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Chapter 52
An Innovative Approach to the Development of an International Software Process Lifecycle Standard for Very Small Entities

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ABSTRACT

For very small software development companies, the quality of their software products is a key to competitive advantage. However, the usage of Software Engineering standards is extremely low amongst such very small software companies. A primary reason cited by many such companies for this lack of quality standards adoption is the perception that they have been developed for large multi-national software companies and not with small and very small organizations in mind and are therefore not suitable for their specific needs. This paper describes an innovative systematic approach to the development of the software process lifecycle standard for very small entities ISO/IEC 29110, following the Rogers model of the Innovation-Development process. The ISO/IEC 29110 standard is unique amongst software and systems engineering standards, in that the working group mandated to develop a new standard approached industry to conduct a needs assessment and gather actual requirements for a new standard as part of the standards development process. This paper presents a unique insight from the perspective of some of the standards authors on the development of the ISO/IEC 29110 standard, including the rationale behind its development and the innovative design of implementation guides to assist very small companies in adopting the standards, as well outlining a pilot project scheme for usage in early trials of this standard.

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1. INTRODUCTION

For many small and very small software companies, implementing controls and structures to properly manage their software development activity is a major challenge. Administering software development in this way is usually achieved through the introduction of a software process. All software companies are not the same and vary according to factors including size, market sector, time in business, management style, product range and geographical location. 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 (Coleman & O'Connor, 2008a).

In a time when software quality is a key to competitive advantage, the use of ISO/IEC systems and software engineering standards remains limited to a few of the most popular ones. Research shows that small and very small companies can find it difficult to relate ISO/IEC standards to their business needs and to justify the application of the standards to their business practices (Laporte et al., 2008; O'Connor & Coleman, 2009). Most of these companies don't have the expertise or can't afford the resources - in number of employees, cost, and time - or see a net benefit in establishing software life-cycle processes. There is sometimes a disconnect between the short-term vision of the company, looking at what will keep it in business for another six months or so, and the long-term or mid-term benefits of gradually improving the ways the company can manage its software development and maintenance. A primary reason cited by many small software companies for this lack of adoption of software engineering standards, is the perception that they have been developed for large software companies and not with the small organization in mind (Coleman & O'Connor 2008b). To date the industrial reality is that Very Small Entities (VSEs) have limited ways to be recognized, by large organizations, as enterprises that produce quality software systems within budget and calendar in their domain and may therefore be cut off from some economic activities.

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 recently published ISO/IEC 29110 standard "Lifecycle profiles for Very Small Entities" (ISO, 2011a) is aimed at addressing the issues identified above and addresses the specific needs of VSEs.

The purpose of this paper is to chart the design and development of this new ISO/IEC standard by harnessing the expressive power of the 6-stage model of the innovation-development process model, developed by Rogers (2003). In addition it presents a unique insight from the perspective of two of the standards authors, as well as the initial results of some early pilot trials of ISO/IEC 29110.

The structure of this paper is as follows: Section 2 introduces background concepts and definitions such as the concept of Very Small Entities, Standards and their usage in small companies. Section 3 provides a high level summary of the approach used in this paper and a detailed description of the application of this approach and its outcomes. Section 4 will discuss the impact of this work, its limitations and planned future work.

2. BACKGROUND CONTEXT

2.1. Very Small Entities

The definition of "Small" and "Very Small" Entities is challengingly ambiguous, as there is no commonly accepted definition of the terms. For example, the participants of the 1995 Capability Maturity Model (CMM) tailoring workshop (Ginsberg & Quinn, 1995) could not even agree on what "small" really meant. Subsequently in 1998 SEPG conference panel on the CMM and small projects (Hadden, 1998), small was defined as "*3-4 months in duration with 5 or fewer staff*". Johnson and Brodman (1998) define a small organization as "fewer than 50 software developers and a small project as fewer than 20 software developers". Another definition for VSE introduced by Laporte et al. (2006a) as "*any IT services, organizations and projects with between 1 and 25 employees*".

To take a legalistic perspective the European Commission (2005) defines three levels of Small to Medium-sized Enterprise (SME) as being: Small to medium - "*employ fewer than 250 persons and which have an annual turnover not exceeding 50 million Euro, and/or an annual balance sheet total not exceeding 43 million Euro*"; Small - "*which employ fewer than 50 persons, and whose annual turnover or annual balance sheet total does not exceed 10 million Euro" and Micro - "which employ fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million*".

To better understand the dichotomy between the definitions above it is necessary to examine the size of software companies operating in the market today. According to the Organization for Economic Co-operation and Development (OECD) SME and Entrepreneurship Outlook report (2005), "SMEs constitute the dominant form of business organization in all countries world-wide, accounting for over 95% and up to 99% of the business population depending on country"'. In Europe, for instance, 85% of the Information Technology (IT) sector's companies have 1 to 10 employees. In the context of indigenous Irish software firms 1.9% (10 companies), out of a total of 630 employed more than 100 people whilst 61% of the total employed 10 or fewer, with the average size of indigenous Irish software firms being about 16 employees (Coleman & O'Connor, 2008a). In Canada, the Montreal area was surveyed. It was found that 78% of software development enterprises have less than 25 employees and 50% have fewer than 10 employees (Laporte et al., 2006b). In Brazil, small IT companies (companies with less than 50 employees) represent about 70% of the total number of companies (Anacleto et al., 2004).

Therefore based on the above discussions and the debate within the ISO community, for the purposes of this paper we are adopting the definition for VSE introduced in Laporte et al. (2006b) as "*any enterprise, organization, department and project having up to 25 people*". Furthermore, this is the definition agreed to by the various national representatives of the working group 24 of ISO/IEC JTC1 SC7.

The unique characteristics of small enterprises as well as the uniqueness of their needs make their style of business different (Mtigwe, 2005). Some of the unique differences between small and large enterprises behavior are given in Table 1. Software VSEs are subject to a number of distinctive and intrinsic characteristics that make them different from their larger counterparts, therefore affecting the content, the nature and the extent of the activities. We partition our discussion of VSE characteristics below based on four main categories: financial constraints, typical customer profile, the focus of internal business processes and the constraints on learning and growth (Basri & O'Connor, 2011).

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 al-

Table 1. Characteristic differences between small and large enterprises (from Mtigwe, 2005)

Characteristic	Small Enterprise	Large Enterprise
Planning orientation	Unstructured/operational	Structured/strategic
Flexibility	High	Structured/strategic
Risk orientation	High	Medium
Managerial process	Informal	Low
Learning and knowledge absorption capacity	Limited	High
Impact of negative market effects	More profound	More manageable
Competitive advantage	Human capital centered	Organizational capital centered

located for training; Little or no budget to perform quality assurance activities; No budget for software reuse processes; Low budget to identify, plan and mitigate risks; and Limited budget to perform Process Improvement and /or obtain a certification/assessment of their processes.

Typically the VSEs product has a single customer at a time, where the customer is in charge of the management of the system; the software integration, installation and operation. It is not a current practice for the customer 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. For example, in contrast to small companies, very small companies often do not have regularly formal project meetings (O'Connor et al., 2010).

The internal business process of VSEs is usually focused on developing custom software systems, where the software product is elaborated progressively and incrementally, and typically software projects are independent of one another. Usually 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.

The learning and growth characteristics of VSE are characterized by a lack of knowledge (or acceptance) of software process assessment and improvement and a lack of human resources to engage in standardization.

2.2. Standards: Benefits and Drawbacks

There are multiple approaches to organizing the software development process and multiple factors influencing the software development process (Clarke & O'Connor, 2012), which should be harmonized with software development setting (Jeners et al., 2013). Quality orientated process approaches and standards are maturing and gaining acceptance in many organizations. Standards emphasize communication and shared understanding more than anything. Examples are: any documentation is consistent and what is needed to meet the needs of the organization; all users understand the same meaning of words used - if one person says, 'Testing is completed 'all affected bodies understand what those words mean. This kind of understanding is not only important in a global development environment; even a small group working in the same office might have difficulties in communication and understanding of issues shared by

all. Standards can help in these and other areas to make the business more profitable because less time is spent on non-productive work.

There are many potential benefits of using standards. From a VSE perspective, 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 widely recognized standards.

Although commercial Software Process Improvement (SPI) models (such as Capability Maturity Model Integration for Development, CMMI-DEV) (SEI, 2010) have been highly publicized and marketed, they are not being widely adopted and their influence in the software industry therefore remains more at a theoretical than practical level (Coleman & O'Connor, 2006; O'Connor & Coleman, 2009). In the case of CMMI®, evidence for this lack of adoption can be seen by examining the SEI (Software Engineering Institute) CMMI data for the three-year period March 2008 to March 2011 (CMMI, 2011), which shows that worldwide during that period less than 3,500 individual appraisals were reported, which includes many divisions of the same company. It is clear that this represents a very small proportion of the world's software companies and company in-house developers. In addition, there is evidence that the majority of small and very small software organizations are not adopting standards such as CMMI. For example, an Australian study (Staples et al., 2007) found that small organizations considered that adopting CMMI "*would be infeasible*".

Further investigation of the SEI CMMI appraisal data reveals that in the case of Ireland – a country whose indigenous software industry is primarily made of small to medium sized organizations (SME) - fewer than 10 CMMI appraisals were conducted during the ten-year period 2001 - 2011, from a population of more than 900 software companies. Therefore it is also clear that the Irish software industry is largely ignoring the most highly publicized SPI models. In the case of CMMI (and its predecessor Software CMM), 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.

Though it is not new to claim that SPI has an associated cost, many companies are deterred from investigating SPI models because of a perceived cost. Managers' perceptions are that SPI means increased documentation and bureaucracy (O'Connor et al., 2010). Such a perception is widespread and is seen as a 'feature' of standards such as CMMI. Whether or not this is true is a debatable point. The fact that managers associate CMMI with increased overhead means that most small companies do not see the model as being a viable solution or even worthy of investigation.

There is evidence (Laporte et al., 2008; Coleman & O'Connor 2008a; O'Connor & Coleman, 2009) 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 in terms of number of employees, size does actually matter. 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 (e.g. ISO/IEC 12207) and maturity models (e.g. CMMI for Development).

2.3. VSE and Standards Usage

In a time when software quality is a key to competitive advantage, the use of ISO/IEC systems and software engineering standards by VSEs remains limited to a few of the most popular ones, such as ISO 9001. Research shows that VSEs can find it difficult to relate ISO/IEC standards to their business needs and to justify the application of the standards to their business practices. Most of these VSEs can't afford the resources - in number of employees, expertise, cost, and time - or see a net benefit in establishing software life-cycle processes. There is sometimes a disconnect between the short-term vision of the organization, looking at what will keep it in business for another six months or so, and the long-term benefits of gradually improving the ways the company can manage its software development and maintenance. A primary reason cited by many small software organizations for this lack of adoption of such ISO standards, is the perception that they have been developed by and for large multi-national software companies and not with the small organization in mind (Ahern et al., 2004). Subsequently, VSEs have no or very limited ways to be recognized as enterprises that produce quality software systems in their domain and may therefore be cut off from some economic activities.

Small software organizations, in the first instance, focus mostly on survival. This, in part, explains the success of agile methodologies whose 'light', non-bureaucratic techniques support companies in survival mode attempting to establish good, fundamental software development practices. Though CMMI is firmly anchored in the belief that better processes means better products, many small Irish software product companies are merely concerned about getting a product released to the market as quickly as possible. Development models, such as those within the agile approach, rather than CMMI or ISO 9000, are perceived as supporting this objective. This clearly poses questions for CMMI and ISO 9001 researchers. However, if SPI models are to be more widely deployed by early stage (start-ups) companies, existing models may have to be broadened to take account of the necessity for these companies to meet their development targets and 'walk before they can run' (Basri & O'Connor, 2010a; Basri & O'Connor, 2010b).

2.4. International Organization for Standardization

The mandate of the International Organization for Standardization (ISO) Sub-Committee 7 (SC7) is to develop, maintain, promote and facilitate IT standards required by global markets to meet business and user requirements concerning Software and Systems Engineering. A description of SC7 and of the development of ISO/IEC JTC1/SC7 standards is presented in Coallier (2003).

In 2005, a new ISO/IEC JCT1/SC7 Working Group (WG 24) was established with a mandate to investigate the need for and propose software life cycle profiles and guidelines for use in very small entities. In 2011, a first set of documents, titled ISO/IEC 29110, targeted at VSEs involved in the development or maintenance of software has been published by ISO (2011).

It should be noted that the authors of this paper are all key members of the ISO/IEC JTC1/SC7 WG24 standards development group and are also editors of various parts of the ISO/IEC 29110 standard. As such they have a unique insight into the development of a new standard and a direct influence on its development. In addition the papers authors are author/editors of the Deployment Packages and Implementation Guides, which will be described later in this paper. Accordingly the authors are in a position to provide a unique insight into the design, development and initial deployment of this innovative standard.

3. INNOVATION-DEVELOPMENT PROCESS APPROACH

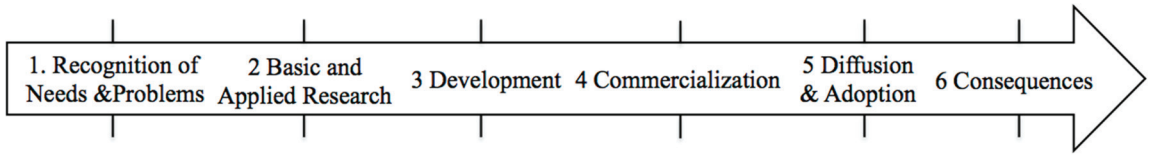
This section provides an explanation of the approach taken to the design, development and implementation of ISO/IEC 29110 from a research perspective. To illustrate the development of the standards we have adopted the 6-stage model of the innovation-development process model, developed by Rogers (2003), as illustrated in Figure 1. Rogers defines the innovation-development process as follows: all the decisions, activities, and their impacts that occur from recognition of a need or problem, through research, development, and commercialization of an innovation through diffusion and adoption of the innovation by users, to its consequences.

Here we will briefly outline the 6 stages of Rogers model and outline the key actions required by ISO/IEC 29110 standard developers to utilize this model for the design and development of a new standard (Laporte, 2009):

- **Stage 1 - The Recognition of Needs and Problems:** Primarily concerned with the awareness of a problem. In this paper we outline the lack of awareness and acceptance of existing standards by small and very small software companies and justify the need for a new approach to the development of process standards aimed specifically at very small companies;
- **Stage 2 - Basic and Applied Research:** We describe both the design and results of an international survey of very small software companies, leading to an enhanced understanding of the actual needs of very small software companies from a process standard;
- **Stage 3 - Development:** We describe the combination of the traditional approach to the development of a new standard with a novel approach to support the implementation, i.e. the development of a set of Deployment Packages;
- **Stage 4 - Commercialization:** We depart from the traditional Rogers model by examining the route to the formal publication and of a new international standard and the dissemination exercise aimed at those businesses wishing to put in place a portfolio of software development management practices;
- **Stage 5 - Diffusion and Adoption:** We describe a series of mini-research pilot projects with very small software companies as a means to accelerate the adoption and utilization of ISO/IEC 29110;
- **Stage 6 - Consequences of an Innovation:** We present the potential positive and negative consequences of the publication of standards, the novel approach taken and the results to date of the research pilot projects.

The main body of this paper (Section 3) is structured according to the 6 stages above. However, prior to that discussion it is necessary to clearly define the target audience for this standard, namely Very Small Entities (VSEs).

Figure 1. Stages of the innovation-development process (adapted from Rogers 2003)



In the remainder of this section, we describe the design, development and implementation of a new standard according to the six stages of the Rogers model of Innovation-Development Process.

3.1. Stage 1: The Recognition of Needs and Problems

The ISO/IEC 29110 standard is unique amongst software and systems engineering standards, in that the working group mandated to develop a new standard approached industry to conduct a needs assessment and gather actual requirements for a new standard.

The origins of the ISO/IEC 29110 project date back to a 2004 meeting of the ISO sub-committee (SC7) mandated to develop international Software Engineering standards, where there was a general recognition of the adoption issues presented by SC7 standards for small and very small companies. This lead directly to the subsequent formation of a working group (ISO/IEC JCT1/SC7 WG24) whose brief was to develop a software process lifecycle standard specific to meet the needs of VSEs whilst remaining compatible with existing ISO/IEC standards to allow a path for VSEs future growth and standards adoption (Laporte et al., 2008).

Commercial SPI models have not been widely adopted by small and very small companies and their influence in the software industry therefore remains more at a theoretical than practical level. There is now a substantial body of research evidence (Laporte et al., 2008; Coleman & O'Connor, 2008b) that the majority of small software organizations are not adopting existing standards because they perceive the standards as being orientated towards large organizations. 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.

However quality-orientated process approaches and standards are maturing and gaining acceptance in many companies (O'Connor & Laporte, 2011a) and there is a clear benefit even to VSEs in the usage of standards. Amongst other positive effects, standards emphasize communication and shared understanding more than anything. Examples are: any documentation is consistent and what is needed to meet the needs of the organization; all users understand the same meaning of words used - if one person says, 'Testing is completed!', all affected bodies understand what those words mean. This kind of understanding is not only important in a global development environment; even a small group working in the same office might have difficulties in communication and understanding of issues shared by all. Standards can help in these and other areas to make the business more profitable because less time is spent on non-productive work.

3.2. Stage 2: Basic and Applied Research

In order to ascertain an enhanced understanding of the utilization of ISO/SC7 standards and to collect data to identify problems and potential solutions specific to VSEs, a survey of VSEs was designed to validate some of the groups initial working goals and better understand VSE attitudes to and requirements of standards. A survey questionnaire was developed and translated into 9 languages: English, French, German, Korean, Portuguese, Thai, Turkish, Russian and Spanish. The survey is made up of 20 questions structured in 5 parts: General information, Information about standards utilization in VSEs, Information about implementation and assessment problems in VSEs, Information about VSE needs and Information about justification for compliance to standard(s).

Over 400 responses were collected from 29 countries. The detailed major findings are documented in (Laporte et al., 2008), however some salient points are discussed here. An interesting finding of the survey is the difference in the percentage of certified companies with regard to company size: less than 18% of VSEs are certified, while 53% of larger companies (more than 25 employees) claim to be certified. Furthermore, among those 18% who are certified, 75% of them do not use standards. In larger companies using standards, two families of standards and models emerge from the list: ISO standards (55%) and models from the Software Engineering Institute (SEI; 47%).

The survey anticipated the weak use of standards by VSEs by asking questions designed to provide a better understanding of the reasons for this. The three main ones are: lack of resources; standards are not required; and the nature of the standards themselves, with 15% of the respondents consider that the standards are difficult and bureaucratic, and do not provide adequate guidance for use in a small business environment.

For a large majority (74%) of VSEs, it is very important to be evaluated or certified against a standard. ISO certification is requested by 40% of them. Of those requesting official market recognition, only 4% are interested in a national certification. From the VSE perspective, some benefits provided by certification are:

- Increased competitiveness;
- Greater customer confidence and satisfaction;
- Greater software product quality;
- Increased sponsorship for process improvement;
- Decreased development risk;
- Facilitation of marketing (e.g. better image);
- Higher potential to export.

However, VSEs are expressing the need for assistance in order to adopt and implement standards. Over 62% would like more guidance with examples, and 55% are asking for lightweight and easy-to-understand standards complete with templates. Finally, the respondents indicated that it has to be possible to implement standards with minimum cost, time and resources. All data about VSEs and standards clearly confirm WG24's fundamental assumption and the requirements. Therefore, WG24 uses this information to help define its approach for the development of profiles, guides and templates to meet VSE needs.

3.3. Stage 3: Development

The approach (Laporte et al., 2008) used to develop ISO/IEC 29110 started with the pre-existing international standard ISO/IEC 12207 (ISO, 2008) dedicated to software process lifecycles. The overall approach consisted of three steps: (1) Selecting ISO/IEC 12207 process subset applicable to VSEs (2) Tailor the subset to fit VSE needs; and (3) Develop guidelines for VSEs.

At the core of this standard is a Management and Engineering Guide (ISO/IEC 29110-5; ISO, 2011a) focusing on Project Management and Software Implementation and an Assessment Guide (ISO/IEC 29110-3; ISO, 2011b). It is worth noting that as with all proposed ISO standards, ISO/IEC 29110 is subject to the normal ISO review process. During the development of the standard in excess of 1250 comments have been processed between 2008 and 2010. The entire set of documents, targeted by audience, has been developed to improve product, service quality, and process performance. These are Part

1: Overview, Part 2: Framework and Taxonomy, Part 3: Assessment Guide, Part 4: Profile Specifications and Part 5: Management and Engineering Guides. Parts 1 and 5 are mainly targeted to VSEs, Part 3 is targeted for Assessors and VSEs and Parts 2 and 4 are targeted for standards producers, tool vendors and methodology vendors. When a new profile is needed, Parts 4 and 5 can be developed or tailored from existing Parts 4 and 5 without impacting the other documents and they become Part 4-x and Part 5-x respectively through the ISO/IEC process.

3.4. Stage 4: Commercialization

A novel approach taken to assist VSEs in the deployment of ISO/IEC 29110 is the development of a series of deployment packages (DP), to define guidelines explaining in more details the processes defined in the ISO/IEC 29110 profiles (Laporte, 2009). These guidelines will be freely accessible on the Internet to VSEs. A DP is a set of artifacts developed to facilitate the implementation of a set of practices, of the selected framework, in a VSE. A DP is not a process reference model (i.e. it is not prescriptive). The elements of a typical DP are: description of processes, activities, tasks, roles and products, template, checklist, example, reference 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 standards, such as ISO/IEC 12207, or models, such as the CMMI for Development, hence by deploying and implementing the package, a VSE can see its concrete step to achieve or demonstrate coverage. Packages are designed such that a VSE can implement its content, without having to implement the complete framework at the same time. A set of nine DPs have been developed to date and are freely available from (DP, 2011). In addition a series of "Implementation Guides" have been developed to help implement a specific process supported by a tool and are freely available from (DP, 2011). To date five such guides have been developed.

These Deployment Packages and Implementation Guides mark a significant departure from existing standards development and are specifically designed to ease many of the issues and problems VSE have with implementing standards on a day to day basis, as outlined earlier. In addition a series of Eclipse plug-ins and have been made freely available to the public.

It is worth noting that the formal ISO mandate of a working group stops at this point with publication a new standard, as ISO are not directly involved with the usage of new standards. However, the authors have been involved in the full Rogers cycle on innovation-development with respect to the standard. Further, many members of WG24 have participated in commercialization type activities of ISO/IEC 29110 through the publication of papers, the participation in conferences and workshops and participation in numerous industry events.

The Rogers (2003) model envisages a traditional view of commercialization of an innovation. However, that is not strictly compatible with the development and launch of an international standard, as ISO standards are not commercial in the pure sense. Although many ISO standards are sold on a commercial basis, the costs involved are comparatively small. In the case of ISO/IEC 29110, most parts of the standard are being made freely available.

It is worth noting that as with all proposed ISO standards, ISO/IEC 29110 was subject to the normal ISO review and ballot (voting) process, with a final successful ballot in 2010 and formal publication in 2011 (ISO, 2011a). In 2012, the Entry profile, targeted at a six person-months effort project or a start-up VSE, has been published (ISO 2012a). Upon the request of WG24, ISO has made available at no cost the set of ISO/IEC 29110 technical reports.

3.5. Stage 5: Diffusion and Adoption

The authors are advocating the use of pilot projects as a means to accelerate the adoption and utilization of ISO/IEC 29110 by VSEs. 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. A successful pilot project is also an effective means of building adoption of new practices by members of a VSE. Pilot projects are based on the ISO/IEC 29110-5 Management and Engineering Guide (ISO, 2011a) and the deployment package(s). In particular these are aimed to collect, as a minimum, the following data:

- Effort and time to deploy by the VSE;
- Usefulness for the VSE;
- Verification of the understanding of the VSE;
- Self-assessments data - A self-assessment at the beginning of the pilot and at the end of the pilot project DP.

To further assist with the roll out of a pilot project and to ensure that all pilot projects are conducted similarly around the world, a set of pilot project guidelines were developed in the form of a Deployment Package (DP, 2011) to describe a process to conduct pilot projects. The primary purpose of this Deployment Package is to provide tailorable and usable guidelines and materials in order to select and conduct pilot projects in VSEs. The high-level tasks of this Deployment Package are:

- Assess the opportunity to conduct a pilot project;
- Plan the pilot project;
- Conduct the pilot project; and
- Evaluate the results of the pilot project.

An additional target audience, and an often forgotten one, in the area of software engineering standards comprise undergraduate and graduate students. In 2009, at the WG24 meeting in India, an informal interest group about education was formed (Laporte, 2009). The 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. Work is already underway on the development of course modules to support DPs via a VSE Education Special Interest Group. To date four of the six courses have been developed and are freely available (VSE SIG, 2011). In addition the WG245 team has created an initial set of Wikipedia information pages in the English, French, Portuguese and Spanish language versions of Wikipedia and also a set of introductory videos (in both English and French) available on both PlanetISO (http://www.youtube.com/user/PlanetISO) and YouTube.

3.5.1. Network of Support Centres

An informal meeting of the ISO working group delegates was organized, by Canada in 2008, to launch a Network of collaborators as well as to explain to new participants of WG24 the purpose, objectives, the collaboration agreement and accomplishments of the new Network (Laporte, 2009). Essentially, the purpose of the Network aims to promote, facilitate and develop collaborative activities between institu-

tions in the field of software engineering, information technology and others to improve VSE capabilities especially in Software Engineering and Information Technology (Laporte et al., 2008). The main objectives of the Network are to accelerate deployment of Standard and Guides for VSEs and to accelerate the development and application of Guides and Deployment Packages (e.g. through pilot projects). The current participants to the Network are:

- **Belgium:** Centre d'Excellence en Technologies de l'Information et de la Communication (CETIC).
- **Brazil:** RIOSOFT agent for Brazilian software excellence in Rio de Janeiro.
- **Canada:** École de Technologie Supérieure (ETS).
- **Colombia:** Parquesoft Foundation.
- **Finland:** Tampere University of Technology, Pori.
- **France:** Université de Bretagne Occidentale.
- **Haiti:** Institut Universitaire Quisqueya-Amérique (INUQUA).
- **Hong Kong:** Polytechnic University.
- **Ireland:** Lero, The Irish Software Engineering Research Centre.
- **Luxembourg:** Public Research Centre Henri Tudor.
- **Peru:** University of Lima; Universidad Peruana de Ciencas Aplicadas; and Universidad de San Martin de Porres.
- **Thailand:** Institute of Software Promotion for Industries.

Additional countries, such as Ecuador, Mexico, Spain and Japan are considering joining the Network.

3.6. Stage 6: Consequences of an Innovation

As the official publication of this standard occurred in 2011 (ISO, 2011a) and given the slow nature of adoption of standards by VSEs, it is still somewhat early to definitively comment on the consequences of the development of ISO/IEC 29110. Some potential consequences or side-effects that could result from the publication of the ISO/IEC 29110 standards in imposing the standards on all the VSEs in a country or on all a customer's VSEs are (Laporte, 2009):

- Some VSEs may lose valuable employees who do not want to use formal processes;
- Some VSEs may decide to ignore the regulation or shut down;
- Some VSEs might not be able to afford to implement the standard because of lack of internal expertise;
- The standards may impose practices that are in opposition to the culture of a VSE;
- VSEs may not be eligible for contracts if they do not comply with the standards;
- A VSE of a multi-national organization could be forced to put in place compliant processes which are different from those of other VSEs in the same organization, burdening that VSE with having to use the standards (e.g. VSEs may need 2 sets of processes: one to comply with national regulations and one to engage in development with other members of a multi-national company).

Some potential consequences or side-effects by not imposing the standards on VSEs (*laissez-faire*) are (Laporte, 2009):

- Some VSEs may decide to ignore the standard, thereby slowly losing competitiveness;
- Some VSEs may not know that such a standard exists, thereby missing an opportunity to become more competitive;
- No government support is available to help VSEs adapt and implement the standards;
- Each VSE would have to invest separately to implement the standard (e.g. purchase training courses);
- Assessors may not be locally available to consult on, or assess, compliance with the standards.

However, extremely positive feedback has been received in relation to the pilot projects and also to the innovative development of Deployment Packages.

Whilst space limitations do not allow for a detailed discussion on research methodology, it is worth noting that the purpose of a pilot project is as an exploratory study. This may be used as a prelude to larger research study and for doing causal investigations and is aimed at elucidating and understanding the internal dynamics of program operations. The primary advantage of this type of case study approach is "it often highlights new insights or ideas and when used as a pilot study, it can sometimes generate ideas and focus research" (Patton, 1987).

4. DISCUSSION

Prior studies have shown the main reason for VSEs not adopting standards include a lack customer requirement, a lack of resources and the perceived difficulties in defining an organizational process (O'Connor, 2012). However, this study also revealed a pattern that indicates that the acceptance level of quality standards such as ISO/IEC 29110 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 customer requirement and 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. It is therefore critical that this standard is introduced to VSE in a systematic manner to demonstrate first hand to VSEs the benefits of ISO/IEC 29110.

4.1. Pilot Projects

The working group (ISO/IEC JTC1/SC7 WG 24) behind the development of this standard is advocating the use of pilot projects as a means to accelerate the adoption and utilization of ISO/IEC 29110 by VSEs around the world. 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. A successful pilot project is also an effective means of building adoption of new practices by members of a VSE. Pilot projects are based on the ISO/IEC 29110-5 Management and engineering guide (ISO, 2011a) and the deployment package(s). In particular these are aimed to collect, as a minimum, the following data:

- Effort and time to deploy by the VSE;
- Usefulness for the VSE;

- Verification of the understanding of the VSE;
- Self-assessments data - A self-assessment at the beginning of the pilot and at the end of the pilot project DP.

To date a series of pilot projects have been completed in several countries utilizing some of the deployment packages developed. For example in Canada a pilot study has been conducted in an IT department with a staff of 4: 1 analyst and 3 developers, who were involved in the translation and implemented 3 DPs: Software Requirements, Version Control, Project Management (O'Connor & Laporte, 2012). In Belgium a VSE of 25 people started with a process assessment phase aiming to identify strengths and weaknesses in development related processes (Boucher et al., 2012). This company is now working on improvement actions mainly based on the following Deployment Packages: Requirement Analysis, Version Control, and Project Management.

A series of pilot projects are currently underway in Canada (Laporte et al., 2013a), Ireland (O'Connor and Sanders 2013), Belgium and France (Ribaud et al., 2010), with further pilot projects planned in the near future. To date we have published (Ribaud et al., 2010) the final conclusions and results of one pilot project that was conducted with a 14-person VSE based in France, which successfully implemented ISO/IEC 29110 processes practices utilizing the available Deployment Packages. From this we have identified some potential additional infrastructure and support process activities and suggestions for the future evolution of ISO/IEC 29110 Process Profiles.

Brazil has developed, with the Brazilian Standard organization ABNT (Associação Brasileira de Normas Técnicas) an ISO/IEC 29110 certification scheme. A first series of VSEs from Brazil should obtain an ISO/IEC 29110 certificate of conformity in 2013. The auditing scheme, developed by Brazil, will probably be used by other countries, such as Canada, to audit their VSEs (Laporte et al., 2013b).

4.2. Future Work

As ISO/IEC 29110 is an emerging standard there is much work yet to be completed (Laporte et al., 2013c). The main remaining work item is to finalize the development of the remaining two profiles: (a) Intermediate Level - Management of more than one project and (b) Advanced Level - business management and portfolio management practices. The Intermediate profile is targeted for publication by ISO either at the end of 2014 or at the beginning of 2015 (ISO, 2012c). In addition the development of additional Profile Groups for other domains such as critical software, game industry, scientific software development are being studied.

With any new initiative there is much to be learned from conducting pilot projects. One issue of major importance to VSEs which is emerging from these pilot projects and similar work by the ISO working group is the need for a light-weight flexible approach to process assessment. Whilst work is currently underway on an assessment mechanism for ISO/IEC 29110 (ISO, 2011b), 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 (O'Connor & Laporte, 2011b). In particular there is a strong need to ensure that VSEs are not required to invest 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 a suitable alternative to meet the unique needs of VSEs. It is clear that the process assessment community will have to rethink process assessment, new methods and ideas for assessing processes in VSEs.

Furthermore, work is currently underway on broadening the ISO/ISE 29110 standard from purely Software Engineering lifecycle support to explicitly include Systems Engineering lifecycles (Laporte et al., 2012). It is anticipated that in the near future a Systems Engineering suite of VSE standards will emerge from ISO/IEC JCT1/SC7 Working Group 24. A systems engineering first profile, the Basic profile, has been circulated for a second round of review in 2012 (ISO 2012d). The Basic profile should be published by ISO in 2014. The draft Basic profile is already being piloted by a subway equipment manufacturer in Canada. The development of the systems engineering Entry profile has also been initiated in 2013. The Entry profile could be published either at the end of 2014 or at the beginning of 2015.

5. CONCLUSION

The documents used by WG24 and the approach that led to the development of the International Standards and Technical Reports for VSEs were presented. The approach taken by WG24 corresponds to the mixed economy approach, where the intent is to help VSEs succeed in business by providing them with a set of software engineering practices tailored to their needs, in the form of international standards, technical reports and deployment packages.

It is expected that some VSEs will use the technology developed on their own, other VSEs will get some help from government organizations, such as training or coaching, and some large organizations will impose the ISO/IEC 29110 standards on the VSEs that supply components for their products. A few countries have opted for the 'survival of the fittest' strategy for their VSEs, i.e. an approach where a government does not intervene in the marketplace and lets the market decide which VSEs will survive. At the same time, a number of government agencies, universities, research centers and associations are working to determine how to help VSEs. They share some of the following assumptions about the needs of VSEs (Laporte & Palza-Vargas, 2012):

- VSEs require low-cost solutions;
- VSEs require readily usable processes supported by guides, templates, examples and tools;
- VSEs require additional effort in communications and in standardizing vocabulary;
- VSEs require a staged approach to help them grow their capabilities;
- VSEs require ways to identify potential quick wins;
- VSEs require guidance in the selection and implementation of software practices.

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APPENDIX

Overview of ISO/IEC 29110

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

As illustrated in Figure 3, the customer's statement of work is used to initiate the PM process. The project plan will be used to guide the execution of the software requirements analysis, soft- ware 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. The PM process closure activity will deliver the Software Configuration (i.e. a set of software products) and will obtain the customer's acceptance to formalize the end of the project.

Overview of the Project Management Process

The purpose of the Project Management process is to establish and carry out the tasks of the software implementation project in a systematic way, which allows compliance with the project's objectives in terms of expected quality, time, and costs. The seven objectives of the PM process are listed in Table 2.

Figure 3 illustrates the 4 activities of the project management process as well as their input and output product. Each activity is composed of tasks. The task description doesn't impose any technique or method to perform it. Even though, a sequential view is presented in Figure 3, ISO/IEC 29110 is not intended to preclude the use of different life cycles such as waterfall, iterative, incremental, evolutionary or agile.

Figure 2. ISO/IEC 29110 project management and software implementation relationship

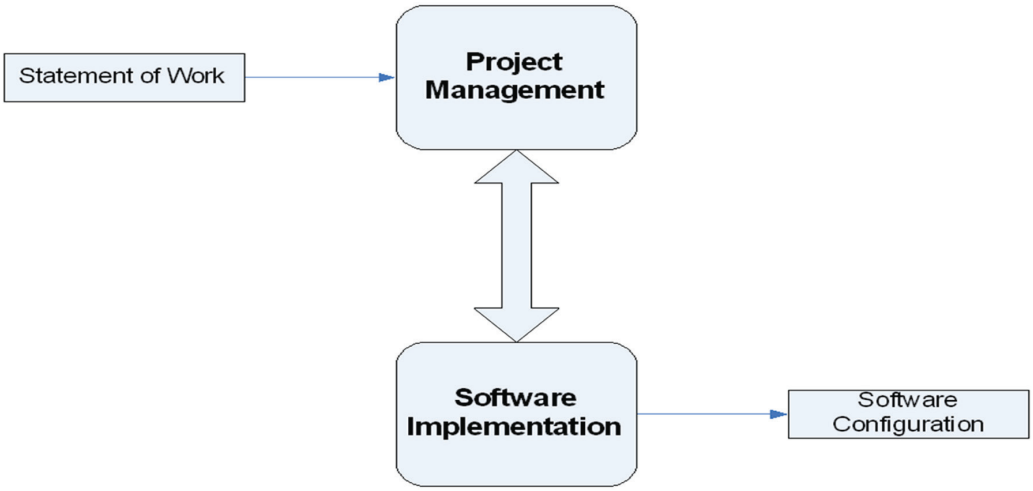
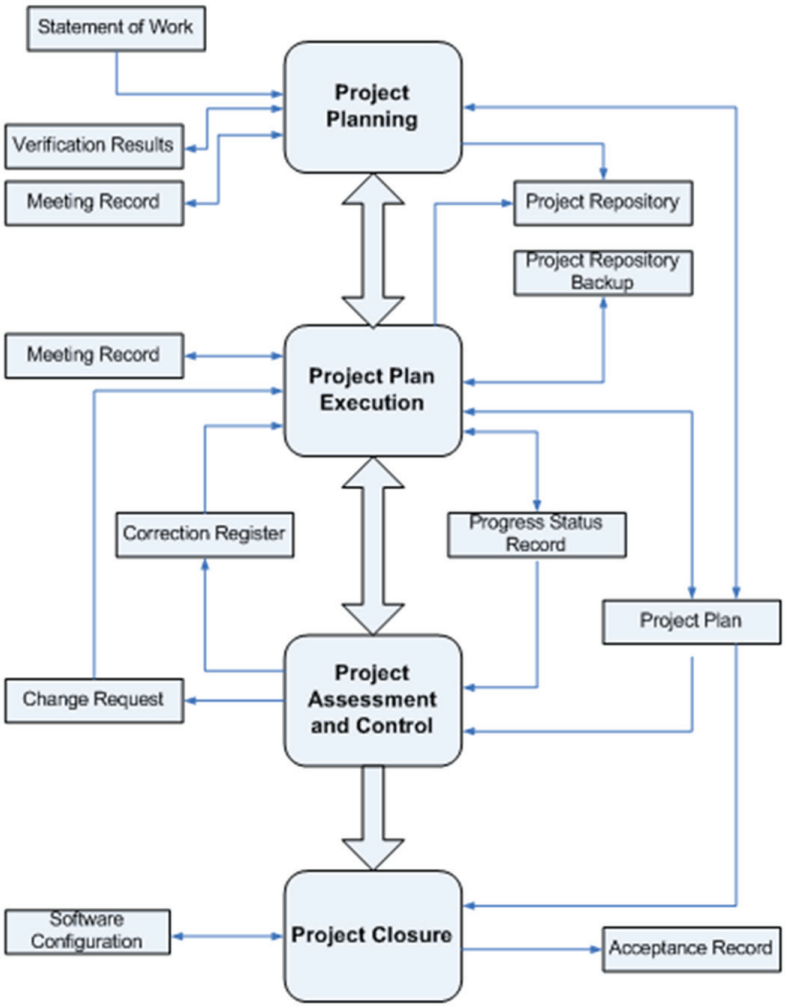


Table 2. Objectives of the project management process of the basic profile

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.

Figure 3. ISO/IEC 29110 project management process



For illustration purposes, two tasks of the Project Planning activity are listed in Table 3. On the left side of the table are listed the roles involved in a task. 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.

Overview of the Software Implementation Process

The purpose of the Software Implementation process, illustrated in Figure 4, 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. Figure 4 illustrates the 4 activities of the SI process as well as their input and output products. Even though, a sequential view is presented in Figures 3 and 4, ISO/IEC 29110 is not intended to preclude the use of different lifecycles such as waterfall, iterative, incremental, evolutionary or agile.

The purpose of the (SI) process 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 4.

Table 3. Example of 2 tasks of the project planning activity

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]

Table 4. 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. Consistency and traceability to software requirements are established.
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. Traceability to the requirements and design are established.
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. Defects are corrected and consistency and traceability to Software Design are established.
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. Needs for changes to the Software Configuration are detected and related change requests are initiated.
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. Defects are identified, and corrected; records are stored in the Verification/Validation Results.

Figure 4. ISO/IEC 29110 software implementation process