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Software Process Improvement: The Competisoft Project

Competisoft provides the Latin American software industry with a reference framework for improvement and certification of its software processes. The project is based on proven solutions, including the MoProSoft model that four Mexican software companies applied to increase their processes' capacity level.

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oftware constitutes an important industry for developing Latin American countries. The small- and medium-sized companies that account for up to half the industry's employment face serious problems, however, when they start to grow. In many cases, the absence of a visible software-development process creates chaos for the entire organization, including its products.[1] The companies' lack of competitiveness seriously limits their growth.[2]

USING EXISTING REFERENCE MODELS

Recently, small Latin American software companies have tried to improve their software processes' capability as a fundamental step toward increasing product quality. They've addressed two main concerns:

- their image, a key factor for establishing and maintaining a position in the global marketplace; and
- the efficiency and effectiveness of software process management.

Many of these businesses deploy reference models proposed by the Software Engineering Institute (SEI), the Capability Maturity Model Institute (CMMI), or the International Organization for Standardization (ISO). However, these reference models' complex recommendations and significant time and resource commitment make their application difficult for small organizations.[3-5]

The situation is especially troublesome for small Latin American organizations due to the absence of tailor-made process reference models and the adoption of models defined in other countries without suitable adaptation. Indeed, software-process-improvement advocate Sami Zahran[6] observed that an organization will reject a process if it doesn't match its culture, just as the human body will reject a mismatched transplanted organ. Software-engineering researcher Tore Dyba, meanwhile, noted that cultural differences play a role in the success of software process improvement.[7]

Standards Application in Very Small Enterprises

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International software-engineering standards weren't written with very small enterprises (fewer than 25 employees) in mind, even though a majority of organizations fall into this category. Microenterprises (nine or fewer employees) represent 93 percent of companies in Europe, 56 percent in the US, and 66 percent of total employment globally.[1] As Table A shows, a 2004 survey of the Montreal area's IT sector found that 78 percent of software-development companies had 25 or fewer employees, and 50 percent had fewer than 10 employees (http://profs.logti.etsmtl.ca/claporte/English/Publications/index.html).

Since ISO/IEC software standards are difficult to apply in such settings, WG24, an ISO/IEC JTC1 SC7 working group, has been established to develop international standard profiles and technical reports to help VSEs comply with ISO software-engineering standards (www.tudor.lu/spice2006). The group will use parts of ISO standards and parts of national standards to create a profile, defined as a set of one or more base standards necessary to fulfill a particular function.

Australia, Belgium, Canada, the Czech Republic, Finland, India, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, South Africa, Thailand, and the United Kingdom are participating in WG24, along with the IEEE Computer Society and the International Council on Systems Engineering.

WG24 surveyed VSEs to identify problems and potential solutions to help them apply standards and become more competitive. Available in English, French, German, Korean, Portuguese, Russian, Spanish, Thai, and Turkish, the survey yielded more than 444 responses from 32 countries. About half the responses were from Latin American countries, mainly Brazil, Colombia, and Mexico.

When respondents were asked why they didn't use standards,

- 28 percent indicated a lack of resources (expertise, budget, time),
- 24 percent indicated that customers or management didn't require them, and
- 15 percent indicated they were bureaucratic and difficult to apply.

Table A. Employment by different-sized software-development companies in the Montreal area (2004).

Size (employees)	Software companies		Jobs	
	Number	Percent	Number	Percent
1 to 25	540	78	5,105	29
26 to 100	127	18	6,221	36
Over 100	26	4	6,056	35
Total	693	100	17,382	100

The SEI emphasizes that it's expensive and difficult to implement CMMI and the Standard CMMI Appraisal Method for Process Improvement (SCAMPI) in the US.[2,8] Applying these models would be even more expensive and difficult for Latin American companies, which must make copyright and certification payments to the US.

With limited resources, small companies generally need external assistance in planning and implementing process improvement to keep abreast of state-of-the-art software-engineering research and practice. Furthermore, the current international life-cycle processes (ISO/IEC 12207 and ISO/IEC 15288) don't explicitly address the needs of small organizations. The new ISO/IEC JTC1 SC7 Working Group 24, which was created to develop software life-cycle profiles and guidelines for very small enterprises (those with fewer than 25 employees), recognizes the need to adapt ISO/IEC 12207 increasingly to small organizations. The "Standards Application in Very Small Enterprises" sidebar provides additional information about these efforts.

Several researchers seek to adapt models for process assessment and improvement (mainly from ISO and SEI) to the special characteristics of small organizations. The SEI's *Proceedings of the First International Research Workshop for Process Improvement in Small Settings*,[9] for example, includes many articles on the challenges of process improvement in small organizations.

THE MOPROSOFT EXPERIENCE

Mexico's attempts to improve its software industry led to development of the Process Model for the Software Industry (Modelo de Procesos para la Industria de Software) reference model in 2002.[10] MoProSoft built on the well-known practices of the SEI's now-retired Capability Maturity Model for Software, ISO 9000: 2000, the Project Management Institute's project management body of knowledge (PMBOK), and others. It offered a new process structure, some new process-documentation elements, a more precise process relationship, and an explicit process-improvement mechanism.

In addition to conforming with ISO/IEC 15504, the government needed a model suitable for small- and medium-sized enterprises, inexpensive to adopt and assess, feasible as a national standard, specific for soft-

More than 74 percent of respondents indicated it was important to be either recognized or certified. Among the respondents, 40 percent requested ISO certification, and 28 percent requested market recognition. A national certification interested only 4 percent of the respondents. Regarding the need for assistance, 62 percent ask for more guidance and examples, and 55 percent require lightweight and easy-to-understand standards provided with examples, templates, and checklists.

In 1997, the council responsible for IEEE Software Engineering Standards surveyed software-engineering-standards users to improve those standards.[2] The 148 responses, mainly from the US and companies with more than 100 employees, indicated that IEEE standards needed examples, templates, a life-cycle process definition, and support for metrics and measurement.

At its 2005 meeting, WG24 considered that Mexico's MoProSoft could serve as the basis for a first working draft, even though the standard is aimed at larger enterprises. The following year, WG24 tailored the Mexican standard for VSEs, and earlier this year decided to develop Profile 1 using the tailored Mexican standard.

To help VSEs implement forthcoming ISO profiles, the group also decided to develop deployment kits that would enable VSEs to rapidly deploy a subset of the total profile. For example, a VSE could attend a half-day workshop about version control. The deployment kit would contain the information required to deploy version control, such as a description of the process, guides, templates, checklists, an evaluation form, and an installation and user guide for an open software version-control tool.

WG24 also plans pilot projects to validate the approach and obtain feedback to improve the documents before seeking ISO/IEC publication. Production of a working draft is set for 2007, a final draft in 2009, and ISO/IEC publication in 2010.

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ware-development and maintenance organizations, and defined as a set of processes based on internationally recognized practices.

MoProSoft was complemented by the EvalProSoft process-assessment method,[9] based on the recommendations of ISO/IEC 15504 (Part 2). Trials of MoProSoft and EvalProSoft in four Mexican companies confirmed the model's suitability for small organizations with low maturity levels, borne out by the improvements achieved and the low cost of process adoption.[9]

In August 2005, Mexico approved MoProSoft and EvalProSoft as standard NMX-059-NYCE-2005. Together, they were intended to provide Mexico's software industry with an easy-to-understand model based on best international practices that would help organizations standardize their practices.

Process model structure

Defining the process model's structure requires analyzing the structure of software-development enterprises. In most firms—even microenterprises with fewer than 10 people—top management makes decisions on the business's direction, middle management is responsible for project and resource procurement and control, and an operations group develops projects using allotted resources. The members of those groups acknowledge responsibilities through their assigned roles, which have vertical authority alignment and horizontal collaboration relationships.

We considered three process categories:

- *Top management.* Members of this category are concerned with business-management practices and direct and receive reports from middle management.
- *Middle management.* Members of this category deal with process-, project-, and resource-management practices in line with top management's business goals. They provide elements for the performance of operations processes, receive and evaluate the information those processes generate, and inform top management of the results. The resource-management process includes three subprocesses: human resources and work environment; goods, services, and infrastructure; and knowledge of the organization.
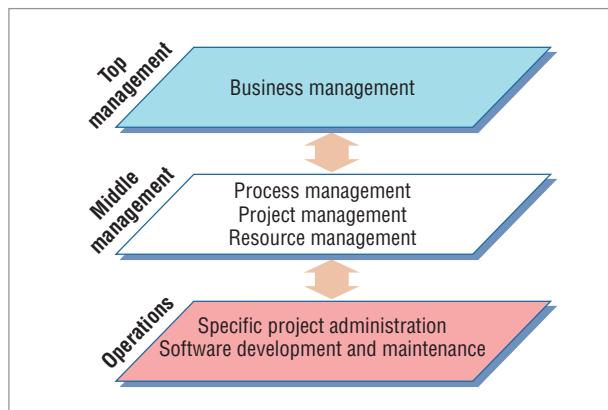
Figure 1. MoProSoft's process categories. An analysis of the structure of software-development enterprises provided the basis for the process categories.

- *Operations.* Members of this category address the practices of software-development and -maintenance projects. They perform activities using elements management provides and deliver reports and the software products generated.

We based these categories on management and governance structure, as Figure 1 shows.

Process pattern

The model's innovative process pattern, the set of elements needed to document a process, consists of a *general process definition*, *tailoring guidelines*, and a *practices section.*

The general process definition includes the process name, category, and purpose; an abstract of process activities; goals, goal indicators, responsibility, and authority roles; subprocesses (if any) and related processes; inputs, outputs, and internal products; and bibliographical references.

Tailoring guidelines suggest the possible process modifications, which shouldn't affect achieving process goals.

The practices section includes recommended training practices, exceptional situation management, use of lessons learned, and a UML activity diagram. It identifies the roles involved in the process, the training required, and the infrastructure resources needed to support activities. The practices session describes product verifications and any required validations as well as activities associating them with the process goals and the roles involved. It lists products that should be incorporated into the organization's knowledge base and exemplifies process measurements for each goal indicator.

Organizations use this pattern to document all MoProSoft processes. An organization that decides to introduce standardized processes without knowing how to do so can start with this model as the initial process documentation and adjust it with local techniques, prod-

ucts form, and terminology. The process pattern also facilitates the inclusion of new processes in the model. For example, if the organization needs a client-service process, it can use the pattern to define and incorporate the model.

Interrelated processes

MoProSoft processes are interrelated. The process pattern defines its relationship based on product interchange and role participation. Each output product that the process generates is explicitly identified as the input product in one or more other processes. The same process that generates internal products also "consumes" them.

The process relationship based on role participation means that some roles of one process participate in activities of others. This interrelation makes it possible to follow the product and workflow between processes and facilitates the assignment of personal responsibilities through roles. It's particularly important for small organizations where a few people must play several roles.

Assessing other standards

Organizations can use MoProSoft as a vehicle to assess or audit other standards. Several studies show coverage of 92 percent of the requirements of ISO 9000:2000;[11] 95 percent of the process purposes in Annex F of ISO 12207 within the scope of the MoProSoft processes; and 77 percent of the specific and general goals and practices of CMMI 1.1 Level 2.[12]

According to the MoProSoft model, an organization should establish its own strategies for setting up the processes it defines, and the processes should evolve in line with suggestions for improvement. That will allow coverage of the organization's strategic plan objectives and setting of increasingly ambitious goals. In this way, the company can reach maturity progressively through ongoing process improvement.

Testing MoProSoft

In 2004, four trials were run in typical small Mexican software companies to evaluate the ease of application and usefulness of MoProSoft as a software process model for small companies and to determine the cost of the EvalProSoft assessment method.

Initial assessments to establish the baseline capabilities of the enterprise processes showed them all to be between 0 and 1. Over the next six months, consultants coached the companies on MoProSoft tailoring and adoption. When the companies were assessed a second time, all enterprises achieved an average increase of 1.08 in the capacity level of all their processes.

Table 1 shows the number of employees, the total improvement effort in hours, and the effort per person for each company. The last column indicates the average capacity improvement per process. It's interesting to

observe the relationship between the effort per person and the average process improvement. For example, Company C invested the largest number of hours per person and achieved the greatest process improvement. The average number of employees was 18, and the average effort per person was 21.28 hours over six months.

THE COMPETISOFT APPROACH

In 2005, several researchers and practitioners recognized the importance of an improvement and certification framework for small organizations. They proposed Competisoft to the Ibero-American Science and Technology Development Program (Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo), a group created in 1984 for multilateral scientific and technological cooperation and supported by 21 Latin American countries plus Spain and Portugal. CYTED aims to establish cooperation between university research groups, R&D institutes, and innovative companies in the countries involved to transfer scientific and technological results to productive systems and social politics.

Participants applied action research, a collaborative approach featuring continual feedback between the researchers and companies in the definition, refinement, and application of the Competisoft model. Participants in Competisoft fell into two main categories:

- researchers from universities in Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Peru, Portugal, Spain, Uruguay, and Venezuela; and
- the critical reference group, consisting of the Argentinian IRAM (Institute for Standardization and Certification), the government of Argentina's Neuquén region, and small companies, including five from Colombia, four from Peru, three from Spain, and one each from Argentina, Chile, Ecuador, Mexico, and Uruguay.

To develop the Competisoft project, we studied different Latin American initiatives, such as MoProSoft, the Brazilian Process Improvement Model (Melhoria de Processos do Software Brasileiro), and also agile software process improvement (SPI). The Spanish Ministry of Public Administration's Métrica v3 was also considered, since it's aimed at improving software processes and products.

As Figure 2 shows, we developed Competisoft by borrowing heavily from well-known assessment methods intended for small companies, especially MoProSoft, as a process reference model. In fact, we can

Table 1. Improvement experience using MoProSoft.

Company	Employees	Total effort (hours)	Effort per person (hours)	Average improvement
A	17	479	28.18	1.00
B	8	199	24.88	1.00
C	17	628	36.94	1.56
D	29	221	7.62	0.78
Average	18	383	21.28	1.08

view Competisoft as an evolution of MoProSoft, with researchers' and practitioners' experience in software process deployment and improvement leading to a new process reference and evaluation model that enhances MoProSoft and EvalProSoft, and a new process-improvement model based on agile SPI.

Process reference model

The Competisoft process reference model incorporates several improvements and refinements.

Process management. We developed a self-assessment questionnaire that can help small organizations with the first contact with the assessment and improvement of their process maturity.

Project management. We selected basic software project measurements and indicators aligned to the project and process objectives. We integrated them with the administration of specific projects and with the software-development processes to facilitate use by small organizations. We're also tackling the improvement of estimation techniques, a fundamental need in small organizations but one that's difficult to understand and apply in these settings.
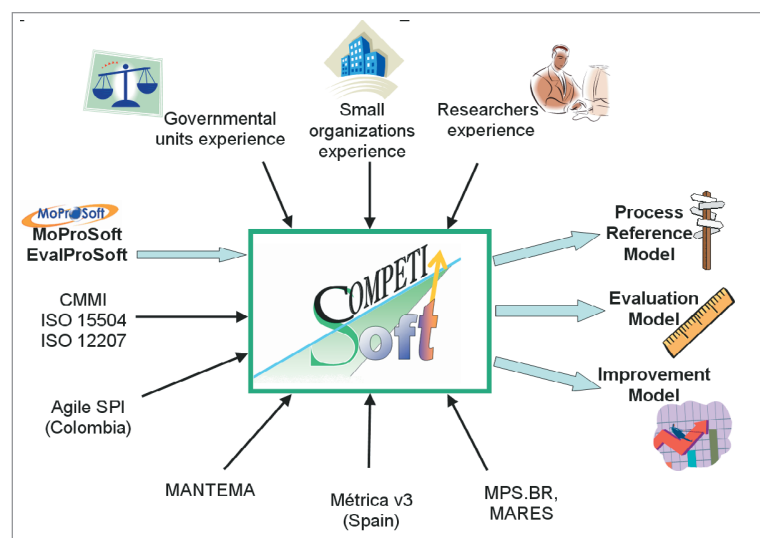

Figure 2. Competisoft project overview. Several different Latin American initiatives were studied for Competisoft.
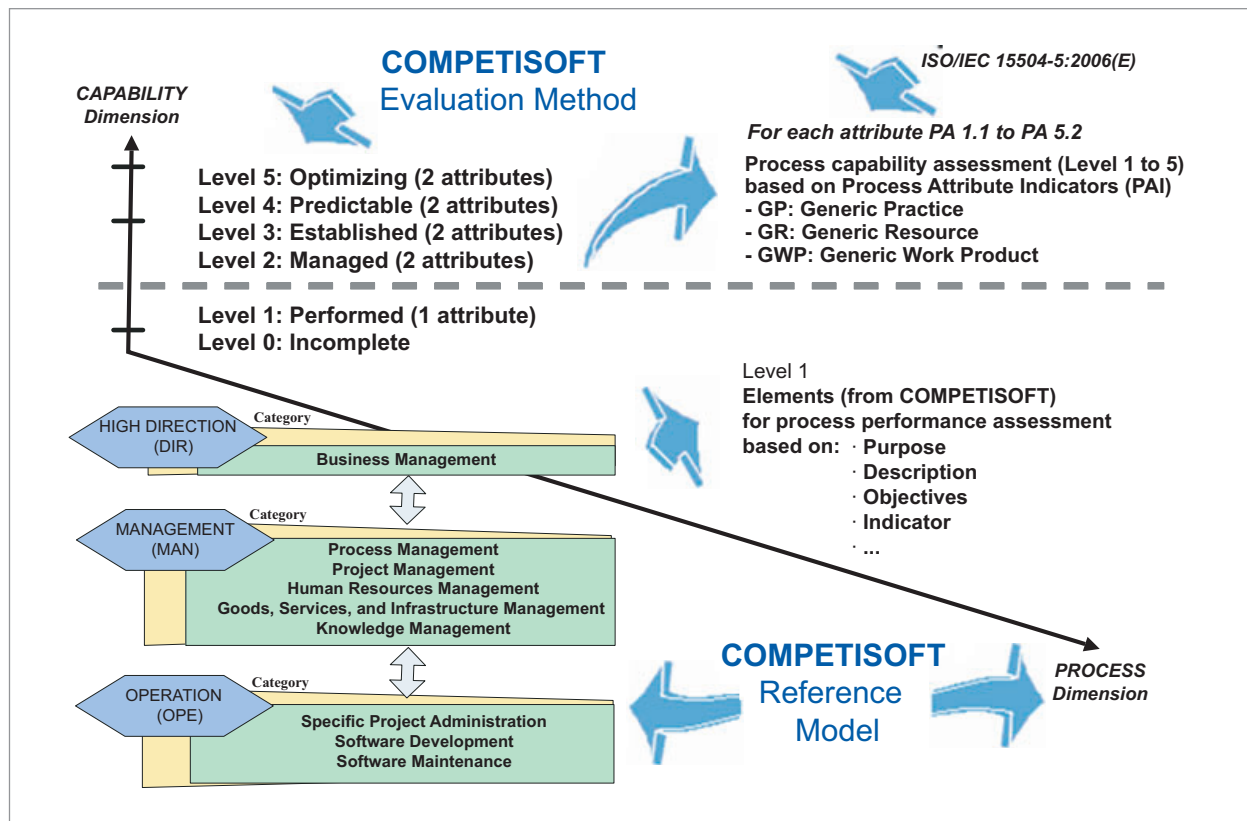
Figure 3. Competisoft evaluation model. Based on EvalProSoft, the model defines a set of measures for estimating the capability and performance of software processes.

Development. We built in examples of deployment guidelines for requirements, analysis and design, construction, testing, and measurement activities to facilitate application in small organizations. The deployment guides describe techniques and specific work products, suggest support tools, recommend a bibliography, and provide an application example. This strategy gives small organizations more flexibility in running the development process, as companies of this kind tend to integrate techniques from different approaches depending on the context.

Maintenance. It's important to tackle maintenance separately from development, as their nature and characteristics are different and many development techniques, tools, model processes, and so on aren't directly applicable to maintenance. Indeed, many small organizations must develop pure software-maintenance projects, which makes it important for them to apply specific maintenance methodologies.

In this regard, the Competisoft approach has developed a maintenance process adapting the Mantema[12] and Scrum methodologies to small organizations. This process defines two levels of maintenance services: basic, which includes urgent, nonurgent, and perfective kinds of maintenance; and advanced, which is concerned with adaptive and preventive maintenance.

We're currently tackling several other issues associated with the reference model. In addition to improvements proposed for specific processes, two aspects common to all processes are the incorporation of free and open source software—a key element for small organizations to reduce costs—and development of specific techniques for the improvement of systems usability.

Business management. As small organizations work to better align their business objectives and information technologies, we need to include virtual enterprises and intercompany connectivity, a key requirement to guarantee the survival of small organization clusters in today's marketplace.

Resource management. We'll emphasize the importance of reusability by developing an experience base structured according to the processes in the reference model. To this end, we'll consider other similar experiences.[13] Indeed, Competisoft places great importance on the experience base from the outset at all organizational levels, regardless of the quality of the components stored in the base, as they may all be useful. We also recognize the value of a more formal, yet still lightweight, method of eliciting experience that's easy for a small organization to use, providing guidance and structure to assist users in creating more experiences for the base. Other important issues to address are documentation and configuration management.

Evaluation model

The Competisoft evaluation model is based on the EvalProSoft model. The first task was to define a set of measures for estimating the capability and performance of software processes. The aim was to help small organizations carry out their assessments by reducing subjectivity and making the process more formal.

As Figure 3 shows, the measures are grouped into two main types:

- The *capability measures*, which use process attribute indicators to evaluate process capability (from Level 1 to 5) on the basis of generic practices, resources, and work products; and
- The *performance measures*, which are based on purpose, description, work products, and activities from the Competisoft reference model.

The organization is also developing a software tool with a Web interface to support the evaluation model.

Improvement model

The Competisoft improvement model is based on agile SPI, which establishes the elements necessary for economically running improvement programs in small organizations. The model defines PmCompetisoft, an improvement process that follows the process pattern defined in Competisoft. Designed to be easier and more intuitive for small software organizations, PmCompetisoft offers

- early and continuous achievements of improvement,
- continuous and fast process diagnosis,
- elemental process measurement,
- effective group communication, and
- continuous learning.

PmCompetisoft is a lightweight process that follows an iterative and incremental approach to guide the implementation of an improvement cycle. To achieve this, PmCompetisoft is highly influenced by the Ideal model as well as by agile methodologies such as eXtreme Programming and Scrum. It's composed of one or more improvement cycles, each one involving five activities: initiating the cycle, diagnosing the process, formulating improvements, executing improvements, and revising the cycle. The model clearly defines these activities by describing the roles involved, the expected work products, and, for each work product, a fully detailed self-content template.

Furthermore, the Competisoft improvement model defines a set of high-priority processes for small organizations implementing a process-improvement project. The strategy's fundamental principle is that companies must connect process improvement with the other software process-management responsibilities. A consultant guide must advise the program leader on using PmCompetisoft to start a process-improvement cycle.

To date, Competisoft has resulted in the development of a common methodological framework suitable for small Latin American organizations and oriented toward continual software process improvement. The project has introduced the Latin American software industry to a process-improvement culture, and it has introduced standardization and certification organizations to methodological principles. Currently, six small companies are applying the Competisoft model over a four-month period. The goal is to increase by one the process capability and measure the effort required to conduct the improvement. We will generate new versions of the process reference, evaluation, and improvement models on the basis of feedback and lessons learned. ■

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