Industry recognizes very small enterprises for their contribution of valuable products and services. As software quality increasingly becomes a subject of concern, and as process approaches are maturing and earning the confidence of companies, the use of ISO/IEC JTC1/SC7 international standards is spreading in organizations of all sizes. These standards, however, were not written for very small development organizations—that is, those with one to 25 employees—and are consequently difficult to apply in such settings. A new ISO/IEC JTC1/SC7 working group has been established to address these difficulties by developing profiles and providing guidance for compliance with ISO software engineering standards. A survey was conducted among very small enterprises on their use of standards, as well as to collect data to identify problems and potential solutions to help these enterprises apply them. More than 400 responses were received from 31 countries.

Key Words

life cycle, process, software engineering process, standards, very small enterprise

SQP References

Standards: Help, Hindrance, or Delusion?
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GENERAL KNOWLEDGE

The Application of International Software Engineering Standards in Very Small Enterprises

CLAUDE Y. LAPORTE
École de technologie supérieure

SIMON ALEXANDRE
Centre d'excellence en technologies de l'information et de la communication

ALAIN RENAULT
Centre de Recherche Public Henri Tudor

INTRODUCTION

Today, the ability of an organization to compete, adapt, and survive depends increasingly on software. By 2010, it is estimated that a cellular phone, for example, will contain 20 million lines of code, and an automobile manufacturer has estimated that the software in its cars will contain up to 100 million lines of code by that time (Charette 2005). Manufacturers depend increasingly on the components produced by their suppliers. A manufacturing chain of large mass market products often has a pyramidal

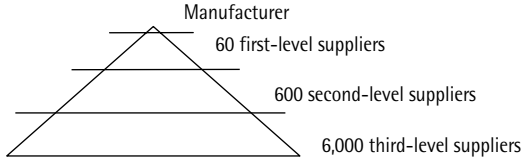
structure, as illustrated in Figure 1. For example, a large manufacturer recently integrated into one of its mass-produced products a part made by one of its 6,000 lower-level suppliers that contained a software error. This defective part resulted in a loss for that manufacturer of more than $200 million.

Industry recognizes the importance of very small enterprises (VSEs) in contributing valuable products and services. In Europe, for instance, 85 percent of the information technology (IT) sector's companies have one to 10 employees. In Canada, a recent survey of the Montreal area revealed, as illustrated in Table 1, that 78 percent of software development enterprises have fewer than 25 employees and 50 percent have fewer than 10 employees (Laporte et al. 2005). In Brazil, small IT companies represent about 70 percent of the total number of companies (Anaclecto et al. 2004).

There is a need to help these organizations understand the benefit of the concepts, processes, and practices described in the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) Joint Technical Committee 1/Subcommittee 7's (JTC1/SC7) international software engineering standards, and initiate their use. This article describes a new project formed to facilitate access to, and use of, ISO software engineering standards by VSEs with fewer than 25 employees. This article is divided into six sections. The remaining sections include:

- A history of the events that led to an ISO/IEC JTC1 SC7 project proposal for VSEs
- The results of a worldwide survey of VSEs
- An overview of the approach and processes used by Working Group 24 (WG24) to produce an initial profile, guides, and templates
- Results from recent WG24 meetings
- A conclusion and the direction of future work of WG24

FIGURE 1 Example of the supply chain of a large manufacturer



HISTORY LEADING TO AN ISO/IEC JTC1/SC7 WORKING GROUP FOR VSEs

To rectify some of these difficulties, delegates from five national bodies of the 2004 ISO/IEC JTC1/ SC7 plenary meeting in Australia reached a consensus regarding the need to provide VSEs with standards adapted to their size and particular context, including a set of profiles and guides. They agreed on the following general objectives:

- To make the current software engineering standards more accessible to VSEs
- To provide documentation requiring minimal tailoring and adaptation effort
- To provide harmonized documentation integrating available standards, such as process standards, work products and deliverables, assessment and quality, and modeling and tools
- To take into account, if desirable, the notions of capability and maturity levels presented in ISO/IEC 15504 and the Software Engineering Institute's (SEI's) Capability Maturity Model Integration (CMMI®)

In 2005, at the SC7 Plenary meeting in Finland, Thailand proposed the creation of a new working group to meet these objectives. Twelve countries supported the establishment of a working group (WG24): Belgium, Canada, the Czech Republic, Ireland, Italy, Japan, Korea, Luxembourg, South Africa, Thailand, the United Kingdom, and the United States. The group appointed Thailand's Tanin Uthayanaka as convener. It also appointed Claude Y. Laporte, representing the IEEE Computer Society, as project editor, and Jean Bérubé, a delegate from Canada, as secretary.

TABLE 1 Size of software development companies in the Montreal area

Size (number of employees)	Software enterprises		Jobs	
	Number	%	Number	%
1 to 25	540	78%	5,105	29%
26 to 100	127	18%	6,221	36%
more than 100	26	4%	6,056	35%
Total	**693**	**100%**	**17,382**	**100%**

PRESENTATION OF THE SURVEY VSEs

In 1997, the Technical Council on Software Engineering responsible for IEEE Software Engineering Standards (SES) initiated a survey to capture information from software engineering standards users in order to improve those standards (Land 1997). They gathered 148 answers, mainly from the United States (79 percent) and large companies (87 percent of them having more than 100 employees). The purpose of this section is not to systematically compare the two sets of survey results, but to highlight some interesting findings that were revealed, even though IEEE survey objectives differed from those of the WG24 survey. The IEEE survey underscores the fact that ISO standards, such as ISO 9001, are often used in organizations rather than IEEE standards. IEEE survey respondents also indicated that IEEE standards need to be improved, mainly by adding examples and templates, as well as a life-cycle process definition, and by providing support for metrics and measurement.

The WG24 survey was developed to question VSEs about their use of ISO standards and to collect data to identify problems and potential solutions to help them apply those standards and become more competitive. From the beginning, WG24 drew up several hypotheses regarding VSEs. The survey was intended to validate some of these hypotheses, including:

- The VSE context requires light and well-focused life-cycle profiles.
- Particular business contexts require particular profiles.
- There are significant differences, in terms of available resources and infrastructure, between a VSE employing one to 10 people and an IT department of the same size in a large company.
- VSEs are limited in both time and resources, which leads to a lack of understanding of how to use the standards to their advantage.
- The benefits for VSEs may include recognition through assessment or audit by an accredited body.

The survey questionnaire and an introductory text were developed by WG24 and translated into nine languages: English, French, German, Korean, Portuguese, Thai, Turkish, Russian, and Spanish. The survey was made up of 20 questions structured in five parts: general information, information about standards use in VSEs, information about implementation and assessment problems in VSEs, information about VSE needs, and information about justification for compliance with standards.

A Web site, hosted by the École de technologie supérieure (ÉTS), was developed to maximize the number of responses and facilitate data collection and analysis. A mailing list was created using WG24 members' contact networks. The authors also contacted technology transfer centers and software engineering professors specializing in small software enterprises.

Respondents were told that it would take a maximum of 15 minutes to complete the survey. They were informed that all data would be kept confidential, and that only summary results and project data that could not be matched to a specific VSE would be included in the published results. The survey was launched in February 2006, and as of June 2006, more than 392 responses had been collected from 29 countries.

Categorization of the Sample According to the Size Criterion

To avoid developing profiles that would not meet the needs of VSEs, WG24 defined a VSE in terms of size. At the time, there was no official definition of a VSE, while the concept of the small and medium-sized enterprise (SME) was clearly defined in Europe (fewer than 250 employees or with a turnover of less than or equal to 50 million Euro dollars) and in United States (fewer than 500 employees). The Organization for Economic Co-operation and Development (OECD) subdivides the SME category into several subcategories: micro (zero to nine employees), small (10 to 49 employees), and medium (50 to 250 employees, or 500 employees in the United States). In Europe, micro enterprises represent 93 percent of the total number of companies (56 percent in United States) and 66 percent of the total employment (OECD 2002).

Of the 392 respondent, 228 were enterprises with zero to 25 employees (58 percent), as illustrated in Figure 2. These 228 VSEs constitute the sample for this study. The following paragraphs present findings common to the 228 VSEs and identify correlations within the sample and findings that differ from those of the bigger companies that contributed to the survey.

This categorization and several studies underscore the differences between micro, small, and medium-sized enterprises (CITA 1997) in terms of available resources. Therefore, WG24 decided to focus on the first category (micro enterprises with zero to nine employees) and on a subpart of the small enterprise category (10 to 25 employees).

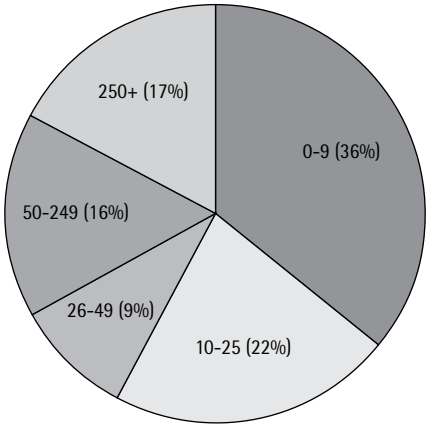
General Characteristics

Here, the authors draw attention to some weaknesses of the sample itself. It was not truly random, since the survey was initiated through WG24 contacts, and this may have impacted the survey results. The first observation about the respondent sample, as illustrated in Table 2, is the geographical distribution of the responses, a large number of which were collected from Latin America (mainly from Colombia and Brazil).

At the same time, the authors received only a few responses from European countries (48), Japan (3), and the United States (3). Possible reasons for this are:

- The invitation to participate in the survey was not disseminated in some countries.
- Many Software Process Improvement Network (SPIN) members are employed in larger companies not directly targeted by this survey.
- Most SPIN members already use CMMI and they may not be interested in ISO standards.
- Most VSEs do not care about IT standardization, so only those aware of it took the time to contribute.

FIGURE 2 Number of employees in the enterprises surveyed



Therefore, the authors' results might only generalize to the broader populations of projects in each region to the extent that this sample represents them. Moreover, they have no evidence that participating companies are representative of the situation in their own countries. Conclusions drawn from these survey results should be confirmed with additional responses.

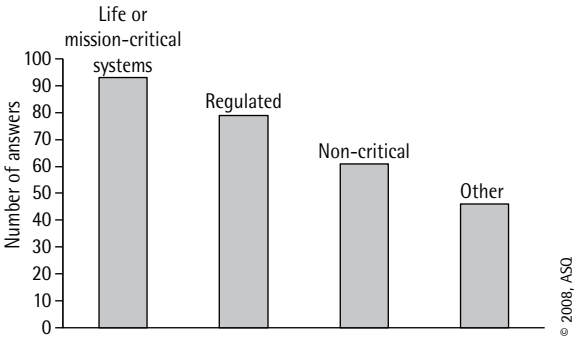
The strong representation of Latin American countries in the sample had no impact on the final results of the study. These VSEs differ from the rest of the respondents in the types of development, that is, more specialized products, and the application domain, as they are more involved in critical applications, with almost 50 percent of VSEs working in these fields.

Of the respondents, the majority (79 percent) are private companies and 78 percent operate at their national level only. Regarding the application domain, as shown in Figure 3, almost half the respondents are working either

TABLE 2 Number of survey responses per country

Country	Number of responses	Country	Number of responses
Argentina	2	Ireland	10
Australia	10	Italy	2
Belgium	10	Japan	3
Brazil	70	South Korea	4
Bulgaria	3	Luxembourg	2
Canada	9	Mexico	20
Chile	1	New Zealand	1
Colombia	109	Peru	4
Czech Republic	3	Russia	4
Dominican Republic	1	South Africa	10
		Spain	3
Ecuador	9	Taiwan	1
Finland	13	Thailand	58
France	4	Turkey	1
Germany	1	United Kingdom	2
India	57	United States	3

FIGURE 3 Application domain



on life- or mission-critical systems or on regulated projects. More than 40 percent of the respondents develop software for life- or mission-critical systems and 34 percent work on regulated software development.

With regard to the types of software development, the majority involve customized (tailored) software and specialized products, as shown in Figure 4.

Features of the VSE Results

More than 70 percent of VSEs are either working on life- or mission-critical systems, or in a regulated market. This underscores the authors' hypothesis concerning the awareness of the participating companies, as it is assumed that companies working in these contexts are prone to using standards for contractual reasons.

The survey found a marked difference in the percentage of certified companies with regard to company size: Less than 18 percent of VSEs are certified, while 53 percent of larger companies (those with more than 25 employees) claim to be certified. Further, among the 82 percent of VSE not certified only 25 percent claim to use standards. In larger companies using standards, two families of standards and models emerge from the list: ISO standards (55 percent) and models from the Software Engineering Institute (47 percent).

WG24 anticipated the weak use of standards by VSEs by asking questions designed to provide a better understanding of the reasons for this. The three main reasons are shown in Figure 5. The first is a lack of resources (28 percent), the second is that standards are not required (24 percent), and the third derives from the nature of the standards themselves: 15 percent of the respondents consider that the standards are difficult and bureaucratic and do not provide adequate guidance for use in a small business environment.

For the majority (74 percent) of VSEs, however, it is very important to be recognized or certified against a standard. ISO certification is requested by 40 percent of them. Of the 28 percent requesting official market recognition, only 4 percent are interested in a national certification. From the VSE perspective, some benefits provided by certification are:

- Increased competitiveness
- Greater customer confidence and satisfaction
- Greater software product quality
- Increased sponsorship for process improvement
- Decreased development risk
- Facilitation of marketing (for example, better image)
- Greater potential for export

VSEs, however, are expressing the need for assistance in order to adopt and implement standards. More than 62 percent would like more guidance with examples, and 55 percent are asking for lightweight and easy-to-understand standards complete with templates. Finally, the respondents indicated that it must be possible to implement standards at minimum cost, in the shortest time, and with the fewest resources. All data about VSEs and standards clearly confirm WG24's hypothesis and requirements. Therefore, WG24 used this information for the development of profiles, guides, and templates to meet VSE needs.

THE WG24 APPROACH

The approach used by WG24 had to take into account, as a starting point, the ISO requirements in terms of the definition of a standard. Indeed, since an international standard dedicated to the software life cycle processes

FIGURE 4 Types of software development

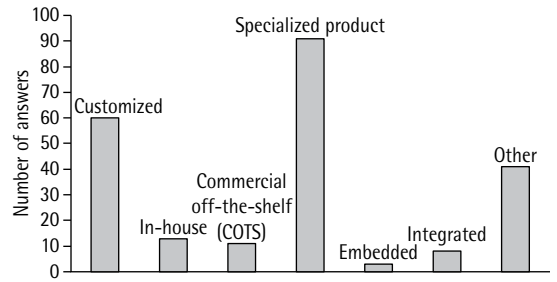
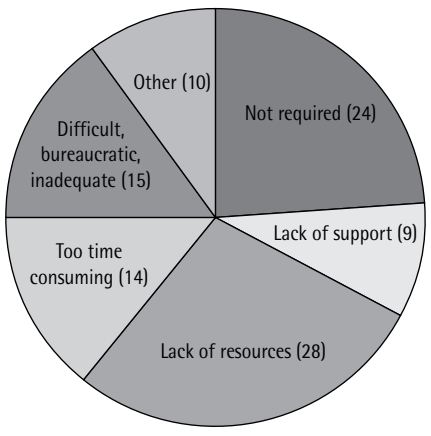


FIGURE 5 Why VSEs don't use standards



was already available (that is, ISO/IEC 12207), WG24 had to use the concept of the ISO International Standardized Profile (ISP) to develop the new standard for VSEs. A profile is defined as: "A set of one or more base standards and/or ISPs, and, where applicable, the identification of chosen classes, conforming subsets, options, and parameters of those base standards, or ISPs, necessary to accomplish a particular function" (ISO 1998). From a practical point of view, a profile is a kind of matrix that precisely identifies all the elements that are taken from existing standards from those that are not. This not only prevents copying to the new standard content from the existing ISO/IEC 12207 standard, but also allows some clauses to be highlighted if and when appropriate.

The overall approach followed by WG24 to develop this new standard for VSEs consisted of three steps:

- Selecting the ISO/IEC12207 process subset applicable to VSEs with fewer than 10 employees
- Tailoring the subset to fit VSE needs
- Developing guidelines

First, since WG24 wished to prepare an initial set of software development standards as quickly as possible, the group analyzed international reference standards and models that could help tailor subset ISO/IEC 12207 for low-maturity VSEs. To create these initial products quickly, WG24 began a search for existing standards or models that could be tailored. MoProSoft, a Mexican standard developed to assist Mexican small and medium-sized enterprises (SMEs), was selected to achieve this objective (NMX 2005).

The Mexican standard is divided into four parts: Part 1: Definition of Concepts and Products; Part 2: Process Requirements (MoProSoft); Part 3: Guidelines for Process Implementation; and Part 4: Guidelines for Process Assessment (EvalProSoft). MoProSoft uses ISO/IEC 12207 as a general framework. It borrows practices from ISO 9001, the CMMI®, the Project Management Body of Knowledge (PMBOK), and the Software Engineering Body of Knowledge (SWEBOK) (Abran et al. 2004; ISO 2005). MoProSoft also addresses the process model requirements of ISO/IEC 15504-2 (ISO 15504). The percentage of coverage by MoProSoft with respect to these practices is (Vasquez 2006):

- ISO 9001:2000 (92 percent)
- ISO/IEC 12207 (Amds. 1 & 2) (95 percent)
- CMMI level (77 percent)

MoProSoft focuses on processes and considers three basic organizational or structural levels under which processes are organized: top management, management, and operations.

- The top management category contains the business management process. Its purpose is to establish the reason for the existence of an organization, its goals, and the conditions required to achieve those goals.
- The management category consists of process management, project portfolio management, and resource management.
- The operation category consists of specific project management, as well as software development and maintenance.

EvalProSoft, the Guidelines for Process Assessment, is based on ISO/IEC 15504-2. The process assessment model defines five levels of capability and their associated attributes. For VSEs, WG24 will develop profiles, guides, and templates for capability levels 1 and 2. After reaching level 2, a VSE should be mature enough to make appropriate decisions about future improvement activities.

WG24, however, thought that MoProSoft addressed the needs of organizations larger than the targeted VSEs. Therefore, in a second step, WG24 decided to tailor MoProSoft to address key characteristics of low-maturity VSEs. The tailoring approach led to the development of incremental profile, targeting, as a starting point, low-maturity VSEs with fewer than 10 employees, and, in a second phase, those with 10 to 25 employees. Therefore, the first profile developed by WG24 contains basic activities from project management- and software development-related processes. The idea was to concentrate on the core activities that a low-maturity VSE should perform.

The third step of the approach consisted of defining guidelines explaining the processes defined in the profile in greater detail. These guidelines are to be published as ISO technical reports, which ideally should be freely accessible to VSEs. These guidelines integrate a series of deployment packages. A deployment package is a set of artifacts developed to facilitate the implementation of a set of practices of the selected framework in a VSE. The elements of a typical deployment package are listed in Table 3. WG24 designed the deployment package so that a VSE can implement its content without having to implement the complete framework at the same time, as shown in Figure 6.

RECENT DEVELOPMENTS

At the Montreal meeting of WG24 in October 2007, the requirement analysis and management deployment package was reviewed and received broad support from the group members. The group decided to develop additional deployment packages for its Berlin meeting in May 2008: change management, project management, and testing.

Having profiles and guides for VSEs, however, is not sufficient to ensure broad use and adoption. These have to be tested with real VSEs in a few countries. The Mexican delegation presented the results of the introduction of the first profile developed by WG24 as a pilot project in a number of Latin American countries (Oktaba 2007). At the Montreal meeting, a new country, Colombia, and a new organization, the European Software Institute (ESI), joined WG24.

The delegate from Colombia works as the quality assurance director of the Parquesoft Foundation. Parquesoft, a nonprofit organization, houses more than 250 VSEs and more than 1,000 software engineering professionals. In Cali there are more than 125 VSEs under the same roof. Such a setting will facilitate the piloting of deployment packages in many VSEs under the supervision of its quality assurance director.

CONCLUSION

Industry recognizes the contribution of VSEs in terms of the valuable products and services they offer. About 75 percent of software enterprises worldwide have fewer than 25 employees. The current collection of ISO/IEC JTC1 SC7 standards is not easily applied in VSEs, however, as these enterprises generally find standards difficult to understand. WG24, established by JTC1/SC7 to address this issue, conducted an international survey of VSEs in order to refine the requirements related to the design of a software engineering standard for this type of company. Results of the survey mainly underscore the VSE's need for guidance and practical support material to implement standards. Taking into account these findings, WG24 started implementing a reference model based on a Mexican national standard developed for SMEs.

With regard to future work, WG24 plans to invite VSEs, especially those that responded to the survey, to participate in the field trials. Since a few WG24 delegates are already working closely with VSEs, they will play a key role in coordinating the trials. These trials will help to validate the approach and obtain feedback in order to improve the documents before they go to ISO/IEC publication. Profiles and guides, such as the assessment guide and the management and engineering guide, will also be circulated by the ISO for review and ballot in 2008. WG24 is planning to produce a final draft in 2009. Publication by the ISO/IEC is scheduled for 2010. In the meantime, deployment packages will be made available to VSEs on public Web sites.

Additional Information

The following Web sites provide more information and articles by WG24 members and deployment packages:

- http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html
- http://www.cetic.be/indexEN.php3

TABLE 3 Table of contents in a deployment package

1. Introduction Purpose of this document Key definitions
2. Why this process is important
3. Overview of main tasks 3.1 Tasks 3.2 Roles and artifacts 3.3 Activity life cycle and examples of life cycles
Appendix A Templates B Checklists C Coverage matrices (ISO 12207, ISO 9001, CMMI) D Tools E Training material F Deployment package evaluation form

FIGURE 6 Example of a deployment package

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The authors would like to thank all those who helped translate the survey and invited VSEs to respond to it.

REFERENCES

Abran, A., J. W. Moore, P. Bourque, and R. Dupuis, R., eds. 2004. *Guide to the software engineering body of knowledge*. New York: IEEE Computer Society Press.

Anacleto, A., C. G. von Wangenheim, C. F. Salviano, and R. Savi. 2004. Experiences gained from applying ISO/IEC 15504 to small software companies in Brazil. In *Proceedings of the Fourth International SPICE Conference on Process Assessment and Improvement*, Lisbon, Portugal. April, 33-37.

Charette, R. N. 2005. Why software fails. *Spectrum* (September): 42-49.

CITA. 1997. Cellule Interfacultaire de Technology Assessment, Utilisation des Systèmes d'Information Inter Organisationnels [SIO] par les PME Belges. SIO Research Report. Belgium: University of Namur. (In French.)

ISO/IEC. 2003. ISO/IEC 15504, Information technology—Process assessment. Geneva, Switzerland: International Organization for Standardization.

ISO. 2000. ISO 9001:2000 Quality Management System Requirements. Geneva, Switzerland: International Organization for Standardization.

ISO. 1998. ISO/IEC TR 10000-1:1998, Information technology—Framework and taxonomy of international standardized profiles—Part 1: General principles and documentation framework. Geneva, Switzerland: International Organization for Standardization.

ISO. 2005. Software Engineering Body of Knowledge. Technical Report ISO/IEC TR 19759. Geneva, Switzerland: International Organization for Standardization.

Land, S. K. 1997. Results of the IEEE survey of software engineering standards users. In *Proceedings of the Software Engineering Standards Symposium and Forum, Emerging International Standards ISESS 97, Third IEEE International*, 1-6 June, 242-270.

Laporte, C.Y., A. Renault, J. M. Desharnais, N. Habra, M. Abou El Fattah, and J. C. Bamba. 2005. Initiating software process improvement in small enterprises: Experiment with micro-evaluation framework, SWDC-REK. In *Proceedings of the International Conference on Software Development*, University of Iceland, Reykjavik, Iceland, 27 May 27- 1 June, 153-163.

NMX. 2005. NMX-059-NYCE-2005, Information Technology-Software-Models of Processes and Assessment for Software Development and Maintenance. Part 01: Definition of Concepts and Products; Part 02: Process Requirements (MoProSoft); Part 03: Guidelines for Process Implementation; Part 04: Guidelines for Process Assessment (EvalProSoft), Ministry of the Economy, Mexico.

OECD. 2002. Organization for Economic Co-Operation and Development (OECD), Small and Medium Enterprise Outlook. Paris: OECD.

Oktaba, H., F. Garcia, M. Piattini, F. Ruiz, F. J. Pino, and C. Alquicira. 2007. Software process improvement: The Competisoft project. *IEEE Computer* 40, no. 10 (October): 21-28.

Vazquez, A. 2006. A software process model for very small enterprises. Presentation to ISO/IEC JTC1 SC7-WG24, Bangkok, Thailand, May.

BIOGRAPHIES

Claude Y. Laporte is a professor at the École de Technologie Supérieure, an engineering school, where he teaches graduate and undergraduate courses in software engineering. His research interests include software process improvement in small and very small companies, and software quality assurance. He received a master's degree in physics from the Université de Montréal and a master's degree in applied sciences from the École Polytechnique de Montréal. He is the editor of an ISO/IEC-JTC1 SC7 working group, WG24, tasked to develop software life-cycle profiles and guidelines for use in very small enterprises. He is a member of IEEE, PMI, and INCOSE, and a member of the Professional Association of Engineers of the Province of Québec. He can be contacted at the École de technologie supérieure, Department of Software and IT Engineering, 1100 rue Notre-Dame ouest, Montréal, Québec, Canada, H3C 1K3, or by e-mail at Claude.Y.Laporte@etsmtl.ca.

Simon Alexandre is in charge of the Software & System Engineering R&D Department at CETIC, an ICT research center in Belgium. He has been a scientific collaborator in the software engineering department of the Computer Institute of the University of Namur since 2001. His interests are software process assessment and improvement techniques for small and medium-sized enterprises, agile methodologies, automation of software product quality analysis, and open source development processes. He received his master's degree in informatics from the University of Namur. He is a member of the ISO/IEC-SC7 Working Group 24, which is tasked to develop profiles and guidelines for software life cycle use in very small enterprises. He can be contacted by e-mail at simon.alexandre@cetic.be.

Alain Renault is a project leader at the Public Research Center Henri Tudor—Luxembourg. He is a 1984 software engineering graduate. After nine years in the industry as a software engineer, he returned to university, where he contributed to the development of OWPL (SPI framework and micro-evaluation for SME). He has been working on SME projects for the past eight years, recently focusing on security and service management. He is a member of an ISO/IEC SC7 working group tasked to develop software life-cycle profiles and guidelines for use in very small enterprises. Renault is also coeditor of an ISO/SC7 new work item proposal aiming to develop an incremental conformity to ISO/IEC 20000-1 on IT Service Management. He can be contacted by e-mail at alain.renault@tudor.lu.