survey.' centered on the page. Below this text is a blue button labeled 'Take Survey'. The 'Feedback' button is also present on the right side.

Figure 6.4: After Automatic Assessment, needed Survey

### Survey

The Survey is the Screen where it is needed to answer all the questions; none can be skipped and only after that we can have a full assessment done and a proper result: This survey is not yet implemented, only the questions are selected.

## Results

When all the process is completed we can see the results obtained, as illustrated in Figure 6.5. In this screen we can see the results of a project per process area. Currently, only two process areas are evaluated automatically (PMC and PP).

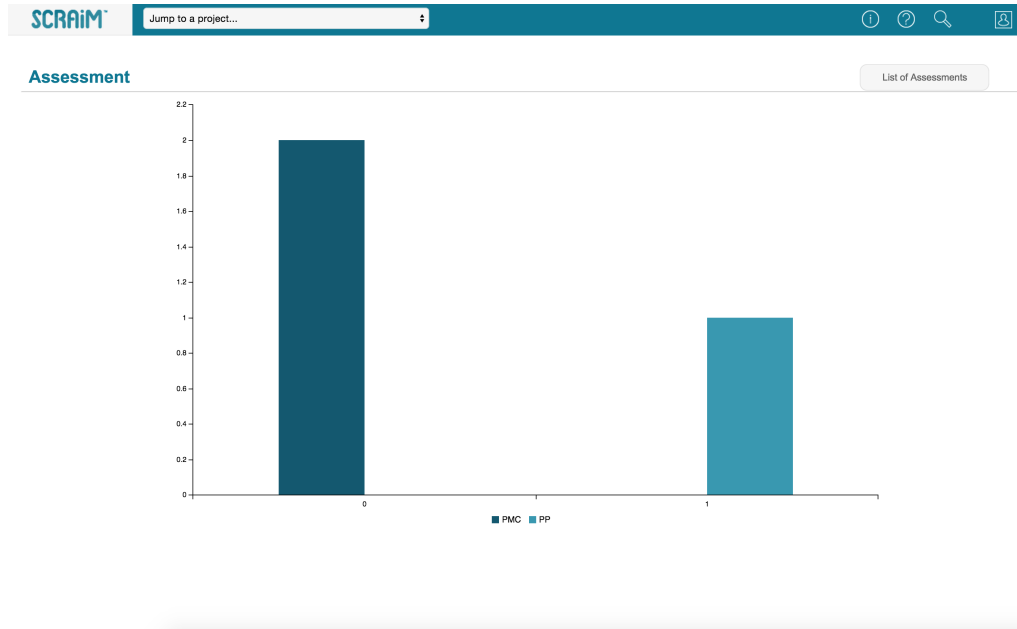


Figure 6.5: Result of assessment, area view

When a certain process area is clicked inside the graph, like for example PP (which stands for Project Planning), the content of the graph changes to the practices results, as illustrated in 6.6.

It is possible to see more in detail the assessment result if the mouse cursor is over the bar that corresponds to a practice. When that bar is clicked, it is shown in the page more information about that practice. Figure 6.7, shows the information appended to the page when the Practice 1.1 of the first goal of Project Planning area is clicked.

After all this process, all views allow the user to return to the Home screen, that contains the list of the assessments done. The assessment that we have done and we are seeing is already present in the list of assessments.

## 6.2 Comparison between automatic and manual assessment

To determine if the electronic assessment generates results close to a manual assessment performed by an expert it is necessary to compare an automatic assessment (performed by the tool) to a manual assessment (performed by a human expert).

For that purpose it was chosen a project that was already finished and instantiated in SCRAIM. In both assessments only the two areas featured in the current implementation of this module are considered for comparison.

## Usage and experimentation



Figure 6.6: Result of assessment, practices view

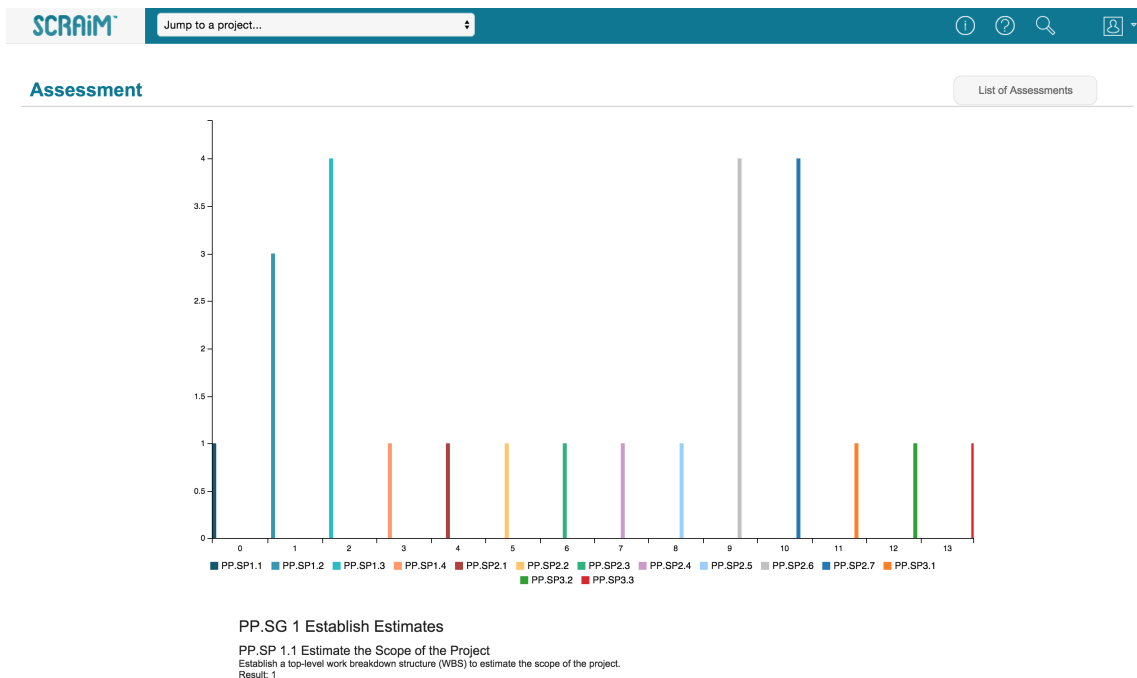


Figure 6.7: Result of assessment, practice view details

**Manual Assessment**

The manual assessment that is shown in Figure 6.8 was performed by a Consultant from Strongstep.

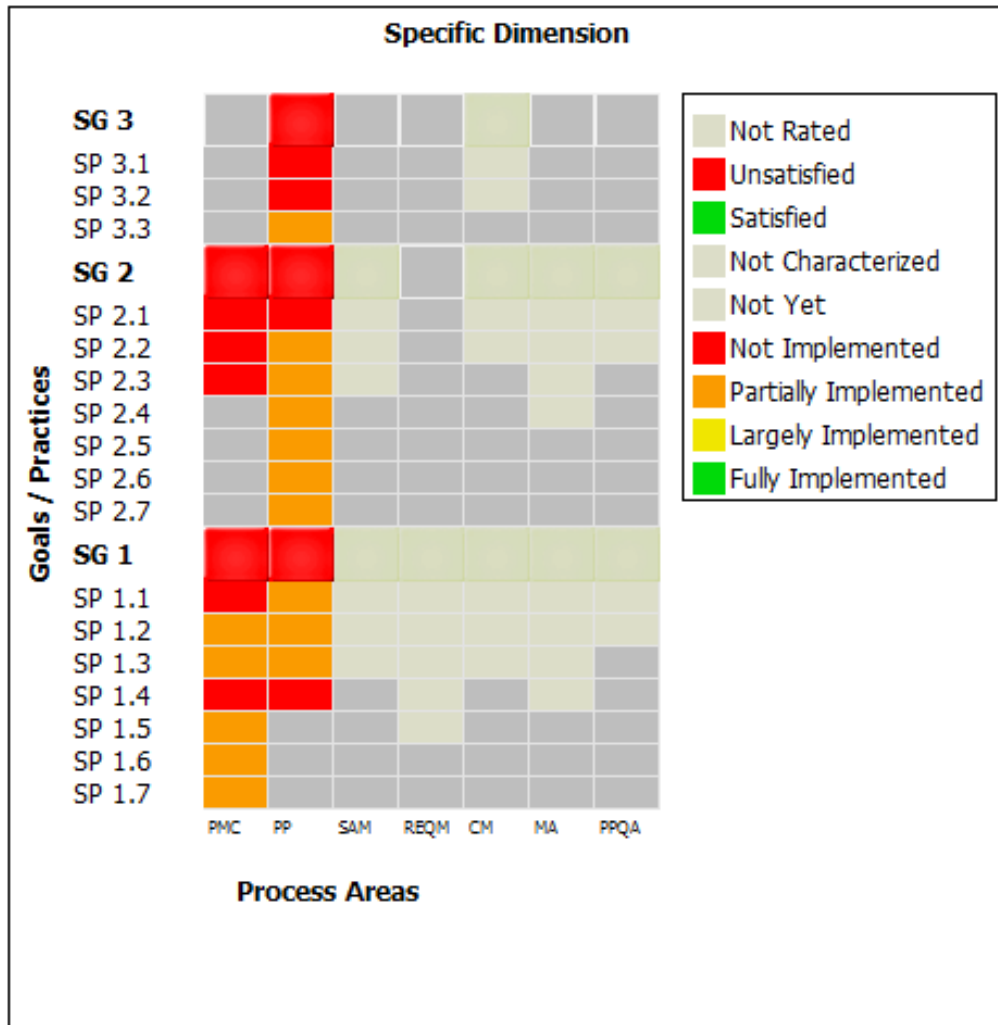


Figure 6.8: Manual assessment, done for one appraisal

In the manual assessment we can see that in Project Planing for the first goal only the last practice is not implemented and the other practices are partially implemented. For the second goal all practices are partially implemented except the first one. In the third goal only the last practice is partially implemented the others are not implemented.

For the area Project Monitoring and Control in the first goal the first and forth practices are classified as not implemented and the others as partially implemented. In the second goal all practices are not implemented.

**Automatic Assessment**

The results of the automatic assessment performed by the developed module can be seen in Figure 6.9.

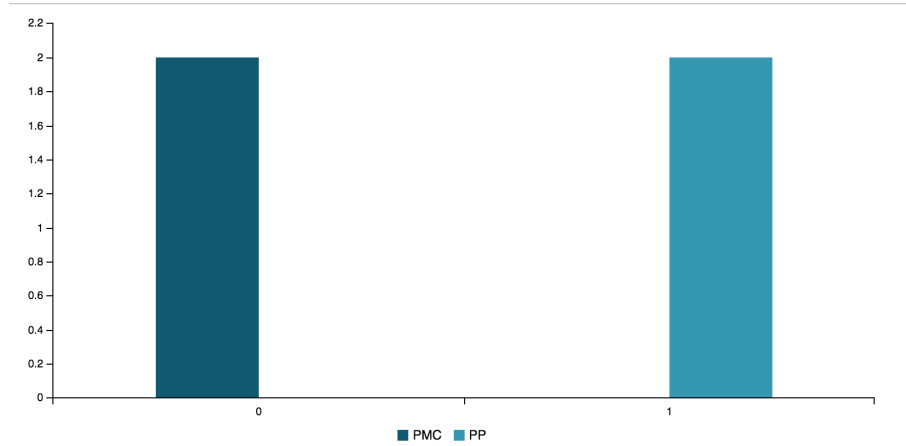


Figure 6.9: Scram Automatic Assessment

In Figure 6.9 is presented the assessment of the two areas. In this case the assessment results for the areas of PP and PMC are 2 and 2 in the SCRAIM scale, meaning partially implemented.

For the PP area, the practices results are shown in Figure 6.10.

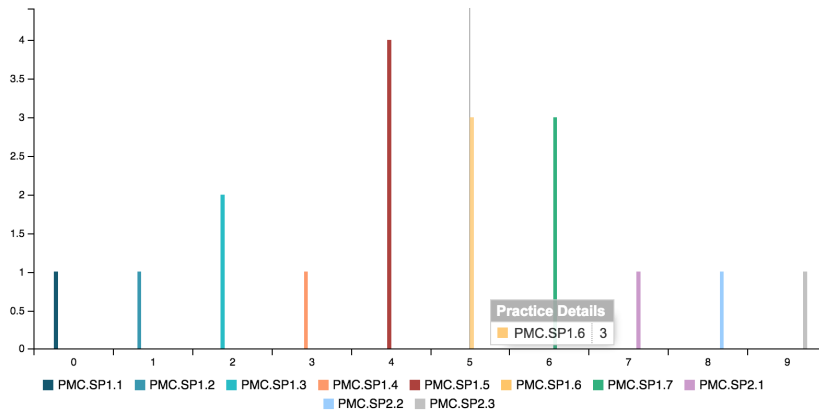


Figure 6.10: Project Monitoring and Control Results

Using for method of approximation the scale presented in Section 4.3 and comparing the automatic results with the manual assessment shown before one can conclude that in most cases the mapping of the tool matched the manual assessment. In some cases like the SP.2.2 the risks of the project weren't recorded on SCRAIM but in a document attached to the project.

Results for the PMC area are represented in Figure 6.11. Using the same method that was used before and comparing the two results, none practice stands out from the results, so the results are close to a real assessment.

## Usage and experimentation

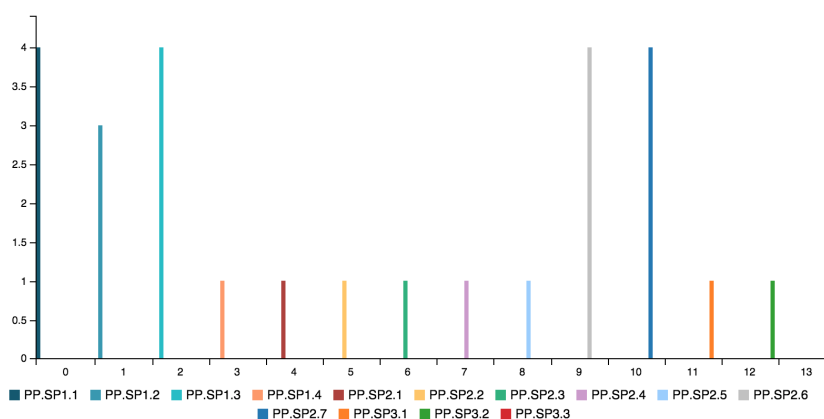


Figure 6.11: Project Planning Results

In Table 6.1 is presented side by side the results obtained, with the corresponding SCRAIM scale conceived in Section 4.3.

Table 6.1: Automatic and Manual assessments

Practice	Automatic	Manual	Manual (with Scraim scale)	Delta (Aut-Man)
PP.SP 1.1	4	Partially Implemented	2	2
PP.SP 1.2	3	Partially Implemented	2	1
PP.SP 1.3	4	Partially Implemented	2	2
PP.SP 1.4	1	Not Implemented	1	0
PP.SP 2.1	1	Not Implemented	1	0
PP.SP 2.2	1	Partially Implemented	2	-1
PP.SP 2.3	1	Partially Implemented	2	-1
PP.SP 2.4	1	Partially Implemented	2	-1
PP.SP 2.5	1	Partially Implemented	2	-1
PP.SP 2.6	4	Partially Implemented	2	2
PP.SP 2.7	4	Partially Implemented	2	2
PP.SP 3.1	1	Not Implemented	1	0
PP.SP 3.2	1	Not Implemented	1	0
PP.SP 3.3	1	Partially Implemented	2	-1
PMC.SP 1.1	1	Not Implemented	1	0
PMC.SP 1.2	1	Partially Implemented	2	-1
PMC.SP 1.3	2	Partially Implemented	2	0
PMC.SP 1.4	1	Not Implemented	1	0
PMC.SP 1.5	4	Partially Implemented	2	2
PMC.SP 1.6	3	Partially Implemented	2	1
PMC.SP 1.7	3	Partially Implemented	2	1
PMC.SP 2.1	1	Not Implemented	1	0
PMC.SP 2.2	1	Not Implemented	1	0
PMC.SP 2.3	1	Not Implemented	1	0

## Usage and experimentation

There is no case in which the ratings have opposite values (not fully and fully implemented). In 79 % of the cases they are identical or differ by at most 1.

In 42 % of the cases (practices) the ratings are identical. These statistics can be seen in Figure 6.12.

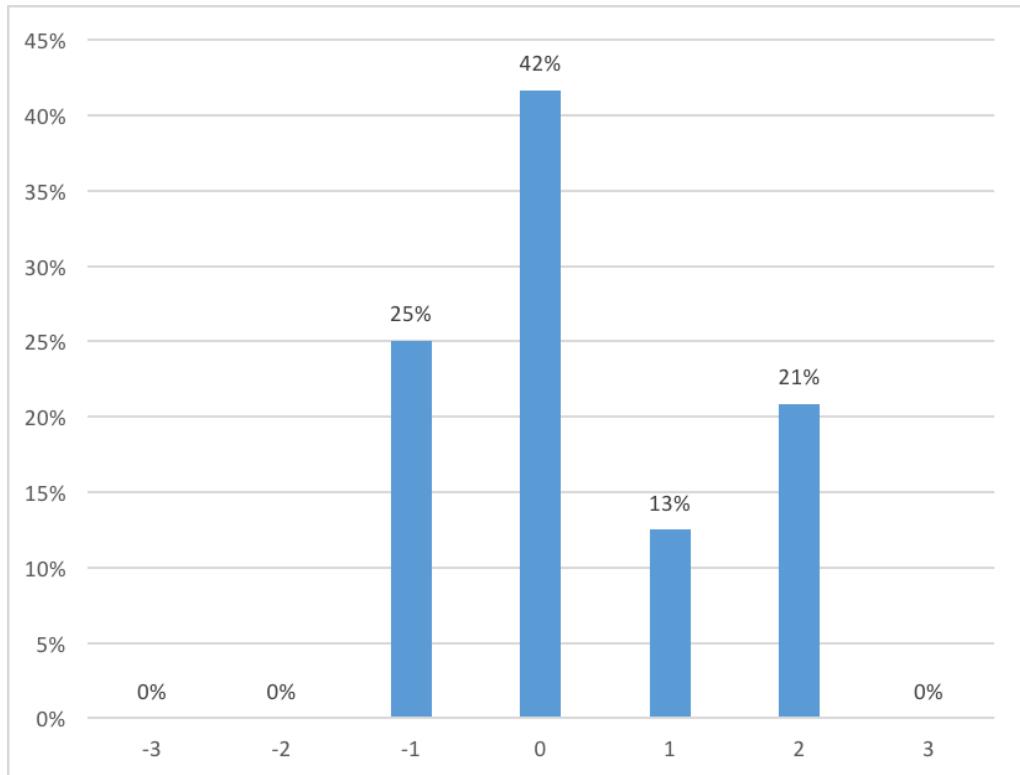


Figure 6.12: Distribution of electronic assessment errors

It is possible to see that the electronic automatic ratings that differ by 2 from the manual assessment are still 21%. The explanation for the difference is that actually it is impossible to check the content of documents submitted to SCRAIM; in some cases just for using SCRAIM it is automatically considered the last level or some practices are evaluated in only two levels, the maximum level (4) or the minimum level (1). For example the practice PP.SP1.1 is rated differently because in the automatic assessment is only seen if WBS are defined and epics are associated with backlog items, but in the manual assessment it is seen the preliminary report submitted on SCRAIM that contains some evidences for this practice not possible to evaluate yet automatically.

Usage and experimentation



## Chapter 7

# Conclusions and future work

In this chapter it is presented the summary of all the work done, the contributions of this thesis and the future work.

### 7.1 Achievements

All the goals established in the start of this thesis were almost completely fulfilled. The group of tools, methodologies and techniques accomplished resulted in a prototype of an automatic assessment module in SCRAIM. The results generated by the prototype are promising, getting very close to a real assessment, as presented in Chapter 6. Despite the success of this tool there is still much work to be done in order to make it more usable and more embracing. This is explained in more detail in Section 7.2.

The greatest difficulty in this thesis was to understand and be able to apply the concepts and methodologies behind the CMMI in order to be able to map its practices to SCRAIM. This was due to the fact that my knowledge about CMMI was very limited. To overcome this limitation it was necessary a very intensive research and extensive study in this area, which led me to acquire interest for Software Engineering. The result of this research is presented in Chapter 2.

One of the objectives of this thesis was to understand the level of support of SCRAIM in the CMMI scenario; this is researched and presented in the Chapter 4, where it is made an assessment of SCRAIM with the help of another tool that is currently used by appraisers. In the same chapter, it is shown the results of that assessment and from that we can conclude that SCRAIM is not yet ready to support a high level of maturity, but supports adequately the level 2.

Despite the high level of coverage of SCRAIM on CMMI level 2 practices, a fully automatic electronic assessment is not feasible, so to complement it is necessary to take a survey in order to answer some practices needs.

Chapter 5 presented the architecture of the prototype created; that was another point of work, in order to get a flexible and scalable architecture and prototype.

A verification and validation of this work was done by presenting an usage example and performing a comparative analysis of a manual assessment and an automatic assessment in Chapter 6.

Initially, it was intended to reduce the costs and time of a SCAMPI evaluation and with the comparative analysis made we can say that this approach will make that happen and the prototype when extended and completed with the future work will facilitate the SCAMPI appraisals.

## 7.2 Future work

The automatic assessment module is a tool that will facilitate the SCAMPI appraisals, but in order to satisfy completely the demands of an appraisal first of all it is necessary to implement all the rules established for all the process areas.

This module is fully capable of being extended so CMMI for Development is only a start point; we can add other assessment techniques like ITMARK and even add more rules and practices to SCRAIM in order to achieve more maturity levels.

In order to satisfy and help the appraisers in their field, another interesting addition is implement a feature where they can run one assessment and get some results automatically and then override the obtained results exporting all the information and generated charts.

One last and crucial thing to do is continuously improve the questions on the survey; with that we can get more accurate and precise results of the practices that we can't obtain automatically.

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