Software Engineering Standards and Guides for Very Small Entities:
Implementation in two start-ups

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Abstract: Very small entities, enterprises, organizations, projects or departments with up to 25 people, are very important to the worldwide economy. However it has ben established that such entities often do not utilize existing standards and frameworks. To address the needs of Very Small Entities (VSEs), a set of international standards and guides known as ISO/IEC 29110 has been developed. In this paper we present the results of early trials of this standard in two IT start-ups VSEs. A Peruvian VSE was recently audited and issued an ISO/IEC 29110 certificate of conformity.

1 INTRODUCTION

Industry recognizes the value of Very Small Entities (VSEs) in contributing valuable products and services. A large majority of enterprises worldwide are VSEs. The term VSE has been defined as being "an enterprise, organization, department or project having up to 25 people" (Laporte et al, 2008).

A large majority of enterprises worldwide are VSEs. In Europe, for instance, as illustrated in Table 1, over 92% of enterprises are micro-enterprises. They have fewer than nine employees. Micro enterprises account for 70% to 90% of enterprises in OECD countries and about 57% in USA.

VSEs have unique characteristics, which make their business styles different to larger organizations and therefore most of the management processes are performed through a more informal and less documented manner (O'Connor et al, 2010). Furthermore there is an acknowledged lack of adoption of standards in small and very small companies, as the perception is that they have been developed for large software companies and not with the small organisation in mind (O'Connor and Coleman, 2009). As smaller software companies have fewer resources in term of people and money there are many challenges (Basri et al 2011). Accordingly a new standard ISO/IEC 29110 "Lifecycle profiles for Very Small Entities" is aimed at meeting the specific needs of VSEs (O'Connor and Laporte, 2011a). The overall objective of this new standard is to assist and encourage very small software organizations in assessing and improving their software process and it is predicted that this new standard could encourage and assist small software companies in assessing their software development process. The approach (O'Connor and Laporte, 2011b) used to develop ISO/IEC 29110 started with the pre-existing international standards, such as the software life cycle standard ISO/IEC/IEEE 12207 and the documentation standard ISO/IEC/IEEE 15289.

Table 1: Size of enterprises in Europe (Moll 2013)

Type	Number of Employees	Annual turnover	No. of enterprises (% of overall)
Micro	1-9	≤2M	92.2
Small	10-49	≤10M	6.5
Medium	50-249	≤50M	1.1
Total	87 100 000		98.8
Large	>250	>50M	
Total	42 990 000		0.2

There is a wide spectrum of development approaches for organizations developing software. Figure 1 illustrates the spectrum of approaches on 2 axes. The horizontal axis (from left to right) illustrates the level of ceremony, from a low ceremony approach with little documentation (e.g.

agile approach) to a high ceremony approach with a comprehensive documentation (e.g. plan driven CMMI® approach). The vertical axes illustrate the approaches based on the level of risk. The top axis illustrates a low risk linear approach using a waterfall approach while the lower part of the axis illustrates a risk-driven project using an iterative approach. As we will explain below, ISO/IEC 29110 is located at about the centre of both axes.

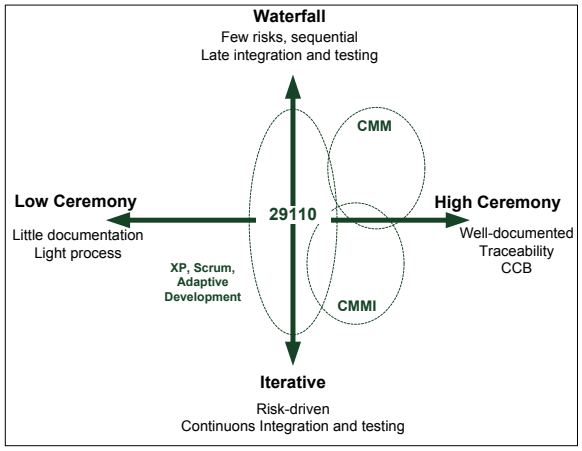

Figure 1: Positioning of the ISO/IEC 29110 (adapted from Kroll 2003)

The working group behind the development of this standard is advocating the use of pilot projects as a mean to accelerate the adoption and utilization of ISO/IEC 29110 by VSEs (O'Connor and Laporte, 2010). Pilot projects are an important mean of reducing risks and learning more about the organizational and technical issues associated with the deployment of new software engineering practices (Laporte et al 2013a). To date a series of pilot projects for the software engineering profile standard have been completed in several countries with the results published in a variety of literature (Laporte et al 2013b; O'Connor, 2012; Ribaud et al 2010).

For most enterprises, but in particular for VSEs, international certifications can enhance credibility, competitiveness and access to national and international markets. Brazil has developed an ISO/IEC 29110 certification process. An ISO/IEC 29110 auditor should be competent in auditing techniques, have expertise in ISO/IEC 29110 and have experience in software development.

2 INTERNATIONAL STANDARDS FOR VSES

2.1 Development

Since an international standard dedicated to the software life cycle processes was already available, i.e. ISO/IEC/IEEE 12207 (2008), WG24, the ISO/IEC JTC1 SC7 working group mandated to develop the new set of standards for VSEs, used the concept of ISO standardized profiles (SP) to develop the new standards for VSEs developing software. From a practical point of view, a profile is a kind of matrix, which identifies precisely the elements that are taken from existing standards from those that are not. The overall approach followed by WG24 to develop this new standard for VSE consisted of the following steps:

- develop a set of profiles for VSEs not involved in critical software development,
- select the ISO/IEC/IEEE 12207 process subsets applicable to VSEs having up to 25 people,
- select the description of the products, to be produced by a project, using ISO/IEC/IEEE 15289 (011) standard
- develop guidelines, checklists, templates, examples to support the subsets selected.

2.2 Generic Profile Group

The basic requirements of a software development process are that it should fit the needs of the project and aid project success (Clarke 2011). And this need should be informed by the situational context where in the project must operate and therefore, the most suitable software development process is contingent on the context (Clarke et al 2012) (Jeners et al 2013). The core situational characteristic of the entities targeted by ISO/IEC 29110 is size

Profile Groups are a collection of profiles. The Generic Profile Group has been defined as applicable to VSEs that do not develop critical software. This Profile Group is a collection of four profiles (Entry, Basic, Intermediate, Advanced) providing a roadmap to satisfying a vast majority of VSEs worldwide. VSEs targeted by the Entry Profile are VSEs working on small projects (e.g. at most six person-months effort) and for start-up VSEs. The Basic Profile describes software development practices of a single application by a single project team of a VSE. The Intermediate Profile is targeted at VSEs developing multiple projects with more than

one project team. The Advanced Profile is target to VSEs which want to sustain and grow as a competitive software development business.

The ISO/IEC 29110 standards and technical reports targeted by audience. The set of documents for the Basic profile (including ISO/IEC TR 29110-5-1-2:2011 (2011) and ISO/IEC TR 29110-1:2011 (2011) were published in 2011. At the request of WG24, all ISO/IEC 29110 TRs are available at no cost from ISO. The Management and Engineering Guide, the most valuable document for VSEs, has being translated in French and in Spanish by Peru and adopted as a Peruvian national standard. The set of 5 documents has been translated in Portuguese by Brazil and adopted as a Brazilian national standard. The set of 5 documents has been translated in Spanish by Uruguay and adopted as a national standard. Japan has translated and adopted ISO/IEC 29110 as a Japanese national standard. The Management and Engineering guide of the Entry profile has been published in English, in French, Portuguese and in Spanish.

2.3 Overview of the Basic Profile for VSEs developing software

The purpose of the Basic Profile is to define Software Implementation (SI) and Project Management (PM) processes from a subset of ISO/IEC/IEEE 12207 and ISO/IEC/IEEE 15289 appropriate for VSEs. The main reason to include project management is that the core business of VSEs is software development and their financial success depends on successful project completion within schedule and on budget, as well as on making a profit. The high-level view and the relationships between the Software Implementation Process and the Project Management processes are illustrated in Figure 2.

As illustrated in figure 2, the customer's statement of work (SOW) is used to initiate the PM process. The project plan will be used to guide the execution of the software requirements analysis, software architectural and detailed design, software construction, and software integration and test, and product delivery activities. The PM process closure activity will deliver the Software Configuration (i.e. a set of software products such as documentation, code and tests) and will obtain the customer's acceptance to formalize the end of the project.

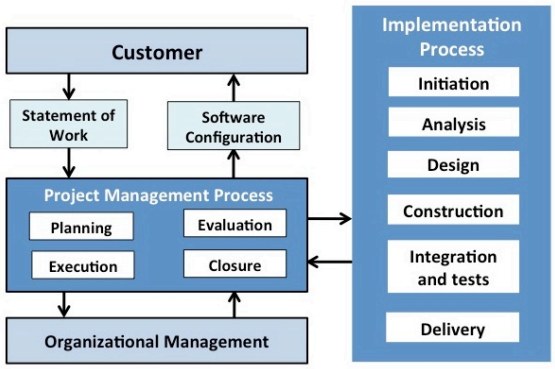

Figure 2: Basic profile processes and activities

2.4 Development of Deployment Packages

A novel approach was taken to assist VSEs with the deployment of ISO/IEC 29110 and to provide guidance on the actual implementation this standard. A set of Deployment Packages (DPs) have been developed to define guidelines and explain in more detail the processes defined in the ISO/IEC 29110 profiles (O'Connor and Laporte 2014). The elements of a typical DP are: description of processes, activities, tasks, steps, roles, products, templates, checklists, examples, references and mapping to standards and models, and a list of tools.

DPs were designed such that a VSE can implement its content, without having to implement the complete ISO/IEC 29110 framework, i.e. all the management and engineering activities, at the same time. A set of nine DPs have been developed and are freely available from (DP 2014). Figure 3 illustrates the set of DPs developed to support the Basic Profile.

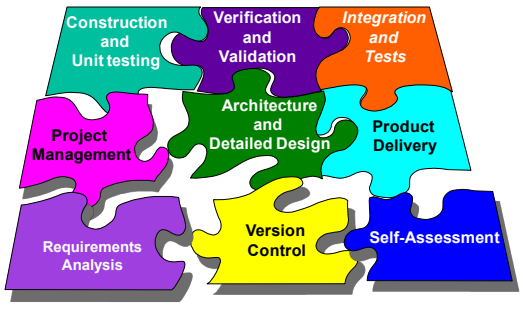

Figure 3: DPs support for Basic Profile

3 IMPLEMENTATION TRIALS

In this section we will present 2 trial implementations of ISO/IEC 29110 in IT start-ups. The purpose of these trials is to illustrate the usage of this standard in an industrial context and to provide feedback to standards authors. Whilst not a detailed methodological approach to validation of this standard and whilst acknowledging the validation limitations, we believe that these high level results are useful to researchers and practitioners alike.

3.1 Implementation in a Peruvian IT start-up

Over 98% of Perú are micro, small and medium enterprises (MSMEs) having fewer than 10 workers. About 7,6 million people work in companies having fewer than 10 workers. About 14,000 Peruvian companies are associated with the Information Technology and Communications (ITC) industry (Krasner 1998).

An implementation of ISO/IEC 29110 has been conducted in a four-people start-up VSE created in 2012 (Garcia et al 2015). During its two years of existence, the VSE has been involved in over 80 projects, most of which have lasted less than two months. The VSE used agile practices to implement software solutions such as Web 2.0 responsive design systems and mobile applications. After completing the implementation of the Basic profile of ISO/IEC 29110, the VSE executed in 2014 a project under contract. The product developed was a software solution that facilitates communication between clients and legal consultants at one of the largest insurance companies in Peru. The solution had to be implemented on a web platform and deployed into a cloud environment.

Since the VSE was using agile methods to implement its software projects, customer requirements were expressed as user stories. For this project, the VSE had determined that the duration of a sprint would be one week. The project had 6 sprints. All software components, test cases, test procedures and user stories were linked through a traceability matrix. A subset of the traceability matrix for a user story is shown in figure 4.

User Story - SDCLR-009	Task Related	Responsible
SDCLR-009: As a consultant I need to manage my standard replies to streamline the process for responding to clients using a predefined template.	T01 - Review and analysis of database	Employee 1
	T02 -Design Prototyping	Employee 1
	T03 - Creating software components	Employee 1
	T04 - Unit and functional tests	Employee 2
Support tool: Jira Agile	Support tool: Jira Agile	

Software Components - SDCLR-009	Physical Location
Visual components	Folder Views/Questions: Respuesta.cshtml and Respuestas.cshtml files
Logic components	Folder ViewModel/Questions: RespuestaViewModel.cs and RespuestasViewModel.cs files
Controller components	Folder Controllers: QuestionController.cs file
Persistence components	Folder model: Respuesta.cs file
Support tool: Visual Studio 2012 / Microsoft team foundation	

SDCLR-009 - Test Cases	Test Results
SDLR-009-CP-01: List template answers	Success (SDLR-009-CP Log)
SDLR-009-CP-03: Add template responses with empty title	Success (SDLR-009-CP Log)
. . .	. . .
Support tool: Test Link.	

Figure 4: Subset of traceability matrix for one user story (Garcia et al 2015)

As illustrated in table 2, the total effort to implement the project was 882 hours. The effort devoted to prevention activities such as installation of the environment (servers, tools, etc.) was 14 hours, task execution took 585 hours, reviews took 124 hours and effort to correct defects identified in reviews and in testing took 159 hours. The start-up wasted only 18% of the total project effort (i.e. 159 hours/882 hours) on rework.

Since it was the first time the VSE had executed the new ISO/IEC 29110 processes in a real project, so there was a learning curve that resulted in additional hours spent on rework for different project tasks. Despite this situation, the result was close to the percentage of rework (i.e. about 15% to 25%) of an organization that has implemented the Capability Maturity Model and is at maturity level 3.

Table 2: effort to execute, detect and correct errors (Garcia et al 2015)

Title of task	Prevention (hours)	Execution (Hours)	Review (Hours)	Rework (Hours)
Environment installation	14			
Project plan development		15	3	7
Project plan execution and project assessment & control		108		
Specification		107	28	58

development				
Architecture development		35	10	14
Test plan development		45	8	11
Code development and testing		253	70	62
Develop user guide & maintenance document		14	5	7
Product deployment		6		
Project closure		2		
Total hours	**14**	**585**	**124**	**159**

As illustrated in figure 5, the ISO/IEC 29110 certification process is composed of four stages. In the first stage, a VSE applies for an ISO/IEC 29110 audit and if it is successful, a commercial and technical agreement is entered into with the accreditation body. Then, the initial certification audit begins. If the audit is successful, a three-year initial certificate is issued by a national accreditation body. In this case, the certificate was issued by the Brazilian national accreditation body.

For the first stage of the audit process, the Peruvian VSE invested about 22 hours. For the initial certification stage, the VSE invested about 63 hours. The cost of the auditor, excluding the travel expenses, was 1,500$. The total effort and cost of an ISO/IEC 29110 audit is very small compared to a typical CMMI assessment. This start-up became the first Peruvian VSE to obtain an ISO/IEC 29110 certification.

The third stage of a certification cycle involves the completion of two surveillance audits one and two years after obtaining the initial certification. Finally, the fourth stage is the recertification of the VSE; once the 3-year certification cycle has elapsed.

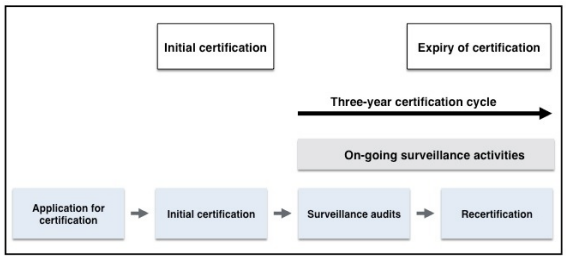

Figure 5: ISO/IEC 29110 certification process (Laporte et al 2014d)

In order to promote the recognition of qualifications between countries, there are international organizations such as the International Accreditation Forum (IAF). The IAF is the world association of conformity assessment accreditation bodies in the fields of management systems, products and services, and to date, it has more than 60 member countries. The Peruvian and the Brazilian accreditation bodies are members of this organization. An ISO/IEC 29110 certificate of conformity issued by an accreditation body member of the IAF is recognized by all members of IAF. The conformity certificate has become a major differentiator with regard to the main competitors of the VSE. The Peruvian start-up VSE has gained access to larger software development projects and increased its customer base. The VSE has increased its number of workers to date, from 4 to 10 employees.

3.2 Implementation in a Canadian IT start-up

An implementation project has been conducted in an IT start-up VSE by a team of two (part-time) developers. Their web application allows users to collaborate, share and plan their trips simply and accessible to all. The use of the Basic profile of ISO/IEC 29110 has guided the start-up to develop an application of high quality while using proven practices of ISO 29110. The total effort of this project was nearly 1000 hours. The two members of the team were assigned roles and activities of ISO 29110.

During the software development, a traceability matrix was developed between the software requirements, defined in the requirements specification document, and the software components. Since, in most projects requirements, defined in the requirements activity, are never finalized at the end of this activity, a traceability matrix is very useful. One advantage of such a matrix is the possibility of rapidly identifying the impacted software components when modifications, additions, deletions, of software requirements are done during a project.

Verification tasks, such as peer reviews, were performed on documents such as the requirement specifications and the architecture. The team used the desk-check to review their documents which is inexpensive and easy to implement in any organization and can be used to detect anomalies, omissions, improve a document or present and discuss alternative solutions.

As defined in ISO/IEC 29110, the software integration and tests activity ensures that the integrated Software Components satisfy the software requirements. This activity provides (ISO 2011c):

Work team review of the project plan to determine task assignment.

- Understanding of test cases and procedures and the integration environment.
- Integrated software components, corrected defects and documented results.
- Traceability of requirements and design to the integrated software product.
- Documented and verified operational and software user documentations.
- Verified software baseline.

To manage the defects detected, a tracking tool was used. Such software allowed the team to do an inventory of problems found during the integration and testing activity, to track problems and to classify them, and to determine a priority for each defect found. In this project, the open source Bugzilla software tool had been used to manage the defects.

The test report presents the results of tests carried out using the test plan. These results are used to illustrate the number of problems found and the progress of the resolution of anomalies. The test plan includes 112 cases which have been successfully completed with the exception test cases connected to one type of defect: the validation of the date format when manually entered by a user. Since this defect was classified as "minor", it was decided not to correct their instances during the first cycle of development. Table 3 illustrates the percentage of defects detected during the execution of the tests for each category of defects.

Table 3: Number and types of defects detected through testing and corrected (Laporte et al 2014c)

Seriousness	No. of defects detected	No. of defects corrected	% of defects corrected
Blocker	3	3	100%
Critical	22	22	100%
Major	11	11	100%
Normal	12	12	100%
Minor	19	6	32%

The defects classified by severity using the following defect classification:

- Blocker: prevents function from being used, no work-around, blocking progress on multiple fronts
- Critical: prevents function from being used, no work-around
- Major: prevents function from being used, but a work-around is possible
- Normal: a problem making a function difficult to use but no special work-around is required
- Minor: a problem not affecting the actual function, but the behaviour is not natural

The members of the start-up have recorded the effort, in person-hours, spent on tasks of the project to the nearest 30 minutes. Table 4 shows, for each major task, the effort to execute the task, the effort required to review a document, such as the software specification document, in order to detect errors and, the effort required to correct the errors (i.e. the rework). As an example, for the development of the software architecture document, it took 42.5 hours to develop, an additional 1.5 hour to conduct a review and an additional 3.5 hours to correct the errors.

As illustrated in table 4 for this start-up project, about 8.9% (i.e. 89 hours/990.5 hours) of the total project effort has been spent in prevention tasks such as the installation of the server, the workstations and the software tools; and only 12.6% has been spent on rework (i.e. 125 hours /990.5 hours). This indicates that the use of appropriate standards, in this case for a start-up company, can guide all the phases of the development of a product such that the wasted effort (i.e. rework) is about the same as a more mature organization (i.e. about level 3 of CMM).

In most start-ups, the wasted effort, for a project similar to this one, would have added about 90 hours (i.e. 30% of 716 or 215 hours – 125 hours). This also implies, that for a net effort of about 6 hours per member per day (if we subtract from an 8-hour day interruptions (e.g. phone call), answering emails, discussions in corridors, etc.), the product would have been ready for delivery to a customer about 15 days, of 6 hours, later than with a project with only 12.6% of waste.

Table 4: Effort to execute, detect and correct errors by the 2-member team (Laporte et al 2014c)

Title of task	Prevention (hours)	Execution (Hours)	Review (Hours)	Rework (Hours)
Environment installation	89			
Project plan development		35	3	4
Project plan execution and project assessment & control		47		

Specification & prototype development		199.5	7	18
Architecture development		42.5	1.5	3.5
Test plan development		12.5	1	2
Code development and testing		361	47	96.5
Develop user guide & maintenance document		8	1	1
Web site deployment		8.5		
Project closure		2		
Total hours	**89**	**716**	**60.5**	**125**

These two projects have demonstrated that, by using ISO/IEC 29110, it was possible to properly plan the project and develop the software product using proven software practices documented in standards as well as not interfering with the creativity during the development of their web site. People who think that standards are a burden, an unnecessary overhead and a treat to creativity should look at this start-up project and revisit their results.

4 CONCLUSIONS AND FUTURE WORK

The relationship between the success of a software company and the software process it utilized has been investigated (Laporte and O'Connor 2014a) (O'Connor and Basri 2014) showing the need for all organizations, not just VSEs to pay attention to software process practices such as ISO standards. As ISO/IEC 29110 is an emerging standard there is much work yet to be completed. The main remaining work item is to finalize the development of the remaining two software profiles of the Generic Profile Group: (a) Intermediate - management of more than one project and (b) Advanced - business management and portfolio management practices.

The ISO working group, initially mandated to develop the ISO/IEC 29110 for software, was also mandated to develop a similar approach for VSEs involved in systems engineering (Laporte and O'Connor 2014b). In August 2014, ISO published the ISO/IEC 29110 systems engineering and management guide of the Basic profile ISO/IEC TR 29110-5-6-2:2014 (2014). The systems engineering and management guide of the Entry profile has been published in 2015 as ISO/IEC TR 29110-5-6-1:2015 (2015).

ADDITIONAL INFORMATION

The following web site provides more information: http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html

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