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The Education of Students About ISO/IEC 29110 Software Engineering Standards and Their Implementations in Very Small Entities

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Abstract— Worldwide, a large majority of organizations developing software are entities having up to 25 people. Since most published software engineering standards had been developed by and for large organizations, most Very Small Entities (VSEs) did not have the expertise to adapt or tailor those software engineering standards to meet their needs. The ISO/IEC 29110 series of standards and guides was specifically developed for VSEs developing software. Many countries that had not participated to international standard development, decided to join the ISO working group mandated to develop the ISO/IEC 29110 series. Since the ISO/IEC 29110 engineering and management guides are easily understandable and freely available, it has greatly helped their adoption. More than 17 countries, such as Colombia, Brazil, Haiti, Jordan, Malaysia, Mexico, Peru and Thailand are teaching ISO/IEC 29110. ISO/IEC 29110 has been used by many students to develop their first products. Many countries have adopted ISO/IEC 29110 as a national standard. A few countries are helping their VSEs in the adoption, implementation and certification activities with government programs. Low cost independent certification and assessment schemes allow VSEs to demonstrate recognition of their competences to local and international customers and partners.

Keywords— *Very Small Entities, ISO/IEC 29110, management and engineering guide, education, standard*

I. INTRODUCTION

Small and medium-sized enterprises (SMEs) are a very important source of employment and economic growth in the member countries of Organization for Economic Cooperation and Development (OECD). According to OECD, SMEs are the

dominant form of business organization, accounting between 95% and 99% of all enterprises [1]. In Europe, for instance over 92% of enterprises, called micro-enterprises, have up to 9 employees and another 6.5% have between 10 and 49 employees [2]. In Thailand, very small entities represent about 90% of the software industry [3]. In Perú, of all the companies that are part of this software industry, 63 percent are micro-enterprises [4].

The World Information Technology and Service Alliance Global Insight, estimated that spending on computer software and services (excluding software embedded in devices) amounted to about \$1.2 trillion in 2011. Less than one fifth of this amount is accounted for by developing countries. In many developing countries, the software sector is dominated by small, i.e. of 20 employees or less, and young enterprises [5].

From the various surveys and studies conducted, it was clear that software engineering life cycle standards, such as ISO/IEC/IEEE 12207 [6], did not address the needs of Very Small Entities (VSEs). Their perception about engineering standards was that they have been developed by large organizations to meet the needs of large organizations. VSEs perceived engineering standards as being bureaucratic and being expensive to implement. Most VSEs did not have the resources in terms of expertise and money to adapt heavyweight standards to meet their needs. Also, VSEs had no, or very limited ways to be recognized as entities that produce quality systems or software products in their domain. Therefore, they were cut off from some economic activities [7].

In early 2005, the Thailand Industrial Standards Institute and the Thailand Software industrial promotion agency (SiPA)

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sponsored 2 one-week workshops in Bangkok to kick-start the development of a series of standards and guides addressing the needs of VSEs. The outputs of the workshops led to the establishment, in 2005 of an ISO/IEC working group (WG24) mandated to develop what is now called the ISO/IEC 29110 series. Many countries that hadn't previously participated actively in the development of ISO/IEC systems and software engineering standards including Argentina, Colombia, the Czech Republic, India, Mexico, Peru and Thailand decided to join WG24.

Unfortunately, a majority of developing countries are still not aware of the ISO/IEC 29110 series. Some countries like Thailand have been deploying, since 2009, ISO/IEC 29110 in government, industry and academia, while some countries, like Tunisia, are just initiating projects to deploy ISO/IEC 29110.

In the following sections of this paper, the authors present an overview of ISO/IEC 29110. Then, we present examples of deployment and implementation of ISO/IEC 29110 in Thailand, Mexico, Tunisia, Peru and Colombia.

II. OVERVIEW OF ISO/IEC 29110

The ISO/IEC 29110 series (ISO 29110 hereon) defines Very Small Entities (VSEs) as enterprises, organizations (e.g. government, not-for profit), departments or projects having up to 25 people [8]. VSEs can play different roles such as developers, maintainers or integrators of software. Since most large organizations are structured in a way to be more manageable (e.g. project, department), VSEs are present in most product manufacturing chains.

WG24 developed an ISO 29110 four-stage road map, also called profiles, to meet the needs of start-ups, one-project VSEs, multi-project VSEs and growing VSEs. For example, the management and engineering guide of the Basic profile [8], targeted at VSEs developing a single application by a single work team, is composed of 2 processes: Project Management (PM) process and Software Implementation (SI) process. As illustrated in figure 1, a Customer provides his needs, described in a Statement of Work (SOW), as an input to the PM process. The PM process will use the project plan developed by the planning until the customer receives, as the output of the SI process, the product requested (e.g. documentation, code).

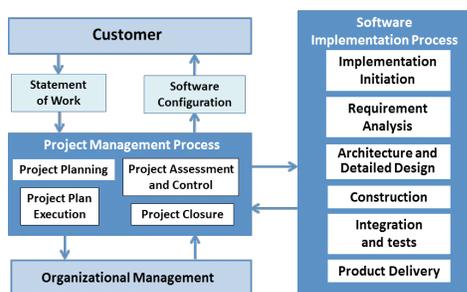


Fig. 1. Processes and activities of the ISO 29110 software engineering Basic profile [9]

For illustration purposes, one task of the Project Planning activity of the PM process is listed in Table 1.

TABLE I. EXAMPLE OF ONE TASK OF THE PROJECT PLANNING ACTIVITY

Role	Task list	Input	Output
PM CUS	PM.1.2 Define with the Customer the <i>Delivery Instructions</i> of each one of the <i>Deliverables</i> specified in the <i>Statement of Work</i> .	Statement of Work [reviewed]	Project Plan - Delivery Instructions

On the left side of the table are listed the roles involved in this task: the Project Manager (PM) and the Customer (CUS). In the next column, the task is described. The two columns on the right list the input required to perform the task and the output of this task. The descriptions of each activity are so complete that the ISO 29110 management and engineering guides could be used ‘as is’ by most VSEs.

VSEs that develop systems, i.e. typically composed of hardware and software components, can also benefit from the Systems Engineering ISO 29110 series of management and engineering guides. ISO 29110 standard and a guide [10] addressing the delivery of services should be available in 2018.

ISO 29110 has been initially implemented, in many countries, by VSEs developing software [11, 12]. ISO systems and software engineering standards are usually published only in English. However, international demand for the ISO 29110 standards and management and engineering guides became so great that they have been translated into Czech, French, Japanese, Portuguese, Spanish and Thai. A few countries, such as Brazil, Japan, Peru and Mexico, also decided to adopt ISO 29110 as a national standard.

III. IMPLEMENTATION IN THAILAND

As mentioned above, Thailand has been very active, since 2005, in the development and deployment of ISO 29110 in Thai industry, government and academia.

A. ISO 29110 in Thai government and industry

In 2011, the Ministry of Information and Communication Technology, the Software Industrial Promotion Agency and the Innovation Foundation signed a memorandum of understanding and started a project that aimed to encourage the government agencies and the private sector to improve their software development processes using the ISO 29110.

The ‘ISO/IEC 29110 Driven Thailand Flagship’ is one driver of Thai digital economy [13]. The main components of the ISO 29110 flagship are government vision, leadership and policies, clusters of VSEs, network of consultants and assessors and training and academic institutions. One objective of the flagship is to get over 250 VSEs to obtain an ISO 29110 certification. To achieve this goal, VSEs were trained about

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ISO 29110. Then, they were guided to perform a gap analysis between their actual software process and the ISO 29110 Basic profile. Once the gaps were filled, their processes were evaluated by an independent process assessor. So far, over 320 private organizations and 15 public organizations have been ISO 29110 certified against the Basic profile [13].

B. ISO 29110 in Government Procurement

In 2015, the Thai government included a reference to the ISO 29110 standard in its national procurement process by giving priority to organizations certified to ISO 29110 in tenders for outsourced software development contracts [14]. The Thai government sponsored the development of a procurement handbook based on ISO 29110. To facilitate its use, the handbook includes processes, activities, templates and checklists. Over 200 government officers, having ICT budget approval authority, have been trained as part of this ISO 29110 handbook project [3].

C. ISO 29110 in Academia

In 2009 and 2010, one co-author of this paper was invited to teach a software quality assurance course and ISO 29110 in the software engineering program of the Chiang Mai university. At this university, ISO 29110 is also taught in their software process improvement course. Students use ISO 29110 in their team software engineering project. In Chiang Mai and Phayao universities students must present their final software development project with ISO 29110 as a criterion for graduation. During their last session, students do a 4-month internship. Many internships are conducted in VSEs that are using ISO 29110 or have been certified against the ISO 29110.

In addition to the Chiang Mai and Phayao universities, 8 other universities are teaching ISO 29110 in Thailand.

IV. IMPLEMENTATION IN MEXICO

According to a report published by the National Survey on Productivity and Competitiveness of Micro, Small and Medium Enterprises (ENAPROCE by its Spanish acronym) in 2016 [15], there are about four million enterprises in Mexico, about 98% of them are very small enterprises.

In this context, software development companies have shown significant economic activity and in recent years. Moreover, the growth in the importance of software development provides the opportunity for VSEs to produce software products and services to satisfy market needs. This situation highlights the increasing need for improving their development processes to stay in the market and achieve steady growth.

Mexico has been actively participating to the development and diffusion of ISO 29110 since 2006. In fact, the work of WG24 was greatly accelerated when Mexico provided an English translation of the Mexican national standard MoProSoft. However, WG24 felt that MoProSoft addressed

the needs of organizations larger, i.e. about 50 people, than targeted VSEs. Therefore, WG24 decided to tailor MoProSoft to address key characteristics of VSEs, having of up to 25 people, targeted by ISO 29110.

A. Mexican Government Strategy

To provide a solution to this situation the Mexican government together with other important organizations such as the National Camera of Electronics Industry, Telecommunications and Information Technology (CANIETI by its Spanish acronym), as well as the most important associations and institutes in the country related to IT such as the Mexican Association of Information Technology Industry (AMITI by its Spanish acronym), the Mexican Association of Internet (AMIPCI by its Spanish acronym), the National Association of Computer Technology and Communications Distributors (ANADIC by its Spanish acronym), the Mexican Association Business of Open Source Software (AMESOL by its Spanish acronym) and the Mexican Institute of Teleservices (IMT) are pushing a program named as PROSOFT [15]. PROSOFT program aims to create conditions to have with an international competitive IT services sector and ensure its long-term growth, as well as, to promote a better use of them.

Among other strategies, two PROSOFT strategies are highlighted because they are focusing on reinforcing the Mexican organizations to make them competitive internationally [16]:

- Increasing the quality and quantity of talent in the software development and its services: it refers to the availability of more a better human capital to take advantage of the great growth of the sector in both at local level and to access to international markets.
- Achieving an international level in process capacity: it refers to increase the capacity of the IT services sector so that Mexican industry can be competitive internationally. In this way, the adoption of models and standards could increase the productivity and quality of organizations.

The PROSOFT program offers economical support to VSEs to help them get training toward achieving the certification in different models and standards such as ISO 29110.

An advantage that ISO 29110 offers is that it can be implemented also in start-ups. This is very important in Mexico due to the amount of economical investment that the Mexican government is giving as its national strategy to push the innovation in states such as Aguascalientes and Zacatecas.

B. Certification of Mexican VSEs

Mexico has adopted ISO 29110 as one of the Quality Standards that have the recognition of the government and industry. Since 2013, there has been an increasing interest of

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VSEs regarding the ISO 29110. To motivate VSEs in obtaining an ISO 29110 certification, the Mexican government offers to support them by paying about 25% of the cost of implementation and certification.

Actually, there are thirty-three VSEs certified to the ISO 29110 Basic profile by NYCE, the Mexican certification body [17]. Two of them already had an annual follow-up audit.

C. Academic Strategy

The academic sector plays an important role in the training high quality human resource to be integrated in software development organizations, and in Mexico this is not the exception.

Actually, universities and research centers such as Software Engineering Unit of CIMAT (*Centro de Investigación en Matemáticas*), CUCEI (*Centro Universitario de Ciencias Exactas e Ingenierías*), Universidad de Sonora and Universidad de Aguascalientes are doing researching focusing on ISO 29110. Also, these universities are integrating a team to work together using ISO 29110 mainly in two states of Mexico, Zacatecas and Aguascalientes, having these two goals:

- Performing research focused on helping VSEs in the implementation of ISO 29110.
- Training undergraduates and master students in the ISO 29110.

Five researchers, of the universities listed above, translated in Spanish the ISO 29110 Entry profile and its 2 deployment packages (DPs) as a contribution to the Mexican economy. The Entry profile is targeted at start-up VSEs and/or at VSEs working on small projects (e.g. project size of less than six person months). A DP is a set of artifacts developed to facilitate the implementation of a specific management and engineering guide of ISO 29110 to a VSE.

The Entry profile is very important to Mexico due to the growing number of start-ups as well as the economic resources and programs that the Mexican government is supporting. The Entry Profile should be adopted as a Mexican national standard in 2017.

V. IMPLEMENTATION IN HAITI

In 2011, a first ISO 29110 project was conducted in Haiti with 2 VSEs. One VSE, a government agency responsible to collect taxes of importing goods, had an IT team of 5 employees. The other VSE was developing management software and web applications. This VSE had an IT team of 15 developers (20 developers in 2017). Both VSEs were assessed against the Basic profile to identify their strengths and weaknesses. Since then, most ISO 29110 activities have been conducted, by one co-author of this paper, at the University of INUKA (Institut Universitaire Quisqueya-Amérique) of Port-au-Prince.

At INUKA, in the winter session of 2014, over 14 VSEs of Haiti have been evaluated against the ISO 29110 Basic profile as part of an undergraduate software quality assurance course (SQA). Fourteen teams of students made these evaluations. For the summer session of 2014, over 80 students have evaluated the development processes of other VSEs using the ISO 29110 [18].

The ISO 29110 has been taught during the winter session of 2015 to 132 undergraduate students of the software quality assurance course taught by one co-author of this paper using 2 French SQA textbooks (an English SQA textbook will be published in 2017 [19]). In this course, students debated the difficulty of producing quality software and showed how the execution of ISO 29110 can improve the development processes of VSEs.

For the 2017 winter session, over 29 VSEs of Haiti have been evaluated using ISO 29110 as part of a SQA course of INUKA. Twenty-nine teams of five students conducted those evaluations. For the 2017 summer session, about 147 students, divided in 3 classes, will evaluate the development processes of VSEs using ISO 29110.

As part of the evaluation of VSEs, students develop an improvement plan that includes a review of the current status of the organizational development process, list of gaps with ISO 29110, strengths and weaknesses, and proposed improvements. This improvement plan is submitted to the manager of a VSE. Then, students that graduated from the bachelor program as well as graduate students from the master program in computer science use these plans, under the supervision of one co-author of this paper, to coach these VSEs in the implementation of ISO 29110. This is a way to help to improve the development process of VSEs of Haiti in order to produce quality software. Most of the targeted organizations for these improvement projects are the IT department of banks.

The IT research and development center of INUKA developed three applications using ISO 29110: a mobile and a web-oriented application, a system allowing students to access their grades online from a mobile phone or computer. Finally, an application that manages the presence of professors and employees using fingerprints has also been developed.

VI. IMPLEMENTATION IN PERÚ

Perú started its participation to WG24 in 2008. Since then Perú has been very active in the diffusion and implementation of ISO 29110.

In 2004, the ONGEI (National Office of Electronic Government and Information) that is responsible for all informatics related subjects in the Peruvian government mandated the use of ISO 12207 for government use. In 2012, three ISO 29110 documents were translated in Spanish and were adopted as Peruvian national standards. Since the ISO 29110 has, as its foundation ISO 12207, in 2015 the ONGEI

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declared its interest in adopting ISO 29110 as a means to facilitate the implementation of the ISO 12207 [20].

A. Development and Deployment by the Pontificia Universidad Católica del Perú

In 2012, ISO 29110 was introduced in two undergraduate courses. In the first course every team developed separately the same project, while in the second course they work together on only one project [20].

In 2013, the Institute for Quality of the university certified to the ISO 29110 Basic profile the first Peruvian software development company. In 2014, the development of a service management model aligned to the ISO 29110 was completed. In 2015, an improved version was circulated to international experts for review [20].

B. Implementation in a Peruvian IT Start-up

An ISO 29110 process improvement project was conducted by BitPerfect, a Peruvian IT start-up of 4 people [21]. After completing the implementation of the 2 processes of the Basic profile using an agile approach, these processes were executed in a project with the second-largest insurance companies in Peru. Managing the project and developing the software took about 900 hours.

The start-up expended only 18% of the total project effort on rework (i.e. wasted effort) as opposed to about 40 percent of rework, typical of a vast number of organizations [22].

VII. IMPLEMENTATION IN TUNISIA

In 2017, with the sponsorship of the digital industry Tunisian State Secretary and the Tunisian Standardization Institute, an expert from Tunisia should join the ISO working Group mandated to develop ISO 29110. Tunisia is also considering the adoption of ISO 29110 as a national standard as well as the establishment of an organization mandated to conduct ISO 29110 certifications. ISO 29110 will be used by software developers of the Bizerte Smart City project.

A. IT Start-up Collocated in Tunisia and Canada

Metam is a company founded in 2013. The VSE has one software development site in Tunisia with 18 employees and one site in Canada with 2 employees. Its business domains are software development services, web solutions, mobile applications as well as consulting services to implement ERP solutions. The Basic profile was used as the framework for the company's software processes [22]. In 2016, the VSE was audited by a third-party auditor against the Basic profile.

VIII. IMPLEMENTATION IN COLOMBIA

In 2017, the government of Colombia issued a request for proposals with the objective of implementing and certifying organizations to the ISO 29110 Basic profile. The 1.15 million

\$US program will finance about 85% of the cost of ISO 29110 implementation and certification of about 110 VSEs [24].

IX. CONCLUSION

We have presented the needs and challenges of very small entities concerning the use of software engineering standards. The ISO 29110 series addresses the needs of VSEs developing software as well as system components. We have briefly presented one management and engineering guide developed to assist VSEs. Then, we presented examples of deployment and implementation of ISO 29110 in Columbia, Thailand, Mexico and Peru. Due to space limitations, it was not possible to present implementations of ISO 29110 in Argentina, Brazil, Jordan, Malaysia and Uruguay.

We have presented examples describing the involvement of academia in teaching ISO 29110 in Asia and America. ISO 29110 could be used by government agencies, not-for profit organizations and enterprises to provide quality software products to their local and national markets as well as to the international markets.

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