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Assessment methodology for software process improvement in small organizations

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ABSTRACT

Context: Diagnosing processes in a small company requires process assessment practices which give qualitative and quantitative results; these should offer an overall view of the process capability. The purpose is to obtain relevant information about the running of processes, for use in their control and improvement. However, small organizations have some problems in running process assessment, due to their specific characteristics and limitations.
Objective: This paper presents a methodology for assessing software processes which assist the activity of software process diagnosis in small organizations. There is an attempt to address issues such as the fact that: (i) process assessment is expensive and typically requires major company resources and (ii) many light assessment methods do not provide information that is detailed enough for diagnosing and improving processes.
Method: To achieve all this, the METvalCOMPETISOFT assessment methodology was developed. This methodology: (i) incorporates the strategy of internal assessments known as rapid assessment, meaning that these assessments do not take up too much time or use an excessive quantity of resources, nor are they too rigorous and (ii) meets all the requirements described in the literature for an assessment proposal which is customized to the typical features of small companies.
Results: This paper also describes the experience of the application of this methodology in eight small software organizations that took part in the COMPETISOFT project. The results obtained show that this approach allows us to obtain reliable information about the strengths and weaknesses of software processes, along with information to companies on opportunities for improvement.
Conclusion: The assessment methodology proposed sets out the elements needed to assist with diagnosing the process in small organizations step-by-step while seeking to make its application economically feasible in terms of resources and time. From the initial application it may be seen that this assessment methodology can be useful, practical and suitable for diagnosing processes in this type of organizations.

1. Introduction

Small software organizations are very important to the economic growth of many countries and constitute the majority of software organizations around the world. In the context of the present study and using the terms of reference given by [1], small organizations are companies with fewer than 50 employees and medium organizations are companies with a staff of between 50 and 249. In Europe, 85% of the companies in the information technology sector are micro, with 1–10 employees [2]. Such companies represent 93% of all businesses in Europe and 56% in the US – 66% of total employment [3]. In Latin America, 75% of software companies have fewer than 50 employees [4]. According to [5], approximately 94% of companies developing software are small organizations working on significant products, for which good software engineering practices are needed. These practices must also be tailored to their particular size and business type [5]. One practice that since the end of 1990s has increased in popularity in small software organizations, is software process improvement (SPI) [6,7]. Tailor-making efficient practices for small organizations means bearing in mind that they are generally extremely reactive and flexible; they typically have a flat structure and a free-flowing management style that encourages entrepreneurship and innovation; they have limited economic movement and lightweight processes. Furthermore, they do not usually have enough staff to develop specialized functions that would enable them to perform complex tasks or develop secondary products [6].

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With all this in mind, organizations like the Software Engineering Institute (SEI) or the International Organization for Standardization (ISO) are currently working towards ensuring that their models or standards, respectively, can be applied to small software organizations. Such bodies as the SEI's International Process Research Consortium (IPRC) [8], ISO's working group SC7-WG24 [9] and others working on process improvement in small organizations have emerged precisely because, as many authors agree, their special characteristics require process improvement projects to be specifically for them and visibly different from those applied in large organizations – it is not enough to scale down versions of programmes used in larger companies [10]. Although, SEI and ISO have created and structured proposals for process improvement for large organizations (such as CMMI, IDEAL, SCAMPI, ISO 12207, ISO 15504), they are not normally suitable for small ones, for the return on investment has to be seen from a long-term perspective, the recommendations are highly complex, and improvement projects involve a large investment in terms of money, time and resources [11,12]. A few exceptions do exist, however, where these proposals have been applied successfully in small firms.

In recent years, a significant percentage of small software companies in Latin America have inspired several initiatives focusing on SPI in small organizations, including the MPS.BR model [13], the MoProSoft and EvalProSoft models [14], and the SIMEP-SW project [15]. In this context, it is important to highlight the COMPETISOFT project [16] (which we are involved in), which integrates several country-specific and international proposals. COMPETISOFT is funded by the "Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo", CYTED (Ibero-American Science and Technology Development Programme), which involves 1 national body for standardization and certification, more than 10 small software companies and 27 research groups from 13 countries in Latin America. Its aim is to increase the competitiveness of small software organizations through the creation and dissemination of a common methodological framework for improvement and certification of their software processes. This framework would be adapted to the particular characteristics of the Latin American software industry.

The methodological framework of COMPETISOFT comprises a *process reference model*, a *process assessment model* and a framework for guiding the implementation of improvements (*improvement framework*). The improvement framework defines a process known as PmCOMPETISOFT [17] for guiding ongoing process improvement. It comprises five activities: initiating the cycle of improvement, diagnosing the process, formulating improvements, executing improvements and revising the cycle of improvement. Diagnosing processes in a small company requires process assessment practices giving qualitative and quantitative results affording an overall view of the process capability. The information from the results helps to determine the current state of software processes, with their strengths and weaknesses, while serving to define strategies for improving them. However, process assessment is expensive and typically requires major company resources [18], while the high abstraction level of many light assessment methods does not provide information that is sufficiently detailed for diagnosing and improving processes [19]. Furthermore, small organizations still have problems running process assessment due to their specific characteristics and limitations [19,20].

In order to address these issues we have developed a methodology for software process assessment called METvalCOMPETISOFT. To obtain relevant information about the processes, companies need a methodology suited to their characteristics which thus makes process assessment easier. In this regard, we have taken the following into account:

- Processes can be diagnosed internally in small organizations [21], in a short space of time and using few resources. Such assessments – rapid software process assessments – need not be extremely rigorous and are known to be a success factor for process improvements in such firms [7].
- Based on the typical features of small organizations, a set of requirements for a customized assessment proposal has been identified in [22]. To it we have added a new requirement concerning the integration of the assessment proposal in an improvement framework, which we consider important when the assessment is used for SPI. Although, several proposals exist for process assessment in small companies (see Section 2), none of them fully meets all these requirements.

In the light of the above, in this paper, we present METvalCOMPETISOFT, which tackles the process assessment problems of small businesses by using the strategy of rapid assessment while meeting all the above requirements. We also set out the experience of the application of this methodology in several small software firms that took part in the COMPETISOFT project. This methodology allows us to obtain reliable information about the strengths and weaknesses of software processes, along with information on opportunities for improvement for companies to act on when making decisions on process improvement. This methodology includes:

- A process for software processes assessment, PvalCOMPETISOFT, to aid with diagnosing the software processes step-by-step.
- An assessment model for determining the capability of software processes of a small organization, Light MECPDS.
- A tool to support the process assessment, EvalTOOL.

The rest of the paper is organized as follows. Section 2 gives an overview of related studies. The methodology for software process assessment is described in Section 3. Section 4 deals with the application and use of the assessment methodology in eight software companies. Finally, conclusions are drawn and future work is suggested. Throughout the paper, several terms used in previous studies and proposed assessment methodology and its application are written in italic to facilitate reading.

2. Related studies

A number of proposals have emerged from research on software process assessment for SPI in small settings in recent years. These include SPINI [19], RAPID [21], MARES [22], EvalProSoft [23], ADEPT [24], and MA-MPS [13], which are compared in Table 1 bearing in mind the requirements for a customized assessment method together with the criteria used to evaluate these requirements and the comparison scheme presented in [22]. To all this, we have added the requirement *Integrated in an improvement framework*, on the basis of experience gained in conducting improvement initiatives in small organizations in the context of the SIMEP-SW [15] and COMPETISOFT projects. During early fieldwork in these projects, the first step was to obtain information on the state of software processes by means of a process assessment strategy. However, afterwards we noticed that many companies did not know what to do with this information in order to further their improvement initiative, several abandoning the initiative without achieving the goals set. The new requirement is therefore very significant, for small organizations need further support in using the assessment information to carry out the necessary improvements, which they can do if the assessment and improvement activities are integrated and coordinated accordingly.

Table 1
Proposals for software process assessment in small organizations.

Requirements	SPINI	RAPID	MARES	EvalProSoft	ADEPT	MA-MPS	METval-COMPETISOFT
Low cost	o	+	+	–	+	–	+
Detailed description of assessment process	+	o	+	+	+	+	+
Guidance for process selection	–	– (8 processes predefined)	%	– (6 process predefined)	+	– (23 processes predefined)	+
Detailed definition of assessment model	+	+	+	+	+	+	+
Support for identification of risks and improvement suggestions	o	–	%	–	+	–	+
Support for high-level process modelling	–	–	%	–	–	–	+
Conformity with ISO/IEC 15504	+Level 3	+Level 3	+Level 3	+Level 5	+?	+Level 5	+Level 2
No specific SE knowledge required from company representatives	+	+	+	–	+	–	+
Tool support	o (DC)	– (PF)	%	– (PF)	– (PF)	– (PF)	+(PF, ST, EPG)
Integrated in a assessment methodology	?	?	%	+	?	+	+
Public availability	?	–	+	–	–	+	+
Integrated in an improvement framework	+	–	–	–	o	–	+

+ Satisfies; o more or less; - does not satisfy; ? no information found; % being developed (no current information found)
Tools support: PF (paper forms), ST (software tool), EPG (electronic process guides), DC (data collection)

Table 1 shows that all the proposals have a *detailed description of the assessment model and process*; furthermore, they *conform to ISO/IEC 15504-2*, and ADEPT also integrates the ARC 1.1 requirements for a CMMI Class C. Except for ADEPT, the structure of the capability dimension of all proposals is identical: (i) SPINI, RAPID and MARES focus on assessments up to level 3, (ii) EvalProSoft and MA-MPS focus on assessments up to level 5, and (iii) METvalCOMPETISOFT concentrates on assessments up to level 2. METvalCOMPETISOFT's assessment model defines a measurement framework, which in the capability dimension has only three levels (levels 0–2), making the model lighter and easier to apply in small organizations. The decision to consider only those levels is supported by the evidence found on SPI in small organizations in the systematic review presented in [7].

Only MA-MPS and EvalProSoft include a method and a process for conducting a formal evaluation of the software development processes. Both proposals are aimed at external auditors from a certification organization able to provide appropriate levels of process capability and organizational maturity. Other proposals consist of informal internal assessment focusing on improvement rather than certification, for application in small companies and fulfilling the requirements of *low cost* and *not requiring specific knowledge in software process assessment*.

As Table 1 shows, all the proposals met some requirements to some extent. One of the main contributions of the current proposal is that all the requirements are fulfilled. In this regard, it is important to emphasize the following:

- Except for SPINI and METvalCOMPETISOFT, the proposals are not explicitly *integrated into an improvement framework* for small organizations (ADEPT contributes to the diagnosis stage in the IDEAL model [25]). METvalCOMPETISOFT's methodology for process assessment (internal non-formal evaluation) is integrated into a framework that guides the management and implementation of process improvement (*Improvement framework*). It belongs to the methodological framework developed in the COMPETISOFT project for the support of SPI activities in small organizations. The description of these frameworks is beyond the scope of this paper.
- With a view to guiding the diagnosis of the process step-by-step when implementing SPI in small organizations, our methodology includes two *software tools to support* the assessment process and the model. The METvalCOMPETISOFT methodology was modelled with SPEM 2.0 [26] using the EPF Composer editor [27], which allows for availability of the activities, roles, work products and guidelines on the WEB. *Software tool support* for the execution of the assessment process and model has also been developed [28].
- Only METvalCOMPETISOFT provides *support for high-level process modelling*. The explicit representation of each process assessed, as in our proposal by means of activity diagrams, is essential, because it allows for early visibility of the organization's processes, while helping to instil the process-oriented approach and process improvement in the minds of those involved.
- Regarding *guidance for process selection*, in ADEPT, the process areas of CMMI most applicable to some small firms in Ireland were identified. To support small organizations dealing with the first processes of an SPI project, in METvalCOMPETISOFT a set of processes is described which we consider to be of high priority for organizations of this type [29]. It should be emphasized that this guidance seeks to make it clear to them which processes should be tackled first, regardless of the process reference model chosen. The one model currently used by our assessment methodology is that defined in the COMPETISOFT project, used also as a basis for technical report ISO/IEC 29110 Software Engineering – Lifecycle Profiles for Very Small Enterprises [3], developed by WG 24/SC7 of ISO.

Table 2 shows the stages of the different proposals. Only ADEPT and METvalCOMPETISOFT contain stages to support the identification of risks and suggest improvements. In stage 7 of ADEPT an SPI roadmap focusing on the company's business goals is developed. Here we would point out that METvalCOMPETISOFT includes two additional activities: prioritization of processes and preliminary planning of improvements. The first activity is essential in an improvement project, for it allows us to determine the order of implementation of the improvements to be made in a cycle. The second activity utilizes the synergy of the work done and the motivation gained through the assessment activity, thus allowing the development and implementation of the improvement opportunities to continue the effort of improvement already initiated.

3. Assessment methodology – METvalCOMPETISOFT

This section presents METvalCOMPETISOFT's *assessment methodology* in detail describing (i) its context, (ii) the considerations

Table 2
Stages of the assessment process of the different proposals.

Name	Stages of the assessment process
SPINI	(1) Start-up session, (2) work product review, (3) assessment session, (4) reporting, (5) feedback session
RAPID	(1) Prepare and send demographic questionnaire, (2) complete demographic questionnaire, (3) prepare assessment plan, (4) prepare assessment instrument, (5) conduct RAPID assessment, (6) prepare assessment report
MARES	(1) Planning, (2) contextualization, (3) execution, (4) monitoring and control, (5) post-mortem
EvalProSoft	(1) Preparation, (2) planning, (3) execution, (4) generate results, (5) deliver results, (6) close evaluation
ADEPT	(1) Develop appraisal schedule and receive site briefing, (2) conduct overview briefing, (3) analyse software documentation, (4) conduct process area interviews, (5) generate assessment results and create the findings report, (6) deliver the findings report, (7) develop an SPI path with the company, (8) review the SPI path and produce a final report.
MA-MPS	(1) Contracting the assessment, (2) preparing to perform the assessment, (3) performing the assessment, (4) recording assessment output
METval-COMPETISOFT	(1) assessment planning, (2) assessment execution, (3) results generation and socialization, (4) processes prioritization, (5) preliminary planning of improvements

for its creation, (iii) the *assessment process*, (iv) the *assessment model* and (v) the *tool to support the process assessment.*

3.1. Context of the assessment methodology

For the definition, refinement and application of the components of the methodological framework of the COMPETISOFT project, we used the Action–Research method [30,31], which is a collaborative research method, merging theory and practice. Its application is iterative, based on continual feedback between the researchers and the companies involved, in order to improve solutions. The Action–Research method divides the project participants into two groups: one made up of *researchers* from different universities and the certification national body, and a *critical reference group*, which includes computer professionals from small software businesses.

The METvalCOMPETISOFT *assessment methodology* is a component of the *improvement framework* of COMPETISOFT (see Fig. 1), which currently comprises:

- A process, PmCOMPETISOFT, for managing and leading the software improvement process step-by-step [17].
- A lightweight process for incorporating improvements, which uses the agile SCRUM method to manage and carry out of the activities of their formulation and execution. Our objective is to offer all those involved in the improvement cycle a lightweight sub-process to allow them to implant any improvement opportunities encountered.
- A strategy for process selection and prioritization, to show a small company which processes to be considered first in an improvement project [29].

The *process reference model* [16], the *PmCOMPETISOFT process* [17], the *lightweight process* and the *Strategy for process selection and prioritization* [29] are beyond the scope of this article, which focuses only on the description of METvalCOMPETISOFT.

3.2. General considerations of the assessment methodology

The METvalCOMPETISOFT methodology seeks to assist in *diagnosing processes* from PmCOMPETISOFT, by defining an assessment process, model and tool (see Fig. 1). METvalCOMPETISOFT supports the fast and ongoing diagnostic principle of processes proposed by the *improvement framework* of COMPETISOFT.

The METvalCOMPETISOFT methodology has been developed in order to:

- Provide the person *responsible for process improvement* with the elements necessary for process assessment in the context of a cycle of SPI.
- Make it possible to assess processes in small software companies cheaply and quickly.
- Diagnose the processes of the small firm on an ongoing basis.

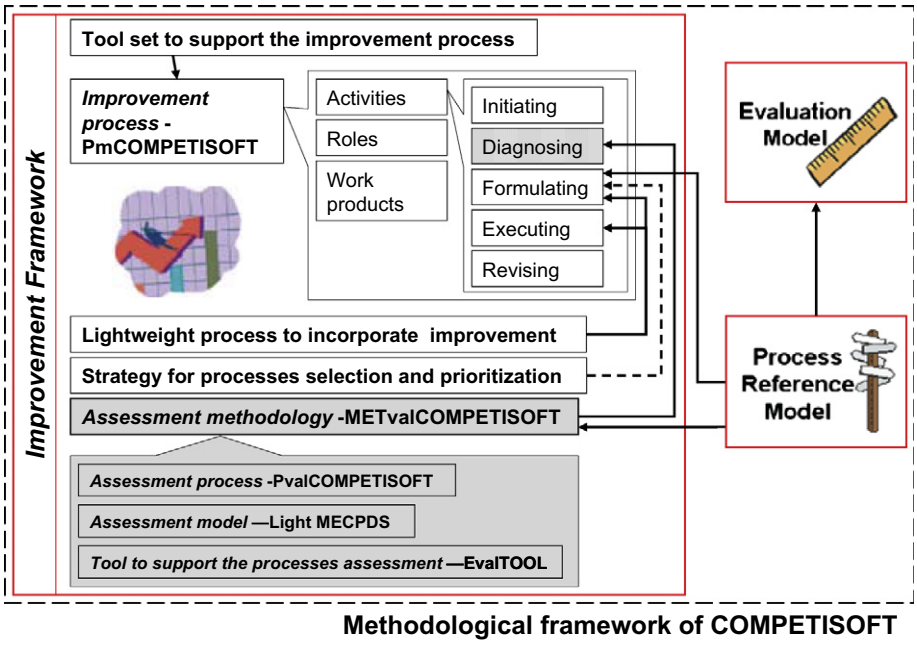

Fig. 1. Components of the improvement framework of COMPETISOFT.

3.3. The assessment process – PvalCOMPETISOFT

PvalCOMPETISOFT is described here according to the process elements (purpose, objectives, activity diagram, activities description, work products and roles) defined by the process pattern of the COMPETISOFT project.

3.3.1. Purpose

PvalCOMPETISOFT is a process for assessing processes and its purpose is to generate reliable information to identify the strengths, weaknesses and risks of the software processes of an organization in a general way. Decisions in the improvement cycle will be based on this information.

3.3.2. Objectives

PvalCOMPETISOFT defines the following objectives:

- To perform a diagnosis of the process through the disciplined execution of the activities and work products proposed by the assessment process.
- To define the objectives and scope of the assessment, based on improvement objectives described in the *improvement proposal* of the organization.
- To assess the results of each *cycle of improvement* regarding the improvements introduced in the processes, and to supervise the *cycle of improvement*, frequently assessing its efficiency in the organization.

3.3.3. Activity diagram

Fig. 2 shows the activities, roles and work products of PvalCOMPETISOFT, following the SPEM 2.0 notation.

Given the importance of the diagnosis of processes, a process supporting it is a significant contribution. Fig. 2 shows how, the activities presented by the PvalCOMPETISOFT assessment process help with the diagnosis of the processes of PmCOMPETISOFT. It also presents the relationship that PvalCOMPETISOFT has with the activities in PmCOMPETISOFT of *initiating the cycle* and *formulating and executing improvements*.

3.3.4. Description

The process for Software process assessment consists of five activities:

- *Assessment planning*: An assessment plan is developed and documented from the *improvement proposal*. This proposal contains: the general objective of the improvement; the ongoing improvement process; and the scope, overall goals and resources of the present *cycle of improvement*. The *evaluator* and person *responsible for process improvement (facilitator)* describe the objectives and scope of the assessment, together with the assessment model to be used to determine the process capability and the instrument for collecting the information to apply in the organization (based on the *process reference model* and *assessment model* chosen). The project to be evaluated (the firm's) and an assessment schedule are also described, with the date, activities, estimated time needed to carry out each activity, and the roles involved, among other things.
- *Assessment execution*: Bearing in mind the scope defined in the previous activity, the *evaluator* collects and systematically validates the data needed for assessment processes, using such evidence-collection techniques as the interview and survey and the information-gathering instruments especially defined or created for that purpose. To validate the information, the *evaluator* gathers information separately from the person responsible for the process (*participant*) to be evaluated (so the documentation of the organization's processes is inspected) and the person involved (*participant*) in the actual execution of this process.

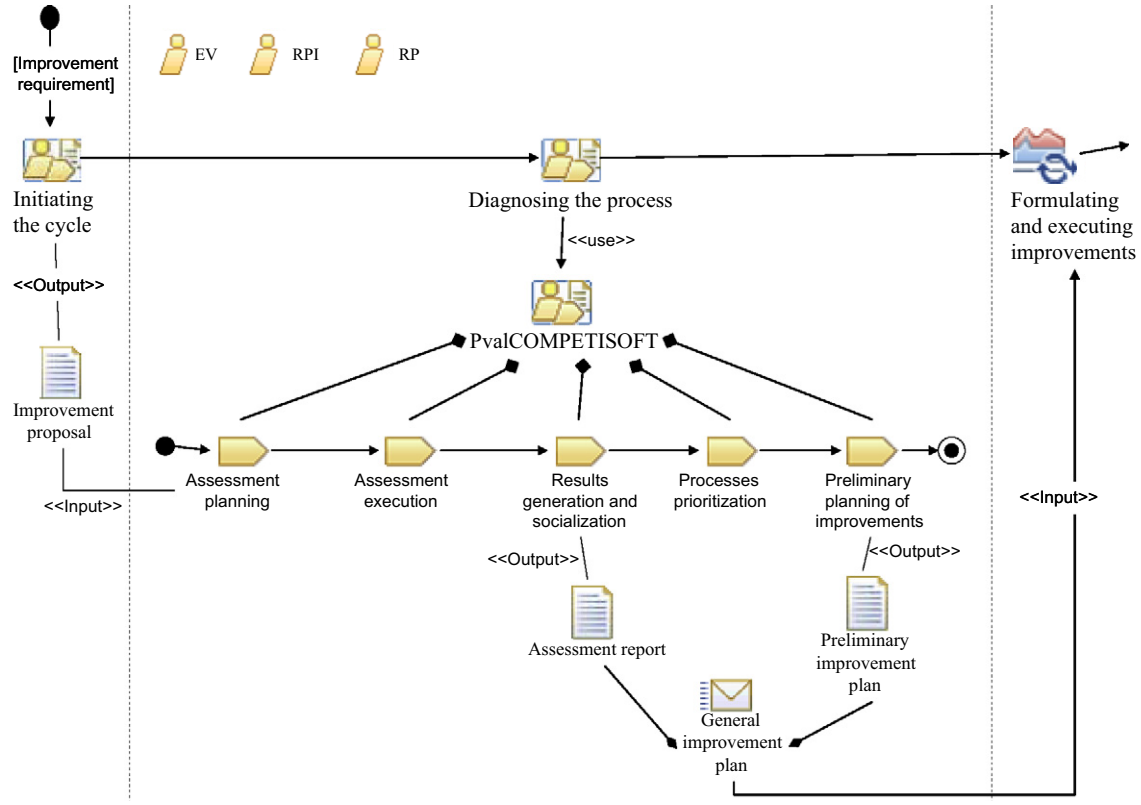

Fig. 2. PvalCOMPETISOFT activity diagram and their relationship with PmCOMPETISOFT.

- *Results generation and socialization*: The *evaluator* analyses and synthesizes the data obtained with the information-gathering instruments to determine the state of current processes by discovering their weaknesses, risks and strengths. For each process assessed, information related to its activity diagram is presented, along with any discoveries made, the work products, and the *improvement opportunities*. Finally, the *evaluator* assigns a value to the processes attributes so as to establish a profile of the capability level of the processes assessed in the organization. The *evaluator* gives the person *responsible for process improvement* the work product known as the *assessment report* (PT02_1_AR), which contains the results of the assessment of the organization's processes for their validation and refinement.
- *Process prioritization*: On the basis of the information in the *assessment report,* the person *responsible for process improvement* prioritizes the *improvement opportunities* of the processes assessed to establish the order of their formulation and execution. This is done with different focuses in mind, for example: (i) improving the essential and fundamental processes required for the suitable performance of a small organization, such as those concerning software development and project management, (ii) improving processes supporting the objectives of the organization's strategic plan, and (iii) establishing ongoing process improvement centred on a process management approach, as in [29]. The order of priority for *improvement opportunities* must take into account the business goals of the organization and the goals of the improvement cycle.
- *Preliminary planning of improvements*: The *facilitator* analyses the prioritized *improvement opportunities* and may group them into *cases for improvement,* thereby managing their complexity. He also plans and documents the strategies to be used in implementing the *cases for improvement* by means of iterations. These strategies guide the different improvement iterations to be carried out in the organization. The *facilitator* proposes the number of iterations for the current *cycle of improvement* and a draft of its general planning (not in detail), and also defines the process measurement plan, as well as the plans for training and risk management with regard to the *cycle of improvement*. Using the deliverables of the tasks performed, the *facilitator* generates the work product *preliminary improvement plan (PT02_2_PIP)*.

3.3.5. Work products

A self-contained template has been developed for each PvalCOMPETISOFT work product in order to facilitate construction. Each template lists the items desired of the work product and a description of each one, to guide its construction. It also registers the effort needed to carry out the activities related with each work product. The PvalCOMPETISOFT output work products are:

- *(PT02_1_AR) Assessment report*: This document collects the information on assessment planning and execution and registers the state of the processes as regards their capability of beginning a *cycle of improvement*, as well as the *improvement opportunities* of the processes assessed. It describes the people responsible for the assessment and the participants and sets out the plan and execution of the assessment, the discoveries made and the level of process capability.
- *(PT02_2_PIP) Preliminary improvement plan*: This document contains the improvement guidelines for the work to be done in the phases following *diagnosing the process*. It describes the prioritization of *improvement opportunities* and the *cases for improvement*, and proposes a draft setting out the number of iterations of the *cycle of improvement*, along with general planning, the measurement plan, the training plan, the risk-management plan and the schedule for the different iterations.

Table 3
Description of the roles in PvalCOMPETISOFT.

Name	Role	Remits
EV	Evaluator	Knowledge of the methodology and assessment of the application process, and analysis of the data collected
RPI	Responsible for process improvement (*Facilitator*)	Capacity for leadership and management. Knowledge of SPI. Ability to design processes, guide implementation and train staff in the new processes defined by the improvement cycle
RP	Responsible for process (*Participant*)	Sound knowledge of the process for which he is accountable. Management knowledge associated with the process, its diagnosis and improvements

3.3.6. Roles

The roles involved in PvalCOMPETISOFT are shown in Table 3. It is important to consider that any one employee can take on various roles and that a given role can be performed by several employees.

The relationships between tasks, primary performers and work products used and produced in PvalCOMPETISOFT are presented in Fig. 3.

3.4. The assessment model – light MECPDS

The PvalCOMPETISOFT process is independent of the assessment model, which, in the case of METvalCOMPETISOFT is a light assessment model called LightMECPDS, the initial version of which was discussed in [32].

Bearing mind the characteristics and limitations of organizations where the model was to be applied, along with the fact that the vast majority of small organizations do not reach level 2 of capability when they start their first improvement projects [7], and generally to make the assessment model lighter, we based it on international standards ISO/IEC 15504-2:2004 [33] and ISO/IEC 15504-5:2006 [34] but only up to level two of the capability model and its three process attributes (of the nine given by the standard). This means that a company wishing to assess the state of its processes is able to make the assessment significantly more lightweight in form.

The evaluation of Light MECPDS is based on the following set of indicators demonstrating what the *process attributes* have achieved regarding the capability level of the assessment model:

- *For the process capability dimension: The management practices* and *generic work products* associated with obtaining the results of the *process attributes*.
- *For the process performance dimension: The base practices* and *work products* associated with satisfying the purpose statement of the processes defined in the *process reference model*.

The degree of implementation of the practices (base and management) is evaluated by means of three types of evidence:

- *Direct*: Products resulting from an activity.
- *Indirect*: In general, documents showing that an activity has been carried out.
- *Comments*: Opinions of those involved in the process being evaluated.

As the indicators described above (process attributes, management practices and base practices) need a specific scale of measurement, values are thus expressed on a discrete scale as follows: (i) F, fully achieved, 86–100%; (ii) L, largely achieved,

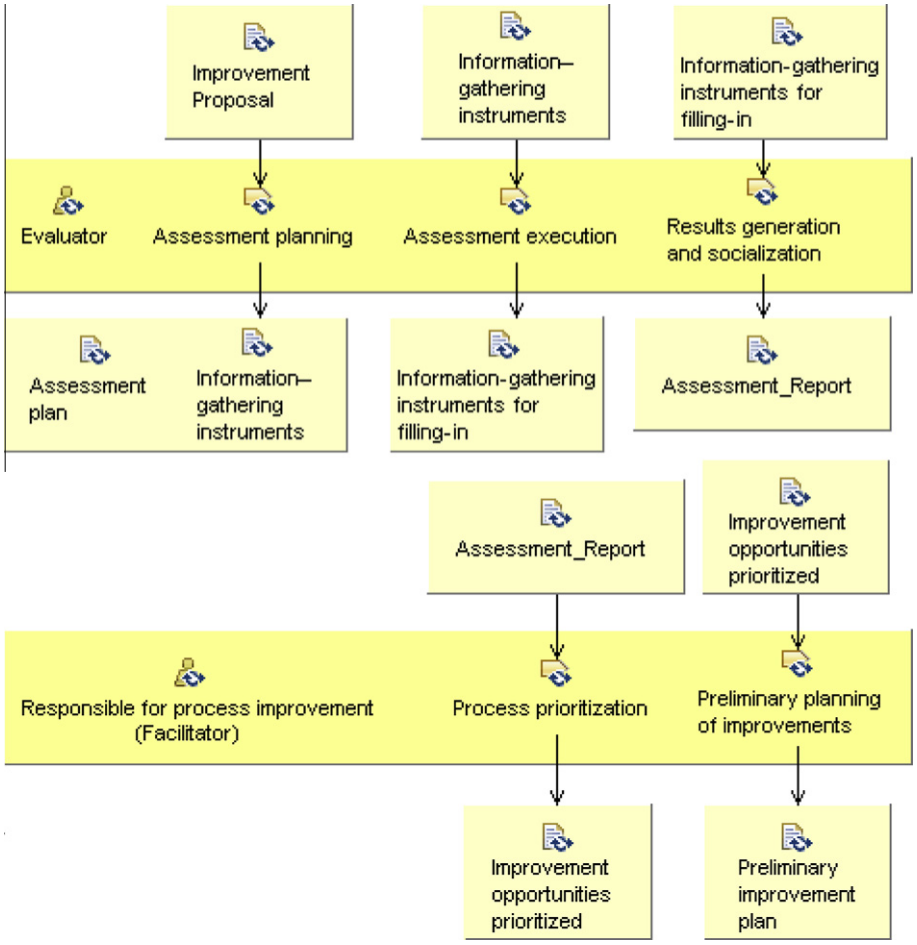

Fig. 3. Relationship between roles, activities and work products of PvalCOMPETISOFT.

51–85%; (iii) P, partially achieved, 16–50%, and (iv) N, not achieved, 0–15%. In [35], we present a measurement strategy and a set of measures designed to assess the performance and capability of software processes, following international standard ISO/IEC 15504.

3.4.1. Process capability dimension

This is defined by a hierarchical scale of three levels, representing increases in the capabilities of the software development processes: (i) Level 0, incomplete process; (ii) Level 1, performed process, and (iii) Level 2, managed process. Reaching a level is shown in this dimension by the fulfilment of the corresponding process attributes, which are features of a process that can be evaluated on a scale of achievement, providing a measure of that capability to the process. Applicable to all processes, process attributes are made up of management practices (principal indicators of process capability) and generic work products. A management practice is an activity of a generic type providing guidance on the implementation of the attribute's characteristics, while generic work products would be expected to be evident as results of the achievement of an attribute.

A capability level is a set of process attributes that work together to provide a major enhancement in the capability to perform a process. In Table 4, Tables 5 and 6 (presented earlier in [32]) process attributes (PA) are specified, along with the management practices (MP) associated with them.

The value of a process attribute is obtained from the average of the percentage values of the management practices as proved by generic work products. It should be noted that each management practice is assumed to have the same weight in a process attribute. Table 7 defines the level of capability associated with a process as a function of its process attributes.

Table 4
Process performance attribute.

Id. Attribute	Description attribute: process performance		Scale
PA 1.1	The process performance attribute is a measure of the extent to which the process purpose is achieved.		N, P, L, F
Level	Id. Practice	Description of the management practice	N, P, L, F
1. Performed	MP 1.1.1	The process achieves its defined outcomes	

3.4.2. Process performance dimension

This dimension is characterized by its focus on the characteristics and purposes of a specific process established and defined by a *process reference model*. Satisfying the purpose statements of a process represents the first step in building a level 1 process capability. The processes are made up of base practices and work products, which are software engineering activities that directly guide the purpose of a particular process, contributing to the generation of its outputs.

The goal of this dimension is for small organizations to be able to assess each one of their processes in order to identify their

Table 5
Performance management attribute.

Id. Attribute	Description attribute: performance management		Scale
PA 2.1	The performance management attribute is a measure of the management of the performance of the process.		N, P, L, F
Level	Id. Practice	Description of the management practice	N, P, L, F
2. Managed	MP 2.1.1	Objectives for the performance of the process are identified.	
	MP 2.1.2	Performance of the process is planned and monitored.	
	MP 2.1.3	Performance of the process is adjusted to meet plans.	
	MP 2.1.4	Responsibilities and authorities for performing the process are defined, assigned and communicated.	
	MP 2.1.5	Resources and information necessary for performing the process are identified, made available, allocated and used;	
	MP 2.1.6	Interfaces between the parties involved are managed to ensure both effective communication and clear assignment of responsibility.	

Table 6
Work product management attribute.

Id. Attribute	Description of attribute: work product management		Scale
PA 2.2	The work product management attribute is a measure of the proper management of the work products produced by the process.		N, P, L, F
Level	Id. Practice	Description of the management practice	N, P, L, F
2. Managed	MP 2.2.1	Requirements for the work products of the process are defined.	
	MP 2.2.2	Requirements for documentation and control of the work products are defined.	
	MP 2.2.3	Work products are appropriately identified, documented, and controlled.	
	MP 2.2.4	Work products are reviewed in accordance with arrangements and adjusted as necessary to meet requirements.	

Table 7
Capability levels with process attributes.

Capability level	Process attributes	Rating
Level 0. Incomplete process	–	
Level 1. Performed process	PA 1.1 process performance	L or F
Level 2. Managed process	PA 1.1 process performance	F
	PA 2.1 performance management	L or F
	PA 2.2 work product management	L or F

strong and weak points, therefore providing the basis for the improvement of each organization's processes, as it requires the definition and determination of how their processes are carried out. At the very least, these small organizations must achieve fulfilment level L in their processes in order to guarantee a minimum knowledge of the processes to be assessed.

In this dimension, reaching the maximum value on a measurement scale for a process is demonstrated by fulfilling the base practices associated with the process being assessed. The base practices can be individually measured, allowing small companies to ascertain the value of process performance. The process performance value is obtained from the average of the percentage values of the base practices as proved by work products, expressed in the values defined above. It should be noted that each base practice is assumed to have the same weight in a given process.

The next figure shows an overview of the LightMECPDS assessment model (see Fig. 4).

3.5. Tool for supporting the process assessment – EvalTOOL

For METvalCOMPETISOFT to be applicable in small software organizations, they must be provided with the appropriate software tools for performing the process assessment. Tools of this kind support repetitive actions by reducing the cognitive load of those involved in the assessment activity, as well as any administrative load associated with the manual application of this activity [6,36].

To support METvalCOMPETISOFT, a Flexible Environment for the Capability Assessment of the Software Processes has been developed, called EvalTOOL [28]. Its main characteristic is that it allows for process assessment using various assessment models and process reference models (provided the assessment models and processes are compatible with the environment core). To support this characteristic, EvalTOOL defines a generic metamodel, which has taken into account the elements defined in major process reference models (such as COMPETISOFT, ISO 12207, CMMI) and their respective assessment models (LightMECPDS, ISO 15504, SCAMPI). The environment uses this metamodel to guide the assessments, and is thus flexible, that is, it is able to assess any processes (from a process reference model) defined in terms of their being in accord with this metamodel. Any new process included in the environment therefore depends on conformance of the process reference model with the metamodel defined in the core of the environment. In addition, some modules are designed to implement the other assessment models.

EvalTOOL is composed of two parts: one manages the process reference models and the other applies the assessment models to these processes. Fig. 5 shows the relationship between the two parts, which are described below:

- *Process model management*: This component (Fig. 5, left) manages the process reference models used for conducting the assessments. It supports the inclusion of flexibility in the environment processes related to different process reference models. It is able to generate the schema associated with each model, and allows for storage of the information from each process in a way that is compatible with the environment.
- *Model application and evaluation*: This component (Fig. 5, right) allows for the definition and assessment of software processes, using the databases created by the component described above. Its job is to define a new assessment based on existing reference models, already included in the database. This assessment is then able to assess the processes chosen by answering several questions, which are defined from the process reference model stored in the database.

4. Case studies

This assessment methodology is currently being applied to give support to diagnosing processes in the performance of a *cycle of improvement* in different small software companies in Spain, Colombia and Argentina forming part of the *critical reference group*

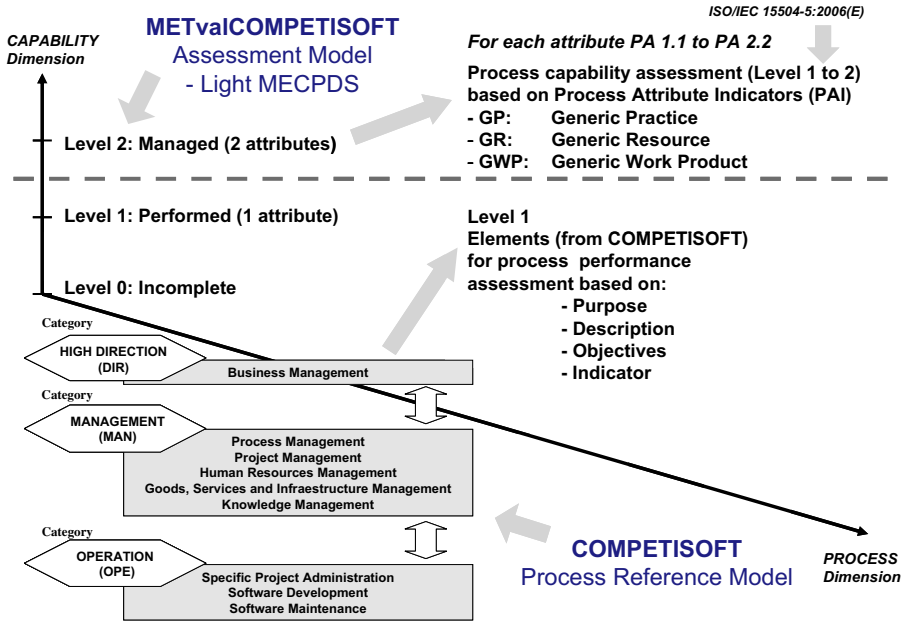

Fig. 4. Structure of LightMECPDS.

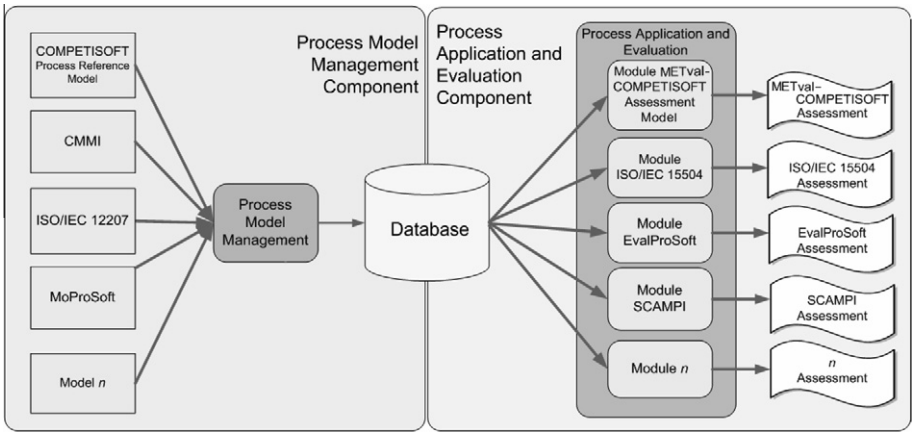

Fig. 5. Components of the EvalTOOL environment [28].

defined by the Action–Research method. In order to validate METvalCOMPETISOFT, we conducted eight case studies, following the protocol template [37]. The following subsections describe these studies in terms of design, subjects, field procedures and analysis of results.

4.1. Design

The *main research question* addressed by this study is: Is the METvalCOMPETISOFT methodology suitable (useful and practical) for carrying out software process assessment efforts in small software enterprises? *Additional research questions* addressed by these case studies are: (i) Is the effort involved suitable for small companies? (A "suitable" effort is defined as one that a company can take on following the proposed methodology) (ii) Does the proposed methodology actually give small companies knowledge of how they conduct their processes and awareness of their capability? and (iii) Does the proposed methodology enable small companies to obtain reliable information to serve as the basis for improving the capability of their processes? With these questions we seek to discover whether METvalCOMPETISOFT has a useful function, if it is of practical use and whether it is respects the reality of small companies. That is, is it suitable for them? In addition, taking the approach presented by [38], the *design type* of our case study is one of multiple cases – embedded, since METvalCOMPETISOFT was applied in eight different firms to assess the software development processes and specific project administration (two different units of analysis). The *object of study* is a new methodology for assessing software processes in small software organizations. The *measures* used in the research were: (i) the effort used in carrying out the tasks associated with PvalCOMPETISOFT (related to practical use and the reality of companies) and (ii) the capability level of the processes under analysis (those which needed to be improved) of each company (related to useful functions). We also took into account the benefits described by the companies involved.

4.2. Subjects and analysis units

The *participating organizations* in the case studies are part of the *critical reference group* of the COMPETISOFT project and each of them had started a *cycle of improvement* with the support of an adviser in improvement processes from the COMPETISOFT project

researchers group. The *improvement framework* and the *process reference model* of COMPETISOFT were applied. The *analysis units* are the METvalCOMPETISOFT activities and the processes to be assessed and improved within each company.

The organizations taking part in the case study were two small firms and one medium-sized company in Spain, four small firms in Colombia and one small one in Argentina. To preserve their anonymity, we refer to them here as EOne, ETwo, EThree, EFour, EFive, ESix, ESeven and EEight. Although, our methodology focuses on small organizations, we included a larger one (EThree) because this company expressed interest in a cycle of improvement. This gave us the opportunity of receiving feedback from a different source and information from different settings to analyse and improve our proposal. Table 8 describes the properties of the firms taking part in the case studies for analysis of the application of METvalCOMPETISOFT in a real managerial context. EOne and ETwo were also involved in case studies discussed in [17] and [29], respectively concerning the PmCOMPETISOFT process and the Strategy for process selection and prioritization.

The senior management of EOne, ETwo, EFour, EFive, ESix and EEight had decided to opt for improvement processes which would give systematic support to the consolidation and growth of the firms. They aimed to increase the capability level of their processes, seeking clarity, follow-up and organization of the processes that they use in the development of their software products. The quality assurance departments of EThree and ESeven see the software processes improvement as a strategy for achieving the ongoing improvement of their processes. Five organizations (EOne, ETwo, EFour, ESix and EEight) had no experience in software improvement processes. EThree had experience in software administration and quality assurance and is certified according to ISO 9001:2000 Quality Management System. EFive and ESix had a short, rather informal and on–off approach to improvement processes.

The three Spanish companies shared one COMPETISOFT project adviser (the first author of this paper, who developed METvalCOMPETISOFT under the supervision of the third and fourth authors), who was in charge of preparing: (i) the assessment instruments and (ii) the way of analysing and summarizing the information yielded by them. He also conducted the assessments in each one of these firms and provided the COMPETISOFT project adviser in Colombia (the second author of this paper) and Argentina with the elements necessary for diagnosing processes there. Following the guidelines offered by METvalCOMPETISOFT, the COMPETISOFT project consultant for Colombia diagnosed processes and assigned a person with basic knowledge in process improvement to each enterprise to conduct the assessments.

4.3. Field procedure and data collection

The procedure for fieldwork and data collection during the case studies is closely related to the PvalCOMPETISOFT process activities, roles and work products. In the following subsections, we present an overview of the work carried out on *diagnosing the processes* in the eight organizations, following the proposed methodology.

To support the application of this methodology in the different firms involved, METvalCOMPETISOFT was described using standard SPEM 2.0 and edited with the EPF Composer [27]. This ensured generating documentation in a standard format updated and available through the Web (See Fig. 6).

Before *diagnosing the processes* in the organizations, preliminary work was necessary, consisting in initiating the cycle of improvement in each one through the following tasks:

- Launch of the *cycle of improvement* to collect information about the firms. A joint commitment to carry out the cycle of improvement was then signed by their senior management and the COMPETISOFT adviser.
- Creation of the *improvement proposal*. For all the organizations, the scope for the *cycle of improvement* was set out, comprising the processes of specific project administration (SPA) and software development (SD) of the COMPETISOFT *process reference model*. A quantitative goal was set of increasing the capability level of these processes by one. The resources for the cycle of improvement and its planning were assigned and the pilot project to be worked on was defined for each company.
- Socialization of the cycle of improvement, whereby the adviser shared out the work to be done and received feedback from the employees' expectations.

The PvalCOMPETISOFT assessment process was used to drive the activity of *diagnosing the processes* in each organization, the application of which is described below.

4.3.1. Assessment planning

Assessment planning involved consideration of the *improvement proposal* created and approved in the *initiating the cycle of improvement* as an input work product. A person was chosen to be responsible for each of the roles involved in the assessment with the aim in view of forming an overall view of the current state of each organization's processes with regard to capability level 2 of the Light MECPDS *assessment model*. The assessment scope of the first *cycle of improvement* was to discover the state of the *SD and SPA processes* of an organization's pilot project. The COMPETISOFT adviser created an instrument for gathering information, whose starting point was the *base practices* of *SD and SPA processes* described by the COMPETISOFT *process reference model* and in all *process attributes* of the Light MECPDS model. The assessment surveys were included in the EvalTOOL *assessment tool*. Each of the five activities to be performed was described and planned, roles were assigned to the person responsible and those taking part, and the resources and time necessary for each activity were estimated.

Table 8
Characteristics of the firms involved in the case studies.

Organization	Country	Employees	Age	Market	Main areas of professional activity
EOne	Spain	7 (6)	4	N	Software development on WEB
ETwo	Spain	21 (15)	12	N	Software development through contracts and agreements with public organizations
EThree	Spain	60 (60)	17	N and I	Integral systems of service management based on the use of information technology online. Solutions based on open systems and free software
EFour	Colombia	4 (4)	2	N	Software to manage and control the ISO 9001–2000 quality management system
EFive	Colombia	4 (4)	3	N	Software for mobile telephony and handheld devices for mobile telephony
ESix	Colombia	7 (6)	4	N	Software to support the processes of organizational knowledge management
ESeven	Colombia	18 (10)	7	N	Software for financial management, automation systems and mobile logistics
EEight	Argentina	12 (5)	3	N and I	Custom software development

Employees: total number of employees (employees involved in software development and maintenance)
Age: number of years of existence of the company
Market: commercial scope of the products developed by the organization (N: national, I: international)

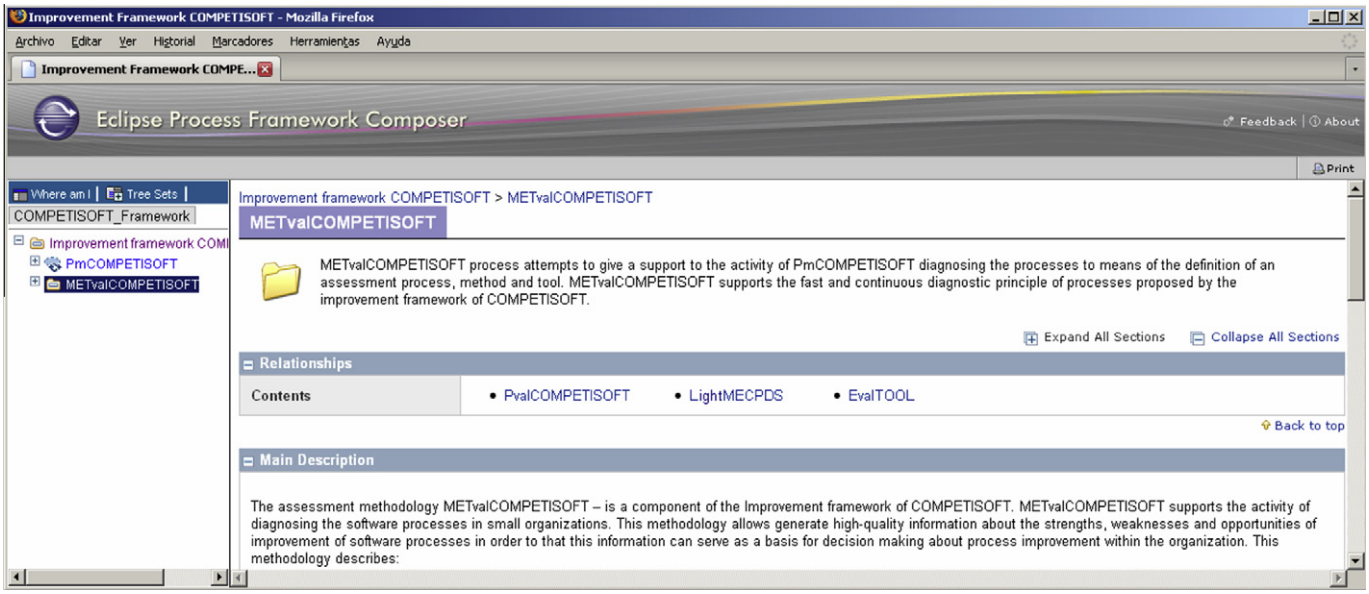

Fig. 6. METvalCOMPETISOFT described with EPF Composer.

The role of *evaluator* was assigned to the COMPETISOFT project adviser.

4.3.2. Assessment execution

A visit of 2 days was made to each firm in order to make the initial assessment of the processes chosen, for which evidence-gathering techniques (interview and surveys) were applied using specially created information-collecting instruments. The assessment surveys were conducted using EvalTOOL. (See Fig. 7).

In the firms with no documentation of their processes (all except EThree), a meeting was held with the person *responsible* for the processes to be appraised, in order to draw up the activity diagram. Another meeting was then arranged with a *participant* in the *SPA and SD process,* with a view to applying the assessment instrument. In EThree the inspection of the documentation and the application of the assessment instrument of the *SPA and SD processes* were carried out in the first instance with two individuals who were *responsible* for the company's quality assurance, and then the assessment instrument of the *SD process* was applied to the person *responsible* for the organization's development department.

4.3.3. Results generation

The information generated from the data obtained may be of different kinds and its purpose is to provide a view of the state of the organization's processes. The *evaluator* used this information to create the *assessment report*. For example, Fig. 8 shows the activities diagram of the *SD process* obtained from EOne.

Information on the strengths of the processes was also generated. Examples of EThree's strengths are: (i) processes clearly described in the company's documentation, as it has an ISO 9001 quality administration system and (ii) staff stability in software development.

The information on the capability of the processes (see Table 9) was obtained by analysing and summarizing the data collected on each firm's *SD and SPA processes* concerning (i) the *base practices* and *work products* described in these processes from the *process reference model* (regarding *process attribute* PA 1.1) and (ii) the *management practices* (and the *generic work products* expected from their implementation) as described in *process attributes* PA 2.1 and PA 2.2 defined in the Light MECPDS model. The numeric values of the *process attributes* shown in Table 9 were obtained following the strategy presented in [35], which assigns the same importance to each practice (management or base) and to each work product (generic or non-generic) when assessing the capability of the processes. Using the information-gathering instrument (from EvalTOOL), the *evaluator* assigned a numeric value of 0 (never), 0.5 (sometimes) or 1 (always) to each practice and work product, depending on the level of fulfilment that the process appraised shows with regard to the chosen *reference process model* and *assessment model*. Values thus assigned were: (i) "never" if there was no evidence of practice implementation or existence of a product, (ii) "always" if there was *direct* evidence, and (iii) "sometimes" if there was *indirect* evidence or *comments*. For instance, the value of 4% for PA 2.1 of EOne's *SD process* was obtained as follows:

- The instrument designed for information-gathering for process attribute PA 2.1 consisted of 12 questions, each one testing a specific management practice, obtained from the breakdown of the six management practices presented in the Table 5. For example, practice MP 2.1.2 "Performance of the process is planned and monitored" has been divided into two practices: (i) "Performance of the process is planned" and (ii) "Performance of the process is monitored". The information-gathering instrument also permits investigation of generic work products that prove the achievement of the management practices and therefore the process attribute. For attribute process AP 2.1 we expected 13 generic work products.
- For EOne only 2 of these specific management practices were registered as "sometimes" (numeric value 0.5) and the rest as "never" (0). Furthermore, this organization had no generic work product related to this process attribute, which means that the numeric value of the fulfilment of: (i) the management practices is $8.33\% = ((2 * 0.5)/12) * 100$), and (ii) the generic work products is $0\% = (0/13) * 100$. Finally, the fulfilment value of 4% (N: Not Achieved) for PA 2.1 of the *SD process* was obtained from the average of those two values.

The *evaluator* analysed the information collected during the process assessment of each organization in order to identify their potential *improvement opportunities*, the base and management practices (and their work products) not undertaken. So, EOne's 18% on PA 1.1 means it carried out very few – or none – of the base practices and work products described in the *SD process* of COMPETISOFT *process reference model*. In fact, no evidence showed

Fig. 7. Interface of EvalTOOL for process assessment.

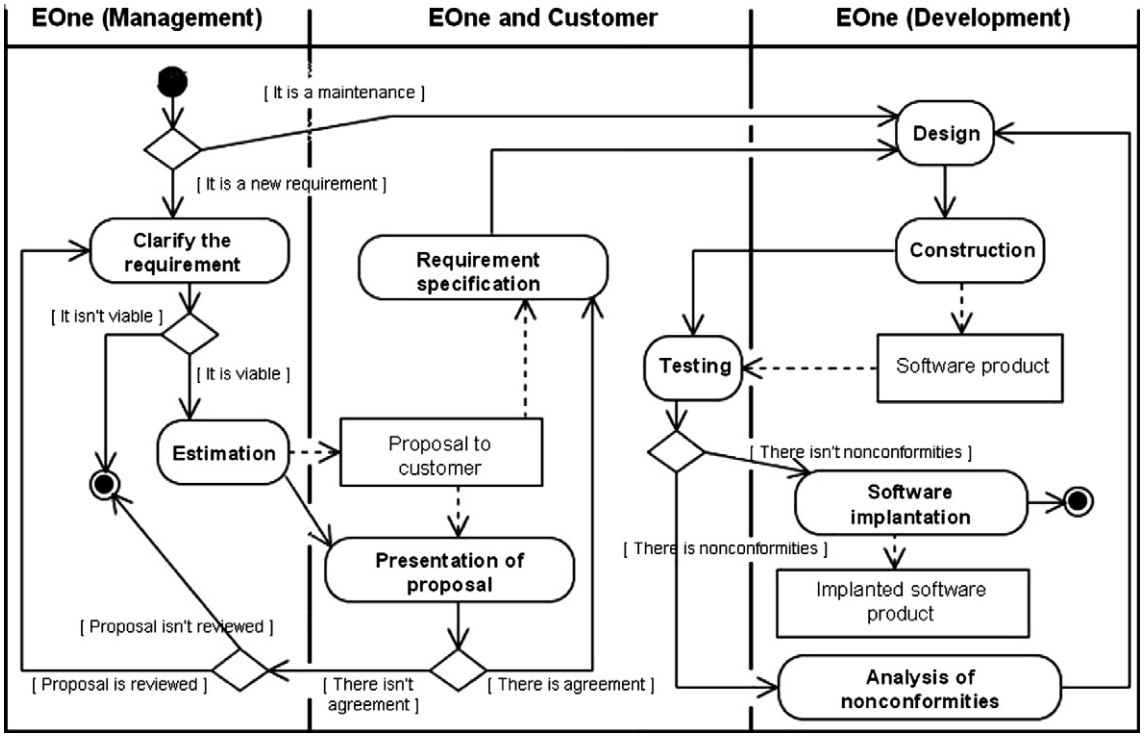

Fig. 8. Flow diagram of SD process activities of EOne.

fulfilment of base practices in the *SD process* in this organization and very little existed for work products. Base and management practices (and their work products) not addressed by firms were the potential *improvement opportunities* reported by the *evaluator*, and were analysed in each case by the person *responsible for process improvement* for their approval on the basis of each firm's improvement objectives and business needs. For example the *SD process* at EThree was found to include: (i) an established repository of

Table 9
Process capability of organizations involved in assessment.

Organization	Process	Process attributes (value in %)			Level
		PA 1.1	PA 2.1	PA 2.2	
EOne	*SD*	18 (P)	4 (N)	0 (N)	0 (Incomplete)
	SPA	0 (N)	0 (N)	0 (N)	0 (Incomplete)
ETwo	*SD*	21 (P)	10 (N)	10 (N)	0 (Incomplete)
	SPA	0 (N)	0 (N)	0 (N)	0 (Incomplete)
EThree	*SD*	87 (F)	70 (L)	72 (L)	2 (Managed)
	SPA	72 (L)	80 (L)	75 (L)	1 (Performed)
EFour	*SD*	58 (L)	29 (P)	0 (N)	1 (Performed)
	SPA	4 (N)	25 (P)	0 (N)	0 (Incomplete)
EFive	*SD*	19 (P)	4 (N)	4 (N)	0 (Incomplete)
	SPA	23 (P)	25 (P)	0 (N)	0 (Incomplete)
ESix	*SD*	14 (N)	0 (N)	0 (N)	0 (Incomplete)
	SPA	29 (P)	0 (N)	0 (N)	0 (Incomplete)
ESeven	*SD*	8 (N)	0 (N)	0 (N)	0 (Incomplete)
	SPA	38 (P)	29 (P)	0 (N)	0 (Incomplete)
EEight	*SD*	15 (N)	0 (N)	0 (N)	0 (Incomplete)
	SPA	5 (P)	0 (N)	0 (N)	0 (Incomplete)

components (group of related code units performing a function); (ii) a tracking registry to guarantee the relationship between requirements, elements of analysis and design components, and the supporting plans; and (iii) the description of a group of elements to facilitate understanding and execution of future modifications (requirement specification, maintenance manual).

4.3.4. Process prioritization

For this *cycle of improvement* the COMPETISOFT project defined the processes to be improved as those of its basic profile, that is, the *SD and SPA processes,* which is why only these processes were assessed in the eight organizations. The seven small organizations decided to improve the *SD process* first, achieving level 1 for this process before going onto improve the *SPA process*. EThree, on the other hand, wanted to improve the *SPA process* first in order to complete the practices allowing it to execute a project on time and within the budget set. Furthermore, the *improvement opportunities* for each process were also prioritized according to each firm's needs and characteristics.

4.3.5. Preliminary improvement planning

The COMPETISOFT adviser and the person *responsible for process improvement* created the *preliminary improvement plan* to take advantage of the assessment work already carried out, in order to initiate the formulation and execution of the process *improvement opportunities* found. For each firm the *preliminary improvement plan* was defined, and the number of iterations making up the *cycle of improvement* presented, together with the order of their execution and the overall schedule. Proactive administration of the major risks involved in the *cycle of improvement* was established and the corresponding management strategy was registered. Training was planned for those involved and it was established that the basic process measures would be performed on two things: (i) the processes to be improved in an organization (based on the extent to which it obtained their capability level) and (ii) the improvement process to be used (with a measure of the effort made in carrying out this process). The person *responsible for process improvement* created the *general improvement plan* with the *assessment report* and the *preliminary improvement plan*.

4.4. Analysis of results and lessons learned

In this section, we highlight the most relevant aspects of the application of the METvalCOMPETISOFT *assessment methodology* in the eight organizations.

4.4.1. Investigation methods applied

The application of the infrastructure suggested by the *Action–Research investigation method* permitted a centralized administration of the construction and application of the METvalCOMPETISOFT investigation product. The *assessment methodology* was applied in the firms in the *critical reference group*, which are geographically dispersed, according to the general guidelines established by the *researchers group*. This afforded us a homogeneous application and reliable information on applying METvalCOMPETISOFT. Among other things, the guidelines lay down the same instruments for collecting information and the same way of analysing and synthesizing the data. The Action–Research method is strengthened with the Case Study method because it allows more control in the execution of the proposals developed. That is, the researchers carry out the intervention with the new proposal in the *critical reference group*, using the case study research method in a systematic manner, which leads to increasingly reliable results. The integration of the two research methods provided a well-defined structure for the development of the proposed methodology and its application in small enterprises.

4.4.2. Instruction by the COMPETISOFT consultant

In the assessment of processes of the first improvement cycles instruction is provided by the COMPETISOFT adviser, who works in close relationship with the person *responsible for process improvement* in each company. They do not only receive training in process assessment, but also gain the experience needed to do their job properly. In the first improvement cycles METvalCOMPETISOFT seeks to decide on the basic infrastructure of process assessment that will support software process improvement and management. It is hoped that process diagnosis should be ongoing in the organization, supported by its own staff and with no need for an adviser.

To ensure suitable consultancy and because seven of the firms taking part (EOne–ESeven) in the case studies were dispersed geographically in four different cities (two in Spain and two in Colombia), a strategy was established for weekly communication with advisers by means of an internet application sustaining video conferences. This permitted continual communication and feedback from the assessment methodology application in the seven organizations. However, no communication strategy was set up with EEight in Argentina, which allowed us to observe the application of the methodology without the help of advisers.

4.4.3. Effort

Fig. 9 shows the measure of effort involved in carrying out *diagnosis of the processes* following the assessment methodology proposed.

Fig. 9 shows that ETwo required the greatest COMPETISOFT adviser effort of the Colombian and Spanish organizations (EOne–ESeven), because ETwo was the first company to be assessed, and familiarization with METvalCOMPETISOFT and the instruments for collecting information and interpretation of data gathered for the generation of the assessment results took correspondingly longer, as the adviser of the assessment methodology needed to invest more effort in learning and acquiring experience. However, Fig. 9 also shows that the adviser effort of ETwo was very similar to that of EEight, where no communications strategy had been established with the company's consultant, who needed to invest effort in becoming familiar with the assessment methodology and learning how to use it. The effort made by these two companies, shown in Fig. 9, gives an idea of the amount of effort required to implement the assessment methodology for the first time.

In Fig. 9 also shows that the effort of carrying out the diagnosis is greater in EThree because its larger size made the assessment

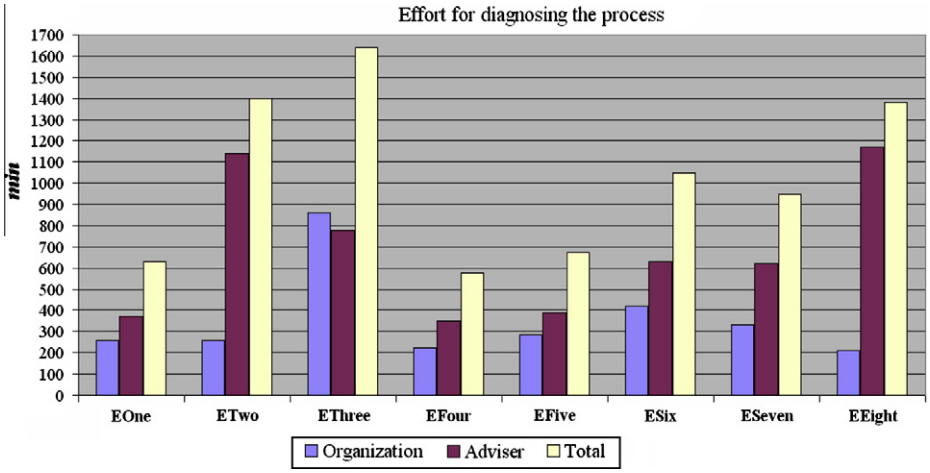

Fig. 9. Effort involved in diagnosing a process with METvalCOMPETISOFT.

more costly to perform (the inspection of their process documentation took longer and there were more people involved).

The assessment activities required an average effort of 16 h for the small organizations (11 for the adviser and 5 for the firm). EThree needed 27 h (13 for the adviser and 14 for the firm). If we assume an organization utilization rate of 7 h per employee-day, then the average commitment for the two processes assessments is the equivalent of a quarter of an employee-week for the small companies and half an employee-week for EThree. Assuming a similar utilization rate for an adviser, the adviser average cost is equivalent to half an employee-week for the small firms and EThree alike. Furthermore the case studies showed us that the different roles defined in METvalCOMPETISOFT were correctly played by the companies' employees and the adviser. In addition, it should be pointed out that the employees of the small organizations took on the additional workload well, a desired characteristic when working with organizations of this type.

We consider that the effort of applying the proposed methodology was reasonable for the characteristics of the organizations involved in the assessment, as the employees were able to take on this effort without any negative effect on their normal activities.

Little information is currently available in the literature on the costs associated with conducting a process assessment in small companies [18], especially regarding SEI and ISO assessment proposals such as SCAMPI and ISO/IEC 15504, of which only SCAMPI class C is focused in small teams, and its resource needs are low [39]. However, this class of SCAMPI requires at least one SEI appraisal leader, which increases the cost of this type of assessment in comparison with our proposed methodology. A brief discussion of the cost of implementing improvement based on CMMI formal assessment is presented in [18], where a very high expenditure is reportedly required. Comparing the information on CMMI formal assessment described in the study above with the data on the effort required for process assessment using METvalCOMPETISOFT shows a clear difference in resources, time and cost. For example, by following our proposal, the team size required to assess two processes was about one employee a day (5 h) and one adviser for 2 days (11 h), with a cost of 1430€ (given a company cost of 350€ per staff day and an adviser cost of 750€ per day, according to the values described in [18]). Currently, a level 2 CMMI prior appraisal (which includes seven process areas) involves, approximately, two employees for 5 days and one SEI appraisal leader for 7 days. This brings the cost of this type of assessments to 8750€ (taking into account the values described above). It is important to highlight that the fee per day for an appraisal leader is much higher than for an adviser as used in our proposals, but we maintained the same values for the sake of comparison. According to [40,41], CMMI involves 20 persons per day for evaluations on a programme to secure CMM(I) level 2, at a cost of 35,000€. This analysis supports the opinion that our proposal is more suitable for small companies. In any event, it is evident that when SEI and ISO assessment proposals are used to run formal assessments, they involve more resources and cost than our proposal. However, it must be remembered that a reliable comparison of our assessment methodology and SEI or ISO assessment proposals is difficult because: (i) objectives differ, for SEI or ISO assessment proposals are for formal assessments and our methodology is intended for internal and non-formal assessments and (ii) there is little information in the literature on the use of these proposals for non-formal assessment.

4.4.4. Process capability vs. company size

Companies must interpret the process capability reflected by the assessment in order to: (i) realize exactly how they develop software and (ii) grasp opportunities for improvement.

As Table 9 shows, the capability level of the processes assessed is 0 for all the small firms with the exception of EFour's *SD process*. There is evidence of a lack of visibility of processes in this type of enterprise, which means that software development depends very heavily on people, rather than on processes. However, although, the processes are not set out in a visual scheme, nor are they well-defined, those responsible for carrying out the activities related to them (RP – *responsible for process*) do indeed exist and they were involved in the assessment. Assessment allowed the small firms taking part in the case studies to set out and define their processes assessed through the activity diagram created, which is the first step towards process improvement, for improvement requires visibility.

Fig. 10 shows the average capability of the *SD and SPA processes* of the seven small firms involved (EOne, ETwo, EFour, EFive, ESix, ESeven and EEight), according to the *process attributes* of: PA 1.1 Process performance, PA 2.1 Performance management and PA 2.2 Work product management.

Below are some remarks on the capability level of the *SD and SPA processes* for the small organizations participating in the case studies:

– In general *SD and SPA processes* have a capability level of 0 (incomplete process). It will be observed that in these processes there is little or no evidence of any systematic achievement of

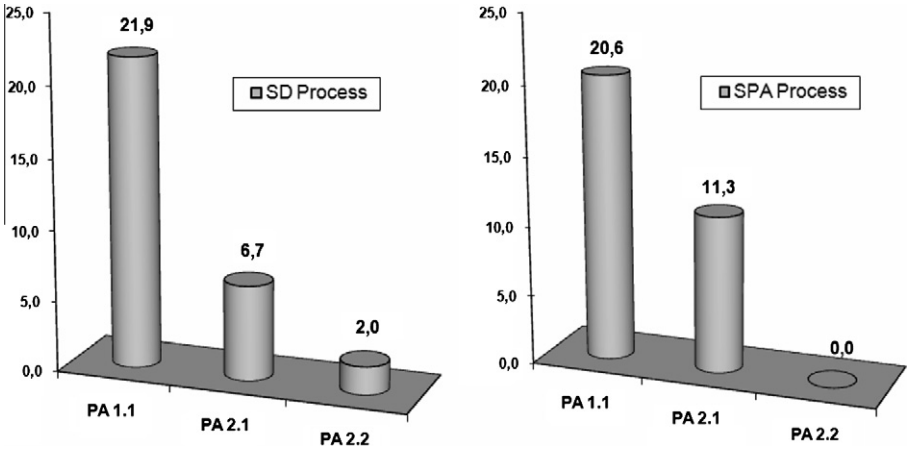

Fig. 10. Average capability of SD and SPA processes.

the purpose of the process. There are very few intermediate work products, which hinders the fulfilment of the objectives and purposes of the *SD and SPA processes*.

- Regarding the *SD process*, the average value of *process attribute* PA 1.1 is observed to be 21.9% (partially achieved), because these organizations evidently have no defined guidelines for software development and maintenance (basic for a common understanding and a commitment to the project). In several study cases the only visible work product is the software developed; there is not even a technical product that shows a formal elicitation of requirements.
- With regard to the *SD process*, the average value of *process attribute* PA 2.1 is 6.7 % and that of PA 2.2 is 2.0 % (not achieved). That means that there is little evidence of practices for managing the software development process and the work products, showing that the firms are more interested in performing the development process than managing it. Software development is chaotic and depends on people, not on the *SD process*.
- The *process attribute* value PA 2.2 for the *SPA process* is 0%, which means that they do not carry out any practice related to the product management of this process. It is also to be noticed that they fulfil more practices and work products for *SPA process* management than *SD process* management (*process attribute* PA 2.1 has a value of 11.3 %). This could indicate that these small enterprises are interested in tackling their software project management.
- We should point out that EFour scored the highest grades in the management attributes for both processes. This is because the software product that they are implementing is related directly to the administration, control and management of an ongoing improvement project according to ISO 9001:2000, which has allowed them to adopt practices for their processes according to this standard.

EThree has a process capability nearing level 2, because of management quality system ISO 9001, which the firm is certified as having. However, the assessment detected potential *improvement opportunities*, which are now being implemented.

With the information generated by METvalCOMPETISOFT on processes assessed (including their state, flow diagrams, strengths, *improvement opportunities* and capability), each organization has gained knowledge of how it performs its processes, along with their capability.

4.4.5. Improvement cycle

With data generated from the assessment, five of the seven small enterprises (EOne, ETwo, EFour, EFive and EEight) finished the first improvement cycle completely, which allowed them to increase the capability level of some of their processes. Furthermore, EThree increased the capability of its SPA process to level 2 (see Table 10), which was observed when the assessment methodology was executed again, once the improvement cycle was finished.

Table 10
Process capability of organizations after an improvement cycle.

Organization	Process	Process attributes (value in %)			Level
		PA 1.1	PA 2.1	PA 2.2	
EOne	*SD*	87 (F)	41 (P)	48 (P)	1 (Performed)
	SPA	0 (N)	0 (N)	0 (N)	0 (Incomplete)
ETwo	*SD*	87 (F)	41 (P)	48 (P)	1 (Performed)
	SPA	0 (N)	0 (N)	0 (N)	0 (Incomplete)
EThree	*SD*	87 (F)	70 (L)	72 (L)	2 (Managed)
	SPA	90 (F)	80 (L)	75 (L)	2 (Managed)
EFour	*SD*	99 (F)	62 (L)	37 (P)	1 (Performed)
	SPA	81 (L)	46 (P)	0 (N)	1 (Performed)
EFive	*SD*	93 (F)	38 (P)	4 (N)	1 (Performed)
	SPA	83 (L)	33 (P)	0 (N)	1 (Performed)
EEight	*SD*	30 (P)	0 (N)	0 (N)	0 (Incomplete)
	SPA	75 (L)	0 (N)	0 (N)	1 (Performed)

It must be said that EThree increased its capability level with less effort than EOne, ETwo, EFour, EFive or EEight. This is because of its process-oriented focus, and because the capability levels assessed are high. This indicates that it already carries out many practices and that these generate work products. On the other hand, the small firms had to start from the very beginning, so they had to visualize, describe and improve their own processes, which took longer, as they had to interpret and assimilate this new focus. However, in this last assessment the values of process attributes PA 2.1 and PA 2.2 of the *SD process* of EOne, ETwo and EFour were very close to *largely achieved* (>50% and <85%), so this process could reach capability level 2 quite soon, within the next improvement cycle.

The main benefits reported by firms at the end of the first improvement cycle were the following:

- Both the management and the employees of the organizations saw the benefits of the result and, more importantly, they realized the need for ongoing assessment and improvement, following this same approach for future cycles. Process improvement, based on the results of the assessment carried out, allowed firms to move from a chaotic and unpredictable software process to a tangible one, which is currently being used on development projects.

- The companies now keep a register of the work products related to the processes improved, together with the instancing in the projects applied (for example, EOne and ETwo are using collaborative Web applications to support this information). This has allowed them to begin to generate a knowledge base to make historical data available when decisions are made.
- The companies have a more specific vision of themselves, which has helped and motivated them to set out on the road to quality certification. For instance, EOne has started to work towards a CMMI level 2 formal assessment.

We consider that the characteristics of small organizations should not be an impediment to having a working focus oriented to processes allowing them to increase their maturity. From the results of the first improvement cycle issued by EOne, ETwo, EFour, EFive and EEight along with the improvement work being done with other companies, we believe this is possible. We have also observed from those results that the improvements arising from the improvement cycle are aimed at meeting the companies' original business goals.

On the basis of the analysis described above, we consider that evidence from the data collected at the end of the first improvement cycle shows that the METvalCOMPETISOFT methodology generated reliable information, which was used to formulate and execute process improvement in small organizations with the aim of increasing the capability of their processes.

4.4.6. Conformance with the assessment process described in ISO 15504

The *base practices* carried out through the application of the PvalCOMPETISOFT assessment process in the organizations mentioned conform with 88% of those described in the assessment process of standard ISO/IEC 15504-5:2006 (PIM.2 process assessment). The *base practices* described in this standard and established by PvalCOMPETISOFT are: define assessment goals, plan the assessment, perform the assessment to collect data, analyse the assessment data, report the assessment results, and validate the assessment data. PvalCOMPETISOFT's *assessment report* on work products indicates where evidence for the fulfilment of these *base practices* exists. Although, the information obtained from the assessment process is registered in the same format through the use of the self-contained template of the work products, we consider that the base practice, PIM.2.BP8 Maintain assessment record, is not satisfied because this process does not deal explicitly with maintenance and access to this information. Base practice PIM.2.BP3, Obtain commitment of the enterprise, is fulfilled in the *initiating the cycle of improvement* activity. Evidence of its fulfilment is found in the input work product of PvalCOMPETISOFT, called PT01_IP *improvement proposal*. The Light MECPDS assessment model is also in line with the ISO/IEC 15504-2:2004 standards.

4.4.7. Plan validity

To address threats to the validity of the case studies, the following issues were considered:

- The design of the case study and the data collection plan were checked against the checklists for case studies on Software Engineering proposed in [42], with a high percentage of positive results.
- Regarding the construct validity, we collected data from participants with different roles and from multiple sources, including document archives, surveys, interviews and participant observation. Furthermore, the use of templates related to each activity of the field procedure allowed us to maintain a chain of evidence with traceability between research questions, recorded data, evidences and analysis.
- As for internal validity, the analysis presented in this section shows that the decision to use METvalCOMPETISOFT to guide process assessment in small organizations allowed them to obtain reliable information on the state of their processes and use it to improve them.
- As regards external validity, we initially applied the METvalCOMPETISOFT assessment methodology at ETwo. This first application allowed the Spanish adviser to review, validate and refine the protocol and the field procedure of the case study. He then carried out the case studies at EOne and EThree, using this material. Finally, the replication material of the case study was distributed to the advisers in Colombia and Argentina so that the replication of the case study could be carried out in the remaining five companies.
- Regarding reliability, the Spanish adviser (researcher) developed the replication material of the case study and it was distributed to the advisers in Colombia and Argentina. It was observed that following this material at EOne, EThree, EFour, EFive, ESix, ESeven and EEight resulted in similar findings and conclusions to those obtained in the first case study (ETwo).

Throughout the description of the case studies results from EThree have been contrasted with those obtained from the small firms to form a broader view of the application of METvalCOMPETISOFT, as EThree's inclusion in the case studies permitted further analysis and discussion of results of the application of the proposed methodology. However, to avoid any bias arising from the inclusion of a larger organization, we analysed its data separately from that of the small companies regarding such aspects as effort, process capability and improvement cycle (which are sensitive to these data).

Reflection on the case studies executed led to some considerations that could lend useful support to research results. The researcher must develop and maintain a detailed protocol for the systematic and rigorous execution of the case studies. In this way, researchers can (i) give detailed information on how they answer the research questions posed and (ii) corroborate their results. In this regard, it is fundamental to have a case study protocol from the outset, in order to define and record in detail matters like design, case selection, case study procedures and roles, data collection, collecting evidence, analysis, plan validity, study limitations data, among others. Studies such as those described in [37,38,42,43] should be taken into account in the creation of the protocol, which should be reviewed by other researcher with more experience in the empirical research field, initially to validate it and subsequently to track the case study execution in order to ensure that it was performed properly. In any event, the checklist for case studies presented in [42] is a suitable guide for determining whether all the elements that must be taken into account when performing a case study have been considered. At the end of each of the main activities involved (design, preparation for data collection, collecting evidence, analysis of collected data and reporting), each group of questions on the checklist must be checked. In addition, feedback on the data collected from those involved in a case study could be useful for reviewing and confirming findings. This lets us validate and improve each activity planned in the protocol, thereby guaranteeing the rigour of the case study and the greater reliability of the results obtained.

4.4.8. Limitations

The case studies set out in this paper have certain limits:

- The observations and conclusions presented are based on only eight case studies, which could limit the power of generalization. Although, these companies are representative of the software industry in Latin America, they represent a low

percentage of the overall population. Furthermore, the methodology of a study made in Latin America may not apply to other settings, such as North America or Asia.
– The bias of the case studies, as employees' performance of daily activities may be affected by being observed. Bias could also arise from a particular kind of handling of events and data by the advisers.

5. Conclusions and future work

In this article a methodology for assessment is presented, which is integrated into an *improvement framework*, which at the same time forms part of a methodological framework developed specifically by the COMPETISOFT project to improve processes in small software businesses. Its application in eight organizations that are presently carrying out an SPI project is also presented. The case studies of the application of METvalCOMPETISOFT involved four firms with fewer than 10 employees, three with 10–50 employees, and one larger company with 60 employees. In addition, from these case studies we observed that playing the roles proposed in this assessment methodology does not take up all of any employee's time. The results obtained from the case studies and discussed in this paper show that this methodology is applicable to small organizations.

The *assessment methodology* proposed sets out the elements needed to assist with *diagnosing the process* in small organizations step-by-step while seeking to make its application economically feasible in terms of resources and time. From the initial application in the eight organizations and bearing in mind (i) the effort involved, (ii) the knowledge of processes acquired, (iii) process improvement carried out based on this knowledge and (iv) the benefits described by the firms, it can be seen that the assessment methodology proposed can be useful, practical and suitable for diagnosing processes in small enterprises. Furthermore, the results of its application at EThree show that the *assessment methodology* proposed can also be suitable for medium-sized organizations. With the information generated by the assessment methodology and starting with the preliminary assessment plan, six improvement cycles were performed and completed in six organizations, which allowed them to increase the capability level of the processes assessed. Currently, the other organizations are working on formulating and executing improvements to their process, based on the information generated by this assessment methodology.

In future work we aim to track the use of the assessment methodology proposed by the SPI projects carried out by the enterprises involved in the COMPETISOFT project. The objective is to obtain, from a representative collection of case studies, the feedback necessary for further evaluation, refinement and validation of this methodology.

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