

Reinforcing Very Small Entities Using Agile Methodologies with the ISO/IEC 29110

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Abstract. Software development organizations have had significant economic impact activity in recent years. The growing of the software demand has created opportunities for very small entities (VSEs) to produce software and services to satisfy market needs. This situation highlights the increasing need for improving their development software processes to stay in the market and to develop quality software products and services to achieve steady growth. Unfortunately, a common issue that most of the VSEs are facing is the lack of the knowledge and practical experience regarding the implementation of current software process improvements (SPI) models and standards. This problem becomes critical because VSEs are under increasing pressure to improve their productivity and quality while keeping costs to a minimum. This paper describes experience to reinforce the software development process of 4 software development organizations that had used agile methodologies and implemented the ISO/IEC 29110 standard in the state of Zacatecas of México. The paper presents this experience, the benefits, lessons learned and the goals achieved.

Keywords: ISO/IEC 29110, software industry, very small entities, VSEs, project management, implementation process, standard, agile methodology, Scrum.

1 Introduction

Nowadays, a large percentage of small and medium enterprises (SMEs) are using agile methodologies in an effort to produce software that meets the time requested by the market [1]. However, in most cases the lack of knowledge about how to correctly apply agile methodologies and software engineering proven practices might be contributing to inefficient software development (e.g. in quality, cost and time), and very small entities (VSEs) are not the exception.

Therefore, implementing proven practices contained in software process improvement (SPI) models and standards in real environments of software development organizations represent a big challenge, especially in VSEs (i.e. enterprises, organizations, departments or projects having up to 25 people) which

must work harder in order to survive, and must also spend time and effort in improving their operation and processes [2][3].

This highlights the importance of developing quality products provided by this type of organizations. According to [2] VSEs are developing and/or maintaining the software used for most organizations.

Even when standard organizations such as ISO and IEC provide solutions to help VSEs to implement proven practices such as the ISO/IEC 29110 standard series [4], a common problem that most of them are facing is the lack of knowledge and practical experience regarding the implementation of an SPI model or a standard.

This paper aims to describe the experience of a group of VSEs that improved their productivity and quality while keeping costs to a minimum by using the ISO/IEC 29110. In México, this standard has been adopted as one of the Quality Standards that have the recognition of the government and the industry [5].

After the introduction, this paper is structured as follows: section 2 shows an introduction of agile methodologies; section 3 shows an introduction of ISO/IEC 29110; section 4 shows related works regarding the implementation of ISO/IEC 29110 in other countries; section 5 describes our five-step improvement method and the experience of implementing the ISO/IEC 29110 in a group of 4 software development VSEs of Zacatecas, México; and in section 6 we present a discussion, conclusions and the next steps.

2 Agile Methodologies

Known as lightweight methods, the agile methods are characterized by short, iterative development cycles, performed by self-organizing teams, which use techniques such as simpler designs, code refactoring, test-development, frequent customer involvement. The agile method emphasizes on providing a demonstrable working product with each development cycle [6].

According to the agile alliance, Agile is the ability to create and respond to changes in order to have succeed in uncertain and turbulent environment [7].

Agile software development aims to develop software faster, incrementally and producing satisfied customer. To achieve these objectives, agile methods provide a conceptual framework of practices and principles [7]. The agile methodologies define how to develop software under agile values and principles of the agile manifesto such as iterative development, frequent and early delivery of working software and simplicity [1, 6, 7].

These methodologies emphasized a close collaboration between the development team and the business stakeholder, frequent delivery and self-organizing teams.

There are many agile methodologies, some of the most popular are Rapid Application Development (RAD); eXtreme Programming (XP), Scrum and Feature-Driven Development (FDD) [8].

3 ISO/IEC 29110 Systems and Software Engineering Series

As one solution to the challenges of VSEs regarding pressure to improve their productivity and quality while keeping costs to a minimum, the ISO working group 24 (WG24) developed the ISO/IEC 29110 series [5].

The ISO/IEC 29110 series have been designed to help VSEs that develop systems or software. In the context of ISO/IEC 29110, systems are typically composed of hardware and software components. The ISO/IEC 29110 series of software standards and management and engineering guides have been developed to help VSEs to improve their software development process, helping them in the implementation of proven practices focused in the VSEs, in order to get benefits such as increasing their product quality, reducing their delivering time, and reducing their costs of production.

The ISO/IEC 29110 series for software has the following features:

- It contains a set of 4 profiles to be used by VSEs according to their goals: The Generic Profile Group is a four-stage roadmap, called profiles: VSEs targeted by the Entry Profile are VSEs working on small projects (e.g. at most six per-person-months effort) and start-ups. The Basic Profile targets VSEs developing a single application by a single work team. The Intermediate Profile is targeted at VSEs developing more than one project in parallel with more than one work team. The Advanced Profile is target to VSEs that want to sustain and grow as an independent competitive system and/or software development business. Nowadays, the Basic profile it's the only profile in which a VSE can be certified.
- It provides, as a foundation, two processes, the project management process and the software implementation process.
- It can be used to establish processes in VSEs using any development approach, methodology or tool.
- It provides a set of process elements such as objective, activities, task, roles and work products.

The software engineering basic profile is composed by two processes [4, 5, 9]: the project management process and the software implementation process. Each process is composed of a set of activities and each activity is composed of a set of tasks. Table 1 describes the processes, their purpose and their activities

Table 1. ISO/IEC 29110 processes of the software engineering basic profile.

Process	Purpose	Activities
Project management	Establishes and carries out the tasks related to a project implementation in a systematic way, so that the project's objectives are complying with the expected quality, time and costs.	Project Planning Project Plan execution Project Assessment and Control Project Closure
Software Implementation	Performances in a systematic way the activities related to the analysis, design, construction, integration and test according to the requirements specified of new or modified software products.	Software implementation Initiation Software requirement analysis Software component identification Software construction

4 Related Works

Many authors have published success cases in the implementation of ISO/IEC 29110 since it has been adopted in many countries. Next, a set of success cases are briefly described.

In [10] there were reported seven success cases of the implementation of ISO/IEC 29110 in different countries: one from IT start-up from Peru and six from Canadian (2 IT start-ups, one of them with location in Canada and Tunisia; 1 large Canadian financial institution; 1 from automotive domain, 1 from transportation and 1 division of a large American engineering company).

In [11] there were reported pilot projects one from Canada conducted with an IT department with a staff of 4; one from Belgium in a VSE of 25 people; one in France that builds and sells counting systems about the frequenting of natural spaces and public sites with a 14-people VSE. It also mentions some projects executed by graduates and undergraduates' students of the ÉTS (École de technologie supérieure), one in an engineering firm having over 400 employees and other one from a website developed by a VSE of 2 people.

In [12] there were reported the implementation of ISO/IEC 29110 in two very small software development companies in Perú.

In [13] a previous work of the authors of this paper, it reported the implementation of ISO/IEC 29110 in eleven VSEs: one IT start-up; An IT start-up with locations in Canada and Tunisia, A development team at a Canadian IT start-up; four VSEs in México; one software developers at a power train manufacturer; one project teams in a large engineering company's Transmission & Distribution of Electricity division; one software team at a large public utility and a software team in a large financial institution's IT division.

All of them have demonstrated very good results in the implementation of the ISO/IEC 29110, such as reduce rework, access to new customers, increase quality, improve their processes among others. However, even if México has a high number of VSEs certified, i.e. having 31 of a total of 38 VSEs certified in ISO/IEC 29110 [14], there are very few case studies published from México which is the target of this paper.

5 Experience in Reinforcing VSEs by Implementing the ISO/IEC 29110

In this section, we describe the experience of implementing the ISO/IEC 29110 in a group of 4 software development companies of Zacatecas that are using the Scrum methodology and are certified by auditors of NYCE, the Mexican Certification Body

5.1 Problems Identified in the Four VSEs

An analysis of the VSEs was performed to identify gaps they have in their development processes. It is important to mention that the four organizations use Scrum as base methodology to perform their projects. The problems identified were classified according to the ISO/IEC 29110 processes as follows:

- a) Problems related to project management process: this process covers the planning, execution, assessment and control, and closure of a project. Table 2 shows the detected problems regarding each process activity.

Table 2. Problems classified by activity of the project management process

Process	Problems
Project planning	<ul style="list-style-type: none"> • In most of the cases, they do not have a formal way to receive a request of work by the customer, they do it just by talking with their customer. • They do not develop a project plan including resources and training needs.
Project plan execution	<ul style="list-style-type: none"> • They do not have an evidence of the reviews performed to know the project progress. • Most of them do not have information about plan versus actual values.
Project assessment and control	<ul style="list-style-type: none"> • They do not have a formal way to register a change request. • They do not register agreements of meetings in a formal way as well as the performed meetings. • They do not have a control/track of corrective actions applied in case of significant deviations. • They have a lack in the use of baselines. • They do not perform a configuration management or it depends of the features of the software tools they are using. • They do not perform software quality assurance.
Project Closure	<ul style="list-style-type: none"> • They do not have a formal way to get the customer approval.

- b) Problems related to software implementation process: this process covers the software implementation initiation, software requirement analysis, software component identification, software construction, software integration and test, and software delivery. Table 3 shows the detected problems regarding each process activity.

Table 3. Problems classified by activity of the software implementation process

Process	Problems
Software implementation initiation	<ul style="list-style-type: none"> • They do not have evidence the project plan review with team members through which common understanding and commitment to the project is achieved.

Software requirements analysis	<ul style="list-style-type: none"> • They do not have an evidence of changes to the requirements
Software component identification	<ul style="list-style-type: none"> • In most of the cases, they do not perform an architectural design as well as a software design
Software construction	<ul style="list-style-type: none"> • They do not document the unit tests performed to the software components
Software integration and test	<ul style="list-style-type: none"> • They do not have evidence of the test procedures followed • They do not register test results • They do not produce verification and validation results
Product Delivery	<ul style="list-style-type: none"> • Lack of evidence of the product delivery and acceptance

5.2 Method Used to Reinforce the VSEs with the Implementation of the ISO/IEC 29110

To be able to reinforce the four VSEs, we performed a five-step method:

1. *Identify the main problems of VSEs have performing their projects as they used to work:* this activity is related to having a meeting in which the VSE talked about the way the perform its projects was performed. We addressed this meeting helping us with a questionnaire which contains questions related to project management and software development.
2. *Map the actual processes of VSEs to the ISO/IEC 29110 Basic profile processes:* this activity is related to ask the VSE to identify the way they perform their project management and software development. To achieve it, a sheet with the processes, activities and tasks provided in the ISO/IEC 29110 were provided to the VSE, and then in a second meeting were performed.
3. *Identify and formalize the VSEs proved practices:* this activity is related to provide support to the VSE, so that they identify the practices they are performing regarding the project management and software implementation according to those practices provided in the ISO/IEC 29110 standard. It helps to make aware them on those practices that are still performing within their organization. To show the information a third meeting were performed.
4. *Select and adapt the practices provided by the ISO/IEC 29110 standard to the context of each VSE:* this activity refers to identify the gaps between their actual practices and those provided in the ISO/IEC 29110 standard. Then, once their practices were identified and formalized, a fourth meeting was performed in which were analyzed set of practices provided by the standard, so that they can understand the importance and impact of its adaptation, besides we provide support to help them to identify how they can tailor the practice to their VSE environment.
5. *Review the projects in which the ISO/IEC 29110 practices were implemented and report the non-conformities with respect to the standard:* this activity refers to review a complete project selected by the VSE. To achieve this activity two meetings were performed. On the one way, during the first meeting the VSE showed the project and we took notes. On the other hand, during the second meeting, we provided a report with the non-

conformities detected and after that they showed evidence of some to cover the non-conformities. The non-conformities that could not be resolved, were worked by the VSE to solve them.

It is important to mention that the execution of the five-step method was conducted by a series of about 6 meetings with each VSE with a duration average of 4 hours per meeting.

To perform the meeting there were integrated a team of 6 people from a research center as follows:

- Two people with high experience in process definition and improvement in multimodel environments. They have high experience in managing models and standards such as CMMI, ISO 15504, ISO 12207, Moprosoft and ISO/IEC 29110; other frameworks such as PMP and SWEBOK and the methodologies such as TSP, Scrum, XP and crystal.
- Four people with knowledge in software engineering practices, software tools, the CMMI model and the ISO/IEC 29110 standard and in the Scrum methodology.

Besides, each VSE integrate a team according to its characteristics as Table 4 shows.

Table 4. VSEs of Zacatecas certified to the basic profile of ISO/IEC 29110

VSE_ID	Organization' Description	People involved in the improvement process
VSE1	<ul style="list-style-type: none"> • Develops hardware and software solutions. • Has 12 employees • Has highly-trained specialist in electronic development, and in hardware and software development 	1 person with experience in CMMI-Dev certification in maturity level 2 and he have a Scrum Master certification
VSE2	<ul style="list-style-type: none"> • Started its operation in 2014. • Has 7 employees. • Uses technologies and platforms oriented to web and mobile applications. • Has its own software products that are used by its customers. 	2 people with knowledge in software process. Both have a Scrum master certification
VSE3	<ul style="list-style-type: none"> • Provides IT services to other organizations. • Has 3 employees 	1 person with knowledge in CMMI-Dev and Scrum methodology
VSE4	<ul style="list-style-type: none"> • Offers hardware, firmware and software solutions. • Has 4 employees • Provides different quality products to achieve needs of different productive sectors such as mining, pyrotechnic, educational and technological 	2 people with knowledge in agile practices

Once the VSE start the certification process three more meetings were performed but together with the four VSE, the first after the branch analysis, the second after the pre-auditory and the last one after the auditory.

5.3 The four VSEs reinforced by the implementation of ISO/IEC 29110

This section presents the four VSEs that were reinforced by the ISO/IEC 29110. It is important to mention that an overview of this 4 VSEs was previously included in [13]. However, this paper analyzes in detail the information regarding the benefits detected in the VSEs.

It is important to highlight that the 4 VSEs achieved the certification, by independent auditors of NYCE, to the Basic profile of ISO/IEC 29110 standard, Table 5 describes the VSEs, the organization description, the project that was used for certification and the benefits they have identified following the implementation of ISO/IEC 29110.

Table 5. VSEs of Zacatecas certified to the basic profile of ISO/IEC 29110

VSE_ID	Project Description	Detected Benefits
VSE1	<ul style="list-style-type: none"> System to control the access for the company offices. 	<ul style="list-style-type: none"> Provides a software development cycle with defined steps, work products and roles Reinforces the project plan information Reinforces the monitoring and control activities to have the project under control Enables the control of software and tools to be used in a project Improves the project versioning and the software delivery
VSE2	<ul style="list-style-type: none"> Web system that quotes and compares car insurances. 	<ul style="list-style-type: none"> Improves the software development process. Improves the communication with the customer. Improves the change request. Provides documented forms to be implemented as part of the development cycle. Improves the procedure related to the verification. Improves the procedures related to validation and approval of documents. Improves the documentation of test.
VSE3	<ul style="list-style-type: none"> Software to manage medical consultation. 	<ul style="list-style-type: none"> Improves the activities related to project monitoring and control Improves customer communication by using delivery instructions Improves the management of risks
VSE4	<ul style="list-style-type: none"> Redesign of Control Systems of Permanent Magnet Engines. 	<ul style="list-style-type: none"> Achieves the implementation of a standardized methodology for project management, so that it is possible to reduce cost (mainly unforeseen costs), as well as the reduction of estimated delivery times Improves the quality of estimated projects Enable to place the products more quickly and efficiently way in the market

6 Discussion, Conclusions and Next Steps

Nowadays, most of the VSE uses agile methodologies in an effort to produce software that meets the time requested by the market. However, a lack of knowledge of how to correctly apply agile methodologies might be contributing to inefficient software development. Some of the main problems that a VSE faces when using an agile methodology in both the project management and software implementation was listed in Tables 2 and 3 of the section 5.1.

This highlights the increasing need related to the implementation and use of software engineering practices as key aspect to help software development organizations in improving their performance.

In this context and in an effort of providing a solution to this need, the software engineering basic profile of the ISO/IEC 29110 series provides a standard and a set of management and engineering guides that are well accepted by software industry because they provide a set of minimum software engineering practices through two key processes: the project management process and the software implementation process. By the way, in México this standard has have a well acceptance.

This paper presented the experience of reinforcing 4 VSEs using the Scrum methodology with the implementation of the basic profile of ISO/IEC 29110.

The main lessons learned identified from the experience are:

- Start by helping organizations to “identify” and “formalize” what are they doing regarding the project management and software implementation processes, by this way it is possible on the one way, to make aware the organizations of the importance of the processes use. On the other way to help them to adapt the standard to the organizations needs and not to adapt the organization to the standard.
- Provide support to VSEs from the beginning of the implementation until they get the certification, by this way it is possible to understand the needs and doubts regarding the implementation and adoption of software engineering practices within their real environment.
- Maintain feedback meetings throughout all steps. These meetings were performed during the performance of the five-steps methods, this allows us to be part of the VSE’s team, so that the resistance to change was reduced.
- Provide the technical support available for the VSEs whenever they have questions or doubts, even when, there are a set of guidelines developed to help in the implementation of the ISO/IEC 29110, most of VSE feels more comfortable if someone is available to help them.

A few improvement opportunities have also been identified:

- Provide training focused on understanding the ISO/IEC 29110 terminology. One of the main problems is the lack of understanding of the concepts hanging in the standard such as baseline, traceability matrix, verification and validation activities. So that, most of the time this misunderstanding created a barrier toward the implementation or adoption of a software engineering practice.
- Develop support using software tools during the standard training as well as for the implementation of the ISO/IEC 29110 standard. The experience of reinforcing the 4 VSEs with the ISO/IEC 29110 show us that the implementation of this initiatives should have software tools that reduce the effort in the implementation of software engineering practices, so that, it helps to reduce the change resistance in the adoption and use of a new software engineering

practice. However, this software tools should be developed in a way that they can be configured according to the VSE needs.

According to the experience of reinforcing the 4 VSEs with the ISO/IEC 29110, we can conclude that the set of practices provided in the standard can be easily implemented and help VSEs in providing quality products within approved budget and schedule.

Finally, as the next steps, we are working with more VSEs using agile methodologies to get additional results about our implementing method to reinforce them with the practices provided by quality models or standards such as in the ISO/IEC 29110. We are also working to improve the efficiency and effectiveness of our five-step method.

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