

Implementing Process Improvement in Very Small Enterprises with ISO/IEC 29110

A Multiple Case Study Analysis

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Abstract— This paper outlines the details of nine case studies involving the pilot usage of the new ISO/IEC 29110 Lifecycle Profiles for Very Small Entities standards and guides, which were specifically designed to address the standardization needs of Very Small Entities. The purpose of this paper is to disseminate the early success stories from pilot trials of this new and emerging standard. The lessons learnt from these case studies should assist the adoption of this new standard in an industrial setting.

Keywords—ISO Standards, ISO/IEC 29110, VSE

I. INTRODUCTION

In terms of software development, small and very small companies typically have the challenge of handling multiple small-scale, fast-moving projects, which allow little room for heavy-weight management processes, but still requiring an efficient and straightforward monitoring process [1]. Moreover, due to the small number of people involved in the project and the organization, most of the management processes are performed through an informal way [2] and less documented [3]. Furthermore there is an acknowledged lack of adoption of standards in small and very small companies (for example see studies such as [4]) as the perception is that they have been developed for large software companies and not with the small organisation in mind [5]. The perception of heavyweight processes, especially in terms of documentation, cost and nonalignment with current development process, are among the reasons why many companies do not plan to adopt a lifecycle standard in the short to medium term [6].

Industry recognizes the value of Very Small Entities (VSEs), i.e., enterprises, organizations (e.g. government agencies and non-profit organizations), departments or projects with up to 25 people, 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” [7]. Accordingly, the new standard ISO/IEC 29110 “Lifecycle profiles for Very Small Entities” is aimed at meeting the specific needs of VSEs [8]. The overall objective of this new standard is to assist and encourage very small software organization in assessing and improving their software process.

The approach [9] used to develop ISO/IEC 29110 started with the pre-existing international standards, such as the systems and software life cycle standards ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207 and the documentation standard ISO/IEC/IEEE 15289.

The ISO/IEC working group behind the creation of this ISO/IEC 29110 is encouraging the use of pilot projects as a mean to accelerate the adoption of the standard by VSEs [10, 11]. To date a series of individual pilot projects (such as [12, 13]) have been completed in several countries, however this paper brings together a series of 9 case studies of ISO/IEC 29110 implementations in a Canadian context in a more comprehensive case study setting.

II. THE ISO/IEC 29110 STANDARD

A. Background history of ISO/IEC 29110

The overall approach [14] followed by the ISO/IEC JTC1 SC7 working group 24 mandated to develop the new set of standards and guides for VSEs.

The basic requirements of a software development process are that it should fit the needs of the project and aid project success [15, 16]. 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 [17, 18]. The core situational characteristic [19] of the entities targeted by ISO 29110 (ISO 29110 hereon) is size.

At the core the Basic Profile of this standard is a Management and Engineering Guide, officially known as ISO/IEC TR 29110-5-1-2 [20], which focuses on Project Management and Software Implementation as illustrated in Figure 1. 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 artefacts from 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.

As illustrated in figure 1, 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. Verification, validation, and test tasks are included in the SI process.

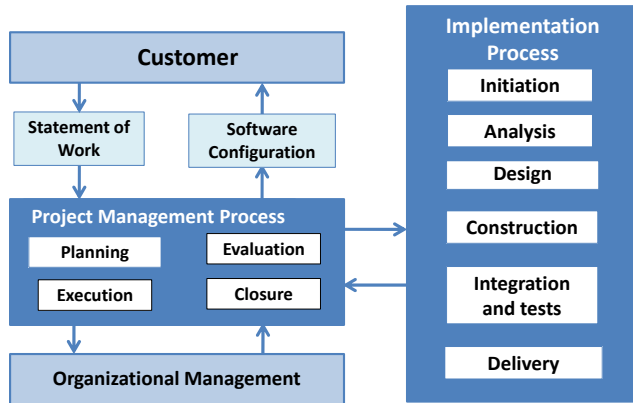


Fig. 1. ISO 29110 Basic profile processes and activities

The PM process closure activity will deliver the Software Configuration (i.e. a set of software products such as documentation and code) and will obtain the customer's acceptance to formalize the end of the project.

B. Deployment Assistance

A novel approach taken to assist VSEs with the deployment of ISO 29110 and to provide guidance on the actual implementation of the Management and Engineering Guides in VSEs, a series of Deployment Packages (DPs) have been developed to define guidelines and explain in more detail the processes defined in the ISO 29110 profiles [21]. 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. The mappings show that a deployment package has explicit links to standards, such as ISO/IEC/IEEE 12207, or models, such as the CMMI[®] for Development (CMMI-DEV). Hence by implementing a DP, a VSE can see its concrete step to achieve or demonstrate coverage [22].

DPs were designed such that a VSE can implement its content, without having to implement the complete ISO/IEC 29110 framework, i.e. of all the management and engineering activities, at the same time. A set of nine DPs have been developed in English, translated in Czech and Spanish, to date and are freely available from [23].

III. IMPLEMENTATION CASE STUDIES

In this section we will present a brief review of 9 case studies of ISO 29110 implementations in a Canadian context. The purpose of these case studies was to disseminate the early success stories from pilot trials of this new and emerging standard. The lessons learnt from these case studies should assist the adoption of this new standard in an industrial setting.

A. Case 1: An IT Start-up

An implementation project has been conducted in an IT start-up VSE by a team of two developers [24]. 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 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 expending only 13 percent of the total project effort on rework (i.e., wasted effort). The two members of the team were assigned roles and activities of ISO 29110.

This project has demonstrated that, by using ISO 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 threat to creativity should look at this start-up project and revisit their results.

B. Case 2: A Canadian/Tunisian IT start-up

Metam is a company founded in 2013 by a software engineering graduate student of ÉTS [25]. The company has one site in Canada and one site in Tunisia. Its business domains are software development services, web solutions, mobile applications as well as consulting services to implement ERP solutions. The Basic profile of ISO 29110 was used as the framework for the company's software processes. It was also used as a foundation to start the implementation of CMMI-DEV level 2 practices since it is requested by some military contracts. In 2016, the VSE had 20 employees (18 employees working in Tunisia). The VSE is planning to conduct an independent ISO 29110 audit in 2016.

C. Case 3: A large IT consulting firm

A department of 9 people, of a large consulting firm of about 1,000 employees with 7 offices in Canada and one office in France, implemented the Basic profile. The company specializes in the design, implementation, integration, and support of management and accounting solutions, and in the development of e-business operations. Once a decision has been made to implement the Basic profile in a division, an informal assessment of the practices in used against the Basic profile was performed.

The division decided to focus its efforts in the software implementation process the Basic profile of ISO 29110. On a part-time basis, a few employees developed and implemented a series of templates and tools using mainly Jira and Sharepoint. It took about 180 hours of effort, on a part-time basis, over a period of 8 months to develop and deploy the updated processes. The new tasks have been implemented gradually over a period of 3 months. Since January 2015, all employees of the division must use the updated processes. The division is also looking to obtain an ISO 29110 certification.

D. Case 4: A large Canadian financial institution

The Cash Management IT department, of a large Canadian financial institution, is responsible for the development and maintenance of software tools used by traders. The software

team is composed of 6 people. Each year, the division is faced with an increase in the numbers of requests to add, correct or modify features related to supported applications. Before the implementation of the ISO 29110-agile process, customers had a series of complaints. In response to this problem, their software process was evaluated by comparing the activities of the maintenance process to those of the software Basic profile of the ISO 29110. Some shortcomings were found in the project management process and in the software implementation process.

The new agile process, using the Basic profile of the ISO 29110, has been tested on three pilot projects. In this organisation, an incident is classified as minor or major using a set of criteria such as the number of impacted systems, the severity, number of customers impacted and criticality of the impact.

The new ISO 29110-agile process has been tested on three pilot projects. The new process helped to significantly reduce the number of major incidents caused by changes to the tools of the traders. In this financial organisation, an incident is classified as minor or major using a set of criteria such as the number of impacted systems, the severity, number of customers impacted and criticality of the impact. The criticality is evaluated on a 1 (low impact) to 5 (high impact) scale [26]. Figure 2 illustrates the decrease in the numbers of systems impacted as well as in the total criticality level.

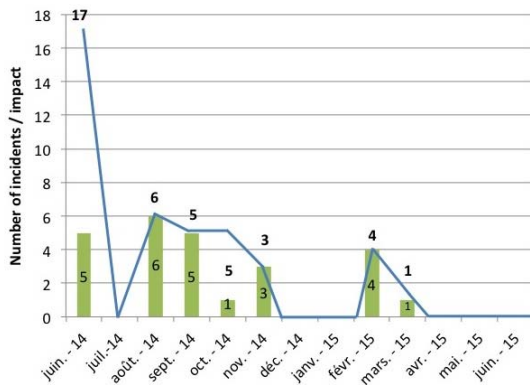


Fig. 2. Reduction of the number of monthly incidents (Translated from [26])

The users of the new process are delighted with the new agile planning and control approach, which allows them to better manage their priorities and to always know the status of their requests. The maintenance team was also very pleased to see an improvement in the quality of the change requests, resulting in a noticeable decrease in the number of defects in the software tools handed to traders.

E. Case 5: A division of a large Engineering Enterprise

A Canadian division of a large American engineering company, the Transmission & Distribution of electricity division, has implemented a program to define and implement project management processes for their small-scale and medium-scale projects [27]. The division, composed of about 15 project managers, already had a robust and proven process to manage their large-scale projects. The objectives of this

process improvement project were to reduce cost overruns and project delays, standardize practices to facilitate the integration of new managers, increase the level of customer satisfaction and to reduce risk-related planning deviations.

Pilot projects have been conducted to test the project management processes and associated support tools (e.g. templates, checklists). The pilot projects consisted of running three different projects where project managers implemented the process and the associated tools. Managers then evaluated the proposed processes, identified problems and potential improvements. The lessons learned sessions conducted at the end of the pilot projects have identified minor adjustments to the processes and tools.

The engineering enterprise estimated that, over a three-year timeframe, savings of about 780,000\$ CAD would be realized due to the implementation of project management processes using the ISO 29110. The engineering firm is planning to document and implement their systems engineering (SE) processes with ISO 29110.

F. Case 6: An Automotive Enterprise

TM4 is a Canadian company of 140 people (14 software engineers), designs and sells electric powertrain systems in the automotive field. Their products are embedded software that controls the operation of engines in real time and software that controls the interactions between the components of a vehicle.

ISO 29110 was used in this effort to improve its processes. A coverage analysis was conducted to establish the difference between the practices in place and those proposed by the ISO 29110. A pilot project has been successfully completed in May 2015. New projects use the ISO 29110-based processes.

An economic impact assessment of the implementation of ISO 29110 was conducted using the methodology developed by ISO [28].

G. Case 7: A large electricity provider

The IT division of a large Canadian electricity provider already has implemented process areas of the CMMI-DEV. A small department within the IT division, the Mobility and Georeferenced Solutions department, is composed of 6 developers and 3 analysts, an architect and a manager. Typical projects of the department are requests from internal customers to improve a few applications. Due to the increased area of mobility, the small department was required to develop applications more quickly, and with very different technologies. Increasingly, the department had to develop proof of concepts. The problem was that the deliverables requested by the current methodology for typical projects of the IT division were too numerous, the level of documentation required was not suitable for small projects and small teams.

A project was launched within the small department to tailor ISO 29110 to their needs and adapted to a Scrum approach. A pilot project, involving the creation of a web application for property management, has been conducted. This application greatly facilitated geographic data consultation.

The use of ISO 29110 gave the team short and long-term benefits. The use of proven practices quickly improved the

quality and quantity of the software application developed. By centralizing the data of geographical maps, their customers no longer have to update them. In addition, geographical information is more uniform across the enterprise. The ISO 29110 pilot project allowed the small department of 11 people to shine within the IT division, as it became a model for future small IT projects. About 9.6% of the 1,500-hour project has been expended on rework. For a large IT division, of close to 2000 people, the benefits of the ISO 29110 implementation are always welcomed for a public utility provider.

H. Case 8: A medical R&D VSE

A project has been conducted to develop and implement a quality management system for a medical R&D company of 15 employees. The VSE manufactures a family of neuronavigation products which are used in over 400 laboratories around the world in the fields of cognitive neuroscience, rehabilitation research and veterinary sciences. This project improved the business processes and implemented a quality management system in accordance with the ISO 13485 medical standard.

This project used the ISO 29110 systems engineering Basic profile to facilitate the implementation of ISO 13485. ISO 29110 has guided the VSE in the development of tools, guides and templates. During this project, totalling more than 1,000 hours of effort, the implementation of the quality system was planned; processes, guides and templates were defined in collaboration with key resources of the company. A pilot project was conducted to validate the adequacy of the established process. The use of ISO 29110 systems engineering Basic profile facilitated the implementation and the adaptation of a standard such as ISO 13485 for a VSE.

I. Case 9: A young transportation company

This project was created to define and implement project management and SE processes at CSinTrans Inc. (CSiT), a Canadian company, created in 2011 [29]. The company specializes in the integration of interactive systems, communication and security in the field of public transport such as trains, subways and buses and railway stations, and stations bus stops. ISO 29110 standards and guides for SE have been used as the main reference for the development of the processes [30]. Systems, in the context of ISO 29110, are typically composed of hardware and software components.

ISO 29110 standard has helped raise the maturity of the young organization by implementing proven practices and developing uniform work products. ISO 29110 was a good starting point to align processes with selected level 2 and 3 practices of the CMMI model. Table 1 illustrates the percent of coverage of CSiT processes to CMMI-DEV.

TABLE I. COVERAGE OF CSiT PROCESSES TO CMMI-DEV

CMMI Level 2 Process Areas	Percentage of Coverage
Configuration Management	50-70%
Measure and Analysis	20-40%
Project Monitoring and Control	70-90%
Project Planning	70-90%
Process and Product Quality Assurance	45-65%
Requirements Management	90-100%
Supplier Agreement Management	70-90%

Compliance with the ISO standard allowed CSiT to be recognized as producing quality products. ISO 29110 has also helped in developing lightweight processes allowing the VSE to remain flexible as well as its ability to react quickly to its customers.

Recently, the processes of CSiT, based on the Basic Profile of the ISO 29110, have been successfully audited by a third-party audit composed of 2 independent auditors. One member of the audit team was a SE domain expert. In 2016, CSiT had 10 employees.

J. Additional case studies

Table II lists organizations involved in additional completed ISO 29110 implementation activities in Canada.

TABLE II. ADDITIONAL CANADIAN PROJECTS

Description of organization	Project Description
An enterprise specialized in industrial process control.	A department of 13 employees ISO 29110 Entry profile was used to assess practices in use The management of requirements was the focus of the project
An IT start-up involved in the development of web traffic surveillance.	A start-up of 4 employees Documentation of the software development process using the Basic profile of ISO 29110
A large civil engineering and construction firm.	A department of 15 people responsible for the development and maintenance of software for the other units of the company. After an analysis of current practices using the Entry profile of ISO 29110, the firm implemented a change request management process

IV. LESSONS LEARNED AND RECOMMENDATIONS

A few lessons have been learned as a result of the implementation of ISO 29110 in VSEs.

A one-person VSE can learn from ISO 29110 to better organize work and produce quality software. But, it would be a bit premature to implement both processes of ISO 29110. It would be better to implement first the Software Implementation process of the Entry profile.

Many VSEs have never collected process or product measures. The ISO 29110 management and engineering guides of the Entry and Basic profiles list the tasks associated to the collection and use of measures (e.g. resource, cost, time). Unfortunately, the Entry and Basic profile guides do not provide information about how to collect and analyze measures.

The Entry and Basic profiles present a project management process and development process using a waterfall lifecycle notation. A few VSEs that were using agile approaches complained about the notation used. The new ISO 29110 guides indicate that they do not require the waterfall lifecycle, leaving VSEs to use the lifecycle that best suits their needs.

The addition of an annex in the guides describing agile approaches should facilitate its implementation.

For VSEs that are developing systems, i.e. where hardware components must be purchased and integrated, the SE Basic profile does not provide an acquisition process. Such a process is included in the Intermediate and Advanced profiles. This deficiency has been reported to the ISO WG24. The second edition of the SE Basic profile will correct this deficiency.

Most young VSEs are usually staffed with competent technical people. Unfortunately, technical people are usually not well trained in the management of projects. As illustrated in one case, a VSE may start the implementation of ISO 29110 by first deploying the project management process. Since all tasks are targeted at the project manager, developers could keep doing their technical tasks without having to do the management tasks of ISO 29110.

VSEs are often intimidated by the list of work products of the management and engineering guides. A VSE may select to combine work products (e.g. verification results and validation results) in one document.

For many VSEs, it could be difficult to transition from an environment where processes are often improvised and not documented, to an environment where activities, tasks, roles and content of work products are defined. Sometime, employees do not understand the need to work according to the company's process, thinking that it may burdening their tasks and slowdown their projects. Without a strong leadership and commitment of management, the transition will not happen by itself.

The implementation of ISO 29110 on an ongoing project may create confusion amongst developers and managers. Since a majority of projects conducted by VSEs are not very long, a better approach would be to let a project reach completion. Only new projects will be using ISO 29110.

Before implementing ISO 29110 in a project, a VSE should adapt the terminology (e.g. work product, role) of the selected management and engineering guide to fit to the terminology currently used by the VSE.

V. DISCUSSION

The pilot case studies presented in this paper have demonstrated that by using ISO 29110, it was possible to properly plan and execute projects and develop products or conduct projects using proven system or software engineering practices, thus proving wrong the perception that a process standard interfere with the creativity of software developers. The relationship between the success of a software company and the software process it utilized has been investigated [31, 32] showing the need for all organizations, not just VSEs to pay attention to software process practices such as ISO standards.

Work currently underway on audit and assessment mechanisms for ISO 29110, a clear niche market need is emerging which may force the process assessment community to change their views on how process assessments are carried

out for VSEs. It is clear that the process assessment community will have to rethink process assessment, new methods and ideas for assessing processes in VSEs.

In 2009, it was proposed by the project editor of ISO 29110 to establish an informal interest group about education. Its main objective is to develop a set of courses for software undergraduate and graduate students such that students learn about the ISO standards for VSEs before they graduate.

One way to develop standards professionals is by having professional graduate students involved in the application and improvement of international standards. At the École de technologie supérieure, a 10,000-student engineering school of Montréal, International Software Engineering Standards are introduced and used in Software Quality Assurance and Software Process Improvement courses and industrial projects conducted by graduate professional software engineering and IT students [32].

The role of education is a significant issue in ensuring that the next generation of software project managers and software process engineers are both familiar with the benefits of standards, specifically in VSEs and the role of ISO 29110 in particular. Such education programmes may assist with addressing the perceived issues with standards adoption and the lack of managerial commitment in adopting VSE standards. In 2016, over 15 countries are teaching ISO 29110. As an example, ISO 29110 is taught in 10 universities of Thailand as well as in undergraduate and graduates courses in Canada.

As ISO 29110 is an emerging standard there is much work yet to be completed [33]. The main remaining work item is to finalize the development of the remaining two software profiles of the Generic Profile Group: (a) Intermediate - targeted at VSEs involved in the management of more than one project in parallel with more than one work team (should be published by ISO in 2016) and (b) Advanced - targeted at VSEs which want to sustain and grow as an independent competitive system and/or software development business. Once these software profiles are ready, WG24 will develop matching SE profiles for VSEs.

Similar to the existing set of software ISO 29110 TRs, the systems engineering Management and Engineering Guides are also available at no cost by ISO in English and French. A set of systems engineering DPs and its application in a low-cost autonomous rover has started [34]. In addition, Japanese, Portuguese, Spanish and Check ISO 29110 documents are available on Internet. A German version of the Basic profile will be published by DIN next year.

ADDITIONAL INFORMATION:

The following Web site provides more information, as well as articles by WG24 members and deployment packages for software and systems engineering: <http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html>

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