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Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Qing Wang Vahid Garousi
Raymond Madachy Dietmar Pfahl (Eds.)

Trustworthy Software Development Processes

International Conference on Software Process, ICSP 2009
Vancouver, Canada, May 16-17, 2009
Proceedings

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Preface

This volume contains papers presented at the International Conference on Software Process (ICSP 2009) held in Vancouver, Canada, during May 16-17, 2009. ICSP 2009 was the third conference of the ICSP series, continuing the software process workshops from 25 years ago. The theme of ICSP 2009 was "Processes to Develop Trustworthy Software."

Software development takes place in a dynamic context of frequently changing technologies and limited resources. Teams worldwide are under increasing pressure to deliver trustworthy software products more quickly and with higher levels of quality. At the same time, global competition is forcing software development organizations to cut costs by rationalizing processes, outsourcing part or all of their activities, reusing existing software in new or modified applications and evolving existing systems to meet new needs, while still minimizing the risk of projects failing to deliver. To address these difficulties, new or modified processes are emerging including lean and agile methods, plan-based product line development, and increased integration with systems engineering processes.

Papers present research and real-world experience in many areas of software and systems processes impacting trustworthy software including: new software development approaches; software quality; integrating software and business processes; CMMI and other process improvement initiatives; simulation and modeling of software processes; techniques for software process representation and analysis; and process tools and metrics.

In response to the call for papers, 96 submissions were received from 26 different countries and regions including: Australia, Austria, Brazil, Canada, Chile, China, Colombia, Finland, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, New Zealand, Pakistan, Russia, Serbia, Singapore, Spain, Sweden, Turkey, UK, and USA. Each paper was rigorously reviewed and held to very high quality standards, and finally 33 papers from 12 countries and regions were accepted as regular papers for presentations at the conference.

The papers were clustered around topics and presented in seven regular sessions organized in two parallel threads. Topics included process management, process tools, process modeling and representation, process analysis, process simulation modeling, experience report, process metrics.

Highlights of the ICSP2009 program were three keynote speeches, delivered by Günther Ruhe (University of Calgary, Canada), Rick Selby (Northrop Grumman Space Technology, USA), and Lionel C. Briand (Simula Research Laboratory and University of Oslo, Norway).

On this 25th anniversary of workshops in the field, it was gratifying to see increasing maturity in the work with the continued high rate of submissions from all over the world. Although this was only the third ICSP conference, it continued a long tradition of important workshops and conferences in the field starting with the International Software Process Workshop (ISPW, from 1984 to 1996), the International

Conference on the Software Process (ICSP, from 1991 until 1996), the International Workshop on Software Process Simulation and Modeling (ProSim, from 1998 until 2006), and the Software Process Workshop (SPW, in 2005 and 2006). ProSim and SPW were held together in 2006 and merged in 2007 to form the new International Conference on Software Process. This year we were able to tighten the review process with the help of our reviewers to keep up the tradition.

This conference would not have been possible without the dedication and professional work of many colleagues. We wish to express our gratitude to all contributors for submitting papers. Their work forms the basis for the success of the conference. We also would like to thank the Program Committee members and reviewers because their work guarantees the high quality of the workshop. Special thanks go to the keynote speakers for giving their excellent presentations at the conference. Finally, we also would like to thank the members of the Steering Committee, Barry Boehm, Mingshu Li, Leon Osterweil, David Raffo, and Wilhelm Schäfer for their advice, encouragement, and support.

We wish to express our thanks to the organizers for their hard work. The conference was sponsored by the Chinese Academy of Sciences (ISCAS) and the ISCAS Laboratory for Internet Software Technologies (iTechs). We also wish to thank the 31st International Conference on Software Engineering (ICSE 2009) for sponsoring this meeting as an ICSE co-located event. Finally, we acknowledge the editorial support from Springer for the publication of this proceeding.

For further information, please visit our website at http://www.icsp-conferences.org/icsp2009.

March 2009

Dietmar Pfahl
Raymond Madachy
Qing Wang

International Conference on Software Process 2009

Vancouver, Canada
May 16–17, 2009

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System Engineering in the Energy and Maritime Sectors: Towards a Solution Based on Model-Centric Processes

Lionel Briand

Simula Research Laboratory
University of Oslo

Abstract. The Maritime and Energy industry is facing rapid change with an increasing reliance on software embedded systems and integrated control and monitoring systems. From a practical stand point, challenges are related to increased system complexity, increasingly integrated sub-systems relying on Commercial-Of-The-Shelf software, longer supply chains for equipment and components delivered by different suppliers, and short duration for construction and commissioning of ships and offshore platforms. As a result, there is a lack of visibility into the architecture of systems, their design rationale, how subsystems/components were verified and integrated, and finally how systems were validated and certified with a particular focus on safety. In turn, this has hindered effective collaboration among stakeholders, including suppliers and system integrators.

This talk will present a recent initiative, led by Simula Research Laboratory and Det Norske Veritas (DNV), Norway, to address the above problems. The general approach relies on model-centric processes, where models of the system specifications, architecture, and design properties, are used to support the documentation of architecture and design rationale, traceability among development artifacts, and guide safety analysis and testing, among other things. The project is focused on devising novel but scalable approaches to the long-standing model-driven development challenges.

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A Process for Driving Process Improvement in VSEs

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Abstract. A success factor in Software Process Improvement -SPI- in very small enterprises -VSEs- is that improvement effort must be guided and managed by means of specific process. Nonetheless, many proposals related to this issue have not considered that type of process explicitly. So, aiming to establish SPI in VSEs systematically and coherently, we have defined a light process for managing and leading the improvement process step-by-step, called PmCOMPETISOFT. This paper introduces that process, which guides the implantation of an improvement cycle in an iterative and incremental manner. It also describes our experience of the application of the proposed process in four VSEs, through case studies. The results of the case studies show that the companies increased the capability of their processes, and that it is feasible to implement this process in this type of organizations, by investing an effort which corresponds to the particular characteristics of each.

Keywords: SPI, VSEs, improvement process, case studies.

1 Introduction

If we are to carry out a software process improvement –SPI- initiative in an organization, it is necessary to take several proposals into account (models, methods or standards) so that we may: (i) have good and available practices for software development (processes reference model), (ii) determine the state of the processes and discover opportunities for improvement (process assessment method) and (iii) direct the process improvement activities towards the innermost part of the organization (model to guide SPI). Although SPI proposals are available to all enterprises, many very small software enterprises –VSEs- (firms with fewer than 25 employees, according to [1]) do not use these proposals. Some of the reasons for this phenomenon include the following: the organizations remain unaware of these methodologies [2] and the proposals are difficult to apply to these organizations due to the large investment of time, money, and resources involved in an improvement project [3].

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According to [4], in those small companies which use process improvement models, the one which *model to guide SPI* is that which is used least. It is also the case that many national and international proposals related to SPI in small software organizations have not given explicit consideration to *model to guide SPI*. This is a great drawback, since this type of model for guiding SPI provides the guidelines that are needed to organize all the activities related to process improvement (including the process reference model and the process assessment method). We should also point out that one success factor for SPI in VSEs is that the improvement effort be guided by means of specific procedures and the combination of different approaches, following a systematic and coherent initiative [4].

In response to the situation outlined above, in the methodological framework for SPI in VSEs created in the COMPETISOFT Ibero-American project [5], great importance is given to the model for guiding SPI activities. This is due to the fact that this project maintains that if we are to help small companies set up and pursue the path towards process improvement, then a guideline of this type is needed (including greater depth of detail, the way in which the process becomes integrated into other components of the methodological framework, and its suitability with regard to the company's particular characteristics and needs). Given all this, one of the components of the methodological framework is a specific *framework for guiding activities of SPI* (*improvement framework*), see Fig. 1. This *improvement framework* defines four components, but this article focuses on a presentation of PmCOMPETISOFT, which is a process for the establishment of process improvement in small software organizations. It aims to improve the processes in the organization in a systematic and coherent way, in line with the company's own specific business goals. A description of the application of this process in four case studies is also given in this paper.

The paper is structured as follows. The next section presents related works. The COMPETISOFT improvement framework and its PmCOMPETISOFT process are then described. Section 4 describes the application of this process in four case studies. Finally, conclusions and future work are set out.

2 Related Work

Several proposals exist which present a set of processes that small companies could use to attain significant benefit from process improvement. These include MoProSoft [6] (which proposes 6 processes based on ISO 12207, CMM, ISO 9001), MPS.BR [7] (which proposes 23 processes based on ISO 12207 and CMMI), Adept [8] (which proposes 12 processes based on CMMI), Rapid [9] (which proposes 8 processes based on ISO 15504:1998), among others. All of these proposals are related to assessment methods or process reference models and all of them define a group of processes that should be taken into account by small companies in their improvement efforts.

With regard to research on models that direct improvement implementation for small companies, several proposals have emerged in recent years. These include, amongst others: (i) IMPACT [10], which is based on the idea that the process is an abstraction of the practices carried out in many different projects by many different people; (ii) MESOPyME [11], which has as its focal point the reduction of time and effort in the implementation of SPI by using the concept of action packages as a base; (iii) The application of the IDEAL model to small and medium enterprises such as

[12] and [13]; and (iv) PROCESSUS [14], based on the process modeling paradigm, in which each procedure is dealt with as a process, which is defined, established, implemented and maintained.

The contribution of the proposal described in this paper is to present an explicit process which will be a step-by-step guide to the implementation of process improvement, and which small software organizations will be capable of taking on. This process constitutes the backbone of the improvement framework. The improvement framework describes four components which have been defined by taking into account: (i) widely recognized frameworks, such as ISO/IEC 15504-4 [15], IDEAL and SCRUM; and (ii) special characteristics of the VSEs, as presented in [2] and [4]. These components describe tailored and integrated improvement practices, aiming to offer to the VSEs a framework which is useful and practical for addressing SPI. Furthermore, according to [4] the strategies that have been used to SPI on VSEs are diverse and include: adaptation and use of SPI models, establishment of software processes to guide the SPI efforts, prioritization of the SPI efforts and evaluation of a SPI programme. Only the improvement framework addresses these improvement strategies in an integrated manner, and the component integrator is PmCOMPETISOFT.

3 Improvement Framework

Fig. 1 shows the three elements of the COMPETISOFT methodological framework and displays the four components of its *improvement framework*.

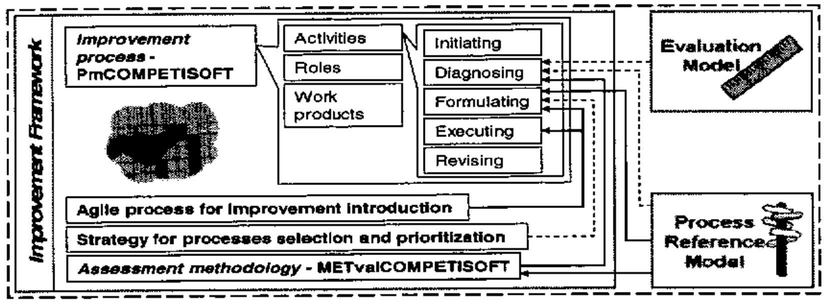

Fig. 1. Methodological framework of COMPETISOFT

The *COMPETISOFT improvement framework* defines: (i) A process, called PmCOMPETISOFT, with which to manage and lead the software improvement process step-by-step; (ii) An agile process for improvement introduction, which uses the SCRUM agile method to support the managing and carrying out of the activities of the formulation and execution of improvement; (iii) A strategy for process selection and prioritization, which presents the selection of a set of processes that are considered critical to the implementation of a process improvement project in small companies [16]; and (iv) A methodology for software process assessment, called METvalCOMPETISOFT, which supports the activity of diagnosing the software processes in small organizations.

The agile process, the strategy for process selection and prioritization, and methodology for software process assessment are outside the scope of this article, which is focused on the description of the PmCOMPETISOFT process.

3.1 The PmCOMPETISOFT Process

This section provides a detailed description of PmCOMPETISOFT, which plans to satisfy the following principles: (i) Early and continuous achievement of improvements, (ii) Continuous and rapid process diagnosis, (iii) Elemental process measurement, (iv) Effective group collaboration and communication, and (v) Continuous learning. This process is influenced by the ISO/IEC 15504-4, IDEAL and SCRUM models. From these, we have analyzed, integrated and tailored several improvement practices, in order to offer a specialized and suitable guide which will meet the needs of the VSEs when leading SPI. In this sense, PmCOMPETISOFT is described in terms of purpose, objectives, roles, activity diagram, activities, work products, and tools support, according to the process pattern established by COMPETISOFT. Due to space restrictions, we have described only some of these elements, but in [17] a complete description of PmCOMPETISOFT is presented.

Activity diagram. Fig. 2 shows the PmCOMPETISOFT activity diagram, which uses SPEM 2.0 notation and includes roles, activities and work products.

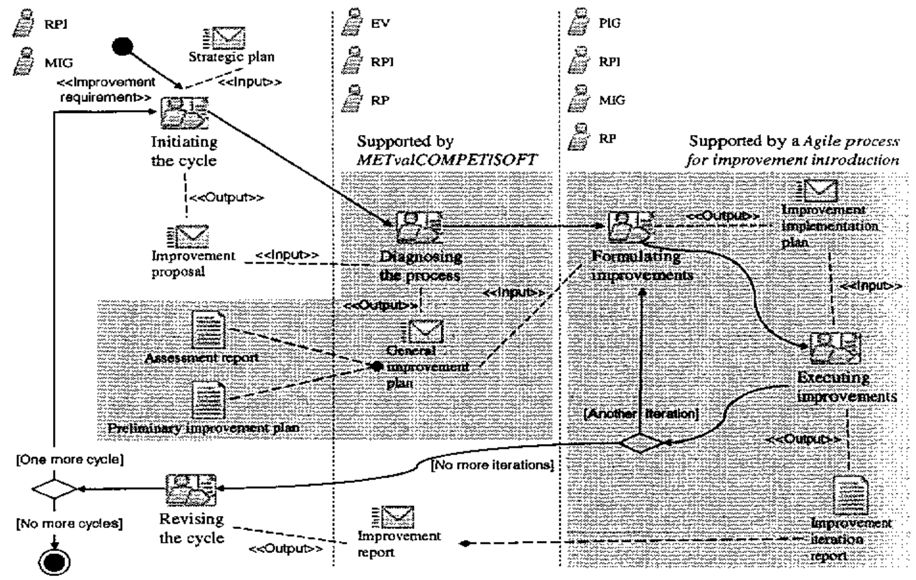

Fig. 2. PmCOMPETISOFT Activity Diagram

Roles. The roles involved in PmCOMPETISOFT are: Management Improvement Group (MIG), Responsible for process improvement (RPI), Process Improvement Group (PIG), Responsible for process or Participant (RP), Evaluator (EV). It is important to consider both that one employee may play various roles and that a single role can be played by several employees.

Activities. The continuous improvement process is made up of one or more improvement cycles. Each improvement cycle consists of 5 activities: Initiating the cycle, Diagnosing the process, Formulating improvements, Executing improvements and Revising the cycle. These activities are presented below:

- *Initiating the cycle:* the person *Responsible for the process improvement* and the *Management Improvement Group* create an *Improvement Proposal* which is aligned to the organization's strategic planning as laid out in the *Strategic Plan*. This proposal guides the organization through each of the following activities of the cycle. The proposal must be approved by the *Improvement Management Group* (MIG) if the assignation of the necessary resources is to be guaranteed.
- *Diagnosing the process:* the *Evaluator* and the person *Responsible for process improvement* carry out the process assessment activity (internal evaluation) in order to discover the general state of the organization's processes and to analyze the results. The objective is both to establish opportunities to improve a process (improvement cases) and to define their improvement priority. The improvement priority permits them to define the order in which the iterations will take place. Preliminary and general planning for the improvement cycle is carried out. The information related to this activity is registered in the *General Improvement Plan*.
- *Formulating improvements:* the *Process Improvement Group* validates the *General improvement plan*. This group plans and designs the improvement cycle's current iterations (based on the process improvement cases) and defines the strategy to be followed to improve the process which has been selected. The effort required in the first iteration is used as a basis for, amongst other things, the estimation of effort, cost, time and resources in the other iterations of the improvement cycle. The information related to this activity is registered in the *Improvement Implementation Plan*. This activity can be executed in the cycle once or various times.
- *Executing improvements:* the *Process Improvement Group* manages and executes the improvement cases which correspond with the current iteration, in accordance with the established plans. If the plan of the iteration has been satisfactorily developed, it is accepted and the new processes or changes are established within the organization. The information related to this activity is registered in the *Improvement iteration report,* which is part of the Improvement Report. This report describes the performance and evaluation of the current iteration and also analyzes the improvements introduced into the organization's processes. This activity can be executed once or several times in the improvement cycle.
- *Revising the cycle:* all the elements related to the execution of each of the improvement cycles are corrected or adjusted. Finally, a post-mortem analysis of the work carried out in the entire improvement cycle takes place. The person *Responsible for Process Improvement* (RPI) reinforces the improvement cycle which has been carried out before reinitiating the installation phase of a new cycle. The lessons learnt, measurements developed to measure the fulfillment of the objectives, the processes improved, etc. are registered in the *Improvement Report*.

When more explicit guidelines are required to support the *Diagnosing the process* activity, VSEs can use the *Assessment methodology – METvalCOMPETISOFT*. The *Agile process for improvement introduction* can similarly be used to guide the *Formulating and Executing improvements* activities (see Fig. 1 and Fig. 2).

Work Products. A concrete self-contained template has been developed for each of PmCOMPETISOFT's work products, to make its construction easier. These work products are: Improvement proposal, General improvement plan (make up of the Assessment report and Preliminary improvement plan), Improvement implementation plan, and Improvement report. The effort of carrying out the tasks associated with each activity and related to said products is registered in each of the work products.

PmCOMPETISOFT has been described with the standard SPEM 2.0 and edited with the EPF Composer, in order to generate documentation in a standard format which is updated and is available to organizations through the Web. We also have developed a tool called GENESIS [18], which is used to support the person *Responsible for process improvement* in the management and implementation of an SPI project and in the administration of generated knowledge.

4 Case Studies

The definition, refinement and application of COMPETISOFT's components have been carried out through the use of the Action-Research investigation method (A-R), which divides the project participants into two groups: the first is made up of researchers from different universities and the second, called the critical reference group, includes computer professionals from small software organizations. In order to validate the proposed process we have conducted four case studies by following the protocol template for case studies presented in [19] (Fig. 3). The following subsection describes the case studies in terms of design, subjects, field procedures and analysis.

4.1 Design

The *main research question* addressed by this study is: Is the PmCOMPETISOFT process suitable for carrying out Software Process Improvement efforts in small software enterprises? *Additional research questions* addressed by these case studies are: (i) Is the effort of applying the proposed process suitable for the small companies? and (ii) Does the PmCOMPETISOFT process enable small companies to increase their process capabilities? Taking into account the focus presented by [20], the *design type* of the case study in this work is multiple cases – holistic, since the strategy has been applied in the context of four small companies. The *objet of study* is a new process through which to establish SPI in VSEs (PmCOMPETISOFT). The *measures* used to investigate the research questions are: (i) the effort of carrying out the tasks associated with each PmCOMPETISOFT activity, and (ii) the capability level of the processes under analysis (which need to be improved) of each company.

4.2 Subjects and Analysis Unit

The *Participating companies* in the case studies are from Argentina, Chile y Spain (called in this work E1, E2, E3 and E4), and they are part of the COMPETISOFT project critical reference group. The *analysis units* are the PmCOMPETISOFT activities and the processes to be improved within each company.

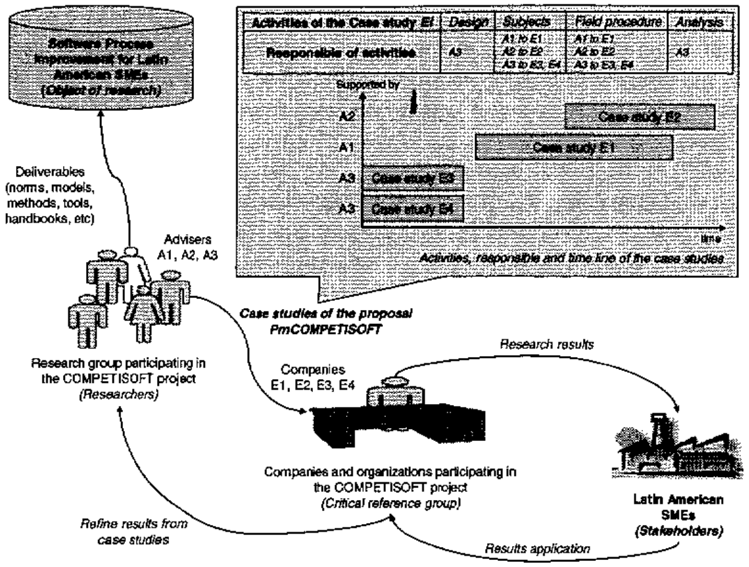

Fig. 3. Application of A-R and Case studies to the COMPETISOFT project

All of these organizations started the first process improvement cycle with the support of an adviser in improvement processes who is part of the COMPETISOFT project researchers group. Table 1 describes the properties of the participant enterprises in the case studies carried out to observe and analyze the application of PmCOMPETISOFT in a real managerial context. It was suggested to the companies taking part in the case study that in the first improvement cycle they should incorporate the processes related to Profile 1 of the Process Reference Model of COMPETISOFT, which includes the processes of: *Software development* - SD, *Software maintenance* – MS, and *Specific project administration* - SPA. A further recommendation was that the *PmCOMPETISOFT process* should be used to perform the improvement activities in each organization.

Table 1. Characteristics of organizations involved in the case studies

Company	Country	Employees	Path	Main areas of professional activity
E1	Argentina	8 (7)	15 years / N&I	Development of new tailored information systems with ongoing integration of new technology
E2	Chile	18 (12)	9 years / N&I	Computer Engineering projects for the agricultural (wine and food) industry.
E3	Spain	7 (6)	4 years / N	Software development on WEB.
E4	Spain	21 (15)	12 years / N	Software development through contracts and agreements with public organizations.

Employees: Number of employees in the enterprise (People in software development and maintenance).
Path: Number of years of existence of the company / scope of the market for its products (National–N / International–I).

4.3 Field Procedure and Data Collection

The procedure governing field procedure and the data collection of the case studies is closely related to the PmCOMPETISOFT process activities, roles and work products. A description of this procedure is presented in the following subsection.

Initiating. A formal agreement in working towards process improvement was signed between each of the companies and the advisor. For the improvement cycle, E1, E3 and E4 assigned a person to the role *RPI,* and permitted them 4 hours/week. E2 also assigned a person to this role with 16 hours/week. A weekly meeting with the advisor and the *MIG* to monitor the progress of the project was also agreed on.

Each company took the processes that it was particularly interested in improving from Profile 1 of COMPETISOFT, based on its own needs and business objectives. In addition, a development project of the company was chosen, into which improvements were introduced (pilot project). The objective set out in the *Improvement proposal* of the first improvement cycle for the E1 enterprise was to improve the SPA process. For the companies E2, E3 and E4 it was to improve the SD and SPA processes. As well as these goals, the different companies too set as objective for the first cycle to increase by one level the capability of the processes chosen for improvement, taking as their starting point the value of the capability of the processes, which was established by means of an initial assessment.

Diagnosing. The process attributes of level 2 of the assessment method were used to carry out the initial assessment of the companies' processes as well as to determine the capability of the chosen processes. These attributes are PA1.1 Process performance, PA2.1 Performance management, PA2.2 Work product management and the process capability level ratings defined by assessment methodology – METvalCOMPETISOFT (which conforms to ISO/IEC 15504-2). The COMPETISOFT advisor played the role *EV*. The advisor evaluated the processes by applying the technique of evidence gathering: interviews and surveys, using the information-gathering tools developed for this purpose. The initial assessment was reported and published in each one of the firms by means of its respective *Assessment report*. Table 2 shows the initial capability of the processes in each of the enterprises.

The information concerning these processes, which was registered in the *Assessment report*, was analyzed by the *RPI* and the advisor, in order to determinate specific opportunities for improvement in each organization. For instance, apart from the improvement opportunities for the chosen processes, E1 took the decision to customize the software tool which is used to support management (Visual Studio Team System-VSTM) with regard to the COMPETISOFT reference model, in order to support its process improvement efforts. It was established that this tool would give support to the activities, documents and roles of the 9 processes of the reference model (apart from those of Profile 1, the Business Management -BM, Process Management- PM, Project Management-PjM, Human Resources Management- HRM, Infrastructure, Goods and Service Management- IM and Knowledge Management-KM). E1 put one person to work on this for 20 hours/week throughout a 2 month period. Likewise, E2 also decided to improve the formulation of proposals along with establishing the scope of software projects, which are activities that are specific to the BM process. A *Preliminary improvement plan* was generated for each VSE.

Formulating. In order to set out a general plan (establishing the improvement iterations) for carrying on with the tasks of formulation and execution of improvements, the *MIG* analyzed the *Improvement proposal* and the *General Improvement plan*. The aim of this was to refine and validate the scope of the improvement cycle, by considering the state of the processes, the company's requirements and the resources available, amongst other things. E3 and E4 therefore refined their improvement objective for the SPA process in terms of implanting some base practices only. That was due to the fact that the initial evaluation reported that no practice related to this process was being carried out. Enterprise E1 planned two iterations, while E2, E3 and E4 planned three. For each iteration the PIG (made up of advisor and RPI) used the improvement opportunities found to plan and design the corresponding improvements which were registered in the *Improvements implementation plan*. The definition of processes was based on the activities and work products of level 1 established by the COMPETISOFT reference model.

Execution. The proposed improvement activities were given to the *RPI* of each organization who, along with the person *RP*, was in charge of introducing the activities into the organization. In all the companies the employees related to the processes to be improved were given an active part to play. This was done to involve them in carrying out the improvement, thus optimizing this success factor. For instance the employees were involved in defining techniques, specific activities and templates of processes, the object being to promote the bottom-up improvement strategy. A meeting that took place at least once a week was programmed between the advisor, the RPI and the RP, in an effort to work on how to carry out the improvement activities that had been designed. The information relating to executing the improvement was registered in the *Improvement iteration report*.

Revising. We performed a post-mortem analysis of the work which took place throughout the improvement cycle, the object being to obtain a knowledge base for future improvement cycles. At the end of the improvement cycle a final assessment was carried out, and we also established how much effort was used to carry out this cycle (see Table 2). An *Improvement Report* was generated for each VSE.

Table 2. Initial and final capability of the organization´s process and cycle effort

Com.	Assess-ment	Capability of Processes									Cycle length (months)	Effort (hours)		
		SD	SPA	SM	BM	PM	PjM	HRM	KM	IM		Adviser (A)	Comp. (C)	Total
E1	*Initial*	-	2	-	-	-	-	-	-	-	6	40	264	304
	Final	1	2	*	1	1	1	1	1	1				
E2	*Initial*	0	1	0	-	-	-	-	-	-	5	89	255	344
	Final	1	2	*	*	-	-	-	-	-				
E3	*Initial*	0	0	-	-	-	-	-	-	-	3	15	39	54
	Final	1	*	-	-	-	-	-	-	-				
E4	*Initial*	0	0	-	-	-	-	-	-	-	3	41	47	88
	Final	1	*	-	-	-	-	-	-	-				

* Base practices of this process have been implanted.

4.4 Analysis and Discussion

Table 2 shows that the four VSEs have increased the capability level of their SD and SPA processes, among others. It is important to highlight that other processes such as SM and BM have also increased the capabilities of enterprises E1 and E2. This increase can be observed in the established base practices, which have been reported in the Improvement Reports. The table shows that E1 was the company which increased its level of capability in the greatest number of processes. We consider that

personalization and the use of the software management tool were decisive factors in fostering and accelerating the development of the improvement cycle. Through the application of the PmCOMPETISOFT the small companies have introduced new base practices to their processes, thus allowing them to increase their capability. Based on the collected data, there is evidence that the PmCOMPETISOFT process has enabled these small companies to increase the capability of their processes.

Table 2 also shows that E2 was the firm which invested the largest amount of effort in the improvement cycle. At the same time, the mean effort per improved process is the highest of the four companies (172 hours per process). This is due to the fact that the improvement was, to a great extent, held up by the high turn-over of staff in the organization. This has made the company give priority to the management of Human Resources and to Knowledge management with regard to their next improvement cycle. Note that the effort involved on the part of companies E3 and E4 is similar (39h and 47h). However, the advisor's effort (each of the companies had the same advisor) is greater (almost triple) in the case of E4. This is because the gathering and analysis of information relating to the activities of initiating, diagnosing and formulating were performed first for E4, and then for E3. That is, this effort is related to the learning and experience acquired by the advisor in the tasks and products that had to be carried out in order to perform the process improvement activities.

From Table 2 we may can also draw the conclusion that the effort spent on improving processes per week for each organization is E1 12.7 h, E2 17.2 h, E3 4.5 h and E4 7.3 h (including the advisor's time). So the average effort spent on improvement initiatives is approximately one person taking ten hours per week. We observed that employees of each organization involved in the improvement cycle were able to take on this effort in improvement activities with no detriment to their daily activities. The percentage of effort taken with regard to each of the PmCOMPETISOFT activities for the four firms were: Initiating 4.2% (2.2% Adviser -A- and 2.0% Company -C-), Diagnosing 10.5% (6.9% A and 3.6% C), Formulating and Executing 79 % (11.2% A and 67.8% C) and Revising 6.3% (3.15% A and 3.15% C). The analysis described above offers evidence that the effort of applying the proposed process is suitable for small companies.

The main benefits which the firms have reported are the following:

- The companies have moved from a chaotic and unpredictable software process to a tangible one, which is currently being used on development projects. Both the management and the employees of the companies have seen the benefits of this result and, most importantly, they have realized the need to maintain continuous and ongoing improvement, following this same approach for future cycles.
- The firms now keep a registry of the work products related to the improved processes, together with the instancing in the projects applied (for example, E3 and E4 are using collaborative Web applications to support this information). This has allowed them to begin to generate a knowledge base which makes historic data available when decisions are being taken.
- According to E1, the implementation of COMPETISOFT has provided them with an ordered process setting. It has also meant the incorporation of good practices which are progressively implanted, together with the personalization and adaptation of a robust management tool. This has allowed them to systematically implement the activities, work products and level 1 capability responsibilities in 8 processes of the reference model.

- Company E2 has now allotted more man-hours to the RPI, designating him/her as the person in charge of institutional Quality. The quest is to continue improving processes and to implement other strategies to ensure the quality of the company's product and processes.
- The companies have a more specific vision of the organization itself which has helped and motivated it to set out on the road to quality certification. For instance, currently the E1 is conducting an ISO 9001:2000 certification, and the E3 has started to work towards a formal assessment CMMI level 2.

Based on the case studies carried out, the increase of the capability of the processes to be improved, the effort of applying the proposed process and the described benefits we consider that the PmCOMPETISOFT process is suitable to lead the projects of Software Process Improvement in small software enterprises. The results, in terms of effort, increase of capability and benefits, are an indicator that PmCOMPETISOFT can be a practical and useful strategy when facing the difficulty of carrying out SPI in VSEs. Furthermore, from the case studies we have been able to confirm that the proposed process was established and executed properly by the VSEs involved.

5 Conclusions and Future Work

The interpretation and adaptation of COMPETISOFT's methodological framework to fit in with the reality of the four VSEs has opened the way towards a rapid improvement in the chosen processes. Similarly, as in all processes of change, the process of learning and getting to know the system has been necessary, so as to make it fit in with the work style of the whole firm. The VSEs using PmCOMPETISOFT defined certain processes, thus allowing them to have an overview of the way in which they are developing their software. This has meant that VSEs are able to have clear vision of their process, seeing into which of them they should incorporate good practices and pointing the way towards a definition of specific work products and to the designation of the people to be responsible for such tasks. The overall goal for the VSEs is to have tangible processes for software development, with all the advantages that this brings with it. What is being sought is for firms to produce software that has a process-oriented focus, thereby decreasing the high dependence on people that the enterprises have hitherto had. We should emphasize that these VSEs have seen in the improvement work carried out thus far an option that would permit them to take their first steps towards ongoing process improvement. This has, moreover, allowed them to believe that the improvement of software processes, along with the benefits brought with it, can actually become a reality in their companies.

Given that the results of the case studies are encouraging, new improvement cycles are planned for the four organizations, which will take into account the aspects discovered in the first cycles. We shall conduct a follow-up in the companies in order to attempt to determine whether this strategy has made an impact on the companies' success in terms of market attributes.

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