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Software Development Process Standards for Very Small Companies

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INTRODUCTION

In recent times quality orientated process approaches and standards have matured and gained acceptance in many software development organizations. Standards emphasize communication and shared understanding more than anything. There are many potential benefits of using standards. In particular for small and very small companies, the benefits that certification can provide include: increased competitiveness, greater customer confidence and satisfaction, greater software product quality, increased sponsorship for process improvement, decreased development risk, facilitation of marketing, and higher potential to export. While good internal software management might help meet the first five claims; the last two can only be the benefits of using a widely recognized standard.

It is commonly agreed that very small software companies, implementing management procedures, and controls to appropriately administer their software development activity is a significant challenge (Laporte et al, 2015). For example, a software company operating in India may have a completely different set of operational problems when compared to a software company in Canada, Mexico or Ireland. Even within a single geographical area such as Ireland, the range of operational issues faced by a small local Irish-owned firm can be radically different to those affecting a multinational subsidiary. The fact that all companies are not the same raises important questions for those who develop software process and process improvement models. To be widely adopted by the software industry, any process or process improvement model should be capable of handling the differences in the operational contexts of the companies making up that industry. But process improvement models, though highly publicized and marketed, are far from being extensively deployed and their influence in the software industry therefore remains more at a theoretical than practical level.

With this in mind, the standardization body ISO/IEC has recently published the ISO/IEC 29110 standard "Lifecycle profiles for Very Small Entities" with the overall objective being to assist and encourage very small software organization in assessing and improving their software. The purpose of this chapter is provide a primer on the ISO/IEC 29110 standard focusing on two main process areas of Project Management and Software Implementation. This chapter will start with an explanation of the rationale and justification for the development of this new standard, followed by an overview of its structure and explain how to deploy ISO/IEC 29110 in a typical very small software company.

BACKGROUND

This section will introduce the problem with standards and explain the specific case of very small entities, before presenting the ISO/IEC standard as a solution specifically designed to address these problems for very small companies.

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Very Small Companies

The definition of "Small" and "Very Small" Entities is challengingly ambiguous, as there is no commonly accepted definition of the terms. The term "Very Small Entity" (VSE) had been defined by the ISO/IEC JTC1/SC7 Working Group 24 and subsequently adopted for use in the new ISO/IEC 29110 software process lifecycle standard as being "an entity (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.

Typically VSEs are economically vulnerable as they are driven by cash flow and depend on project profits, so they need to perform the projects within budget. They tend to have low budgets which have many impacts, such as: lack of funds to perform corrective post delivery maintenance; few resources allocated for training; little or no budget to perform quality assurance activities; no budget for software reuse processes; low budget to respond to risks; and limited budget to perform Process Improvement and / or obtain a certification/assessment. Typically the VSE's product has a single customer, where the customer is in charge of the management of the system and the software integration, installation and operation. It is normal practice for the customer not to define quantitative quality requirements and for customer satisfaction to depend on the fulfillment of specific requirements that may change during the project. A close relationship between all involved project members including the customer shows that software development in small and very small companies is strongly human-oriented and communication between them is important.

The internal business process of VSEs is usually focused on developing custom software systems, where the software product is elaborated progressively and which typically does not have strong relationship with other projects. Typically most management processes (such as human resource and infrastructure management) are performed through informal mechanisms, with the majority of communication, decision-making and problem resolution being performed face-to-face.

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

Problems With Standards

Although commercial SPI models have been highly publicized, they are not being widely adopted and their influence in the software industry therefore remains more at a theoretical than practical level (O'Connor and Coleman, 2009). For example, in the case of Capability Maturity Model Integration (CMMI), an Australian study found that small organizations considered that adopting CMMI would be infeasible (Staples et al, 2007) and an Irish study found significant resistance due to negative perceptions surrounding levels of bureaucracy and required documentation (Coleman and O'Connor, 2006). Further investigation of the CMMI by Staples and Niazi (2006) discovered, after systematically reviewing 600 papers, that there has been little published evidence about those organizations who have decided not to adopt CMMI.

There is evidence that the majority of small and very small software organizations are not adopting existing standards / proven best practice models because they perceive the standards as being developed by large organizations and orientated towards large organizations, thus provoking the

debate the in terms of number of employees, size does actually matter (O'Connor and Coleman, 2008a). Studies have shown that small firms' negative perceptions of process model standards are primarily driven by negative views of cost, documentation and bureaucracy. In addition, it has been reported that SMEs find it difficult to relate standards to their business needs and to justify the application of the international standards in their operations. Most SMEs cannot afford the resources for, or see a net benefit in, establishing software processes as defined by current standards and maturity models (O'Connor and Coleman, 2008b).

ISO/IEC 29110 Standard Proposed

Accordingly there is a need to help such organizations understand and use the concepts, processes and practices proposed in the ISO/IEC JTC1/SC7's international software engineering standards. The ISO/IEC 29110 standard "Lifecycle profiles for Very Small Entities" is aimed at addressing the issues identified above and addresses the specific needs of VSEs. The approach (Laporte et al, 2013a) used to develop ISO/IEC 29110 (2001) started with the pre-existing international standard ISO/IEC 12207 (2008) dedicated to software process lifecycles. The overall approach consisted of three steps: (1) Selecting ISO/IEC 12207 process subset applicable to VSEs of up to 25 employees; (2) Tailor the subset to fit VSE needs; and (3) Develop guidelines for VSEs.

Furthermore, in late 2009, the International Council on Systems Engineering (INCOSE) Very Small and Micro Entities Working Group (VSME) was established to evaluate the possibility of developing a standard, using the Generic profile group scheme of the ISO/IEC 29110 series, based on ISO/IEC 15288 (2008), for organizations developing systems. Late 2011 saw the launch of the official development of the systems engineering ISs and TRs for VSEs. 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). Similar to the existing set of software ISO/IEC 29110 TRs, the Management and Engineering Guide for systems engineering should also be made available at no cost by ISO (Laporte et al, 2014).

STRUCTURE OF ISO/IEC 29110

The basic requirements of a software development process are that it should fit the needs of the project and aid project success. 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. The core situational characteristic (Clarke and O'Connor, 2012) of the entities targeted by ISO/IEC 29110 is size, however there are other aspects and characteristics of VSEs that may affect profile preparation or selection. Creating one profile for each possible combination of values of the various dimensions introduced above would result in an unmanageable set of profiles. Accordingly VSE's profiles are grouped in such a way as to be applicable to more than one category. Table 2 illustrates a Profile Group, which contains three profiles (labeled A, B and C) that are mapped to nine combinations of business models and situational factors.

Profile Groups are a collection of profiles, which are related either by composition of processes (i.e. activities, tasks), or by capability level, or both. The "Generic" profile group is applicable

Table 2. Allocating VSE characteristics to profile groups

	Profile Situational Factors		
Business Models	**Critical**	**User Uncertainty**	**Environment Change**
Contract	Profile A	Profile A	Profile A
In-House	Profile C	Profile B	Profile A
Commercial	Profile B	Profile A	Profile A

to a vast majority of VSEs that do not develop critical software and have typical situational factors. This profile group does not imply any specific application domain, however, it is envisaged that in the future new domain-specific sub-profiles may be developed in the future. Table 3 illustrates this profile group as a collection of four profiles, providing a progressive approach to satisfying the requirements of profile group. To date the Basic Profile has been published, the purpose of which is to define a software development and project management guide for performing one project at a time.

Engineering and Management Guide

At the core of this standard is a Management and Engineering Guide, officially know as ISO/IEC TR 29110-5-1-2 (2011), 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 12207 (2008) and ISO/IEC 15289 (2011) appropriate for VSEs, as illustrated in Figure 1.

Project Management Process

The purpose of the Project Management (PM) process is to establish and carry out the tasks of the

Table 3. Graduated profile of the Generic profile group.

	Generic Profile Group		
Entry	Basic	Intermediate	Advanced

software implementation project in a systematic way, which allows compliance with the project's objectives in terms of expected quality, time, and costs (O'Connor and Laporte, 2012). The seven objectives of the PM process are listed in table 4.

Figure 2 illustrates the 4 activities of the project management process as well as their input and output product. The four activities of the Project Management Process are:

- **Project Planning:** The primary objective of this process is to produce and communicate effective and workable project plans. This process determines the scope of the project management and technical activities, identifies process outputs, project tasks and deliverables, establishes schedules for project task conduct, including achievement criteria, and required resources to accomplish project tasks.

Figure 1. ISO/IEC 29110 project management and software implementation relationship

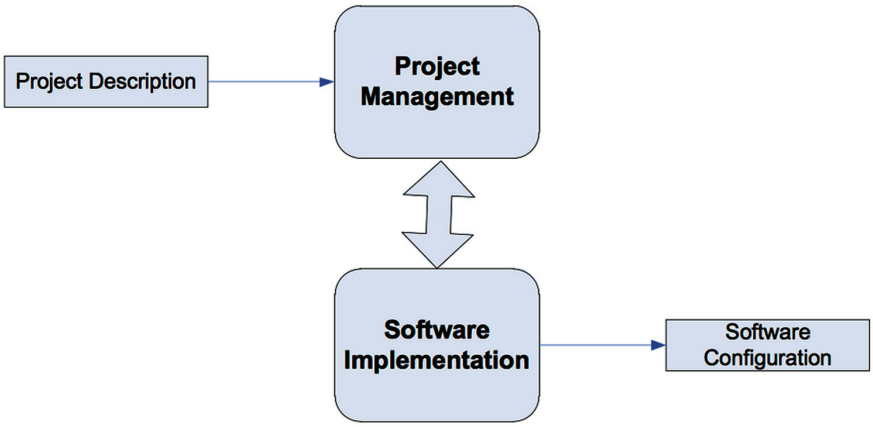


Table 4. Objectives of the project management process of the basic profile (ISO/IEC TR 29110-5-1-2, 2011)

Objective	Description
PM.O1	The Project Plan for the execution of the project is developed according to the Statement of Work and reviewed and accepted by the Customer. The tasks and resources necessary to complete the work are sized and estimated.
PM.O2	Progress of the project is monitored against the Project Plan and recorded in the Progress Status Record.
PM.O3	The Change Requests are addressed through their reception and analysis. Changes to software requirements are evaluated for cost, schedule and technical impact.
PM.O4	Review meetings with the Work Team and the Customer are held. Agreements are registered and tracked.
PM.O5	Risks are identified as they develop and during the conduct of the project.
PM.O6	A software Version Control Strategy is developed. Items of Software Configuration are identified, defined and baselined. Modifications and releases of the items are controlled and made available to the Customer and Work Team including the storage, handling and delivery of the items.
PM.O7	Software Quality Assurance is performed to provide assurance that work products and processes comply with the Project Plan and Requirements Specification.

- **Project Plan Execution:** To implement the actual work tasks of the project in accordance with the project plan. Ideally when the project plan has been agreed and communicated to all teams members, work of the development of the product, which is the subject of the project, should commence.
- **Project Assessment and Control:** Purpose is to determine the status of the project and ensure that the project performs according to plans and schedules, within projected budgets and it satisfies technical objectives.
- **Project Closure:** Typically involves releasing the final deliverables to the customer, handing over project documentation to the business, terminating supplier contracts, releasing project resources and communicating project closure to all stakeholders.

For illustration purposes, two tasks of the Project Planning activity are listed in Table 5. The project manager (PM) and the customer (CUS) are involved in these 2 tasks. The customer is involved, during the execution of the project, when he submits change requests, during project review meetings, for the validation and approval of the requirements specifications and for the acceptance of the deliverables.

Software Implementation Process

The purpose of the Software Implementation (SI) process, illustrated in Figure 3, is to achieve systematic performance of the analysis, design, construction, integration, and test activities for new or modified software products according to the specified requirements. The seven objectives of the SI process are listed in Table 6.

Table 5. Example of 2 tasks of the project planning activity (ISO/IEC TR 29110-5-1-2, 2011)

Role	Task	Input	Output
PM CUS	PM.1.2 Define with the Customer the Delivery Instructions of each one of the Deliverables specified in the Statement of Work.	Statement of Work [reviewed	Project Plan Delivery Instructions
PM CUS	PM.1.14 Review and accept the Project Plan. Customer reviews and accepts the Project Plan, making sure that the Project Plan elements match with the Statement of Work.	Project Plan [verified]	Meeting Record Project Plan [accepted]

Figure 2. ISO/IEC 29110 project management process

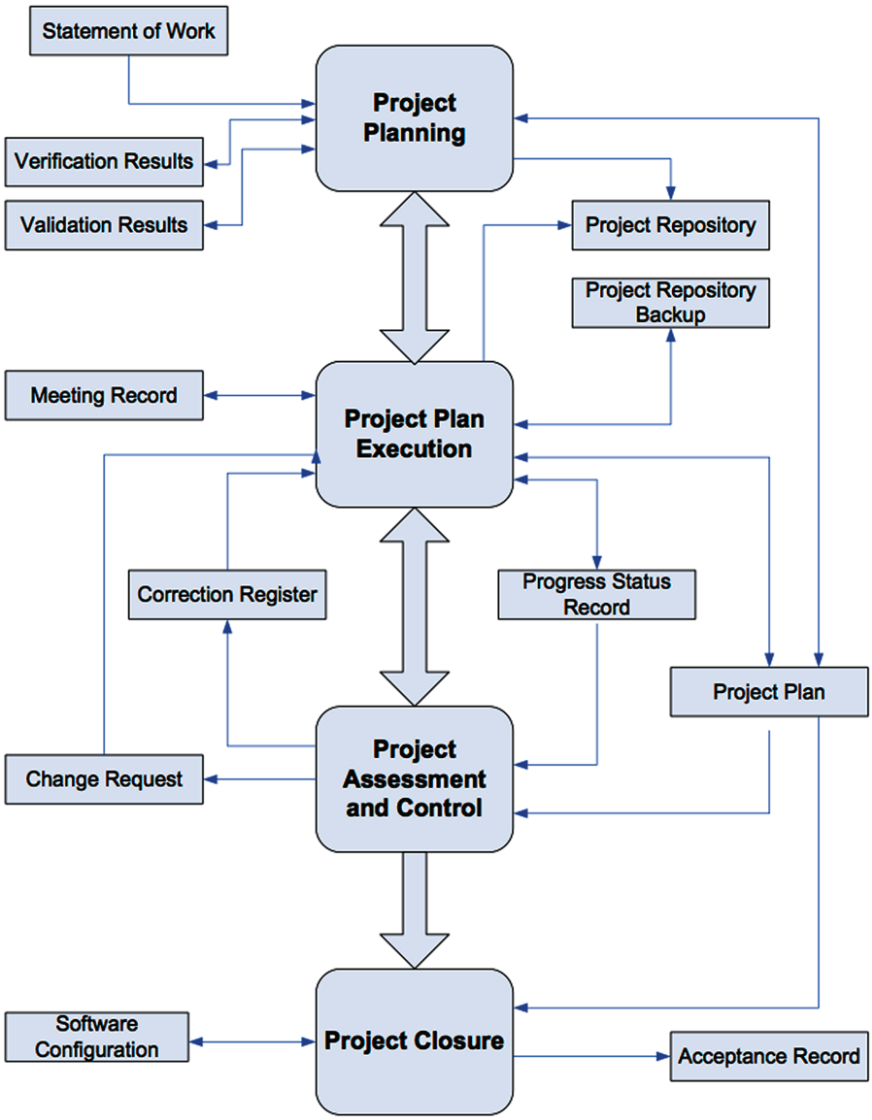


Table 6. Objectives of the software implementation process of the basic profile

Objective	Description
SI.O21	Tasks of the activities are performed through the accomplishment of the current Project Plan.
SI.O2.	Software requirements are defined, analyzed for correctness and testability, approved by the Customer, baselined and communicated.
SI.O3.	Software architectural and detailed design is developed and baselined. It describes the Software Components and internal and external interfaces of them.
SI.O4.	Software Components defined by the design are produced. Unit test are defined and performed to verify the consistency with requirements and the design. T
SI.O5.	Software is produced performing integration of Software Components and verified using Test Cases and Test Procedures. Results are recorded at the Test Report.
SI.O6.	A Software Configuration, that meets the Requirements Specification as agreed to with the Customer, which includes user, operation and maintenance documentations, is integrated, baselined and stored at the Project Repository.
SI.O8.	Verification and Validation Tasks of all required work products are performed using the defined criteria to achieve consistency among output and input products in each activity.

The activities of the Software Implementation Process are:

- **Software Implementation Initiation:** Ensures that the Project Plan established in Project Planning activity is committed to by the Work Team.
- **Software Requirements Analysis:** Analyzes the agreed Customer's requirements and establishes the validated project requirements.

The activity provides:

- **Software Architectural and Detailed Design:** Transforms the software requirements to the system software architecture and software detailed design.
- **Software Construction:** Develops the software code and data from the Software Design.
- **Software Integration and Tests:** Ensures that the integrated Software Components satisfy the software requirements.
- **Product Delivery:** Provides the integrated software product to the Customer.

IMPLEMENTING THE ISO/ IEC 29110 STANDARD

In order to facilitate the implementation, by VSEs, of a Profile, a set of Deployment Packages (2013) are available. A deployment package is a set of artifacts developed to facilitate the implementation of a set of practices, of the selected framework, in a VSE. A deployment package is not a process reference model (i.e. it is not prescriptive). The elements of a typical deployment package are: description of processes, activities, tasks, roles and products, template, checklist, example, reference and mapping to standards and models, and a list of tools. Deployment packages are not intended to preclude or discourage the use of additional guidelines that VSEs find useful.

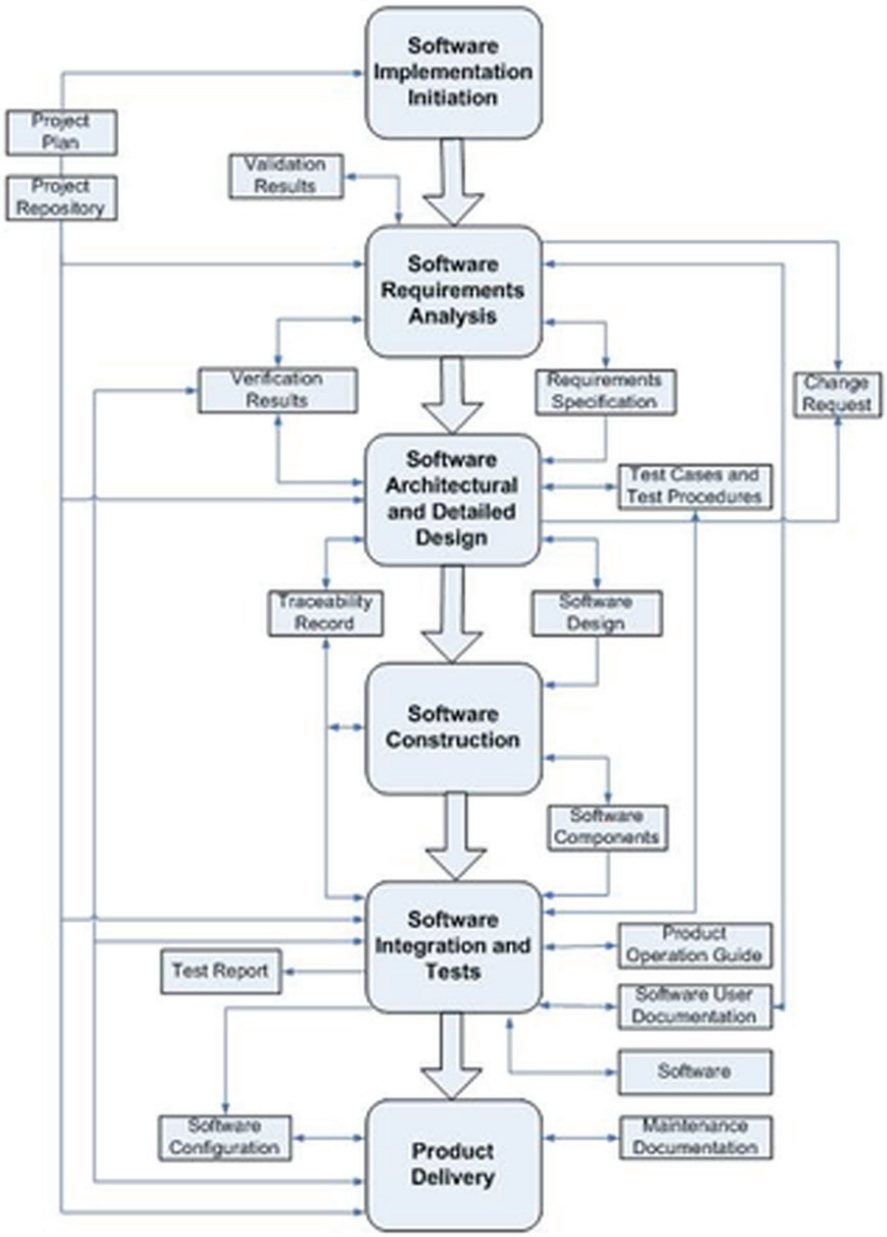
The elements of a typical deployment package are: technical description, relationships with ISO/ IEC 29110, key definitions, detailed description of processes, activities, tasks, roles and products, template, checklist, example, references and mapping to standards and models, and a list of tools. The mapping is only given as information to show that a Deployment Package has explicit links to Part 5, ISO standards, such as ISO/IEC 12207, or models such as the CMMI developed by the Software Engineering Institute. Hence by deploying and implementing a package (O'Connor and Sanders, 2013) a VSE can see its concrete step to achieve or demonstrate coverage to Part 5.

The working group (ISO/IEC JTC1/SC7 WG 24) 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. Pilot projects are an important means of reducing risks and learning more about the organizational and technical issues associated with the deployment of new software engineering practices. Pilot projects are based on the ISO/IEC 29110-5 Management and engineering guide and the deployment package(s).

To date a series of pilot projects have been completed in several countries utilizing some of the deployment packages developed. For example Ribaud et al. (2010) have documented the results of one pilot project that conducted with a 14-person VSE based in France, which successfully implemented ISO/IEC 29110 processes practices utilizing the available Deployment Packages. From which they have identified some potential additional infrastructure and support process activities and suggestions for future evolution of ISO/IEC 29110 Process Profiles. A further series of pilot projects are currently underway in research laboratories and enterprises in Canada, Ireland, Belgium and France, with further pilot projects planned in the near future.

The results from one pilot study in Canada concluded that the tools developed to support the project management processes proved very useful and helped the project managers rapidly

Figure 3. ISO/IEC 29110 software implementation process



integrate the knowledge required to execute the processes (Laporte et al, 2013b). In the case of this trial company, for the first time, the company has documented management processes for small-scale projects. Besides, some project managers have joined forces to promote project management practices within this engineering firm's division. The improvement programme was so successful that managers of the company's other divisions have shown an interest in learning this approach in order to implement it within their respective divisions.

Laporte et al (2015) report on two successful trials of ISO/IEC 29110, that demonstrate it was possible to properly plan the project and develop the software product using proven software prac-

tices 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.

CONCLUSION

For most enterprises, but in particular for VSEs, international certifications can enhance credibility, competitiveness and access to national and international markets. Brazil has led the development of 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. For VSEs, such a certification should not be too expensive and short. The certification process has been successfully piloted in a few VSEs.

Finally, research studies have been undertaken to understanding the perception of VSEs towards the adoption of process standards (Basri et al, 2010) and also to evaluate management sentiment towards ISO/IEC 29110 (O'Connor, 2012) and management commitment to SPI and ISO/IEC 2910 in particular in Europe (O'Connor et al, 2010) and South America (Sanchez-Gordon et al, 2015). These revealed that the acceptance level of any type or model of software quality or lifecycle standard in VSEs is a very low priority item, but the level of awareness of standards and potential benefits was high. Furthermore these studies showed the main reason for not adopting standards was a lack customer requirement, a lack of resources and the perceived difficulties in defining an organizational process. Furthermore, this analysis reveals a pattern that indicates that the acceptance level of quality standard such as ISO among VSEs are still low even though the staff and management are knowledgeable and aware the benefit of adopting such standards. The main reasons are more related to the lack of the customer requirement and the limited resources in the company. In addition the perception a heavyweight process especially in terms of documentation, cost and non- alignment with current development process are among the reasons why the companies did not plan to adopt a lifecycle standard in the short to medium term. However from the analysis, VSEs may still be interested in lifecycle standards if certain important criteria are met and such standards are closely related to their needs. Therefore it can be concluded that the market and demand for ISO/IEC 29110 in VSEs has a positive outlook.

FUTURE RESEARCH DIRECTIONS

In terms of future work, as ISO/IEC 29110 is an emerging standard there is much work yet to be completed (O'Connor and Laporte, 2014). The main remaining work item is to finalize the development of the remaining three profiles: (a) Entry – a six person-months effort project or a start-up VSEs; (b) Intermediate - Management of more than one project and (c) Advanced - business management and portfolio management practices. In addition the development of additional Profile Groups for other domains such as critical software, game industry, scientific software developments are being studied.

Whilst work is currently underway on an assessment mechanism for ISO/IEC 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. In particular there is a strong need to ensure that VSEs are not required to invest the anything similar in terms of time, money and other resources on process assessments, as may be expected from their larger SMEs (small and medium enterprises), or even MNC (multinational corporations) counterparts. Indeed some form of self-assessment, possibly supported by Internet based tools, along with periodic spot-checks may be suitable alternative to meet the unique needs of VSEs.

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KEY TERMS AND DEFINITIONS

Process Assessment: The disciplined examination of the processes by an organisation against a set of criteria to determine capability of those processes to perform within quality, cost and schedule goals.

Project Implementation: Is defined as a specified set of activities designed to put into practice an activity or program of known dimensions.

Project Management: This is the process and activity of planning, organizing, motivating, and controlling resources to achieve specific goals.

Software Process: A set of activities, methods, practices and transformations that people use to develop and maintain software and the associated products.

Software Process Improvement (SPI): Aims to understand the software process as it is used within an organisation and thus drive the implementation of changes to that process to achieve specific goals such as increasing development speed, achieving higher product quality or reducing costs.

Very Small Entity: An enterprise, organization, department or project having up to 25 people.