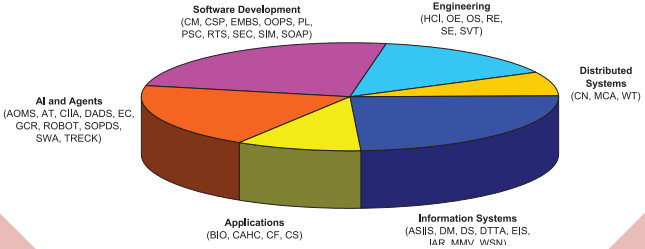
2009
Symposium on Applied Computing



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The 24th Annual ACM Symposium on Applied Computing

Honolulu, Hawaii, USA
March 8-12, 2009

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Message from the Symposium Chairs

On behalf of the Organizing Committee, we welcome you to the 24th Annual ACM Symposium on Applied Computing (SAC 2009) hosted by Chaminade University in Hawaii. This international forum has been dedicated to computer scientists, engineers and practitioners for the purpose of presenting their findings and research results in various areas of computer applications. The organizing committee is grateful for your participation in this exiting international event. We hope that this conference proves interesting and beneficial.

The Symposium is sponsored by the ACM Special Interest Group on Applied Computing (SIGAPP), whose mission is to further the interests of computing professionals engaged in the design and development of new computing applications, interdisciplinary applications areas, and applied research. This conference is dedicated to the study of applied research of real-world problems. This event provides an avenue to discuss and exchange new ideas in the wide spectrum of application areas. We all recognize the importance of keeping up with the latest developments in our current areas of expedites.

SAC 2009 offers Technical Tracks and Posters. The success of the conference can be attributed to the substantial contribution of talented Track Chairs and Co-Chairs. Each track maintains a program committee and a set of highly qualified reviewers. We wish to thank the Track Chairs, Co-Chairs, Committee Members and participating reviewers for their hard work and effort to make the SAC 2009 conference a high quality conference. We also thank our invited keynote speakers, Dr. Vahid Tarokh, Harvard University and Dr. Rolf-Peter Kudritzki, University of Hawaii's Institute for Astronomy for sharing their knowledge with SAC attendees. Most of all, special thanks to the authors and presenters for sharing their experience with the rest of us and to all attendees for joining us in Honolulu, Hawaii this year.

The local organizing committee has always been a central contributor to the success of the SAC 2009 conference. Our gratitude goes to the Conference Vice-Chair Dr. Paulo Martins of Chaminade University and Local Chair Dr. Martha Crosby of University of Hawaii at Mānoa. We also extend our thanks to the Publication Chair, Dr. Dongwan Shin, New Mexico Tech for his tremendous effort in putting together the conference proceedings, Posters Chair Dr. Jiman Hong of Soongsil University for his hard work to make a successful Poster Program, Publicity Chair, Dr. Udo Fritzke, PUC-Minas for his hard work, and eConference Management Chair, Dr Mathew J. Palakal of Indiana University Purdue University for successfully maintaining the eCMS system. A special thanks goes to our Program Chairs Dr. Mirko Viroli, Università di Bologna and Dr. Ronaldo Menezes, Florida Institute of Technology for coordinating and bringing together an excellent Technical Program.

Again, we welcome you to SAC 2009 and the beautiful city of Honolulu, Hawaii. We hope you enjoy the SAC 2009 conference and your stay in Hawaii. Next year, we invite you to participate in SAC 2010 to be held in Crans Montana, Switzerland. The conference will be hosted by the University of Applied Sciences of Western Switzerland.

Sung Y. Shin and Sascha Ossowski
SAC 2009 Conference Chairs

Key processes to start software process improvement in small companies

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ABSTRACT
To support Small Software Enterprises –VSEs– when they are dealing with the first processes that must be considered as they undertake a project of Software Process Improvement –SPI–, we have defined a set of processes which we consider to be of high-priority when initiating the implementation of an improvement project in VSEs. This paper introduces this set of processes and the way in which they have been obtained, based on the analysis and synthesis of three research works carried out within the context of the COMPETISOFT project. It also describes our experience of the application of both the process selection and the prioritization strategy in four VSEs. The result of implementing the proposal shows that it is feasible to implement it in VSEs and that it can be done with an expense of effort that is suitable for them.

Categories and Subject Descriptors
D.2.9 **[Software]**: Management - Software process models; K.6.3 **[Computing Milieux]**: Software Management - Software process.

General Terms
Management, Performance.

Keywords
Process software improvement, process software, processes prioritization, small software organizations, SPI, SMEs, VSEs.

1. INTRODUCTION
From the beginning of the 21st century onwards, the Software Engineering community (industry and researchers) has expressed a special interest in Software Process Improvement –SPI– for Small Software Enterprises –VSEs (fewer of 25 employees). This growing interest is due to the fact that the software industry in most countries has an industrial backcloth, made up mainly of small software organizations which are enhancing the growth of their national economies. These organizations develop significant products and to build them they need efficient Software Engineering practices that are suitable for their particular size and type of business [4].

With this premise in mind, then, it is important to help these organizations to understand and use practices offered to VSEs by the different standards proposed, as well as to related SPI at international and regional levels. A good strategy for achieving this goal is to carry out theoretical and/or practical studies in the area of SPI for VSEs. Providing information that will yield more criteria with which to make good judgments, these studies facilitate the adoption and implantation of international or regional standards related to SPI in VSEs.

In similar vein, this article presents the selection of a set of processes that are considered critical to the implementation of a process improvement project in small software enterprises, as well as to the prioritization of these processes. The objective is to present the VSEs with a strategy for dealing with the first processes that must be considered when they undertake an improvement project. The fundamental principle of the proposal is that process improvement must be connected to the other software process management responsibilities. The set of processes proposed are based, fundamentally, on the analysis and contrast of several research works (theoretical and practical) carried out by the COMPETISOFT project [13], which aims to increase the level of competitiveness of small Latin American software organizations. Additionally, process prioritization focuses on establishing a basic infrastructure of software process management, because process improvement is a responsibility of software process management. This paper also shows the experience of the application of process selection and prioritization strategy in four small software organizations participating in the COMPETISOFT project.

This paper proceeds as follows. In Section 2 we give a background of related works and then go on to present the strategy of process selection and prioritization. The implementation of the strategy on four VSEs is shown in Section 4 and finally, our conclusions are outlined.

2. BACKGROUND
In this section, we first of all outline the related works from other researchers and then we present the earlier research works used for the selection and prioritization of processes.

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2.1 Related work

There are various related works that present a set of processes which VSEs could use to derive significant benefit from process improvement. These include:

- MoProSoft [12] proposes 6 processes (based on ISO 12207, CMM, ISO 9001): Business management, Process Management, Project Management, Resource management, Administration of specific projects and Software development.
- MPS.BR [16] proposes 23 processes (based on ISO 12207 and CMMI): Organizational innovation and deployment, Causal analysis and resolution, Organizational process performance, Quantitative project management, Risk management, Decision analysis and resolution, Requirement development, Technical solution, Validation, Verification, Software integration, Software installation, Product release, Training, Process establishment, Process assessment and improvement, a Tailoring process for project management, Configuration management, Quality assurance, Acquisition, Measurement, Project management and Requirement management.
- ADEPT [11] proposes 12 processes (based on CMMI): Requirement management, Configuration management, Project planning, Project monitoring & control, Measurement & analysis, Process & product quality assurance, Risk management, Technical solution, Verification, Validation, Requirement development, Product integration.
- RAPID [2] proposes 8 processes (based on ISO 15504:1998): Requirement elicitation, Software development, Configuration management, Quality assurance, Project management, Problem resolution, Risk management, Process establishment.
- PROCESSUS [6] proposes 6 processes (based on CMM and ISO 9001): Customer relationship management, Project management, Software engineering, Supporting activities, Process management and Process automation.

All these works are related to assessment methods or reference models, and all of them define a group of processes that should be taken into account by VSEs in their improvement initiatives. However, these proposals do not consider important aspects such as the reasons that led them to select a particular process, or the particular criteria used to define a priority.

The main contribution that this work intends to make in the subject of SPI in VSEs is (i) to propose a set of processes based on the analysis and scrutiny of three research works carried out within the context of the COMPETISOFT project, (ii) prioritize these processes in order to establish a basic process management infrastructure (as the process improvement is not an isolated activity, but is closely related to other activities of the software process management) and (iii) to present the conceptual basis about VSEs and SPI which supports the analysis and synthesis for both the process selection and the strategy of prioritization.

It is important to emphasize that this work wishes to make clear to VSEs which processes to tackle at the beginning of an SPI project, regardless of the process reference model chosen. The explanation of the processes, as well as their description, outcomes, practices, inputs, outputs, conclusions, etc., are available in process reference model material such as MoProSoft, MPS.BR, RAPID, PROCESSUS, ADEPT, ISO 12207, CMMI.

2.2 Research works carried out previously for process selection and prioritization

At this moment in time, the COMPETISOFT project [13] is in process of development, aiming to increase the level of competitiveness of small software organizations. This would be done through the creation and dissemination of a common methodological framework for the improvement and certification of their software processes, adapted to the typical characteristics of the Latin American software industry. The methodological framework is composed of (i) a *process reference model*, (ii) a *process assessment method* and (iii) an *improvement framework* for guiding the activities of implementation of improvements.

The strategy for process selection and prioritization which is described in this paper is a component of the *improvement framework*. The processes proposed are based on the analysis and comparison of three pieces of research carried out previously by the COMPETISOFT project (see sub-sections 2.2.1, 2.2.2 and 2.2.3). All the processes in these works are described in terms of some groups of processes defined in the ISO 15504 standard [10]. These groups are: *Engineering Process Group* – ENG, *Management Process Group* – MAN, *Support Process Group* – SUP and *Process improvement process group* - PIM.

2.2.1 The background to the software process practice of South-western Colombia.

This sub-section offers an overview of the state of the software development processes in the software industry of south-western Colombia. This information was obtained by means of research carried out with the intention of discovering what techniques or practices these small companies used to support each of their fundamental disciplines or areas of software development. This research took place in 20 VSEs, where 2 researchers applied a survey and interview prepared for this purpose. The interviews first focused upon the managing directors and then on the head of development. During the survey, the research group was always present, in order to clarify the objectives and the manner in which the questions should be answered, and to resolve any of the doubts that the participants may have had. That information was used to create a profile about which of those disciplines were used most by the companies polled (see Figure 1).

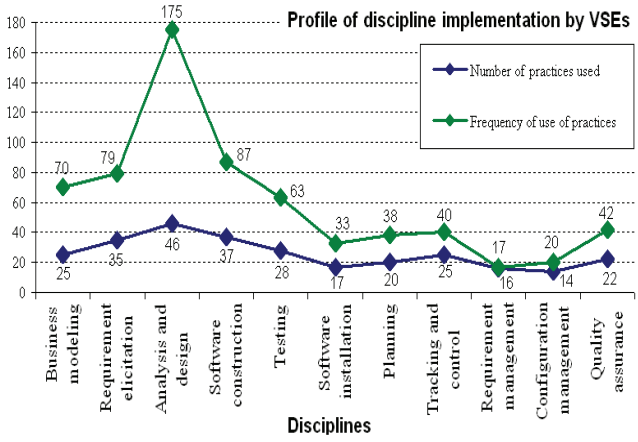

Figure 1. Profile of discipline implementation by the VSEs

From this research work we can see that companies are more interested in the implementation of disciplines related to the *Engineering Process Group* (requirement elicitation, analysis and design, software construction and software testing). Companies are less interested in disciplines related to the *Management Process Group* (planning, tracking and control) and to the *Support Process Group* (quality assurance, configuration and requirement management). The modest interest in business modeling could be explained by the fact that most of these kinds of companies make software products for a specific business area, and in-depth knowledge of this business area becomes a competitive advantage.

2.2.2 Systematic review of SPI in small software enterprises.

An overview of improvement efforts that have been concentrated on by small software enterprises is presented in [15]. In this study the processes which are most frequently improved in VSEs are shown (Figure 2).

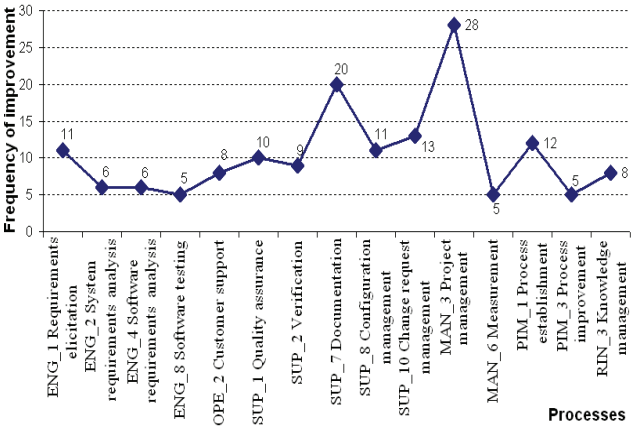

Figure 2. Processes with a greater frequency of improvement within VSEs

From this research work we can see that companies are most interested in improving: (i) the processes of project management related to the *Management Process Group*; and (ii) the documentation processes, change request management and configuration management related to the *Support Process Group*. Companies do not appear to show much interest in carrying out improvements to the *Engineering Process Group*, with the exception of the requirement elicitation process.

2.2.3 International standards and process management and improvement.

The way in which some areas of knowledge from SWEBOK [7] and the processes defined in the ISO/IEC 12207:2004 [8] standard contribute to the support of the four key responsibilities of software process management (definition, measure, control and improvement of processes [5]), is discussed in [14]. Figure 3 shows the way in which processes of this standard support these four responsibilities. It also offers a general view of the close relationship that exists between process management and process improvement.

As this work is related to the area of software process improvement, it is important to express a special interest in the processes which are strongly connected to the responsibility of improving processes: (i) organizational alignment and measurement related to the *Management Process Group*, and (ii) process establishment, process assessment and process improvement related to the *Process Improvement Process Group*. It is essential to bear in mind that software process improvement is an integral part of software process management.

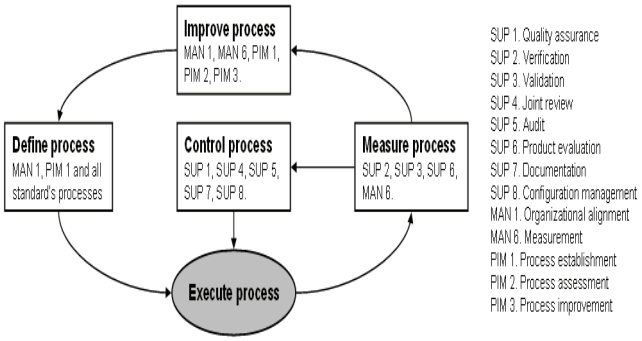

Figure 3. ISO 12207 processes and their relationship with process management responsibilities

3. Strategy for process selection and prioritization

In this section, we present the processes selected and then the prioritization of these processes is described.

3.1 Selection of processes

The processes that are proposed as high-priority in the implementation of a software process improvement programme in small software enterprises are described in Table 1. In this table the relationship between each of these processes and the research work (RW) supporting them is shown. So as to express these processes in terms of an internationally recognized standard, the nomenclature of processes and groups of process defined in the ISO 15504 standard is followed. This standard has been chosen because its process group has a greater degree of detail.

Table 1. Set of processes for initiating SPI in VSEs

ISO 15504	Processes	From RW		
		2.2.1	2.2.2	2.2.3
PIM — Process Improvement	PIM_1 Process establishment		X	X
	PIM_2 Process assessment			X
	PIM_3 Process improvement			X
MAN — Management	MAN_1 Organizational alignment			X
	MAN_3 Project management		X	
	MAN_6 Measurement			X
SUP — Support	SUP_1 Quality assurance	X	X	X
	SUP_7 Documentation		X	X
	SUP_8 Configuration management		X	X
	SUP_10 Change request management		X	
ENG — Engineering	ENG_1 Requirements elicitation	X	X	
	ENG_2 System requirements analysis	X		
	ENG_3 System architectural design	X		
	ENG_4 Software requirements analysis	X		
	ENG_5 Software design	X		
	ENG_6 Software construction	X		
	ENG_7 Software integration	X		
	ENG_8 Software testing	X		
	ENG_11 Software maintenance	X		

The set of selected processes displayed in the table above is organized into process groups. It has been obtained from the analysis of information related to software engineering practices (which VSEs have a greater interest in implementing and improving) drawn from the three research works listed in section 2.2. In addition, for the selection of these processes the following issues have been considered:

- The *engineering process group*, aiming to improve and complement the technical disciplines (analysis and design, software construction, etc), which are those most frequently carried out by VSEs (section 3.1). The intention is to consolidate this area in order to guarantee that the responsibilities should be carried out by following the best practices proposed by a reference model. It is necessary to place great emphasis on requirement elicitation because it is a discipline in which there is much interest in implementation and improvement (see Figure 1 and Figure 2).
- The processes of project management, documentation, change request management, process establishment, configuration management and quality assurance. These processes have been the subject of many attempts at improvement by means of SPI efforts carried out in VSEs (see Figure 2). They also contribute to the support of control process responsibility within *software process management*.
- The processes of organizational alignment, measurement, process establishment, process assessment and process improvement, because these practices are closely related to the responsibilities of defining, measuring and improving processes within *software process management*. These practices are, moreover, essential in the implementation of a process improvement project.

3.2 Prioritization of processes

According to [3], the emphasis on processes and on process management provides the main justification for many standardization initiatives, such as CMMI, ISO/IEC 15504, ISO/IEC 12207 (in addition to the efforts in measuring process capability) and therefore for other proposals based on the philosophy of these standards. Process improvement, as regards the measuring of capability, is focused on the management process and its four key responsibilities. It is also important to emphasize that process improvement is an integrated responsibility in *software process management* [5]; see Figure 3.

On the other hand, VSEs are generally created as the result of having carried out a successful project. In fact, in these organizations the process is carried out in an innate way. It is born with the organization although it is neither defined nor visible. These organizations start their operation by carrying out technical processes, which is an inherent responsibility of project management. According to the information presented in Section 2.2, there is a high risk that VSEs will never perform other processes (different from the technical processes), since: (i) their interest is in implementing these processes and (ii) the improvements introduced in these kind of companies concentrate on project management.

It is therefore fundamental that, by means of *software process improvement*, the VSEs can carry out their processes, from the execution of technical process and project management, right up to the establishment of the four responsibilities of software process management. To assist VSEs in taking a step forward in this respect, we propose that when starting to implement a project of software processes improvement on this type of enterprises, process groups should be prioritized by setting them up in the following order:

- First of all, the process improvement process group.
- Secondly, the management process group.
- Thirdly, the support process group.
- Finally, the engineering process group.

Base practices of the *process groups of engineering and support* are described in the *process reference model* of COMPETISOFT. The main practices of the *process groups of improvement and management* are likewise described in the components PmCOMPETISOFT and METvalCOMPETISOFT of the *improvement framework*.

The *improvement framework* guides the improvement of processes within the VSE in an iterative and incremental way. The initial objective is to create a basic infrastructure to support process management at the first iteration. This infrastructure is based on the early implementation in VSEs of processes related to *process groups of improvement and management,* such as: process improvement, process establishment, process assessment, organizational alignment, project management and measurement. With the improvement or creation of these processes and their later execution within the VSE, the ring composed of responsibilities of the improvement process - define process - execute process - measure process, is supported (see Figure 3).

The *support process group* and *engineering process group* can have the same level of priority. But we are proposing to carry out the improvement of the *support processes* first because they offer added value to the *engineering processes*. It is also important to consider that *engineering processes* are the ones implemented most by the VSEs (see Figure 1). The following step is to use a second improvement project iteration to set up the processes related to the *support process group*. Besides being those that the majority of VSEs look to improve, these processes also help to support and deal with the responsibility of the control process. With the improvement or creation of these processes and their later execution within the VSE, the responsibility of control process is supported (see Figure 3). Finally, practices relating to the *engineering process group* must be established through more improvement project iterations. It is also possible to include other processes determined by the organization's business objectives.

In the first improvement iterations, the VSEs can establish any process from the *support or engineering process group* as an improvement goal. To improve this specific process, implantation in the VSE of the proposed *processes of management and improvement group* must be guaranteed. In other words, although in the early iterations the goal is to improve a specific process, the means to achieve this is by the establishment of processes proposed by *management and improvement process groups*.

4. APLICATION OF THE STRATEGY

In the following paragraphs, we present the case studies carried out in four companies, then we discuss how the strategy proposed in this paper has been implemented through the execution of improvement projects using the methodological framework of COMPETISOFT; finally, the lessons learned are described.

4.1 Case studies

For the definition, refinement and application of all components of COMPETISOFT, the A-R (Investigation - Action) investigation method has been used, which divides the project participants into two groups: a first one, made up of *researchers* from different universities and a second one, called the *critical reference group*, which includes computer professionals from small software organizations. Figure 4 provides a summary of the A-R application in the COMPETISOFT project.

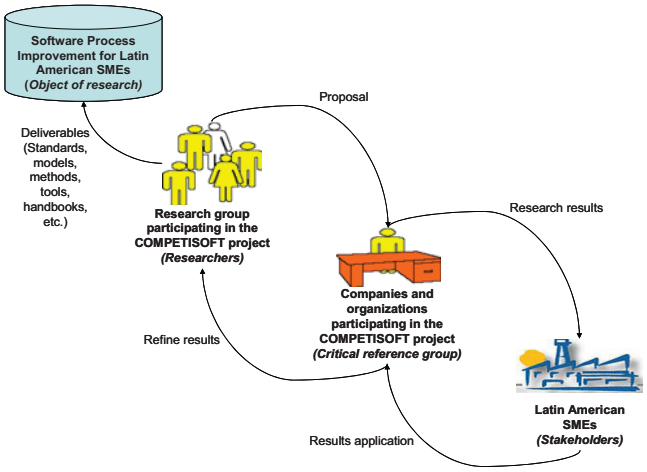

Figure 4. Application of A-R to the COMPETISOFT project

The application of the strategy of process selection and prioritization in VSEs has been carried out in case studies. The main research question is: Can the strategy of selection and prioritization of process be applied within small software enterprises? Additional research questions in these case studies included: (i) Is the effort of applying the strategy, through the methodological framework of COMPETISOFT, suitable for the VSEs? and (ii) Does the proposed strategy enable us to increase the capability of processes of the VSEs? Taking into account the focus presented by [17] [1], 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 VSEs (in this work they are called VSE1, VSE2, VSE3 and VSE4). The object of study is a strategy that defines a set of processes which must be implemented when VSEs initiate a project of SPI.

These enterprises are part of the *critical reference group* and they had started a process improvement cycle with the support of an *Adviser* in process improvement who is part of the *researchers group* of the COMPETISOFT project. The VSE1 is an Argentinean company with 8 employees (7 in software development and maintenance – D&M), the VSE2 is a company from Chile with 18 employees (12 in D&M), and the VSE3 and VSE4 are Spanish companies with 7 employees (6 in D&M) and 21 employees (15 in D&M) respectively. These VSEs don't have any experience in SPI projects.

For the improvement cycle installation on each VSE, the first process implemented was the PmCOMPETISOFT improvement process, (that is responsible for guiding improvement activities), which is related to process improvement PIM_3 from Table 1. This process describes five activities: initiating, diagnosing, formulating, executing and revising. Through these activities we have implemented some base practices related to process groups *Process Improvement Process* (PIM) and *Management Process* (MAN). In the first improvement cycle the companies incorporated and followed the processes of the COMPETISOFT's Profile 1, which includes: Software development – SD and Software maintenance – SM (related to the *Engineering process group ENG*), and Specific project administration – SPA (related to Project management MAN_3).

An agreement to collaborate in working towards process improvement was signed between each of the companies and the advisor. For the improvement cycle, VSE1, VSE2, VSE3 and VSE4 assigned a person *Responsible for improvement process*. The objective set out in the *Improvement proposal* the VSE1 enterprise was to improve SPA process. For the companies VSE2, VSE3 and VSE4 it was to improve SPA and SD processes. As well as these goals, the different companies also set as the objective for the first cycle to increase by one level the capability of the processes chosen for improvement. In this they took as their starting point the value of the capability of the processes, which was established by means of an initial assessment. In addition, a development project of the company was chosen (pilot project), into which improvements were introduced.

The assessment methodology METvalCOMPETISOFT (which conforms to ISO/IEC 15504 [9] and that defines a assessment process named PvalCOMPETISOFT) was used to carry out the diagnosing of company processes, the aim being to determine their capability. This methodology is related to process assessment PIM_2. The COMPETISOFT advisor played the role of *Evaluator* (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 organizations by means of its respective *Assessment report*. Table 2 shows the initial capability of the processes in each of the enterprises.

The information registered in the *Assessment report* was analyzed by the person *Responsible for improvement process* and the *Advisor*, in order to determine specific opportunities for improvement in each organization. A *Preliminary improvement plan* was also generated. For instance, VSE1 took the decision to customize the software tool which it uses to support management with respect to the reference model of COMPETISOFT, 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 other processes of the reference model (Business Management -BM, Process Management -PM, Project Management -PjM, Knowledge Management -KM, Human Resources Management -HRM, Infrastructure, Goods and Service Management -IM). Likewise, VSE2 also decided to improve the formulation of proposals and the establishing of the scope of software projects, which are specific activities of the Business Management process (related to Organizational alignment MAN_1).

To set out a general plan (establishing the improvement iterations) for carrying on with the tasks of formulation and execution of improvements, the *Management improvement group* analyzed the *Improvement proposal*, the *Assessment report* and the *Preliminary improvement plan*. This was with the aim of refining and validating the scope of the improvement cycle, considering the state of the processes, the company's requirements, the resources available, amongst other things. Each company planned its iterations; for each iteration the *Advisor* and the *Responsible for process improvement* used the improvement opportunities already found to plan and design the corresponding improvements of process which were registered in the *Improvements implementation plan*. We used an agile process for introducing improvement to support the managing and carrying out of the activities of the formulation and execution of improvement (related to Process establishment PIM_1). This process integrates SCRUM within PmCOMPETISOFT process, aiming to form a comprehensive package for the teams in charge of improvement formulation and execution. The definition and establishment of processes was based on the activities and work products of level 1 of processes of the reference model.

The proposed improvement activities were given to the individual *Responsible for improvement process* of the companies who, along with the person *Responsible for process*, is in charge of introducing the activities into the enterprise. In defining techniques, specific activities and templates of processes, the employees were involved; the objective was to promote the bottom-up improvement strategy. A meeting to take place at least once a week was programmed, between the *advisor*, the person *responsible for improvement process* and the participating employees, in an effort to work on how to carry out the improvement activities that had been designed. The information relating to execution was registered in the *Improvement iteration report.*

A post-mortem analysis of the work done throughout the improvement cycle was performed, the object being to obtain a knowledge base for future improvement cycles. At the end of this cycle a final assessment was done and in addition it was established how much effort was used to carry out the cycle (see Table 2). An *Improvement Report* was generated for each enterprise.

Table 2. Initial and final assessment and cycle effort

Company	Assessment	Capability of Processes									Effort Total (hours / pers.)
		SD	SPA	SM	BM	PM	PjM	HRM	KM	IM	
VSE1	*Ini*	-	2	-	-	-	-	-	-	-	304
8/7	*Fin*	1	2	*	1	1	1	1	1	1	
VSE2	*Ini*	0	1	0	-	-	-	-	-	-	344
18/12	*Fin*	1	2	*	*	-	-	-	-	-	
VSE3	*Ini*	0	0	-	-	-	-	-	-	-	54
7/6	*Fin*	1	*	-	-	-	-	-	-	-	
VSE4	*Ini*	0	0	-	-	-	-	-	-	-	88
21/15	*Fin*	1	*	-	-	-	-	-	-	-	

- Not assessed

* Base practices of this process has been implemented

4.2 Results and discussion

This section highlights the most important aspects of the work done in these VSEs and their relation to the implementation of the strategy for process selection and prioritization. Table 3 shows the order of process implementation, established base practices (PB) based on those described by the ISO 15504, as well as indicators as to where there is evidence of the carrying out of base practices and the degree of implementation of this process. This can be found by dividing the number of PB performed by the described PB by the standard.

Table 3. Deployment of processes in the case studies

Order	Process	Established base practices (PB)	Indicators	Degree
First	PIM_3 Improvement	1. Establish commitment 2. Identify issues 3. Establish process improvement objectives 4. Prioritize improvements 5. Plan process changes 6. Implement process changes 7. Confirm process improvement 8. Communicate results of improvement	Collaboration agreement (PB 1) Improvement proposal (PB 1, 2, 3) Assessment report (PB 4) Preliminary improvement plan (PB 5) Improvements implementation plan (PB 5, 6, 7, 8) Improvement report (PB 8)	89 % (8/9)
Second	PIM_2 Assessment	9. Define assessment goals 10. Plan the assessment 11. Obtain commitment 12. Perform the assessment to collect data 13. Validate the assessment data 14. Analyze the assessment data 15. Report the assessment results	Collaboration agreement (PB 11) Assessment report (PB 9, 10, 12, 13, 14, 15)	88 % (7/8)
Third	MAN_6 Measurement	16. Develop a measurement strategy 17. Identify measurement information needs 18. Specify measures 19. Collect and store measurement data 20. Analyze measurement data	Preliminary improvement plan (PB 16, 17, 18) Assessment report (PB 19) In each work product the effort to carry out activities is measured and registered (PB 19) Improvement report (PB 20)	56 % (5/9)
Fourth	PIM_1 Establishment	21. Define process architecture 22. Support deployment of processes 23. Define standard processes 24. Identify performance expectations 25. Establish process tailoring guidelines	Improvements implementation plan (PB 21, 22, 23, 24, 25)	83 % (5/6)

The methodological framework of COMPETISOFT has allowed us to implement new base practices within the VSEs. In summary, by means of the Improvement framework of COMPETISOFT we deployed: (i) a large number of base practices in all processes (PIM_1, PIM_2 and PIM_3) of the *Improvement process group* described in Table 1, and (ii) some base practices of MAN_6 Process measurement. By means of processes of the Profile 1 of COMPETISOFT we deployed base practices of level 1 of processes of the *Engineering Process group* –ENG-, MAN_3 Project management and MAN_1 Organizational Alignment. Thus, in this first improvement cycle the VSEs established as improvement scope the processes SD, SM (both of ENG) and SPA (MAN_3). But, in order to improve these specific processes we first implemented in the VSEs the processes: PmCOMPETISOFT (PIM_3), PvalCOMPETISOFT (PIM_2), agile improvement introduction (PIM_1). An elementary measurement process (MAN_6) was also introduced; for the first cycle only two entities were measured: the process to be improved (capability) and the improvement process used (effort).

From Table 2 we can observe that the four small enterprises have increased the capability level of their processes of SD, SM and SPA, among others. It is important to highlight that other processes also have increased their capability within these enterprises, for instance: PIM_1 Establishment, PIM_2 Assessment, PIM_3 Improvement and MAN_6 Measurement. This increase can be observed by the established base practices, which have been shown in Table 3. With the results of the first improvement cycles that have been put out by VSE1, VSE2, VSE3 and VSE4 we believe that the strategy enables us to increase the capability of processes of VSEs. We consider that the characteristics peculiar to these organizations are not an impediment to their having a working focus oriented to processes (as the proposed strategy) that in turn allows them to increase their maturity.

The improvement cycle duration for each company was 24 weeks for VSE1, 20 for VSE2 and 12 for VSE3 and VSE4. From Table 2 and considering the improvement cycle duration of each company, we can draw the conclusion that the effort spent in improving processes per week for each organization is VSE1 12.7 hours (h), VSE2 17.2 h, VSE3 4.5h y VSE4 7.3h (including the advisor's time). So the average effort spent in improvement initiatives is approximately one person taking ten hours/week; we believe this is an effort that lies within the reach of small companies and that they can indeed take on this task without overstretching. Thus we believe that the effort of applying the strategy (following the methodological framework of COMPETISOFT) is suitable for the VSEs.

Some benefits which the firms have reported are:

- The companies had 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 they have realized the need to maintain continuous and ongoing improvement.
- The companies begin to generate a knowledge base which means historic data are available when decisions are being taken. Now they keep a registry of the work products related to the improved processes, together with the instancing in the projects applied, thus supporting their knowledge base.
- 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 VSE1 is conducting an ISO 9001:2000 certification, and the VSE3 has started to work towards a formal assessment CMMI level 2.

4.3 Lessons learned

We now present some lessons learnt after applying this strategy in companies:

- For the improvement iteration, firstly define as an improvement goal a process that has some established base practices. In the first iteration the goal was to improve the SD process, since the VSEs had established base practices related to this process. This allowed an early involvement of the VSE employees. That involved working on improving a known process in order to implement the basic infrastructure that supports the improvement, assessment, definition and measurement of processes. With this infrastructure established in the VSEs, the following iterations for improving other processes were easier o implement.
- When performing the Initiating the improvement cycle we had difficulty in aligning the Improvement Proposal with the strategic planning of the company. The reason is that there was not a Strategic Plan. However, this fact should not be viewed as a problem but as an opportunity for improvement, since it highlights the company's 'raison d'être', goals and its strategies for attaining them, i.e., Business Management. All companies gave a high degree of priority to this process, since it allows the company to respond in a changing environment. It is also the case that VSE1 implemented all the practices of level 1 associated with this process and that VSE2 worked on some of the practices related to this process. Moreover VSE3 and VSE4 agreed to improve this process in the next improvement cycle.
- The first improvement iterations must implant a basic measurement process. The measuring of both the process capability level and the effort of improvement implementation allowed us to perceive the benefits to the VSEs deriving from the first improvement cycle, when compared with the effort involved. The measurement process will have to grow as the companies run other improvement cycles, so as to increase the degree of implementation of this process in VSE. Once this discipline is implemented, it is important that it evolve towards another entity, such as the measuring of the software product.
- Joint work between the adviser and the person responsible for process improvement in the VSE. In the first improvement cycle the COMPETISOFT adviser was present, working in close relationship with the person in charge of process improvement in each one of the VSEs, the purpose of this being that this person should acquire the training and the required experience in the improvement process. The aim is to work on process improvement in the VSE in an ongoing way with the support of their own staff. There is also the intention

for the next improvement cycles to depend less on the external adviser.

5. CONCLUSIONS AND FUTURE WORK

This article has selected and prioritized a group of processes with which to guide VSEs as they begin an SPI project. It has also shown the application in four VSEs. 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 fundamental principle of our proposal is that process improvement must be connected to the other process management responsibilities. Having taken this into consideration, a project for SPI in VSEs must first establish a basic infrastructure related to the responsibilities of process management. This is the reason why the first processes to be established must be those in the improvement and management group, the objective being to create the ring of Improve-Define-Execute-Measure that is necessary for process management. The second step is to include the control process through the support process group. Finally, engineering process improvement must be carried out. It is important to emphasize that the establishment of this infrastructure in itself implies process improvement within the VSE.

For this first improvement initiative the goal was to improve first the SD process and then the SPA process. The means to achieve this has been the establishment of the processes for improvement, evaluation, measurement and definition through the improvement framework of COMPETISOFT. The results of the case study show that it is feasible to implement this strategy in VSEs, considering that the activities have been developed with an expense of effort that is suitable for VSEs and that they have achieved the goals of improvement (to increase the level of capability of selected processes).

Our future work is to continue the application of this proposal, refining and validating it. This application will be performed on other improvement cycles with the aim of improving other processes of interest to these VSEs, such as business management and process management, from the process reference model. We will be conducting a follow-up in companies, to try to determine if this strategy has made an impact on the company's success in terms of market attributes. It will also be applied in other process improvement projects that are currently being carried out in several Latin American companies involved in the COMPETISOFT project.

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